Final Alternatives Assessment for Phosphorus Compliance
Badger Mill Creek, Outfall 005
Madison Metropolitan Sewerage District

Madison Metropolitan Sewerage District
April 2023

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Recommendation

Based on the analysis of District staff and experts summarized as findings in this report, the District is recommending a final compliance option for Badger Mill Creek that involves a two-part strategy. The findings indicate that while Badger Mill Creek is expected to maintain flow with or without District effluent, many other environmental factors restrict its future as a high-quality community asset.

Through various assessments, we have found that the District's effluent is not controlling the overall health of Badger Mill Creek. Maintaining the return to Badger Mill Creek uses significant energy, and the stream's overall health and future regulations will further restrict the District's ability to maintain the effluent return. As such, we have determined it is time to cease effluent return to Badger Mill Creek. Ceasing flow allows the District to meet the phosphorus water quality standard for this waterway as required by the Wisconsin Department of Natural Resources (WDNR). In addition, the stream benefits by reducing the amount of chloride and the higher temperatures contained in District effluent.

During this analysis, the District uncovered various needs for the stream to thrive fully. These include habitat improvement, low-flow channel design, and debris and sediment removal. In addition, the current flooding and high water upstream of the current return point are valuable assets that could be leveraged for future low-flow-related concerns while also helping to solve the current flooding and high-water challenges.

As part of the project to cease operations of the Badger Mill Creek return, this recommendation includes the District providing financial resources to local communities and organizations to move forward with enhancement projects.

Background

Badger Mill Creek PLUS is the Madison Metropolitan Sewerage District's (MMSD or the District) project to assess compliance options for total phosphorus (TP) in the stream. This is a requirement of the District's Wisconsin Pollution Discharge Elimination System (WPDES) permit, which WDNR issues. PLUS stands for Phosphorus Limits and Updated Solutions.

Since 1998, the District has pumped treated effluent to Badger Mill Creek daily. This effluent is pumped through an approximately 10-mile-long force main and enters the stream at a cascade aerator. Over the years, this demonstration has improved the community connection with the water cycle and the value of treated effluent as a community asset and renewable resource.

At present, about 8% of the District's effluent is returned to Badger Mill Creek (Photo 1). The remaining 92%, approximately, is directed to the District's primary discharge site, Badfish Creek (Photo 2).

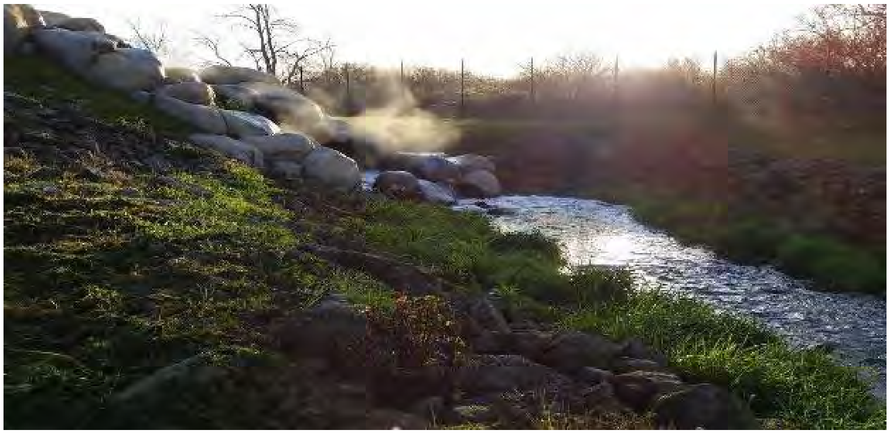

Photo 1 - Cascade Aerator at Badger Mill Creek

Photo 2 - Cascade Aerator at Badfish Creek

Historically, the City of Verona owned and operated a wastewater treatment plant that discharged treated effluent to the Sugar River. When the City of Verona faced significant upgrades at its facility due to new phosphorus requirements promulgated in 1992, the City decided to regionalize with the Madison Metropolitan Sewerage District. In 1993, the District annexed the City of Verona wastewater treatment plant. At that point, facility planning began and was finalized in October 1994. Subsequently, construction began on a pumping station on the site of the former treatment plant, and a force main was constructed to route wastewater to the District's Nine Springs Wastewater Treatment plant. The District assumed ownership and operation of the City of Verona wastewater treatment plant, and in January 1995, wastewater began being pumped to the District's Nine Springs Wastewater Treatment plant, and the City of Verona plant was disassembled.

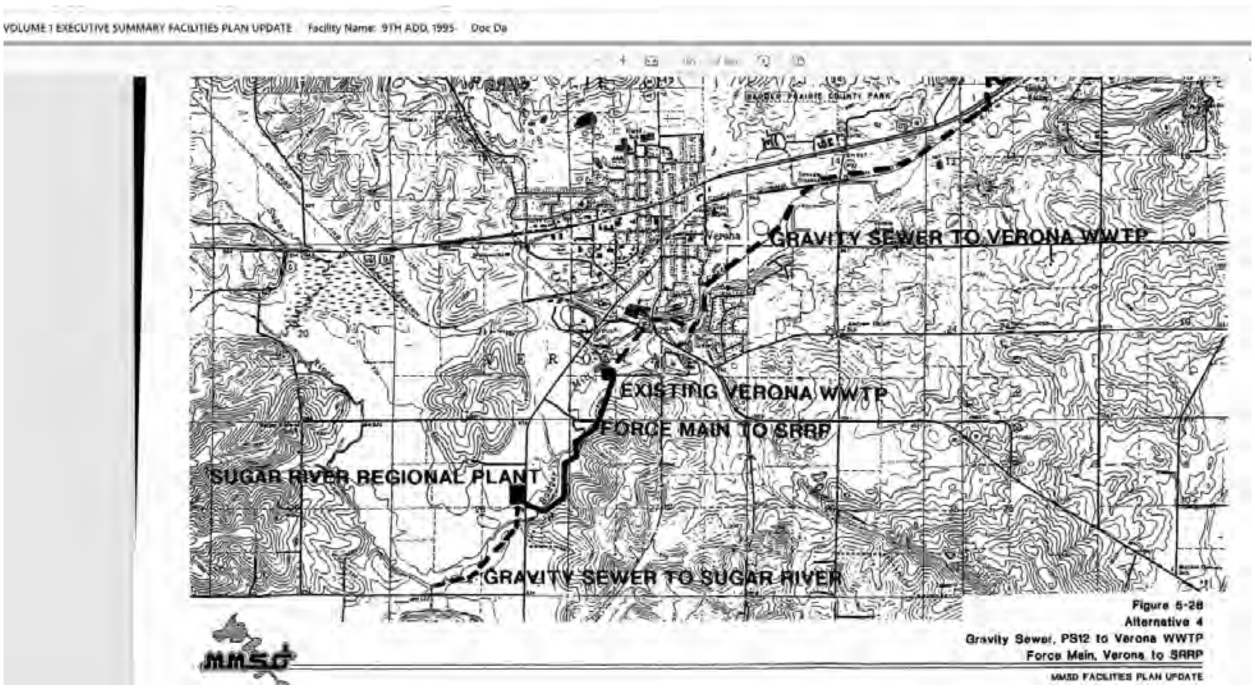

Figure 1 - Location Map for Future Sugar River Regional Wastewater Plant, MMSD 9th Addition Facility Planning

During this regionalization, significant discussion occurred regarding maintaining a discharge location for the Sugar River watershed. This was an important consideration in the 1995 9th Addition Facility Planning undertaken by the District and its consultants. In addition, the District purchased a first right of refusal on land in the watershed for a future satellite wastewater treatment plant (Figure 1). However, as part of the District's 50-year master planning (Malcolm Pirnie, Inc. & Strands & Associates, 2009) process in 2009, a request was made to WDNR (Exhibit L) that resulted in a determination that no satellite plant would be constructed in the Sugar River basin, and the property was let go.

A critical factor in the District's decision not to pursue a discharge location in the Sugar River was a future wastewater limits memorandum created by WDNR in 2010. That memorandum (included in Exhibit L) indicated that if a wastewater treatment plant were to be built in the Sugar River basin, it would need to meet a chloride water quality standard of 210 mg/L because of the stream classification. This standard is significantly more restrictive than the state water quality standard of 395 mg/L, which the District's other discharge stream, Badfish Creek is subject to, and the District is unable to meet routinely. Because meeting a standard of 210 mg/L would likely require extreme wastewater treatment technology, resulting in costs significantly higher than the original planning considered, the concept of a future wastewater treatment plant in the Sugar River basin was removed from consideration in the 50-Year Master Plan (Exhibit L).

The term "interbasin transfer of water" was regionally coined by the Dane County Regional Planning Commission (DCRPC) and first used in the mid-1990s. That term has persisted, with it routinely coming up in discussion. However, the District's interest in maintaining a discharge location has not been as prevalent in everyday discussions. The District's 9th Addition Facility Plan includes the following section:

> WATERSHED MANAGEMENT GOALS: The Dane County Regional Planning Commission's laid out water quality goals for Dane County watersheds through the Dane County Water Quality Plan.

> This areawide water quality plan provided an integrated approach to setting water quality goals within each watershed. As part of that planning effort, the DCRPC evaluated the hydrologic, water quality, and biological impacts of wastewater treatment planning alternatives. Wastewater treatment planning alternatives that result in the net export of water from a watershed will have hydrologic impacts on local bodies of water. The DCRPC has initiated a regional hydrologic study to evaluate the effect of interbasin water diversions in Dane County. The study is scheduled for completion in 1995. The study may show that continued interbasin transfer of water may be adversely affecting water resources in the exporting watershed. In these cases, wastewater treatment alternatives that prevent or mitigate interbasin transfer will be favored. Thus, regional watershed management goals will affect the selection of wastewater treatment alternatives during facilities planning.

Historically, there was the belief that groundwater pumping would lower surface or near-surface aquifers, which could reduce the baseflow in streams. These were found to be the driving factors for a return effluent pipe to Badger Mill Creek (Exhibit L). At that time, references to the Dane County Groundwater model speculated that by 2020, local streams would not be functional without these inputs. However, since the mid-1990s, significant hydrologic changes have occurred that weren't predicted. Most notable are the improved farming practices and stormwater regulations by WDNR, Dane County, and local municipalities.

Improved farming practices help keep water on the land, and stormwater ordinances set management standards to attenuate the adverse impacts of increased stormwater runoff. Increased stormwater management increases baseflow and groundwater recharge but also decreases the speed at which water runs off the surface and gets into lakes, streams, rivers, and wetlands. While surface water runoff increases flooding frequency and severity, which also increases the input of pollutants, which degrades water quality and aquatic habitat, improved stormwater management and farming practices have the opposite impact. The outcomes of these improved stormwater and farming practices are shown in the January 2016 USGS "Changes in Streamflow Characteristics in Wisconsin as Related to Precipitation and Land Use" report (Gebert et al. 2016) and by the findings of the Dane County Groundwater model (Parsen et al., 2016). In contrast to the predictions of the 1990s, the baseflow in local streams, including the Sugar River, has increased over the past 25 years due to improved stormwater practices.

There have been many changes in the Badger Mill Creek watershed since the original discussion in the 1990s (Figure 2). Specifically, the hypotheses of depleted water resources have not been realized in the Badger Mill Creek watershed. Rainfall has increased (Exhibit H), flooding is occurring upstream of the District's effluent return (Exhibit G; AE2S, 2021), the amount of drinking water withdrawn from deep wells has decreased by over 3 million gallons per year instead of increasing as predicted (Exhibit D), and stream flows are higher than predicted in the Dane County Groundwater model (Parsen et al., 2016).

Analysis

The original decision to return effluent to Badger Mill Creek was based on two factors. These included a desire to maintain a discharge location in the Sugar River Basin and to provide streamflow benefits.

The District's effluent has played an important role in Badger Mill Creek for the past 25 years by showcasing the importance of treated effluent. It has made the invisible visible and has transformed the value of reclaimed water. In his 1997 memorandum (Exhibit L), former Chief Engineer and Director Jim Nemke wrote about this desire, which has been realized. For the wastewater treatment industry, it has been a true success.

Highly treated effluent is a valued asset, and that sentiment was routinely repeated throughout this analysis. But the value initially assigned to the District's effluent is not accurate. When the return began in the late 1990s, the estimates of flow in Badger Mill Creek were low and future projections even lower, and it was believed the District effluent would mitigate those projections. But time and new models have shown otherwise — the past models were incorrect, and actual streamflow exceeds expectations, with both the USGS and the Dane County Groundwater models and their experts showing that flows have increased. In short, groundwater is rising, and local streams are not experiencing lower flows. In addition, stormwater management and agricultural management of water have improved, which supports the flow of Badger Mill Creek. While DCRPC recommended in the 1990s that interbasin transfers of water happen for all wastewater in the region, the 1998 BMC return was the only one ever undertaken (Figure 2). The foundational assumptions made to support the interbasin transfer do not hold up today. The water that flows to the District originates in many watersheds, and all of these watersheds combine into the Rock River and flow to the Gulf of Mexico (Figure 3).

This showcase project would likely continue unquestioned if it were not for existing and future permit requirements and the need to address current and future challenges. The District already faces phosphorus regulations, current alternative effluent limits for temperature, and chloride and mercury variances, which may become more challenging given the discussion of a more restrictive stream classification for Badger Mill Creek. In addition, we anticipate nitrogen and PFAS requirements in the future. The District also faces rising energy costs, yet, it takes twice the energy per gallon to pump water to Badger Mill Creek than Badfish Creek. Continuing flow to Badger Mill Creek would require infrastructure rehabilitation and high capital costs, coupled with the fact that the planning horizon for this diversion has been exceeded. Given all these factors and more, it is important to assess whether this return has served its purpose and if it should be removed from service.

During a January 2010 Review of Master Plan Findings and Recommendations for Service in the Sugar River Watershed (Exhibit L), the District noted: "It is expected that future discharges to Badger Mill Creek or the Sugar River will require a higher quality effluent."

Subsequently, as part of the planning process, the District requested a limits determination from WDNR that indicated future chloride limits for the Sugar River basin would be 210 mg/L. This is significantly lower than the chloride standard of 395 mg/L that returned water to Badfish Creek needs to meet. With this impending future limit, the District noted the following in its July 26, 2010 memorandum:

> …to meet the required chloride effluent limit of 210 mg/L for a discharge to the Sugar River, it would be necessary to use reverse osmosis; an extremely sophisticated and expensive process with limited operational applications. The phosphorus limit will require the use of chemical addition and membrane filtration or chemical addition and a more conventional filtration process together with trading. The construction and operating costs for a treatment plant incorporating such advanced processes would undoubtedly be at or higher than the $40 million estimated in the Master Plan. Therefore, there is no need to perform additional studies for

providing services in the Sugar River watershed, and the approach defined in the Master Plan should guide the District's planning for providing service in that watershed. (Exhibit L)

From the wastewater treatment plant's perspective, a long-term goal of this project was to highlight treated effluent as a valuable resource. In 1997, Chief Engineer Jim Nemke wrote a memorandum, "Effluent as a Resource" (Exhibit L), which provided a guiding vision where effluent was no longer viewed as a waste but was found to be a community asset. Based on the public engagement with the District's Project PLUS, this appears to have been successful. During this multi-year assessment of phosphorus compliance options for Outfall 005 on Badger Mill Creek, we have been involved in many public interactions. There has been overwhelmingly positive public sentiment focused on the value of this resource.

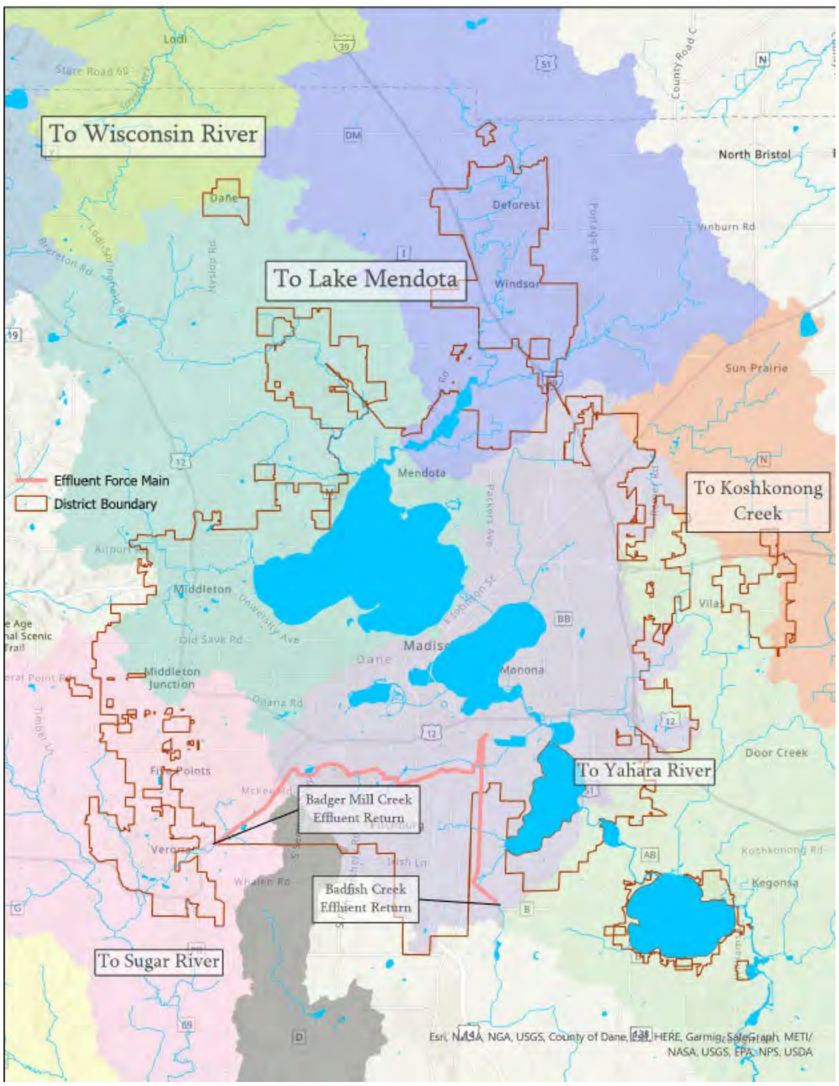

Figure 2 2 - BMC was the only interbasin transfer completed. The District spans many watersheds.

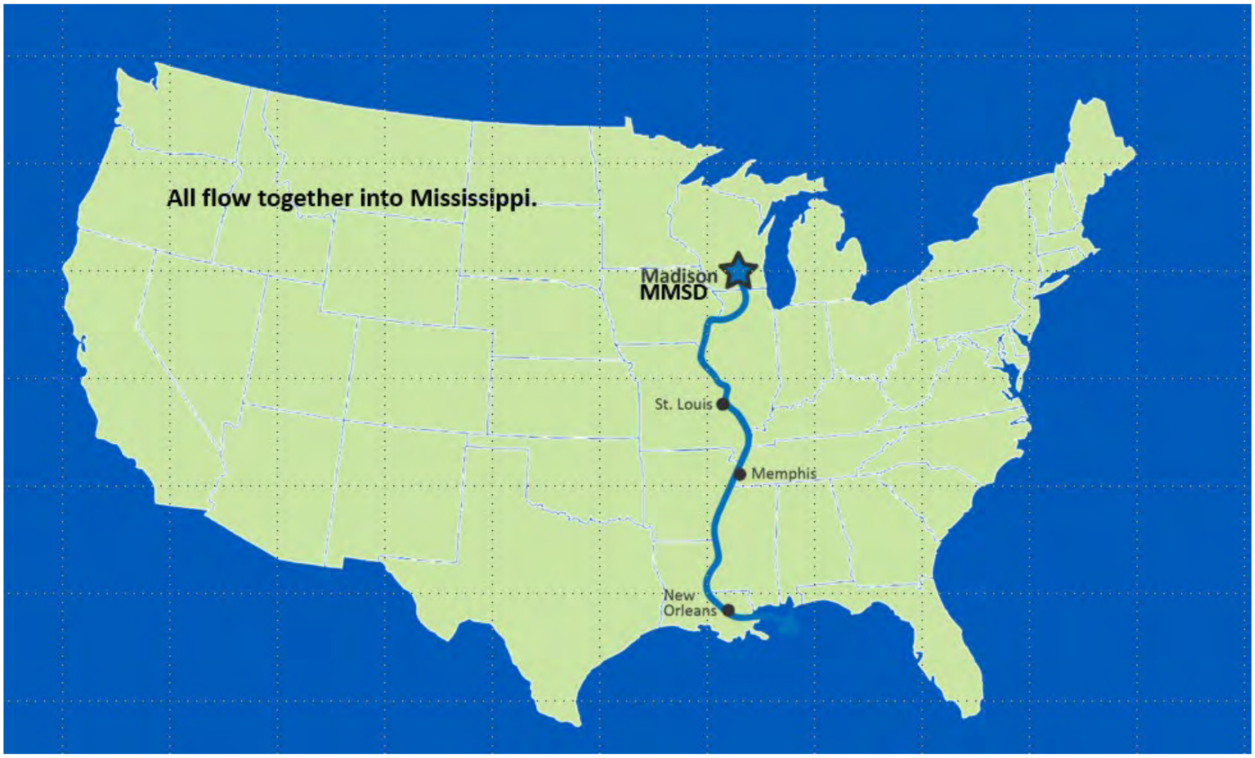

Figure 33 - The Sugar and Yahara rivers combine into the Rock River, which combines into the Mississippi River.

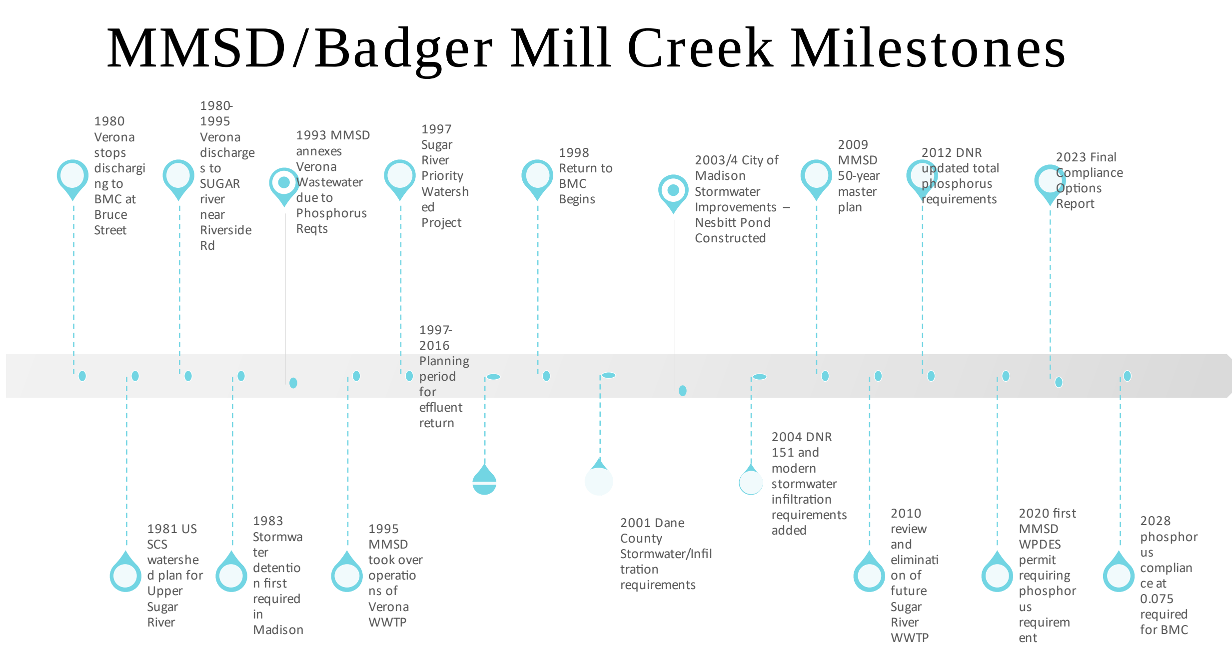

Figure 4 - Timeline of Changes in the BMC Watershed

Alternatives assessed

Exhibit N includes the full Preliminary Compliance Alternatives Plan (PCAP) presented to the District's Commission on June 6, 2022. This section builds on that report and includes the evolution of our understanding since that point. Exhibit M includes the WDNR's response to our PCAP. WDNR's response letters further increased the District's understanding of what would be allowable as a compliance solution. The District continued to pursue three compliance alternatives with this new understanding, tertiary treatment, watershed solutions, or eliminating the return of water to Badger Mill Creek. Each of these is further analyzed below.

Watershed approaches

In the preliminary compliance alternatives plan the District submitted to WDNR in 2022, the District's recommended alternative involved water quality trading in an expanded watershed, including both the Upper Sugar River and Badger Mill Creek watersheds. Since submitting the PCAP to WDNR, the District has continued discussions on adaptive management and water quality trading. However, WDNR provided a very specific response letter to our PCAP (Exhibit M), which they received concurrence on from the U.S. Environmental Protection Agency (Exhibit M). The District believes these letters eliminate the possibility that watershed approaches could be a viable phosphorus compliance strategy for Badger Mill Creek.

Water quality trading

In general, WDNR's response letter (Exhibit M) notes that while the PCAP recommended pursuing water quality trading as a compliance strategy, WDNR would not expand the trading area outside the very urbanized Badger Mill Creek HUC 12 (HUC 070900040201) as requested by the District (Figure 5). WDNR further noted that the District could not use credits generated further downstream or in other watersheds because they determined that these credits would not aid in meeting water quality standards specifically in the District's receiving water. WDNR further indicated that since water quality trading is not a viable compliance alternative, the District needed to evaluate different alternatives.

The District has continued to pursue possible trading opportunities and work with landowners and agencies to evaluate and ground truth possible projects. Exhibit E includes a detailed assessment of possible projects in the Badger Mill Creek and adjacent Upper Sugar River watershed that could be considered for water quality trading or adaptive management. These projects could result in improved water quality, but alone will not accomplish the reductions required for the District's phosphorus compliance strategy (Exhibit E).

Specific to water quality trading, the District discharges approximately 2,200 pounds more phosphorus per year than allowed in our permit. In a March 2023 email (Exhibit M), WDNR clarified specific water quality trading criteria. Specifically, they noted that for water quality trading, the point of compliance is where the stream receives the discharge. Any reduction above that point would be considered an "upstream trade," and any reduction implemented below that point would be considered a "downstream trade." The delivery factor would be around 0.1. The downstream trading factors would be around 0.8. In addition, the WDNR guidance notes that the minimum trade ratio would be 1.1:1 and that uncertainty factors would be added to the delivery and trading factors and trade ratio, increasing the factor or ratio. Point-to-point trades generally have lower uncertainty, and construction projects generally have lower trade ratios than agricultural conversion, cropping, or tillage projects. All projects intended to yield pound reductions for trades would need to be implemented before the pounds are discharged, and the trades must remain operational during the period that they are used for phosphorus compliance.

When looking at the impact of these ratios on the number of pounds needed to achieve compliance, water quality trading becomes very difficult. Specifically:

- A trade ratio (covered below) of 2.8 equals **6,200** pounds.
- A trade ratio of 4 equals 8,800 pounds.
- Any City of Verona projects that enter downstream of the effluent return are subject to the downstream trading factor, even if they are point-to-point trades.
- Any areas to the south and southeast of the District's aerator or that enter Badger Mill Creek downstream of the aerator will have downstream trade ratios added. This area in the HUC 12 has the largest amount of non-developed land. However, this land faces development pressure, which makes it difficult to find perpetual commitment.

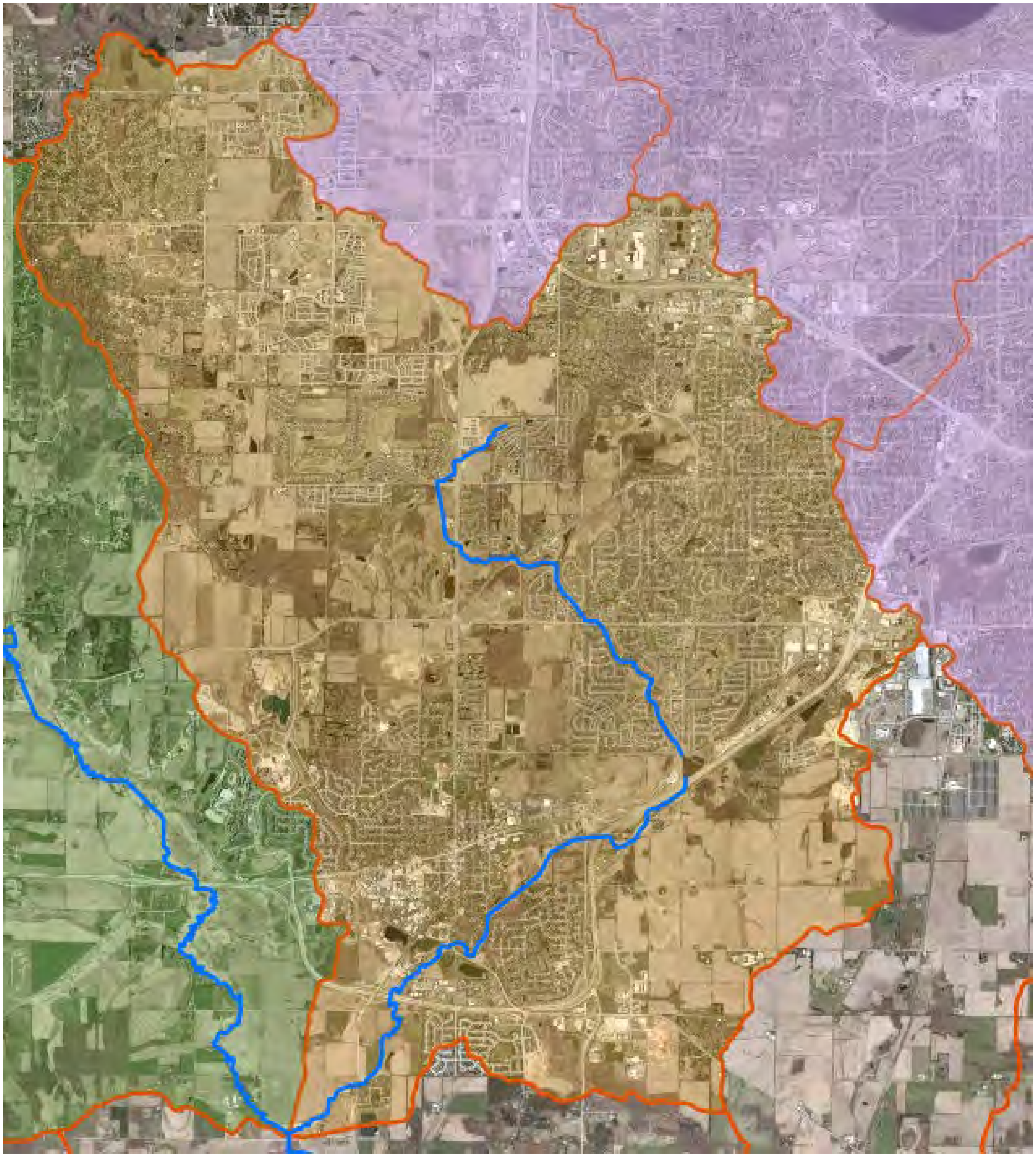

Figure 5 – Highly urbanized Badger Mill Creek Watershed (HUC 070900040201). The HUC 12 is shaded in orange, Upper Sugar River in Green, and the Purple area drains to the Yahara River

Adaptive management

WDNR's March 2023 email (Exhibit M) noted that whether or not an adaptive management plan expands to include the Upper Sugar River watershed and Badger Mill Creek, the plan would need to achieve compliance with water quality criteria before Badger Mill Creek enters the Sugar River. This means that the water quality criteria would need to be met in Badger Mill Creek, even if an adaptive management plan were expanded to include the Upper Sugar River watershed. Based on phosphorus sampling and USGS monitoring, the amount of pounds that would have to be reduced to meet water quality criteria in Badger Mill Creek is estimated to be in excess of 7,620 pounds of phosphorus reduction and require in-stream monitoring to prove success over time. (Exhibit E).

The District's phosphorus compliance for Badfish Creek is using watershed adaptive management. To undertake a second adaptive management project, the District would need to make a request to WDNR and create an adaptive management plan, which requires approval by WDNR. To be approved by WDNR, the plan must show a viable pathway to achieving in-stream water quality of 0.075 mg/L in Badger Mill Creek. In addition, reapproval is required every five years and depends on demonstrating sufficient progress toward the goals.

With the District's current discharge to Badger Mill Creek at 0.29 mg/L and the substantial existing development within the watershed, there are not enough pounds for reduction to meet the 0.075 mg/L criterion at the compliance point. Therefore, an adaptive management program does not appear to be a viable compliance strategy, as creating an approvable adaptive management plan is challenging and limited by various factors. In fact, removing the District's effluent from the stream would more quickly help the stream near in-stream phosphorus criteria and with greater certainty. A more detailed assessment of watershed approaches can be found in Exhibit E.

BMC effluent tertiary treatment

The District hired the consulting engineers, Strand Associates, Inc., to assess adding tertiary treatment at the Nine Springs Wastewater Treatment Plant to achieve compliance with total phosphorus standards in Badger Mill Creek. Their completed report is attached as Exhibit A - "Badger Mill Creek Phosphorus Compliance Preliminary Engineering Feasibility Report."

The report finds that tertiary treatment could help the District achieve compliance with phosphorus standards for the Badger Mill Creek effluent location. The consultants reviewed various technologies during their design process and worked with District staff to develop recommendations. Based on the monetary and nonmonetary analysis, Alternative 3, as presented in the report, was selected as the best alternative for the tertiary treatment option. This alternative includes installing the BluePRO reactive filtration system in a proposed new Tertiary Treatment Building at the Nine Springs Wastewater Treatment Plant. The BluePRO system has a 20-year total present worth cost of $24.3 million. The BluePRO technology would add less chloride to the effluent than other alternatives evaluated and would be more flexible with the addition of nitrogen removal technology when required in the future. However, this treatment technology will not help the District achieve compliance with temperature, mercury, or chloride standards.

The addition of tertiary treatment also impacts District operations and District service charges, as outlined in a memo by the District's Director of Wastewater Operations and Reliability, "Risk Review of Tertiary Treatment Infrastructure Project" (Exhibit B). In general, while it is possible to add tertiary treatment to the effluent returned to Badger Mill Creek, it will cost District ratepayers $24.3 million, which is between 2.2% and 3.2% of current District baseline revenues and will therefore increase service charges by 2% to 3% (Table 1). In addition, it will compete with other District projects and staff, which could negatively impact the District's resiliency. From an operations and maintenance perspective, tertiary treatment for phosphorous in Badger Mill Creek poses significant risks. Primary factors include:

a) Harmful delays in other capital projects, notably electrical upgrades, heat and power changes, liquid processing improvements, and general maintenance work;
b) Disruption to operations and maintenance teams, hindering their ability to ensure proper plant operations and to implement needed reliability-centered maintenance practices; and
c) The inflexibility that would be created for future regulatory requirements.

Finally, while possible to treat the Badger Mill Creek effluent to remove phosphorus to meet compliance (Exhibit A), there are many opportunity costs and consequences of that decision (Exhibit B).

	Low	**High**
Annual loan payment costs	$1,100,000	$1,100,000
Annual new staffing and material costs	$600,000	$1,300,000
Baseline 2028 service charge revenues (year of full implementation)	$75,600,000	$75,600,000
Additional costs as a percent of baseline revenues	2.2%	3.2%
Bottom line: With tertiary treatment, service charges will be 2%-3% higher than they would've been otherwise (low and high costs differ in staffing and material/energy costs.)		

Table 1 - Expected service charge impact for BMC tertiary treatment

Discontinuation of flow

The third alternative is to discontinue effluent return to Badger Mill Creek and return all District effluent to Badfish Creek. Exhibit B "Badger Mill Creek Assessment" contains a detailed analysis of this option, with a general summary below.

Water quality can be viewed on many levels and is based on various parameters. However, throughout Badger Mill Creek (BMC) Project PLUS, the main interest expressed is the potential change in water levels in the stream with the discontinuance of the effluent return.

With WDNR guidance and consultant assistance, the District began flow, depth, temperature, and habitat measurements at various sites along Badger Mill Creek and the Sugar River in Winter 2023. These measurements occurred twice under two scenarios:

- Scenario 1: District effluent discharged as normal per the District's permit.
- Scenario 2: District effluent not discharged.

During the assessment, effluent return was slowly reduced starting at the end of January 2023. On February 6, 2023, the effluent return was fully discontinued. The effluent return was resumed on April 17, 2023.

The before-and-after study design allowed the District to understand the impact of the effluent flow on the stream under current climatological and hydraulic conditions. In consultation with the WDNR and using historic U.S. Geological Survey (USGS) hydrograph data, this specific assessment's timeline aligned with the winter months. This was done to understand further the impact of treated effluent on the stream when flow and depth are historically at their lowest.

Consulting firm Emmons & Oliver Resources, Inc. (EOR) took in-stream measurements of flow, depth, temperature, and habitat. The EOR report (Exhibit C) indicates that when effluent was discontinued during low-flow conditions, the largest observed difference was a 2-inch water level reduction in Badger Mill Creek in the heart of Verona. It became even smaller as the water flowed to the Sugar River. Without the District effluent contributing to stream flow, the flow at Badger Mill Creek near State Highway 69 exceeded 9 cfs (cubic feet per second) in low-flow conditions, with no change to the stream's width. The District study, plus submitted observation reports, recorded that all observed sites remained flowing during low-flow conditions when effluent was removed. EOR also assessed upstream and downstream of where Badger Mill Creek enters the Sugar River. These assessments show little to no impact on the Sugar River with or without District effluent. In fact, while stream flow in Badger Mill Creek was shown to decrease proportionally to the amount of effluent returned, the Sugar River upstream and downstream of the confluence with Badger Mill Creek show the same reduction in flow, which indicates that the flow in the Sugar River is not dependent on the flow in Badger Mill Creek. Further discussion is included below and shown in the EOR report. A more detailed assessment of the stream assessment can be found in the EOR report as Exhibit C.

Each month, District staff take water quality samples at various locations along Badger Mill Creek to monitor and assess the health of the waterways. These parameters include temperature, chloride, metals, CBOD, dissolved oxygen, and other indicators. During the stream assessment led by EOR, the District continued monthly in-stream sampling. Some parameters are measured monthly, and others, like metals, are only measured quarterly. Therefore, for some parameters, there were two monthly sampling dates for data comparison, and for others, there was only one monthly sampling date for data comparison. This analysis uncovered no negative water quality impacts due to ceasing the effluent.

Chloride levels are the most significant difference in water quality when comparing data with or without effluent. Chloride is a component of salt, which is used for winter maintenance and salt-based water softening systems. While salt dissolves in water, it doesn’t go away and is found in rivers, lakes, streams, wastewater, and even drinking water through runoff, groundwater infiltration, and treatment plant discharges. Research continues to determine the actual levels of salt that are critical for freshwater organisms and freshwater systems. The District works to reduce all sources of salt, but due to the regional reliance on salt-based water softening systems, the District’s effluent still contains significant chloride, and the District currently carries a variance to the state’s chloride water quality standard. When looking at USGS's continuous conductivity monitoring data, the reduction of instream salt when effluent is ceased is evident in the USGS gaging data for both Badger Mill Creek and the Sugar River (Exhibit D).

Stream classification

Water quality standards set by WDNR ensure the appropriate level of protection by (per WDNR):

- Determining the types of activities the water should support by establishing designated uses;
- Developing water quality criteria to protect these uses from excess pollution;
- Establishing an antidegradation policy to maintain and protect existing uses and high-quality waters; and
- Identifying general policies to implement these protection levels in point source discharge permits.

Water quality standards also support efforts to achieve and maintain protective water quality conditions, including the:

- Development of reports that document current water quality conditions;
- Establishment of permit limits for wastewater discharges to protect the state's waters;
- Development of total maximum daily load (TMDL) analyses which determine how much pollutant reduction is needed in a watershed to protect water quality; and
- Development of water quality management plans that prescribe the regulatory, construction, and management activities necessary to meet the water body goals.

From a wastewater treatment plant perspective, the types of requirements in a WPDES permit can be directly influenced by the stream classification of the receiving water. Discharging treated effluent to waterways classified as being higher quality means that more restrictive water quality criteria need to be met.

The District has two effluent discharge locations: Badfish Creek and Badger Mill Creek. Badfish Creek is designated as an "effluent channel" at our discharge location. The District's discharge location for Badger Mill Creek is classified as a "limited forage fishery (LFF) water." On Badger Mill Creek, the LFF designation led to more restrictive thermal standards for discharge. Further classifications on this waterway will increase the number of months and deviation from the thermal standard included in future alternative effluent limitations for the District. WDNR notes that Badger Mill Creek is classified as a trout water from the confluence with Sugar River upstream past the District's effluent pipe (T. Baumann, personal communication, April 10, 2022). The recent WDNR Fishery study, "Trout Stream Management and Status Report of the Sugar River Watershed Dane and Green Counties, Wisconsin 2020-2021" (Exhibit K), includes detailed information on the stream and the fishery aspects, including a discussion about additional discharge requirements.

Badger Mill Creek is considered a cool-cold mainstem under the state's natural community determinations (Wisconsin DNR, n.d.-d). Cool (Cold-Transition) Mainstem streams are moderate-to-large but still wadeable perennial with cold-to-cool summer temperatures. Coldwater fishes are common to uncommon; transitional fishes are abundant to common, and warm water fishes are uncommon to absent. Headwater species are common to absent, mainstem species are abundant to common, and river species are common to absent."

Natural community determinations are modeled after results validated by WDNR that confirm or update predicted conditions based on flow and temperature modeling from historical and current landscape features and related variables. Predicted flow and temperatures for waters are associated with predicated fish communities (hence the term 'natural communities'). WDNR evaluates the modeled results against current field survey data to ground truth the modeled results and whether biological indicators show water quality degradation. This analysis is a core component of the WDNR resource management framework.

The District's current WPDES permit includes more restrictive criteria for ammonia, carbonaceous biochemical oxygen demand (CBOD), total suspended solids (TSS), and temperature in Badger Mill Creek compared to Badfish Creek as a result of the different classifications. Any future stream classification changes to Badger Mill Creek could further change already restrictive criteria.

In 2005 WDNR included in their evaluation of alternative effluent limits that:

> The department conducted a comprehensive survey of multiple sites along the creek to determine its status and provide management recommendations. The department concluded that Badger Mill Creek should be considered a "Coldwater B – Class IIx" system from the Lincoln Street footbridge downstream to its confluence with the Sugar River. The WDNR evaluation also recommended the section upstream of the Lincoln Street footbridge to the effluent discharge point be classified as "Diverse Fish and Aquatic Life – Coolwater" (Wisconsin DNR, n.d.-b). In 2008, WDNR designated Badger Mill from its mouth at the Sugar River upstream to the uppermost STH 18/151 crossing as a "Class II" trout water.

Wisconsin WDNR further notes:

> Water quality-based effluent limitations are calculated in order to ensure that discharges to waters of the state are in compliance with water quality standards. Water quality standards include water quality criteria (such as those in chs. NR 102, 104, and 105, Wis. Adm. Code), use designations or classifications of the state's waters (examples include fish and aquatic life uses, public water supplies, recreational uses, outstanding or exceptional resource waters), and antidegradation provisions to address new or increased discharges to waters of the state. All of these standards are considered together in order to protect Wisconsin's aquatic life, wildlife and human health from the effects associated with the discharge of toxic (poisonous) and organoleptic (adverse impacts on sensory organs) substances to the state's surface waters (Wisconsin DNR, n.d.-c.).

It is clear that changing a stream's classification will impact water quality standards. There is potential for a future designation of a coldwater trout fishery for Badger Mill Creek. When Badger Mill Creek's classification changes, the District will have to meet the additional requirements, which could pose a challenge as the thermal requirements become more restrictive. The District already has Alternate Effluent Limits for thermal. Reclassifying the stream would trigger a re-evaluation of the current Alternative Effluent Limits with little certainty that the District can meet the new limits.

Energy use

The Badger Mill Creek effluent return uses about 3,400 kWh/day (Carollo, 2021). The average flow via BMC for the energy study period was 3.3 million gallons per day (MGD), making the BMC energy intensity 1,030 kWh/MGD. Energy intensity for BFC at 41 MGD is calculated to be 485 kWh/MGD. As a result, BMC uses about 2.1 times more energy per gallon pumped than Badfish Creek. The District has committed to improving its resiliency and reducing energy use. Discontinuing effluent return to BMC aligns with these goals (Carollo, 2021).

Legal assessment

Since the District is in a unique situation with one treatment plant and two discharge locations, the District assessed legal aspects relating to the option of ceasing effluent flow to Badger Mill Creek. In addition, this analysis investigated past and present resolutions related to this outfall throughout the region to ascertain what, if any, actions would be necessary.

The conclusion was that only WDNR has decision authority for any change implemented by the District to comply with discharge regulations. The Capital Area Regional Planning Commission (CARPC) (successor to the Dane County Regional Planning Commission) water quality management plan is an inventory of all point source discharges. An amendment will need to be made to this plan as part of any final compliance solution. There are multiple intertwining statutes and regulations regarding the authority of WDNR and CARPC regarding the approval of water quality management plans. Wis. Stat. 283.83(1m)(f) specifically prohibits WDNR from ceding its approval authority of water quality management plans in Dane County:

> "The department may contract with a regional planning commission or other entity to provide advisory services relating to the review of proposed revisions to the areawide water quality management plan for the area consisting of Dane County, but the department may not delegate its authority to approve or reject proposed revisions." The approval by WDNR of the amended water quality management plan must be based "on whether the proposed revision complies with the water quality standards under s. 281.15." Wis. Stat. 283.83(1m)(a).

This means that the District must submit an application to change its discharge location as reflected in the water quality management plan for Dane County. WDNR and CARPC will review it, and WDNR will not have any discretion to deny the application if the District complies with the statutory requirements. The role of CARPC is to offer input and can work with the District, but it does not have any authority over the final approval of the water quality management plan.

Regarding the continuing validity of District resolutions passed in the 1990s, it is the District's legal opinion that "[o]ne legislature may not bind a future legislature's flexibility to address changing needs. Thus, one legislature may not enact a statute which has implications of control over the final deliberations or actions of future legislatures." (*Flynn v. Dep't of Admin.*, 216 Wis. 2d 521, 543, 576 N.W.2d 245, 254 (1998)). Therefore, if the District determines that circumstances have changed and a new discharge location is necessary, the prior resolution cannot prohibit that action.

Badfish Creek impacts

If effluent flow were discontinued to Badger Mill Creek, it would flow to Badfish Creek, and changes will need to be made to the District's WPDES permit. The District currently returns the majority of its flow to Badfish Creek. Any flow over the 3.6 MGD discharged to Badger Mill Creek goes to Badfish Creek. As part of the District permit, there are times when Badfish Creek has received all of the flow. During flooding conditions, when USGS's Bruce Street gage reads 1080 cfs, District effluent to Badger Mill Creek is automatically shut down to reduce the exacerbation of flooding in Badger Mill Creek and its floodplain.

The District assessed the impact on operations to discharge all effluent to Badfish Creek. The District generally operates a two-pump scenario to pump effluent to Badfish Creek. Three pumps may be used in peak flow conditions, but regardless of the number of pumps used, pumping is capped at 75 MGD. If flow exceeds 75 MGD, that treated effluent is stored at the plant or in our adjacent lagoons. In peak flow events, storage at the lagoons is found to have sufficient capacity, and our lagoon return pump can handle any additional flow. Any additional quantity of bypass with only two Badfish Creek pumps running will not significantly impact District operations.

Moving all effluent discharge to Badfish Creek would not result in flow rates entering the creek. One pump in operation will discharge approximately 35 MGD; two pumps will discharge approximately 55 MGD; and three pumps will discharge approximately 75 MGD. Looking at historic influent flow data dating to 2010, if the District had not operated a second discharge to BMC at 3.6 MGD, we would have operated with one pump for approximately 40 days more than present, two pumps for about 6 days extra each year, and three pumps for about a quarter of a day (6 hours) each year.

The District does not routinely operate three pumps. Operationally, we rely on two pumps. With our current internal control limits of two pumps operating, there would be approximately six more days of water moving to the lagoons to be stored. Looking at influent flows over the past 13 years, with no effluent pumping controls, and if the District operated three pumps more routinely, there would only have been 79 hours of additional (12 million gallons) pumped to the lagoons over 13 years. Therefore, operationally, the District's current infrastructure can account for the additional flow from Badger Mill Creek.

Variances

The District has two variances to water quality criteria, one for chloride and one for mercury. For both chloride and mercury, the variances address the entire effluent flow from the District and implement concentration-based interim effluent limitations. As part of the variance requirements, the District is working on pollution minimization programs for both mercury and chloride. Although concentrations vary daily and throughout the year, these PMPs have been showing continuing success as a general trend (Figure 7 and Figure 8). Significant reductions have been made throughout the period of the variances, but continued efforts throughout the sewershed are required to routinely meet water quality standards. As noted above, the impact of relocating flow to Badfish Creek will trigger some review of the District's WPDES permit and the associated variances by DNR and EPA. However, because the District's variances are based on concentrations of mercury and chloride in total effluent and the District does not anticipate that the concentrations will change, the waterways will not see additional concentrations of mercury or chloride if the District's effluent streams are combined. As a result, we are not anticipating an issue with the variances.

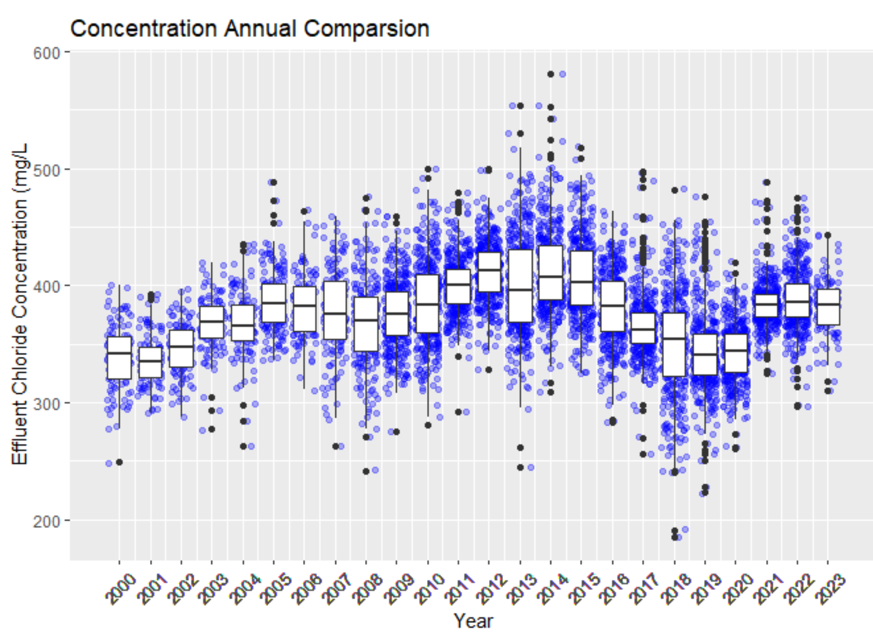

Figure 76 – District chloride concentration over the past 20 years

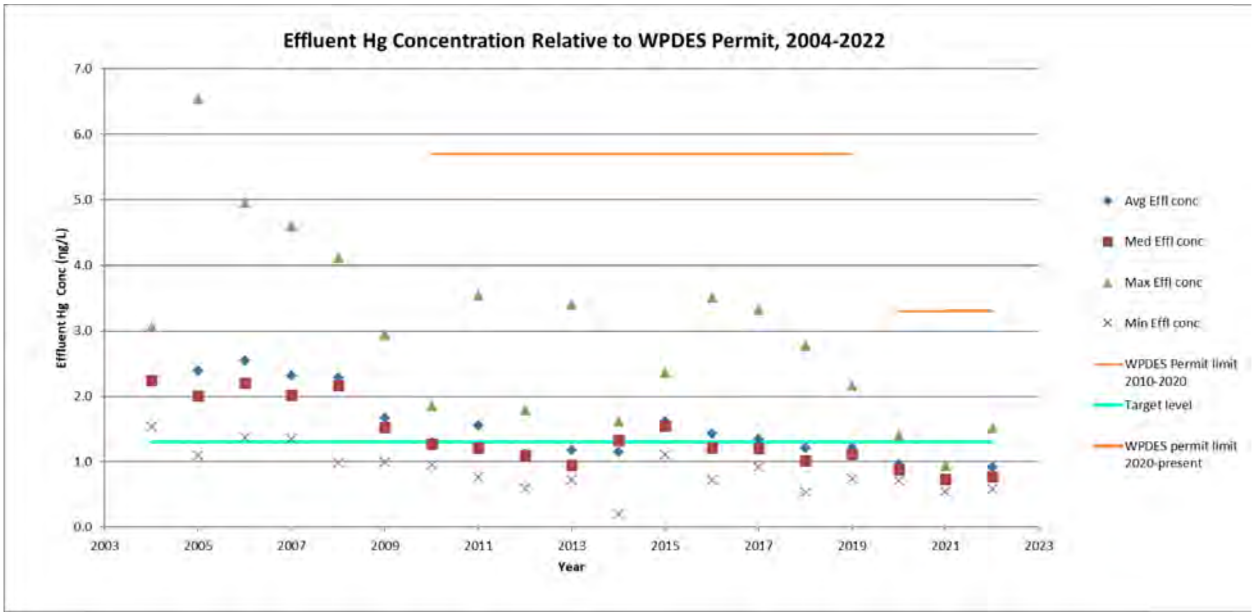

Figure 8- Historic District Effluent Hg Concentration

Yahara WINS

The District needs to meet water quality criteria for phosphorus. In the Badfish Creek watershed, the District is part of the Yahara WINS Adaptive Management Project for compliance. With a Badger Mill Creek compliance approach that discontinues effluent to the creek, the additional phosphorus pounds, along with the flow, would be sent to Badfish Creek. The District has made a request to Yahara WINS to determine if they would be amenable to adding the additional phosphorus to the Yahara WINS project. The organization's approval is found in Exhibit O. The Yahara WINS Adaptive Management Plan includes a process for including the additional pounds in the overall Yahara WINS project. In addition, the District would be responsible for paying for the additional pounds as determined by the Yahara WINS Intergovernmental Agreement (IGA) in section 9.a.1, which allows point source dischargers to adjust their payment to Yahara WINS if flow or loadings change. This is noted to occur on a five-year averaging period.

Because of the unique situation that the District is in with two discharge locations, the District proposes to adjust the payment on a date before any discontinuation of flow rather than wait for the next five-year averaging period allowable in the Yahara WINS IGA. This provides Yahara WINS the resources and time needed to put projects in place throughout the watershed that reduce the additional pounds of phosphorus that will be added to the project's overall goal by directing flow from Badger Mill Creek to Badfish Creek.

Communications summary

District staff began having stakeholder conversations and presenting to our Commission regarding the need for phosphorus compliance for Badger Mill Creek in 2018. With the submission of the PCAP to WDNR in April 2022, the District had the information it needed to begin more targeted and informed community outreach, which started in June 2022.

Communications and outreach on phosphorus compliance at Badger Mill Creek specific to Project PLUS began on June 13, 2022 and will continue as needed. The project has been featured in various outreach messages to commissioners, owner communities, staff, stakeholders, newsletter subscribers, and the general public. District staff also created a dedicated project web page and four blog articles on phosphorus reduction and compliance. In addition, there were social media posts on District-owned social media channels, with advertising dollars placed behind two posts to reach residents of Verona and the area surrounding Badger Mill Creek. The team also worked extensively on public relations with local media to highlight the project on websites and newspapers like the Verona Press. In addition, the team paid for advertisements featuring the project and public events that appeared in print, online, and via email. More information is included in Exhibit I.

Digital reporting app

Before the test period, District staff developed a digital application (Figure 9) that could be used to assess changes witnessed in the stream during the test period. The digital app was available to anyone who wanted to use it. The longitudinal value of the test and the community interest expressed through the digital tool are included in Exhibit J.

Staff from the District, Town of Verona, and other community members provided ongoing photo-log and observation reports. The peak periods of logged observations appear to correlate with District outreach work and community discussions. In general, when communication to the public noted the effluent was off, more community members commented negatively on the stream after the communication went out, even though the effluent had been turned off well before the communication went out. When community discussions arose organically speculating that the effluent return was back on, community members commented positively on the aesthetic and flow of the stream, even though the comments were made as the effluent return remained off. Exhibit J provides additional detail about the stream observations made through the digital reporting app.

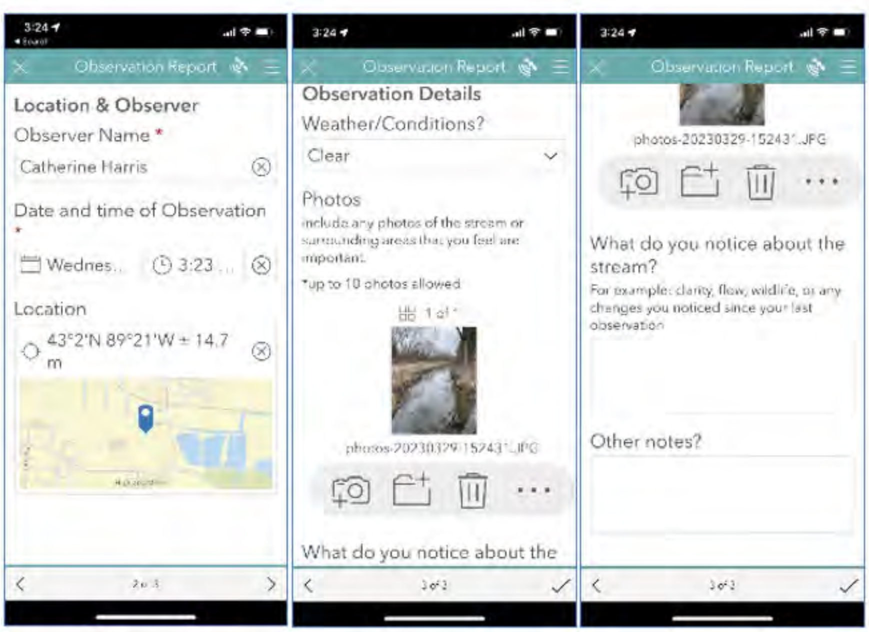

Figure 97 - Screenshots of the digital app

Risk analysis

The phosphorous compliance alternatives for Outfall 005 include a variety of risks. Each type of risk is unique, yet each risk's impact on decision-making must be contemplated. The Nine Springs Wastewater Treatment plant uses biological processes to clean water. The District balances numerous factors to successfully operate a reliable wastewater treatment plant that consistently removes a variety of constituents, meets WPDES permit requirements, moves toward energy neutrality, is prepared for future regulation, and can operate in the unpredictable natural world. The District takes its mission to protect public health and the environment seriously.

With biological processes, balance is required. For instance, phosphorus and nitrogen compete for the same food supply to obtain removal rates in the treatment process. Currently, the District is not regulated for nitrogen removal, but if nitrogen regulations are promulgated as expected and the plant adjusts to remove more nitrogen, total phosphorus concentrations may slightly increase. Overall, the environmental outcome of total nutrient reduction would be achieved, but if total phosphorus concentrations go up, even slightly, it would require more pounds to be offset with watershed approaches for phosphorus compliance. This would be more difficult to account for in the highly urbanized Badger Mill Creek watershed.

Watershed approaches depend on partners, landowners, and the weather and are considered less reliable than built infrastructure — this is why trade ratios are included with approved water quality trades. Adaptive management involves meeting in-stream water quality criteria. Therefore, any changes within the watershed could impact the ability of the overall project to succeed.

To move forward with an adaptive management project, an adaptive management plan must be approved by WDNR. The approval of the adaptive management plan and permit requirement of adaptive management is not immediately guaranteed for 20 years. Compliance reports need to be submitted each year to show progress toward the overall goals, and WDNR reviews the adaptive management every five years. If the agency believes sufficient progress is being made, another five-year window will be granted. If WDNR finds that progress is insufficient, the plan can be pulled, and the District would be left to implement a different solution. Additionally, if the stream is not in compliance after the 20-year period ends, the District would need to deploy another solution to achieve compliance.

The District will incur future risk by maintaining Outfall 005, requiring operation and maintenance (pumps, force main, etc.), and the ability to comply with current and future regulations. As presently noted, it is clear that nitrogen requirements will be required. In addition, the District already has alternative effluent limits (AEL) for temperature specific to the Badger Mill Creek outfall, which will need to continue in future permits. Furthermore, when assessing current discharge information, we expect that the number of months requiring AELs will increase in the future, even with the same stream classifications. The current stream classification and uncertainty regarding future classification changes for Badger Mill Creek increase the risk of continuing discharge to Badger Mill Creek as it could trigger more restrictive limits for temperature and/or other parameters.

Triple bottom line assessment of alternatives

Total phosphorus compliance in the Badger Mill Creek watershed could be achieved in various ways. Each has its own opportunities and risks. This section compares the compliance options using multiple criteria summarized from a variety of factors, including social, economic, and environmental factors relating to each alternative.

	Will it work?	Energy	O&M	Reliability	Ability to meet future regulations	Risk	Public Acceptance	Cost
Watershed	▼	=	▼	▼	▼	▼	▲	▼
Treatment	▲	▼	▼	▲	▼	▲	▲	▼
Eliminate BMC Flow	▲	▲	▲	▲	▲	▲	▼ *	▲

Key: **Green = More desirable** Yellow = No change **Red = Less desirable**

Table 2 - Triple Bottom Line Summary

* Neighbors and BMC stakeholders have low acceptance of the option to eliminate flow, while stakeholders in other areas of the District's service area do not share those views and favor this fiscally sound alternative.

When the various alternatives are looked at through this lens, the option of reducing effluent flow to BMC rises to the top in all categories except public acceptance. Coupled with an analysis that found the District's effluent is not controlling the health of the stream, the District has proposed a two-pronged approach of eliminating flow to BMC and providing funds for local municipalities and/or organizations to implement enhancements within the corridor to sustain and improve the stream. Exhibit F provides additional detail about the triple-bottom-line assessment.

Possible enhancements

While this analysis did not find negative impacts to discontinuing effluent return to Badger Mill Creek, the analysis did find a variety of opportunities to enhance the stream corridor. Some of these are included below.

Streambank and channel

Flow was seen throughout the corridor throughout the period of no effluent in Badger Mill Creek. The upstream-most site that EOR monitored was immediately downstream of a natural channel obstruction where the water widened into a pool. The EOR study shows that stream velocities could be low in wider sections in the upstream portions of Badger Mill Creek during low-flow conditions. The current channel has been designed or naturally changed to accommodate the much larger flood flows. There is an opportunity to strategically design the stream to reinforce a narrower, low-flow channel in the upper portion of Badger Mill Creek, which could provide natural low-flow channel conditions. In the Badger Mill Creek reach between CTH PB and Bruce Street, stream re-meandering and lower-flow channel creation are created using habitat structures designed to capture sediment during high-flow events. This approach was recommended by WDNR's Dan Oele and included in the Chapter 30 permit application for habitat improvements.

Habitat

The upper reaches of Badger Mill Creek were found to have significant muck and sediment deposits. Excavating or dredging that material could improve the overall habitat within the stream corridor and provide better fish habitat and stream aesthetic. Habitat structures could also be added to help with channel re-meander and habitat. In addition, Dane County has a countywide program focused on removing similar legacy sediments to improve the overall health of Dane County's waterways.

Flow

Rainfall trends have been increasing in the region, resulting in flooding challenges for areas upstream of the current effluent discharge location. The City of Fitchburg and the Town of Verona have collaboratively worked on a project, the Fitchrona Road Study, and the study's recommendations aim to alleviate flooding and lower the current water levels in the Goose Lake area. Other flooding and erosion challenges persist in the region. Overall stormwater flow patterns have changed over time, and the area could benefit from an overall assessment. These additional surface and groundwater resources are helping to supplement flow in Badger Mill Creek, and there could be a unique opportunity to leverage upstream stored water to provide for additional low-flow mitigation. Further, adding additional infiltration practices and/or enhancing local wetlands may help to increase shallow groundwater and aid streamflow.

Temperature

District effluent is more than 10 degrees warmer than allowed for warm-water streams and up to 20 degrees warmer than the requirements for cold-water streams. Even without District effluent, the stream is fed by stormwater, which could have warmer temperatures at certain times of the year. Current stormwater requirements in the Sugar River basin require thermal controls for stormwater management facilities. There is an opportunity to expand those requirements into the Badger Mill Creek watershed to help the stream maintain cooler temperatures.

Further nutrient removal

Even without effluent, the upstream portion of BMC has significant legacy sediment and muck. It also shows higher total phosphorus numbers. Removing legacy sediment from this area will likely help both the habitat and provide for additional phosphorus reductions stemming from the release of phosphorus from the sediments into the water column. Also, throughout the process, various projects were assessed for possible watershed adaptive management or water quality trading projects. Many of these projects could be helpful for overall stream health.

Removal or modification of obstructions

Currently, there are a variety of obstructions within the channel that restrict flow. Animals created some, while others are a result of streambank and habitat structures that were moved during high-flow events. Yet others are the result of sediment deposits, garbage, and vegetation falling into the stream. In addition, there are existing culverts that carry the stream through the Verona airport area. In looking at aerial photos, these culverts appear to be holding flow back and, based on landowner concerns, are causing additional erosion. There is even a bridge sitting on the bottom of the channel; as water moves around this obstruction, it further erodes the banks. Modifying and/or removing these obstructions or mitigating high flows in these areas could help improve the corridor's overall flow and the stream's health.

Community organization initiatives

Currently, there are a variety of municipalities and community organizations (e.g., friends groups and restoration groups) doing great work in the Badger Mill Creek, Sugar River, and Badfish Creek watersheds. Many opportunities exist for these organizations to continue their work with additional District monetary support that can benefit the stream corridor and improve water quality.

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Exhibits

Exhibit A: Badger Mill Creek Phosphorus Compliance Preliminary Engineering Feasibility Report -- Link to Exhibit A on web

Exhibit B: Risk Review of Tertiary Treatment Infrastructure Project -- Link to Exhibit B on web

Exhibit C: Badger Mill Creek Hydrologic Assessment, Emmons & Oliver Resources, Inc. -- Link to Exhibit C on web

Exhibit D: Additional Analysis of Effluent Impact on Badger Mill Creek -- Link to Exhibit D on web

Exhibit E: Watershed Approaches -- Link to Exhibit E on web

Exhibit F: Risk and Triple Bottom Line Assessment -- Link to Exhibit F on web

Exhibit G: Badger Mill Creek and Goose Lake Historic Change PowerPoint Slides -- Link to Exhibit G on web

Exhibit H: Fish Lake, Crystal Lake PowerPoint Slides -- Link to Exhibit H on web

Exhibit I: Communications and Outreach Summary -- Link to Exhibit I on web

Exhibit J: Digital Observation Reporting Summary -- Link to Exhibit J on web

Exhibit K: WDNR Trout Report (WDNR Trout Stream Management and Status Report of the Sugar River Watershed 2020-2021) -- Link to Exhibit K on web

Exhibit L: Historical Documents Related to Effluent Return -- Link to Exhibit L on web

Exhibit M: WDNR-USEPA Responses to PCAP, Water Quality Trading/Adaptive Management -- Link to Exhibit M on web

Exhibit N: Preliminary Compliance Alternatives Report to Commission -- Link to Exhibit N on web

Exhibit O: Yahara WINS Acknowledgement Letter -- Link to Exhibit O on web

Report for

Madison Metropolitan Sewerage District

Badger Mill Creek Phosphorus Compliance Preliminary Engineering Feasibility Report

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EXECUTIVE SUMMARY

The Madison Metropolitan Sewerage District's (MMSD's) current Wisconsin Pollutant Discharge Elimination System permit proposes more stringent effluent total phosphorus (TP) concentration limits of 0.225 milligrams per liter (mg/L) as a monthly average and 0.075 mg/L as a 6-month average. The Nine Springs Wastewater Treatment Plant (NSWWTP) currently achieves an average effluent TP concentration of 0.3 mg/L. MMSD has two permitted discharge locations: Badfish Creek (BFC) and Badger Mill Creek (BMC). BMC is the smaller of the two discharges with an average annual flow of 3.6 million gallons per day (MGD).

The proposed TP effluent limits will take effect on March 31, 2028. In preparation, MMSD has evaluated various compliance options to meet the proposed discharge requirements at the BMC outfall, one of them being the addition of tertiary treatment. From 2018 through 2019, MMSD conducted pilot studies of several tertiary treatment technologies to demonstrate the feasibility of meeting the proposed TP limit.

The focus of this Phosphorus Compliance Preliminary Engineering Feasibility Report is to develop a design concept and budgetary planning costs for tertiary treatment to meet the future effluent TP limits at the BMC discharge. Based on the existing NSWWTP infrastructure, influent characteristics, and pilot test performance, the following three alternatives were short-listed for potential implementation at the NSWWTP:

1. Alternative 3–Reactive Filtration
2. Alternative 4–Cloth Disk Filtration
3. Alternative 5–Ballasted Settling

A hydraulic assessment of the NSWWTP was conducted to aid in the evaluation of the tertiary treatment technologies. Each of the short-listed technologies have similar hydraulic infrastructure requirements.

The total present worth cost is expected to be in the range of $23.8 to $30.6 million depending on the selected alternative. Pricing considers system footprint and redundancy.

All the alternatives are established technologies and were successful during pilot testing; however, Alternative 4 gave the most inconsistent results. Despite this limitation, Alternative 4 has a lower maintenance requirement and is easier to operate compared to Alternative 5. Alternative 3 combines the functionality of Alternative 4 with the performance of Alternative 5.

Based on the monetary and nonmonetary analysis, MMSD has selected Alternative 3, the installation of the BluePRO® reactive filtration system. This technology has a total present worth cost of approximately $24.3 million.

In addition to TP effluent concentration limits, the United States Environmental Protection Agency is expecting states to develop water quality standards for total nitrogen (TN) in future permit cycles. The addition of BluePRO denitrifying filters could be added in the future to allow for TN removal.

Alternative 3 is the selected technology for reliably treating TP in the BMC discharge with the current average flow of 3.6 MGD. A different technology would likely be used if MMSD was required to treat the entire plant effluent flow of approximately 80 MGD. Other technologies may be better suited to scale up to the required capacity for the combined BFC and BMC discharge flow.

ABBREVIATIONS

The following list of abbreviations is included as an aid to the reader:

AASI	Aqua-Aerobic Systems, Inc.
BFC	Badfish Creek
BMC	Badger Mill Creek
BNR	biological nutrient removal
CO_2	carbon dioxide
DO	dissolved oxygen
Evoqua	Evoqua Water Technologies
Feasibility Report	Phosphorus Compliance Preliminary Engineering Feasibility Report
ft	feet
ft^2	square feet
HVAC	heating, ventilation, and air conditioning
lb/day	pounds per day
lb/yr	pounds per year
mg/L	milligrams per liter
MGD	million gallons per day
ML	mixed liquor
MMSD	Madison Metropolitan Sewerage District
Mw-h/yr	megawatt hour per year
N_2	nitrogen gas
NH_3-N	ammonia nitrogen
NO_3	nitrate
NO_x	nitrogen oxide
NSWWTP	Nine Springs Wastewater Treatment Plant
O&M	operation and maintenance
OPCC	Opinion of Probable Capital Costs
PO_4	phosphate
RAS	return activated sludge
SE	secondary effluent
SO_2	sulfur dioxide
TN	total nitrogen
ton/yr	tons per year
TP	total phosphorus
TSS	total suspended solids
UV	ultraviolet
WAS	waste activated sludge
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollution Discharge Elimination System
WQBELs	water quality based effluent limits

BACKGROUND AND SCOPE

The Madison Metropolitan Sewerage District (MMSD) is a municipal corporation in Madison, Wisconsin that provides service to 25 municipal customers, including cities, villages, utility districts, and sanitary districts in the area. The MMSD service area includes approximately 187 square miles with a population of approximately 407,000 people. All the wastewater collected in the MMSD service area is conveyed to the Nine Springs Wastewater Treatment Plant (NSWWTP) for treatment. The NSWWTP is an advanced activated sludge plant and includes biological nutrient removal (BNR) process to remove phosphorus and nitrogen. MMSD has two permitted discharge locations: Badfish Creek (BFC) at outfall 001 and Badger Mill Creek (BMC) at outfall 005. BMC is the smaller of the two outfalls with an average annual design flow of 3.6 million gallons per day (MGD).

The proposed effluent total phosphorus (TP) concentration limits included in MMSD's most recent Wisconsin Pollutant Discharge Elimination System (WPDES) permit are 0.225 milligrams per liter (mg/L) as a monthly average and 0.075 mg/L as a 6-month average. The proposed TP effluent limits will take effect on March 31, 2028, based on the WPDES permit compliance schedule. The NSWWTP achieves a relatively low effluent TP concentration that has ranged from approximately 0.2 to 0.5 mg/L with an average value of 0.3 mg/L over the past 5 years (Table 1).

	Monthly Average Effluent TP Concentration (mg/L)				
	2018	2019	2020	2021	2022
January	0.28	0.28	0.26	0.26	0.24
February	0.25	0.25	0.20	0.26	0.23
March	0.21	0.20	0.20	0.21	0.25
April	0.21	0.22	0.24	0.32	0.30
May	0.31	0.29	0.29	0.31	0.35
June	0.31	0.26	0.26	0.29	0.38
July	0.35	0.34	0.34	0.39	0.38
August	0.32	0.33	0.31	0.55	0.40
September	0.36	0.34	0.29	0.36	0.43
October	0.36	0.30	0.26	0.32	0.30
November	0.37	0.23	0.26	0.41	0.33
December	0.28	0.26	0.37	0.32	0.26
Annual Average	0.30	0.28	0.27	0.33	0.32

Note: BMC has an average annual flow of approximately 3.6 MGD.

Table 1 NSWWTP Effluent TP Data (2017 to 2022)

MMSD published a study in June of 2022 titled, *Preliminary Compliance Alternatives Assessment Phosphorus Compliance Badger Mill Creek, Outfall 005 Madison Metropolitan Sewerage District*. In this study MMSD evaluated six compliance options that would allow them to meet the proposed effluent phosphorus limit. From this study, MMSD narrowed down their potential compliance options, one of them being the addition of tertiary treatment to meet the BMC discharge requirements.

The focus of this *Phosphorus Compliance Preliminary Engineering Feasibility Report* (Feasibility Report) is to develop a design concept and budgetary planning costs for tertiary treatment to meet the future effluent TP limits at the BMC discharge. Additionally, this feasibility report will provide a high-level analysis of the nonmonetary factors for the proposed tertiary treatment alternatives.

IDENTIFICATION AND SCREENING OF ALTERNATIVES

A. Description of Alternatives

In this section, potential tertiary treatment technologies are identified and screened for further evaluation. Previously in 2018 through 2019, MMSD conducted pilot studies of several technologies to demonstrate the feasibility of meeting the proposed phosphorus limit. Alternatives previously identified for potential implementation at NSWWTP are as follows:

1. Alternative 1–Membrane Filtration

This alternative consists of ultrafiltration membranes, which are used to remove suspended particulates, macromolecules, and some dissolved compounds from water. There are various types of ultrafiltration membranes, as shown in Figure 1. Submersible membranes are preferred for media filter retrofits, whereas pressurized ultrafiltration membranes are preferred where there are space constraints.

Source: Veolia Water Technologies (formerly Suez Water Technologies)

Figure 1 Ultrafiltration Membrane Models

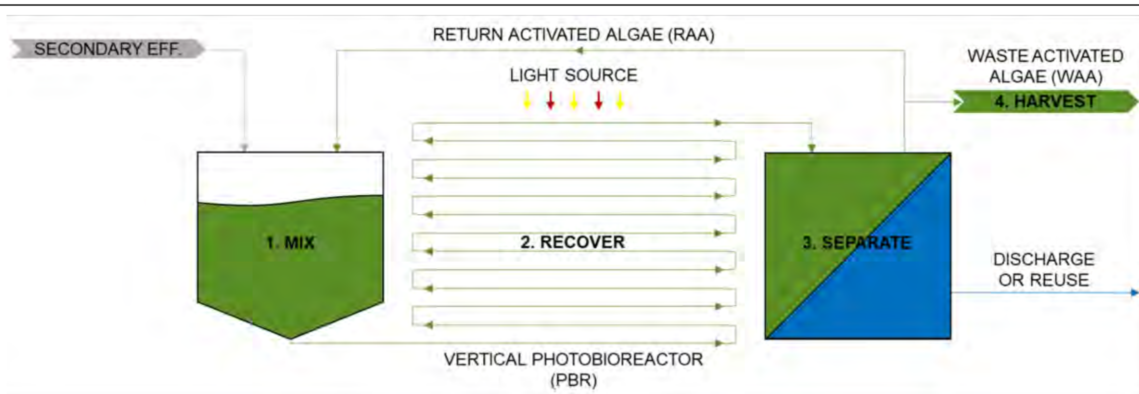
Pilot testing was not conducted for the ultrafiltration membrane technology at MMSD. However, this well-established technology is anticipated to be capable of achieving effluent TP below 0.05 mg/L. There is potential to save on capital costs as this alternative may meet *E. coli* limits without a dedicated disinfection process (pending Wisconsin Department of Natural Resources [WDNR] approval). Although ultrafiltration membranes are relatively simple to operate, they are more energy intensive than other alternatives and require additional pumping. The benefits and limitations of this technology are summarized in Table 2.

Benefits	Limitations
▪ Anticipated to be capable of achieving effluent TP below 0.05 mg/L target ▪ Potential to meet *E. coli* limits without a dedicated disinfection process ▪ Potential removal of some contaminants of emerging concern	▪ More energy intensive than other alternatives ▪ Chemical use ▪ High capital and operation and maintenance (O&M) cost ▪ Requires additional pumping

Table 2 Membrane Filtration Benefit and Limitation Summary

2. Alternative 2–Algae Photobioreactors

CLEARAS Water Recovery manufactures an algae-based tertiary treatment technology that removes both phosphorus and nitrogen from secondary effluent. In this system, secondary effluent is mixed with return activated algae and carbon dioxide before flowing through transparent tubes in which the algae take up phosphorus and nitrogen for cell growth while producing oxygen through photosynthesis. These tube reactors are installed in a greenhouse that can be illuminated with artificial light during periods of low light intensity, allowing for continuous operation. A membrane is used to separate the algae from the treated wastewater, with most of the algae being returned to the beginning of the algae treatment system while a portion is wasted. A visual summary of this process is shown in Figure 2.



Source: CLEARAS

Figure 2 Suspended Growth Algae Photobioreactor

Pilot testing was conducted in September 2019 at the NSWWTP to determine if the algae photobioreactor could achieve an effluent water quality of less than 0.075-mg/L TP. The pilot test had three distinct phases to test the technology under different situations. Phase I focused on treating the secondary effluent at the NSWWTP with no supplemental ammonia dosing. The purpose of this was to evaluate the technology's performance using the existing nitrogen (primarily in the form of nitrate [NO_3]) in the secondary effluent for algae growth and nutrient recovery. Phase II evaluated the effects of changing the nitrogen source on nutrient recovery. Here ammonia was dosed into the influent of the algae photobioreactors. Phase III evaluated system performance given a mixed feed of primary effluent and secondary effluent. This mixture required no additional ammonia dosing as there was sufficient ammonia in the primary effluent. Here the algae had both NO_3 and ammonia available for growth.

Pilot testing results are summarized in Table 3. In Phase I and Phase III, the CLEARAS system successfully reduced the effluent TP levels to well below the 0.075-mg/L target. The pilot testing effectively demonstrated that CLEARAS can efficiently operate on the NSWWTP's secondary effluent with no addition of metal salts or ammonia required.

	Phase I	Phase II	Phase III
Total Phosphorus			
Pilot Test Feed (mg/L)	0.20	0.18	1.56
Pilot Test Effluent (mg/L)	0.029	0.089	0.058
Percent Removal	86	50	96

Table 3 CLEARAS Pilot Testing Results

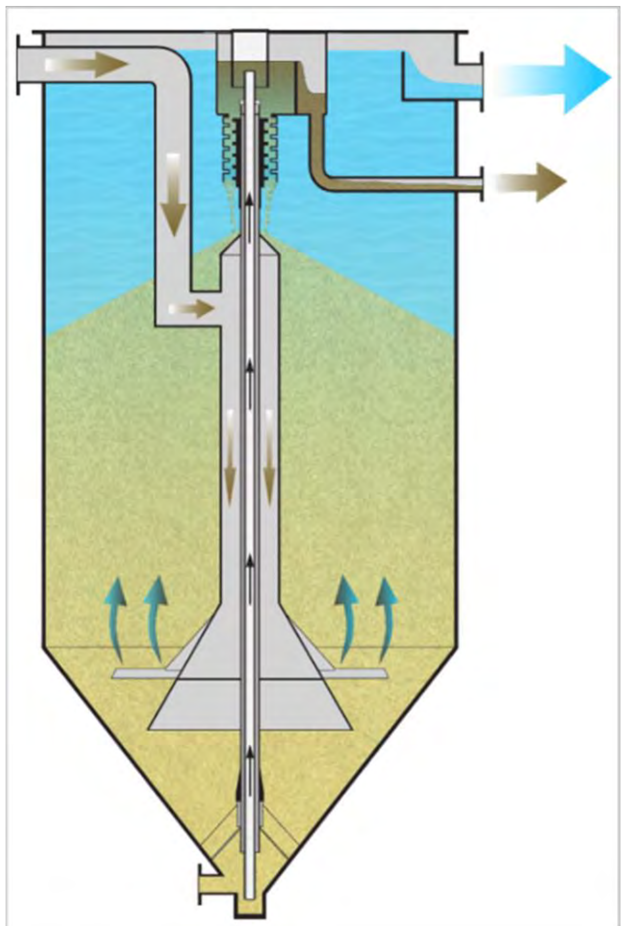
The CLEARAS system is a relatively new technology with few full-scale installations. As a biological system, this technology is less robust and thus may not handle system upsets as well as nonbiological systems. While the potential for continuous operation is a benefit, the illumination of the greenhouse at night has the potential for light pollution. If MMSD were to move forward with this alternative, approximately one acre of space is required on the site, which will be difficult to site without impacting other future site needs. Additional benefits and limitations of this technology are summarized below in Table 4.

Benefits	Limitations
▪ Measured effluent TP during pilot test well below 0.05 mg/L ▪ Potential for resource recovery in the form of algal biomass recovery ▪ No metal salt addition	▪ Large footprint required ▪ Biological system less robust ▪ Potential light pollution ▪ New process with few installations ▪ Proprietary technology ▪ Requires additional pumping ▪ Complicated system operation ▪ Low secondary effluent TP results in low algae production

Table 4 Algae Photobioreactor Benefit and Limitation Summary

3. Alternative 3–Reactive Filtration

This alternative consists of either a single or dual stage upflow sand filter. The BluePRO® system by Nexom™ consists of a fluidized sand bed through which the wastewater flows, and on which the phosphorus is removed through the sand filtration process by removal of suspended solids, as well as reacting with the iron in the filtration media to precipitate as a solid and collect on the sand media. Abrasion within the bed removes phosphorus precipitates off the sand particles, and the solids are recycled to the headwork or the primary clarifiers for removal with the primary sludge. A schematic of the BluePRO system is shown in Figure 3.

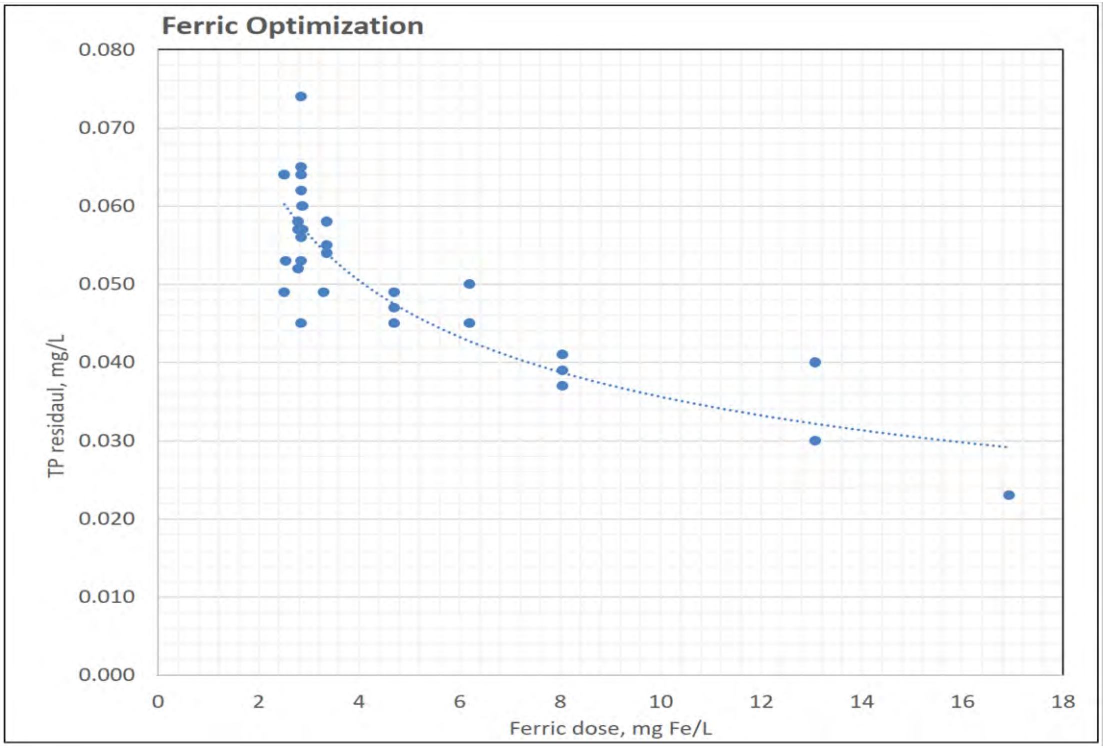


Source: Nexom

Figure 3 Schematic of BluePRO Reactive Filtration

Pilot testing was conducted in June 2019 at the NSWWTP to determine whether the BluePRO reactive filtration system could achieve a secondary effluent TP concentration of less than 0.075 mg/L. A two-stage treatment system was used for pilot testing. Filters A and B were operated in series as the first and second stage, respectively. The goal of Filter A was to determine the optimal ferric dosage necessary to consistently reach the target effluent

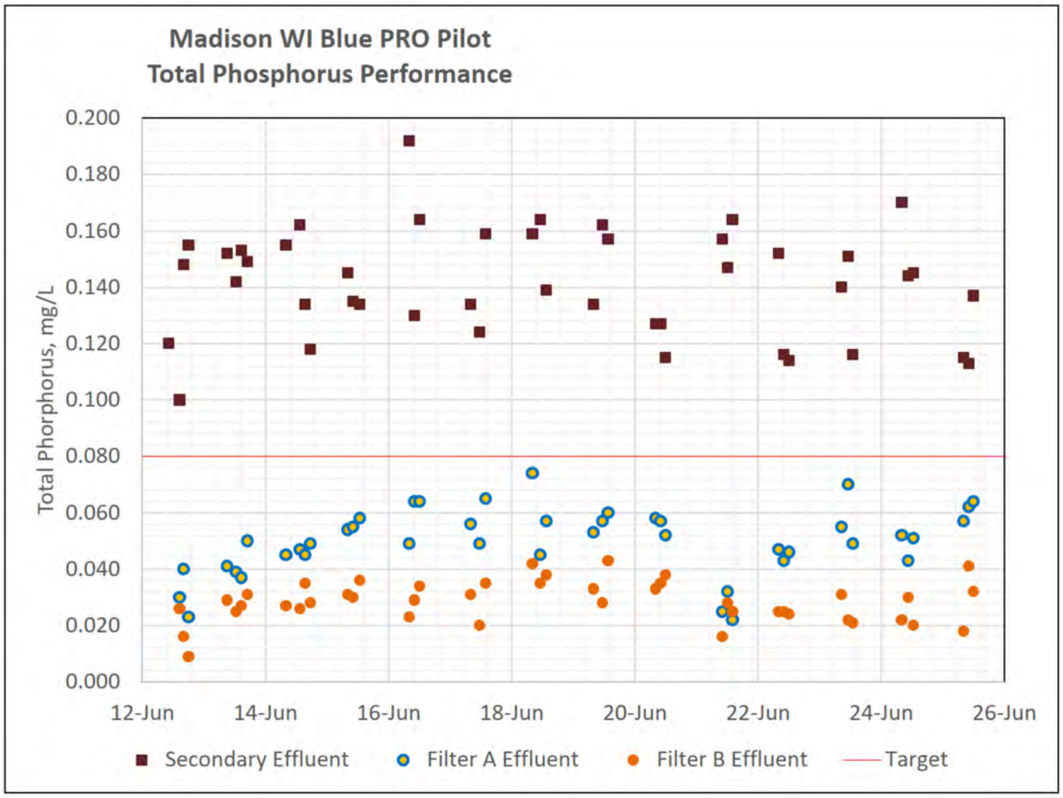
TP concentration. A ferric dosage range of 2.5 to 17 milligrams per liter as iron (mg-Fe/L) was piloted, and the results are shown in Figure 4. Analysis shows that a ferric dose of approximately 2.5 to 3.0 mg-Fe/L is sufficient to meet the treatment goal.



Source: Nexom

Figure 4 BluePRO Pilot Test Ferric Dosage for Filter A

In comparison, the goal of Filter B was to determine the feasibility of this technology to reach even lower effluent TP concentrations. During pilot testing, Filter B was operated continuously with a ferric dosage ranging from 2.5 to 17 mg-Fe/L. Filter B was successful in reaching effluent TP concentration ranging from 0.009 to 0.043 mg/L. The pilot tests were successful in showing that the BluePRO reactive filtration system can achieve the proposed water quality based effluent limit (WQBEL) and that this technology has the potential to meet more stringent phosphorus limits. The performance of Filters A and B are summarized in Figure 5.



Source: Nexom

Figure 5 BluePRO Pilot Testing TP Results for Filters A and B

The BluePRO reactive filtration system has a relatively simple operation and does not require the addition of polymer. This technology can meet the required effluent limit using a single-stage system but has the flexibility to add an additional stage. Additional benefits and limitations of this technology are summarized below in Table 5.

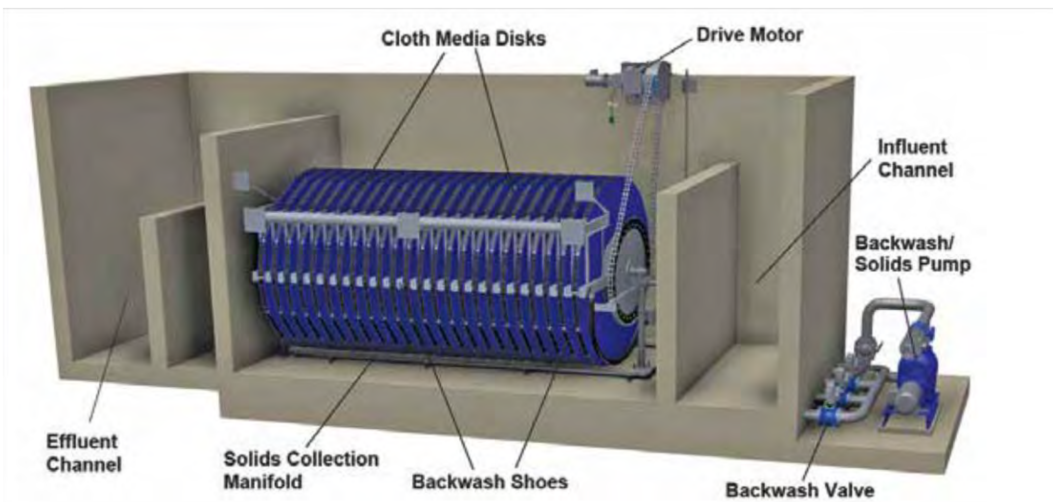
Benefits	Limitations
▪ Met effluent targets without polymer during pilot test ▪ Target effluent TP met with one stage ▪ Relatively simple operation ▪ Flexibility to add second stage if future lower TP or total nitrogen (TN) limits are imposed	▪ Height of units impacts hydraulics and/or building layout

Table 5 BluePRO System Benefit and Limitation Summary

4. Alternative 4–Cloth Disk Filtration

Cloth disk filters remove insoluble phosphorus that is associated with the total suspended solids (TSS). A rapid mix tank, coagulation tank, and flocculation tank are required upstream of the cloth disk filtration system, and ferric chloride and polymer are added to precipitate soluble phosphorus before filtration. There are many cloth disk filter manufacturers, and for the purpose of this Feasibility Report, the AquaDisk® woven cloth media filters manufactured by Aqua-Aerobic Systems, Inc. (AASI) was evaluated.

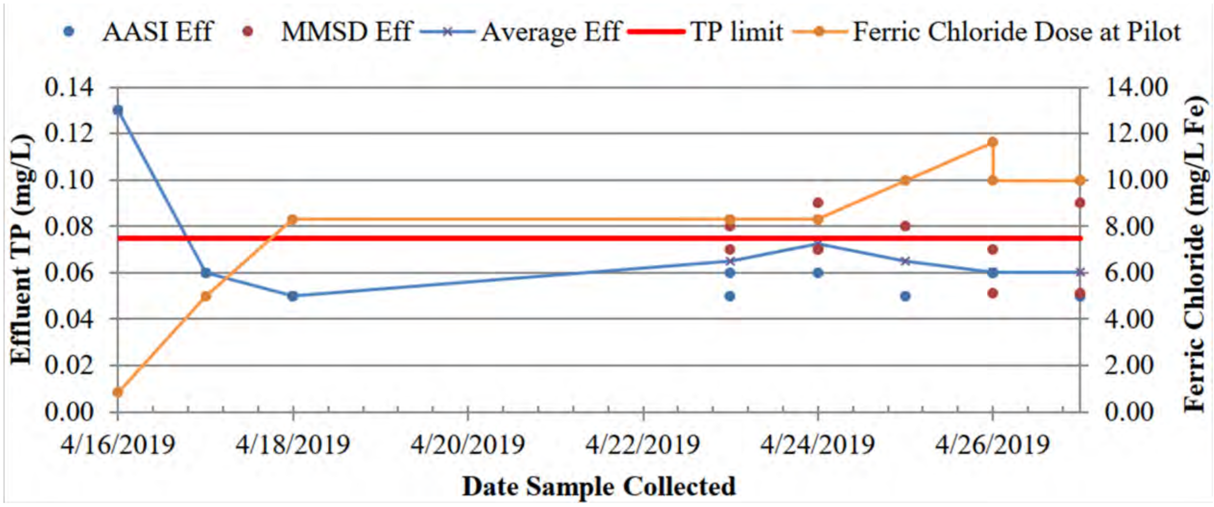
The AquaDisk operates completely submerged in the wastewater. Wastewater flows from the outside of the filtration disks to the inside, and the filtrate flows from the center of the discs to the centertube, which carries the filtered effluent out of the tank. When water levels in the tank increase to a setpoint, a backwash sequence is initiated. During the backwash, pumps are used to draw solids off the cloth media as they rotate. The backwash solids would then be discharged to the West Primary Influent Channel to allow the solids to be removed with the West Primary Sludge. A schematic of an AquaDisk cloth disk filter is shown in Figure 6.



Source: AASI

Figure 6 Schematic of Aqua-Aerobic Systems AquaDisk

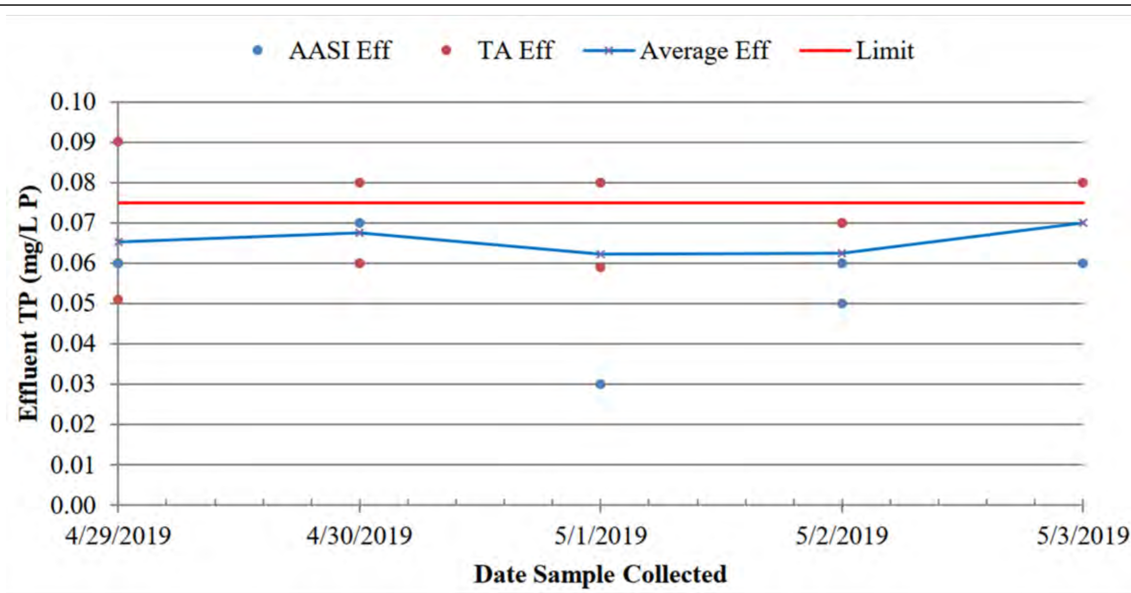
Pilot testing was conducted April through May 2019 at the NSWWTP to determine if the cloth media filtration system could achieve an effluent water quality of less than 0.075 mg/L TP. The Aqua MiniDisk cloth media filtration system was piloted, and the testing was conducted in two phases. Phase I evaluated the effectiveness of ferric chloride addition on the performance of the OptiFiber PES-14® MicroFiber cloth media. Figure 7 shows the varying ferric dosage and resulting effluent TP concentration during Phase I. There was an upset around April 24, 2019, that resulted in effluent TP concentrations over the TP limit. The average effluent TP concentration for Phase I was 0.064 mg/L.



Source: AASI
Note: Eff=effluent

Figure 7 AASI OptiFiber PES-14 MicroFiber Testing Results (Phase I)

Phase II evaluated the performance of the OptiFiber UFS-9® UltraFiber cloth filtration media. The testing results for Phase II are summarized in Figure 8. There were a few upsets with effluent TP values above the TP limit. Overall, UFS-9 reduced effluent TP to an average of 0.065 mg/L.



Source: AASI
Note: mg/L P=milligrams per liter of phosphorus

Figure 8 AASI OptiFiber UFS-9 UltraFiber Testing Results (Phase II)

Although both the PES-14 and UFS-9 cloth media were able to achieve the target effluent TP limit, there were multiple days with results above the 0.075-mg/L limit. Additional pilot testing is warranted if this technology is selected for further consideration. Additional benefits and limitations of this technology are summarized in Table 6.

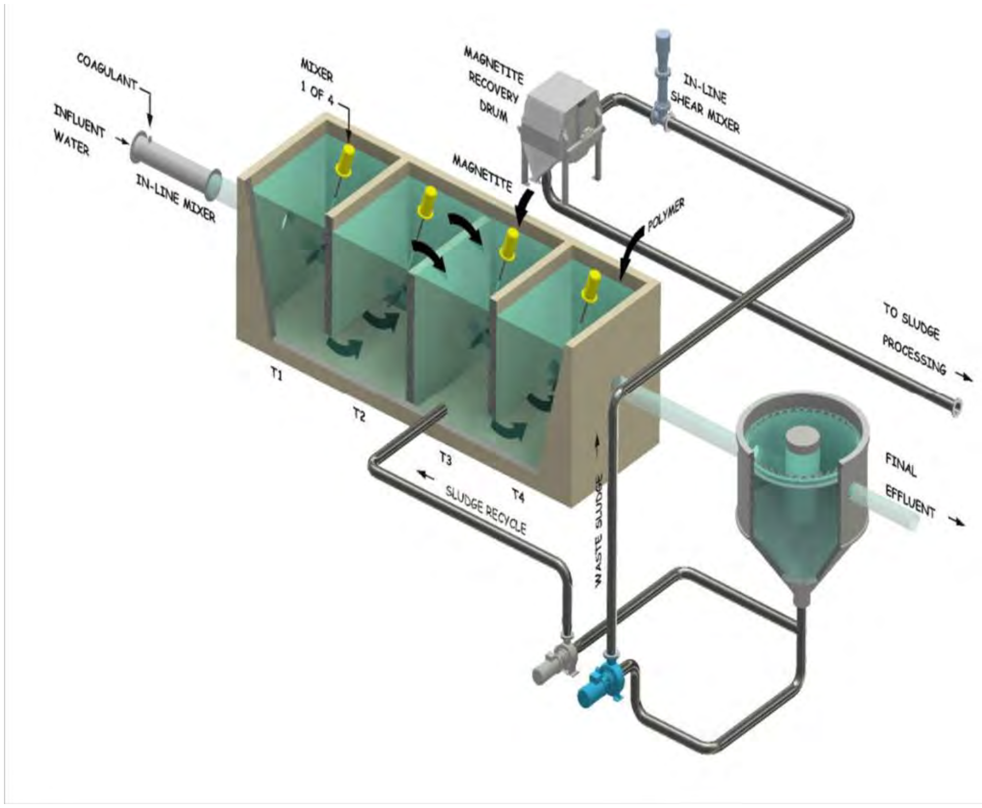
Benefits	Limitations
▪ Well-established technology ▪ Less impact on hydraulic profile than some other technologies ▪ Relatively simple operation	▪ Pilot testing performance was not as consistent as other technologies ▪ Chemical use ▪ 0.05-mg/L target is close to limit of technology

Table 6 AquaDisk Benefit and Limitation Summary

5. Alternative 5–Ballasted Settling

Ballasted settling is a coagulation and sedimentation treatment process that uses a ballast material and the addition of a coagulant and polymer to improve the settling properties of suspended solids. The ballast material provides surface area that enhances flocculation and acts as a weight to increase settling rates. The goal of a ballasted settling system is to form microfloc particles with a specific gravity of greater than two. This high-density floc enables settling rates that are 10 to 60 times greater than conventional clarification. The increased settling rates allow for more compact clarifier designs with high overflow rates and short detention times, which may result in smaller overall system footprints.

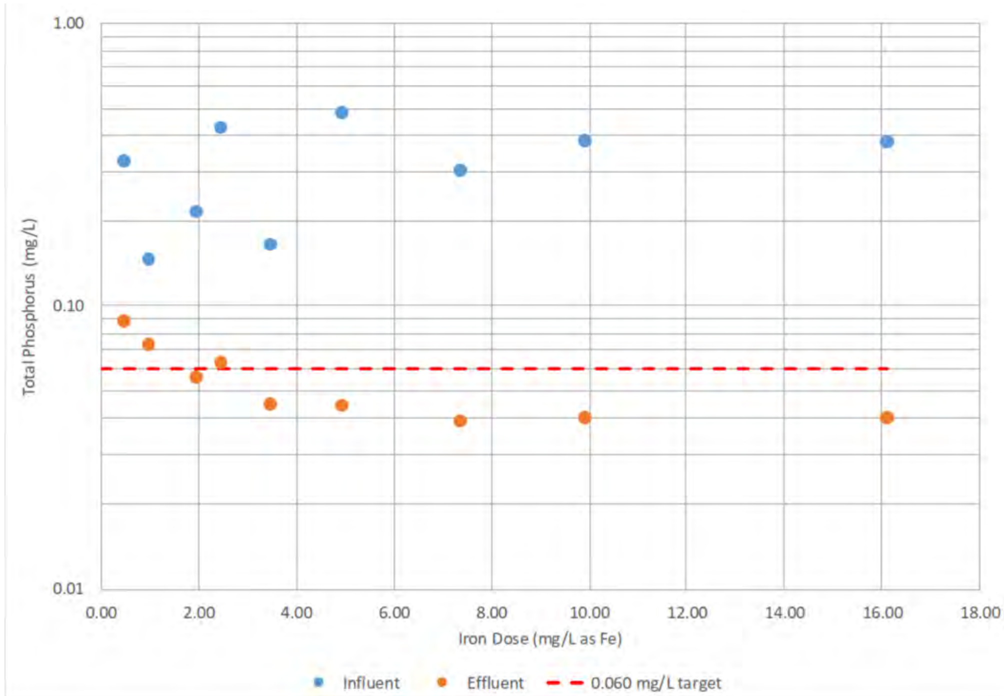
The Evoqua Water Technologies (Evoqua) CoMag™ ballasted settling system uses magnetite as the ballast material. Magnetite is a fully inert, high specific gravity (5.2), finely ground, nonabrasive, iron ore ballast. The CoMag system recycles most of settled solids from the clarifier back to the reaction tanks to increase nucleation sites, enhance precipitation kinetics, and promote sweep flocculation. A schematic of the CoMag system is shown in Figure 9.



Source: Evoqua

Figure 9 Schematic of CoMag Process

Pilot testing was conducted in December 2018 at the NSWWTP to determine if the Evoqua CoMag ballasted settling system could achieve a secondary effluent water quality of less than 0.075 mg/L TP. Coagulant dose response testing was performed using ferric chloride, which determined that the average ferric dose of 11.5 mg-Fe/L was required to consistently meet target TP limit.



Source: Evoqua

Figure 10 Pilot Testing TP Results

Although the CoMag process has a more complex operation with specialized equipment, it is a well-established technology that can consistently achieve the desired effluent TP concentration. This alternative has a lesser impact on the hydraulic profile compared to previously described technologies. Additional benefits and limitations of this technology are summarized in Table 7.

Benefits	Limitations
▪ Measured effluent TP during pilot test of approximately 0.06 mg/L ▪ Well-established technology ▪ Less impact on hydraulic profile than some other technologies	▪ Chemical use ▪ Specialized equipment (magnetic drums) ▪ More complex operation than some alternatives (filters)

Table 7 CoMag Process Benefit and Limitation Summary

B. Alternatives Recommended for Further Evaluation

Based on the existing NSWWTP infrastructure, influent characteristics, and performance requirements, the following three alternatives are recommended for further evaluation:

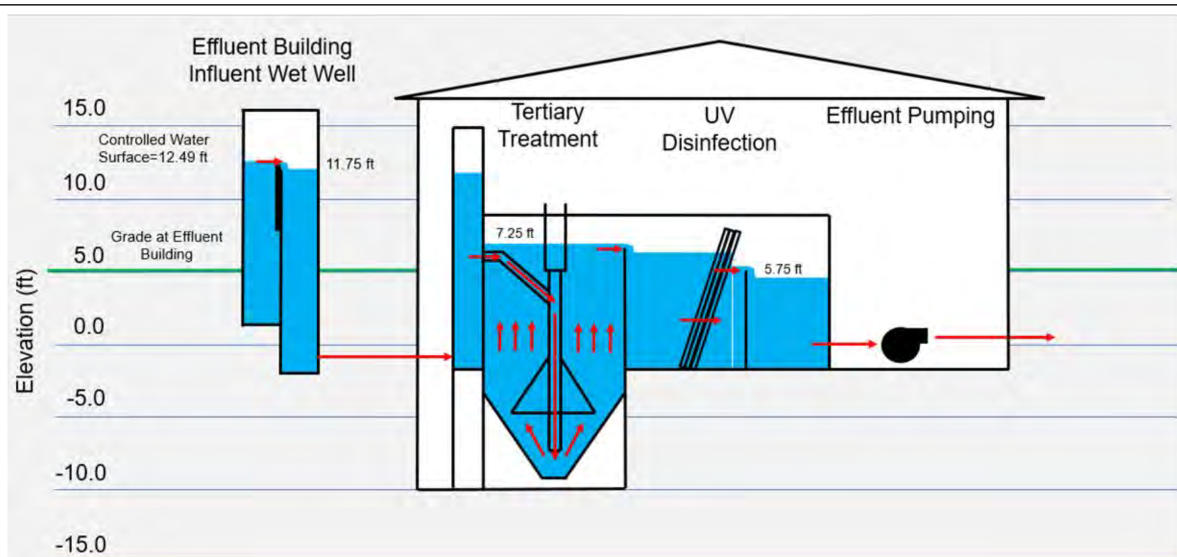
- Alternative 3–Reactive Filtration
- Alternative 4–Cloth Disc Filtration
- Alternative 5–Ballasted Settling

EVALUATION OF ALTERNATIVES

In this section, the three short-listed tertiary treatment alternatives identified in the previous section are evaluated based on hydraulic, monetary, and nonmonetary considerations. Redundancy was considered for all short-listed alternatives. For Alternative 3, the BluePRO system contains a total of six filters where one of the filters is on standby for future use. For Alternative 4, the AquaDisk has a similar setup and build to the previous alternative. Here the AquaDisk system contains a total of three cloth media filters where one of the filters is on standby. Unlike the other technologies, Alternative 5 does not have built-in redundancy as the CoMag system is a series of tanks which connect to a large 30-foot-diameter clarifier. To construct redundancy in case of failure, a duplicate CoMag system is considered.

A. Hydraulic Considerations

A hydraulic assessment of the NSWWTP was conducted to aid in the evaluation of the tertiary treatment technologies. Of the three alternatives, the BluePRO reactive filtration system has the greatest headloss with an expected loss of 4 feet. A conceptual hydraulic profile of the BluePRO system is presented in Figure 11. The controlled water surface elevation in the Effluent Building Influent Wet Well is maintained above 12.49 feet by the ultraviolet (UV) disinfection system. At this elevation, pumping to the proposed tertiary treatment building would not be required; however, during the nondisinfection season, the effluent is routed to the bypass channels, lowering the water surface elevation, and requiring pumping to the tertiary treatment facilities under current conditions. To avoid pumping under all conditions, downward opening weir gates (DOWs) would be installed on the bypass channels to allow the water surface level to be monitored and maintained at or above 12.49 feet during the nondisinfection season. To divert secondary effluent flow to the proposed tertiary treatment building, a tertiary treatment splitter box would be constructed as part of the Effluent Building Influent Wet Well. For flow diversion control, a DOW would be provided at the splitter box.



Note: ft=feet

Figure 11 Hydraulic Profile for Tertiary Treatment

A. Common Elements

There are common elements between each alternative. For ease of evaluation, these common elements are detailed in the following:

1. Addition of splitter box to the Effluent Building Influent Wet Well.
2. Construction of a tertiary treatment building.
3. Installation of site piping to convey secondary effluent to tertiary treatment system.
4. Installation of site piping to convey tertiary effluent to existing force main.
5. Installation of site piping to convey backwash solids to the West Primary Influent Channel.
6. Installation of a dedicated disinfection system with DOWs.
7. Installation of two chemical storage tanks for metal salt.
8. Installation of two backwash pumps.
9. Construction of a tertiary effluent wet well
10. Construction of a waste solids wet well to collect backwash solids.
11. Installation of two waste solids pumps to convey backwash solids to the West Primary Influent Channel.
12. Replacement of the two existing effluent pumps.

B. Description of Alternatives

1. Alternative 3–Reactive Filtration

In addition to the common elements listed above, this alternative also includes the installation of one BluePRO reactive filtration system in the proposed Tertiary Treatment Building. A preliminary site layout of this alternative is presented in Figure 12. This layout is anticipated to be similar for other alternatives.

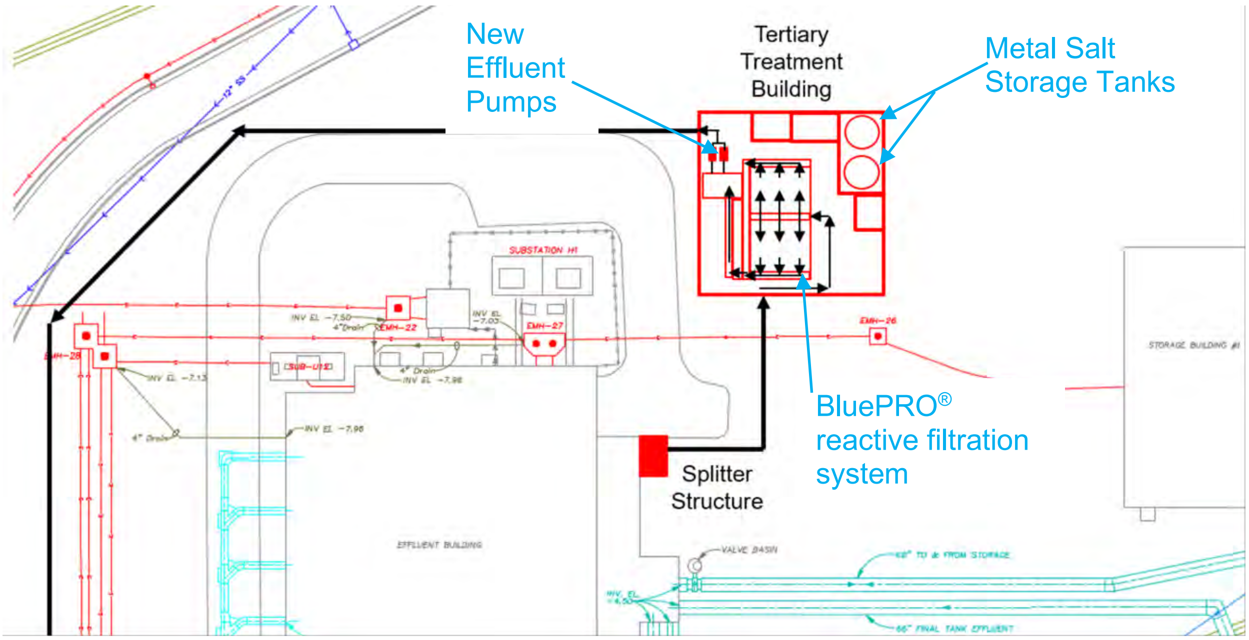


Figure 12 Alternative 3–Preliminary Site Layout Showing BluePRO System

2. Alternative 4–Cloth Disk Filtration

In addition to the common elements listed above, this alternative also includes the installation of one AquaDisk cloth media filtration system in the proposed Tertiary Treatment Building. This technology requires the installation of one rapid mix basin, one coagulation basin, and one flocculation basin. A polymer storage tank in addition to two polymer feed pumps are also included. The preliminary site layout of this alternative is the same as Alternative 3 presented in Figure 12.

3. Alternative 5–Ballasted Settling

This alternative includes the installation of one CoMag system consisting of two treatment trains and two 30-foot-diameter clarifiers for redundancy. The treatment train is made up of four concrete tanks. Tanks 1 and 2 are the first and second stage coagulation tanks, Tank 3 is the ballasting tank, and Tank 4 is the polymer addition tank in the proposed Tertiary Treatment Building. A polymer storage tank in addition to two polymer feed pumps are also included. The preliminary site layout of this alternative is similar to Alternative 3 presented in Figure 12, with the main difference being Alternative 5 requires a larger building footprint.

D. Monetary Evaluation

Table 8 summarizes the 20-year present worth analysis for each tertiary treatment alternative. Additional detail on the present worth analysis is provided in the appendix.

	Alternative 3–BluePRO	Alternative 4–AquaDisk	Alternative 5–CoMag
Equipment/Structure Subtotal	$5,480,000	$5,020,000	$7,040,000
Piping/Mechanical	$1,920,000	$1,760,000	$2,470,000
Electrical	$1,650,000	$1,510,000	$2,120,000
Plumbing/HVAC	$550,000	$510,000	$710,000
Sitework	$780,000	$760,000	$860,000
Major Yard Piping	$500,000	$500,000	$500,000
Undefined Scope	$1,100,000	$1,010,000	$1,410,000
Contractor's General Conditions	$1,800,000	$1,670,000	$2,270,000
Supply Chain Escalator	$1,380,000	$1,280,000	$1,740,000
Contingencies	$3,030,000	$2,800,000	$3,820,000
Technical Services	$2,280,000	$2,110,000	$2,870,000
Opinion of Probable Capital Costs (OPCC)	**$20,470,000**	**$18,930,000**	**$25,810,000**
Annual O&M Costs			
Relative Labor	$31,000	$31,000	$31,000
Power	$137,000	$135,000	$142,000
Chemical	$47,000	$114,000	$72,000
Additional Sludge Handling and Disposal	$14,000	$26,000	$16,000
Maintenance and Supplies	$46,000	$44,000	$79,000
BMC Operation Costs	$52,000	$52,000	$52,000
Total Opinion of Annual O&M	**$327,000**	**$402,000**	**$392,000**
Present Worth of Future Capital Costs/Replacement	$0	$0	$0
Present Worth of O&M	$4,440,000	$5,460,000	$5,330,000
Present Worth of Salvage	($580,000)	($640,000)	($510,000)
TOTAL OPINION OF PRESENT WORTH	**$24,330,000**	**$23,750,000**	**$30,630,000**

Notes:
HVAC=heating, ventilation, and air conditioning
All costs are in first quarter 2023 dollars.
20-year present worth at a discount rate of 4 percent.

Table 8 Summary of Budgetary Costs for Tertiary Treatment Alternatives

E. Nonmonetary Considerations

The following nonmonetary considerations for each alternative were evaluated and are detailed in the following.

1. Chemical Usage

- The AquaDisk system expected to have the highest chemical usage based on pilot testing results.
- The BluePRO system has the lowest chemical usage and is anticipated to be 50 percent less than required by AquaDisk.
- The CoMag system chemical usage lays between the other alternatives.

2. Environmental Impacts

- This is not expected to vary significantly between alternatives. A more in-depth discussion on environmental impacts is provided later in this report.

3. Footprint

- Both the BluePRO and the AquaDisk systems result in a proposed Tertiary Treatment Building with an area of approximately 4,000 square feet (the difference here being the height of the BluePRO system tanks require a slightly deeper Tertiary Treatment Building).
- The CoMag system alternative requires a proposed Tertiary Treatment Building of approximately 5,600 square feet.

4. Maintenance Requirements

- The BluePRO system and the AquaDisk system are anticipated to have the same level of maintenance requirements.
- The CoMag system contains magnetic recovery drums used to recycle metal salts. This drum is a piece of specialized equipment and would require more in-depth maintenance.

5. Operational Complexity

- Both the BluePRO and AquaDisk systems are established tertiary treatment technologies expected to have a similar level of complexity. These two systems are less complicated than the CoMag system.
- The CoMag system is expected to have the most complex operation given the specialized equipment.

6. Performance

- The AquaDisk system gave the most inconsistent results during pilot testing. Here the 0.05-mg/L TP concentration is close to the limit of the technology.
- Both the BluePRO and CoMag systems gave consistent results that met performance expectations.

7. Proven Technology

- All technologies are well-known and are widely used for tertiary treatment.
- Pilot testing was successful for all alternatives.

8. Resiliency to Changing Conditions and Process

- This is not expected to vary between alternatives. Performance of tertiary treatment technologies will be impacted by the secondary effluent quality and flow. Given that there expected flow into the Tertiary Treatment Building is a constant 3.6 MGD, minimal fluctuations are anticipated.
- If MMSD were to transition to operating under low dissolved oxygen (DO) conditions, this could increase the TP concentration of the secondary effluent. Elevated TP concentrations would require additional chemical for TP removal. This would increase costs for chemical usage and sludge handling across all alternatives.

9. Solids Handling Impacts

- This is expected to vary slightly between alternatives; however, impact to the overall solids handling at the NSWWTP is likely minimal.
- Performance of tertiary treatment technologies will be most impacted by secondary effluent quality.

ENVIRONMENTAL IMPACTS

MMSD has a strong interest in mitigating their impact on the environment and climate change. This section of the Feasibility Report conducts a high-level analysis of the environmental impact of the shortlisted tertiary treatment alternatives. The building footprint and energy requirements of each alternative were quantified, and the resulting greenhouse gas (GHG) emissions calculated. GHG emissions were quantified for carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxide (NO_x).

A. Energy Differences

This Feasibility Report considered the footprint of each prelisted technology to determine an appropriate size for the tertiary treatment building. The building size corresponding to each alternative is summarized in Table 9. Here the magnitude of the building footprint for each alternative is used as a proxy for GHG emissions generated from construction. Given minimal variation in the resulting footprint of each alternative, the difference in expected GHG emissions generated from the construction of these alternatives is expected to be negligible. Therefore, GHG emission generated from construction were not quantified. GHG emission calculations were based solely on the anticipated energy use for each alternative, and the energy requirement for each alternative is reported in Table 9. The Emissions & Generation Resource Integrated Database (eGRID) by the United States Environmental Protection Agency (USEPA) was used to convert energy usage to the equivalent pounds of GHG produced per year. Since MMSD falls within the Midwest Reliability Organization East (MORE) region, eGRID references GHG emission rates published by MORE. MORE reports the emission rates for CO_2, SO_2, and NO_x as 1,582.1 pounds per megawatt hour (lb/Mw-h), 0.393 lb/Mw-h, and 0.92 lb/Mw-h, respectively. The resulting GHG emissions for CO_2, SO_2, and NO_x were calculated in megatons per year and are shown in Table 9.

Technology	Building Footprint (ft^2)	Energy Usage (Mw-h/yr)	Equivalent CO_2 (Ton/yr)	Equivalent SO_2 (Ton/yr)	Equivalent NO_x (Ton/yr)
Alternative 3–BluePRO®	4,000	1,590	1,140	0.28	0.66
Alternative 4–AquaDisk®	4,000	1,570	1,130	0.28	0.65
Alternative 5–CoMag™	5,600	1,650	1,180	0.29	0.69

Notes:
ton=metric ton
ft^2=square feet
Mw-h/year=megawatt hour per year
ton/yr=tons per year
Electrical cost set at 0.085 $/kw-h

Table 9 Estimated GHG Emission Equivalent for Each Alternative

SELECTED ALTERNATIVE

Based on the monetary and nonmonetary analysis, MMSD has selected Alternative 3. This alternative includes the installation of the BluePRO reactive filtration system in the proposed Tertiary Treatment Building. The BluePRO system has an estimated capital cost and 20-year total present worth cost of 19.6 and 23.5 million dollars respectively. There is a 3 percent difference in cost between the total present worth values for Alternatives 3 and 4; monetarily, Alternatives 3 and 4 are considered equal. Although Alternatives 3 and 4 are monetarily considered equal on a 20-year basis, the BluePRO system has the lowest annual O&M costs. This is due to low chemical usage and not requiring the addition of polymer. Moreover, less chemical usage results in lower sludge production and hauling costs. The BluePRO system produces approximately 50 percent less sludge annually compared to the AquaDisk system.

Alternative 3 will not only allow MMSD to meet the proposed TP effluent concentration limits, but it will help them minimize chlorides in their effluent discharge. MMSD has a chloride limit at the BMC outfall, and compliance with the chloride limit is of significant concern. Between November 1 to March 31, their WPDES permit allows a weekly average chloride discharge concentration of 465 mg/L. This limit is more stringent April 1 through October 31 with a weekly average chloride discharge concentration of 430 mg/L. The evaluation of the tertiary treatment alternatives used ferric chloride as a coagulant source, but other chemicals may be used. Of the three shortlisted alternatives, the BluePRO system has the smallest anticipated chemical usage and thus would impart the least number of chlorides.

In addition to TP effluent concentration limits, the USEPA is expecting states to develop water quality standards for total nitrogen (TN) and other nutrient-related parameters in future permit cycles. TN includes all forms of nitrogen: organic, ammonia, and inorganic forms like nitrite and nitrate. If the WDNR were to develop a TN WQBEL, the BluePRO technology can be amended by the addition of denitrifying filters to allow for TN removal.

It is important to note that Alternative 3 is the selected technology for reliably treating TP in the BMC discharge with their current average flow of 3.6 MGD. Different technology might be used if MMSD was required to treat the entire plant effluent flow of roughly 80 MGD. This is because other technologies may be better suited to scale up to the required capacity for the BFC and BMC discharge flow.

APPENDIX
OPCC

Madison Metropolitan Sewerage District
Badger Mill Creek Phosphorus Compliance Preliminary Engineering Feasibility Report
Opinion of Present Worth Cost **Discount Rate** 4.000%

Alternative 3-BluePRO

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Effluent Pumping Equipment	$ 220,000	$ -	20	$ -	$ -	$ -
Waste Solids Pumping Equipment	$ 110,000	$ -	20	$ -	$ -	$ -
Splitter Structure	$ 150,000	$ -	40	$ -	$ 75,000	$ 30,000
Tertiary Treatment Building	$ 1,400,000	$ -	40	$ -	$ 700,000	$ 320,000
Process Equipment and Controls	$ 1,663,000	$ -	20	$ -	$ -	$ -
Chemical Feed Tank	$ 110,000	$ -	20	$ -	$ -	$ -
Chemical Feed Equipment	$ 60,000	$ -	20	$ -	$ -	$ -
UV Disinfection Equipment	$ 740,000	$ -	20	$ -	$ -	$ -
Downward Opening Weir Gates	$ 140,000	$ -	40	$ -	$ 70,000	$ 30,000
Process Structural	$ 890,000	$ -	40	$ -	$ 445,000	$ 200,000
Subtotal	$ 5,480,000	$ -		$ -	$ 1,290,000	$ 580,000
Piping/Mechanical	$ 1,920,000					
Electrical	$ 1,650,000					
Plumbing/HVAC	$ 550,000					
Sitework	$ 780,000					
Major Yard Piping	$ 500,000					
Undefined Scope	$ 1,100,000					
Subtotal	$ 11,980,000					
General Conditions	$ 1,800,000					
Subtotal	$ 13,780,000					
Supply Chain Escalator	$ 1,380,000					
Subtotal	$ 15,160,000					
Contingencies	$ 3,030,000					
Technical Services	$ 2,280,000					
Total Capital Costs	$ 20,470,000	$ -		$ -	$ 1,290,000	$ 580,000
Present Worth of Capital Costs	**$ 20,470,000**	**$ -**		**$ -**	**$ 1,290,000**	**$ 580,000**

Estimated Annual O&M Costs	
Relative Labor	$ 31,000
Power	$ 137,000
Chemicals:	
Ferric	$ 47,000
Maintenance and Supplies	$ 38,000
Lamp Replacement	$ 8,000
Additional Sludge Handling and Disposal	$ 14,000
BMC Operation Costs	$ 52,000
Total O&M Costs	$ 327,000
Present Worth of O&M	**$ 4,440,000**

Summary of Present Worth Costs	
Capital Cost	$ 20,470,000
Future Capital Costs/Replacement	$ -
O&M Cost	$ 4,440,000
Salvage Value	$ (580,000)
Total Present Worth	**$ 24,330,000**

Madison Metropolitan Sewerage District
Badger Mill Creek Phosphorus Compliance Preliminary Engineering Feasibility Report
Opinion of Present Worth Cost **Discount Rate** 4.000%

Alternative 4-AquaDisk

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Effluent Pumping Equipment	$ 220,000	$ -	20	$ -	$ -	$ -
Waste Solids Pumping Equipment	$ 110,000	$ -	20	$ -	$ -	$ -
Splitter Structure	$ 150,000	$ -	40	$ -	$ 75,000	$ 30,000
Tertiary Treatment Building	$ 1,090,000	$ -	40	$ -	$ 545,000	$ 250,000
Phorphorus Removal Equipment and Controls	$ 1,641,000	$ -	20	$ -	$ -	$ -
Chemical Feed Tank	$ 110,000	$ -	20	$ -	$ -	$ -
Chemical Feed Equipment	$ 60,000	$ -	20	$ -	$ -	$ -
Polymer Tank and Feed Equipment	$ 60,000	$ -	20	$ -	$ -	$ -
UV Disinfection Equipment	$ 740,000	$ -	40	$ -	$ 370,000	$ 170,000
Downward Opening Weir Gates	$ 140,000	$ -	40	$ -	$ 70,000	$ 30,000
Process Structural	$ 700,000	$ -	40	$ -	$ 350,000	$ 160,000
Subtotal	$ 5,020,000	$ -		$ -	$ 1,410,000	$ 640,000
Piping/Mechanical	$ 1,760,000	$ -				
Electrical	$ 1,510,000	$ -				
Plumbing/HVAC	$ 510,000	$ -				
Sitework	$ 760,000	$ -				
Major Yard Piping	$ 500,000	$ -				
Undefined Scope	$ 1,010,000	$ -				
Subtotal	$ 11,070,000	$ -				
General Conditions	$ 1,670,000	$ -				
Subtotal	$ 12,740,000	$ -				
Supply Chain Escalator	$ 1,280,000					
Subtotal	$ 14,020,000	$ -				
Contingencies	$ 2,800,000					
Technical Services	$ 2,110,000					
Total Capital Costs	$ 18,930,000	$ -		$ -	$ 1,410,000	$ 640,000
Present Worth of Capital Costs	**$ 18,930,000**			**$ -**	**$ 1,410,000**	**$ 640,000**

Estimated Annual O&M Costs	
Relative Labor	$ 31,000
Power	$ 135,000
Chemicals:	
Ferric	$ 83,000
Polymer	$ 31,000
Maintenance and Supplies	$ 36,000
Lamp Replacement	$ 8,000
Additional Sludge Handling and Disposal	$ 26,000
BMC Operation Costs	$ 52,000
Total O&M Costs	$ 402,000
Present Worth of O&M	**$ 5,460,000**

Summary of Present Worth Costs	
Capital Cost	$ 18,930,000
Future Capital Costs/Replacement	$ -
O&M Cost	$ 5,460,000
Salvage Value	$ (640,000)
Total Present Worth	**$ 23,750,000**

Madison Metropolitan Sewerage District
Badger Mill Creek Phosphorus Compliance Preliminary Engineering Feasibility Report
Opinion of Present Worth Cost **Discount Rate** 4.00%

Alternative 5-CoMag

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Effluent Pumping Equipment	$ 220,000	$ -	20	$ -	$ -	$ -
Waste Solids Pumping Equipment	$ 110,000	$ -	20	$ -	$ -	$ -
Splitter Structure	$ 150,000	$ -	40	$ -	$ 75,000	$ 30,000
Tertiary Treatment Building	$ 1,420,000	$ -	40	$ -	$ 710,000	$ 320,000
Phosphorus Removal Equipment and Controls	$ 3,320,000	$ -	20	$ -	$ -	$ -
Chemical Feed Tank	$ 110,000	$ -	20	$ -	$ -	$ -
Chemical Feed Equipment	$ 60,000	$ -	20	$ -	$ -	$ -
Polymer Tank and Feed Equipment	$ 60,000	$ -	20	$ -	$ -	$ -
UV Disinfection Equipment	$ 740,000	$ -	20	$ -	$ -	$ -
Downward Opening Weir Gates	$ 140,000	$ -	20	$ -	$ -	$ -
Process Structural	$ 710,000	$ -	40	$ -	$ 355,000	$ 160,000
Subtotal	$ 7,040,000	$ -		$ -	$ 1,140,000	$ 510,000
Piping/Mechanical	$ 2,470,000	$ -				
Electrical	$ 2,120,000	$ -				
Plumbing/HVAC	$ 710,000	$ -				
Sitework	$ 860,000	$ -				
Major Yard Piping	$ 500,000	$ -				
Undefined Scope	$ 1,410,000	$ -				
Subtotal	$ 15,110,000	$ -				
General Conditions	$ 2,270,000	$ -				
Subtotal	$ 17,380,000	$ -				
Supply Chain Escalator	$ 1,740,000					
Subtotal	$ 19,120,000	$ -				
Contingencies	$ 3,820,000					
Technical Services	$ 2,870,000					
Total Capital Costs	$ 25,810,000	$ -		$ -	$ 1,140,000	$ 510,000
Present Worth of Capital Costs	**$ 25,810,000**			**$ -**	**$ 1,140,000**	**$ 510,000**

Estimated Annual O&M Costs	
Relative Labor	$ 31,000
Power	$ 142,000
Chemicals:	
Ferric	$ 52,000
Polymer	$ 15,000
Magnetite	$ 5,000
Maintenance and Supplies	$ 71,000
Lamp Replacement	$ 8,000
Additional Sludge Handling and Disposal	$ 16,000
BMC Operation Costs	$ 52,000
Total O&M Costs	$ 392,000
Present Worth of O&M	**$ 5,330,000**

Summary of Present Worth Costs	
Capital Cost	$ 25,810,000
Future Capital Costs/Replacement	$ -
O&M Cost	$ 5,330,000
Salvage Value	$ (510,000)
Total Present Worth	**$ 30,630,000**

Madison Metropolitan Sewerage District
1610 Moorland Road • Madison, WI 53713-3398 • P: (608) 222-1201 • F: (608) 299-2129

Memorandum

To: Badger Mill Creek PLUS Project Team

From: Eric Dundee, Director of Wastewater Operations and Reliability ELD

Cc: Alan Grooms, Operations Manager
Erik Rehr, Maintenance and Reliability Manager

Date: April 12, 2023

Subject: Risk Review of Tertiary Treatment Infrastructure Project

Background
This memo provides operational and maintenance considerations for the three compliance options under consideration for Lower Badger Mill Creek. It focuses on the three most pertinent District strategic performance areas: permit compliance, infrastructure reliability, and financial sustainability.

The memo evaluates the following impacts:

1. Disruption and delay in other capital improvements projects.
2. Long-term Compliance Flexibility.
3. Infrastructure maintenance needs.
4. Impact on O&M teams' performance

It is important to recognize that the District's two discharge points, Badger Mill Creek and Badfish Creek, must be treated differently by operations. Each point has different permit requirements because of the unique circumstances of their watersheds. In addition, it is important to note that the flow to Badger Mill Creek is only 8% of total plant discharge. This has the potential to create a disproportionate burden on plant operations and costs. This will further be exacerbated when the Badger Mill Creek TDML requirements and "cold water creek" designation create new infrastructure needs for advanced treatment and even water cooling.

The District has a history of evaluating infrastructure-based and non-infrastructure based solutions to permit requirements in Yahara WINS and chloride minimization. The Badger Mill Creek issue goes further by contrasting an option to add new infrastructure with an option to remove existing infrastructure. From an operations and maintenance perspective, the new infrastructure option obviously adds ongoing burdens while the infrastructure removal option reduces those burdens.

This memo is meant to provide pertinent operations and maintenance information to support the evaluation for Badger Mill Creek.

Analysis

Disruption and Delay in Other Capital Improvements Projects.
Constructing tertiary treatment for Badger Mill Creek would have significant negative impacts on other capital improvement projects.

Tertiary treatment would be in direct competition for space with a project to replace the plant's electrical service equipment, which is at the end of its life. Failure of this equipment jeopardizes the functioning of the plant. The electrical project would have to be delayed until BMC tertiary treatment designs were clear on location and footprint.

More broadly, tertiary treatment would delay six important projects, or categories of projects. These impacts would arise for two main reasons. First, projects affecting the plant require temporary disruptions to plant operation to allow work on certain portions of the plant. These disruptions must be carefully planned to allow project work to proceed without jeopardizing wastewater flow and treatment. For large projects such as the tertiary treatment and the others listed below, only one disruption can occur at a time. Second, such projects require the participation of key District staff with expert knowledge of the plant. This expertise is only gained with experience with Nine Springs operation. Additional staffing or contracting support cannot address these problems.

The primary affected projects are:

1. LPI phase 2. Delay would be harmful because treatment plant blowers are in critical condition with obsolete parts. Any project delays would increase potential equipment failures and permit violations.
2. Heat and power facility planning. This project is to plan the next stage in replacing the District's aging heat and power equipment and, as planned, transition to pipeline injection of biogas. Delay would be harmful because current equipment is in danger of failing. Furthermore, delay extends the time until secondary benefits are realized, including operating cost reductions, easier maintenance, and an additional revenue stream.
3. Biosolids management. This project is to consolidate the infrastructure related to biosolids management. Delay would be harmful because it would perpetuate hauling inefficiencies and hinder fleet maintenance.
4. Campus security. This is to increase security at the plant, including fencing, vehicle access, and visitor check-in. Delay would extend the time to address security limitations.
5. LPI phase 3. This project is a planned continuation of the major liquid process changes underway in phase 2. Delay would continue equipment reliability issues and further delay planned work from 2017.
6. Maintenance projects. This is a class of smaller projects aimed at correcting a backlog of maintenance needs in key areas of the plant. The District is seeing increased failure due to this backlog. Delay would perpetuate and increase the reliability problems posed. It would further increase costs because replacement of failed assets is generally significantly higher than timely maintenance.

Long-Term Compliance Flexibility
Tertiary treatment would reduce space flexibility for future regulatory compliance. The District expects stricter permit limits for nitrogen, chloride, and effluent temperature. The alternative for tertiary treatment for BMC would take the physical space of future tertiary treatment process expansion and is unable to be expanded to meet future limits for these pollutants. Similarly, the tertiary treatment for BMC, although it would be designed for phosphorous removal, would be unable to contribute to potential future limits for Badfish Creek. In addition, BMC tertiary treatment would occupy space that would likely be needed for whole-plant tertiary treatment under stricter regulations.

A watershed approach would avoid the inflexibility of infrastructure. Unified discharge at Badfish Creek would facilitate economies of scale in treatment.

Infrastructure Maintenance Needs
Adding tertiary treatment would increase the amount of infrastructure requiring maintenance by approximately 0.5 FTEs based on preliminary engineering estimates. Maintaining flow to BMC through a watershed approach would also leave the existing 10.18mile forcemain and discharge pumps to maintain. This is achievable with current staffing. However, the BMC forcemain will eventually require replacement, at an estimated current present worth cost of $50 million.

Removing the Badger Mill Creek forcemain from service would require resources to decommission the assets from our systems. This work includes retiring assets, reviewing parts and obsoleting if necessary, deactivating PM's, and removing physical parts and assets from inventory. Once that work is complete, it will free up resources and inventory that can be used on other critical assets, supporting the greater RCM effort.

Impact on O&M Teams' Performance
The District is committed to using reliability centered maintenance (RCM) principles with all of its equipment to promote long term reliability and resiliency. The addition of a new complex treatment process will result in additional preventative and corrective maintenance work for mechanical, electrical and facilities workgroups that will be based on new equipment needs after they are installed and evaluated. This is anticipated to be significant based on current treatment equipment proposals. There will also be continued maintenance on the effluent pumps and forcemain involving all four maintenance work groups. Although actions are being taken to improve efficiency and effectiveness of crews, they are in the very early stages. Installation of this new equipment, without analyzing and adding headcount to support, will stretch staff and force additional prioritization on which maintenance tasks can and cannot be completed on a weekly and monthly basis.

Operations engineering staff is limited to three staff and one manager. The workgroup does not have the ability to support this project along with the projects referenced previously in this memo without negative performance impacts to project development and plant operations oversight. Adding staff may lessen the impact but ultimately not provide a collaborative environment for developing the best project(s) attainable while also overseeing plant operations. Furthermore, pushing staff into roles they are not yet prepared to assume risks burnout, compromised project outcomes, and regulatory permit excursions. Staff dedication to the success of the district could ultimately lead to departures based on work hour demands.

Summary

From an operations and maintenance perspective, tertiary treatment for phosphorous in Badger Mill Creek poses significant risks. Primary factors are: (a) harmful delays in other capital projects, notably electrical upgrades, heat and power changes, liquid processing improvements, and general maintenance work; (b) disruption to operations and maintenance teams, hindering their ability to ensure proper plant operations and to implement needed reliability-centered maintenance practices; and (c) the inflexibility that would be created for future regulatory requirements.

Alternatives that avoid or delay the construction of BMC tertiary treatment are preferrable for these reasons.

technical memo

BADGER MILL CREEK HYDROLOGIC ASSESSMENT

Date |	04/24/2023
To / Contact info |	Kathy Lake, PE, ENV-SP
From / Contact info |	Nick Hayden, Steve Gaffield, and Joe Pallardy
Regarding |	Streamflow & habitat observations during experimental effluent shutdown

Executive Summary

The purpose of this study was to evaluate hydrologic and habitat impacts of a potential shut-down of the Madison Metropolitan Sewerage District effluent return line to Badger Mill Creek. Reducing or eliminating this effluent discharge is under consideration as a means to reduce Total Phosphorus loading to the creek.

Stream baseflow and habitat parameters were measured at several locations on Badger Mill Creek and the Sugar River during low-flow conditions on two dates: one with the effluent discharge operating as normal, and a second with the effluent discharge shut off. Monitoring dates were January 23 and February 13, 2023.

The experimental shut-down reduced the effluent discharge from 4.8 cfs to zero over a period of 1 week. The streams were allowed to adjust to the effluent elimination for another week before the second survey was conducted. Flow at each stream monitoring site dropped by 4.9 to 5.8 cfs between the two monitoring dates, reflecting the effluent elimination and a small regional drop in streamflow between the monitoring dates. Flow at the site farthest upstream on Badger Mill Creek (Old Hwy. PB) dropped from 6.0 cfs to 0.4 cfs between the two surveys. Streamflow increased downstream between monitoring sites at similar rates during each survey, with flow increasing to 5.6 cfs at Bruce Street and 9.3 cfs at the confluence with the Sugar River during the second survey. The discharge reduction caused a decrease in mean velocity, with a change from 0.24 – 0.01 ft/sec at Old Hwy. PB (at the head of pool) and smaller decreases of 0.1 – 0.2 ft/sec farther downstream on Badger Mill Creek (at riffle sites).

Mean water depth at Old Hwy. PB dropped by 0.42 ft between the two surveys, and the decline in depth at the other monitoring sites ranged from 0.08 ft to 0.17 ft. Temperature sensors were installed at 5 sites during the first survey and removed after the second survey, measuring temperature every 5 minutes. Additional temperature data at the USGS gage sites on Badger Mill Creek and the Sugar River were also evaluated. Before the effluent shut-down, the upstream temperature of Badger Mill Creek (at Old PB) was about 10 degrees warmer than the Sugar River sites. After the shut-down, temperatures at this site closely matched the Sugar River sites.

The long-term record of Badger Mill Creek flow at the Bruce St. gage indicates that flows similar to those measured during the experimental shutdown, of approximately 5 cfs at Bruce St. and flow less than 1 cfs at Old PB, would have been common <u>without</u> effluent discharge from 1999 to 2007. However, 3% or fewer days per year would have been at or below these flows during the last 7 years, when regional streamflows have increased.

Background

Emmons and Olivier Resources, Inc. (EOR) performed a hydrologic evaluation of an experimental shutdown of the Madison Metropolitan Sewerage District (MMSD) effluent discharge to Badger Mill Creek in January and February 2023. The purpose of this project is to provide information to MMSD on options to reduce Total Phosphorus loading from its Badger Mill Creek effluent return line to meet Wisconsin Department of Natural Resources (DNR) permit requirements. One option under consideration is reducing or shutting down the effluent return to Badger Mill Creek. This hydrologic assessment addressed questions about the amount of baseflow that could be expected in Badger Mill Creek without the effluent discharge and related changes to in-stream habitat.

Methods

Data Collection

The monitoring activities and timing were coordinated with MMSD and the DNR. The plan was to survey baseflow and habitat measurements at several locations (**Appendix A: Figures**) on Badger Mill Creek and the Sugar River during low-flow conditions when the effluent discharge was operating as normal, then shut down the effluent discharge and repeat the measurements for comparison. The data collection plan for each survey included the following:

- EOR collected discharge measurements at three locations on Badger Mill Creek and one location on the Sugar River, using a Flow Tracker 2 current meter. These measurements were supplemented by data from the United States Geological Survey (USGS) stream gage stations on Badger Mill Creek at Bruce St. and the Sugar River at STH 69. One location (Bruce St.) was chosen to validate EOR's measurements against USGS' gage and long-term record.
- EOR and MMSD established semi-permanent habitat transects at five locations on Badger Mill Creek and one location on the Sugar River (Appendix B). Stakes were placed at each site so that the transect location would be consistent between surveys. Measured water depth and substrate class observations were collected at ten evenly spaced points along the wetted portion of the transect. Additional "dry" measurements were taken on the edges of the transect to quantify the bank position relative to the water surface. The wetted width and taped width were both recorded.
- EOR and MMSD placed temperature sensors at four of the habitat transect sites and one discharge-only site during the first survey. These loggers collected 5-minute temperature readings during and between the two surveys. These data were supplemented by the USGS gage temperature readings at the other two habitat transect sites.

Project Timeline

The study was designed to allow time for streamflow and the groundwater discharge that supplies it to re-equilibrate after the effluent discharge was shut down. EOR evaluated streamflow data from the USGS gage on Badger Mill Creek at Bruce Street during a previous shutdown in May and June 2021. As shown by the gage hydrograph (**Figure 1)** during that time period, the baseflow prior to the event was close to 14 cubic feet per second (cfs). The effluent discharge was reduced from May 11th to May 18th, with an immediate impact of dropping flows in Badger Mill Creek. The flow dropped further and reached an equilibrium within seven days of the effluent being completely off, with a new baseflow hovering around 9.5 cfs (ignoring short-term impacts from rainfall). This event provided confidence that a similar seven-day gradual reduction to zero followed by a seven-day equilibration period would be ample time for the creek's baseflow to adjust and represent a non-effluent discharge condition.

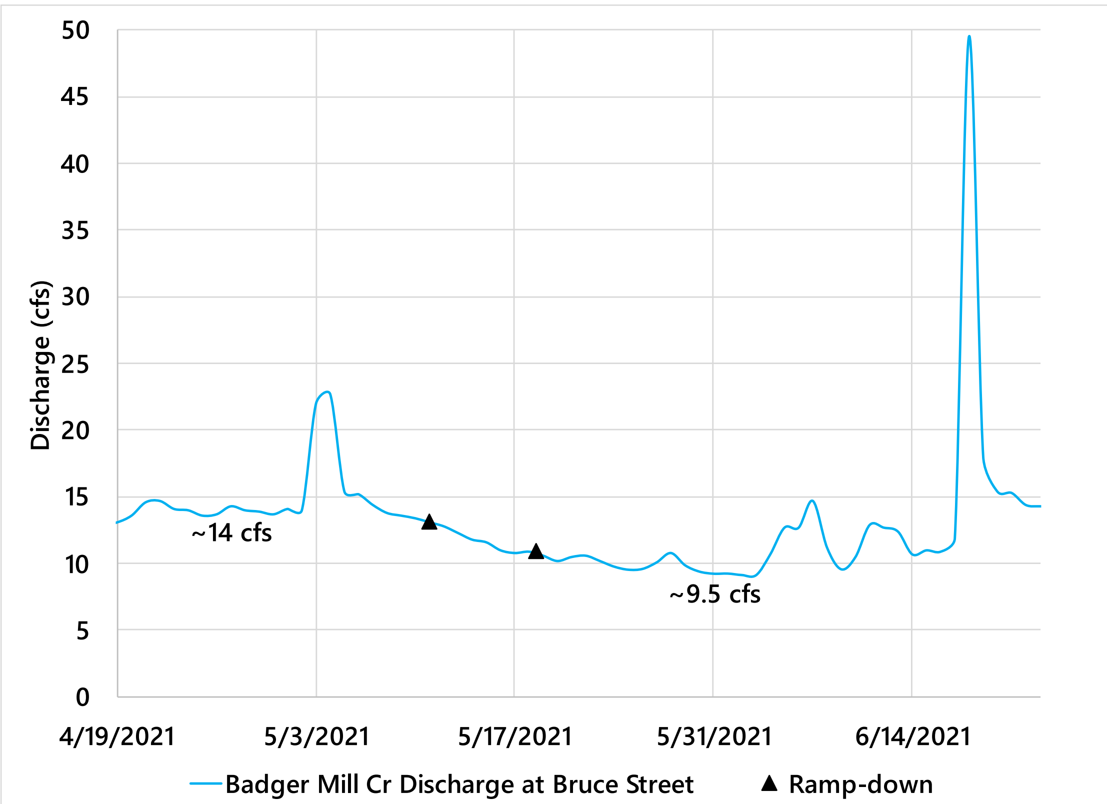


Figure 1. Baseflow Response to May 2021 Effluent Shut-off.

Selecting dates for the shutdown and monitoring required advanced planning, considering current streamflow conditions and the weather forecast. January and February 2023 saw several thaws and precipitation events that led to runoff and streamflow elevated above baseflow conditions. In addition, extreme cold was believed to be a risk to the MMSD pipeline with no discharge. The resulting schedule for the study is summarized in **Table** 1, with the habitat surveys occurring on January 23rd and February 13th, the effluent discharge reduction occurring from January 30th to February 6th, and the effluent remained off for the duration of this study.

Table 1. Project Survey and Effluent Reduction Timeline.

Date	Activity

January 11, 2023	Field site reconnaissance
January 23, 2023	Survey #1 – Normal operation
January 30 – February 6, 2023	Gradual reduction of effluent discharge from 3.1 Million Gallons per Day (MGD) [4.8 cfs]
February 6, 2023, 07:00 am	Complete discharge reduction (zero effluent discharge)
February 13, 2023	Survey #2 – Zero effluent discharge condition
February 14 – end of study	Effluent discharge remained at zero

Project Data

Discharge

Figure 2 shows discharge data from the continuous USGS gage station on Badger Mill Creek at Bruce Street, MMSD effluent discharge, and direct discharge measurements made by EOR and USGS. Note that the USGS applied a uniform shift to their site rating curve after their direct discharge measurement on February 13th, which effectively lowered their previous baseflow discharge estimate by 2.5 cfs following the December 15th runoff event's recession. The USGS applies rating curve shifts when their direct discharge measurement does not match their rating curve for a given stage, and this is typically attributed to changes in channel geometry (sediment deposition or scour) following a high flow event. This complicates the use of their data for the period between December 15th and February 13th when they did not have a direct measurement. Prior to the rating shift, EOR's direct measurement on January 23rd (10.43 cfs) was within five percent of the USGS' provisional discharge value at the same time (11.0 cfs), which is relatively good agreement for a natural channel measurement from different operators and equipment. After the shift, EOR's value is 1.9 cfs higher than the revised USGS provisional value. On February 13th, when both EOR and USGS took a measurement on Badger Mill Creek, EOR's value (5.57 cfs) was within seven percent of the USGS value (5.23 cfs). Both EOR and USGS also took a discharge measurement at the STH 69 Sugar River gage on that day, and those measurements were within three percent of each other. Based on these relatively tight concurrent measurements, the following analysis and discussion of discharge data during the effluent reduction period will focus more on the spatially distributed EOR measurements than the shifted USGS Bruce Street gage values.

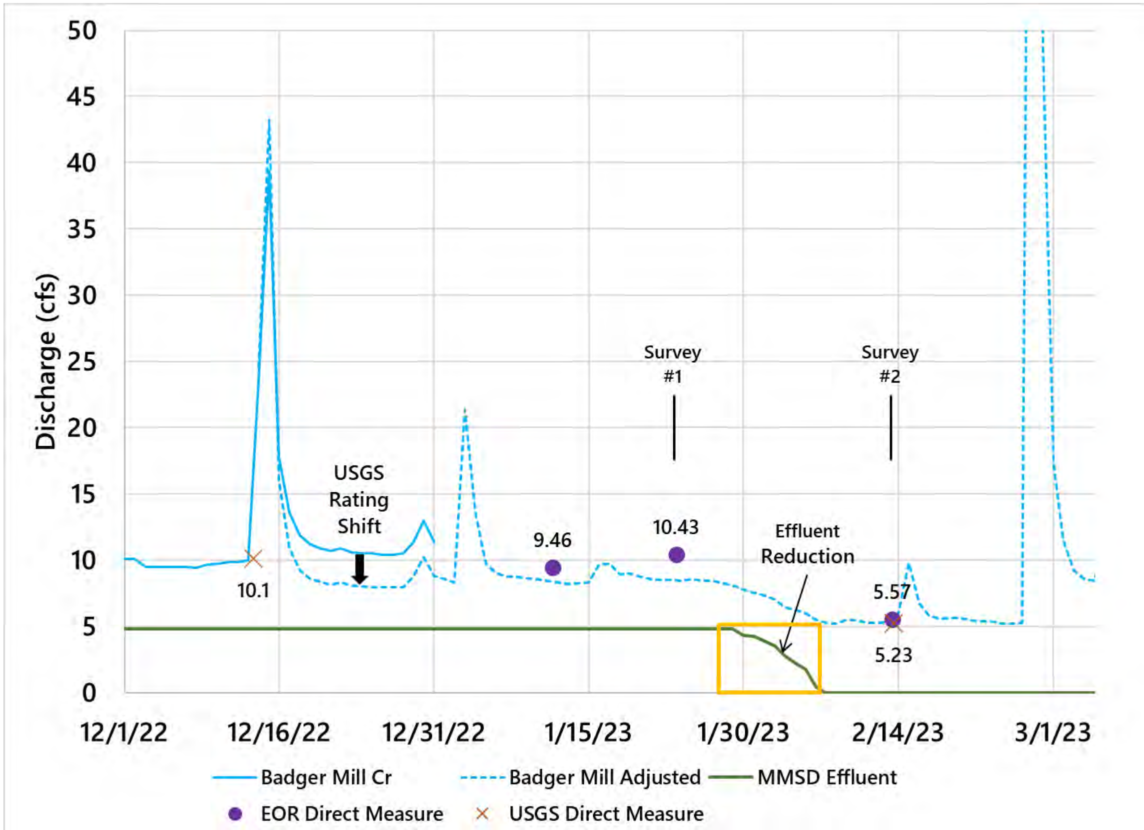


Figure 2. Badger Mill Creek at Bruce Street and Effluent Hydrographs, December 2022 through Feb 2023.

EOR discharge measurements for Survey #1 and Survey #2 are shown in **Table 2**. The change between surveys reflects both the removal of the MMSD effluent discharge (4.8 cfs) and a slight drop in regional baseflow, as demonstrated by an approximately 15% drop at the upstream Sugar River site (SR5).

Table 2. EOR Discharge Measurements during Surveys #1 and #2.

Location	Survey #1 Discharge [Normal Effluent] (cfs)	Survey #2 Discharge [No Effluent] (cfs)	Change (cfs)
BM5 – Old PB	6.0	0.4	-5.6
BM7 – Bruce St.	10.43	5.57	-4.9
BM-AC – above Confluence	14.6	9.3	-5.3
SR5 – Valley Rd.	33.8	28.3	-5.5
SR7 – STH 69[1]	51.0	45.2	-5.8

1 – Values are from USGS gage

Habitat Data

The six habitat transect locations are shown in **Appendix A: Figures** and flow structure, substrate, and other notes are included in **Table 3**. The habitat types ranged from shallow riffles to deeper pools, and except for the upstream-most site (BM5 – muck) there were typically a range of substrate classes present including finer materials (muck-silt-sand) and larger materials (gravel-pebble-cobble). Photos showing both these locations and the discharge-only location (SR5) are included in **Appendix B: Site Photographs**. The photo log documents both survey dates, but unfortunately the "before effluent reduction" condition (Survey #1) is less documented because EOR's field tablet was lost in the deep pool at BM9 and was not able to be recovered. Photos from several individuals present during Survey #1 were combined to document those conditions as best as possible.

Table 3. Habitat Transect Descriptions.

Location	Channel Form	Substate	Other Notes
BM5 – Old PB	Pool	Muck-dominant across entire channel	Steep banks. Habitat surveyed just downstream of pedestrian bridge. Upstream of tributary inflow from spring pond.
BM6 – Lincoln St.	Riffle	Pebble-cobble dominant across main channel, sand/muck present near margins	Shallow riffle. Habitat surveyed downstream of covered bridge.
BM7 – Bruce St.	Riffle / Run	Pebble to boulder substrate dominant across main channel, with pockets of muck and sandy silt near margins	Steep banks. USGS gage site. Habitat surveyed in riffle just downstream of bridge.
BM9 – STH 69	Glide / Head of Pool	Sand-cobble mixture dominant across channel, with boulders present. Muck and boulders near margins.	Near-vertical banks. Habitat surveyed upstream of bridge, just upstream of ditch inflow. Original suggested DNR habitat site (downstream pool) was deep and not wadable.
BM-AC – above Confluence	Riffle	Pebble-cobble dominant with sand/silt pockets across main channel, finer materials near margins.	Wide, shallow riffle.
SR7 – STH 69	Run	Cobble-dominant with sand/silt present across channel, muck near margins.	Steep banks. USGS gage site. Habitat surveyed at USGS discharge transect (large rebar).

Results from the habitat transect surveys are summarized in **Table 4**. Across the sites, discharge decreases ranged between 4.9 to 5.8 cfs, wetted width decreases ranged between 0.0 to 2.1 feet, and mean depth decreases ranged from 0.42 to 0.08 feet. Both the mean and the median statistic were computed but were found to be similar, so only the mean is reported here. Despite the effort to replicate the exact transect and sampling locations, there was some variation in depths at specific points between the surveys due to measurements falling on or near larger substrates (cobbles, boulders). Despite this depth variability in individual measurements, in general Survey #2 depths were shallower than Survey #1.

Table 4. Habitat Transect Results comparing Surveys.

Site Name	Discharge change[1] (cfs)	Wetted Width (ft)			Mean Depth (ft)		
		Survey #1	Survey #2	Change	Before	After	Change
BM5- Old PB	-5.6	21.0	18.9	-2.1	1.20	.78	-0.42
BM6 - Lincoln St.	NA	23.5	21.8	-1.7	0.39	0.23	-0.16
BM7- Bruce St.	-4.9	17.7	15	-2.7	0.59	0.42	-0.16
BM9- STH 69[2]	NA	21.1	21.1	0.0	1.44	1.27	-0.17
BM-AC – above Confluence	-5.3	20.3	20.3	0.0	0.45	0.37	-0.09
SR7 - STH 69	-5.8	35.0	35.0	0.0	1.12	1.04	-0.08

1 – NA signifies no discharge measurement was taken (habitat-only site)

2 – Fence posts were vandalized (removed) so transect location was replicated as best as possible

Temperature Data

MMSD installed HOBO UA-002-64 temperature and light pendants at Sites BM5, BM6, BM9, BM-AC, and SR5 during the first survey. Pendants collected 5-minute temperature readings and were removed following the second survey. These pendant data were supplemented by 15-minute temperature data from the USGS gage sites (BM7, SR7). These data are shown in **Figure 3**.

While the number of temperature sensors, daily air temperature fluctuations, and seasonal groundwater temperature fluctuations complicate data interpretation, the following observations are noted:

- Stream temperatures at BM5 (light blue), the site nearest the MMSD effluent discharge, were always higher than other sites prior to the "zero effluent" period. These temperatures were typically 10 degrees warmer than the Sugar River sites. The higher temperatures at this site reflect input of effluent a short distance upstream, which is warmer than the ambient air temperature in winter and colder in summer.

- Midway through the effluent reduction, BM5 temperatures transitioned to become the lowest of the Badger Mill Creek sites, and closely matched the Sugar River sites for the remainder of the monitoring period.
- Prior to effluent shut-down, the "intermediate" Badger Mill Creek site temperatures (BM6 [purple] and BM7 [grey]) were between BM5 and the "lower" sites (BM9 and BM-AC). After effluent shut-down, those intermediate site temperatures nearly matched those of the lower Badger Mill Creek sites, with all those sites being warmer than BM5 and the Sugar River sites during the final week of data collection leading up to Survey #2.

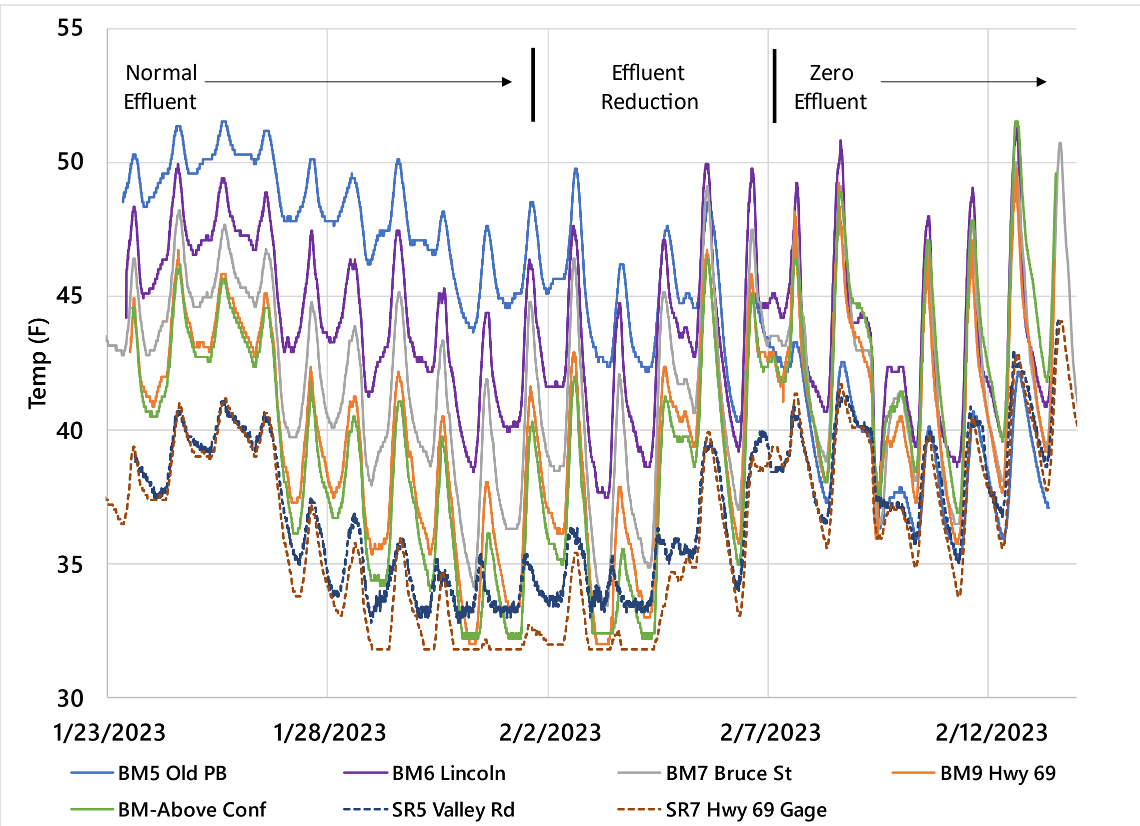


Figure 3. Monitoring Site Temperature Data.

The permanent USGS site temperature data allowed for a longer period of temperature data analysis. These data are compared to mean daily air temperature at the Dane County Regional Airport (MSN) in **Figure 4**. The following observations are noted:

- Temperatures in Badger Mill Creek at the gage site were typically about five degrees warmer than the Sugar River gage site prior to effluent shut-down.

- Following effluent shut-down, Badger Mill Creek temperatures more closely matched the Sugar River, particularly the nighttime (minimum daily) temperatures.
- Both sites experienced larger daily fluctuations towards the end of the period shown, presumably due to increased solar radiation.

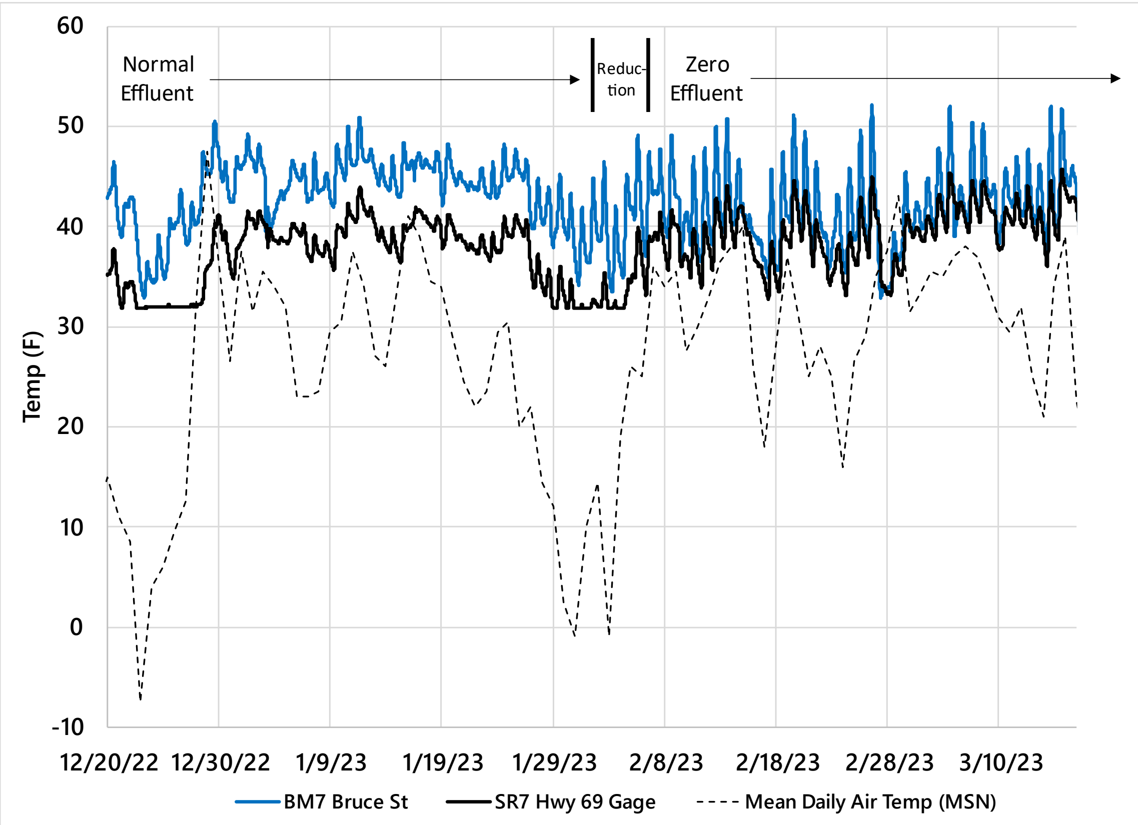


Figure 4. Extended Temperature Data at USGS Gages.

Analysis and Discussion

The DNR classifies Badger Mill Creek as a cool (cold-transition) main stem community.[1] This is defined as a wadeable perennial stream with cold to cool summer temperatures with coldwater and transition fishes. DNR's proposed characteristics for this classification include a maximum daily mean water temperature of 69.3 – 72.5 degrees Fahrenheit and an annual 90% exceedance flow of 3.0 cfs.[2] Implications of shutting down the effluent return flow on these and other habitat characteristics are discussed below.

Discharge, Stage, and Velocity

Badger Mill Creek

The pattern of discharge changes measured by EOR along Badger Mill Creek was mostly as expected given the removal of 4.8 cfs of effluent and dropping regional winter baseflows. The biggest source of measurement uncertainty was the Survey #2 discharge measurement at BM5, which was complicated by low velocities (including backflow) along the stream margins. Without the effluent, Badger Mill Creek continued to gain about 5 cfs between BM5 and BM7 and about 4 cfs between BM7 and BM-AC. This suggests that the sites downstream of BM5 will continue to have perennial flow even if BM5 were to drop to ~0.4 cfs discharge during winter baseflow or substantial drought without the effluent.

The effluent discharge of 4.8 cfs is higher than DNR's 90% exceedance flow of 3.0 cfs for cool-coldwater main stem streams. Without the effluent return, flow at Old PB (site BM5) can be expected to be below 3.0 cfs during most baseflow conditions, so this reach would likely no longer meet the Cool (Cold-Transition) *Main Stem* classification. Whether it would meet the Cool (Cold-Transition) *Headwater* classification would depend on if water temperatures remained cold enough. Lower flows through the wetland upstream of Old PB could lead to increased diurnal fluctuations in dissolved oxygen and potentially higher temperature fluctuations in summer.

The relationship between stream cross-sectional area (wetted width and depth) and discharge is non-linear, as evidenced by the 93% reduction in discharge at BM5 causing only a 10% reduction in wetted width and 35% reduction in mean depth. In addition to stream area, discharge is also a function of water velocity, and in cases where discharge decreases but stream area changes are relatively small, the decrease in velocities will be more pronounced. At BM5, where discharge dropped to approximately 0.4 cfs, mean velocity dropped from 0.24 feet per second (fps) to 0.01 fps between Survey #1 and Survey #2. Note that this 0.01 fps average includes considerable areas along the channel margins where velocity was zero or negative (backwater) at a discharge of 0.4 cfs (**Figure 5)**; velocities in the center of the channel were typically between 0.05 – 0.08 fps during Survey #2.

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[1] https://dnr.wi.gov/water/waterDetail.aspx?key=13654
[2] https://dnr.wisconsin.gov/topic/Rivers/NaturalCommunities.html

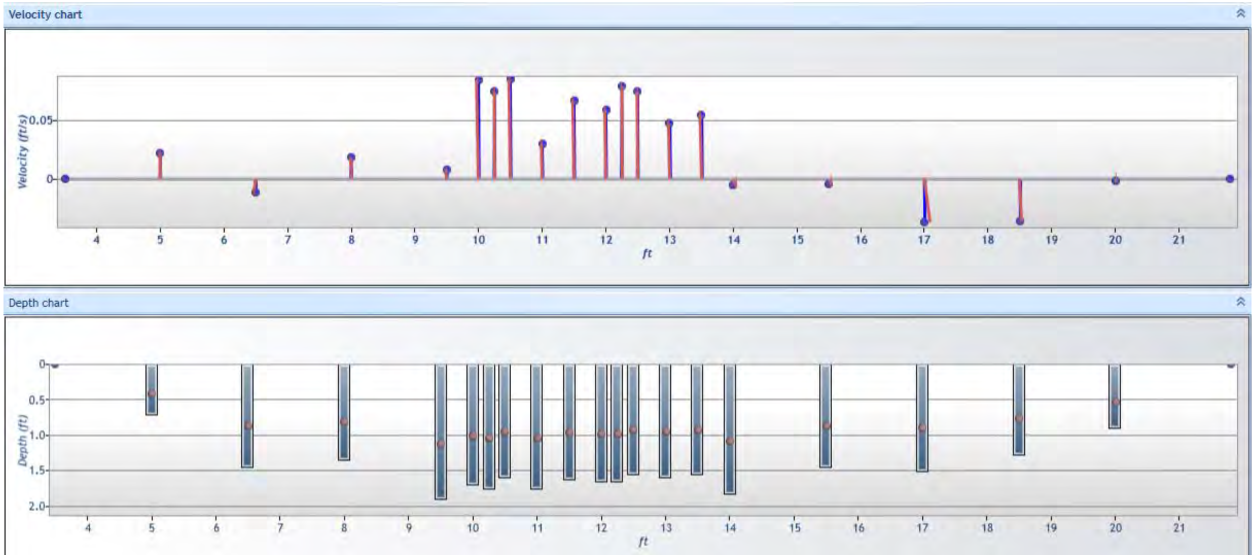


Figure 5. Cross-Section Velocity and Depth Profile at BM5 (Old Pb), Survey #2.

Velocity changes downstream were less pronounced; at BM7 mean velocity dropped from 0.60 fps to 0.47 fps, and at BM-AC mean velocity dropped from 0.95 fps to 0.76 fps. While lower velocity in spawning areas is a potential concern because it can result in less suitable habitat for brown trout[3], at the two sites where EOR discharge measurements coincide with DNR fish survey locations (the confluence and Bruce Street), mean velocity was only reduced by approximately 20% from Survey #1 to Survey #2.

Sugar River

The magnitude of discharge change at the downstream Sugar River site (SR7) was surprising; it was expected that the change would be greater reflecting both the drop in regional baseflow during the time period and the removal of effluent flow in between the two Sugar River sites. One possible explanation for this is the snowpack that was present in rural areas (Sugar River) but not in urban areas (Badger Mill Creek) was observed melting during Survey #2, which could have increased discharges in the Sugar River. Regardless, groundwater dynamics are complicated, and examining the interplay between water table levels, recharge, and surface water inputs on the Sugar River groundwater system would require additional study.

Physical Habitat

The greatest water depth change was observed at the upstream site BM5, where the depth dropped by 0.42 ft or 35%. Water depth at BM 6 (Lincoln Street) and BM7 (Bruce Street) dropped by 0.16 ft, representing reductions of 41% and 27%, respectively at these riffle sites. No sections of the streambed were observed

[3] US Fish and Wildlife Service, 1986. Habitat Suitability Index Models and Instream Flow Suitability Curves: Brown Trout. Biological Report 82(10.124) September 1986 Revised.

to be dry on the no-effluent monitoring date, indicating that connectivity between pools would be maintained as long as water depth over riffles was sufficient for fish passage.

The temperature monitoring data indicate thermal changes with effluent elimination. Reduced discharge and a higher width to depth ratio would cause solar radiation and air temperature to have more of a heating effect in summer. Thermal modeling would be needed to quantify expected temperature changes in summer.

Long-Term Implications

A prediction of occurrences of low discharges is possible due to the long-term record of the USGS gage on Badger Mill Creek at Bruce Street (BM7). **Figure 6** shows gage discharge from 1999 to the present (MMSD effluent discharge started in 1998). The red line indicates times when discharge was below 10 cfs at Bruce Street. As discussed above, based on the effluent discharge, current incremental baseflow increases along Badger Mill Creek, and project measurements, it is likely that a historical discharge of 10 cfs or lower at Bruce Street would have corresponded with a discharge < 1 cfs at Old PB (BM5) and the upstream wetlands if effluent discharge was eliminated. The likelihood of this occurring appears to be lower now than during earlier parts of the record. As shown in **Figure 7**, the percentage of time when the gage is below 10 cfs has dropped dramatically, with 3% or fewer of all days being below 10 cfs over the past seven years. Prior to that, there was a period of dryer years (2012-2015) where it does seem that Site BM5 could have experienced < 1 cfs discharge and near-stagnant conditions along channel margins for lengths of time during each year, and flow at Bruce Street likewise could have been around 5 cfs or slightly less, depending on regional baseflow conditions. Note that 5 cfs at Bruce Street would be above the DNR 90% exceedance flow of 3.0 cfs for a Cool (Cold-Transition) Main Stem stream community, but that flow at Old PB would be below this flow threshold during those conditions.

With the caveat that downstream baseflow increases between BM5 and BM7 have likely fluctuated in the past twenty years, which impacts the assumption of this 10 cfs as an indicator, this supports the conclusion that baseflow has increased substantially since MMSD first began discharging effluent into Badger Mill Creek. This is supported by observations at other regional waterways, like the long-term gage record on the Sugar River near Brodhead, and research showing “significant increasing trends” of baseflow in southern Wisconsin[4]. These data suggest if the effluent were discontinued, the likelihood of a discharge < 1 cfs near BM5, or of discharges lower than observed during Survey #2 at other locations during this study, has decreased over time.

[4] Ayers JR, Villarini G, Jones C, Schilling K. Changes in monthly baseflow across the U.S. Midwest. Hydrological Processes. 2019;33:748–758. https://doi.org/10.1002/hyp.13359

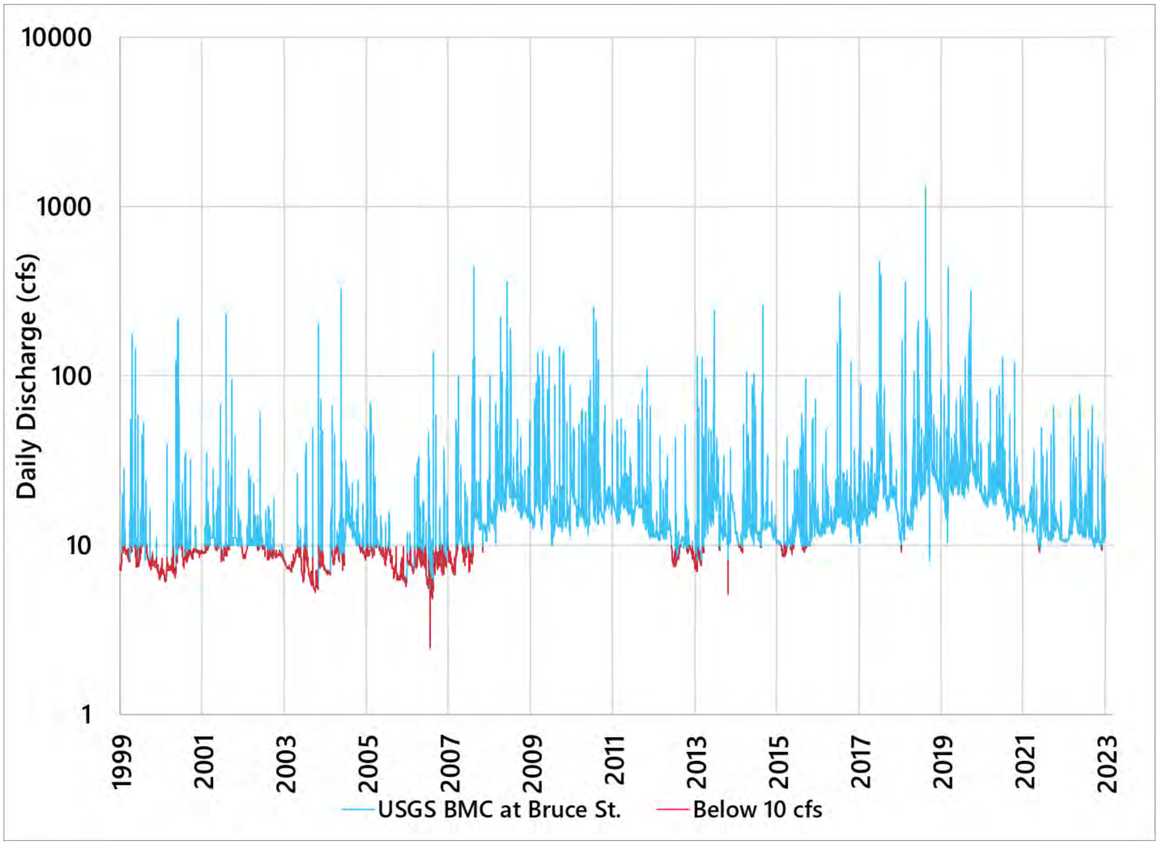


Figure 6. USGS Gage on Badger Mill Creek at Bruce Street, 1999-Present.

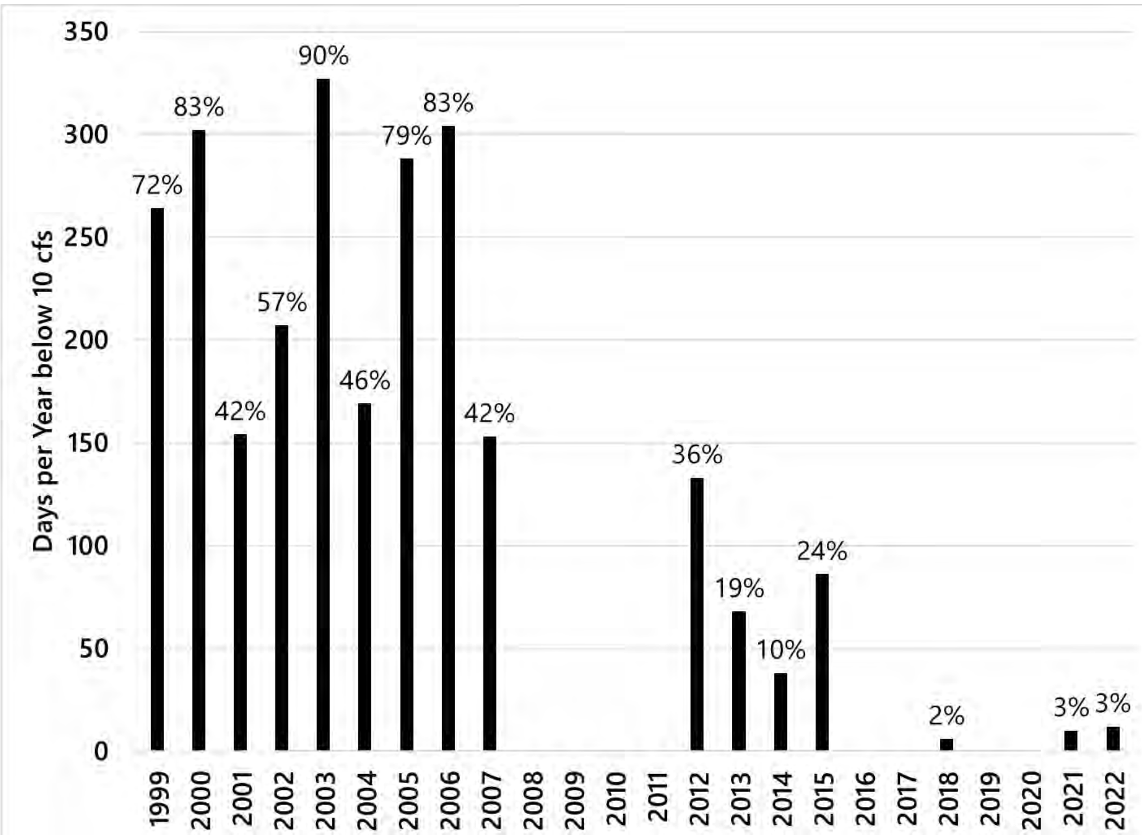


Figure 7. Percent of Days Below 10 cfs at Bruce Street, 1999- Present.

Conclusions

1. During the experimental effluent discharge shutdown, streamflow in Badger Mill Creek dropped by approximately 5 cfs at each of the measurement sites from Old PB downstream to the confluence with the Sugar River. This corresponds to elimination of 4.8 cfs of effluent plus an approximate 15% regional baseflow decline between the two measurement dates in January and February 2023. Decreases in the flow of the Sugar River flow upstream and downstream of Badger Mill Creek were of a similar magnitude.
2. Site BM5 at Old PB had a flow of 0.4 cfs without the effluent discharge, below the threshold of 3.0 cfs for the 90% exceedance flow of a Cool (Cold-Transition) Main Stem stream community which DNR has applied to Badger Mill Creek. All other sites had measured flow above this threshold.
3. Water depth dropped by 0.42 ft at BM5 and 0.08 – 0.17 ft at the other sites. No stream reaches were observed to dry completely during the shutdown.
4. Water velocity change was most pronounced at BM5, where mean velocity dropped from 0.24 fps to 0.01 fps due in part to channel margin areas with zero flow or backwater. Center channel velocities there were higher (approximately 0.05-0.08) during that survey. Smaller changes in mean

velocity were measured farther downstream on Badger Mill Creek (0.60 fps to 0.47 fps at BM7 and 0.95 fps to 0.76 fps at BM-AC).

5. Stream temperature at BM5 dropped by approximately 10 degrees after the shutdown, going from the warmest of the monitoring sites to matching the Sugar River temperature. The effect on downstream sites on Badger Mill Creek was less pronounced. This indicates that higher summer temperatures would be expected in Badger Mill Creek, especially at upstream site BM5. Quantifying this increase was beyond the scope of this study.

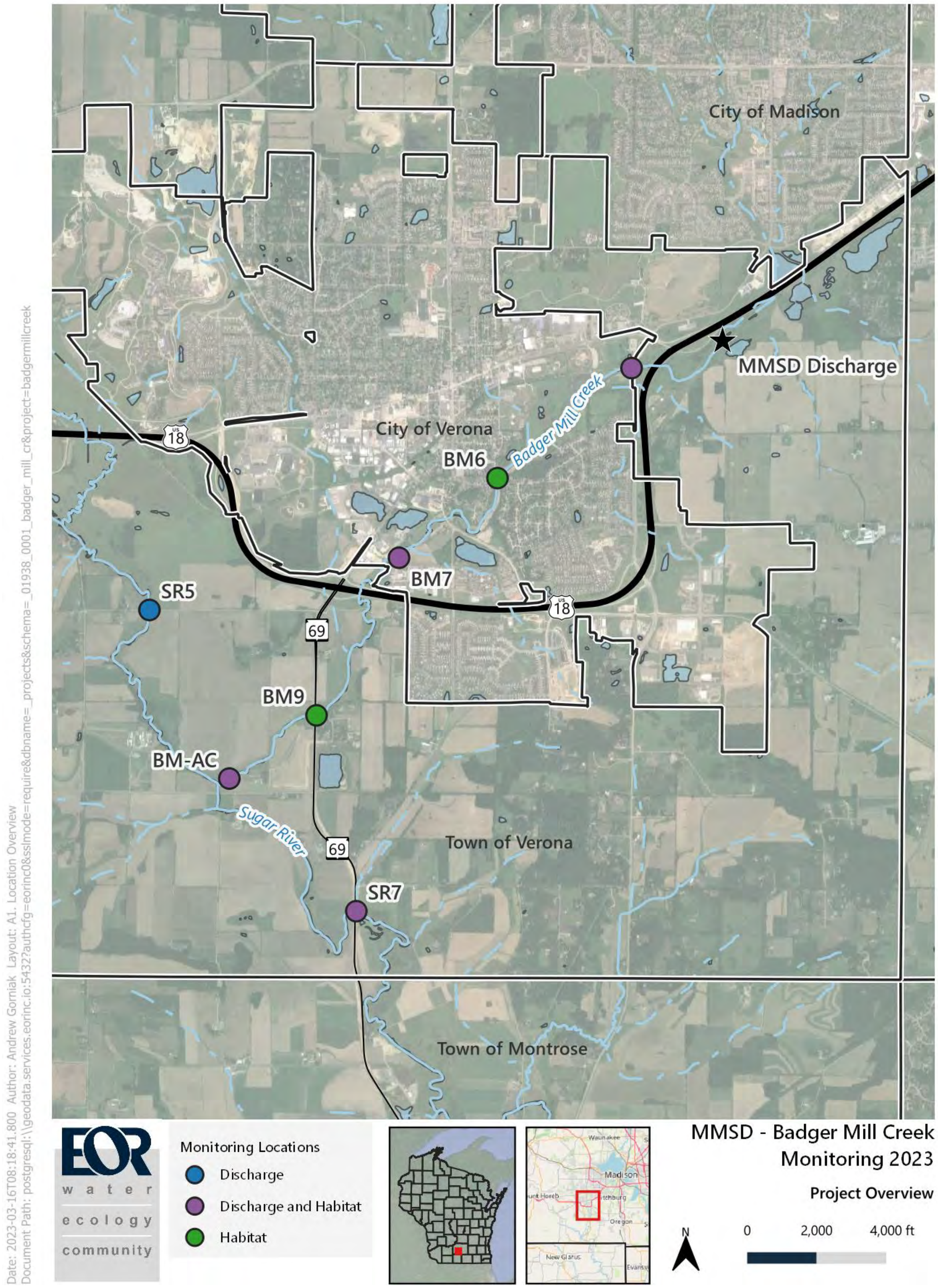
6. The long-term record of Badger Mill Creek flow at the Bruce St. gage indicates that flows similar to those measured during the experimental shutdown, with approximately 5 cfs at Bruce St. and flow less than 1 cfs at Old Hwy. PB, would have been common without effluent discharge from 1999 to 2007. However, 3% of fewer days per year would have been at or below these flows during the last 7 years, when regional streamflows have increased.

Attachments

Appendix A: Figures

Appendix B: Photographs

APPENDIX A: FIGURES




E Verona Ave
E Verona Ave
Maple Grove Drive
Old County Road PB
BM5
Badger Mill Creek at Old PB
Badger Mill Creek
Old County Road PB
18
18
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EOR
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Monitoring Locations
Discharge
Discharge and Habitat
Habitat
Verona
Town of Verona
MMSD - Badger Mill Creek
Monitoring 2023
Badger Mill Creek at Old PB
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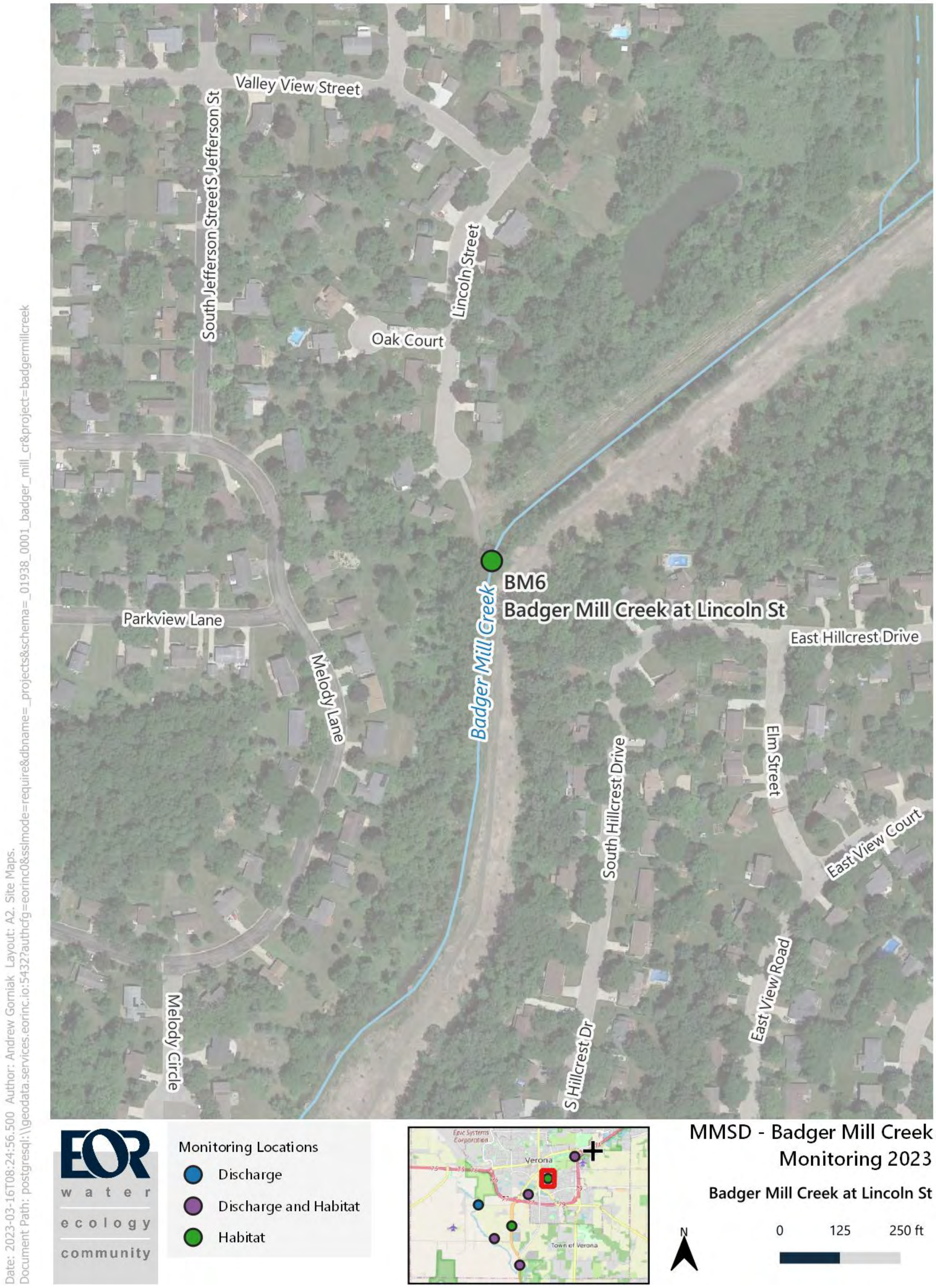
Valley View Street
South Jefferson Street
S Jefferson St
Lincoln Street
Oak Court
BM6
Badger Mill Creek at Lincoln St
Parkview Lane
East Hillcrest Drive
Melody Lane
Badger Mill Creek
South Hillcrest Drive
Elm Street
East View Court
East View Road
Melody Circle
S Hillcrest Dr
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Monitoring Locations
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Discharge and Habitat
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MMSD - Badger Mill Creek
Monitoring 2023
Badger Mill Creek at Lincoln St
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Date: 2023-03-16T08:25:09.658 Author: Andrew Gorniak Layout: A2. Site Maps.
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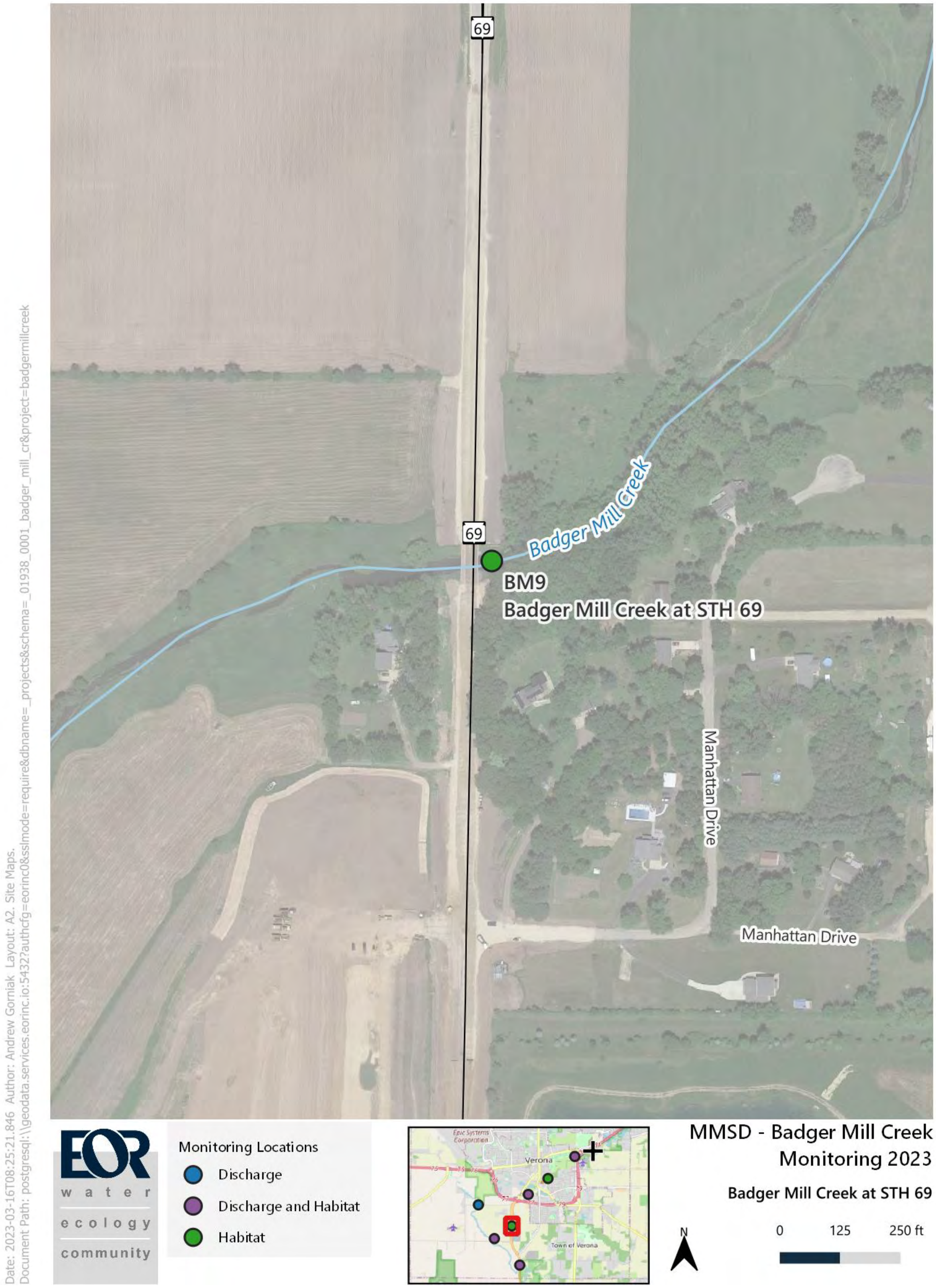
69
Badger Mill Creek
BM9
Badger Mill Creek at STH 69
Manhattan Drive
Manhattan Drive
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Monitoring Locations
Discharge
Discharge and Habitat
Habitat
MMSD - Badger Mill Creek
Monitoring 2023
Badger Mill Creek at STH 69
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Badger Mill Creek
BM-AC
Badger Mill Creek above Confluence
Riverside Road
Riverside Road
Sugar River
Monitoring Locations
Discharge
Discharge and Habitat
Habitat
EOR
water
ecology
community
Verona
Town of Verona
MMSD - Badger Mill Creek
Monitoring 2023
Badger Mill Creek above
Confluence
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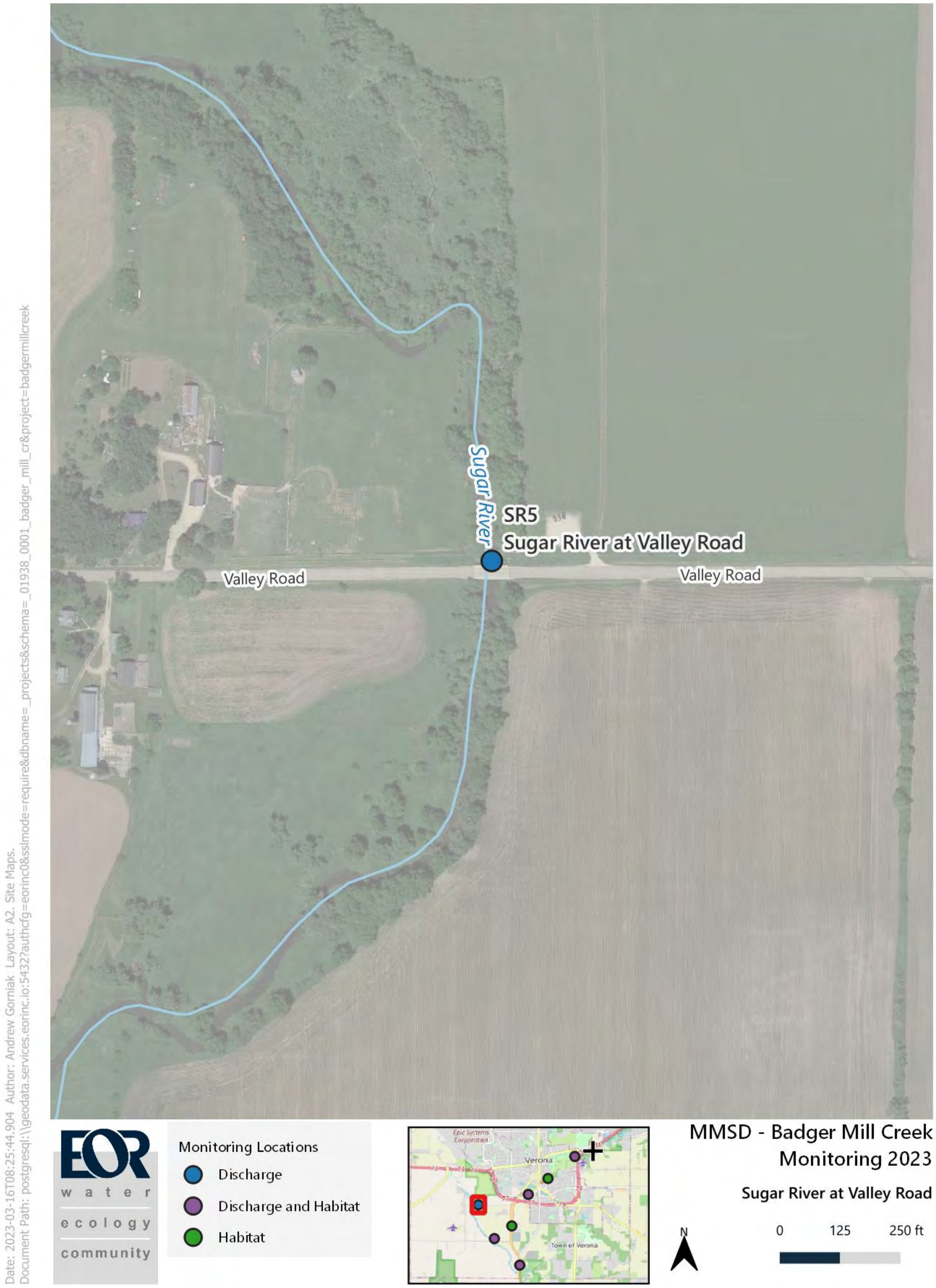

Sugar River
SR5
Sugar River at Valley Road
Valley Road
Valley Road
Monitoring Locations
Discharge
Discharge and Habitat
Habitat
MMSD - Badger Mill Creek
Monitoring 2023
Sugar River at Valley Road
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Verona
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Sunset Drive
SR7
Sugar River at STH 69 (USGS)
Sugar River
69
Monitoring Locations
Discharge
Discharge and Habitat
Habitat
Verona
Town of Verona
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125
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MMSD - Badger Mill Creek
Monitoring 2023
Sugar River at STH 69 (USGS)
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APPENDIX B: SITE PHOTOGRAPHS

BM5 – Old PB

Before effluent shutdown

Photo 1: Looking downstream.

Photo 2: Looking at right bank.

After effluent shutdown

Photo 3: Looking upstream.

Photo 4: Looking at left stream bank.

Photo 5: Looking at right stream bank.

Photo 6: Looking downstream.

BM6 – Lincoln St.

Before effluent shutdown

Photo 7: Looking downstream.

Photo 8: Looking upstream.

After effluent shutdown

Photo 9: Looking upstream.

Photo 10: Looking downstream.

Photo 11: Looking at right stream bank.

BM7 – Bruce St. (USGS Gage)

Before effluent shutdown

Photo 12: Looking at right stream bank.

Photo 13: Discharge measurement.

After effluent shutdown

Photo 14: Looking upstream.

Photo 15: Looking at right stream bank.

Photo 16: Looking at left stream bank.

Photo 17: Looking downstream.

BM9 – STH 69

Before effluent shutdown

Photo 18: Looking at left stream bank.

Photo 19: Looking upstream.

Photo 20: Looking at right stream bank.

After effluent shutdown

Photo 21: Looking at left stream bank.

Photo 22: Looking upstream.

Photo 23: Looking at right stream bank.

Photo 24: Looking downstream.

BM-AC – above Confluence

Before effluent shutdown

Photo 25: Looking downstream.

Photo 26: Looking upstream.

After effluent shutdown

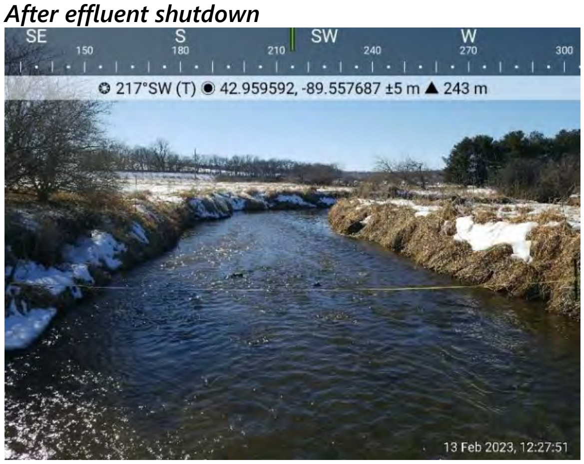

Photo 27: Looking downstream.

Photo 28: Looking upstream.

Photo 29: Looking at left stream bank.

Photo 30: Looking at right stream bank.

SR5 – Valley Rd

Before effluent shutdown

Photo 29: Looking upstream.

Photo 30. Looking downstream.

After effluent shutdown

Photo 31: Looking upstream.

Photo 32: Looking downstream.

Photo 31: Looking at right stream bank.

Photo 32: Looking at left stream bank.

<u>SR7 – STH 69 (USGS Gage)</u>

Before effluent shutdown

Photo 33: Looking upstream.

Photo 34: Looking downstream.

Photo 35: Looking at right stream bank.

Photo 36: Looking at left stream bank.

After effluent shutdown

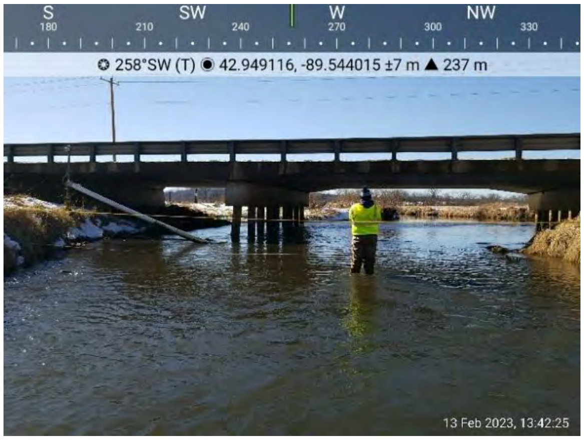

Photo 37. Looking upstream.

Photo 38. Looking downstream.

Photo 39: Looking at right stream bank.

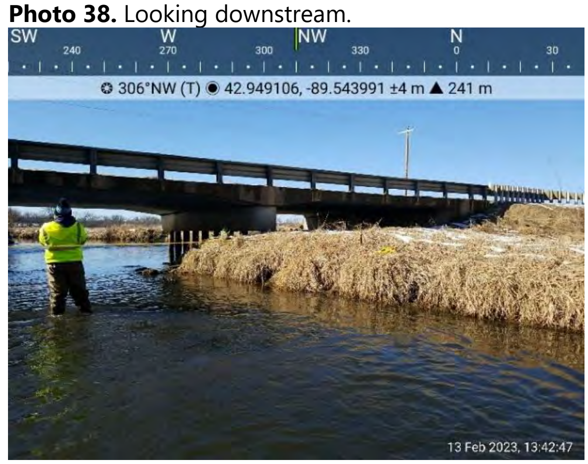

Photo 40: Looking at left stream bank.

Exhibit D: Badger Mill Creek Assessment

Contents

Factors assessed

Water quality can be viewed on many levels and is based on various parameters. Throughout Badger Mill Creek (BMC) Project PLUS, the main interest expressed is the potential change in water levels in the stream with the discontinuance of the effluent return.

With Wisconsin Department of Natural Resources (WDNR) guidance and consultant assistance, the District began flow, depth, temperature, and habitat measurements at various sites along Badger Mill Creek and the Sugar River in Winter 2023. These measurements occurred twice under two scenarios:

- Scenario 1: District effluent discharged as normal per the District's permit.
- Scenario 2: District effluent not discharged.

During the assessment, effluent return was slowly reduced starting at the end of January 2023. On February 6, 2023, effluent return was fully discontinued. The effluent return was resumed April 17, 2023

The before-and-after study design allowed the District to understand the impact of the effluent flow on the stream under current climatological and hydraulic conditions. In consultation with the WDNR and using historic U.S. Geological Survey (USGS) hydrograph data, this specific assessment's timeline aligned with the winter months. This was done to understand further the impact of treated effluent on the stream when flow and depth are historically at their lowest.

Consulting firm Emmons & Oliver Resources, Inc. (EOR) took in-stream measurements of flow, depth, temperature, and habitat. The EOR report (Exhibit C) indicates that when effluent was discontinued during low-flow conditions, the largest observed difference was a 2-inch water level reduction in Badger Mill Creek in the heart of Verona. It became even smaller as the water flowed to the Sugar River. Without the District effluent contributing to stream flow, the flow at Badger Mill Creek near State Highway 69 exceeded 9 cfs (cubic feet per second) in low-flow conditions, with no change to the stream's width. The District study, plus submitted observation reports, recorded that all observed sites remained flowing during low-flow conditions when effluent was removed. EOR also assessed upstream and downstream of where Badger Mill Creek enters the Sugar River. These assessments show little to no impact on the Sugar River with or without District effluent. In fact, while stream flow in Badger Mill Creek was shown to decrease proportionally to the amount of effluent returned, the Sugar River upstream and downstream of the confluence with Badger Mill Creek show the same reduction in flow, which indicates that the flow in the Sugar River is not dependent on the flow in Badger Mill Creek. Further discussion is included below and shown in the EOR report.

Each month, District staff take water quality samples at various locations along Badger Mill Creek to monitor and assess the health of the waterways. These parameters include temperature, chloride, metals, CBOD, dissolved oxygen, and other indicators. During the stream assessment led by EOR, the District continued monthly in-stream sampling. Some parameters are measured monthly, and others, like metals, are only measured quarterly. Therefore, for some parameters, there were two monthly sampling dates for data comparison, and for others, there was only one monthly sampling date for data comparison. This analysis uncovered no negative water quality impacts due to ceasing the effluent.

Chloride levels are the most significant difference in water quality when comparing data with or without effluent. Chloride is a component of salt, which is used for winter maintenance and salt-based water softening systems. While salt dissolves in water, it doesn't go away and is found in rivers, lakes, streams, wastewater, and even drinking water through runoff, groundwater infiltration, and treatment plant discharges. Research continues to determine the actual salt levels critical for freshwater organisms and freshwater systems. The District works to reduce all sources of salt, but due to the regional reliance on salt-based water softening systems, the District's effluent still contains significant chloride, and the District currently carries a variance to the state's chloride water quality standard. The reduction of instream salt when effluent is ceased is evident in the USGS gaging data for both Badger Mill Creek (Figure 1) and the Sugar River when looking at USGS's continuous conductivity monitoring data.

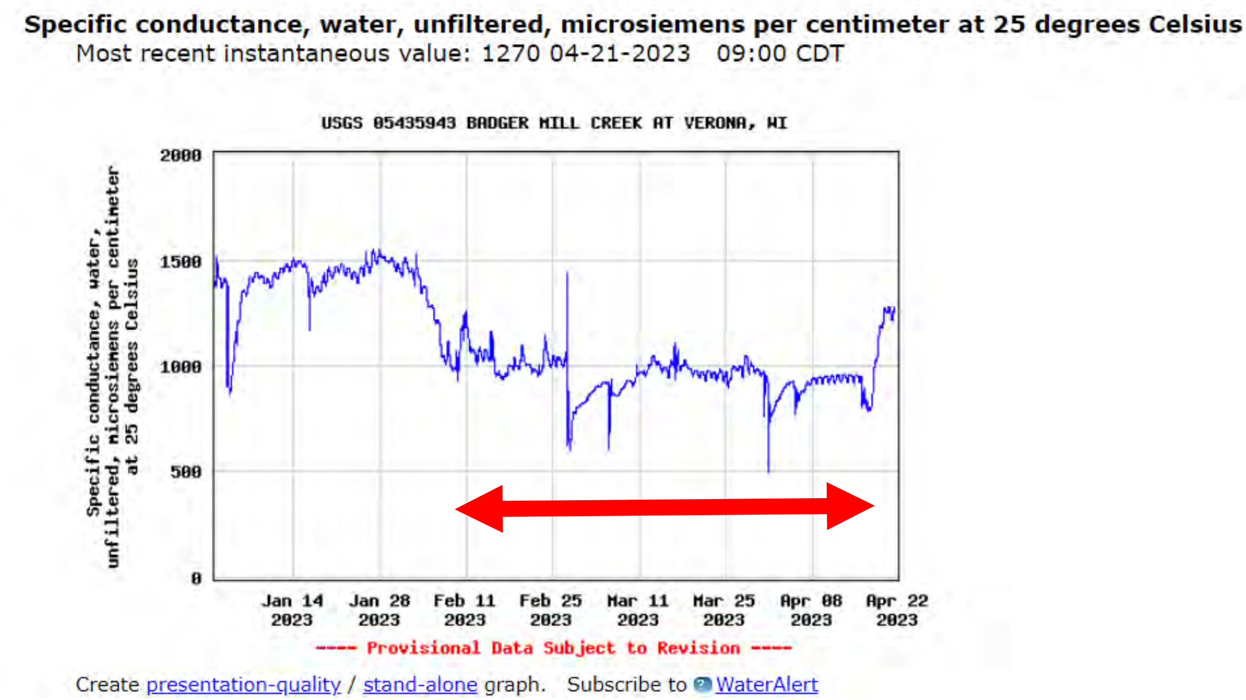

Figure 1 - USGS Conductivity Data at Bruce Street Gage (period effluent was off is shown by red arrow)

Data, experts, and reports consulted

In addition to District staff, including engineers, operators, chemists, and the hired consultants, the District relied on the expertise of numerous organizations and individuals and various reports and documents. Some are listed below, and others are linked in the appendix as "Other data and references noted." Some organizations and experts consulted, and reports used include:

Wisconsin Geological and Natural History Survey

The Wisconsin Geological and Natural History Survey (WGNHS) was created by the Wisconsin Legislature in 1897. It is part of the University of Wisconsin and is an interdisciplinary organization that conducts natural resources surveys and research to produce information used for decision-making, problem-solving, planning, management, development, and education. WGNHS has been consulted, and their data, including the Dane County Groundwater model, have been used in this analysis.

United States Geological Survey

The United States Geological Survey (USGS) was established on March 3, 1879, with a unique combination of responsibilities: "classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain." In 1977, Congress directed the Survey to establish a national water-use information program. It became part of the Federal-State cooperative program by the late 1980s. In Wisconsin and Dane County, USGS operates and maintains a series of stream gaging stations, including one on Badger Mill Creek at

Bruce Street,[1] another on the Sugar River at STH 69,[2] and a variety of others throughout the region, including gages on Pheasant Branch in Middleton,[3] which is referenced in this report. In addition, USGS scientists provided expertise throughout this process.

Wisconsin DNR
Fisheries, water resources, wastewater, and permitting experts were engaged throughout this process. Analyses, including stream analysis[4] and the recently published Trout Assessment (Exhibit K) findings, were used throughout this analysis.

50-Year Master Plan,[5] 9th Addition Facility Plan, Sugar River Effluent Limits, Effluent Return Study, and associated documents (Exhibit L and report)
The original decision to return water to Badger Mill Creek was complicated, involving studies, experts, and public involvement. While writing this report, the historical context and decisions were understood and reassessed. In addition, experts who participated in the original process were consulted and helped guide the District's process, understanding, and recommendations.

Other related projects and reports
The Resource Assessment and Development Analysis for the Upper Sugar River and Badger Mill Creek Southwest of Verona, WI, June 2008 by Montgomery Associates[6] and the Fitchrona Road Stormwater Study[7] along with other local projects including the Fish/Mud & Crystal Lakes Geology and hydrogeology (Exhibit H) overview were used to aid in understanding the many facets of this analysis.

Flow

Throughout the public engagement for Badger Mill Creek Project PLUS (Exhibit I), concerns were raised about the future health of Badger Mill Creek if effluent return was ceased. The concerns expressed included whether flow would remain in the Sugar River and Badger Mill Creek and whether ceasing effluent flow would be detrimental to the biology in the Sugar River and Badger Mill Creek, especially in relation to trout. To answer these questions, the District consulted with WDNR and hired EOR, which undertook the Badger Mill Creek Hydrologic Assessment (Exhibit C). This report assesses the evaluation of an experimental shutdown of the District's effluent return line to Badger Mill Creek. This hydrologic assessment was focused on answering questions about the amount of flow that could be expected in Badger Mill Creek without the effluent discharge and related changes to the in-stream habitat.

The EOR study started during normal District operating conditions in January 2023. To attempt to simulate a worst-case, low-flow scenario, and in consultation with WDNR, the pre- and post-test period used for the test occurred during low-flow, frozen ground conditions in January and February of 2023. The flow rates at the USGS gaging station at Bruce Street in Verona on Badger Mill Creek confirm that

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[1] USGS Badger Mill Creek Gaging Station: link

[2] USGS Sugar River at Hwy 69 Gaging Station: link

[3] USGS Pheasant Branch Gaging Station: link

[4] WDNR 2005 Diverse Fish and Aquatic Life Coolwater

[5] Madison Metropolitan Sewerage District 50-year Master Plan: link

[6] Resource Assessment and Development Analysis for the Upper Sugar River and Badger Mill Creek Southwest of Verona, WI, Montgomery Associates 2007, link

[7] Fitchrona Road Stormwater Study, AE2S: link

the period used for the test was a low-flow period. The first step in the process was site reconnaissance and consultation with fishery experts at the WDNR.

Baseflow higher than predicted in the 1990s planning period

Understanding in the mid to late 1990s

During the period when the return of effluent to the Sugar River basin was being considered, there was an interest that the effluent water would be critical in the future to maintain streamflow. The USGS paper, "The Effects of Large-Scale Pumping and Diversion on the Water Resources of Dane County, Wisconsin,"[8] was published in 2001, and the associated model simulated the baseflow in cubic feet per second at Badger Mill Creek at STH 69 South of Verona. That model predicted that the baseflow was lower in 2000 than before development. At the time of that paper, the estimated baseflow was 0.6 cfs in Badger Mill Creek at STH 69, while pre-development was estimated to be 2.0 cfs in the same location.

Dane County groundwater model

The Dane County Groundwater model[9] uses pre-development stream flows downstream of the Bruce Street USGS gage at STH 69 that were estimated to be 3.63 cfs and simulates that 2010 stream flows at STH 69 on Badger Mill Creek with effluent running are 4.21 cfs. These modeling exercises were done at a much larger scale and looked at overall trends. While the modeling included streams like Badger Mill Creek, various assumptions were made during the process.

Actual conditions

During the District study period, Badger Mill Creek immediately downstream of STH 69 was found to maintain 9.3 cfs of flow (Exhibit C). This further indicates that actual low-flow streamflow is higher than predicted in these earlier studies that informed the original decision to return water to Badger Mill Creek. In addition, significant water resource-related improvements have occurred and continue to occur in the watershed that work to increase baseflow.

In 2016, USGS's Warren Gebert published "Changes in Stream Flow Characteristics in Wisconsin as Related to Precipitation and Land,"[10] a paper that looked at the streamflow from 15 long-term gaging stations, including the Sugar River. In his report, Mr. Gebert found low-flow levels have increased in the Sugar River Basin over time. He attributes the improvement in stream low flows and the reduction in peak flows to improved farming practices and improved stormwater management (Figure 2).

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[8] *The Effects of Large-Scale Pumping and Diversion on the Water Resources of Dane County, Wisconsin, USGS 2001: link*

[9] *Dane County Groundwater Model: link*

[10] *Streamflow: Changes in Streamflow Characteristics in Wisconsin as Related to Precipitation and Land. U.S. Scientific Investigations Report 2015-5140, Version 1.1 January 2016, U.S.*

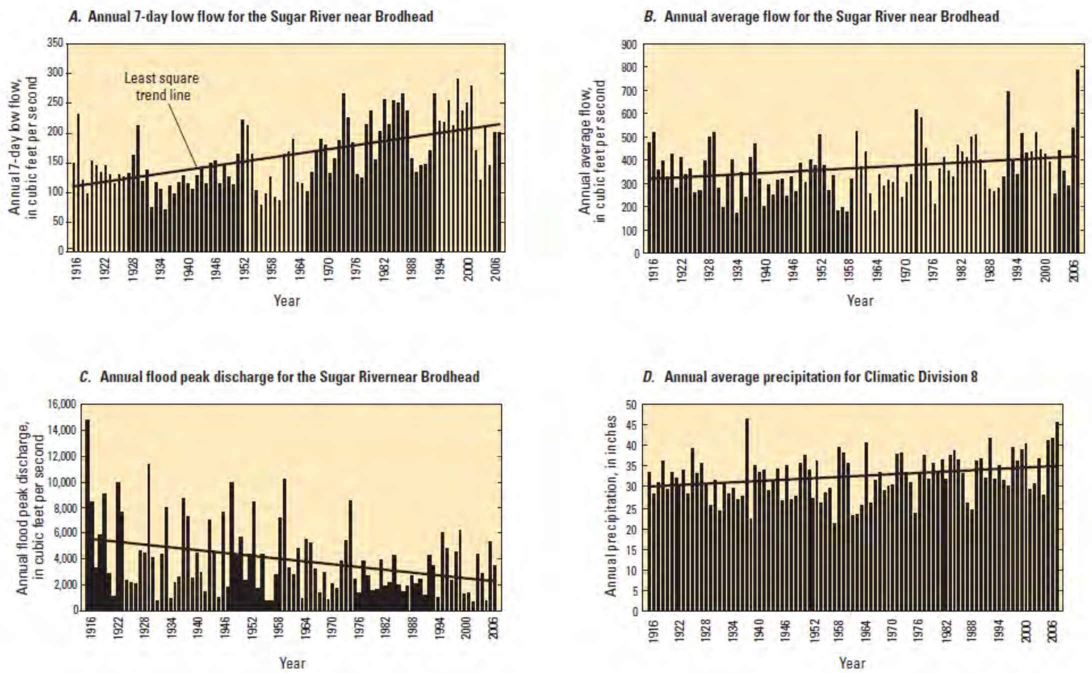

Figure 3. Data for Sugar River near Brodhead, Wisconsin, for the period 1915–2008. *A*, Annual 7-day low flow. *B*, Annual average flow. *C*, Annual flood peak discharge. *D*, Annual average precipitation for climatic division 8.

Figure 2 - Figure 3 from 2016 USGS's Changes in Streamflow in Wisconsin[11] as related to precipitation and land use

This information is corroborated by other work done by the Wisconsin Natural History and Geological Survey (Figures 3 and 4) and USGS (Figure 5). These graphs from the scientific work of USGS and WNHGS are included, and the papers are linked to this report.

[11] *Streamflow: Changes in Streamflow Characteristics in Wisconsin as Related to Precipitation and Land. U.S. Scientific Investigations Report 2015-5140, Version 1.1 January 2016, U.S.*

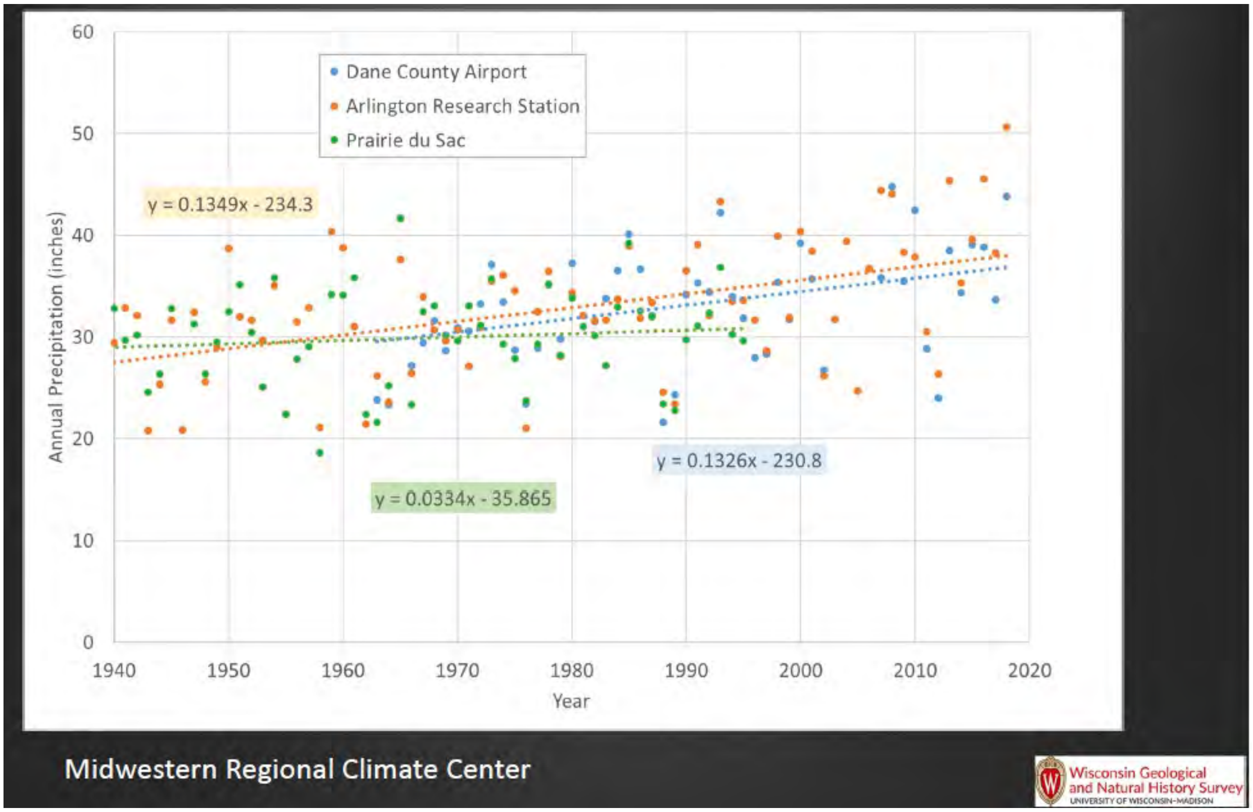

Figure 3 – WGNHS - Rainfall Increasing over the past 80 years – Exhibit H

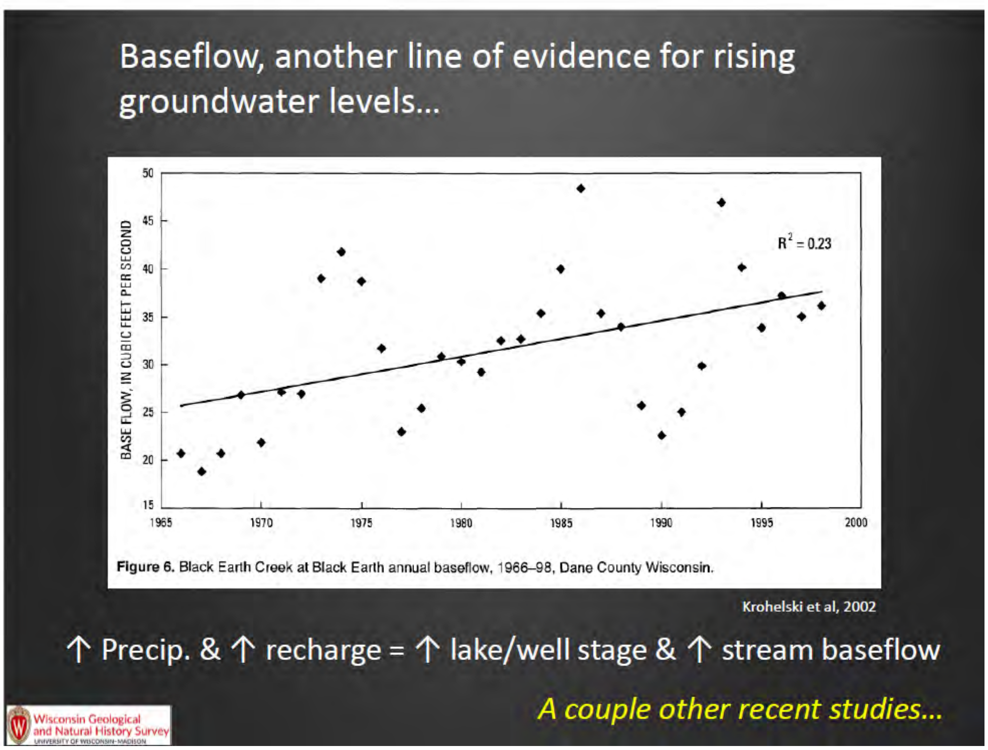

Figure 4 - Baseflow increasing in Black Earth Creek as well (WGNHS) – Exhibit H

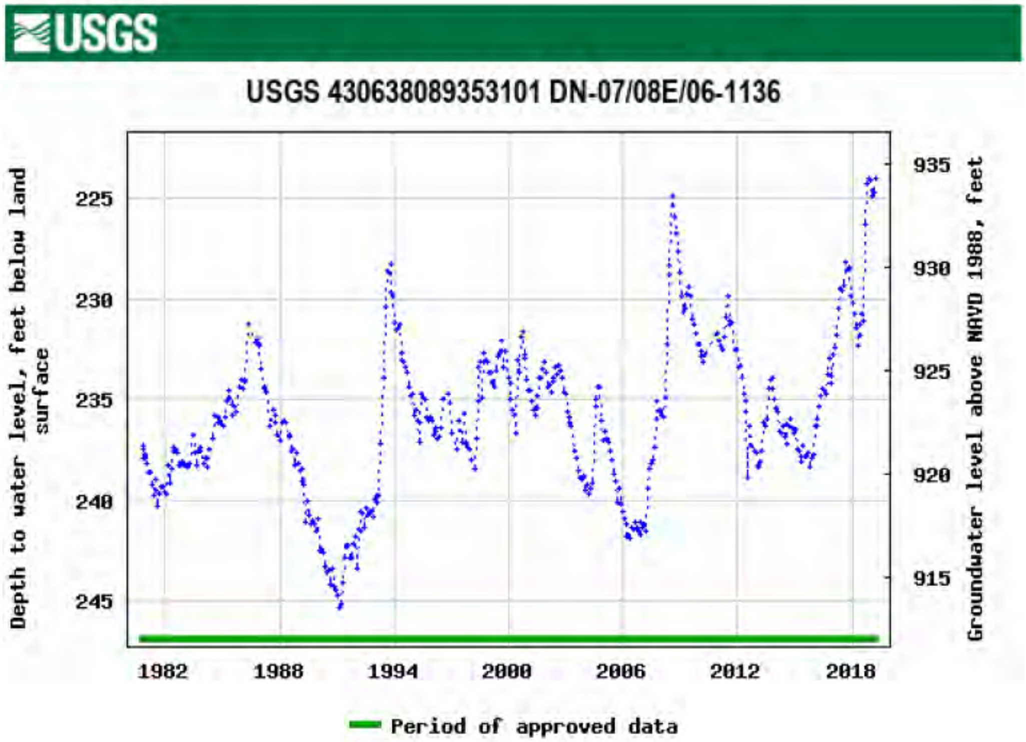

Figure 5 - USGS groundwater levels in Dane County rising (Exhibit H)

Groundwater increasing and water utilities are drawing less groundwater overall

Much of the original discussion regarding the inter-basin transfer of water was based on speculative projections that the Madison Water Utility would draw more and more water each year, resulting in lower baseflows in Badger Mill Creek and other waterways. However, this is a challenging extrapolation because the stream is fed by near-surface groundwater and surface water. In addition, there are few connections between those water sources and the regional deep aquifers that the water utility draws from to provide drinking water.

Rather than experiencing low flows in the region, rainfall has increased, and groundwater pumping has decreased. As a result, instead of seeing lower baseflows in the stream, the Badger Mill Creek watershed is experiencing flooding and rising groundwater and surface water levels. Many of these challenges are articulated in the City of Fitchburg and Town of Verona's Fitchrona Road Stormwater Study.[12] This study includes a recommended alternative to alleviate some of the flooding challenges. The USGS gaging station at Bruce Street shows historical flow data from the year before the effluent return. This station shows the continual flow increase from 1997 to the present (Figure 6).

[12] *Fitchrona Road Stormwater Study, AE2S: link*

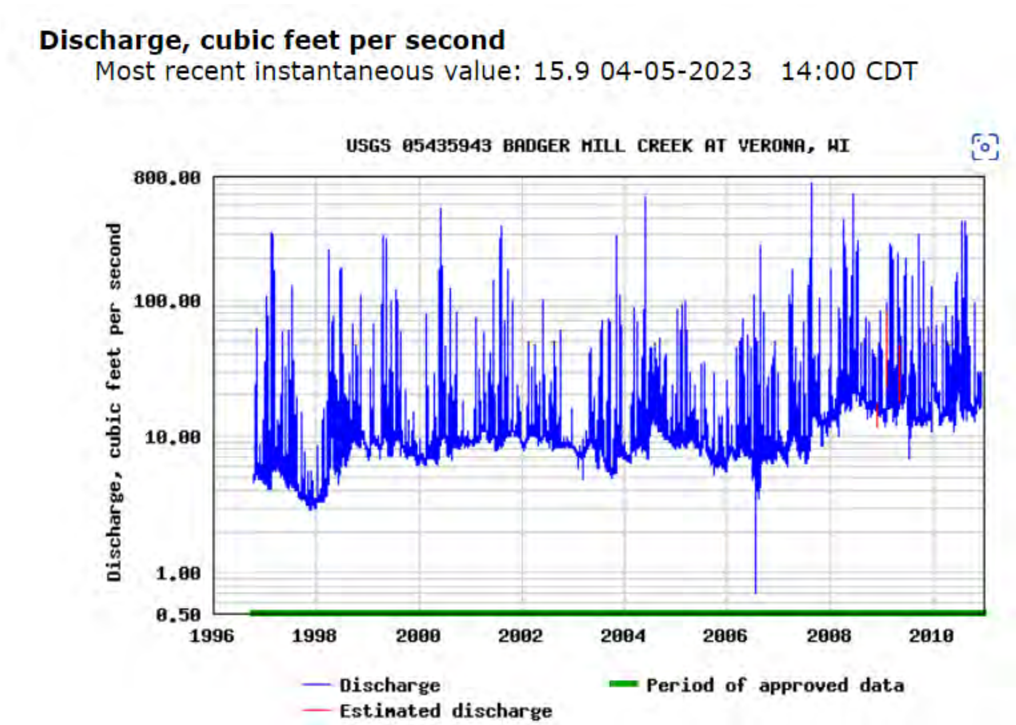

Figure 6 - Historic USGS flow at Bruce Street gage on Badger Mill Creek

Drinking water extraction

The actual pumping from water utilities in the area has been reduced by over 3 million gallons annually since 1998. The Madison Water Utility is pumping about 30% less water than it did in 1998. Water conservation, water-conserving fixtures, and toilet rebates have contributed to this success. The City of Verona has experienced a small increase in the amount of water it pumps. However, due to the differences in scale between the two utilities, it is minor compared to the decreases made by Madison Water Utility. This results in a net decrease of 3,113,183,000 gallons pumped between the two utilities when comparing 1998, the first year the District began returning effluent to Badger Mill Creek, and 2021, the most recent year for which data is available (Tables 1 and 2).

Madison Water Utility Records	Water Extracted Annually
1998	12,120,558,000 gallons
2021	8,921,090,000 gallons
Net	-3,199,470,000 gallons

Table 1 - Madison Water Utility records from Wisconsin Public Service Commission

Verona Water Utility Records	Water Extracted Annually
1998	347,490,000 gallons
2021	433,777,000 gallons
Increase	86,287,000 gallons

Table 2 - Verona Water Utility records from Wisconsin Public Service Commission

The EOR study found that flow was evident in headwater areas without effluent discharge. The ecological assessment of BMC shows that from Bruce Street downstream, with or without effluent, the stream is expected to maintain more water than required for a cool-coldwater mainstem. Physical assessment of the stream indicates that water remains and is moving in all segments of BMC during the study period.

Flow fluctuates significantly in the stream based on a variety of factors. Flows at Bruce Street that are below 10 cfs have decreased significantly over the past 20 years. The EOR study indicates that at 10 cfs, flow would be maintained in all upstream segments without effluent return. (Figure 7).

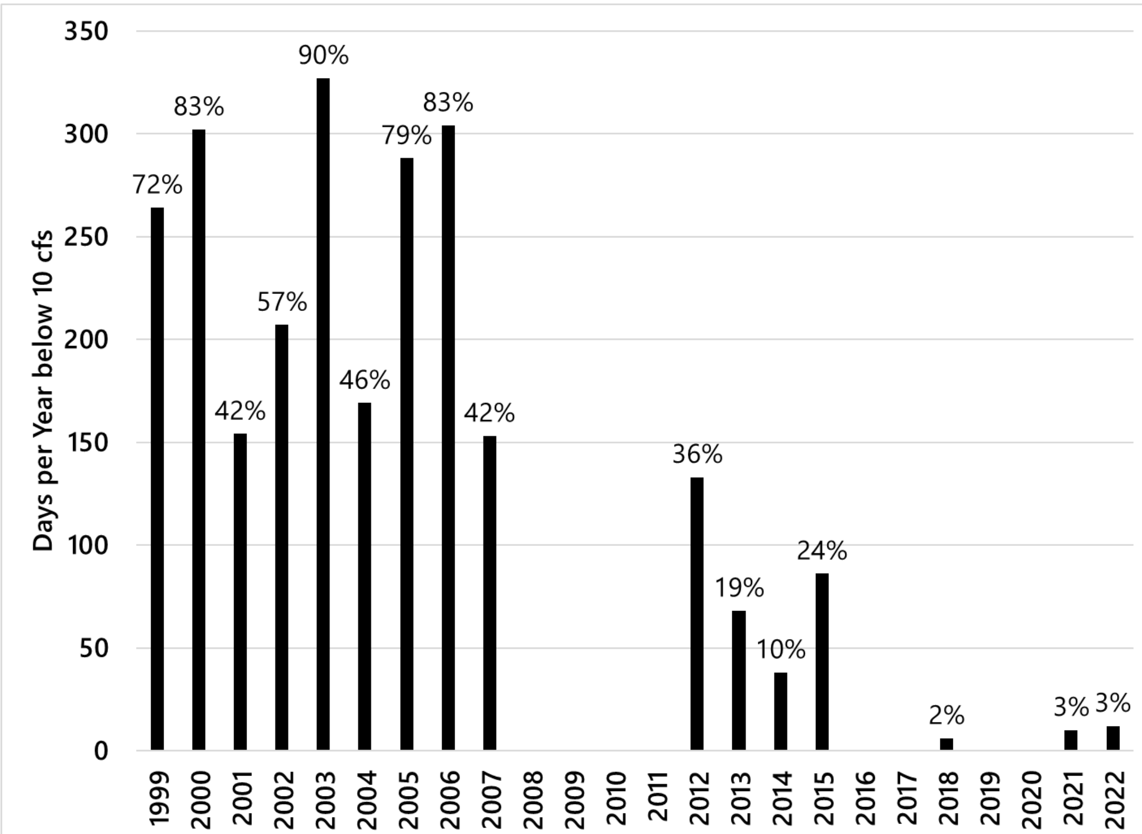

Figure 7- Percentage of days Badger Mill Creek below 10 cfs from 1999-2022

USGS monitoring shows the variability in the stream. The period chosen for the District study was reflective of low-flow conditions. Many changes have occurred in the watershed since the original decision to return effluent. Stormwater detention and infiltration requirements and farming practice improvements have reduced peak runoff and increased baseflow in the stream. Since the return to BMC started, rainfall has trended upward. Flooding and unintended impoundment of water exist upstream of the effluent return location.

Stream depth

While EOR found changes in the stream's depth, they were most pronounced at the most upstream point monitored. This location is upstream of the spring complex that feeds the stream near Highway PB. At this location, a 0.42-foot (5 inches) drop was found, and 0.78 feet (10 inches) of water remained in the stream. From that point downstream, the stream's depth dropped by approximately 0.16 feet (2 inches) at low-flow conditions with and without effluent at Lincoln Street, Bruce Street, and Hwy 69. A one-inch (0.09-foot) difference was found both upstream of where Badger Mill Creek comes into the

Sugar River and downstream of where Badger Mill Creek comes into the Sugar River, further reinforcing that effluent flow is not a significant impact on the Sugar River. The findings of the EOR report are supported by the continuous monitoring by USGS, which indicated the same approximate 2-inch drop in water level at the USGS gage at Bruce Street. Interestingly, the gage height had not returned to that low level while the effluent remained off through April 16, 2023 (Figure 8).

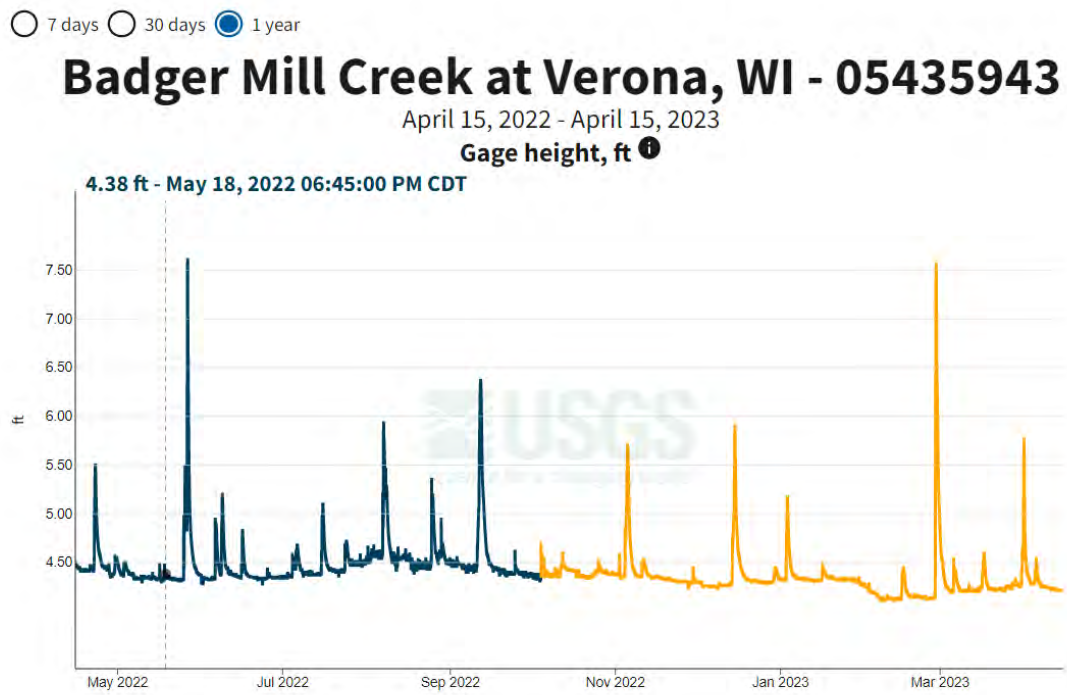

Figure 8 - USGS Badger Mill Creek Gage Height

Streambank work

Another interest raised by stakeholders during conversations with District staff involved questions around risk to the streambank and habitat work added along Badger Mill Creek if the effluent return would be discontinued. Habitat structures have been put in place in the stream to modify the channel configuration and add more natural meanders and stream narrowing. During the design and permitting process for streambank work on Badger Mill Creek, the City of Verona and Trout Unlimited representatives received the following design information from WDNR fish biologist Dan Oele regarding trout habitat for Badger Mill Creek:

> "The area is too wide and shallow and could be narrowed considerably to improve trout habitat. An additional challenge is for the most part there is only one side of the stream that is currently under construction and removing more trees on the other side is not going to be palatable after significant negative feedback from neighborhoods for removing so many trees to begin with. I would suggest the grading and sloping as planned, adding root wads every 30-50ft to bounce the water current off the sloped edge, using rock weirs on the opposite shore staggered, as well as random large boulders to provide additional habitat features there. The idea is to narrow the stream into a v-notch riffle in some areas, there isn't much gradient to work with in that reach, so getting a long tailing spawning riffle isn't going to be feasible (costs, floodplain impacts of a design that could do that with lots of rock additions). The best we can hope for is the bouncing

the current back and forth using the trees and rocks on each side of the bank, wiggling the thalweg within the existing wide banks to promote some gravel scouring while providing a variety of habitats (depth, velocity, trees, rocks, undercut logs, etc.)."

This work was put in place, and as sediment moves through the channel, the sediment fills in and creates more natural meanders. These types of structures are not intended to be underwater to fulfill their function. The elimination of effluent will not harm this work. Adding more of these types of stream structures may continue to help the stream. Areas upstream of the previous work could also benefit from this type of rehabilitation.

Parameter assessment

In addition to flow, there are a variety of other parameters related to water quality assessed for Badger Mill Creek, and many of the parameters associated with treated effluent will no longer influence the stream's water quality if flow is discontinued. Specifically, temperatures in Badger Mill Creek would more closely follow other southern Wisconsin streams. In addition, without District effluent, in-stream conductivity, which is higher due to the excess salt in the District's effluent, would cease. Some specific indices are included below. This analysis uncovered no parameters that would negatively impact Badger Mill Creek if effluent was discontinued.

Fecal coliform bacteria (FCOLI)

Fecal coliform bacteria is a type of coliform bacteria found mainly in animal digestive tracts and feces and are a more specific indicator of fecal contamination of water. Wastewater contains fecal coliform bacteria, and many other sources are also present in local streams. Wastewater is disinfected to minimize the number of coliform bacteria released in treated effluent. The District's permit requires that its effluent remains below a geometric mean (average) count of 400 colony forming units (cfu) per 100 ml on a monthly average basis, and below 780 CFU per 100 ml on a weekly average basis during the disinfection period. Historically, the District's disinfection period ran from April 15 through October 15 each year; starting in 2023, this period was expanded to March 15 through November 15. The in-stream sampling of bacteria shows that when the effluent is not contributing treated wastewater to the stream, the fecal coliform bacteria counts in the stream are significantly lower (Table 3).

	Bruce St.	Lincoln St.	CTH PB	STH 69
1/12/2022 7:30:00 AM	550	813	1370	40
2/9/2022 12:00:00 AM	1070	1750	1970	1060
3/9/2022 7:30:00 AM	420	395	882	300
1/18/2023 7:00:00 AM	592	672	984	283
2/8/2023 7:00:00 AM	100	220	380	88
3/8/2023 7:30:00 AM	25	13	18	7

Table 3 - FCOLI from District in-stream sampling, reported in colony forming units per 100 ml

Note: *The highlighted rows represent test periods without District effluent contribution.*

Total Kjeldahl nitrogen (TKN)

Nitrogen is essential for living organisms to function but can cause nutrification and other challenges in excess quantities. The treatment processes remove significant amounts of nitrogen, and the District's effluent complies with current standards for nitrogen and ammonia, but because of the impact of nutrients like nitrogen on aquatic systems, it will be further regulated in Wisconsin in the near future. Nitrogen exists in many forms, from the basic molecules of ammonia, nitrate, and nitrite, to the more complex amino acids and proteins. Rather than provide all forms of nitrogen, the following analysis looks at TKN, which quantifies the amount of nitrogen contained in organic form. Without District effluent, in-stream TKN (organic nitrogen) concentrations are reduced (Table 4).

	Bruce St.	Lincoln St.	CTH PB	STH 69
1/8/2020 8:00:00 AM	0.58	0.56	1.04	0.58
2/5/2020 7:30:00 AM	0.54	0.6	0.86	1.23
3/11/2020 7:30:00 AM	0.72	0.81	1.04	0.68
1/5/2021 7:30:00 AM	0.51	0.7	1.04	0.81
2/3/2021 7:30:00 AM	0.69	0.78	1.11	0.92
3/11/2021 7:30:00 AM	0.91	0.94	1.08	0.91
1/18/2023 7:00:00 AM	0.91	1.2	1.85	0.67
2/8/2023 7:00:00 AM	0.36	0.7	1.02	0
3/8/2023 7:30:00 AM	0.44	0.44	0.62	0

Table 4 - TKN from District in-stream sampling; measured in mg/L

Note: *The highlighted rows represent test periods with District effluent contribution.*

Total phosphorus

Phosphorus is a nutrient required by all organisms for the basic processes of life. In freshwater lakes and rivers, phosphorus is often found to be the growth-limiting nutrient because it occurs in the least amount relative to the needs of plants. If excessive amounts of phosphorus are added to the water, excessive algae growth can cause algae blooms and eutrophication.

The treatment process removes significant amounts of phosphorus, but the District's effluent does not comply with the current standards for phosphorus.

Phosphorus exists in water in either a particulate phase or a dissolved phase. Phosphorus in water is usually found in the form of phosphates. Phosphates can be in inorganic form (including orthophosphates) or organic form (organically-bound phosphates). Rather than provide all forms of phosphorus, the analysis looks at Total Phosphorus, which is the inorganic and organic forms combined.

Without District effluent, in-stream total phosphorus is closer to the water quality criterion of 0.075 mg/l during the sampling period (Table 5). This is important for two reasons. First, this indicates that without District effluent, the stream will realize lower total phosphorus concentrations. Second, Badger Mill Creek is currently on WDNR's 303d list for phosphorus. This means that Badger Mill Creek is shown to be impaired for phosphorus. Therefore, if the District's effluent ceases, there is a better possibility that the creek would not be required to have a Total Maximum Daily Load (TMDL) developed to achieve compliance with the Wisconsin Phosphorus Water quality standards.

	Bruce St.	Lincoln St.	CTH PB	STH 69
1/5/2021 7:30:00 AM	0.1	0.11	0.18	0.16
2/3/2021 7:30:00 AM	0.1	0.1	0.18	0.14
3/11/2021 7:30:00 AM	0.1	0.13	0.15	0.1
1/12/2022 7:30:00 AM	0.2	0.28	0.22	0.2
2/9/2022 12:00:00 AM	0.17	0.21	0.2	0.2

3/9/2022 7:30:00 AM	0.2	0.49	0.19	0.18
1/18/2023 7:00:00 AM	0.1	0.14	0.29	0
2/8/2023 7:00:00 AM	0.1	0.23	0.36	0.07
3/8/2023 7:30:00 AM	0.1	0.07	0.11	0

Table 5 - Total Phosphorus from District in-stream sampling, measured in mg/L

Note: *The highlighted rows represent test periods without District effluent contribution.*

Chloride

Without District effluent, a significant reduction in in-stream chloride is easily seen in the continuous conductivity data gathered by USGS at its Bruce Street Station (Table 6 and Figure 9) and in the USGS data in the Sugar River at Hwy 69 (Figure 10).

	Bruce St.	Lincoln St.	CTH PB	CTH 69
1/5/2021 7:30:00 AM	168	183	268	161
2/3/2021 7:30:00 AM	176	217	310	169
3/11/2021 7:30:00 AM	174	186	247	188
1/12/2022 7:30:00 AM	102	276	36.4	224
2/9/2022 12:00:00 AM	256	265	371	228
3/9/2022 7:30:00 AM	238	251	332	219
1/18/2023 7:00:00 AM	214	230	326	192
2/8/2023 7:00:00 AM	124	118	170	144
3/8/2023 7:30:00 AM	92.9	103	131	107

Table 6 - Chloride from District in-stream sampling, measured in mg/L

Note: *The highlighted rows represent test periods without District effluent contribution.*

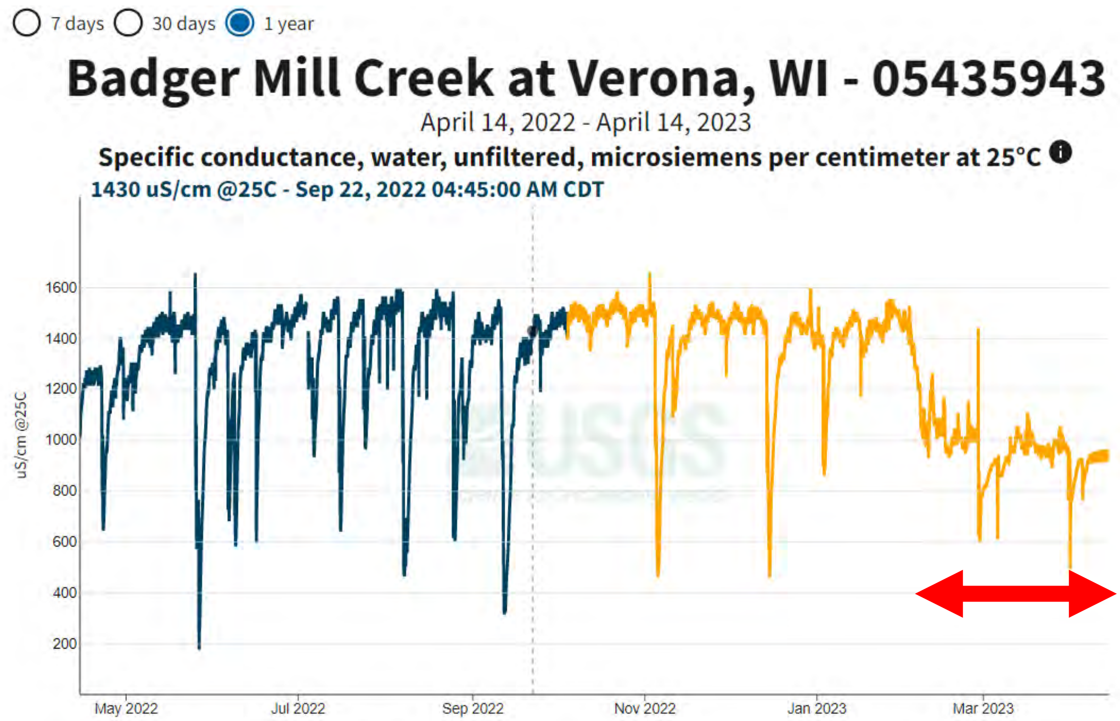

Figure 9 - Badger Mill Creek Conductivity from USGS Continuous Monitoring (in microsiemens per cm). Period without Effluent shown by red arrow.

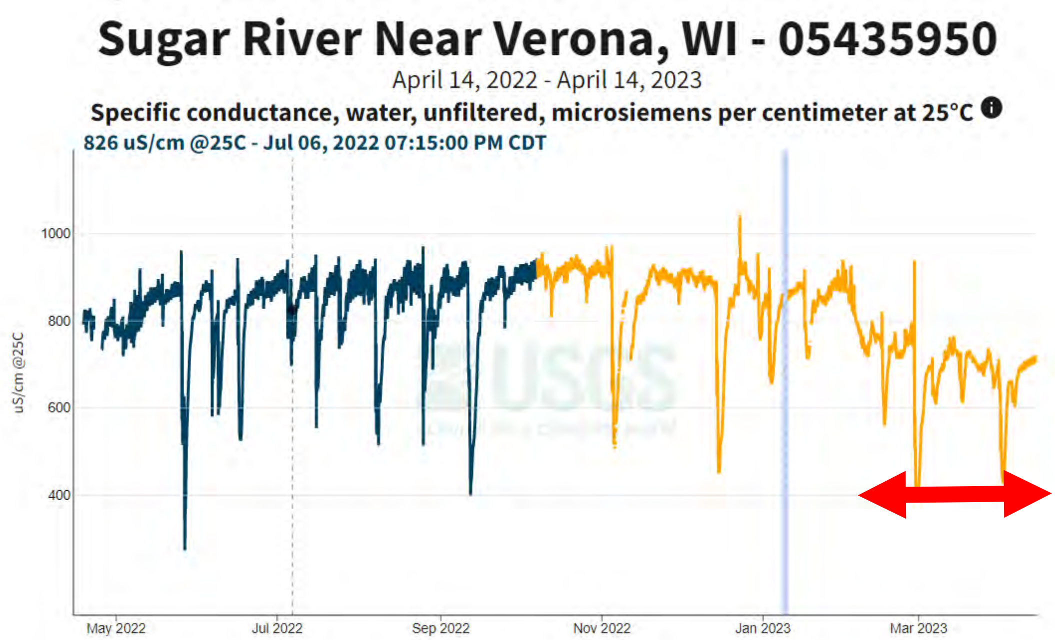

Figure 10 - Sugar River in-stream Conductivity from USGS continuous monitoring in microsiemens per cm (period effluent off is shown by red arrow)

Exhibit D - 15

Dissolved oxygen

The United States Environmental Protection Agency (USEPA) defines dissolved oxygen (DO) as the amount of oxygen present in water and notes that water bodies receive oxygen from the atmosphere and aquatic plants. Running water, such as that of a swift-moving stream, dissolves more oxygen than the still water of a pond or lake.

DO is an important measure of water quality because it is a direct indicator of an aquatic resource's ability to support aquatic life. While each organism has its own DO tolerance range, USEPA notes that generally, DO levels below 3 milligrams per liter (mg/L) are of concern, and waters with levels below 1 mg/L are considered hypoxic and often devoid of life. Dissolved oxygen tends to be higher during periods of colder water and lower during periods of higher water temperatures. In addition, there tends to be a daily (diurnal) shift in dissolved oxygen in water bodies during months with vegetation in the streams. This diurnal shift leads to the lowest DO levels in the early morning.

Effluent returned to Badger Mill Creek needs to meet a minimum DO standard of 4.5 mg/L. The cascade aerator at Badger Mill Creek adds approximately 0.5 mg/L of dissolved oxygen to the effluent. The aerator only adds oxygen to the water piped to Badger Mill Creek. Therefore, when the effluent is not running, the aerator is not operating. There has been concern over the impact of effluent on dissolved oxygen in BMC. The Montgomery Associates study[13] found that Badger Mill Creek DO levels were lower than in the Sugar River during a test period in July of 2007. District monitoring during the test period does not indicate any reductions in DO. USGS continuous monitoring shows that without effluent, DO does not appear to be reduced in BMC.

Oxygen demand

Biochemical oxygen demand (BOD) represents the amount of oxygen consumed by bacteria and other microorganisms as they decompose organic matter under aerobic (oxygen present) conditions at a specified temperature. Organic matter serves as food for microorganisms. The more organic matter present in a sample, the more oxygen is required and the higher the BOD, which results in oxygen more rapidly depleting from a water body.

Carbonaceous BOD is a subset of BOD. BOD results are based on DO depletion from both carbonaceous and nitrogenous actors in a wastewater sample. CBOD measures DO depletion from only carbonaceous sources. The District's WPDES permit CBOD requirements vary depending on the time of year; November through April, a monthly average 16 mg/L daily 24-hour flow-proportional composite limit is in effect. For May through October, a CBOD monthly average of 7.0 mg/L daily 24-hour flow-proportional composite limit is in effect. In general, even well-treated effluent contains an oxygen demand.

District in-stream sampling results for DO

The District maintains a stream sampling program, and District crews take multiple samples from the District's effluent streams monthly. These samples are evaluated for a variety of parameters, including DO. For comparison, only comparable periods from previous months are shown. In general, DO does not appear to be negatively impacted by the reduction in District effluent during the test period. Since DO

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[13] *Resource Assessment and Development Analysis for the Upper Sugar River and Badger Mill Creek Southwest of Verona, WI, Montgomery Associates 2007,* [link]

swings can be higher during summer months, we also consulted the previous Montgomery Associates Study,[14] which included a July test period.

	Bruce St.	Lincoln St.	CTH PB	STH 69
1/8/2020 8:00:00 AM	10.8	9.73	10.3	10.9
2/5/2020 7:30:00 AM	9.11	8.88	8.99	9.5
1/5/2021 7:30:00 AM	9.02	8.78	8.54	10.3
2/3/2021 7:30:00 AM	10.5	9.84	9.89	12.6
1/12/2022 7:30:00 AM	8.35	9	9.33	9.76
2/9/2022 12:00:00 AM	9.23	7.37	9.03	11
1/18/2023 7:00:00 AM	10.1	9.58	9.93	11.5
2/8/2023 7:00:00 AM	11.3	10.3	9.99	12.3

Table 7 - District in-stream monitoring DO results; measured in mg/L.

Note: *The highlighted rows represent test periods without District effluent contribution.*

Montgomery Associates monitoring results

In July 2007, Montgomery Associates did a study[15] that assessed DO in Badger Mill Creek and the Sugar River in the early morning hours, when DO is near its daily minimum and changing slowly. At the time, District effluent was running at its standard rate. This test design allowed for comparing daily minimum DO between sites to detect patterns. This survey indicated that DO is 1 to 2 mg/L lower for Badger Mill Creek than for the Sugar River (Figure 11). This in-stream data was confirmed using data from the USGS Bruce Street and USGS Sugar River at STH 69 gaging station data (Figure 12). In general, even though District effluent must maintain a concentration of dissolved oxygen, because of the remaining BOD/CBOD and/or food in the water, DO concentrations decrease with the effluent.

[14] *Resource Assessment and Development Analysis for the Upper Sugar River and Badger Mill Creek Southwest of Verona, WI, Montgomery Associates 2007, link*

[15] *Resource Assessment and Development Analysis for the Upper Sugar River and Badger Mill Creek Southwest of Verona, WI, Montgomery Associates 2007, link*

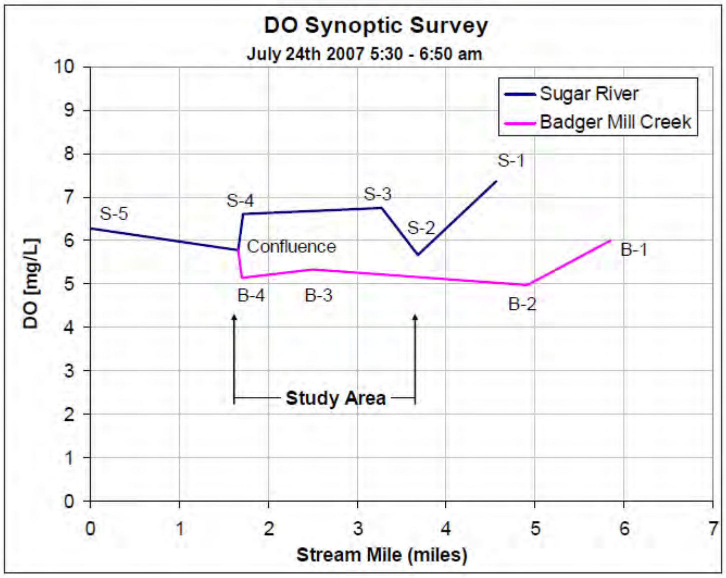
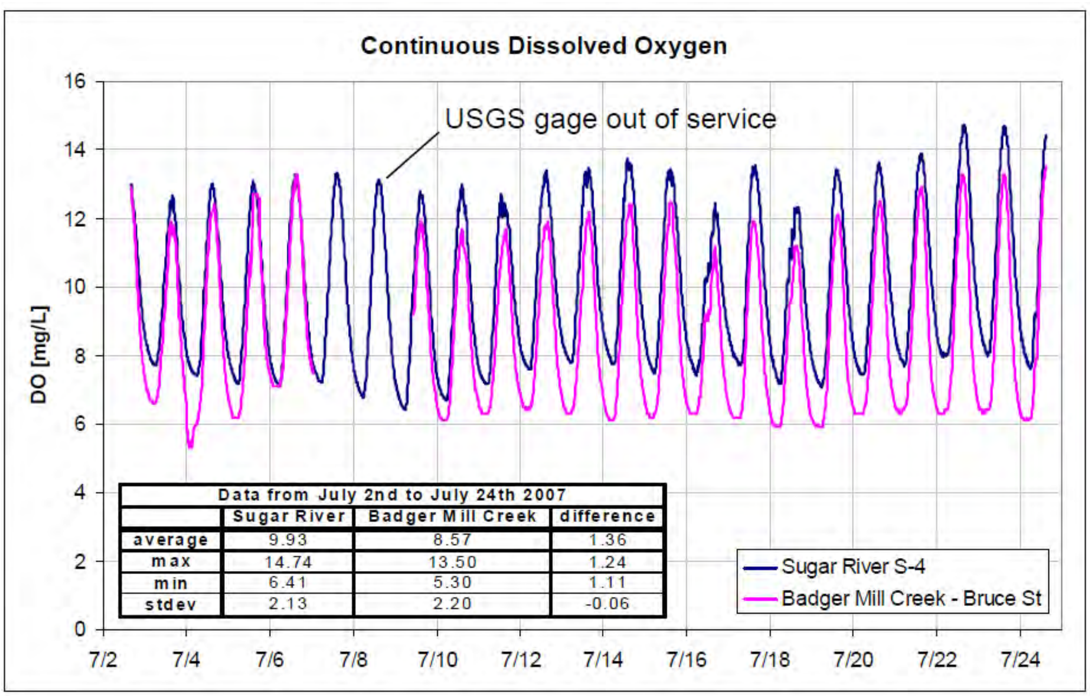


Figure 25. Dissolved Oxygen Synoptic Survey of Daily Low Temperatures for SR and BMC (07/24/07)

Figure 11 - Montgomery Associates DO Survey Figure 25 [16]



Data from July 2nd to July 24th 2007			
	Sugar River	Badger Mill Creek	difference
average	9.93	8.57	1.36
max	14.74	13.50	1.24
min	6.41	5.30	1.11
stdev	2.13	2.20	-0.06

Figure 12 - Comparison of DO from USGS Gaging Stations, Montgomery Assoc. 2007 report [2]

[16] *Ibid.*

USGS dissolved oxygen monitoring

The USGS monitoring stations at Bruce Street on Badger Mill Creek and Highway 69 in the Sugar River contain long-term dissolved oxygen data. Figure 13 shows the long-term DO trend in Badger Mill Creek. Figure 14 shows the January 2022-April 2023 data, which includes the period when effluent was ceased in Badger Mill Creek (February and March 2023). The Montgomery Associates study illustrates that during periods of warmer temperatures, Badger Mill Creek with District effluent tends to have lower DO than the Sugar River. The USGS gaging stations show that without District effluent, there does not appear to be a negative impact associated with removing the effluent.

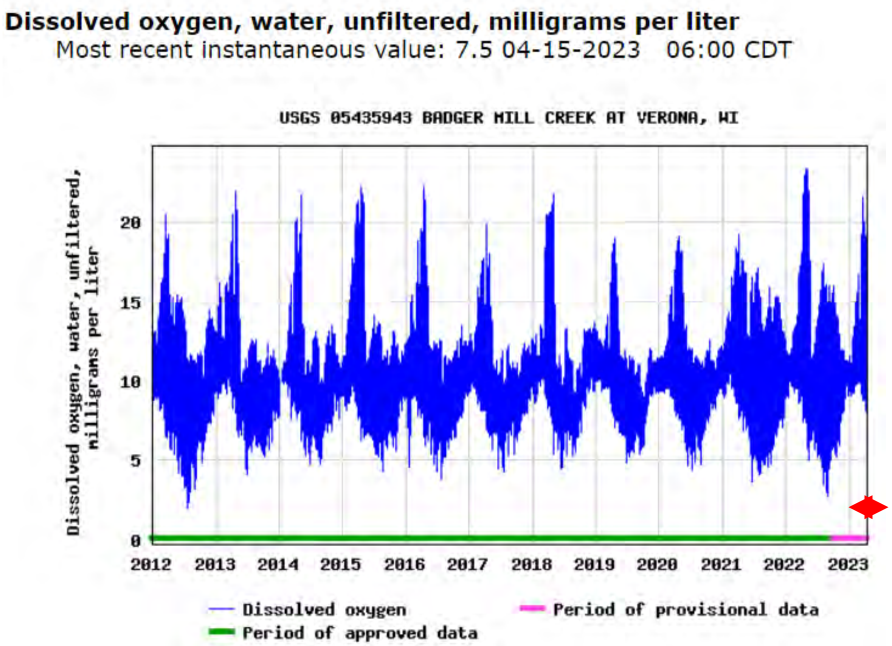


Figure 13 - USGS DO in Badger Mill Creek 2012-present (Red arrow is the period without effluent return)

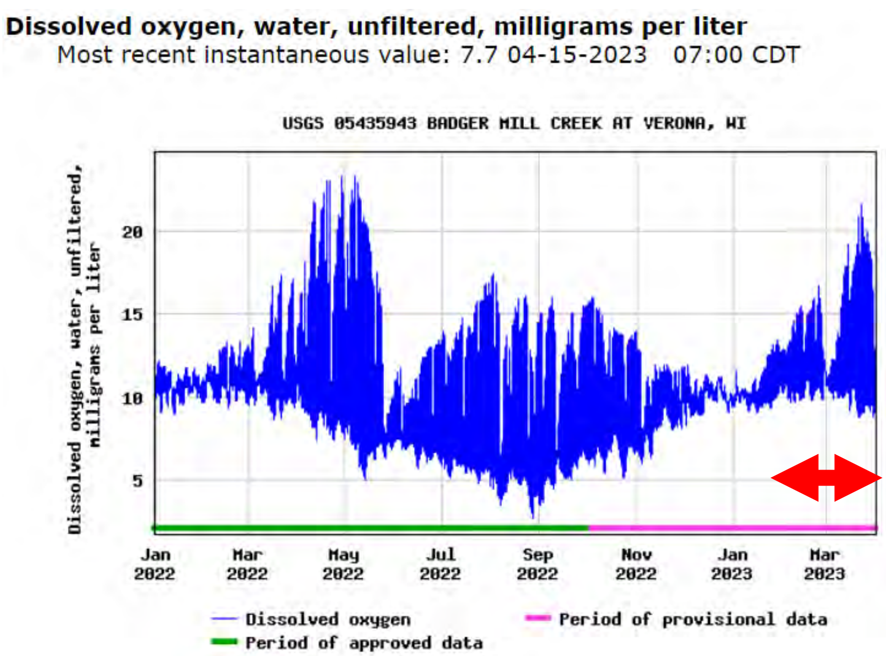


Figure 14 - USGS DO in Badger Mill Creek Jan 2022 to present (period effluent was off is shown by red arrow.

Temperature

The District's effluent exceeds the sublethal criteria set by the WDNR for temperature (Figure 15) for limited forage fish (LFF), small warm water fishery (W-S), and cold water community (C) classifications. The most restrictive classification, cold water community or C, is generally referred to for trout communities (Figure 15 and Table 8).

Table 7
Raw Monthly Sub–Lethal Criteria for Use In Determining Final Sub–Lethal Criteria with Site–Specific Ambient Temperatures
(All values are expressed as degrees Fahrenheit)

Month	C	W–L	W–S	LFF	NIL	SIL	MR	RR	UWR
January	47	50	50	54	50	50	50	50	50
February	45	50	50	54	50	50	50	50	50
March	53	54	54	54	54	54	54	54	54
April	59	65	65	64	63	64	65	65	65
May	59	70	70	75	70	70	70	70	70
June	67	72	72	75	72	72	72	72	72
July	68	74	74	75	75	74	74	74	74
August	68	78	78	77	77	77	78	78	78
September	52	87	87	92	87	87	87	87	87
October	52	54	54	54	54	54	54	54	54
November	50	50	50	54	50	50	50	50	50
December	46	50	50	54	50	50	50	50	50

Month	LWR	LFR	SGB	NGB	SLM	NLM	LS	CB
January	50	50	50	44	44	44	42	42
February	50	50	50	43	43	43	43	43
March	54	54	54	54	52	54	52	52
April	65	65	60	59	61	60	58	58
May	70	70	66	64	67	65	65	65
June	72	72	70	67	68	67	67	67
July	74	74	70	68	68	68	69	69
August	78	78	71	67	67	67	69	69
September	87	87	83	79	79	79	79	79
October	54	54	50	50	50	50	45	54
November	50	50	47	47	47	47	44	46
December	50	50	47	45	45	45	43	44

C = Cold = waters with a fish and other aquatic life use designation of "cold water community"
W–L = Warm –Large = waters with a fish and other aquatic life use designation of "warm water sport fish community" or "warm water forage fish community" and unidirectional 7Q10 flows ≥ 200 cfs (129 mgd)
W–S = Warm – Small = waters with a fish and other aquatic life use designation of "warm water sport fish community" or "warm water forage fish community" and unidirectional 7Q10 flows < 200 cfs (129 mgd)
LFF = waters with a designation of "limited forage fish community"

Figure 15 - Wisconsin DNR Sub-Lethal Temperature Criteria for various classifications

The District's WPDES permit requires reporting for maximum mean daily temperatures. The effluent is up to 20 degrees Fahrenheit warmer than allowed (Table 8). Because the effluent temperatures are too warm, the District is required to apply for, and WDNR and EPA need to approve, Alternative Effluent Limits to continue discharging to Badger Mill Creek. These are not guaranteed and must be approved during each five-year permitting cycle.

In addition, to the warmer winter temperatures, WDNR trout fishery data notes that for cool-cold mainstem trout streams, which is how Badger Mill Creek is classified, the daily maximum mean temperature should be between 68.5 degrees and 72 degrees Fahrenheit. For the District's current WPDES permit term, the maximum mean daily temperatures currently exceed those criteria in June, July, August, and September. Without effluent, there will be more natural fluctuation of temperature, allowing for cooler temperatures in the warmer months.

Through years of in-stream temperature monitoring, the District has not found significant (more than 0.5 degrees) temperature changes from the Nine Springs plant to the effluent return location. Therefore, without effluent, lower evening temperatures will likely reoccur in Badger Mill Creek and benefit the stream's biology.

	District effluent daily mean Maximum temperature (deg F), current permit term	WDNR Thermal Criteria LFF & *degrees effluent exceeds criteria*	WDNR Thermal Criteria for Small Warm & *degrees effluent exceeds criteria*	WDNR Thermal Criteria Cold & *degrees effluent exceeds criteria*
January	57.35	54 *(4)*	50 *(7.4)*	47 *(10.4)*
February	55.68	54 *(1.7)*	50 *(5.7)*	45 *(11.7)*
March	56.5	54 *(2.5)*	54 *(2.5)*	53 *(3.5)*
April	59.95	64	65	59 *(1)*
May	64.24	75	70	59 *(5)*
June	68.89	75	72	67 *(1.9)*
July	71.64	75	74	68 *(3.6)*
August	72.96	77	78	68 *(5)*
September	72.38	92	87	52 *(20.4)*
October	71.53	54 *(7.5)*	54 *(17.5)*	52 *(19.5)*
November	66.32	54 *(12.3)*	50 *(16.3)*	50 *(16.3)*
December	61.84	54 *(7.8)*	50 *(11.8)*	46 *(15.8)*

Table 8 - District effluent temperatures compared to various sublethal criteria

***Note:** The highlighted rows represent test periods when District mean maximum temperature exceeds sublethal thermal criteria.*

Metals

While the wastewater treatment plant removes many constituents and creates high-quality river water, a variety of constituents remain in treated effluent. During the test period, metals were included in the in-stream sampling in February 2023. Comparisons were made to effluent data and the previous year's February data. Copper, nickel, and zinc are shown below. Without effluent contribution, metals in the stream appear to be decreased. The effluent was entirely shut off on February 6, 2023, and the sampling date in February was two days later, which is believed to have had some influence on the results. The Montgomery Associates report[2] notes that Badger Mill Creek's water quality was near EPA freshwater aquatic life chronic standards for cadmium and lead in 2007. The average effluent concentrations and the sampled water are included below.

Copper

Effluent concentrations range from 3.83 parts per billion (ppb) to 13.6 ppb over the past two years, with an average concentration of 8.56 ppb. Monthly stream sampling identified an in-stream reduction in copper concentration during the effluent shutdown test period. Metals sampling is not done in-stream each month, and the February 8, 2023 date was two days after the effluent was fully shut off.

	Bruce St.	Lincoln St.	CTH PB	STH 69
2/9/2022 12:00:00 AM	3.3	4.97	5.31	2.62
2/8/2023 7:00:00 AM	0	2.21	0	0

Table 9 - District in-stream monitoring for copper; measured in ppb.

Note: *The highlighted row represents test period without District effluent contribution.*

Nickel

Effluent concentrations have ranged from 1.4 ppb to 2.11 ppb over the past two years, with an average concentration of 1.78 ppb. Monthly stream sampling identified an in-stream reduction in nickel concentration during the effluent shutdown test period. Metals sampling is not done instream every month. The February 8, 2023 date was two days after the effluent was fully shut off.

	Bruce St.	Lincoln St.	CTH PB	STH 69
2/9/2022 12:00:00 AM	1.92	1.96	1.87	1.85
2/8/2023 7:00:00 AM	0	1.96	1.14	0

Table 10 - District in-stream monitoring for nickel; measured in ppb.

Note: *The highlighted row represents test period without District effluent contribution*

Zinc

Effluent concentrations have ranged from 30.9 to 65.8 ppb over the past two years, with an average concentration of 48 ppb. Monthly stream sampling identified an instream reduction in nickel concentration during the effluent shutdown test period. Metals sampling is not done instream every month. The February 8, 2023 date was two days after the effluent was fully shut off.

	Bruce St.	Lincoln St.	CTH PB	STH 69
2/9/2022 12:00:00 AM	34.1	39.8	46.6	30.4
2/8/2023 7:00:00 AM	13	16.9	9.36	13.9

Table 11 - District in-stream monitoring for zinc; measured in ppb.

Note: *The highlighted row represents test period without District effluent contribution*

Mercury

The District's WPDES permit includes mercury standards of 1.3 ppt (parts per trillion). The District's work on source reduction has helped decrease influent mercury from over 200 ppt in 2007 to around 50 ppt in 2022 (Figure 16). The treatment plant further reduces these influent (arriving) to effluent (leaving) concentrations. Over the period of the effluent return, the district has seen decreases from over 5 ppt to closer to 1.3 ppt. Because the District's effluent is not routinely under 1.3 ppt, it has applied for and received a variance with each of its last three WPDES permits. The District will apply for a variance again with its next WPDES permit as mercury at very low levels is very difficult to completely remove from water, and mercury is a known neurotoxin in aquatic environments.

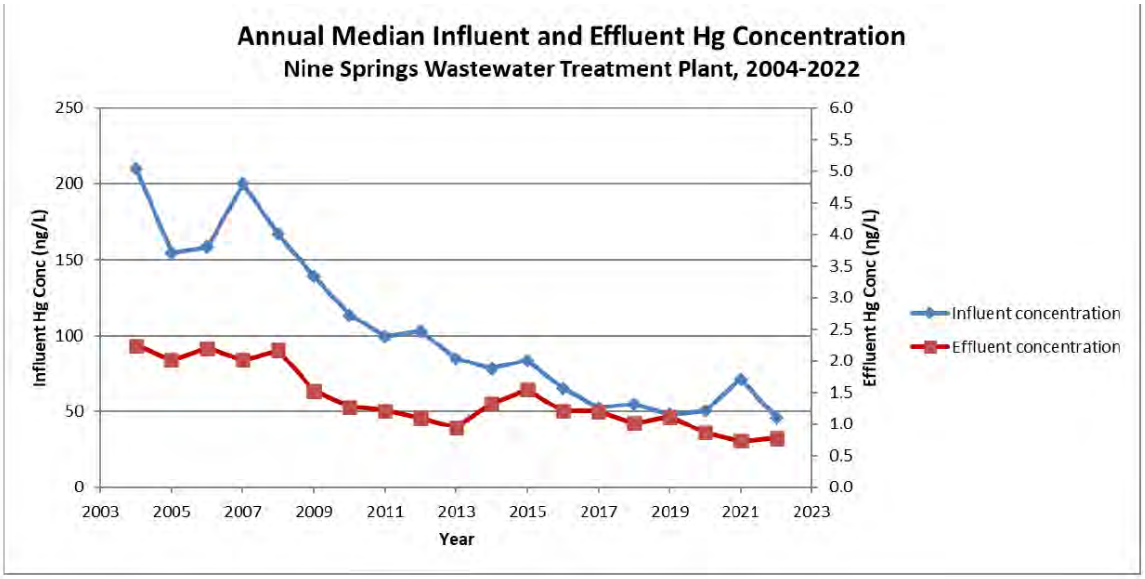


Figure 16 – Annual District median influent & effluent mercury concentrations, 2004-2022

Smell

Treated effluent has a distinct smell. The lack of this usual smell was noticed by some individuals in the observations submitted in the digital application (Exhibit J). Without effluent in Badger Mill Creek, the scent of effluent is no longer present.

Pharmaceuticals, personal care products, and chemicals of emerging concern

As with other constituents in water, the wastewater treatment plant receives a variety of chemicals, pharmaceuticals, and other additions to the water each day. USEPA notes that "there are over 20,000 prescription drugs and personal care products (PPCPs) approved by the Food and Drug Administration (FDA). In addition, there are also chemicals of emerging concern (CECs). While these products can positively impact the quality of human life and provide lifesaving treatments, one unintended result is that some products are also making their way into the nation's water.

Many of these products come from human waste. Wastewater treatment plants (WWTP) and septic systems were not designed to treat CECs, especially PPCPs. WWTPs were originally designed to handle degradable organic material like human waste at high concentrations. CECs tend to be larger, more complex compounds found in low concentrations. Traditional treatment may remove some types of CECs from waste; however, there are multiple common CECs that are not removed by standard biological treatment. The District has reviewed effluent data and found a variety of these constituents in low concentrations. Without effluent contribution to the watershed, additions of these constituents would also cease.

Possible enhancements

While this analysis did not find negative impacts to discontinuing effluent return to Badger Mill Creek, the analysis did find a variety of opportunities to enhance the stream corridor. Some of these are included below.

Streambank and channel

Flow was seen throughout the corridor throughout the period of no effluent in Badger Mill Creek. The upstream-most site that EOR monitored was immediately downstream of a natural channel obstruction where the water widened into a pool. The EOR study shows that stream velocities could be low in wider sections in the upstream portions of Badger Mill Creek during low-flow conditions. The current channel has been designed or naturally changed to accommodate the much larger flood flows. There is an opportunity to strategically design the stream to reinforce a narrower, low-flow channel in the upper portion of Badger Mill Creek, which could provide natural low-flow channel conditions. In the Badger Mill Creek reach between CTH PB and Bruce Street, stream re-meandering and lower-flow channel creation are created using habitat structures designed to capture sediment during high-flow events. This approach was recommended by WDNR's Dan Oele and included in the Chapter 30 permit application for habitat improvements.

Habitat

The upper reaches of Badger Mill Creek were found to have significant muck and sediment deposits. Excavating or dredging that material could improve the overall habitat within the stream corridor and provide better fish habitat and stream aesthetic. Habitat structures could also be added to help with channel re-meander and habitat. In addition, Dane County has a countywide program focused on removing similar legacy sediments to improve the overall health of Dane County's waterways.

Flow

Rainfall trends have been increasing in the region, resulting in flooding challenges for areas upstream of the current effluent discharge location. The City of Fitchburg and Town of Verona have collaboratively worked on a project, the Fitchrona Road Study, and the study's recommendations aim to alleviate flooding and lower the current water levels in the Goose Lake area. Other flooding and erosion challenges persist in the region. Overall stormwater flow patterns have changed over time, and the area could benefit from an overall assessment. These additional surface and groundwater resources are helping to supplement flow in Badger Mill Creek, and there could be a unique opportunity to leverage upstream stored water to provide for additional low-flow mitigation. In addition, adding more infiltration practices and/or enhancing local wetlands may help increase shallow groundwater and aid streamflow.

Temperature

District effluent is more than 10 degrees warmer than allowed for warm-water streams and up to 20 degrees warmer than the requirements for cold-water streams. Even without District effluent, the stream is fed by stormwater, which could have warmer temperatures at certain times of the year. Current stormwater requirements in the Sugar River basin require thermal controls for stormwater management facilities. There is an opportunity to expand those requirements into the Badger Mill Creek watershed to help the stream maintain cooler temperatures.

Further nutrient removal

Even without effluent, the upstream portion of BMC has significant legacy sediment and muck. It also shows higher total phosphorus numbers. Removing legacy sediment from this area will likely help both the habitat and provide for additional phosphorus reductions stemming from the release of phosphorus from the sediments into the water column. Also, throughout the process, various projects were assessed for possible watershed adaptive management or water quality trading projects. Many of these projects could be helpful for overall stream health.

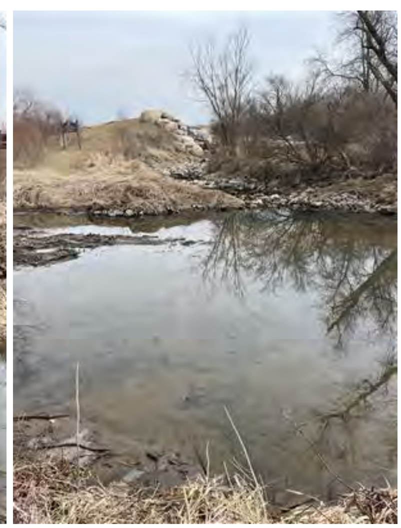
Removal or modification of obstructions

Currently, there are a variety of obstructions within the channel that restrict flow. Animals created some, while others are a result of streambank and habitat structures that were moved during high-flow events. Yet others are the result of sediment deposits, garbage, and vegetation falling into the stream. In addition, there are existing culverts that carry the stream through the Verona airport area. In looking at aerial photos, these culverts appear to be holding flow back and, based on landowner concerns, are causing additional erosion. There is even a bridge sitting on the bottom of the channel; as water moves around this obstruction, it further erodes the banks. Modifying and/or removing these obstructions or mitigating high flows in these areas could help to improve the overall flow in the corridor and the health of the stream.

Photos of sediment



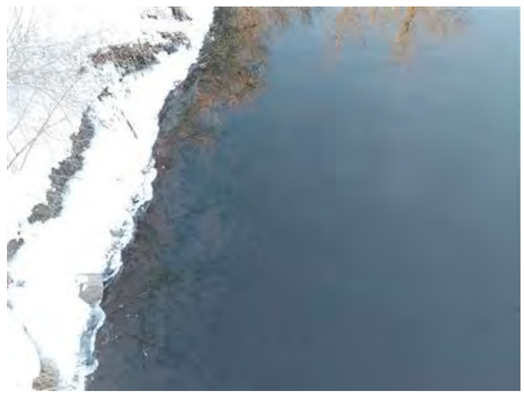


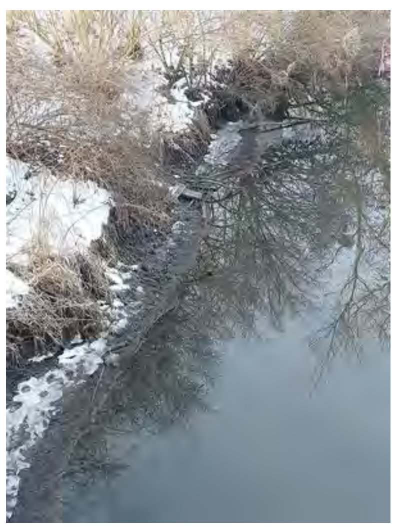


(sediment photos continued on next page)










Photos of vegetation and garbage debris







Photos of animal structures

Photos of bridge

Exhibit D - 28




Many organizations interested in improving water quality

Currently, a variety of organizations, municipalities, friends' groups, and restoration groups are doing great work in the Badger Mill Creek, Sugar River, and Badfish Creek watersheds. Many opportunities exist for these organizations to continue their work with additional District support. Some of these include the Upper Sugar River Watershed Association, Ice Age Trail Alliance, Badger Prairie Community Garden, Farmers for the Upper Sugar, Friends of Badger Mill Creek, Friends of the Badger Mill Creek Environmental Corridor, Friends of Badfish Creek, Goose Lake, City of Fitchburg, City of Madison, City of Verona, Town of Verona, Dane County, and/or others. In addition, there are numerous opportunities and projects in play that will help improve the stream's health. These include the Fitchrona Road Stormwater Study and other projects working toward a water management solution for the area upstream of the current effluent return; expanding Dane County's Suck the Muck project to this corridor; other dredging and streambank protection; invasive species removal; and garbage and obstruction removal.

Exhibit E - Assessment of Watershed Options: Water Quality Trading and Adaptive Management in the Badger Mill Creek Watershed for Phosphorus Compliance

Watershed approaches

Two watershed approaches were assessed as options for phosphorus compliance in Badger Mill Creek – water quality trading and adaptive management. The main difference between the two is how compliance is determined. Adaptive management requires compliance to be determined as achieving the in-stream water quality standard in the receiving stream at a determined point of compliance. On the other hand, water quality trading doesn't require meeting in-stream water quality criteria. Instead, it allows a point source, such as the District, to trade with other point and nonpoint sources to offset the number of pounds of phosphorus discharged by the District.

In the preliminary compliance alternatives plan (PCAP) the District submitted to the Wisconsin Department of Natural Resources (WDNR) in 2022, the District's recommended alternative involved water quality trading in an expanded watershed that included both the Upper Sugar River and Badger Mill Creek watersheds. The expanded watershed was necessary as the District believed that being limited to the HUC 12 watershed, urbanization would prove challenging to find the necessary trades for compliance.

WDNR provided a response letter to the PCAP (Exhibit M), stating it received concurrence from the U.S. Environmental Protection Agency (USEPA) with the position that expanding the trading area beyond the HUC 12 watershed was not available. The District believes this response eliminates the possibility that watershed approaches could be a viable phosphorus compliance strategy for Badger Mill Creek but has continued discussions related to adaptive management and water quality trading to confirm this.

Water quality trading

In general, WDNR's response letter (Exhibit M) notes that while the PCAP recommended water quality trading as a compliance strategy, WDNR would not expand the trading area outside the very urbanized Badger Mill Creek HUC 12 (HUC 070900040201) as requested by the District (Figure 1). The agency further noted that credits generated further downstream or in other watersheds are not able to be used by the District because they determined that they would not aid in meeting water quality standards specifically in the District's receiving water. WDNR further indicated that the District needed to evaluate different alternatives since water quality trading is not a viable compliance alternative.

Following that letter, the District continued to pursue possible trading opportunities, working with landowners and agencies to evaluate and ground truth possible projects. These projects could result in improved water quality, but they alone will not provide the necessary phosphorus reductions required to meet compliance.

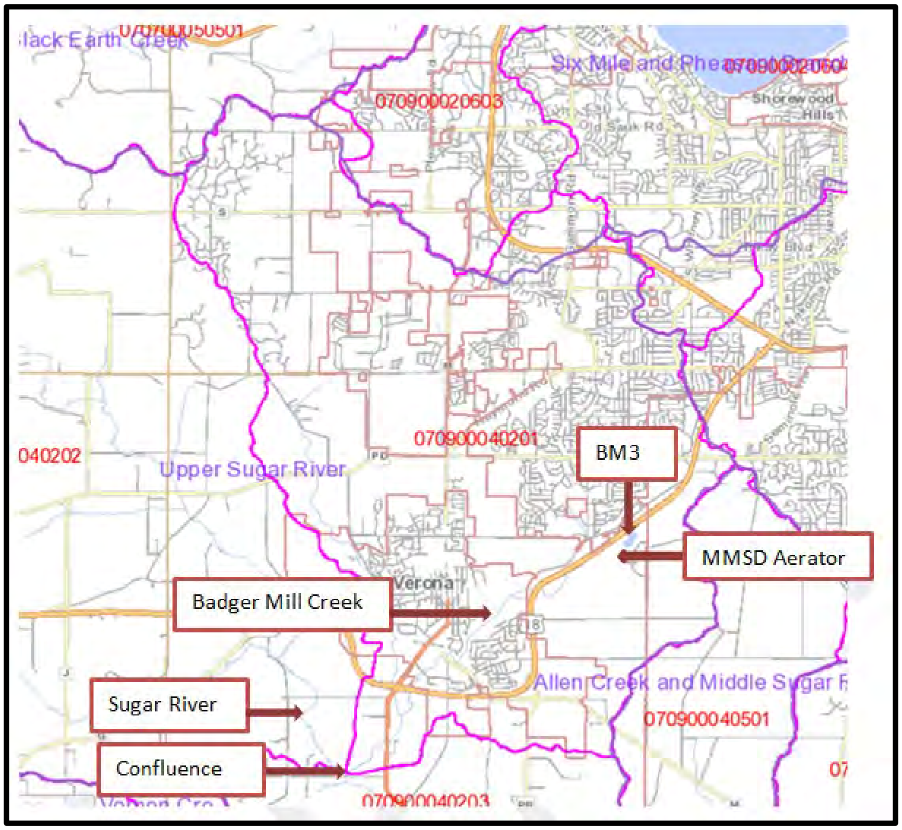


Figure 1 - Location map for HUC 12 watersheds (red numbers) and the District aerator (Outfall 005)

District reduction needed

Per the District's WPDES permit, it must achieve a water quality standard of 0.075 mg/L. This could also be achieved through watershed adaptive management with a target in-stream phosphorus concentration limit of 0.075 mg/L at the point where the District's effluent enters Badger Mill. It could also be accomplished by achieving enough pounds of offset through water quality trading to account for any pounds discharged over the water quality criterion. Given that limit, the average total effluent phosphorus concentration of 0.29 mg/L (Figure 2), and the average flow of 3.4 million gallons per day (MGD), the math for the number of pounds that would need to be offset for water quality trading to work as a compliance option is approximately:

(0.29mg/L-0.075 mg/L) x 3.4 MGD X 8.34 x 365 days/year
= **2,200 pounds of phosphorus reduction for Badger Mill Creek per year**

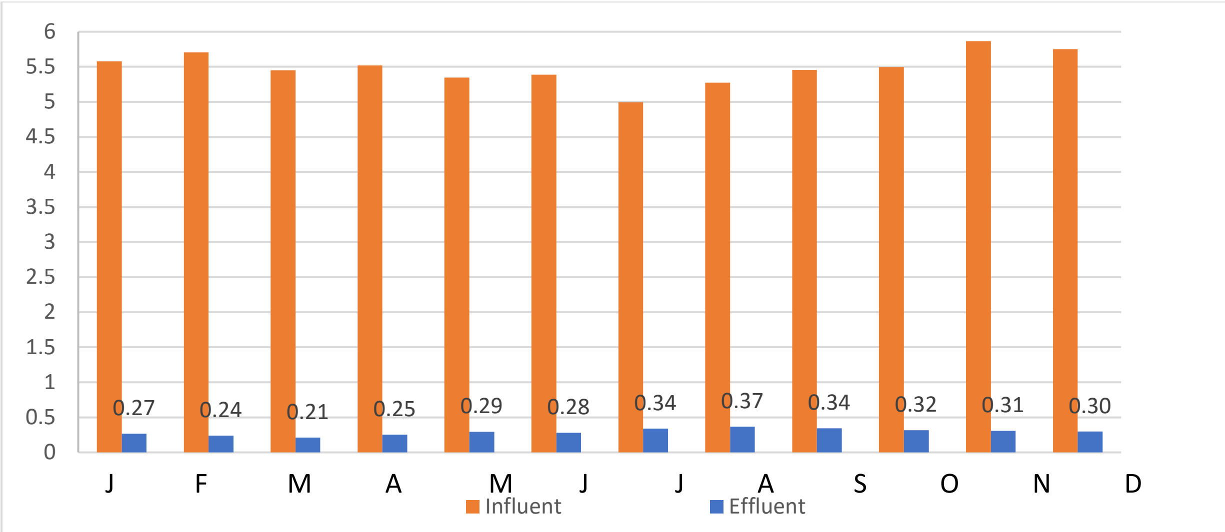


Figure *2* - District Average Monthly Total Phosphorus (TP) Reduction and Remaining TP, 2017 - 2021

Specific to water quality trading, the District discharges approximately 2,200 pounds more phosphorus per year than allowed in our permit. Because of various uncertainties related to water quality trading, the District would need to reduce more pounds through trades than the number of pounds it discharges. DNR's guidance refers to these as trade ratios. In a March 2023 email (Exhibit M), WDNR clarified specific criteria related to water quality trading. Specifically, they noted that for water quality trading, the point of compliance is where the stream receives the discharge. Reductions above that would be considered an "upstream trade," and reductions put in place below that point would be considered a "downstream trade." This means that if all trading pounds are upstream of the point where the District's effluent comes into Badger Mill Creek, the trade ratios are lower than if the pounds enter the creek downstream. Based on WDNR's Exhibit M, the delivery factor would be around 0.1, and the downstream trading factors would be around 0.8. In addition, WDNR guidance notes that the minimum trade ratio would be 1.1:1, and uncertainty factors would be added to the delivery and trading factors, with the trade ratio increasing the factor or ratio. Point-to-point trades generally have lower uncertainty, and construction projects generally have lower trade ratios than agricultural conversion, cropping, or tillage projects. In addition, in-stream habitat improvements can lower trade ratios. All projects intended to yield pound reductions for trades would need to be implemented before the pounds are discharged, and the trades must remain operational during the period that they are used for phosphorus compliance.

When looking at the impact of these ratios on the number of pounds needed to achieve compliance, water quality trading becomes very difficult. Specifically:

- A trade ratio (covered below, Figure 4) of 2.8 equals **6,200** pounds.
- A trade ratio of 4 equals 8,800 pounds.
- Any City of Verona projects that enter downstream of the effluent return are subject to the downstream trading factor, even if they are point-to-point trades.
- Any areas to the south and southeast of the District's aerator or that enter Badger Mill Creek downstream of the aerator will have downstream trade ratios added. This area in the HUC 12 has the largest amount of non-developed land. However, this land faces development pressure, which makes it difficult to find perpetual commitment.

Adaptive management

WDNR's March 2023 email (Exhibit M) noted that whether or not an adaptive management plan expands to include the Upper Sugar River watershed and Badger Mill Creek, the plan would need to achieve compliance with water quality criteria before Badger Mill Creek enters the Sugar River. This means that the water quality criteria would need to be met in Badger Mill Creek, even if an adaptive management plan were expanded to include the Upper Sugar River watershed. Based on phosphorus sampling and USGS monitoring, the amount of pounds that would have to be reduced to meet water quality criteria in Badger Mill Creek is estimated to be in excess of 7,600 pounds of phosphorus reduction and require in-stream monitoring to prove success over time.

The District is experienced with adaptive management through its work on the Yahara WINS project, which is the phosphorus compliance alternative for its Badfish Creek effluent return. To undertake a second adaptive management project, the District would need to make a request to WDNR and create an adaptive management plan, which requires approval by WDNR. To be approved by WDNR, the plan must show a viable pathway to achieving in-stream water quality of 0.075 mg/L in Badger Mill Creek. In addition, reapproval is required every five years and depends on demonstrating sufficient progress toward the goals.

With the District's current phosphorus discharge to Badger Mill Creek around 0.29 mg/L and the substantial existing development within the watershed, there are not enough pounds for reduction to meet the 0.075 mg/L criterion at the compliance point. Therefore, an adaptive management program does not appear to be a viable compliance strategy, as creating an approvable adaptive management plan is challenging and limited by various factors. In fact, removing the District's effluent from the stream would more quickly help the stream meet in-stream phosphorus criteria and with greater certainty.

While there have been ongoing discussions about the health of Badger Mill Creek and its fishery, discussions with the department's biologists have not shown that nutrients are causing impairments to the local fishery. However, WDNR has indicated that additional nutrients could impact downstream waters. Therefore, approaches that reduce nutrient runoff in the broader watershed area could achieve overall nutrient reduction goals and help achieve point source compliance (Exhibit M.)

While the WDNR assessment sounds good in theory, adaptive management requires meeting in-stream water quality standards. This means the stream would need to remain below an in-stream water quality criterion of 0.075 mg/L. For the District, this point of compliance must occur at the location where our effluent meets Badger Mill Creek or at a series of locations downstream from that point on Badger Mill Creek. Based on the in-stream water quality measurements, the number of pounds needed increases as the tributary area of the compliance point increases. If the point of compliance were moved into the Sugar River basin, the number of pounds that need to be reduced is approximately the same, but there is a larger, less urbanized area available to achieve phosphorus reductions.

To determine how many pounds would need to be reduced to achieve the water quality standard, we assessed our stream monitoring data on six-month averaging periods as detailed by WDNR. This data includes grab samples taken at points along Badger Mill Creek and the Sugar River. WDNR states that the six-month average concentration and mass limits apply to the periods of May 1 through October 31 and November 1 through April 30 each year. Therefore, data was assessed based on those periods. At the point where the District's treated effluent enters Badger Mill Creek, approximately 2,200 pounds of phosphorus reduction would be required. The area available for these improvements is mainly north of the effluent return location and highly urbanized. Opportunities for work in this area would mainly involve enhancements to the existing stormwater management system.

Table 1 includes the in-stream total phosphorus Badger Mill Creek and the Sugar River from the past five years of the District's stream sampling. Table 2 includes the average flow from USGS's gaging stations for the Bruce Street and Sugar River at Hwy 69 gages.

	BM7 (Bruce St.)	**Sugar River @STH 69)**
May-October	0.20	0.15
Nov-April	0.12	0.09

Table 1 - BMC instream Total Phosphorus Concentrations for 6-month averaging periods

Flow at Bruce Street Average, May-October	**Flow at Bruce Street Average, November – April**	**Flow at Sugar River STH 69, May to October**	**Flow at Sugar River STH 69, November – April**
31.0 MGD	24.1 MGD	91.7 CFS = 59.2 MGD	79.5 CFS = 51.4 MGD

Table 2 – USGS Flow at various points along BMC by 6-month averaging period

Location & Averaging Period	**Flow (MGD)**	**Phosphorus Concentration**	**Water Quality Standard**	**Pounds to offset per half-year**
Bruce Street, May-Oct	31.0	0.20	.075	5,940
Bruce Street, Nov-Apr	24.3	0.12	.075	1,676
Sugar River @ 69, May-Oct	59.2	0.15	.075	6,758
Sugar River @ 69, Nov-Apr	51.4	0.09	.075	1,174

Table 3 - Pounds to be offset based on averaging period and time

Table 3 uses the data in Tables 1 and 2 to calculate the approximate pounds needed to be offset at different adaptive management compliance points. Based on these calculations, for adaptive management to be successful in the watershed upstream of Bruce Street, approximately 7,617 pounds per year (5,940 lbs. at Bruce St. for May-October + 1,676 lbs. at Bruce St, November-April) would need to be reduced by the end of the adaptive management period, which by statute is 20 years. If the adaptive management plan is expanded to include the watershed upstream of STH 69 on the Sugar River, the total pounds needed to achieve compliance will be about the same, with 7,932 pounds per year. The WDNR email (Exhibit M) indicates that BMC must meet a phosphorus criterion of 0.075 mg/L to meet compliance under adaptive management. This means that a minimum of **7,620 pounds** of the 7,932 pounds would have to be reduced specifically in the smaller, more urbanized Badger Mill Creek watershed. Removing the District's discharge would result in a total phosphorus discharge of approximately 1,800 pounds per half-year [~0.32 mg/l (summer average from Figure 2) x 3.6 MGD (summer flow) x 8.34 x 187], significantly helping the Sugar River and Badger Mill Creek reduce phosphorus concentrations.

The District discharges approximately 2,200 pounds more phosphorus per year to Badger Mill Creek than is allocated. Thus, an adaptive management project would require 5,500 additional pounds of reduction to comply. Table 4 compares how many pounds are required for compliance with the Water Quality Standard for total phosphorus (WQS) to how many pounds would be required to be accomplished for water quality trading (WQT) or adaptive management to be a compliance strategy for the District.

District effluent exceeds WQS by	2,200 pounds

Minimum pounds for water quality trading (WQT)	6,200 pounds (at a 2.8 trade ratio)
Minimum pounds in BMC for adaptive management	7,620 pounds

Table 4 – Comparison of watershed phosphorus reductions needed for compliance

Watershed projects that could reduce phosphorus

We have consulted with agricultural producers and landowners in the watersheds. While we have found some viable trading opportunities with this group in the BMC watershed, the significant development pressure on this area will not allow these trades to be guaranteed for over 10 years. Agricultural producers and landowners indicated that the land may not be in production after 10 years based on land values and development speed. If the District continues to discharge to Badger Mill Creek and wants to use water quality trading as a compliance option, it will need assurance that the trades will remain into the future. We identified one trade opportunity with Dane County that could be possible on a longer-term basis, but that trade is currently restricted to the 12-acre parcel the county owns, which limits the available number of pounds. To move forward with trading as a compliance option, the District needs assurance and longevity. With the continuing growth of the urban service area and urbanization of the watershed, the BMC watershed area (HUC 070900040201) (Figure 3) introduces significant future risk as relying on the long-term continuation of those trades is not certain.

Urban trades

There is opportunity for urban-based practices to be used in a trading program. However, urban phosphorus reduction practices are generally more expensive and less efficient than agricultural practices at addressing phosphorus on a cost-per-pound basis. Urban projects that fall into the category of point-to-point trades have the ability to achieve a trade ratio closer to 1.1:1, reducing the number of total pounds required as part of a trade.

During this analysis, we assessed a point-to-point trading option with the City of Madison (Exhibit M) that could involve active or passive stormwater treatment to remove additional phosphorus. Other municipalities with stormwater facilities in the watershed, including the City of Verona, are not upstream of the District's return point, so any trades in those areas will be subject to higher trade ratios.

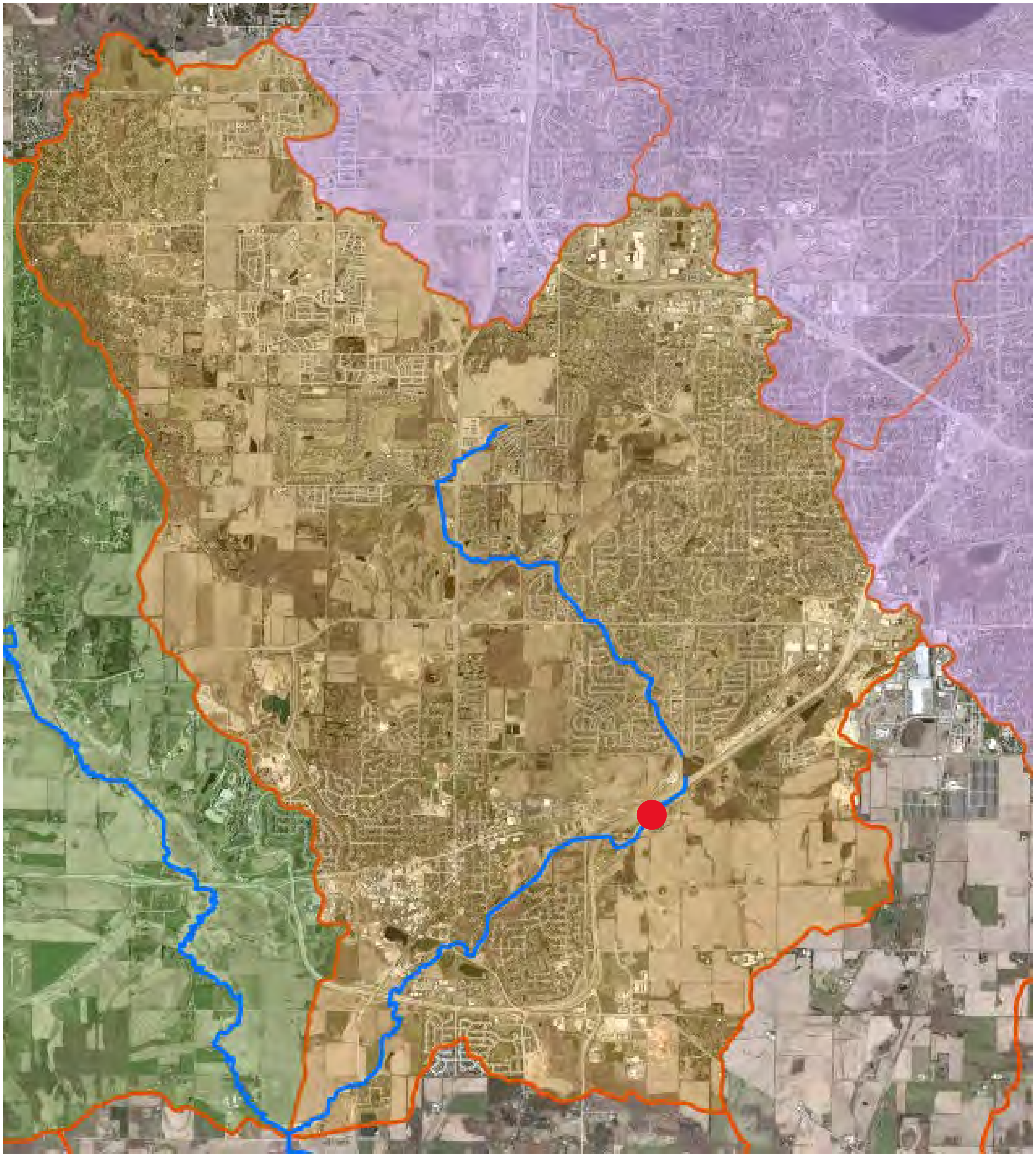


Figure 3 – Highly urbanized Badger Mill Creek Watershed (HUC 070900040201). The HUC 12 is shaded in orange, Upper Sugar River in Green, and the Purple area drains to the Yahara River. The red circle indicates the aerator location.

Environmental corridors

Though much of the Badger Mill Creek watershed is currently developed or will be developed within the next decade, there are still opportunities for water quality improvement. Due to development, access to open land is limited, and any changes to farming practices to obtain phosphorus reductions will be too short-term to meet compliance due to development pressures. With this in mind, land within the watershed deemed inappropriate for development was assessed as another option to utilize under a watershed approach.

Areas within the watershed that are to remain undeveloped to protect water quality and land and water resources are called environmental corridors. These environmental corridors are delineated by the Capital Area Regional Planning Commission[1] (CARPC) in cooperation with local governmental staff within Dane County. Environmental corridors are defined as continuous systems of open space in urban and urbanizing areas and include environmentally sensitive land and natural resources requiring protection from disturbance and development. They are primarily based on drainage ways, stream channels, floodplains, wetlands, and steep slopes. Areas that are not within city boundaries but will require similar protections as development encroaches are called protection areas. Protection areas will become environmental corridors when land is annexed into city boundaries and open for development.

Land acquired for development in Madison and the surrounding area sells for $70,000 to $80,000 per acre or more. Because of this high cost, designating large tracts of land for phosphorus reductions may not be feasible. By focusing efforts on lands designated as environmental corridors,[2] water quality trading could be more affordable and result in longer-term trades. In addition, rather than competing with development interests for land, focusing on environmental corridors and designated protection areas could work with development interests to enhance future open space.

We have identified two areas within the watershed containing active cropland or pasture designated as either environmental corridors or protection areas. In the southern portion of the watershed, there are 38 acres of cropland, 18 acres of managed pasture, and 16 acres of unmanaged pasture within the corridor area. In the northern portion of the watershed, there are a total of 15 acres of mixed cropland and unmanaged woodland surrounding an intermittent stream. This acreage is designated as a protection area and includes an area of steep slopes along the intermittent stream and several small, farmed wetlands. Lastly, additional areas in the southern part of the watershed are identified as protection areas, including approximately 40 acres of cropland recently acquired by Dane County near Badger Mill Creek just before the confluence with the Sugar River.

Basic modeling was completed using SnapPlus[3] to identify potential phosphorus reductions. When running the model, assumptions were made around identifying crop rotation, tillage, nutrient applications, and soil test levels. The state average for soil tests was used for this modeling, which is approximately 50 parts per million (ppm) phosphorus. Soil test levels can dramatically change modeled phosphorus reductions, so it's important to note that reductions will change when actual soil tests are obtained from any potential properties and the model is rerun. For one pasture included in this model,

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[1] *Capital Area Regional Planning Committee, Environmental Corridors, https://www.capitalarearpc.org/environmental-resources/environmental-corridors/*

[2] *Ibid.*

[3] *SnapPlus, https://snapplus.wisc.edu/*

guidance from the Wisconsin Department of Agriculture, Trade and Consumer Protection for pastures[4] was used; this guidance is used when no samples are available, and no mechanical nutrients are added was used. With this guidance, a soil test level of 150 ppm was used for the pasture.

The estimated 'after' scenario assumed that landowners would consider converting modeled acres to permanent grass, knowing that these acres are likely not eligible for development. The modeling results were as follows:

- For cropland acres in the southern part of the watershed (fewer slopes): Phosphorus reductions range from 0 to 1.2 lbs/acre
- Pasture acres[5]: Phosphorus reductions range from 1.5 to 1.75 lbs/acre
- Cropland acres in the northern part of the watershed (steeper slopes): Phosphorus reductions range from 0.3 to 1.3 lbs/acre

Costs to implement permanent grass vary depending on each landowner's situation. Currently, these landowners are likely eligible for federal programs such as CREP or CRP,[6] which provide landowners with a payment to convert farmland to permanent vegetation. Costs for the federal program[7] depend on location and are around $180 per acre in Dane County. Dane County Land and Water Resources Department also has a continuous cover program that pays $150 to $250 per acre, depending on the seed mix.[8] None of the landowners are currently participating in these programs (based on aerial photos). Therefore, the cost associated with these available programs is not enough funding to encourage such change with this subset of landowners. No change in landscape means no phosphorus reductions and no credits to trade with.

Streambank Stabilization or Restoration

Streambank stabilization, restoration, and/or re-meandering can have variable results on phosphorus reduction depending on the streambank soil test phosphorus levels. Examples obtained on the WDNR Water Quality Trading website[9] identify reductions from streambank stabilization between 0.09 and 0.97 pounds of phosphorus reduction per foot of streambank. Reductions are highly dependent on the current streambank conditions and the soil test levels of the streambanks. The higher reductions were associated with both very high phosphorus levels and degraded existing streambanks.

The University of Wisconsin Nelson Institute Water Resource Management Practicums[10] have studied several wetlands throughout the Madison area. In these studies, extremely elevated phosphorus levels are found in the wetlands. Reaches of Badger Mill Creek that flow through large wetlands may provide the largest phosphorus reduction benefits. Examples of urbanized wetland studies include:

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[4] Adding Pasture Applications to Your SnapPlus NM Plan, https://datcp.wi.gov/Documents/AddingPastureApplicationsToYourSnapPlusNMPlan.pdf (DATCP, 2019)
[5] *Ibid.*
[6] *USDA FSA Conservation Reserve Program https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/*
[7] *Ibid.*
[8] *Dane County Land and Water Resource Department, Continuous Cover Program, https://lwrd.countyofdane.com/What-We-Do/agriculture/Conservation-Funding-Opportunities/Continuous-Cover-Program*
[9] *WDNR Adaptive Management and Water Quality Trading Project Locations, https://dnr.wisconsin.gov/topic/Wastewater/AmWqtMap.html*
[10] *University of Wisconsin-Nelson Institute for Environmental Studies, Water Resource Management Practicums, https://nelson.wisc.edu/graduate/water-resources-management/practicum/*

- *Revitalizing a Legacy: A Restoration Proposal for the Nine Springs E-Way (2014*) — Soil tests taken in the Nine Springs Creek Wetland ranged from 1,000 ppm to 2,900 ppm total phosphorus.
- *Restoration of the Arboretum's Eastern Wetlands (2007)* — Soil tests taken in the Gardner and southeast marshes ranged from 1,394 ppm to 5,158 ppm total phosphorus.

Yahara WINS has funded various innovation projects (Table 5), including a few streambank stabilization projects, for phosphorus credit. However, these credits are small in comparison to many agricultural projects. For example, four streambank projects of more than 1,000 feet in length and 3 feet in height only achieved 44 pounds per year of phosphorus reduction. Another 385-foot-long streambank protection project with significant phosphorus in the soil was estimated to reduce phosphorus by 29 pounds per year. While these are valuable projects, they are not at the scale needed to meet the total number of pounds the District requires to meet permit compliance.

Project title	**lbs/year**
Rain garden pilot	0.2
Critical outfall stormwater treatment devices (3)	18
Bioretention	5
Marsh restoration	91
Prairie restoration	52
Rake for the Lakes challenge	43
Bioretention facility	16
Greenway Northwest Pond Enlargement Project	133
Enhanced sand filter	62
Stabilize 350' of eroded Yahara River banks	14
Installation of 2 stormwater treatment devices, dredging of 2,200 cubic yards of accumulated silt & replacement of 2 outfalls	11
Stabilization and restoration of Yahara River streambank	32
Restore existing agricultural field to grass and pollinator cover	66
Streambank restoration	29
Streambank restoration	3
Leaf management pilot projects	18
Streambank restoration	47
Sediment control basin	276

Table 5 - Yahara WINS Innovation Projects and TP reductions per year

Stream dredging

Dredging legacy sediments is also an option to reduce phosphorus from Badger Mill Creek. However, WDNR has informed the District that the agency has not yet encountered a water quality trade based on stream dredging. Dredging is an eligible practice for water quality trading per WDNR trading guidance, but the details regarding phosphorus reduction quantification have not been worked out to date. Nevertheless, the idea of working with WDNR on a pilot project was proposed, and there is potential interest.

Sediment removal conducted by Dane County[11] in 2019 cost $1 million to remove 11,000 tons of sediment from within a two-mile segment of Dorn Creek. It is estimated that 70,000 to 80,000 pounds of phosphorus were removed. Although the total pounds of phosphorus removed is known, it is yet to be determined how the removed phosphorus directly impacts water quality; thus, its value as a trade is hard to quantify. This means it is unknown how many pounds of reduction would be eligible to count as credits toward a trade for permit compliance. To date, the District is unaware of a viable approach to determining phosphorus reduction credits due to dredging but removing sediment that contains legacy phosphorus has been shown to improve water quality and stream health.

[11] *Dane County Land and Water Resource Department, Legacy Sediment Removal,* *https://lwrd.countyofdane.com/CurrentProjects/Detail/Legacy-Sediment-Removal*

Trade ratios

For water quality trading, the point of compliance is where the stream receives the discharge. Reductions above this point are considered upstream trades, and reductions put in place below this point are “downstream trades. The water quality trading guidance document defines how delivery is evaluated (for upstream trades) and a downstream factor (for downstream trades).

> **Delivery factor:** Based on the SPARROW model, there would be a very small delivery factor. The discharge’s SPARROW catchment is 0.85 for a delivery fraction, and there are a few upstream basins with 0.79 delivery fractions. In this case, the delivery factor would add less than 0.1 to the trade ratio.
>
> **Downstream factor:** A downstream factor is used as part of the downstream trading policy that allows credits to be obtained anywhere downstream in the HUC 12 watershed. The percentage of in-stream phosphorus contributed by the point source (at the point of discharge) determines the downstream factor. Using the numbers from WDNR’s PRESTO analysis, Matt Claucherty, WDNR water resources management specialist, notes that it would be in the 0.8 category.
>
> **Uncertainty factors:** As described by WDNR, “The uncertainty factor compensates for the multiple sources of uncertainty that occur in the generation of nonpoint credits. Uncertainties originate from climatic and weather variability, potential inaccuracies in field testing or modeling of the amount of pollutant controlled by a management practice, inability to always synchronize credit generation and use and the episodic nature of nonpoint pollution, and the reliability of a management practice to perform under different hydrologic conditions.” These factors are always above 1 and can be as high as 4 or more. There is some ability to reduce trade ratios by improving aquatic habitats. These could reduce a trade ratio by a whole point in some situations. Trade ratios are covered in more depth in Appendix H of Wisconsin WDNR’s Water Quality Trading Guidance.
>
> **Final trade ratio:** In general, the minimum trade ratio is 1.2:1, but some point-to-point trades may reach 1.1:1. The trade ratio is determined using the following formula:

Trade Ratio = (Delivery + Downstream + Equivalency + Uncertainty) : 1

Figure 4 - WDNR Water Quality Trading Factor determination from Water Quality Trading Guidance.

Yahara WINS potential impact

The District is part of the Yahara WINS adaptive management program within the Yahara watershed. This adaptive management program includes all sources of phosphorus within the Yahara watershed and is the District’s phosphorus compliance strategy for its Badfish Creek effluent return. If flow was redirected from Badger Mill Creek to Badfish Creek, the District could pay additional funds to Yahara WINS to account for this addition of phosphorus to the Yahara watershed. The approximate cost per pound of phosphorus under the Yahara WINS model is $50 per pound for the 2023 calendar year. With 2,200 pounds of phosphorus tied to this redirection of flow, it would cost the District approximately $110,000 each year, resulting in $1,650,000 over the next 15 years. With redirection, the District must recalculate its full allocation for 2024 before September 1, 2023 per the Yahara WINS intergovernmental agreement guidance.

It’s important to note that the Yahara WINS adaptive management program is in its seventh year. It was one of the first adaptive management programs in Wisconsin. As time has progressed, changes have been made based on new understanding and science. Most recently, how phosphorus accounting is done on the landscape has changed. The phosphorus accounting directly impacts the cost of the program. As a result, there is a potential for the cost per pound allocated under Yahara WINS to go up measurably in the coming year.

Analysis

Without a Total Maximum Daily Limit (TMDL) requirement, a timeline for MS4s to comply with WDNR’s NR 151 stormwater standards to ensure certainty of projects or flexibility with the point of standards application and watershed area for trading projects, the number of pounds of reduction needed specifically in the Badger Mill Creek watershed for adaptive management, along with the WDNR’s requirement that all adaptive management projects need to meet in-stream water quality criteria, adaptive management and water quality trading are eliminated as viable compliance strategies.

While the District has looked for long-term trading possibilities in the Badger Mill Creek watershed, the number of non-urban pounds is orders of magnitude below what is needed for compliance, and the urban trades available only partially close the gap. A similar situation applies to adaptive management approaches, and neither provides the District with the certainty nor the reductions required to meet phosphorus reductions in Badger Mill Creek for permit compliance. In addition, both have significant financial, operational, public perception, political, and jurisdictional hurdles to overcome.

Through the District’s work to investigate watershed approaches, it was found that a mix of urban, non-urban, and in-stream practices would benefit the Badger Mill Creek and Sugar River watersheds, helping to further reduce phosphorus, support flow, and enhance the overall health of these waterways and their ecosystems. The best way to move forward with implementing these projects is through committed partners and organizations, with or without the District’s participation.

Exhibit F – Risk and Triple Bottom Line Assessment

Background

Each day, the District faces competing priorities and initiatives. Adherence to its mission of protecting public health and the environment means making tough, thoroughly analyzed recommendations. Using triple-bottom-line criteria helps look at these recommendations from various perspectives to aid a robust analysis. Specifically for this project, total phosphorus compliance in the Badger Mill Creek watershed could be achieved in a variety of ways. Each has its own opportunities and risks. This exhibit compares the compliance options using multiple criteria summarized from a variety of factors, including social, economic, and environmental factors relating to each alternative.

Each category is assessed below, and this table compiles the results:

	Will it work?	Energy	O&M	Reliability	Ability to meet future regulations	Risk	Public Acceptance	Cost
Watershed	▼	=	▼	▼	▼	▼	▲	▼
Treatment	▲	▼	▼	▲	▼	▲	▲	▼
Eliminate BMC Flow	▲	▲	▲	▲	▲	▲	▼ *	▲

Key: Green = More desirable | Yellow = No change | Red = Less desirable

Table 1 - Triple Bottom Line Summary

**Public acceptance is split between those with strong connections to BMC and those focused on district rates and resiliency.*

When the various alternatives are looked at through this lens, the option of reducing effluent flow to BMC rises to the top in all categories except public acceptance. Coupled with an analysis that found the flow elimination option would not harm the stream, the District has proposed a two-pronged approach of eliminating flow to BMC and providing funds for local municipalities and/or organizations to implement enhancements within the corridor to sustain and improve the stream.

Categories of assessment

Will it work?

While projects that could be considered watershed solutions may benefit water quality and stream health, through this assessment, we determined that watershed approaches have very low potential as a regulatory compliance solution for total phosphorus in Badger Mill Creek. Tertiary treatment or elimination of the effluent return to Badger Mill Creek could help the District comply with the total phosphorus requirements contained in its WPDES permit.

Energy

This analysis leverages the work of the District's Energy Management Master Plan.[1] The plan outlines the District's work to reduce energy use, stating:

> For over nine decades, the Madison Metropolitan Sewerage District (MMSD) has served the Madison metropolitan area with safe, reliable wastewater collection and treatment. In recent years, MMSD and stakeholder communities have become increasingly dedicated to sustainable practices, including resource recovery, conservation, and energy efficiency, that protect the environment and public health.
>
> In 2020, MMSD set out to understand how to upgrade or replace aging energy-producing and -consuming infrastructure at the Nine Springs Wastewater Treatment Plant (NSWTP). MMSD sees the need to replace aging infrastructure as an opportunity to consider new ways to improve NSWTP operations and its energy use footprint. MMSD currently reclaims approximately 42 million gallons (MG) of wastewater every day at NSWTP at an energy cost of 90,000 kilowatt-hours (kWh) per day (kWh/day), which is enough to power roughly 3,100 homes. This energy demand is predicted to increase 20 percent by 2040 if MMSD does nothing but maintain existing infrastructure. Additionally, NSWTP's aging energy-producing and -consuming infrastructure will struggle to meet facility needs in their current condition.
>
> To systematically upgrade or replace these aging assets while reducing the plant's energy usage, operational costs, and energy-related environmental footprint, MMSD prepared the 2020 Energy Management Master Plan (Plan), a document that recommends prioritized, targeted improvements to the NSWTP's aging energy infrastructure and energy-management approaches over the next 10 to 20 years.

The Energy Management Master Plan found that effluent pumping is the District's second-highest energy use and that pumping water to Badger Mill Creek takes approximately twice as much energy per gallon than pumping to Badfish Creek. Due to the high energy use, the plan recommended eliminating discharge to Badger Mill Creek and using associated pumps/piping. Pumping all flow to Badfish Creek results in an energy reduction over maintaining the effluent return to Badger Mill Creek.

Adding tertiary treatment would maintain the effluent return to BMC and thus maintain the energy use for pumping and piping. The addition of tertiary treatment also increases energy use. Table 9 from Exhibit A shows that for the recommended tertiary treatment system, Alternative 3, energy use increases by approximately 1,590 MWh/year.

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[1] District Energy Management Master Plan, https://www.madsewer.org/wp-content/uploads/2022/04/2021-REPORT-2020-Energy-Management-Master-Plan.pdf

Technology	Building Footprint (ft^2)	Energy Usage (Mw-h/yr)	Equivalent CO_2 (Ton/yr)	Equivalent SO_2 (Ton/yr)	Equivalent NO_x (Ton/yr)
Alternative 3–BluePRO®	4,000	1,590	1,140	0.28	0.66
Alternative 4–AquaDisk®	4,000	1,570	1,130	0.28	0.65
Alternative 5–CoMag™	5,600	1,650	1,180	0.29	0.69

Notes:
ton=metric ton
ft^2=square feet
Mw-h/year=megawatt hour per year
ton/yr=tons per year
Electrical cost set at 0.085 $/kw-h

Table 9 Estimated GHG Emission Equivalent for Each Alternative

Figure 1 - Table 9 from Exhibit A, Tertiary Treatment Energy and GHG

Operations and maintenance (O&M)

The District's Director of Operations, Maintenance and Reliability analyzed each potential alternative in relation to permit compliance, infrastructure reliability, and financial sustainability. In his memorandum, Risk of Tertiary Treatment Infrastructure Project (Exhibit B), he evaluates the following impacts: disruption and delay in other capital improvements projects; long-term compliance flexibility; infrastructure maintenance needs; and impact on O&M teams' performance. In this memorandum, he notes that from an operations and maintenance (O&M) perspective, tertiary treatment for phosphorus in Badger Mill Creek poses significant risks. Primary factors include (a) harmful delays in other capital projects, notably electrical upgrades, heat and power changes, liquid processing improvements, and general maintenance work; (b) disruption to operations and maintenance teams, hindering their ability to ensure proper plant operations and to implement needed reliability-centered maintenance practices; and (c) the inflexibility that would be created for future regulatory requirements. In general, the ratepayers, community members, and the environment depend on the District making the best overall decisions.

From an O&M perspective, eliminating the return to BMC simplifies District operations and minimizes the number of assets that must be maintained and replaced. Conversely, adding tertiary treatment expands the number of assets and increases the complexity of the District's operations.

Reliability

The Badger Mill Creek effluent return was put into service in 1998, and the pumps, valves, and force main are nearing their design life. In addition, during the reconstruction of Highway 151, soil was removed over the District's effluent return pipe in 2017, leaving portions only about a foot deep. This is a significant concern for District engineering and operations staff if the pipe must be taken out of service during below-freezing temperatures, and it highlights the District's vulnerability and risk with this pipeline for future repairs or emergencies. In addition, more overall assets increase the complexity of the District's reliability-based infrastructure program.

Watershed approaches, including adaptive management or water quality trading, have external dependencies, including the weather, other parties upholding agreements to achieve ongoing compliance, and changes in permit requirements or regulations. In addition, if there are increases in total phosphorus in the District's effluent, it will change the quantity of phosphorus reductions required in the watershed. A future TMDL in the watershed could also increase the District's phosphorus reduction requirements.

Reliably meeting permit compliance through watershed approaches, including water quality trades, must continue as long as the effluent return is maintained. In addition, trades need to be in place and operational prior to a discharge of phosphorus in excess of permit requirements. Therefore, if a trade is planned but is not implemented for any reason, it will not help the District meet compliance. If weather destroys part of a project on the landscape that is needed for compliance, those pounds will not be available for compliance.

Future regulation and permit compliance

Total phosphorus is just one of many requirements in the District's permit. While tertiary treatment and watershed solutions (if feasible to implement) could help the District comply with total phosphorus requirements, neither will help the District comply with temperature standards in Badger Mill Creek or future nitrogen requirements. In addition, Badger Mill Creek's higher stream and fishery classifications lead to more restrictive permit requirements for temperature, Carbonaceous biochemical oxygen demand (CBOD), ammonia, and Total Suspended Solids (TSS). Therefore, future classification changes will future impact District requirements.

Badger Mill Creek is listed as an impaired waterway in relation to total phosphorus. The stream is also listed on WDNR's 303d list and scheduled to become part of a future total maximum daily load (TMDL), which aims at delisting the waterbody. District effluent is one reason that BMC is listed. Without District effluent, the stream moves closer to meeting in-stream phosphorus requirements. If the District continues to discharge to Badger Mill Creek, it will be named in a future TMDL, and additional action will be required.

Risk

The phosphorous compliance alternatives for Outfall 005 include a variety of risks. Each type of risk is unique, yet each risk's impact on decision-making must be contemplated. The Nine Springs Wastewater Treatment plant uses biological processes to clean water. The District balances numerous factors to successfully operate a reliable wastewater treatment plant that consistently removes a variety of constituents, meets WPDES permit requirements, moves toward energy neutrality, is prepared for future regulation, and can operate in the unpredictable natural world. The District takes its mission to protect public health and the environment seriously.

With biological processes, balance is required. For instance, phosphorus and nitrogen compete for the same food supply to obtain removal rates in the treatment process. Currently, the District is not regulated for nitrogen removal, but if nitrogen regulations are promulgated as expected, and the plant adjusts to remove more nitrogen, total phosphorus concentrations may slightly increase. Overall, the environmental outcome of total nutrient reduction would be achieved, but if total phosphorus concentrations go up, even slightly, it would require more pounds to be offset with watershed approaches for phosphorus compliance. This would be more difficult to account for in the highly urbanized Badger Mill Creek watershed.

Watershed approaches depend on partners, landowners, and the weather and are considered less reliable than built infrastructure — this is why trade ratios are included with approved water quality trades. Adaptive management involves meeting in-stream water quality criteria. Therefore, any changes within the watershed could impact the ability of the overall project to succeed.

To move forward with an adaptive management project, an adaptive management plan must be approved by WDNR. The approval of the adaptive management plan and permit requirement of adaptive management is not immediately guaranteed for 20 years. Compliance reports need to be submitted each year to show progress toward the overall goals, and WDNR reviews the adaptive management every five years. If the agency believes sufficient progress is being made, another five-year window will be granted. If WDNR finds that progress is insufficient, the plan can be pulled, and the District would be left to implement a different solution. Additionally, if the stream is not in compliance after the 20-year period ends, the District would need to deploy another solution to achieve compliance.

The District will incur future risk by maintaining Outfall 005, requiring operation and maintenance (pumps, force main, etc.), and the ability to comply with current and future regulations. As presently noted, it is clear that nitrogen requirements will be required. In addition, the District already has alternative effluent limits (AEL) for temperature specific to the Badger Mill Creek outfall, which will need to continue in future permits. Furthermore, when assessing current discharge information, we expect that the number of months requiring AELs will increase in the future, even with the same stream classifications. The current stream classification and uncertainty regarding future classification changes for Badger Mill Creek increase the risk of continuing discharge to Badger Mill Creek as it could trigger more restrictive limits for temperature and/or other parameters.

There is risk inherent to all wastewater treatment design and decision-making. While the District has two effluent discharge locations, there is only one treatment process, so the same effluent flows to both discharge locations. Therefore, if there is a violation of any parameter that impacts both streams, we are reported as having two violations. This is a risk with our regulators, WPDES permit, and public perception. In addition, the stream classification difference between Badfish Creek and Badger Mill Creek creates additional risk for current and future regulations by maintaining a discharge in Badger Mill Creek.

Throughout this analysis, local residents and organizations in the Badger Mill Creek area have focused on the risk to stream during low-flow periods if the effluent return were no longer present. The analysis contained in Exhibit E and discussions with experts, including individuals who were part of the original decision to return effluent to Badger Mill Creek, counter this narrative. While stream flow during extreme low flows will be less without District effluent, this would be most pronounced upstream of CTH PB where the stream habitat suffers from a variety of other challenges, including woody vegetation impeding flow, a bridge sitting on the stream bottom, significant sediment build-up, and bank erosion. Since flow exists in the corridor with or without effluent return, other improvements to the stream will likely provide more overall health improvements than maintaining effluent return. In addition, flooding and rising water levels are currently occurring upstream of the effluent return.

If all effluent were returned to Badfish Creek, the scale of the Yahara WINS adaptive management project would need to increase proportionally. That project is now in its seventh year, and additional practices would need to be funded and put in place to accommodate the additional pounds of phosphorus. Yahara WINS has agreed to take on these additional pounds and believes it can make the needed phosphorus reductions as part of the existing project. The cost for Yahara WINS could increase in future years.

Finally, when assessing watershed solutions, the pounds needed to be achieved and maintained will increase if the total phosphorus returned exceeds the allocation in the District's WPDES permit, which is reviewed and reissued every five years. Relying on watershed solutions increases the risk for WPDES permit compliance due to the ongoing urbanization and development of the area. It is also risky to tie permit compliance to the actions of other entities and the natural risks that may occur while working in a natural environment; for instance, if drought or flooding destroys a practice, we could no longer count it.

Public acceptance

The District is funded by ratepayers in the 25 owner communities that send wastewater to the Nine Springs Plant. Those individuals and communities have pushed for the District to make sound fiscal decisions. Rate increases have been discouraged throughout our public comment period and in our annual budget process through the years.

Specific to Badger Mill Creek, public acceptance falls broadly into two categories. Residents and organizations deeply connected to Badger Mill Creek have expressed strong opposition to any alternative that discontinues flow to BMC. Conversely, ratepayers and owner communities less connected to BMC have asked the District to make smart, long-term decisions in relation to rates and infrastructure reliability.

Cost

Watershed approach

The District's phosphorus compliance option for Badfish Creek involves a watershed adaptive management approach called Yahara WINS, and the District has been a leader in this project. Because of this experience, we understand what it takes to move watershed approaches forward, and our assessment of using this approach for phosphorus compliance in Badger Mill Creek has determined that it is not feasible. There is not enough undeveloped land, there are not enough partners or nonpoint projects, and the projects that are possible are downstream of our effluent return, would either increase the trade ratio, with respect to water quality trading, or increase the number of pounds needed for compliance with respect to watershed adaptive management. Applying Yahara WINS costs per pound to this watershed and using the pound reduction needed for compliance would have led to the assumption of a project of around $110,000. However, the District has found that reducing 2,200 or more pounds upstream of our effluent return in the Badger Mill Creek watershed will cost over $15 million. This difference in cost is because of the limited non-point-reduction possibilities and the need to use urban practices.

Nonpoint practices that lead to reduction are generally implemented a lower cost than urban practices. For example, our cost analysis showed that just one point-to-point treatment project alone is budgeted at over $10 million and would not accomplish sufficient pounds. Land values in the watershed exceed $70,000 per acre. Trade ratios will increase the number of pounds required to be obtained by a factor of 2 to 4 if the District expanded the watershed to include the area down to the confluence with the Sugar River for either watershed adaptive management or water quality trading. This makes achieving compliance through watershed approaches, when relying on urban practices as the main source of reductions, similar in cost to treating effluent at the wastewater treatment plant.

When looking at point trade possibilities, such as treating stormwater to remove additional phosphorus, the costs are similar to tertiary treatment, but the project complexity increases because the District does not own or operate stormwater systems. The stormwater system upstream of the discharge location is in the City of Madison, which has struggled with community support for alum treatment or similar systems. City of Verona stormwater projects enter Badger Mill Creek downstream of the effluent return and are thus subject to higher trade ratios, which make them more expensive per pound. The City of Fitchburg and Town of Verona are working on stormwater projects that are not yet connected to Badger Mill Creek and may or may not come into Badger Mill Creek downstream of the effluent return location.

Discontinuance

The operational costs associated with discontinuing flow to Badger Mill Creek include removing assets from service and decommissioning the assets from our systems. Savings will be found through reducing the operations and maintenance activities associated with the effluent return force main and effluent pumps; less instream effluent testing and biological testing; less whole effluent toxicity testing; less reporting to WDNR; elimination of alternative effluent limits and associated temperature reporting; and an overall less complex WPDES permit. Discontinuing effluent return to Badger Mill Creek will involve buying into Yahara WINS for the pounds that are moved to the Badfish Creek effluent return. At current Yahara WINS price per pound, this will involve approximately $110,000 each year in additional District contribution to Yahara WINS. For a 20-year adaptive management project, that would involve a District investment of $2,200,000. Currently, Yahara WINS is reviewing its cost model and has cautioned that the prices may increase in the future. Even if the Yahara WINS's costs doubled in price, this alternative would also be less expensive than the other two alternatives. In addition, there will be cost savings realized from this alternative. There will be energy savings and operations and maintenance savings each year. Finally, the recommended alternative also includes enhancement projects to improve the overall health of Badger Mill Creek. These are estimated to raise the cost of this project by another $1,000,000.

Treatment

Adding tertiary treatment at the Nine Springs treatment plant to remove the phosphorus needed to comply with water quality standards for the BMC effluent alone will cost between $19 and $24 million and raise rates for owner communities by 2% to 3%. In addition, this cost only addresses total phosphorus for the 8% of District flow returned to Badger Mill Creek. The treatment solution selected for BMC, BluePro, could be expanded to remove additional nitrogen from Badger Mill Creek in the future, albeit at a significant cost. In addition, this system would not be the solution selected if the District were to assess total phosphorus treatment for all its effluent. The scale of a system needed to reduce phosphorus in all the District's effluent to 0.075 mg/l is significantly different and the technology screening would be very different.

Adding treatment to remove phosphorus from Badger Mill Creek is just one in a series of investments of time and money that will be required to maintain the effluent return to Badger Mill Creek. Historically, the District invested the equivalent of $25 million in today's dollars to create the return piping and pumping. Now, the District is looking at a similar investment for phosphorus reduction. The District already has temperature requirements in Badger Mill Creek it is unable to meet. In addition, the District faces more stringent WPDES requirements in Badger Mill Creek than in Badfish Creek because of BMC's current classification, yet there is ongoing discussion on making that criterion even more stringent. For instance, we are required to do nitrogen monitoring that we believe will lead to future nitrogen requirements. Therefore, maintaining the return of effluent to Badger Mill Creek will cost the District ratepayers even more in the future.

Badger Mill Creek & Goose Lake Area Historic Changes

July 12, 2022

Madison Metropolitan Sewerage District

Outline

1. Historic Aerials
2. Summary Timeline
3. Excerpt of Supporting Documents
4. Link to Supporting Documents

1937 Aerial

1955 Aerial

1968 Aerial

1974 Aerial

1987 Aerial

1995 Aerial – During WisDOT Bypass 18/151 Construction

2000 Aerial – Post WisDOT Bypass 18/151 Construction

2005 Aerial

City of Madison
Stormwater Ponds

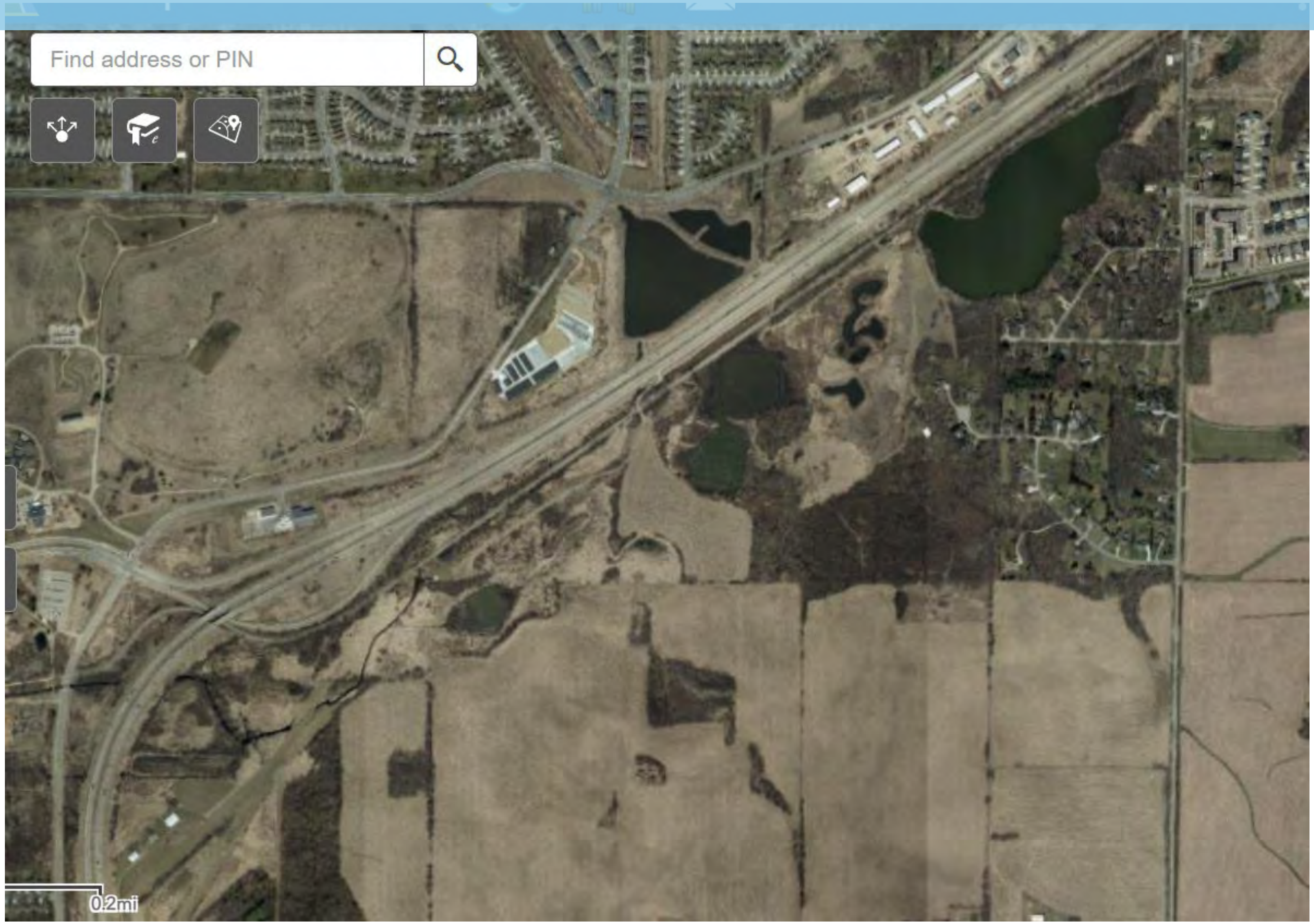
2010 Aerial

2020 Aerial

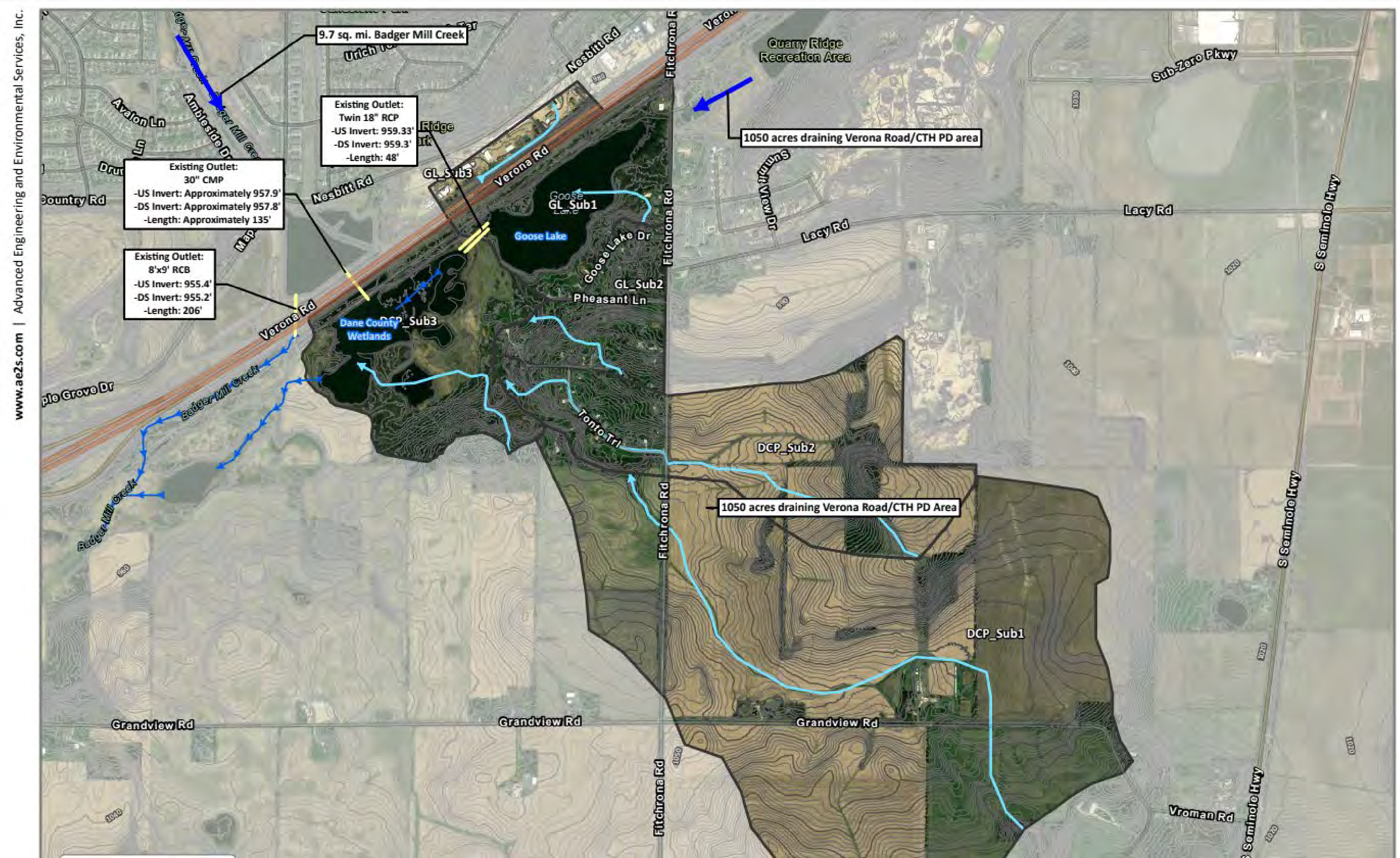
1995 Aerial

2000 Aerial

2022 Aerial



Goose Lake Fitchrona Road Flood Study, AE2S



N
0 500 1,000
Feet
1 inch = 1,000 feet

Locator Map Not to Scale

City of Fitchburg
Dane County, WI

Figure 4
EXISTING CONDITIONS

REGIONAL STORMWATER MANAGEMENT STUDY AND DESIGN- FITCHRONA ROAD AND GOOSE LAKE

Date: 3/10/2021

Summary Timeline

**All item dates are in terms of construction unless otherwise noted*

Approx. 1880s
C&NW "Ridge Runner“ Railroad

1957
WisDOT USH 18/151, 2 lane

1968
MMSD NSVI Mineral Point Extension

1995
WisDOT replaces bridge deck with 3 cell box culvert

WisDOT USH 18/151 expands to 4 lane adds Verona bypass, mitigates wetlands west of Goose Lake

MMSD PS17 Forcemain (north side of highway)

1998
MMSD Badger Mill Effluent Forcemain

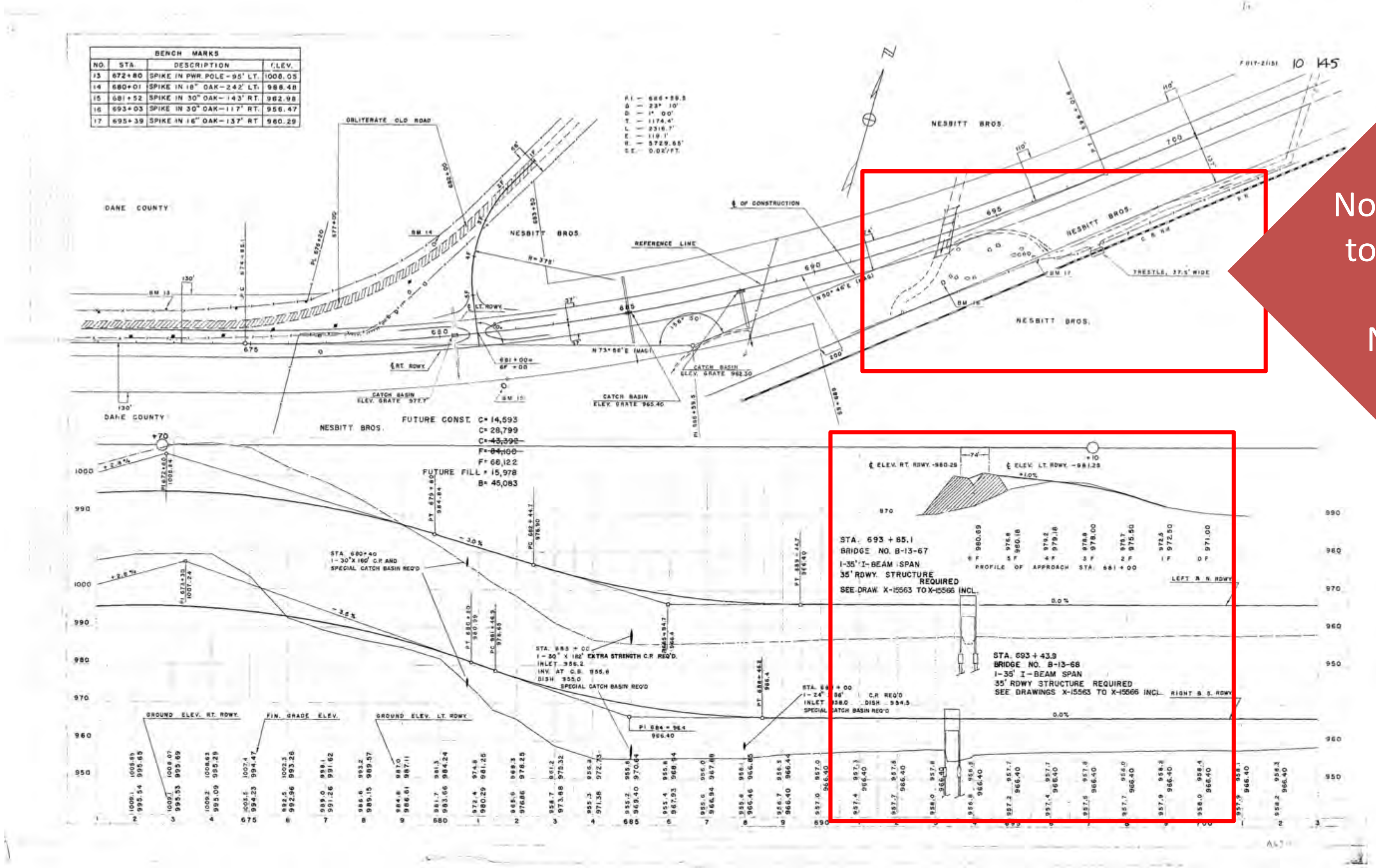
2002
City of Madison constructs Nesbitt stormwater Ponds

2018
Record rainfalls close Fitchrona Road twice

Today

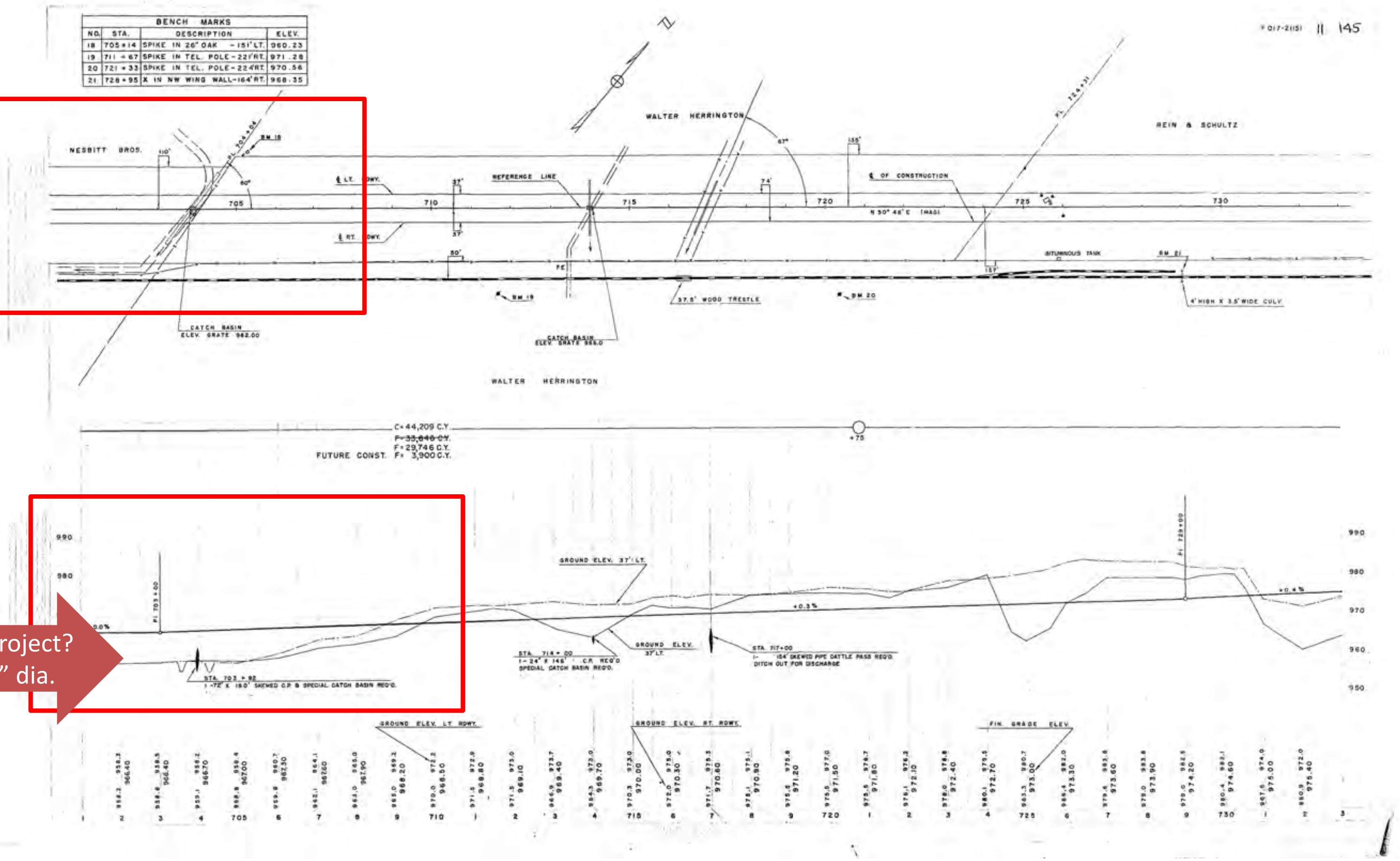
Madison Metropolitan Sewerage District

1957 – Construction of USH 18/151



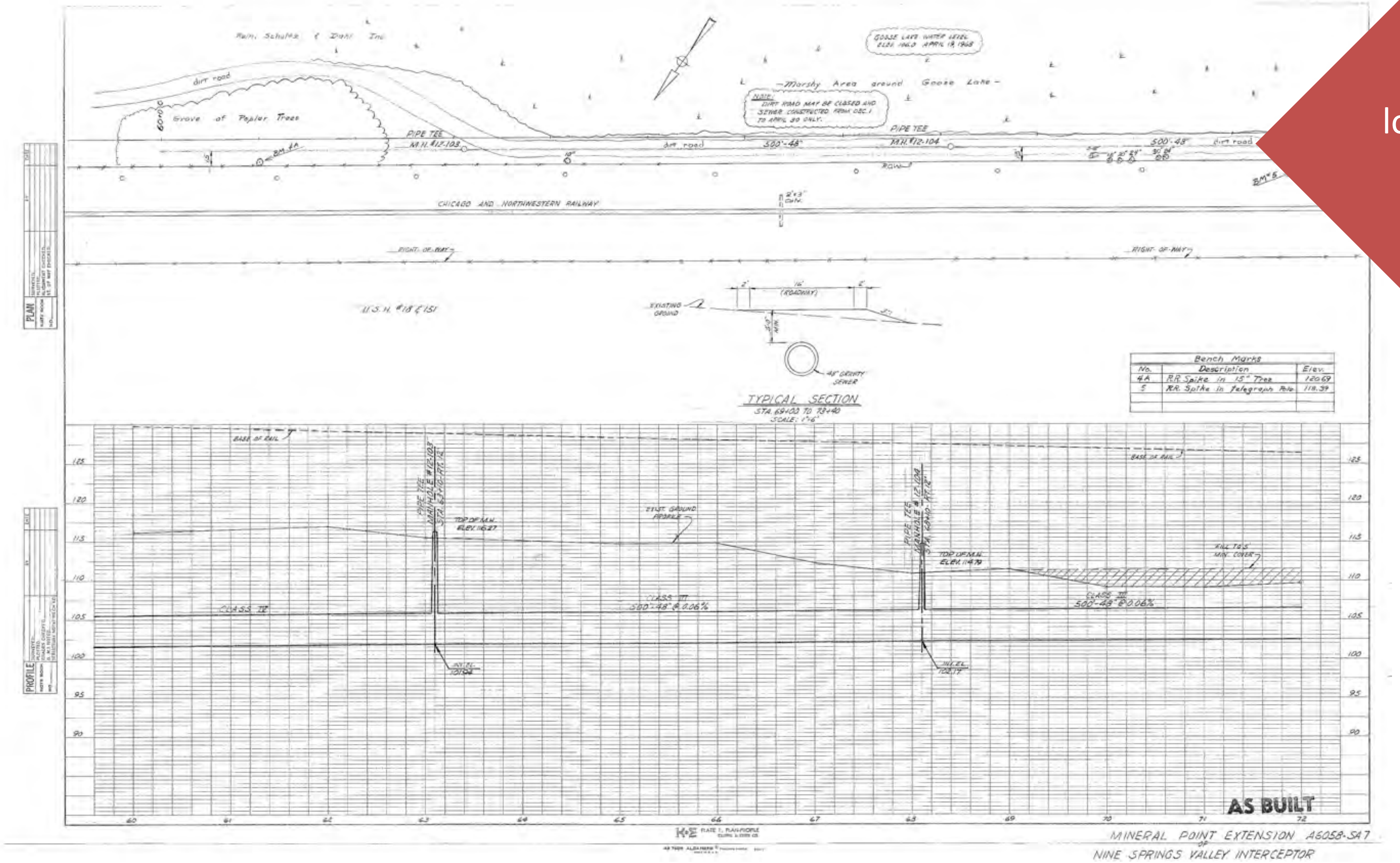
No evidence that drainage to the east was restored, appears to be filled?
Note direction of flow

1957 – Construction of USH 18/151



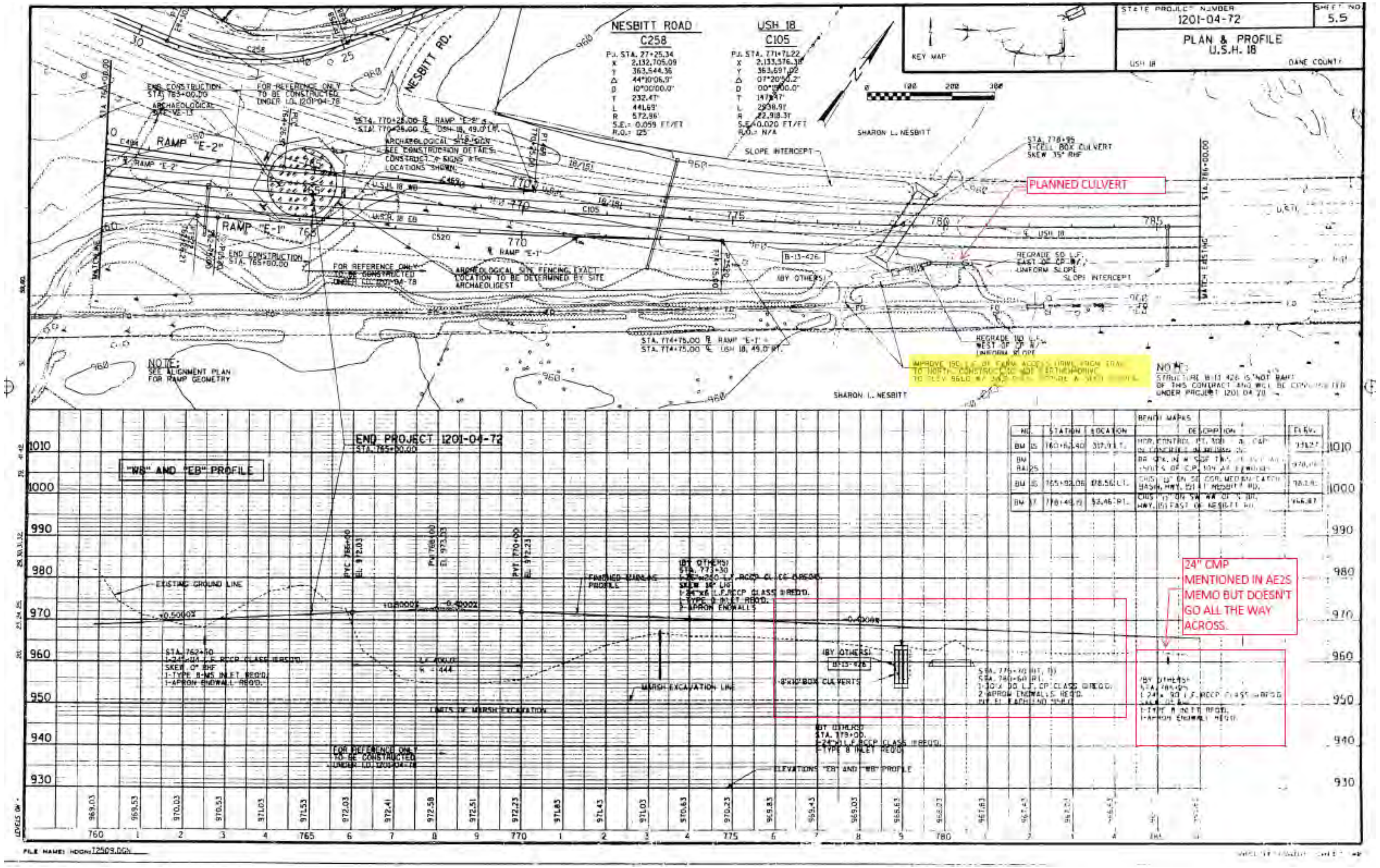
Replaced with Bypass project?
Today's culvert is a 24" dia.

1968 – Construction of NSVI Mineral Pt Extension

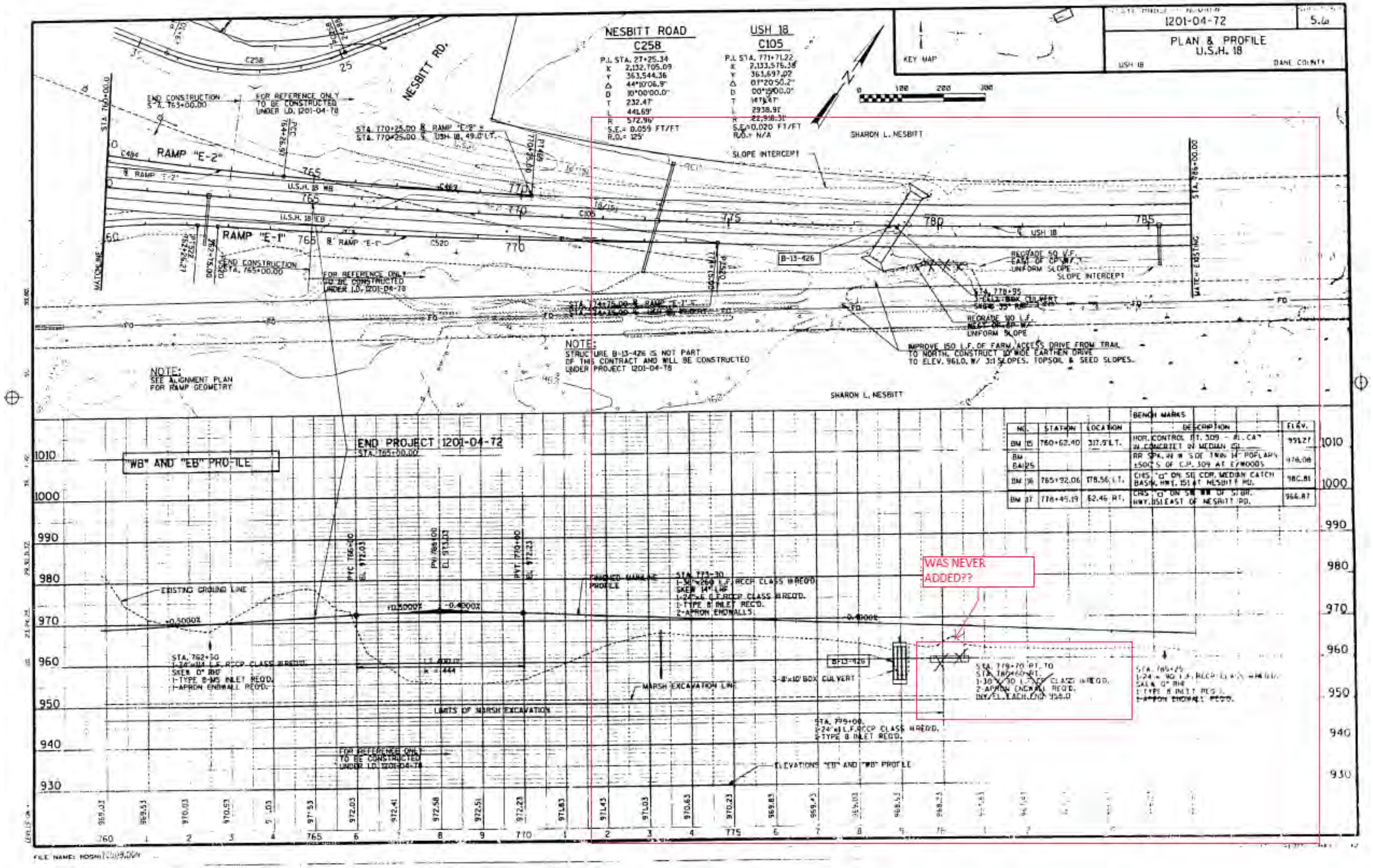


Dirt road which was located on north side of Goose Lake (now underwater)

1995 – Construction of WisDOT Bypass



1995 – Construction of WisDOT Bypass



1995 – Construction of WisDOT Bypass

Preliminary Wetland Mitigation Plan

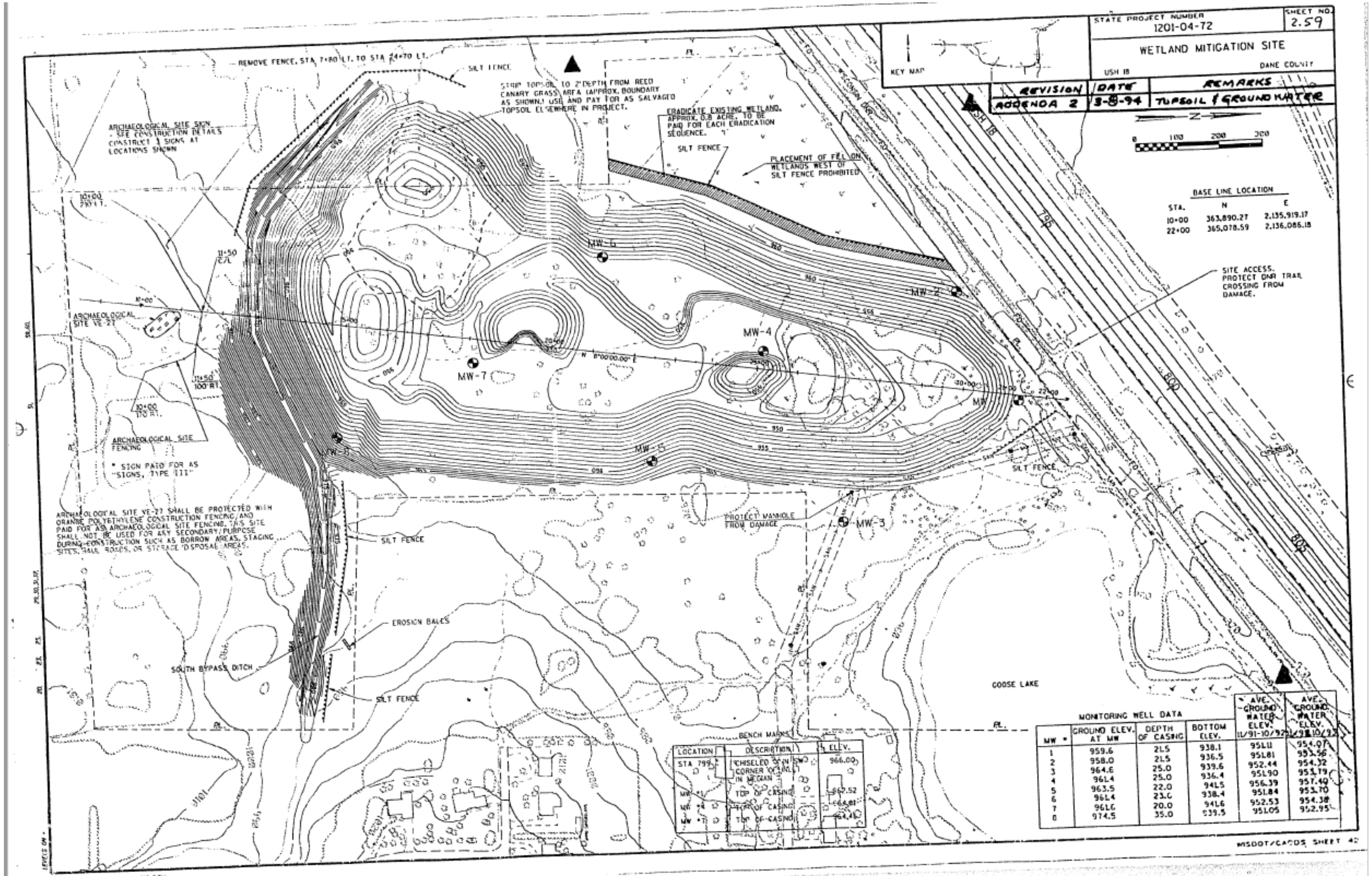
Introduction

This report describes the preliminary plan to implement mitigation measures agreed to in the Final Environmental Impact Statement (FEIS) for the Verona Bypass project in the vicinity of Verona, Dane County, Wisconsin. It focuses on wetland mitigation measures, but also addresses parklands and recreational resources (the Military Ridge State Recreation Trail). Unless otherwise noted or amended herein, impacts will be mitigated as described in the FEIS, Section VIII, Commitments to Impact Mitigation, and as described in the Design Study Report.

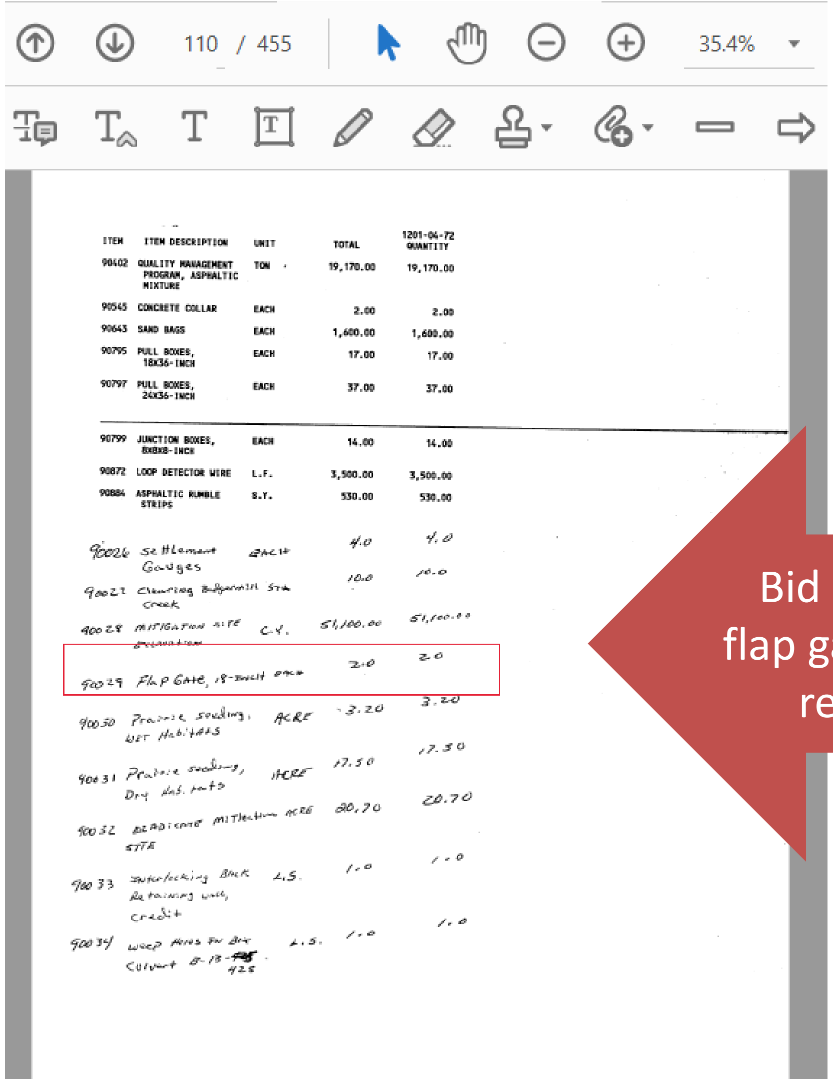
This preliminary plan will be replaced by the final mitigation plan after additional studies of the proposed wetland mitigation site are completed. These studies will include further investigation of groundwater hydrology and the reliability of surface water as a water source, soils analysis, and archaeological work. The final mitigation plan will provide more detailed site information for guidance in developing the final design of the wetland mitigation site.

Both Dane County and WisDOT do not have a copy of the final report

1995 – Construction of WisDOT Bypass Wetland Mitigation



1995 – Construction of WisDOT Bypass



ITEM	ITEM DESCRIPTION	UNIT	TOTAL	1201-04-72 QUANTITY
90402	QUALITY MANAGEMENT PROGRAM, ASPHALTIC MIXTURE	TON	19,170.00	19,170.00
90545	CONCRETE COLLAR	EACH	2.00	2.00
90643	SAND BAGS	EACH	1,600.00	1,600.00
90795	PULL BOXES, 18X36-INCH	EACH	17.00	17.00
90797	PULL BOXES, 24X36-INCH	EACH	37.00	37.00
90799	JUNCTION BOXES, 8X8X8-INCH	EACH	14.00	14.00
90872	LOOP DETECTOR WIRE	L.F.	3,500.00	3,500.00
90884	ASPHALTIC RUMBLE STRIPS	S.Y.	530.00	530.00
90026	Settlement Gauges	EACH	4.0	4.0
90027	Clearing [illegible] STA Creek		10.0	10.0
90028	MITIGATION SITE [illegible]	C.Y.	51,100.00	51,100.00
90029	Flap Gate, 18-Inch	EACH	2.0	2.0
90030	Prairie seeding, Wet Habitats	ACRE	3.20	3.20
90031	Prairie seeding, Dry Habitats	ACRE	17.50	17.50
90032	[illegible] Mitigation SITE	ACRE	20.70	20.70
90033	Interlocking Block Retaining wall, credit	L.S.	1.0	1.0
90034	Weep Holes for Box Culvert B-13-425	L.S.	1.0	1.0

Bid Qty of (2) 18" CMP flap gates matches today's restricting culverts

1995 – Stream continues

2000 – Stream now piped through this section

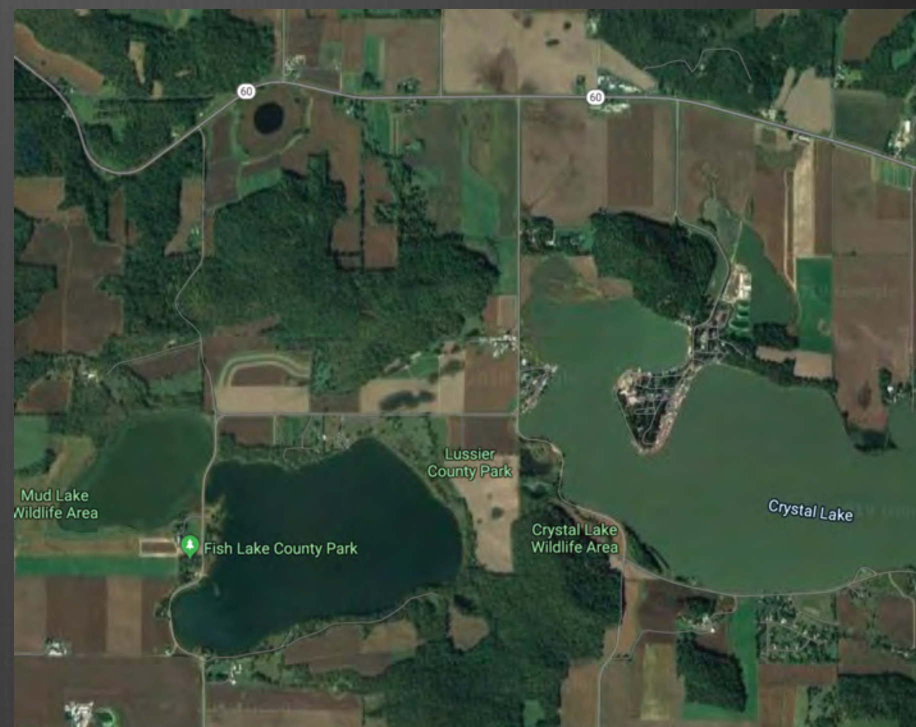
2010 – Stream appears wider and piped section remains

2022– Stream appears even wider and piped section remains

Fish/Mud & Crystal Lakes

Geology and hydrogeology overview

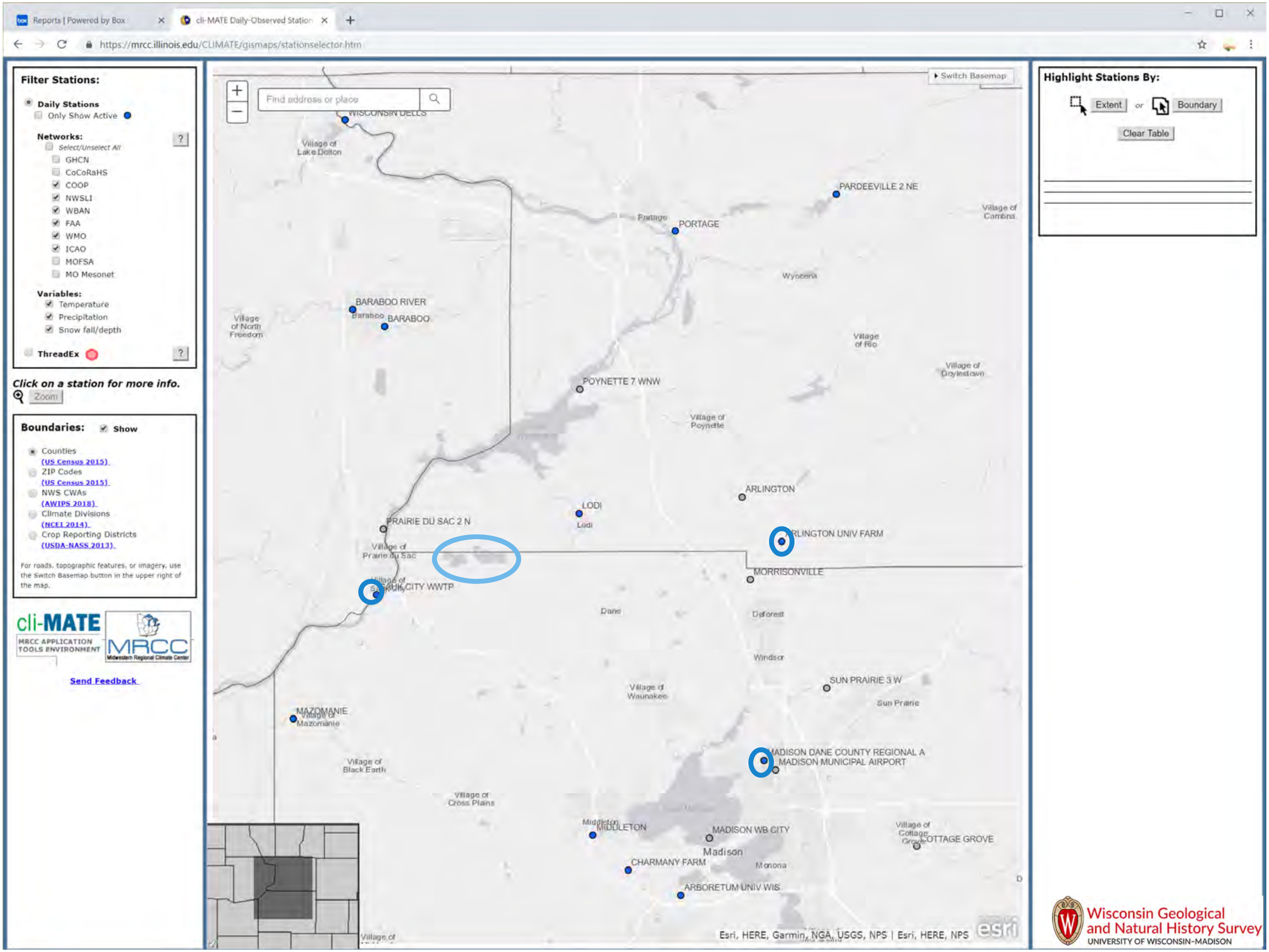
Dane County Technical Advisory Board Meeting – 6/23/2021



Mike Parsen (Hydrogeologist)
mike.parsen@wisc.edu

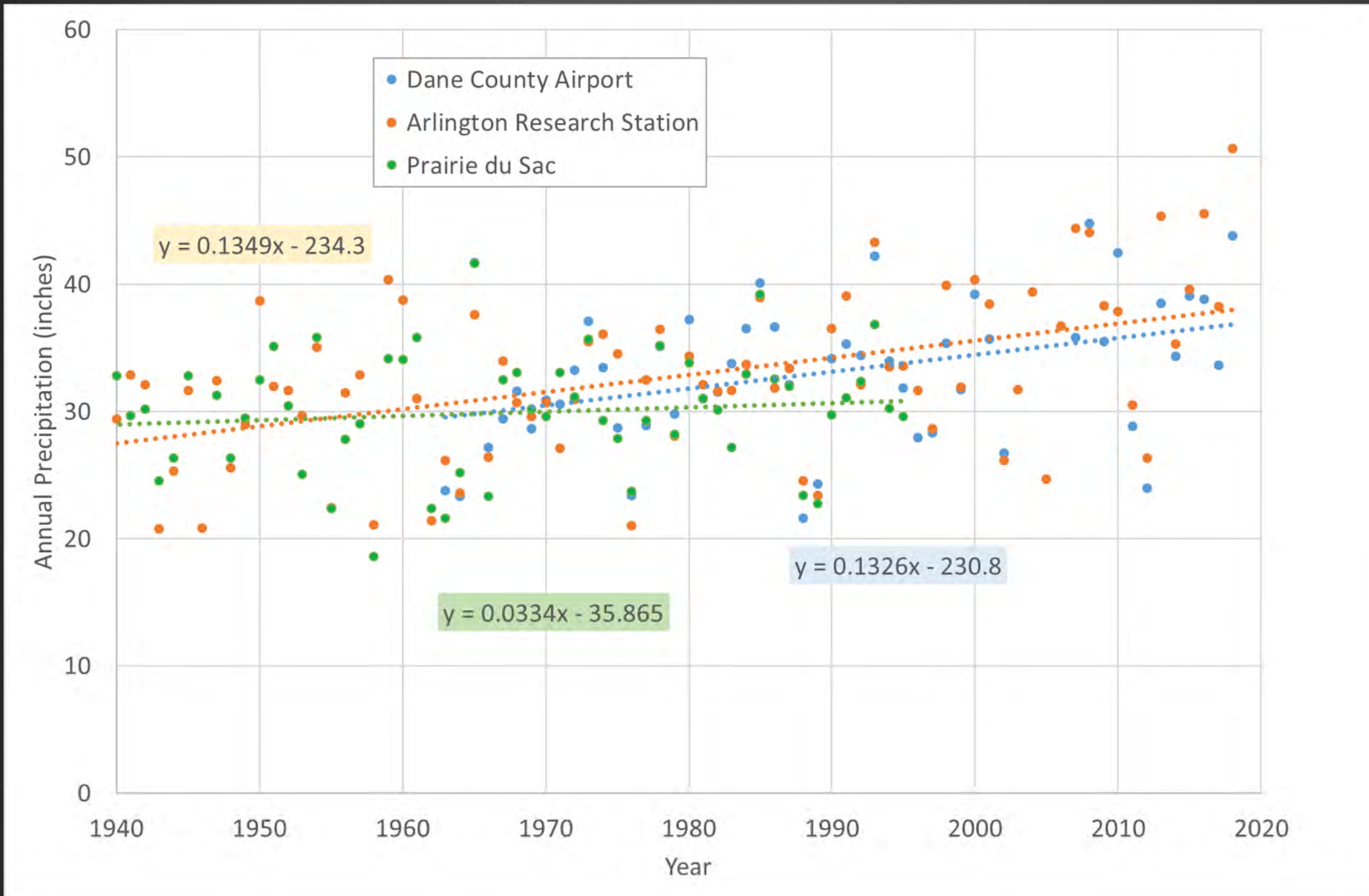
Dr. David Hart (Hydrogeologist)
david.hart@wisc.edu

Wisconsin Geological and Natural History Survey
UNIVERSITY OF WISCONSIN–MADISON



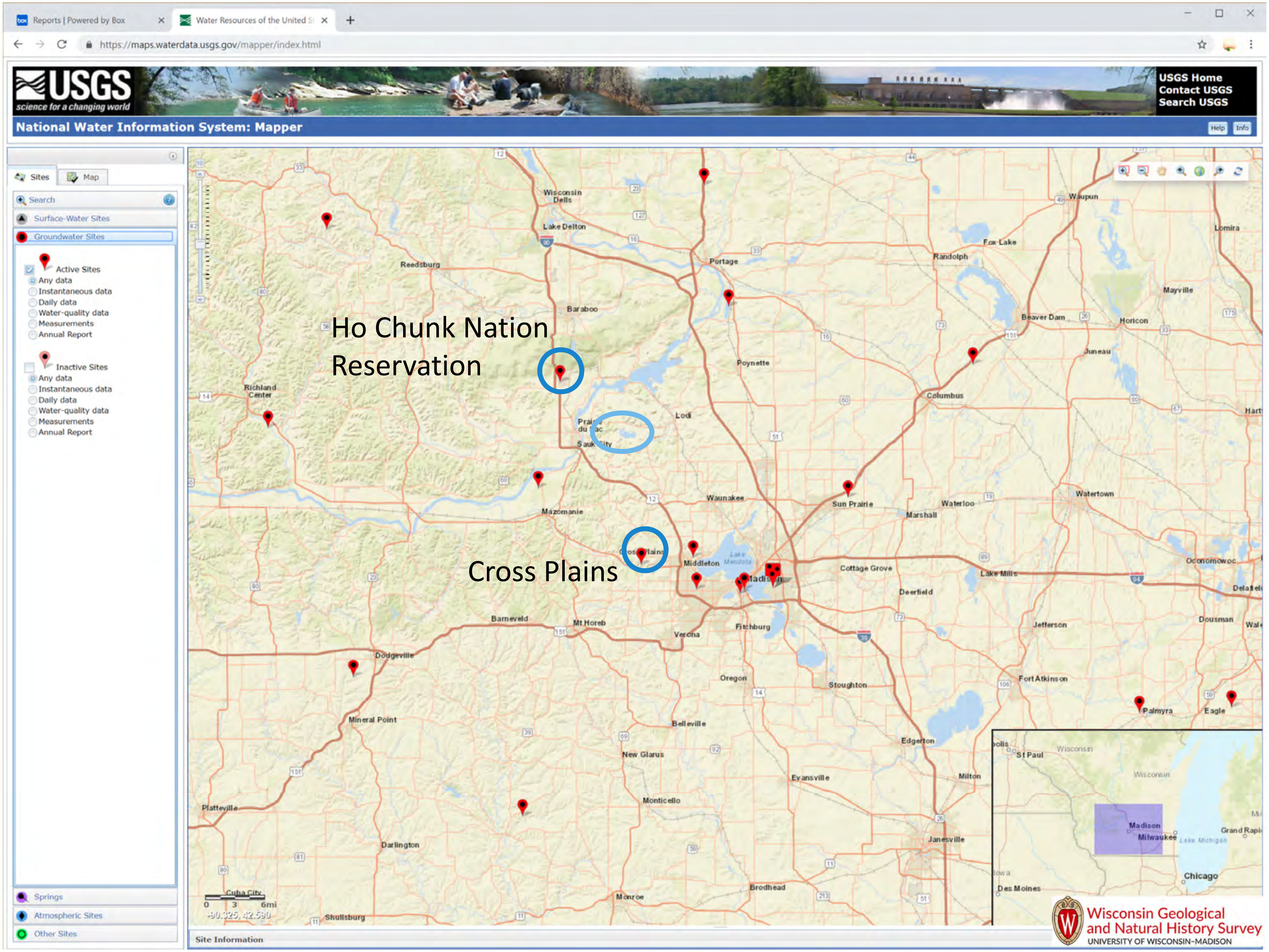
Filter Stations:
Daily Stations
Only Show Active
Networks:
Select/Unselect All
GHCN
CoCoRaHS
COOP
NWSLI
WBAN
FAA
WMO
ICAO
MOFSA
MO Mesonet
Variables:
Temperature
Precipitation
Snow fall/depth
ThreadEx
Click on a station for more info.
Zoom
Boundaries: Show
Counties (US Census 2015)
ZIP Codes (US Census 2015)
NWS CWAs (AWIPS 2018)
Climate Divisions (NCEI 2014)
Crop Reporting Districts (USDA-NASS 2013)
For roads, topographic features, or imagery, use the Switch Basemap button in the upper right of the map.
cli-MATE
MRCC APPLICATION TOOLS ENVIRONMENT
MRCC
Midwestern Regional Climate Center
Send Feedback
Find address or place
Switch Basemap
WISCONSIN DELLS
PARDEEVILLE 2 NE
PORTAGE
BARABOO RIVER
BARABOO
POYNETTE 7 WNW
ARLINGTON
LODI
PRAIRIE DU SAC 2 N
ARLINGTON UNIV FARM
MORRISONVILLE
SAUK CITY WWTP
SUN PRAIRIE 3 W
MAZOMANIE
MADISON DANE COUNTY REGIONAL A
MADISON MUNICIPAL AIRPORT
MIDDLETON
MADISON WB CITY
COTTAGE GROVE
CHARMANY FARM
ARBORETUM UNIV WIS
Madison
Esri, HERE, Garmin, NGA, USGS, NPS | Esri, HERE, NPS
Highlight Stations By:
Extent
Boundary
Clear Table
Wisconsin Geological and Natural History Survey
UNIVERSITY OF WISCONSIN-MADISON

Precipitation and temperature trends at nearby and longer term weather stations

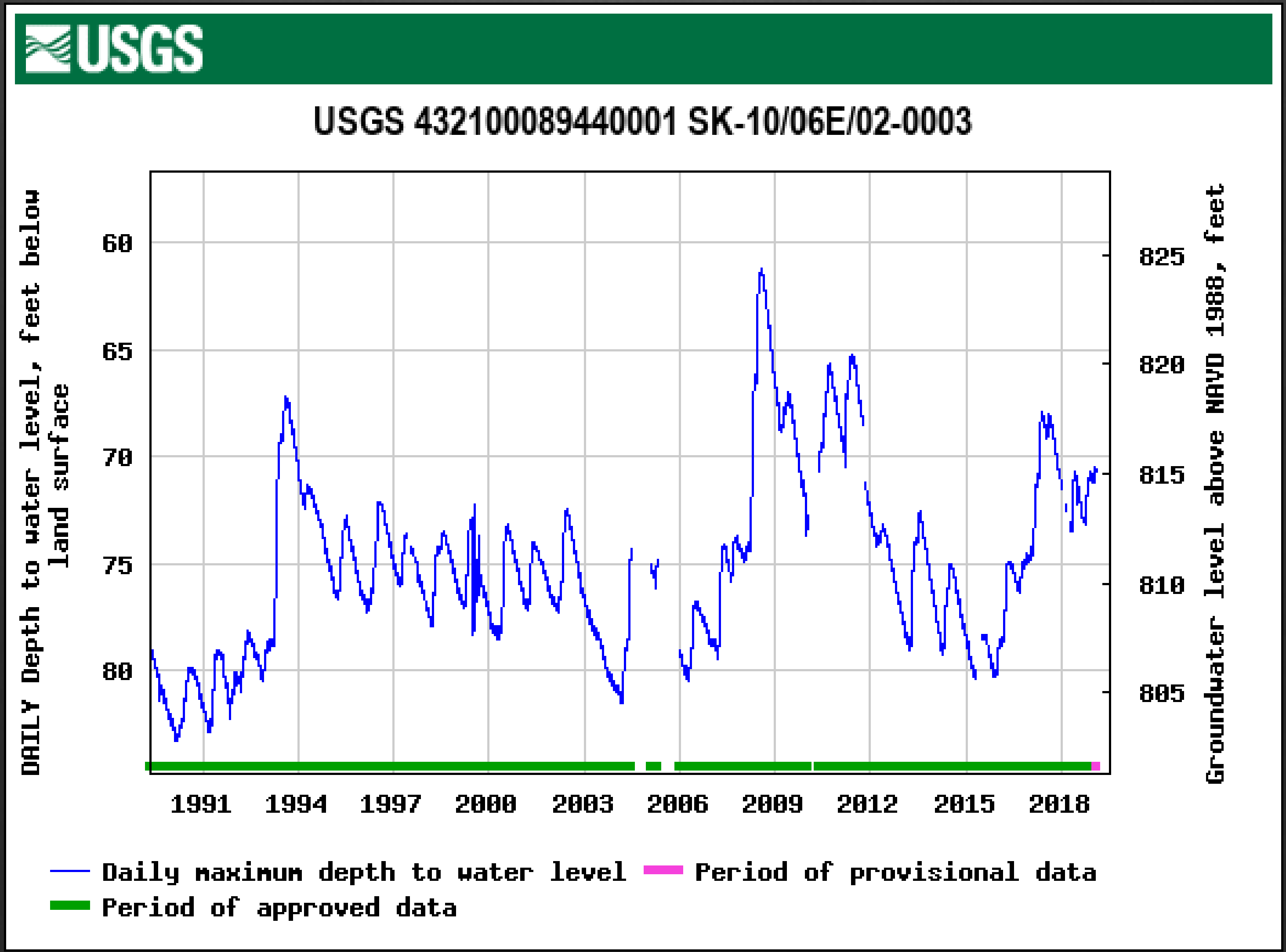


Midwestern Regional Climate Center

Wisconsin Geological and Natural History Survey
UNIVERSITY OF WISCONSIN-MADISON


Ho Chunk Nation Reservation
Cross Plains
National Water Information System: Mapper
USGS Home
Contact USGS
Search USGS
Groundwater Sites
Active Sites
Inactive Sites
Wisconsin Geological and Natural History Survey
UNIVERSITY OF WISCONSIN-MADISON

Groundwater level trends at nearby and longer term monitoring wells Ho Chunk Nation Reservation, WI



Wisconsin Geological and Natural History Survey
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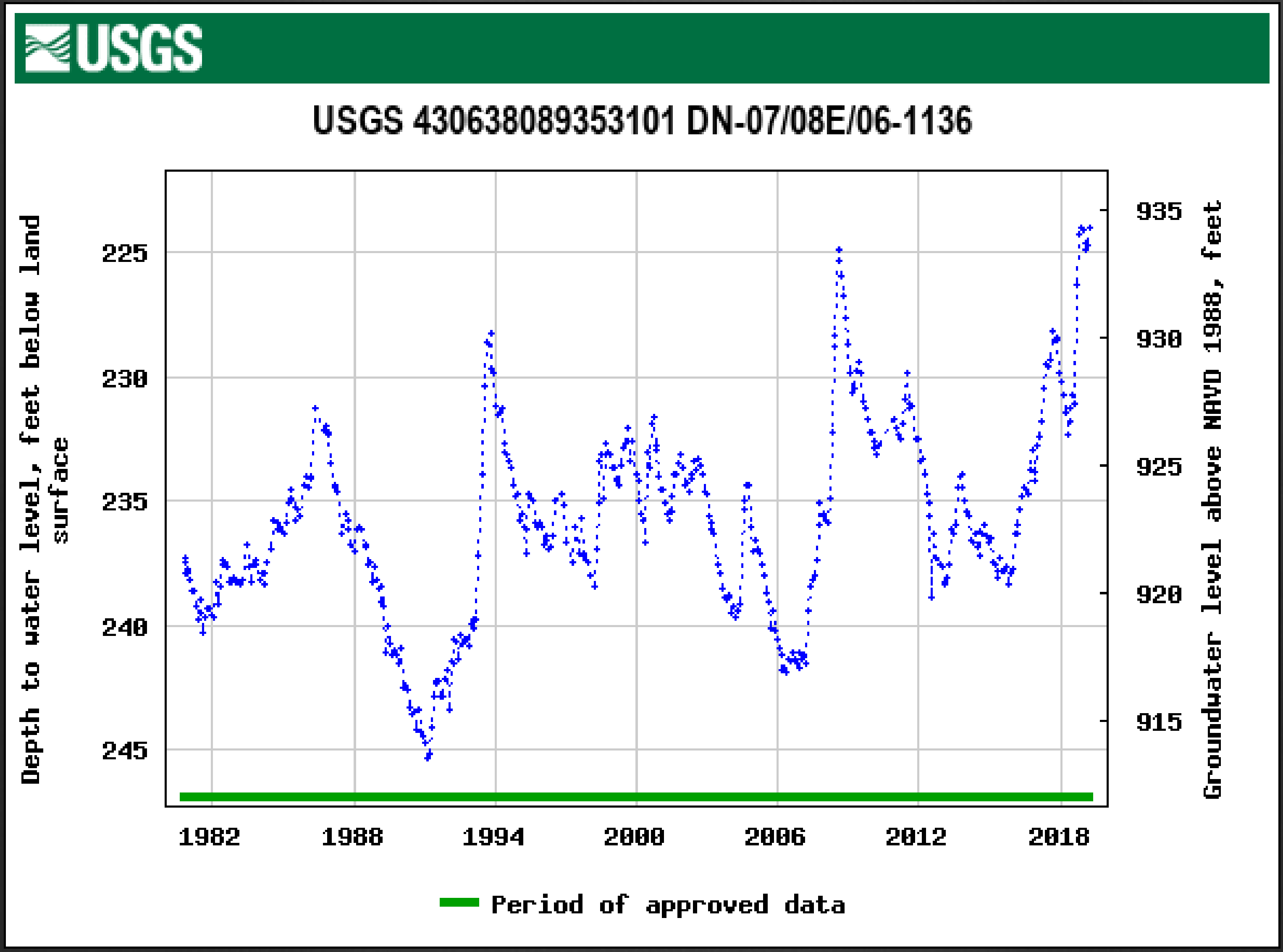
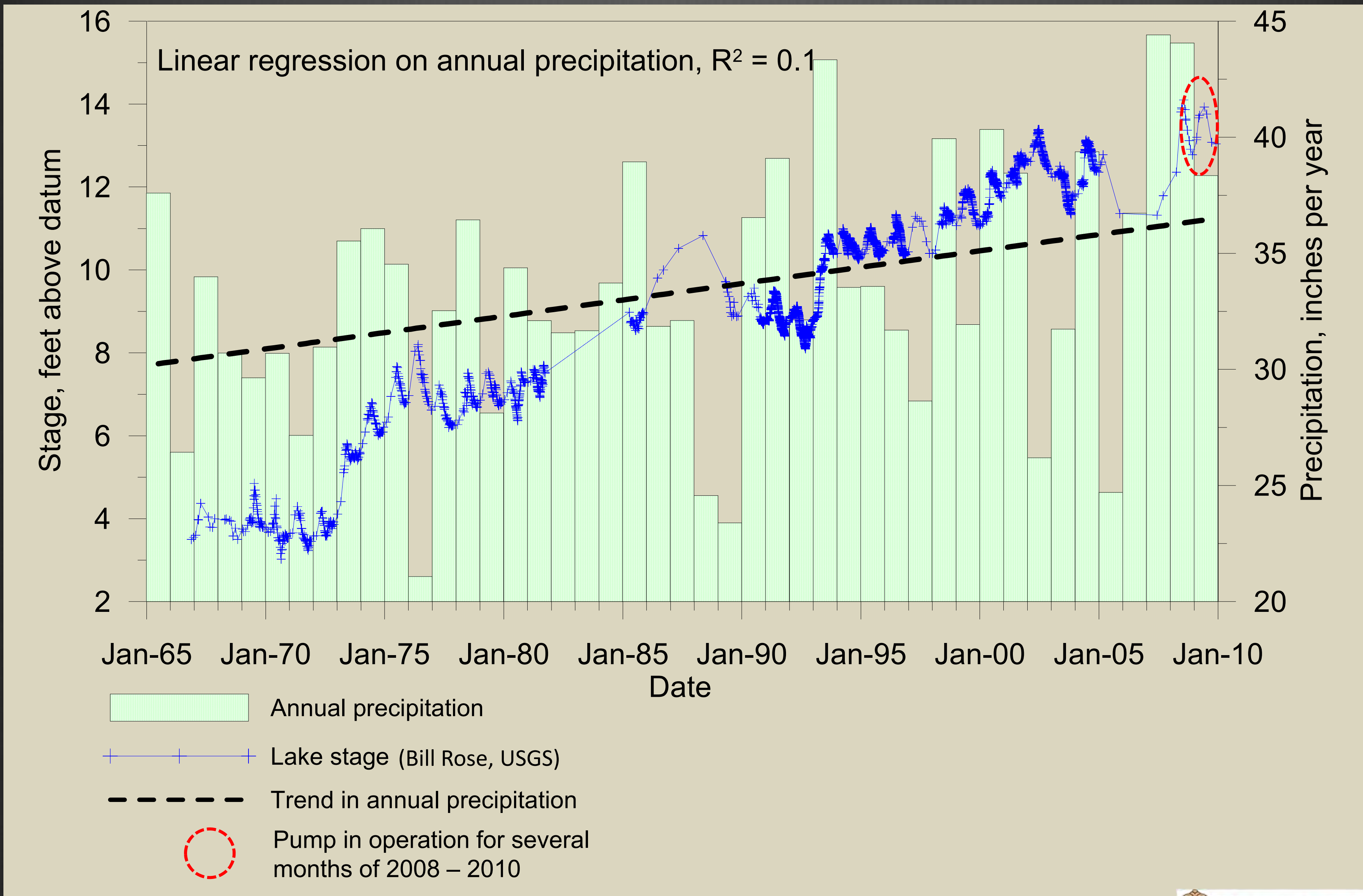
Groundwater level trends at nearby and longer term monitoring wells
Cross Plains, WI



Wisconsin Geological and Natural History Survey
UNIVERSITY OF WISCONSIN-MADISON

Fish Lake's stage has increased 8 to 9 feet over 40 years.



Wisconsin Geological and Natural History Survey
UNIVERSITY OF WISCONSIN–MADISON

Baseflow, another line of evidence for rising groundwater levels…

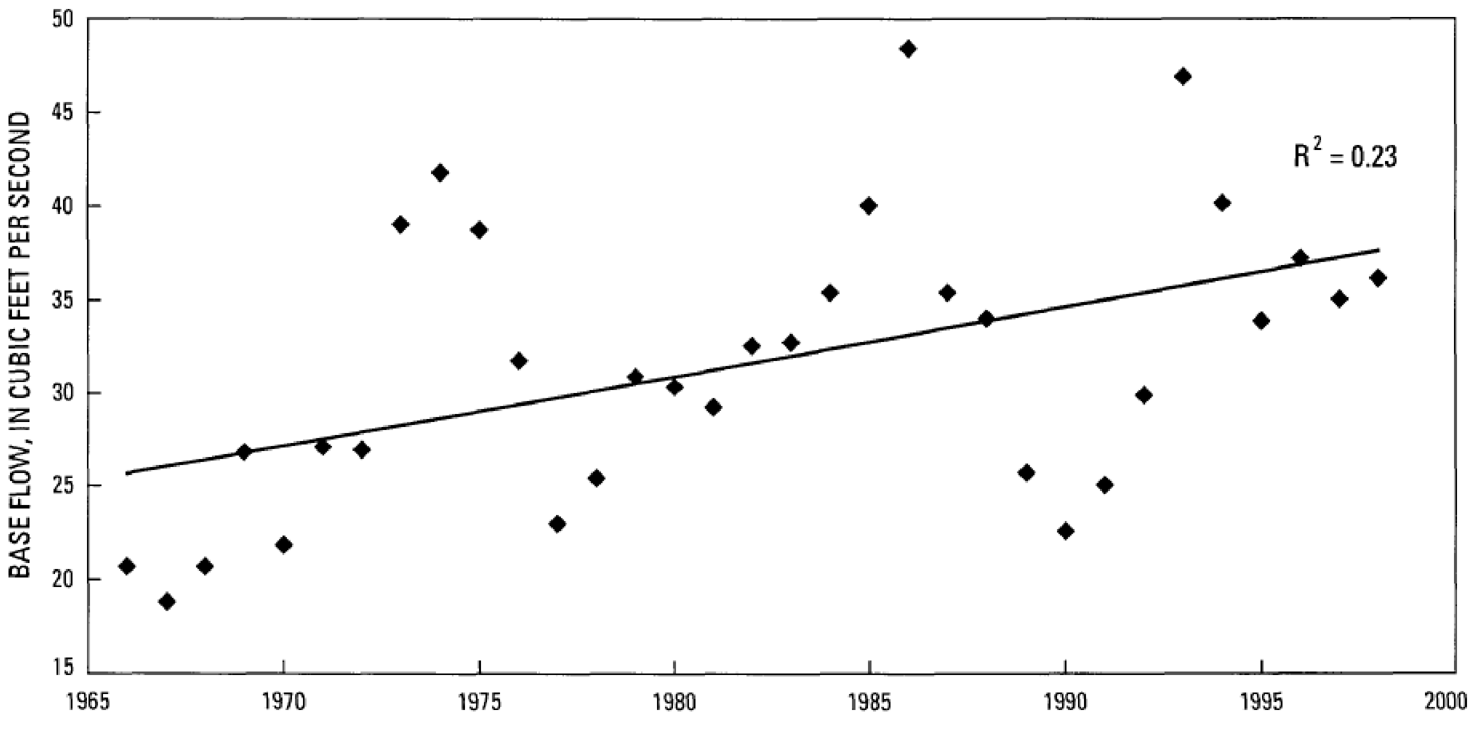


Figure 6. Black Earth Creek at Black Earth annual baseflow, 1966–98, Dane County Wisconsin.

Krohelski et al, 2002

↑ Precip. & ↑ recharge = ↑ lake/well stage & ↑ stream baseflow

A couple other recent studies…

Wisconsin Geological and Natural History Survey
UNIVERSITY OF WISCONSIN-MADISON

Some observations

- Mud, Fish, and Crystal Lakes are kettle lakes within a meltwater stream (tunnel channel) corridor and are well connected to groundwater
- Fine grained sediments observed in proximity to lakes
- Evidence of coarsening sediments to west, within this meltwater/tunnel channel corridor
- Precipitation rates are observed to slowly increase over time
- Groundwater and Lake Level trends seem to generally be increasing over time; long-term baseflow in nearby streams (e.g., Black Earth Cr.) has also risen
- Higher lake levels due to ↑ precipitation (↑ runoff & ↑ GW recharge)
- Steep hydraulic gradient from lakes to Wisconsin River
- Sediment variability poorly constrained west of Fish/Mud Lake
- Uncertainty regarding water-level elevations west of Fish/Mud Lake

Wisconsin Geological and Natural History Survey
UNIVERSITY OF WISCONSIN-MADISON

Exhibit I: Communications & Outreach Summary

The District has been working to determine a phosphorus compliance solution for Badger Mill Creek for over five years. District staff began conversations and early investigation after the Wisconsin Department of Natural Resources indicated a solution may be required as part of the District's updated permit, but that permit was not finalized and reissued until 2020. In anticipation of determining a solution that achieved the compliance standards outlined in the permit but also minimized harm to the biology of the stream and was fiscally responsible to our ratepayers and owner communities, District staff began having stakeholder conversations and presenting to our Commission as early as 2018.

In October 2021, District staff outlined its initial set of preliminary options available, which we submitted to the DNR in an April 2022 Preliminary Compliance Report. With those options solidified, the District had the information it needed to begin more targeted and informed community outreach, which started in June 2022. This Communications & Outreach Report focuses on the period from June 2022 to April 15, 2023.

Communications approach

District internal communications, in partnership with a public relations consultant specializing in community relations, employed a multi-faceted messaging approach to maximize public and stakeholder engagement with Badger Mill Creek Project PLUS. Through building a project brand and leveraging an integrated messaging campaign, the team ensured a wide range of public members would be kept informed, and opportunities to provide feedback were ongoing and accessible. Strategized communications outreach for Project PLUS began in June 2022 and will continue through each project phase.

Objectives

The following objectives have been used to assess the quality and relevance of the information provided, with the leading goal that the information be accurate, up-to-date, and presented in an accessible and understandable format:

- Boost community education about the impact of excess phosphorus;
- Inform the public of the District's responsibility in identifying alternatives to meet compliance in Badger Mill Creek;
- Provide audiences with timely access to project information and updates;
- Create dedicated channels of communication to deliver targeted information; and
- Collect feedback and respond to questions and concerns.

Strategies and tactics

The communication strategies outlined below will be evaluated for total effectiveness in engaging participants and eliciting valuable feedback upon campaign completion. This summary provides a snapshot through April 15, 2023.

Leveraging established messaging pathways

The team utilizes an integrated message strategy that provides timely and expected District updates for internal audiences, stakeholders, owner communities, and Commissioners through the District's well-established communication methods and outreach schedules. Channel examples include:

- District blog (Figure 1)
- District's bimonthly "Nine Springs News" email newsletter
- Unique presentations
- Email updates to Commission, staff, owner communities
- Promotion of project information across District social media channels

Figure 1 – Screenshot of an educational blog post on Wisconsin's phosphorus rule

These activities resulted in a combined average reach of 880 accounts per touchpoint to date.

Creation of dedicated branded channels and PLUS-specific content

To enhance communications outreach and help make a complicated topic more accessible, the team branded the project Badger Mill Creek Project PLUS, which stands for Phosphorus Limits & Updated Solutions. Utilizing this branding, we created dedicated collateral materials, including presentations, a device-readable/shareable QR code, an educational one-pager, a dedicated project webpage (Figure 2) with a friendly URL for search engines and website users, and a subscriber-only email list to better share project information with the public while providing channels to engage with interested individuals directly.

Since September 2022, the project has been featured in 20 emails, four blog posts, nearly a dozen presentations, and more than 85 people have subscribed to the project's dedicated email list.

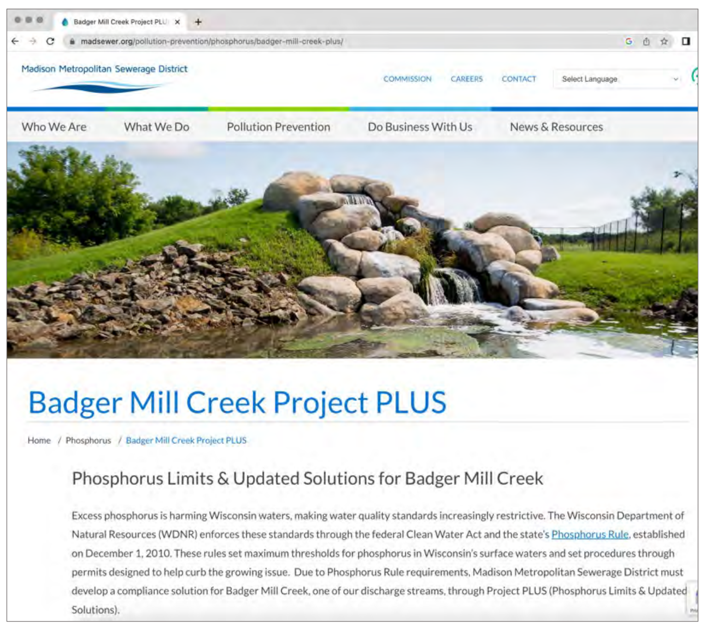


Figure 2 - Screenshot of the District's dedicated Project PLUS webpage

Social media engagement

The District's social media platforms — specifically Facebook, Twitter, LinkedIn and Nextdoor – help engage the online community and amplify the project's reach. The platforms provide real-time project updates, allowing a more informal and conversational approach to gathering feedback and answering community questions. The team crafted specific content for social media posting with 27 dedicated posts. All posts were open for the social media community to ask questions and provide feedback. Posts included educational reading related to project goals and real-time updates and images. In addition, many posts delivered an actionable link for users to engage further and quickly locate more information.

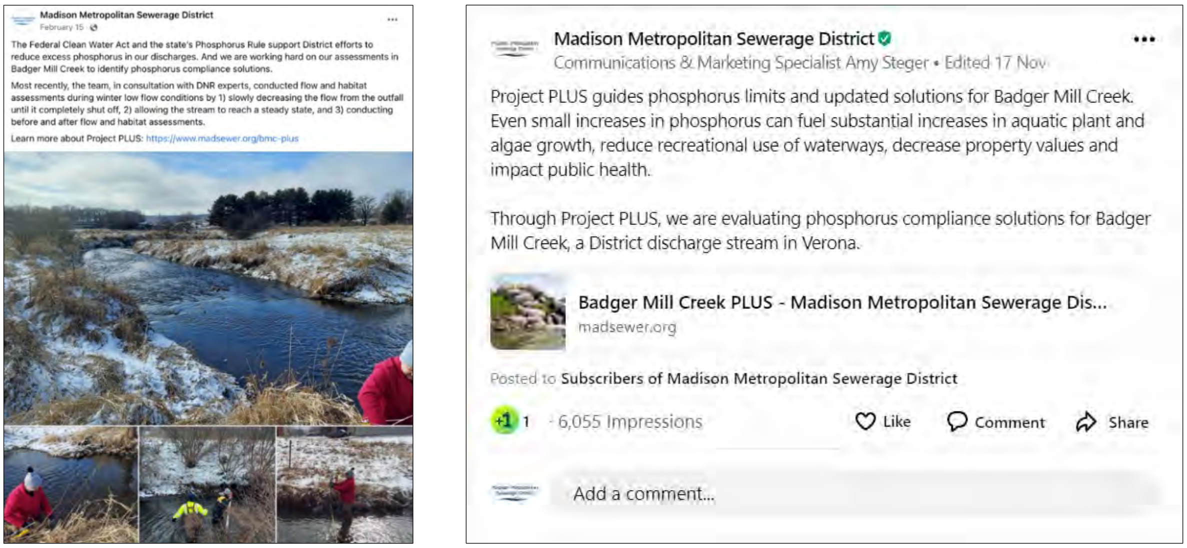


Figure 3 - Examples of Project PLUS social media posts on Facebook (left) and Nextdoor (right)

Media relations and monitoring

Traditional communication channels, such as newspapers, radio, and television, were leveraged. New relationships were also made to provide accurate and timely information about the campaign and coordinate interviews. By building trust and rapport with local journalists (e.g., Verona Press, Figure 4), the District was able to increase the likelihood of positive coverage, proactively address inaccuracies and false claims, and effectively communicate its message to a broader audience.

Figure 4 – Screenshot of Verona Press article in advance of November listening session; appeared in print and online

Public listening sessions

Two town hall-style listening sessions were held in late 2022 to allow stakeholders to ask questions, provide feedback, and voice concerns about the campaign and proposed changes while allowing for real-time engagement and discussion. The first session was held in person on November 30, 2022 at the Verona Public Library, and the second was held via Zoom in an accommodating virtual setting on December 8, 2022. The Verona Press published these events in the paper and online on November 18, 2022.

The listening sessions allowed nearly 50 attendees to learn about PLUS through a brief presentation and share comments, questions, and concerns in small break-out groups with District staff. The District engaged in various tactics outside its owned channels to ensure the community was aware of these listening sessions, including adding the events to local community calendars and paying for distribution through newspaper-owned email newsletters.

The District will hold a public hearing for this project as part of its Commission meeting on Thursday, May 11. A public hearing is not legally required for Project PLUS, but the District understands the community's interest in its final recommended solution and is offering a public hearing to ensure interested parties are heard.

Photo 1 - In-person listening session at Verona Public Library in November 2022

Collection and analysis of feedback

The project team logs critical stakeholder feedback and response and reviews it in bi-weekly communications meetings (or sooner when deemed necessary). The log continues to serve as a valuable listening tool to address concerns, answer trending questions of the groups these stakeholders represent, and respond to misinterpretations of project goals and intent. Official feedback forms were provided at the in-person listening sessions and were anonymous, allowing stakeholders to share their thoughts and concerns without fear of retribution. No forms were submitted as a result of the listening sessions. However, notetakers were committed to detailing all feedback during each listening session.

The team used these notes to evaluate the methods to deliver information, including in-person and virtual collaboration, and assess their effectiveness in reaching the target audience.

A standard feedback form on the District website has remained accessible and available throughout the campaign. The standard form collected two submissions between September 2022 and April 15, 2023. In addition, a more tailored form has been created for the public comment period that will run from April 27 through May 8. Contact information for project/District leads is included in standard communications, including their name, email, and phone number to encourage and welcome discussion.

Participation in community meetings and presentations

During this reporting period, District staff have participated in nearly 20 meetings with key stakeholders, lawmakers, community leaders, or individual ratepayers to provide valuable feedback on the campaign's impact and the impact on the community, ratepayers, and owner communities. This includes at least 11 meetings with or presentations to Dane County officials and committees, leaders and governing bodies of interested municipalities, leaders of the Dane County Cities & Villages Association and Dane County Towns Association, and state elected officials. In addition, it should be noted that countless other meetings and conversations with stakeholders, regulators and interested parties occurred before this reporting period.

Project PLUS was also the topic of the District's December 2022 quarterly owner community meeting. The District serves 25 owner communities across Dane County, and these regular meetings provide an opportunity to update customers on the District's work.

Meetings were attended by District staff either in-person or via video conference using a project presentation specific to address the intended audience and their questions and concerns. Conversations and timely responsiveness with a small group of stakeholders to discuss the campaign, proposed changes, and impact on the community in a more in-depth way have been active from the start. These meetings provide valuable qualitative data on stakeholder attitudes and opinions and the opportunity to address false community narratives in person.

Paid advertising

As a companion to public relations activities, the team paid for two advertisements featuring the project to promote public listening sessions and comment opportunities. In addition, two social media posts were promoted using advertising dollars to target Verona residents and those living near Badger Mill Creek. This strategy was designed to increase awareness of the project among the most affected communities and to encourage more people to participate in listening sessions and engage with the campaign.

Campaign effectiveness

By employing a multi-faceted communications approach that includes regular engagement with stakeholders, use of targeted platforms, email, social media, and public relations, and organizing public events to further educate the public about the project's goals and progress, the team succeeded in generating interest, gauging initial public response, and building general campaign awareness.

Notable benchmarks achieved:

- A combination of communication and community relations methods allowed the District to gather diverse feedback and ensure stakeholder voices were heard and considered in decision-making.
- To date, a general assessment of the campaign's lack of emergency response and stability in audience reach proves successful campaign message design and approach.
- Increased engagement with the issue and increased curiosity and participation in the initiative provides a positive outlook for messaging engagement numbers.
- Public feedback performance and tracking proved that the proposed recommendation timeline was communicated effectively.

Ultimately, the integration of leveraging traditional communication pathways, creating additional campaign-branded channels to the community, and collecting and addressing feedback in a timely manner has created a community of engaged stakeholders invested in the campaign.

Continued communication

The team continues to engage with stakeholders and the broader public as Project PLUS approaches its solution implementation phase. Future communications and outreach activities may include organizing public events or learning webinars where the public can receive timely updates, give feedback, and ask questions. In addition, community relations efforts with local stakeholders and District partners could be used to promote awareness of the project among specific groups.

Exhibit J - BMC Winter 2023 Observation Log Summary

Background

To provide the general public and concerned residents a way to engage with ongoing research of phosphorus compliance options for Badger Mill Creek, the District developed and launched a digital report form for interested citizen scientists to monitor, record their observations, and take photos of their favorite area(s) of the creek and/or Sugar River from their mobile phones. This application was developed and launched on January 26, 2023, so it was operational before the period of effluent shutdown to Badger Mill Creek. Effluent began being stepped down on January 31, 2023 and was fully off by February 6, 2023. The effluent remained off through April 16, 2023.

The District reached out to community leaders before and during the development of the application and requested community engagement through various emails and social media posts, discussed it at presentations, and included it in the frequently asked questions and on the website.

While over 250 responses have been received to date, the majority came from the Town of Verona and Madison Metropolitan Sewerage District employees. During the period that this application was live, there were three time periods when community members submitted their reports (Figure 5.) Those reports are included in this report (Table 1) and organized by the period submitted. In general, these reports express fear of negative consequences if the effluent return was eliminated and how wonderful the stream is when residents thought the effluent had been reinstated, which it had not been. There are many conversations and fear being amplified within the groups and organizations that are passionate about Badger Mill Creek. The observations submitted through this application resulted in another way to hear from the community, understand ongoing conversations, and obtain comments.

This application served as an informative undertaking. Since the location and time are included in each report, it is easy to visually assess the stream chronologically throughout the flow ramp-down period and when no effluent was being delivered to the stream. **Even after effluent was ceased, flow continued in all portions of Badger Mill Creek.** Flow changed daily depending on precipitation, snowmelt, and other weather conditions. Springs were seen to be flowing throughout the entire test period, including days with temperatures below zero. Animals and ducks were observed along the corridor. In lower-flow periods, the stream was found to flow more rapidly in narrower areas and slower in wider sections. During flooding conditions, debris and garbage were moved downstream. The February 27, 2023 flooding dislodged some of the habitat structures in the stream and inundated the floodplain. The debris that was moved remains in portions of the stream as of the April 17 observations.

The digital form

Initially, conversations revolved around having people take pictures and submit observations; District staff then looked at ways to make this process easier and developed and tested a Survey 123 application. This was found to work for reporting as it provides geolocation information and the ability to submit multiple photos. The District also developed a dashboard to view results. Screenshots of the digital application are shown below:

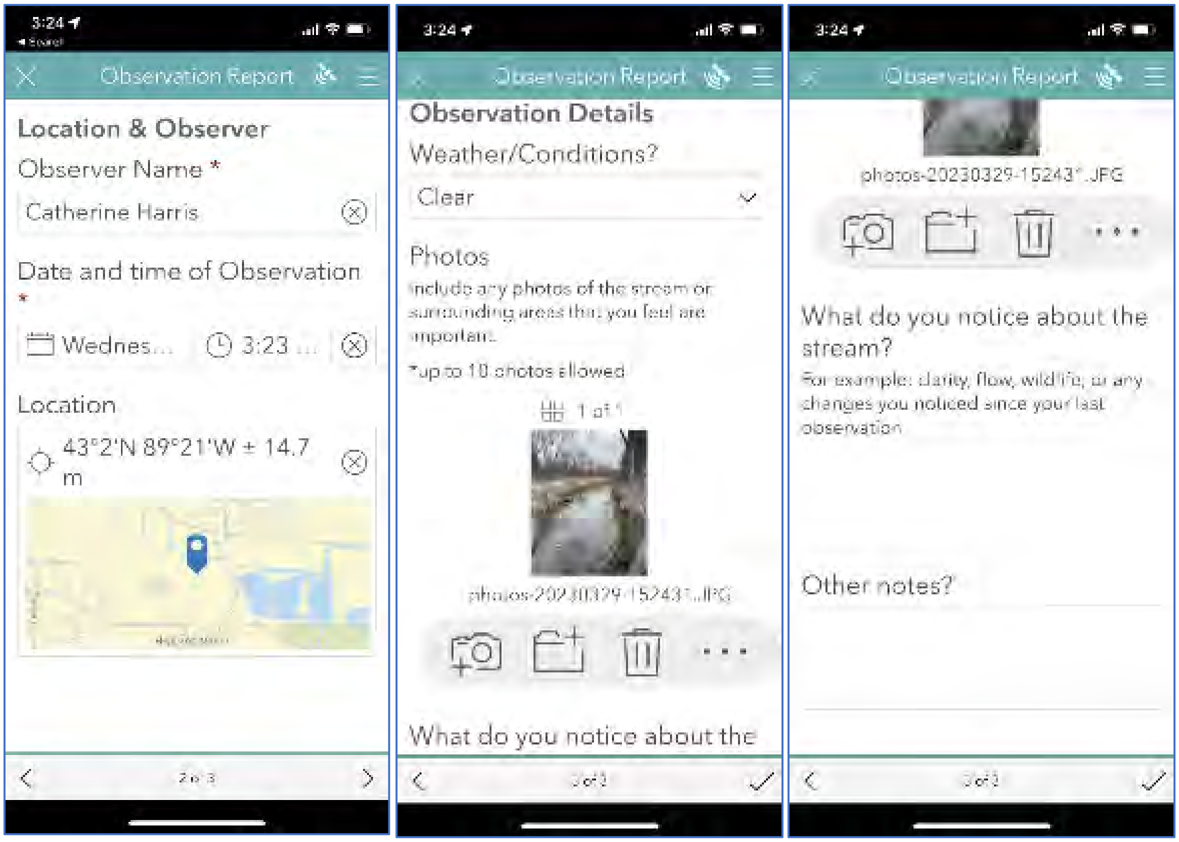


Figure 1 - Screen Shots of the Survey 123 App for Badger Mill Creek

Participation

This form was made publicly accessible through a link on the website madsewer.org/bmc-plus. It was shared with community and organizational leaders on January 26 with the request to roll it out to their networks. It was shared again by the District in February and March through email and social posts. Since the launch, 16 individuals have used it to report 244 observations at numerous sites along the creek (through April 16, 2023). Thirty observations were submitted by residents (vs. municipal or treatment plan staff).

Observation locations

Most observations were in Dane County, from the aerator structure to the creek's crossing at Highway 69. Only a handful of observations were taken further downstream in Green County. One noteworthy item is that all observations found flow in the stream. The Town of Verona provided ongoing stream assessment reporting, and wastewater treatment plant employees observed the stream each week and sometimes multiple times a week. The observations started upstream of the effluent return location and continued downstream to a point south of Belleville on the Sugar River.

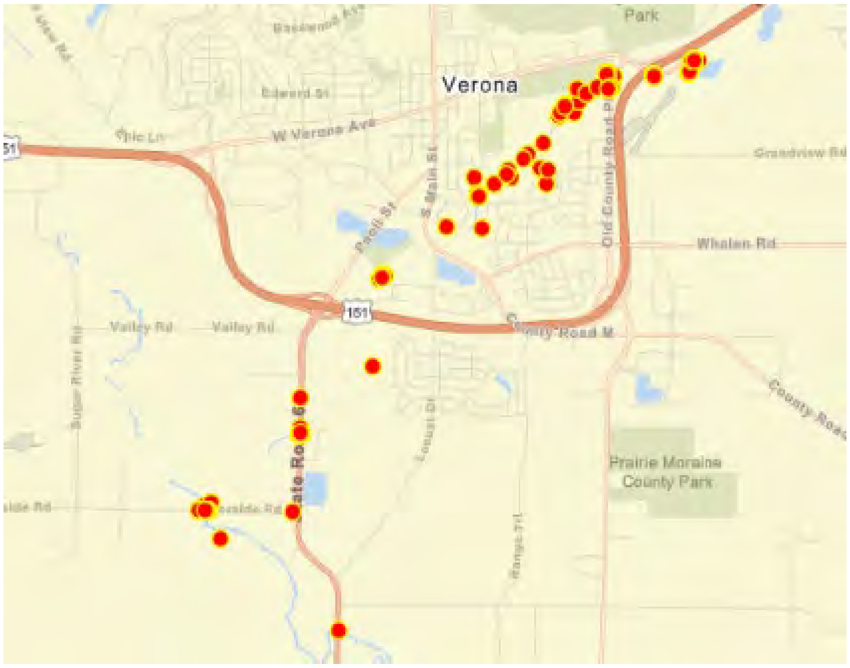


Figure 2 - Geolocation data for observations in Dane County

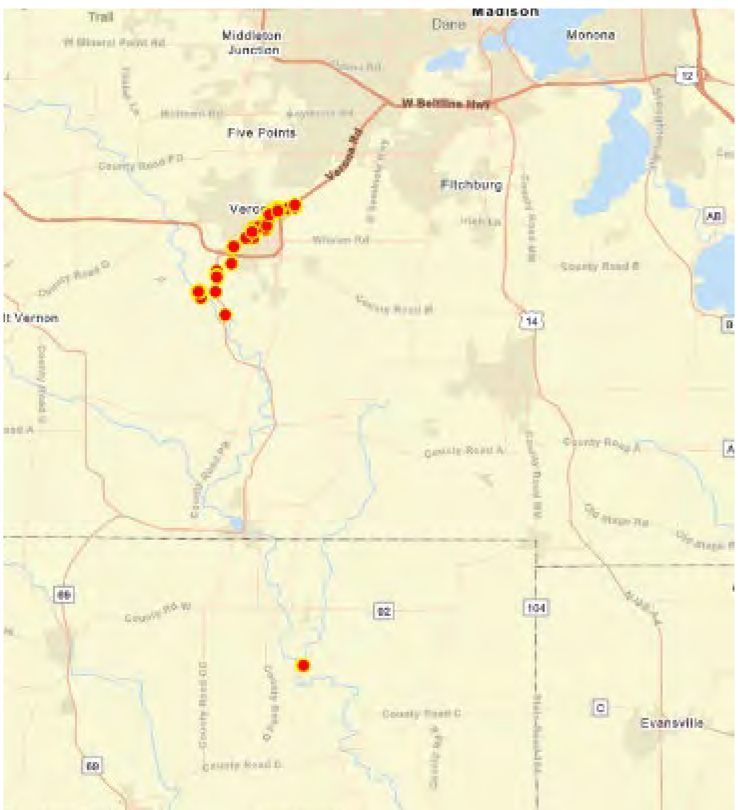


Figure 3 - Geolocation data for all submitted observations.

Observation submittal record over time

All observations

Figure 4 - Timeline of all submitted reports

Community observations

Over time, with treatment plant staff and municipal employees removed

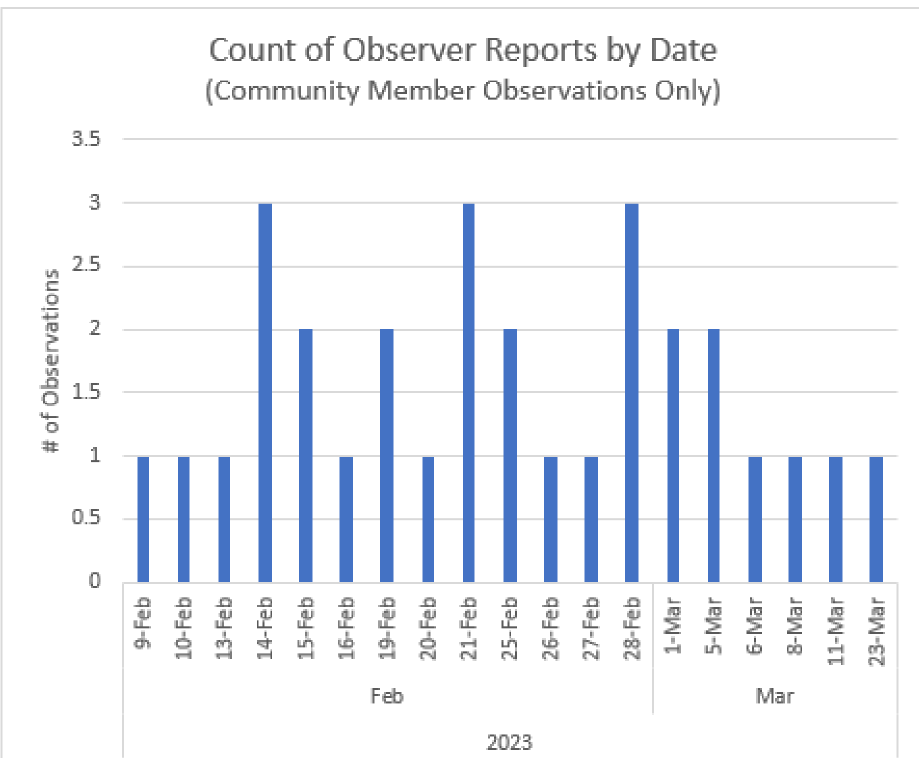


Figure 5 - graph of when reports from Community Members were submitted.

Exhibit J - 4

Community observation summary

(Does not include observations from treatment plant staff)

Table 1 - Community Observation Summary

Up to February 14:
• The stream enhancements that were placed in the previous phase (root balls, trunks, rock structures, etc) aren't even in the water - they're 1 to 2 feet above the water level. For the 2 weeks prior I've noticed Great Blue Herons in the stream - not now, but obviously I have no idea if that's because of water level changes/food availability or other short term factors such as weather, etc. Stream levels below the covered bridge can't be more than 2 to 3 inches today. • I can see to the bottom at the river's edge. There was a splash from a fish • Temperature 32 degrees. Np precipitation. Depth to water 13.0 feet bridge deck to water surface. slightly more turbidity today in the stream flow. Could barely see the bottom. • Temp 11 degrees. Water depth 13.0 feet top of water level to top deck of Bridge. Water clarity was opaque as viewed from the bridge deck. some waterfowl was present. banks were snow covered and have ice at the water interface • depth to water 13.1 feet from bridge deck. Temp -2 degrees. Ice forming along bank edge. Waterfowl present on the north side no change in water clarity. • Air Temperature 37 degrees. Depth to water 13.0 to bridge deck. Water was clear enough to see the bottom, more so than last week. All ice has melted along the banks. • Air temperature 29 degrees. Depth to water for Bridge deck 13.0 feet. Ice is receding slightly No waterfowl present. Water color is opaque. • 24 Degrees, 8" wet snow in the past 24 hours Depth to water is 13.0 feet from bridge deck. water turbidity is cloudy. no wildlife present.
Feb. 15-19
• The stream was extremely low this week. This morning it was a little better - I assume the improvement was because of the rain we had on Tuesday. I walk along BMC almost every weekday morning. I often see one or two great blue herons and lots of ducks and a muskrat. Please don't kill our creek. It is a vital and useful body of water for the critters and a source of beauty and peace for the rest of us. • Temperature is 42 degrees. Depth from Bridge deck to water is 13.0 feet. water turbidity is partly clear, can barely see the bottom. no water fowl present. No precipitation in the last 24 hours • Surface is choppy. Dark water but clear. I scared off hundreds of geese. The flow is steady and typical. Elevation seems reduced from last observation by a few inches. • Rain in the last 24 hours. water depth is 12.3 feet from the Bridge Deck. temperature is 32 degrees. Some snow melt along the banks. turbidity is higher likely form the precipitation no wildlife or fowl. • I walked to the discharge aerator and flow was off. Water very shallow. Expensive instream restoration structures above the waterline.
Feb. 20-25
• Water is not clear or flowing like before. MMSD please continue water flow for this important natural habitat. • the water level was very low, even lower than the summer. The banks were exposed and water was below the habitat structures that had been installed during the sewer project. There will still ducks around, although the numbers seemed lower than usual. I did not see any muskrats, which is unusual. I did not see herons either, although they are not always around. • The water level was extremely low and we could see mud sticking out in the middle. Actually, this has been the case most of the first half of February as well as now. The 50-60 ducks that have been in the creek all winter were mostly gone...maybe less than a 12 ducks. Please do not turn off the water. This will destroy the creek habitat which much money has been spent by the city and county in providing a more desirable environment for fish and other living creatures.

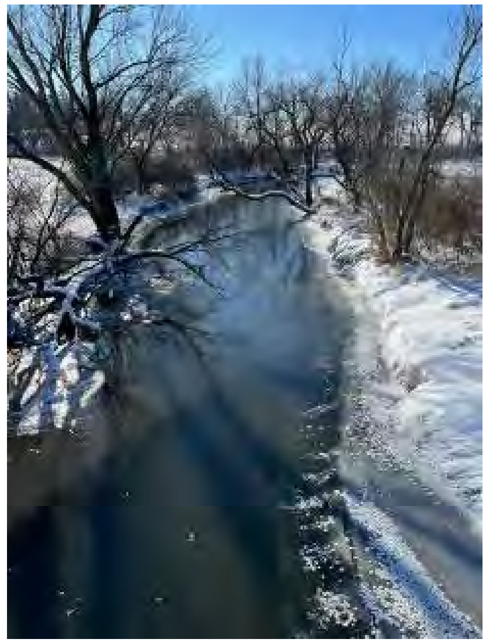
• The little white bubbles are back. Elevation seems same. Very clear today, most clear ive seen it lately. Calm flow with slight rippling on surface. No wildlife seen since earlier in the day. • Significant water flow reduction although there has been snow melting. Mud now visible where stream water used to flow • Lowest I have seen it in the 13 years it has been a part of my backyard • Extremely low, mallard duck walking, not swimming in the creek. Mud bar in the creek fully exposed by the Arbor Vitae bridge. This is the lowest I've ever seen the Creek and I've lived here nearly 33 years! • Creek has been extremely low for a few weeks now on paved path between Main street and Military Ridge trail. There are many dry spots now and little water flow for what is left. This time there were not a lot of ducks or other birds. Dane County created natural habitats along the creek for wildlife and there was talk of stocking with fish. • Air Temp is 31 degrees. Depth to water from bridge deck is 12.8 feet. the stream is quite turbid. no ice is visible along the banks. • air temp is 20 degrees. depth of water form bridge deck is 12.8 feet. turbidity has deceased from yesterday so the bottom is visible. no wildlife or fish visible. banks are clear. • Air Temp 24 degrees. Depth to Water from bridge deck is 13.0 feet. no precipitation since yesterday at 8:00 am. snow along the banks, no waterfowl or wildlife present.
February 26- March 5
• Very low water, muddy in quality. This is a sudden change and with all the rain/snow melt it should be a lot higher and clearer. • Very low flow on the Badger mill creek. Ducks walking on the creek bottom rather than swimming. No muscats compared to up to 6 in the past. • This is the typical spring flood for us. Raging water flow, murky/dirty. Has been above freezing and had a day of rain • Low water, which is slowly killing the plants • It's drying up. Please keep the water flowing. We don't want the wildlife to die or move away. • Down a foot from yesterday • Air Temp 32 degrees. Depth to water from Bridge deck 10.6 feet. Rain and snowmelt on 2-27 1.5" rain. turbidity is higher in the stream, likely to the increased flow and bank erosion. Water surface is at bank full level with some overbank flooding. • Please ask Madison to stop dumping water into our creek • Keep the water flowing • The creek needs more water to thrive • Did not see the Heron or kingfisher as in the past. • Was there a change in water supply to the area? If so this could drastically change the habitat.
Mar. 6-8
• Water flow is a fraction of previous years. Wildlife will suffer. • Very low water in the creek. Snow along the side portions that should be under water. Most of the installed rocks and logs are exposed. • Stream is very low. Side stream is nearly dry. Many animal tracks in the mud (muskrat?) • Normal creek depth. One day after flooding. The rocks are usually just under the water surface. • Flooded. Snow melt and rain overnight contributed to this surge in water but I wonder if the water was turned back on because this is much higher than normal. The water level is way over the banks- easily 24" higher than two days prior. Muskrats are displaced from their home and spend most of the day foraging up on the grass. • This creek is important to the local residents as well as the wildlife. We have a Blue Heron who has fished this portion of the creek for many years. Last year we had an Eagle who spent much of the spring fishing the creek. Without enough water, there will not be habitat for fish and we will lose the birds as well. • The banks are fully exposed and there is a large accumulation of mud along the sides of the creek.

Mar. 9-30
• The stream is looking very untidy and not taken care of. I was under the understanding the project worked on the past two years was to improve appearance, improve habitat and encourage wildlife and fish volumes in the stream. The stream was opened up so it could be enjoyed, but it is now looking less attractive and less healthy than ever. It seems counter productive to clear the stream's edges, add an upgraded walking path and encourage more use only to have a disappointment when viewing the stream which is meant to be one of the paths greatest assets. My observations make me concerned for the future of the livelihood of the stream and the decreased pleasure for its visitors. I'll be honest, I don't quite understand what has been done to cause the derogation of waterflow and messy looking water edges ad why it was done, but I would like to request the county and City of Verona investigate and consider other alternatives to help the stream to regain its beauty to the benefit of all. • When the new sewer connector in the City of Verona was planned and implemented, there was a lot of work and coordination between the City of Verona, Dane County, the Ice Age Trail to restore and conserve Badger Mill Creek in its natural state. There was much interest in this project in Verona and funds were spent to provide for a natural fish and wildlife habitat within the City limits. The shutdown of water by the City of Madison has dramatically reduced the water level of the Creek. Hopefully, the City of Madison will resume daily water flow in order to conserve this important environmental effort.

Photo timeline of Sugar River

With and without effluent, by multiple different observers

January 30, 2023

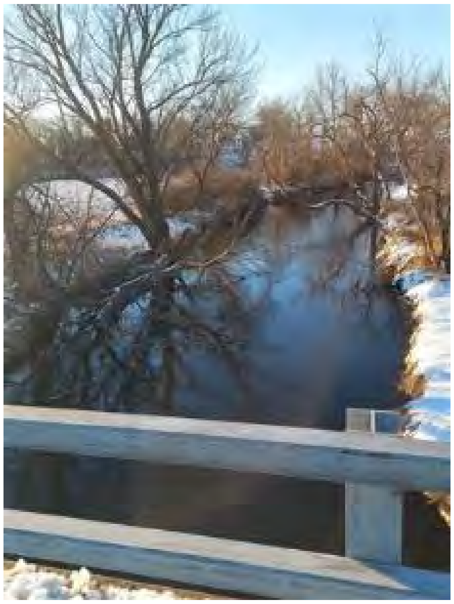


February 1, 2023

February 3, 2023

February 3, 2023

Exhibit J - 8



February 10, 2023

February 13, 2023

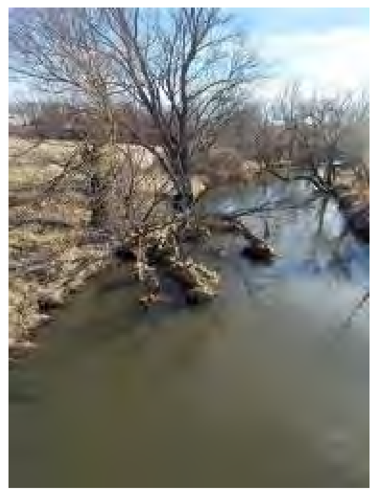
February 17, 2023

February 20, 2023

February 24, 2023

February 27, 2023

February 27, 2023



March 7, 2023

March 17, 2023

March 23, 2023

March 27, 2023

Exhibit J - 10

Photo timeline from Lincoln Street site

Photos from multiple different observers

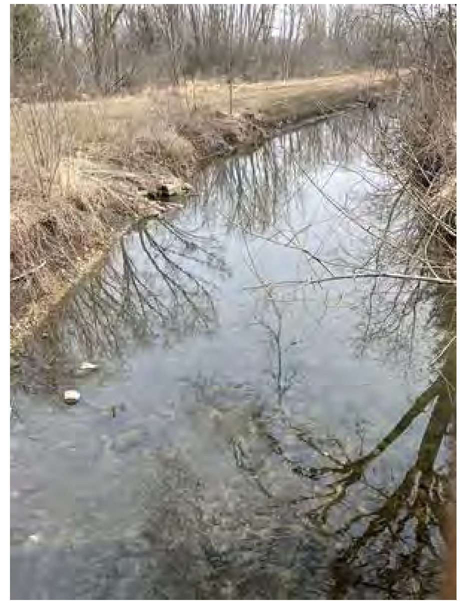
January 26, 2023 – effluent flowing

February 2, 2023 – effluent reduced

February 6, 2023 – no effluent

February 13, 2023

February 27, 2023



March 23, 2023

February 17, 2023: Habitat Structures between Lincoln Street and CTH PB

Instream flooding February 27, 2023 submerged habitat structures downstream of CTH PB

March 7, 2023 – Habitat Structures above water again, sediment movement evident

Exhibit J - 12

Evidence of springs through observation period

April 17, 2023, Springs immediately downstream of CTH PB

February 6, 2023

March 17, 2023

February 2, 2023

At left: February 17, 2023

Exhibit J - 13

These springs shown in the prior photos come together and feed Badger Mill Creek just downstream of the CTH PB monitoring location. This photo is looking at the flow of the spring complex coming into Badger Mill Creek. (BMC is running left to right at the top of the photo).

Photo timeline from CTH PB site

Photos from multiple different observers

January 30, 2023 – Effluent fully on

February 1, 2023 – first 0.5 cfs decrease in effluent flow

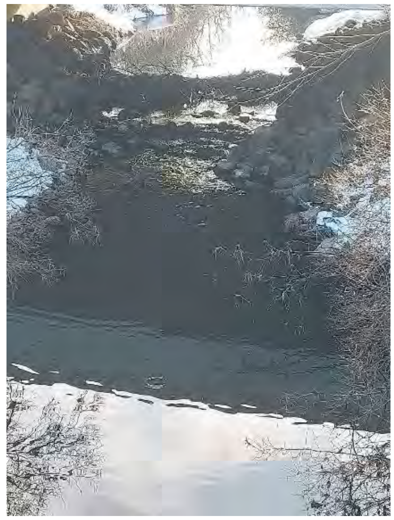
February 8, 2023

February 13, 2023

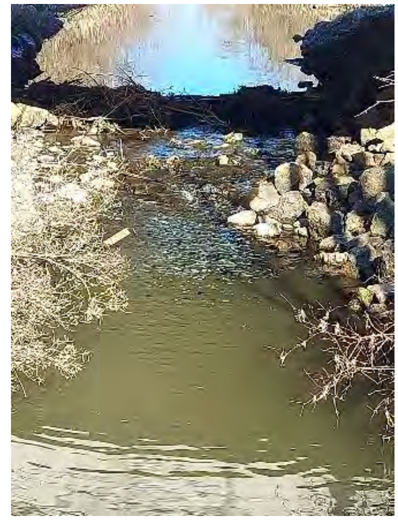
At left: February 17, 2023

Exhibit J - 15

March 21, 2023



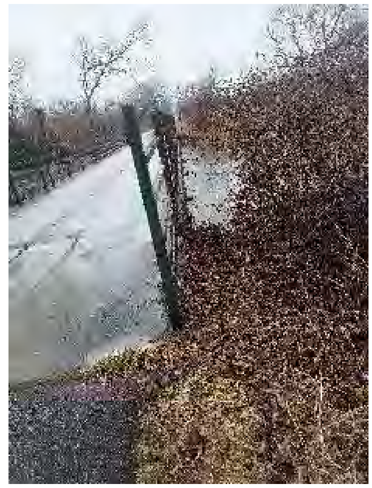
March 27, 2023



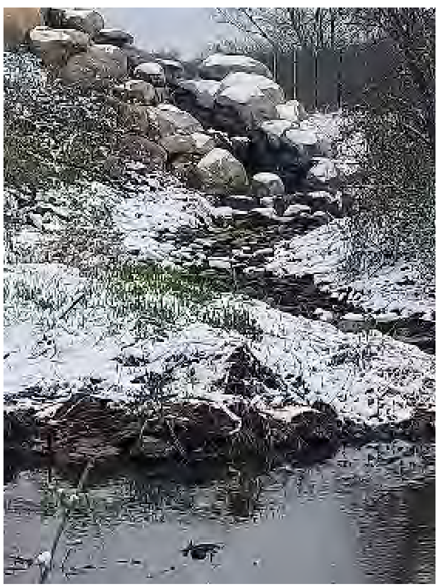
April 6, 2023

April 17, 2023 – effluent remains off at the time of this photograph

Photos of effluent return



Flooding upstream of effluent return 2/27/2023, effluent remains off



April 17, 2023; photo at left is flow coming from upstream of aerator

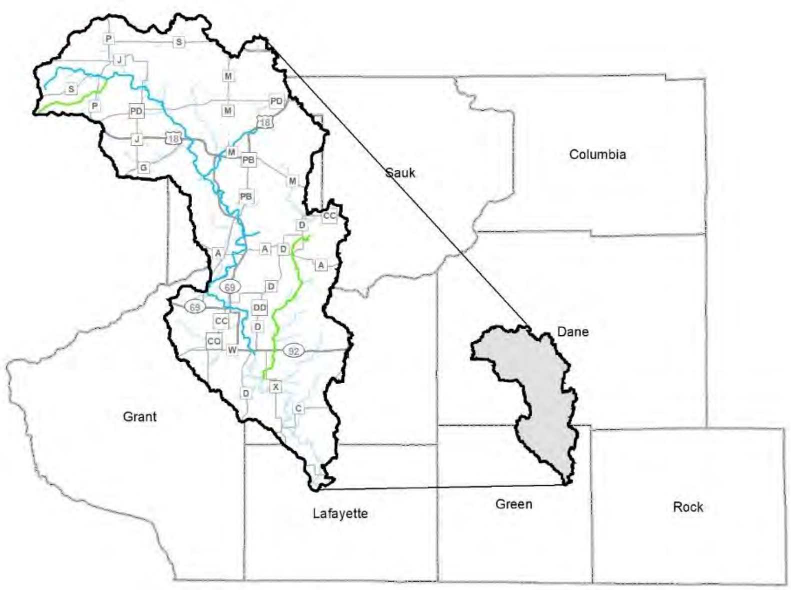
February 24, 2023: Flow from upstream of aerator

March 7, 2023: Bridge sitting on the bottom of stream, downstream of aerator

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Trout Stream Management and Status Report of the Sugar River Watershed

Dane and Green Counties, Wisconsin 2020-2021



Dan Oele
Fisheries Biologist for Dane, Green, Rock Counties
Wisconsin Department of Natural Resources
Fitchburg, Wisconsin

Table of Contents

Executive Summary

The Sugar River watershed is located on the west side of the Madison metropolitan area and contains six trout streams. The Sugar River is a Class 2 trout stream but hasn't been stocked regularly. Story Creek and Schlapbach Creek are Class 1 trout streams and have been stocked with Brook Trout in the past. Badger Mill Creek has changed from a warm water stream, stocked with put-and-take trout, into a Class 2 trout stream that receives fingerling Brown Trout. There is good public access to the Sugar River, Badger Mill and Story Creek through DNR and Dane County owned lands.

We sampled the Sugar River watershed using single pass stream electrofishing following the suspension of stocking to assess natural recruitment and natural reproduction. We found fishable populations and evidence of low to moderate recruitment but inconsistent abundances throughout the Sugar River. We documented abundant Brown Trout and high natural recruitment in Story Creek but a low abundance of Brook Trout in the absence of stocking. Henry and Gill Creek had trout, but in low abundances, while Schlapbach Creek had a healthy, self-sustaining Brook Trout population.

Schlapbach Creek and Story Creek are appropriately classified as Class 1 trout waters, but Story Creek is likely changing to Brown Trout dominance since Brook Trout stocking was stopped in 2016. Other streams in the watershed are appropriately classified as Class 2 trout waters. The DNR will continue stocking Badger Mill Creek and begin stocking Sugar River to increase adult trout abundances. Gill Creek should be classified as Class 2 trout waters, but the DNR will not invest in expensive stocking programs here due to limited public access.

Reproduction and recruitment of trout are limited by degraded habitats trout need at all life stages within the Sugar River watershed and its tributaries but can be improved with investments in stream bank and trout habitat improvement projects. With improved habitat and healthier riparian corridors, we can expect trout recruitment to increase, thereby increasing adult abundances as conditions improve. With abundant springs and cold water throughout the majority of the watershed, this system has the potential to become a destination fishery in several reaches.

The major threat to the watershed is a reduction of cold water inputs to the trout streams, groundwater depletion, increased runoff and wetland disturbance as the watershed is increasingly more developed in the fastest-growing county in the state.

Management recommendations outlined in this report include: stocking large fingerling Brown Trout in Sugar River and continuing stocking efforts within Badger Mill Creek to increase adult abundances, conducting trout habitat improvement projects along publicly owned lands within the Sugar River watershed to increase reproduction and natural recruitment, continuing to stock large fingerling Brook

Trout in Story Creek, reclassifying Gill Creek as a Class 2 trout water during the 2024 reclassification cycle, and no changes to the fishing regulations are recommended at this time.

ACKNOWLEDGEMENTS

Data collection for the 2020 and 2021 surveys were completed by DNR staff Andrew Notbohm, Jim Amrhein, Camille Bruhn, Kim Kuber, Samantha Brose, David Rowe and Dan Oele. Bryce Linden contributed watershed maps. David Rowe and Tim Simonson provided feedback and edits for this report.

Questions or comments about this report? Please contact the author at: (608) 275-3225 or daniel.oele@wisconsin.gov

WATERSHED LOCATION

Sugar River Watershed, Dane and Green counties including Sugar River, Story Creek, Badger Mill Creek, Henry Creek, Schlapbach Creek, Gill Creek and an unnamed tributary of Sugar River.

PURPOSE OF SURVEY

DNR baseline trout rotation and trout potential surveys
Assess trout stream classification
Assess natural reproduction and recruitment
Assess current trout population abundance

DATES OF FIELDWORK

June 15, 2021 – Sept. 2, 2021 (Sugar River, Story Creek, Badger Mill Creek, Gill Creek, unnamed tributary of Sugar River)

July 30, 2020 -Sept. 18, 2020 (Henry Creek and Schlapbach Creek)

FISH SPECIES OBSERVED IN THE SURVEY

All fish encountered were collected and recorded including American Brook Lamprey, Banded Darter, Black Bullhead, Black Crappie, Blackside Darter, Bluegill, Bluntnose Minnow, Brook Stickleback, Brook Trout, Brown Trout, Central Mudminnow, Channel Catfish, Common Carp, Common Shiner, Creek Chub, Fantail Darter, Fathead Minnow, Golden Redhorse, Golden Shiner, Green Sunfish, Hornyhead Chub, Johnny Darter, Lake Chubsucker, Largemouth Bass, Mississippi Silvery Minnow, Mottled Sculpin, Northern Hogsucker, Northern Pike, Orangespotted Sunfish, Pumpkinseed, Quillback, Rainbow Trout, Rock Bass, Sand Shiner, Shorthead Redhorse, Silver Redhorse and Smallmouth Bass.

Introduction

SUMMARY OF THE WATERSHED

The Class 2 trout water within the Sugar River is defined as the waters extending downstream past HWY 92 south of Belleville upstream to the headwaters near the town of Springdale northeast of Mount Horeb in Dane County. The Sugar River and two of its tributaries, Schlapbach and Story Creek, are designated DNR Exceptional Resource waters, indicating these rivers provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat and have good water quality. However, the Sugar River is considered impaired due to elevated total phosphorus levels.

From the headwaters, the Sugar River flows southeast towards Verona, through Paoli and Belleville, with numerous road crossings and public lands in between. Schlapbach Creek originates in a subdivision within Mount Horeb and flows east along the Military State Trail before meeting the Sugar River downstream of Klevenville Riley Road. The small unnamed tributary detailed in this report was surveyed at the Sugar River road crossing near Marshview Road. This creek flows west along HWY G and intersects HWY J. Badger Mill Creek originates in the city of Madison and flows south through Verona, where it gains flow in various springs and wetlands before continuing south to join the Sugar River near Riverside Road within Dane County owned lands. Henry Creek is a small, cold water tributary of the Sugar and originates in a wetland complex east of HWY 69 and joins the Sugar River within Dane County lands within the Basco Unit south of the town of Paoli. Story Creek originates in a large wetland complex north of HWY A in the town of Oregon and flows south through the DNR Brooklyn Wildlife Area and joins the Sugar River south of the town of Exeter near HWY X. Gill Creek begins north of HWY 92 and flows southwest towards Exeter where it meets the Sugar near the HWY X road crossing.

In urbanized and rapidly developing areas like Sugar River and Badger Mill Creek watersheds, two core conservation principles to try to adhere to when balancing development and maintaining healthy trout streams are: protect and maintain groundwater function as it relates to temperature and flow regimens and maintain buffers between wild riparian lands near the bank edge and the encroaching development. Large springs from the confluence of Badger Mill upstream to HWY 18 provide baseflow and supply the cold water trout need to thrive in the lower reaches of the creek. Upstream from there, development pressures have modified the channel morphology, springs and wetlands in the area, and the creek's baseflow is supplemented by Madison Metropolitan Sewage District (MMSD) treated effluent.

Recognizing the importance of urban recreational opportunities and the potential for Badger Mill Creek as a trout stream, DNR, Southern Wisconsin Trout Unlimited, Dane County and the City of Verona developed stream improvement practices in coordination with sewer line upgrades along the creek between Main Street upstream towards HWY PB. While sewer upgrades were underway, crews also installed brush bundles, rock weirs and root wads to improve the channel morphology and increase overhead cover for trout. Future surveys will assess the impact stocking and habitat improvements have made on increasing trout abundances in this area.

The Sugar River watershed encompasses 217 square miles with 66% agriculture, 17% grasslands, 7% forested and 10% other. With the exception of Story Creek, with extensive DNR lands surrounding it, the land use practices and watershed characteristics are similar among all the streams we surveyed. The majority of the watershed is dominated by agriculture, with relatively few reaches of stream with high-quality, undisturbed riparian corridors.

CURRENT STATUS

Class 1 trout streams are those with high-quality habitat with sufficient levels of natural reproduction to sustain the fishery, and no stocking is required. Class 2 streams are those in which some natural reproduction occurs but not enough to utilize all available food and space, and stocking is required to maintain a desirable fishery. Class 3 streams are those in which trout habitat is marginal with no natural reproduction occurring and requires stocking of catchable-sized trout to provide a fishing opportunity. Schlapbach Creek and Story Creek are Class 1 fisheries, whereas the Sugar River, Henry Creek and Badger Mill Creek are Class 2. The tributary to Sugar River and Gill Creek are unclassified trout waters and were surveyed as trout potential sites (Figure 2).

Badger Mill was stocked with yearling Brown Trout from 1988-2014 to provide a put-and-take fishery. MMSD started to discharge treated wastewater to the stream in 1998 to compensate for decreasing baseflows in Badger Mill and the Sugar River resulting from municipal well withdrawals and lower groundwater and stream flows. The discharge increased the baseflow by roughly 35%. Badger Mill Creek was reclassified in 2008 as a Class 2 trout stream, as was Sugar River. Electrofishing surveys documented natural reproduction and recruitment of Brown Trout in both streams, but the fisheries biologists at the time felt that there was more available habitat and stocking could improve the abundance of the fishery. Strangely, after the reclassification, Badger Mill Creek continued to be stocked with yearling Brown Trout until 2014, when the quota was switched to more appropriate large fingerlings to supplement natural recruitment. The Sugar River, despite being classified as a Class 2 stream, did not receive any stocked trout, with the exception of surplus small fingerling Rainbow Trout from Nevin Hatchery starting in 2017.

Story Creek was stocked regularly with Brook Trout until 2016 and was a Class 2 stream until it was reclassed in 2020 as a Class 1 stream. Brook Trout stocking was suspended due to its recent upgrade to Class 1 status, and the DNR determined the brood source in Ash Creek was actually compromised with domestic ancestry. The department didn't want to stock those mixed ancestry genetics on top of natural reproduction. Since then, the department has conducted a genetic analysis that shows the population already is moderately introgressed with domestic genetics.

Henry Creek and Schlapbach Creeks were stocked with Brook Trout from 2004 -2016. Schlapbach Creek has flourished into a Class 1 trout stream, but Henry Creek has not responded as positively and remains a Class 2 stream.

The entire Sugar River watershed is regulated under the standard county-wide 8 inch minimum, three daily bag limit for trout (Figure 2).

PUBLIC ACCESS

The largest swaths of DNR-owned lands in this area are along Story Creek, which lies within the Brooklyn Wildlife area near the Dane and Green County border near HWY 92. Public access is excellent in this area, with ten designated parking areas and several additional road-stream crossings. The Sugar River State Natural Area and Military Ridge Trail system offer users access to the Upper Sugar River within state-owned properties. Dane County owns additional lands along the Sugar River, offering parking and angler access further downstream in the Falk-Wells Wildlife Area and Basco Unit Wildlife area as well as numerous road crossings. Schlapbach, Henry Creek and Gill Creek do not have any public access lands or easements except for right-of-way access at road-stream crossings.

Trout stamp-funded habitat improvement projects have occurred along the Sugar River at the Dane County Basco Unit (Dane County and Trout Unlimited also provided funds) and at Story Creek near Bellbrook Road. The DNR has installed lunker structures, silt traps and bank stabilization and conducted bank sloping in the Brooklyn Wildlife Area upstream of the Alpine Road parking lots and improved the hydrology of the river with ditch filling near Bellbrook Road.

Methods

Understanding the natural reproduction capacity and recruitment of a stream is critical to managing trout populations. In our fishery assessments, natural recruitment is defined by juvenile fish surviving to age-1. Natural reproduction is the presence of age-0 fish (young-of-year, YOY), and they are difficult to accurately assess since their vulnerability to electrofishing gear is more variable than larger-sized fish. Additionally, young-of-year fish are not evenly distributed since they often occur upstream in nursery habitats and migrate downstream to adult and juvenile habitats later in life. Therefore, documenting the lack of natural reproduction does not mean there is necessarily a complete lack of natural recruitment.

To assess recruitment to age-1, all fingerling trout stocking was suspended the year prior to these surveys. Our assumption was that all yearling (age-1) trout are from natural recruitment somewhere in the watershed and all YOY (age-0) trout are from natural reproduction. If any previous stocking occurred, age-2 and older fish are assumed to be from mixed sources. High levels of natural reproduction, natural recruitment and several age classes without stocking are indicative of self-sustaining Class 1 waters. We infer that put-and-grow stocking was effective if we observe an absence or low abundance of yearling trout but an abundance of adult trout and conclude a given stream should be classified as Class 2. Waters where stocked trout survive only during early spring and summer with limited carry-over and no reproduction are Class 3.

COVID-19 safety precautions limited our fieldwork in 2020 and impacted our scheduled workload in 2021. For this report, I used 2020 data for Schlapbach Creek and Henry Creek; all other data are from 2021 surveys. We surveyed three stations in Badger Mill Creek, two in Gill Creek, two in Henry Creek, four in Schlapbach Creek, four in Story Creek, nine in the Sugar River and one in the unnamed tributary to Sugar River (see Figure 1 for a map of sample locations). All 25 stream sites were surveyed with either a tow behind barge stream shocking unit or backpack electrofishing unit.

The number of fish sampling sites in a particular stream was dependent on the stream segment length following DNR Fish Management Handbook protocols. One sampling site is required for stream segments less than 1.5 miles, two sites for stream segments 1.5-3 miles and one site every three miles on long rivers (minimum of three sites). The length of each fish survey at a particular site is determined by stream width; thirty-five times the mean stream width on segments greater than 3 meters and 100 meters minimum for streams less than 3 meters wide.

For each sampling site, we calculated the catch-per-unit-effort (CPUE) by dividing the number of fish collected by the length of the survey yielding a number of trout per mile estimate. This procedure allows for straightforward analyses of catch rates within and among stream sites as well as standardized regional and statewide comparisons. Fish length data are analyzed by size classes and age groups of interest. These groups include the number of age-0 (YOY), age-1 (yearlings) and age-2+ (adult trout). YOY are fish less than 4 inches in length, yearlings are between 4 and 7.9 inches for Brown Trout (between 4 and 7 inches for Brook Trout), and adults are considered greater than 8 inches for Brown Trout (>7 inches for Brook Trout). Preferred-sized fish are often of special interest to anglers and are fish greater than 12 inches for Brown Trout (>10 inches for Brook Trout).

All fish encountered during the survey were collected. We recorded the species of fish and total length (to the nearest tenth of an inch). Non-trout species are counted to calculate a cold water index of biotic integrity (IBI) score (0-100). For added context, catch rates of Mottled Sculpin (less tolerant of poor water quality and a cold water indicator species) and White Sucker (tolerant of poor water quality and warmer water) were also evaluated as a proxy for water temperature profiles at each survey station. The DNR Fisheries Management Handbook Chapter 510 details each of the sampling protocols in greater detail. All fish were returned to the stream.

Water quality and habitat metrics were collected at each survey site. Streamflow (cubic feet per second, cfs) was calculated at one cross-sectional transect at each site using a HACH FH950 handheld flow meter. Temperature, dissolved oxygen, specific conductivity and pH were measured using a handheld YSI Pro 2030 meter. Stream habitat metrics were recorded using a DNR qualitative habitat rating form. For streams less than 10 meters wide, ratings included riparian buffer width, bank erosion, pool area, width: depth ratio, riffle: riffle or bend: bend ratio, fine sediments and cover for fish. For streams greater than 10 meters wide, ratings included bank stability, maximum thalweg depth, riffle: riffle or bend: bend ratio, rocky substrate and cover for fish. All data was recorded digitally using weatherproof handheld Toughbook™ laptops and a custom software application.

Results

SUMMARY

Brown Trout were collected in 22 of the 25 sites we sampled (Table 2), and average catch rates for YOY Brown Trout (<4 inches) was 122 per mile, yearlings (4-8 inches) were 127 per mile, adults (>8 inches) were 201 per mile, preferred-sized trout (>12 inches) were 46 per mile and fish size ranged from 2 to21 inches. YOY Brown Trout (natural reproduction) were observed in 20 locations (Figure 4). Yearling Brown Trout (4-8 inches) were observed in 19 locations (Figure 5), and larger size classes of Brown Trout (>8”) were observed at 19 sites (Table 2).

Brook Trout were observed in Gill Creek, Schlapbach Creek, Story Creek and Henry Creek (Table 3). Schlapbach Creek had the highest catch rates for Brook Trout, with mean catch rates of YOY at 35 per mile, yearlings at 113 per mile and adults at 94 per mile. The upper two stations near the headwaters had the most fish and multiple year classes represented in the sample.

YOY Brown Trout catch rates across the watershed were generally low, and only Story Creek had average YOY catch rates exceeding the statewide median (Figure 4). The most YOY were collected at the HWY 92 station on Story Creek, followed by the Story Creek Circle Wildlife Area station and Valley Road in the Sugar River. Most stations produced low abundances of YOY, and only one station had zero YOY recruits (excluding zeros for YOY Brown Trout in Brook Trout dominant Schlapbach, Table 2).

Yearling catch rates for Brown Trout across the watershed followed a similar pattern as YOY, and only Story Creek had average yearling catch rates, which exceeded the statewide median (Figure 5). The highest catch rates for yearling Brown Trout were at HWY 92 in Story Creek, followed by Bruce Company Bridge in the Sugar River. Nearly all other stations had at least some yearling recruitment, and only three stations recorded zero yearlings for Brown Trout (Table 2).

For adult Brown Trout (>8 inches), Story Creek and Badger Mill Creek had catch rates exceeding the statewide median (with Sugar River close to that benchmark), but only Story Creek exceeded the driftless median benchmark (Figure 6). The highest catch rates of adult Brown Trout >8 inches were found at HWY 92, HWY X and Alpine Road stations in Story Creek, followed by Bruce Company Bridge in the Sugar River. Henry Creek, Gill Creek and the unnamed tributary to the Sugar River all contained very low adult trout abundances (Table 2).

For fish larger than 12 inches, only Story Creek and Sugar River had average catch rates that met or exceeded the statewide benchmark (Figure 7). The highest catch rates of adult Brown Trout >12 inches were found at HWY X, Story Creek Circle Wildlife Area and Alpine Road in Story Creek, followed by Bruce Company Bridge and Bobcat Lane stations in the Sugar River. All other catch rates were < 65 per mile for this size class (Table 2). See Table 6 and Table 7 for a detailed summary of regional and statewide benchmarks for Brook and Brown Trout.

Brook Trout were observed in four streams, but only the upper two stations in Schlapbach Creek can be considered a viable fishing opportunity for Brook Trout at this time. In Schlapbach Creek, mean catch rates for Brook Trout met or exceeded driftless rates for all size classes except YOY. Only two stations produced YOY in modest amounts and were below the driftless median benchmark. The highest abundances of Brook Trout were found at Town Hall Road (611 per mile) and Sletto Road (321 per mile). The highest catch rates of the largest fish were found at Sletto Road (Table 3).

The presence of cold water indicator species like Mottled Sculpin throughout much of the watershed (and low trout abundances) indicate the stream temperatures are suitable and water quality sufficient to support increased trout abundances with habitat improvements. Mottled Sculpin were observed throughout the watershed in all seven streams. The highest abundances were in Schlapbach and Henry creeks, followed by Badger Mill Creek and Sugar River. White Suckers were observed in most of the watershed, with the highest abundances in the lower reaches of the Sugar River and Story Creek but were less abundant in Schlapbach Creek, Gill Creek and Henry Creek (Table 5).

COLD WATER INDEX OF BIOTIC INTEGRITY SCORES AND HABITAT QUALITY

The median cold water IBI score across all sites in the Sugar River watershed was 68 (out of 100) and exceeded the statewide trout stream (60), Driftless Area trout stream (50) and Dane County (50) median scores. Average qualitative habitat ratings for the watershed was 56 (out of 100) with all stations scoring as “Excellent,” “Good” or “Fair,” with one “Poor” score (the unnamed tributary to Sugar River). Average riparian buffer scores were excellent (13 out of 15). Bank erosion scores varied widely, and nearly all stations had some erosion issues (range 0-15 out of 15). Adequate pool area habitat was rare, with a median score of 3 and a max score of 7 (out of 15). Median scores for other physical habitat metrics showed similar heterogeneous patterns, including width: depth ratio (5 out of 15), riffle habitat (10 out of 15), fine sediments present (5 out of 15) and cover for fish (10 out of 15). The average temperature across all stations was 62.7°F (ranged from 53 to 71). The average stream flow was 21.4 cfs (ranged from 1.8 to 55 cfs), with an average width of 8.2 meters (Table 4).

SUGAR RIVER

The highest trout abundances in the Sugar River were found at the HWY PB station (579 per mile), but the other two stations were well below statewide benchmarks (Table 2). The middle reaches of the Sugar River had the highest catch rates of adult Brown Trout (e.g., Valley Road at 293 trout per mile and Bruce Company Bridge at 407 per mile), but all the survey stations had adult trout abundances above the minimal fishable population (50 per mile) and offer angling opportunities throughout this section of the river. The Valley Road station had the healthiest trout population with multiple year classes present and catch rates that exceeded regional benchmarks for YOY, yearling, adult and preferred-size classes (Table 2). The average catch rate for the lowest reaches of the Sugar River sampled was 279 per mile, and none of the stations exceeded the Driftless Area median benchmarks (one of them exceeded statewide marks).

The quality, amount and types of habitat available for trout varied throughout the Sugar River watershed, and trout abundances reflected heterogeneity in available trout habitat. For example, Brown Trout catch rates fluctuated between high and low catches from below the Belleville Dam upstream to the headwaters in Klevenville. Belleville Dam catch rates were 416 per mile, one station upstream at Frenchtown Road, 142 per mile, and further upstream at Bruce Company property, 766 per mile. This pattern of alternating high-low catch rates was repeated throughout the length of the survey stations indicating habitat and physical characteristics of the river likely mediated trout abundances (Table 2).

Only two Brook Trout were observed in the Sugar River at the Valley Road station indicating the abiotic conditions needed for Brook Trout to persist are lacking. Despite surplus stocking of small fingerling Rainbow Trout, only three rainbows were observed in the survey.

The unnamed tributary of the Sugar River that we surveyed had adequate flow and suitable temperature to support trout, but the substrate was dominated by thick layers of silt and the channel was ditched, greatly limiting the trout potential in this reach. However, we did observe a single YOY Brown Trout here, indicating trout had tried to utilize the area for spawning and some reproduction may occur here. Habitat improvements to narrow the stream, enhance scouring and woody habitat additions may boost the trout population in this small tributary.

SCHLAPBACH CREEK

Schlapbach Creek stood out in this survey with high catch rates of Brook Trout, which have so far kept the Brown Trout from invading (only one observed). Town Hall Road boasted the highest catch rates of Brook Trout (611 per mile) and had YOY, yearling and adult size classes represented in the survey. The stream channel is incised and suffers from areas of bank erosion, but the cold water, wooded riparian corridor and good flow with deep bend pools offer Brook Trout a rare opportunity to persist and provide a unique angling opportunity.

BADGER MILL CREEK

We surveyed three stations within Badger Mill Creek, including upstream of the confluence with the Sugar River, at HWY 69 Bridge and upstream of Bruce Street. HWY 69 and Bruce Street catch rates were comparable (>400 trout per mile), while the station near the confluence had 225 trout per mile. YOY and yearling production lagged behind regional benchmarks, but larger-sized fish were more abundant (Table 2, Figure 4-7).

HENRY CREEK

Henry Creek is a very small spring-fed tributary to the Sugar River and flows west from a spring complex south of Paoli and meets the Sugar River within the Dane County Basco Unit lands. We surveyed two stations relatively near one another at the only locations we could gain access to. One station was at the HWY 69 crossing, and the other upstream of the nearby railroad bridge crossing. The relatively small, shallow stream produced similar results at each location, modest YOY and yearling catch rates and very low (or absent) abundances of larger classes of Brown Trout (Table 2).

STORY CREEK

With above average habitat scores, diverse stream channel morphology, cold stream temperatures and good IBI scores, Story Creek had the highest quality trout waters in the watershed (Tables 2 & 4). For example, the HWY 92 station contained the highest total catch rates across all size classes. The YOY catch rates here (1643 per mile) were greater than the YOY catch rates for all other sites in the watershed combined. The other three stations were among the highest five catch rates across the rest of the watershed. The HWY 92 and HWY X stations had the highest abundance of 12-inch and 18-inch fish in the watershed (Table 2). Story Creek was the only trout stream in this watershed to outperform regional Driftless Area and statewide benchmarks across all size classes (Figure 4-7).

Story Creek at Alpine Road and HWY 92 are two DNR annual trend sites. These reaches have been surveyed regularly since the early 2000s (Figure 8-9). The Alpine

Road station has experienced shifts in Brown and Brook Trout dominance coinciding with stocking practices (Table 1, Figure 8). For example, stocking Brook Trout in 2015-2016 produced a fishery dominated by Brook Trout, but in the absence of stocking, Brown Trout have since become dominant by a wide margin (Figure 8). At HWY 92, Brown Trout had been stable, with minor fluctuations between 800-1200 Brown Trout per mile. The 2021 survey revealed a drastic increase in trout abundances, punctuated by a strong YOY Brown Trout year class (Figure 9).

GILL CREEK

Although unclassified trout water, the DNR surveyed this tributary of Sugar River due to its proximity to Story Creek and a history of a remnant trout population. In the two stations we surveyed, very few trout were captured (13 total), none over 12 inches (Table 2-3) with limited YOY and yearling survival (Figure 4-5). Both survey locations suffered from heavy siltation, bank erosion and incision and generally lacked cover for trout. Surprisingly, the headwaters near Freidig Road revealed a remnant Brook Trout population persisting in low abundance (Table 3), indicating the trout potential in this area may warrant closer examination and increased resources to improve the habitat and fishery.

Discussion

The majority of stream reaches within the Sugar River, Badger Mill Creek and Henry Creek are performing as Class 2 fisheries. They provide Minimal Fishable populations, and anglers can expect to catch trout in these areas (e.g., survey reaches contained >50 adult trout per mile). These streams have isolated reaches of spawning and YOY nursery habitat but are not substantial enough to populate the entire system with yearling or adult trout that would be able to fully utilize the available food and space. Evidence for this occurrence is clear in reviewing natural YOY and yearling recruitment catch rates within the watershed. For example, Brown Trout YOY recruitment was low; only one station exceeded the statewide median catch rates (Sugar River at Valley Road). Similarly, for yearling recruitment, only two locations had catch rates above statewide median rates (Table 2).

Currently, Class 1 trout waters, Schlapbach (Brook Trout) and Story Creek (mixed fishery, dominated by Brown Trout), are high in abundance across all size classes and indicate healthy self-sustaining fisheries in these waters, which provide the highest quality angling experiences among the streams we surveyed. Within Story Creek, we observed the highest abundances of trout in the watershed, and average catch rates across all four stations exceeded the statewide and Driftless Area median CPUE for all size classes (Figure 4-7). Though tight casting windows around brush and downed wood can be challenging for some anglers, others enjoy the unique remote feel of the property, and anglers can be confident plenty of trout are lurking in these waters.

Schlapbach Creek offers a relatively new and unique angling experience for Brook Trout in Dane County. DNR Brook Trout stocking efforts in 2015-2016 (Table 1) have produced a self-sustaining Brook Trout population, and as a result, the stream was recently classified as Class 1 trout water. Though the habitat and physical characteristics of the stream could use improvement, standard streambank improvement and habitat projects seeking to stabilize banks and improve aesthetics could promote Brown Trout in the system at the expense of the existing Brook Trout fishery. Work should focus on maintaining the riparian shade and cover for Brook Trout with riffle-run-pool complexes. Current DNR guidance precludes stream bank acquisition or fee title acquisition along this stream, but efforts should be made to protect and maintain groundwater sources, riparian buffers and water quality of this unique fishery. Though currently along privately held lands, when and if DNR easements or acquisition guidance can be modified, and assuming current landowners are agreeable, future stream bank easements and or fee title acquisitions could result in DNR-led initiatives to improve the habitat and enhance the Brook Trout fishery in Schlapbach Creek.

Gill Creek and Henry Creek do not currently provide reliable angling opportunities. Though Henry Creek was stocked in 2015, those Brook Trout have not resulted in a robust recreational fishery in this stream, nor have trout from the Sugar River migrated into Henry Creek (likely due to the steep grade of the HWY 69 crossing). Gill Creek has the temperature profile to support increased abundances of trout, but the habitat is severely degraded and largely inaccessible and unfishable. The stream channel is choked with silt and too wide, but trout are persisting, even Brook Trout in the headwaters.

With 200 trout per mile, Gill Creek should be upgraded from unclassified trout water to Class 2 as it has moderate levels of natural reproduction and yearling recruitment but not enough to fully utilize the available food and space. Low trout abundances should not minimize the importance of these types of tributaries as a vital groundwater protection area or their potential to improve with targeted habitat improvements and improved land use practices. Well-buffered, cold springs and small streams like Henry Creek, Gill Creek and other small tributaries (e.g., unnamed tributary to Sugar River in this report) and their wetland complexes ensure cold, high-quality water inputs to the classified trout waters nearby and should be enhanced and protected.

At the other end of the stream order spectrum, the lower reaches of the main-stem Sugar River do not have high enough trout abundances to warrant upgrading to Class 1 trout waters but do serve as an important overwinter ground for trout. River reaches like these are important habitats that trout seek as water temperatures decrease in winter. At this time, trout will migrate to lower reaches in search of warmer, deeper waters (buffered from cold surface air temps by groundwater) to overwinter and conserve energy. Areas like these can be overlooked but serve an important role in structuring healthy trout fisheries and offer excellent fishing opportunities during the early catch and release seasons.

In contrast to decreased trout catch rates subsequent to regional flooding in 2018 (e.g., Black Earth Creek and Blue Mounds Watershed assessments in 2019), the 2020 and 2021 data presented here indicate that post-flood conditions have resulted in increased trout production and year class formation in some locations. For example, Story Creek had stations with YOY production and yearling recruitment values well above regional benchmarks. Story Creek's catch rate of YOY Brown Trout at HWY 92 was 11.5 times greater than the Driftless Area benchmark. However, Sugar River (except one station at Valley Road) and Badger Mill Creek did not experience dramatic increases in YOY production. Future surveys will examine whether or not freshly scoured spawning riffles and modified stream morphology will continue to produce strong year classes, whether or not contemporary elevated YOY production leads to increased adult trout abundances for anglers to target and if lag-effects of increased scouring will lead to YOY production in places like Sugar River and Badger Mill that so far have not experienced increases that we have seen in other area streams.

Fishery assessments at the Story Creek trend stations clearly show the influence of regular Brook Trout stocking prior to 2016 which produced a fishery that was dominated by Brook Trout over Brown Trout by greater than a 2:1 margin in the years following stocking (Figure 8). However, when stocking ceased, Brown Trout slowly began to increase abundances to the point where the Brook Trout population crashed in 2019, and the 2021 survey showed Brown Trout outnumbered Brook Trout by a 9:1 margin. In addition to relying on stocking to support the population, the discovery of gill lice, a non-native parasite that damages gill filaments and can lead to fish death, has been documented in Story Creek. In an effort to restore the Brook Trout population, the DNR is undertaking a Brook Trout stocking program on selected waters that have a) a history of Brook Trout, b) genetic analyses indicate the strain of established Brook Trout populations is from domestic strains or out of basin strains from historical stocking events. Future large fingerling Brook Trout stocking planned for 2021-2026 in Story Creek has a twofold goal of increasing Brook Trout abundances and evaluating changes in genetic profiles after stocking native Wisconsin feral strains.

Though anglers have reported catching a few of the surplus small fingerling Rainbow Trout that have been stocked in Sugar River over the years, the survival of these fish is very low. Only a dozen rainbows ranging in size from 9-14 inches showed up in our surveys in 2020 and 2021. Despite being stocked into the mainstem Sugar River, rainbows were observed in Henry Creek (1), Schlapbach (1) and Badger Mill creeks (7) in addition to Sugar River (3).

A unique feature of this watershed is the expansive public access comprised of large publicly owned tracts within Dane County and DNR-owned properties, most notably along the Sugar River, Badger Mill Creek and Story Creek. These properties are easily accessible by a wide variety of users, from anglers, hunters, paddlers, hikers, birders and other outdoor recreators. Balancing priorities as it pertains to in-stream and riparian trout habitat is paramount in the sustainability of cold water aquatic resources. For example, paddlers, anglers and conservation groups need to coordinate riparian management activities in consultation with property owners to ensure safe paddler access and angler passage but leaving ample wood in and near the river, which serves important ecological functions and provides fish habitat while standing (e.g., shade) as well as when it falls into the river (e.g., cover for fish).

Investments in new easements or land acquisitions in areas like Badger Mill Creek, Schlapbach Creek and the headwaters and lower reaches of the Sugar River would be particularly valuable in Dane County, the fastest-growing county in the state. Current public access to these streams is limited compared to the rest of the watershed. Stream bank easements are one of the few tools the DNR has to help encourage and enable public use of the resource. DNR Fisheries Management program, along with Dane County and Southern Wisconsin Trout Unlimited, have invested substantial time and effort in recruiting interested landowners to enroll in a stream bank easement program. We encourage any interested landowners to reach out to their local fisheries biologist (contact info on the first page of this report for Dane County) if they have any interest or want to learn about the DNR Stream Bank Easement Program (https://dnr.wi.gov/topic/fishing/streambank/). Priority locations for easement acquisitions should include the high-performing areas outlined in this report but are open to any interested landowner. Increased public access with easements or fee title acquisitions are necessary first steps in order to utilize other funding sources to conduct comprehensive stream bank and in-stream trout habitat improvement projects in the watershed. DNR Fisheries Management program will continue to partner with area conservation organizations to advance this important component of fisheries management and public access to fishing grounds as well as engage in the DNR property management process to allow greater flexibility to acquire lands dedicated to fishing access and angler access.

While most of the land within the Story Creek sub-watershed has been maintained in a wooded and wetland state, improved land use practices in adjacent lands will perhaps be the largest governing factor in maintaining or improving trout abundancies in the rest of the Sugar River watershed. The decrease in trout abundances in the YOY and yearling size classes throughout the watershed (except Story Creek) indicate recruitment failures and is indicative of a lack of physical habitat trout need at different stages of their lifecycle. Most of the qualitative habitat metrics we reported need improvement; bank erosion, incision and fine sediment accumulation have led to many stream reaches devoid of pools and width:depth ratios that cannot support healthy numbers of trout. As a result of siltation and sediment transport, many reaches have eroded banks with monotonous runs over sand and silt substrates with fine sediments forming mucky margins of heavy deposition, resulting in stream corridors that are wide, flat and shallow with few trout. Stream segments like these could be improved by reconnecting the floodplain with bank sloping and stabilization, improving the width:depth ratio to promote deeper runs and pools, and providing habitats for trout at multiple life stages. For example, habitat projects could create adult spawning habitats with increased depth and velocity to form riffles and offer juvenile trout nursery habitat, with vegetated margins of the stream with overhead cover in lower velocity, deeper pools with rootwads and rock weirs.

Protecting and improving groundwater and natural riverine processes associated with flow and temperature profiles are important components of healthy trout fisheries. The agricultural history in Brooklyn Wildlife Area along Story Creek has left many diversions, straightened channels and shallow braided channels resulting in monotonous stream habitats. To improve the habitat and hydrology here, the DNR has conducted ditch filling, wetland restoration and expanded buffers along Story Creek near Bellbrook Road. There are several braided sections, ditch diversions and straightened reaches remaining and the DNR will continue to work to improve the overall ecological condition of the landscape, focusing on improving the trout fishery to the extent feasible.

In addition to physical habitat stressors, invasive species like New Zealand Mudsnails continue to colonize Wisconsin's trout streams. Established populations have been found in Badger Mill Creek and are likely within the Sugar River. Research and monitoring are underway to determine any impacts new invaders like mudsnails pose to the trout fishery and ecology of the stream. Anglers and paddlers need to be mindful of transporting these organisms between the waterways they recreate in. Freezing gear or disinfecting protocols (bleach, Virkon, steam) are the best ways to be sure your gear is free of aquatic invasive species between trips.

Management Goals and Objectives

1) **Goal** – Maintain or increase Brown Trout abundance in Sugar River and Badger Mill Creek
   Objective - Increase adult Brown Trout >8 inches CPE to at least 217 adult trout per mile (the statewide median benchmark for this size class)
   Strategy - Stock large fingerling Brown Trout at appropriate levels and locations that anglers are likely to benefit from
   a. assess status of fishery and need for stocking in the next watershed assessment
2) **Goal** – Increase natural recruitment of Brown Trout on Class 2 waters of Sugar River and Badger Mill Creek
   Objectives – Increase average CPUE yearling catch rates to 209 per mile (meet or exceed statewide median benchmark for this size class)
   a. some reaches meet the definition of Class 1 waters, but overall abundances are lower than desired for Class 1 designation

Strategy – Conduct habitat improvement projects along publicly accessible lands
Strategy – Promote and support groundwater and riparian land protections in sensitive areas subject to development pressures in the watershed.

a. Collaborate with local landowners, conservation organizations and government agencies to acquire easements or lands to increase buffer areas, encourage native vegetated riparian corridors, increase public access and implement habitat improvement projects in the Sugar River
    i. Improve habitat and water quality to increase survival and recruitment of naturally reproduced fish within the watershed with 1-2 miles of Trout Stamp funded habitat improvement project.
    ii. Assess success of stocking program and trout classification in next trout survey rotation

3) **Goal**- Improve Brook Trout genetics in Story Creek to native Wisconsin strain while promoting Brook Trout over Brown Trout, to extent feasible
Objective- Increase adult Brook Trout abundances to meet or exceed the Driftless Area benchmark (85 per mile >7 inches)
Objective – Replace domestic strain Brook Trout genetics with wild Brook Trout genetics
Strategy – Resume stocking large fingerling Brook Trout, with appropriate genetics, and evaluate efficacy with annual trend survey data collections and collect additional genetic samples at conclusion of stocking program to reassess genetic contributions of stocked products
Strategy- Pursue habitat improvements and hydrological improvements within Story Creek designed to promote Brook Trout and deter Brown Trout to extent feasible
    a. Promote cold water habitats Brook Trout prefer with improved hydrology by meandering and connecting disjointed stream threads, filling lateral ditches, increasing pool habitats, and providing overhead cover where it is lacking
    b. Restore or protect forested wetlands and shaded riparian corridors to help promote Brook Trout preferred, coldest water temperatures possible

ADDITIONAL MANAGEMENT RECOMMENDATIONS

1) Reclassify Gill Creek as Class 2 trout waters in 2024 reclassification cycle
2) Maintain harvest opportunities with current regulation of 8 inch minimum, three daily bag limit
3) Evaluate angler-use and harvest within the watershed using angler creel surveys
4) Improve angler access in the Sugar River watershed including its tributaries with fee title acquisitions, stream bank easements or donations or other partnerships
    a. Southeast Glacial Plains regional planning effort within the DNR master planning process will begin in 2024.
        i. Modifying DNR Natural Resource Project Boundaries to follow existing parcel boundaries along classified trout streams would

streamline potential DNR fisheries' acquisition process for new parcels available for public recreation.

1. For example, the current Natural Resources Board boundary excludes most of the Sugar River watershed and tributaries, including headwater reaches of Story Creek, Gill Creek, Badger Mill Creek and Schlapbach Creek, as well the majority of the main-stem Sugar River.
2. Public access is prerequisite for consideration of Trout Stamp funded habitat improvement projects needed to address large scale habitat degradation.

Tables and Figures

Table 1. Trout stocking in the Sugar River Watershed 2015-2021. Stocking events with an asterisk were provided by surplus hatchery production and not initially requested.

Stream	Species	Age	2015	2016	2017	2018	2019	2020	2021
Badger Mill	Brown	Large Fingerling	877	390	500	505			
		Small Fingerling		500					
Henry Creek	Brook	Large Fingerling	417						
Schlapbach	Brook	Large Fingerling	942	400					
Story	Brook	Large Fingerling	3200	3000					759
		Adult		60					
Sugar	Brown	Large Fingerling				7537*			
		Adult							100*
	Brook	Adult							270*
	Rainbow	Small Fingerling			21945*	7500*	8720*	19188*	9935*

Table 2. Brown Trout catch rates in for the Sugar River watershed. Catch Per Unit Effort (CPUE) units are numbers fish per electrofishing mile. Streams marked with asterisk indicate survey data from 2020, all others are from 2021 surveys. Values shown in red indicate a catch rate below the statewide median CPUE.

Stream	Station (ID)	N	Mean Length (In)	<4" YOY CPUE	4-8" Yearling CPUE	>8" CPUE	>12" Preferred CPUE	>15" Memorable CPUE	>18" Trophy CPUE	Total CPUE
Badger Mill	Confluence (5)	28	7.4	48.3	48.3	128.7	0.0	0.0	0.0	225.3
	HWY 69 (6)	69	8.5	72.9	85.0	261.1	54.7	12.1	6.1	419.0
	Bruce St. (3)	71	8.9	11.7	123.2	281.6	41.1	0.0	0.0	416.5
Gill Creek	Behnke Rd. (148)	8	5.1	46.0	61.3	15.3	0.0	0.0	0.0	122.6
	Freidig Rd. (149)	2	4.7	16.1	16.1	0.0	0.0	0.0	0.0	32.2
Henry Creek*	HWY 69 (7)	13	4.2	98.0	70.0	14.0	0.0	0.0	0.0	181.9
	RR Track (8)	9	3.8	112.7	32.2	0.0	0.0	0.0	0.0	144.8
Schlapbach Creek*	Klevenville Riley (10)	1	9.3	0.0	0.0	15.3	0.0	0.0	0.0	15.3
	Sletto Rd.(12)	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Townhall Rd. (14)	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Perimeter Rd. (13)	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Story Creek	HWY X (34)	38	9.2	45.9	275.5	551.0	160.7	45.9	45.9	872.3
	Story Creek Circle (36)	100	7.3	237.6	199.3	329.5	84.3	30.7	0.0	766.4
	HWY 92 (35)	160	5.6	1642.7	625.8	860.4	39.1	19.6	19.6	3128.9
	Alpine Rd. (17)	77	9.9	75.7	142.0	511.2	208.3	94.7	9.5	728.9
Sugar River	Below Dam (24)	71	8.1	64.5	123.2	228.8	58.7	0.0	0.0	416.5
	Frenchtown Rd. (19)	38	9.2	11.2	33.7	97.3	22.5	3.7	0.0	142.2
	Basco Property (29)	34	9.5	12.1	44.3	80.5	36.2	4.0	4.0	136.8
	Bruce Co Bridge (25)	188	8.7	61.1	297.4	407.4	81.5	20.4	8.1	766.0
	Riverside Rd. (22)	52	8.9	21.7	47.8	156.6	21.7	0.0	0.0	226.2
	Valley Rd. (27)	169	5.9	445.9	252.3	293.3	64.5	11.7	5.9	991.5
	Bobcat Lane (30)	32	11.1	14.3	35.8	178.8	78.7	50.1	14.3	228.9
	HWY PD (32)	54	8.5	64.4	193.1	321.9	42.9	21.5	10.7	579.4
	Valley Spring Rd. (31)	2	11.2	0.0	0.0	42.9	21.5	0.0	0.0	42.9
Unnamed trib. to Sugar	Sugar River Rd. (33)	1	3.0	16.1	0.0	0.0	0.0	0.0	0.0	16.1
Driftless Median CPUE				**142**	**238**	**341**	**67**			**730**
Statewide Median CPUE				**128**	**209**	**217**	**52**			**537**

Table 3. Brook Trout catch rates for the Sugar River watershed. Catch Per Unit Effort (CPUE) units are numbers of fish per electrofishing mile. Streams marked with asterisk indicate survey data from 2020, all others are from 2021 surveys. Values shown in red indicate a catch rate below the statewide median CPUE.

Stream	Station (ID)	N	Mean Length (In)	<4" YOY CPUE	4-7" Yearling CPUE	>7" CPUE	>10" Preferred CPUE	>12" CPUE	Total CPUE
Gill Creek	Freidig Rd. (149)	3	7.27	0.00	32.19	16.09	0.00	0.00	48.28
Schlapbach Creek*	Klevenville Riley (10)	1	9.80	0.00	0.00	15.33	0.00	0.00	15.33
	Sletto Rd.(12)	22	9.07	43.89	14.63	263.35	102.41	43.89	321.87
	Town Hall Rd. (14)	38	5.06	96.56	418.43	96.56	0.00	0.00	611.55
	Perimeter Rd. (13)	1	4.50	0.00	18.93	0.00	0.00	0.00	18.93
	Alpine Rd. (17)	8	7.39	18.93	9.47	47.33	18.93	0.00	75.73
Story Creek	HWY 92 (35)	1	6.30	0.00	19.56	0.00	0.00	0.00	19.56
Sugar River	Valley Rd. (27)	2	9.20	0.00	0.00	10.22	5.11	0.00	10.22
Driftless Median CPUE				**132**	**86**	**85**	**18**		**219**
Statewide Median CPUE				**148**	**156**	**85**	**18**		**336**

Table 4. Coldwater index of biotic integrity (IBI) scores, temperature, flow, stream width and habitat ratings for the Sugar River watershed.

Stream	Station (ID)	IBI Score	Temp. (°F)	Flow (CFS)	Mean Stream Width (meters)	Habitat Score
Badger Mill	**2021 Average**	**63.3**	**62.2**	**8.9**	**6.4**	
	Confluence (5)	70	63		5.7	
	HWY 69 (6)	60	62	13.4	7.5	43
	Bruce St. (3)	60	61.7	4.5	6	
Gill Creek	**2021 Average**	**50**	**63**		**1.45**	
	Behnke Rd. (148)	50	64	10.6	1.5	
	Freidig Rd. (149)	50	62		1.4	40
Henry Creek*	**2020 Average**	**40**	**56**		**1.9**	
	HWY 69 (7)	50	59		2	
	RR Track (8)	30	53	3.5	1.75	67
Schlapbach Creek*	**2020 Average**	**73.5**	**54.6**	**3.3**	**2.7**	**49.3**
	Klevenville Riley (10)	90	54	4.6	3	38
	Perimeter Rd. (13)	40	56		2.5	
	Sletto Rd.(12)	80	54.5	3.5	2.6	52
	Town Hall Rd. (14)	80	54	1.8	2.8	58
Story Creek	**2021 Average**	**92.5**	**66.3**	**30.1**	**5.9**	**79.5**
	HWY X (34)	80	70.5	33.2	6.6	77
	Story Creek Circle (36)	100	68	27.9	6	82
	HWY 92 (35)	100	65.6		7	
	Alpine Rd. (17)	90	61	29.3	3.9	77
Sugar River	**2021 Average**	**65.6**	**64.4**	**37.7**	**10.3**	**55.4**
	Below Dam (24)	50	60.6	51.1	25	
	Frenchtown Rd. (19)		68.3	55.1	13	65
	Basco Property (29)	70	70.2	52	13	60
	Bruce Co Bridge (25)	80	65.3	30.3	10	73
	Riverside Rd. (22)	70	63	28.3	10	36
	Valley Rd. (27)	75	62.5	27.1	8.6	62
	Bobcat Lane (30)	70	63	20	5	57
	HWY PD (32)	70	63		4	
	Valley Spring Rd. (31)	40	63.3	5.7	4.2	35
Unnamed trib (Sugar)	Sugar River Rd. (33)	80	71.6	3.9	3	20

Table 5. Total catch rates for Mottled Sculpin and White Sucker, IBI scores and predicted stream natural community categories for the Sugar River watershed.

Stream	Station (ID)	IBI Score	Natural Community Prediction	Mottled Sculpin CPUE	White Sucker CPUE
Badger Mill	Confluence (5)	70	Cool-Cold Mainstem	145	386
	HWY 69 (6)	60	Cool-Cold Mainstem	0	904
	Bruce St. (3)	60	Cool-Cold Mainstem	0	1496
Gill Creek	Behnke Rd. (148)	50	Cool-Cold Headwater	445	322
	Freidig Rd. (149)	50	Cool-Cold Headwater	0	0
Henry Creek*	HWY 69 (7)	50	Coldwater	825	209
	RR Track (8)	30	Coldwater	65	28
Schlapbach Creek*	Klevenville Riley (10)	90	Cool-Cold Headwater	812	31
	Sletto Rd.(12)	80	Cool-Cold Headwater	995	0
	Town Hall Rd. (14)	80	Cool-Cold Headwater	901	0
	Perimeter Rd. (13)	40	Cool-Cold Headwater	0	0
Story Creek	HWY X (34)	80	Cool-Cold Mainstem	275	1079
	Story Creek Circle (36)	100	Cool-Cold Mainstem	138	529
	HWY 92 (35)	100	Cool-Cold Mainstem	254	645
	Alpine Rd. (17)	90	Cool-Cold Mainstem	284	634
Sugar River	Below Dam (24)	50	Cool-Cold Mainstem	24	1472
	Frenchtown Rd. (19)		Cool-Cold Mainstem	0	150
	Basco Property (29)	70	Cool-Cold Mainstem	129	1042
	Bruce Co Bridge (25)	80	Cool-Cold Mainstem	16	566
	Riverside Rd. (22)	70	Cool-Cold Mainstem	149	395
	Valley Rd. (27)	75	Cool-Cold Mainstem	422	459
	Bobcat Lane (30)	70	Cool-Cold Mainstem	193	544
	HWY PD (32)	70	Coldwater	118	300
	Valley Spring Rd. (31)	40	Cool-Cold Mainstem	0	22
Unnamed trib (Sugar)	Sugar River Rd. (33)	80	Coldwater	499	177

Table 6. Brook Trout CPUE (fish/mile) percentile breakdown for stream surveys conducted on Class 1 trout streams in the Driftless Area and statewide where at least one trout was collected, 2012-2021.

	CPUE total	(All sizes)	CPUE age 0	(<4.0 inches)	CPUE age 1	(4.0-6.9 inches)	CPUE adult	(≥7 inches)	CPUE preferred	(≥10 inches)
Percentile	**Driftless Area**	**Statewide**	**Driftless Area**	**Statewide**	**Driftless Area**	**Statewide**	**Driftless Area**	**Statewide**	**Driftless Area**	**Statewide**
10	15.1	22.9	16	16.1	12.4	16.1	12.8	15.3	6.5	5.7
25	53.0	96.6	46	45.3	30.5	48.3	30	32.2	11.1	10.3
35	107.1	174.7	68.6	72.4	44.9	80.5	47.9	48.3	14.3	12.8
50 (median)	219.9	336.8	128.7	145.3	80.5	149.2	80.5	80.5	16.1	16.4
65	402.3	579.7	209.2	241.4	150.9	257.2	124	129.4	29.1	27.5
75	590.1	772.5	321.9	365.5	234.2	366.7	177.7	185.2	37.5	37.4
90	1223.0	1488.4	787.1	812.3	548.7	662.7	347	344	64.4	64.4

Table 7. Brown Trout CPUE (fish/mile) percentile breakdown for fishery surveys conducted on Class 1 trout streams in the Driftless Area and statewide where at least one trout was collected, 2012-2021.

	CPUE total (All sizes)		CPUE age 0 (<4.0 inches)		CPUE age 1 (4.0-7.9 inches)		CPUE adult (≥ 8 inches)		CPUE preferred (≥12 inches)	
Percentile	**Driftless Area**	**Statewide**	**Driftless Area**	**Statewide**	**Driftless Area**	**Statewide**	**Driftless Area**	**Statewide**	**Driftless Area**	**Statewide**
10	108.3	39.7	15.1	12.5	27.9	21	40.2	18.9	16.1	10.6
25	323.6	178.4	40.2	32.2	82.6	70.6	128.7	63.8	31.9	20.3
35	492.2	305.9	71.1	58.1	135.6	115	191.6	112.7	42.9	30.3
50 (median)	729.8	537.3	136.1	119.3	229.9	199.2	330.8	205.8	63.2	47.6
65	1121.4	880.6	256.1	247.5	383.2	337.2	509.7	341.9	85.8	72
75	1478.3	1241.7	405.4	402.1	518.8	482.8	677.6	479.2	115	91.4
90	2720	2203.1	856.7	933.5	877.1	836.6	1194.2	864.5	181.5	156.5

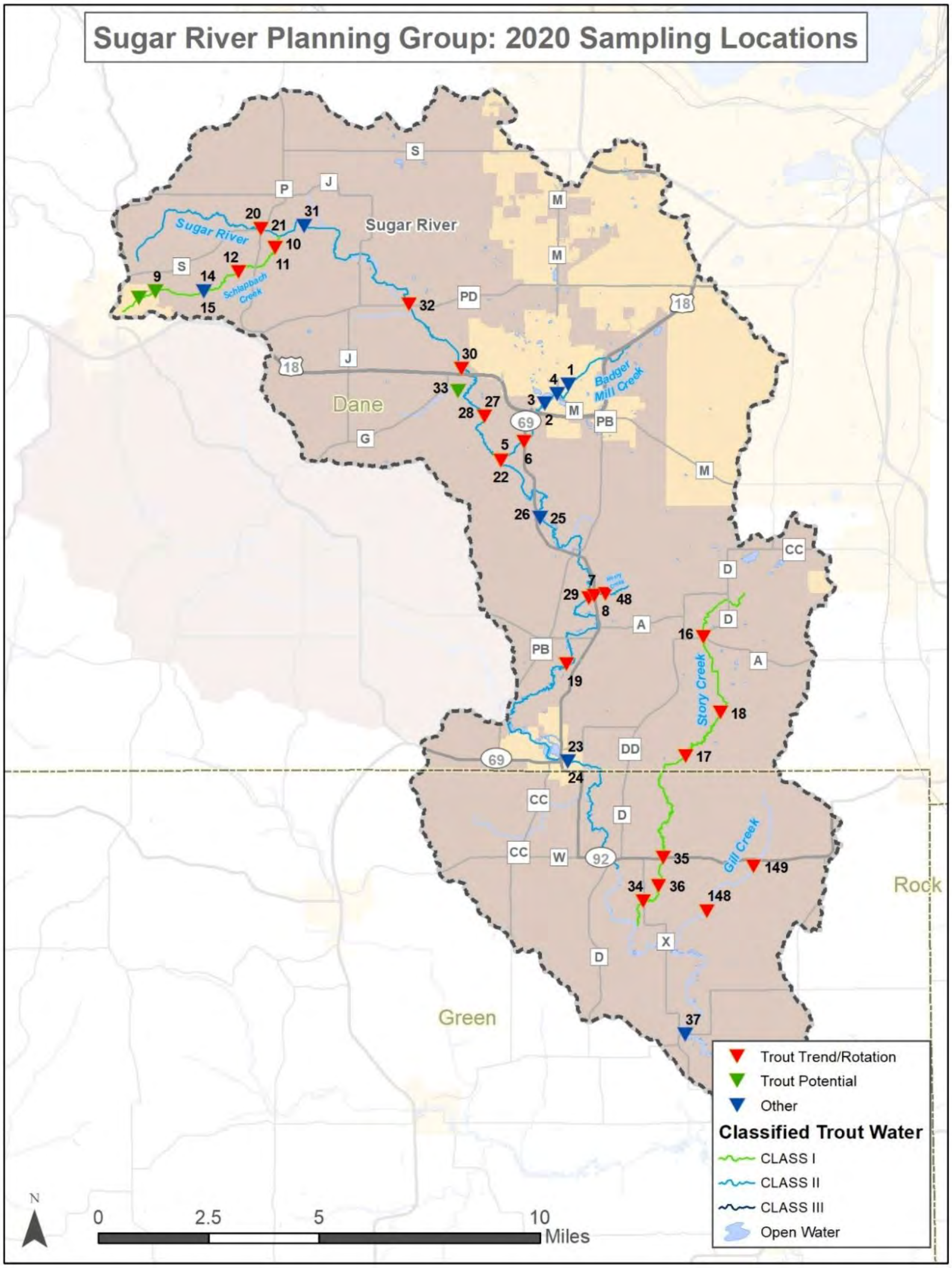


Figure 1. Stream classifications and fishery assessment survey sites within the Sugar River watershed 2020-2021.

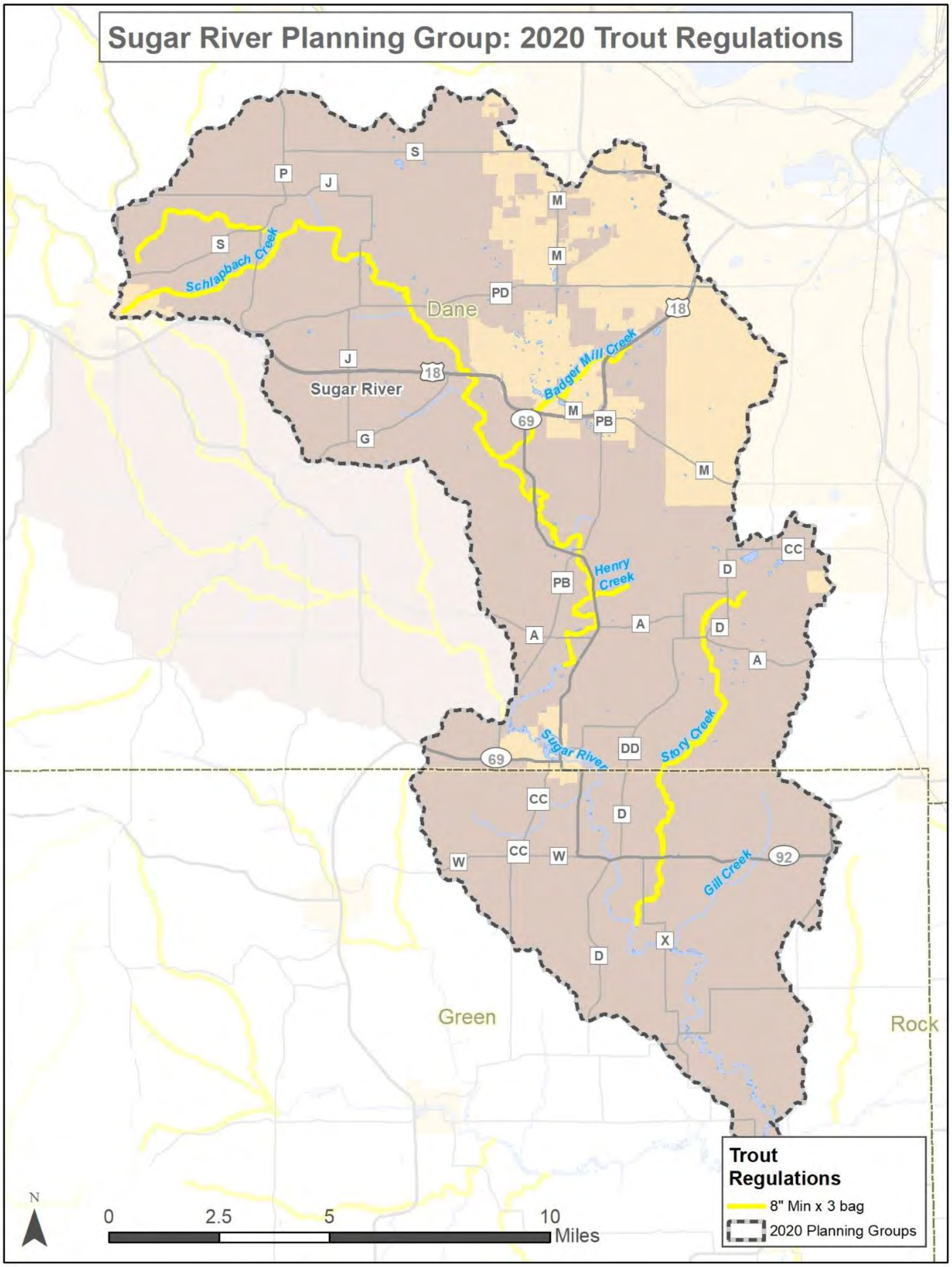


Figure 2. Sugar River watershed trout streams are regulated under the county base 8 -inch minimum length and three daily-bag limit.

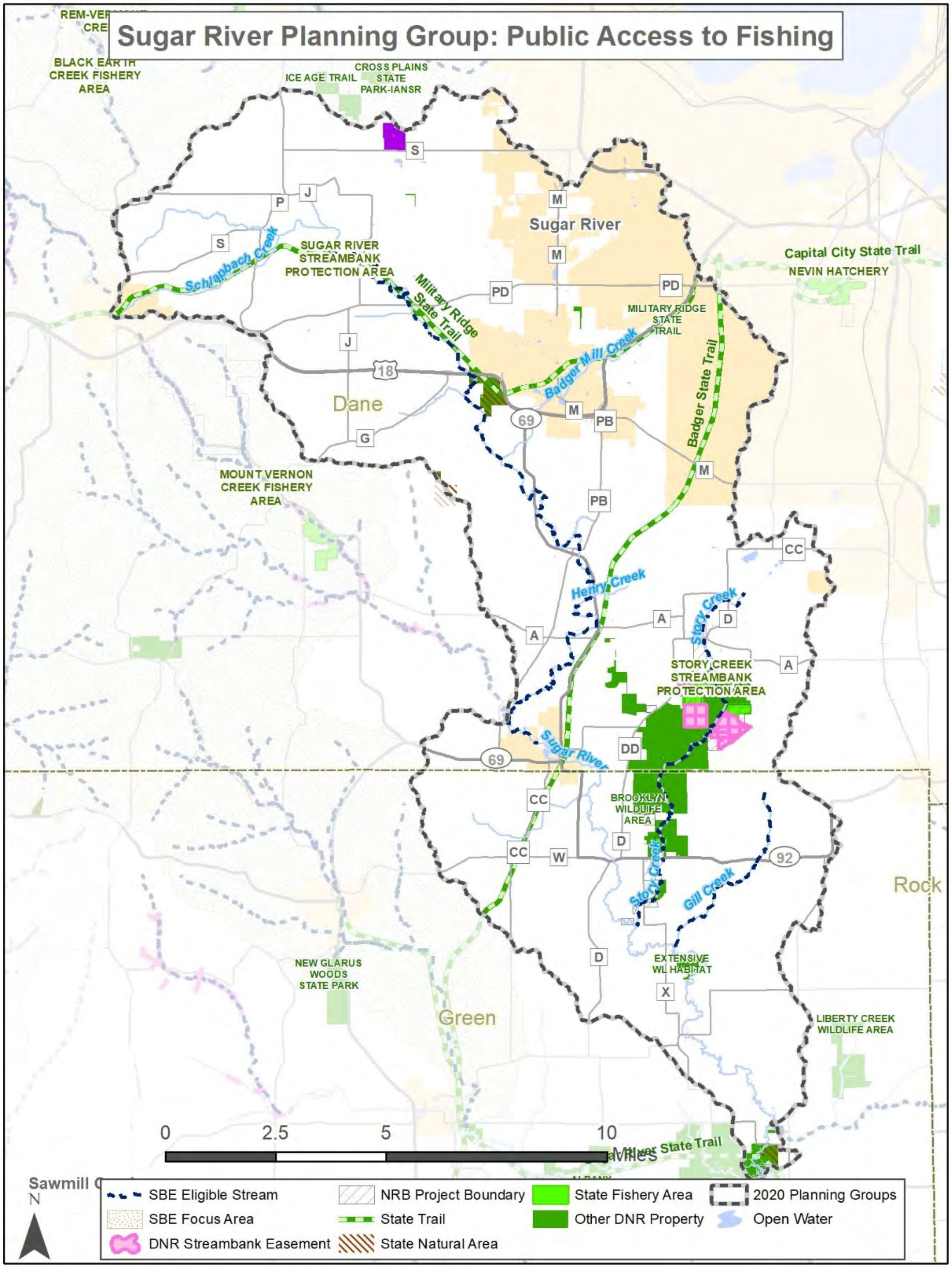


Figure 3. Sugar River watershed public access points and DNR Stream Bank Easement Program eligible waters.

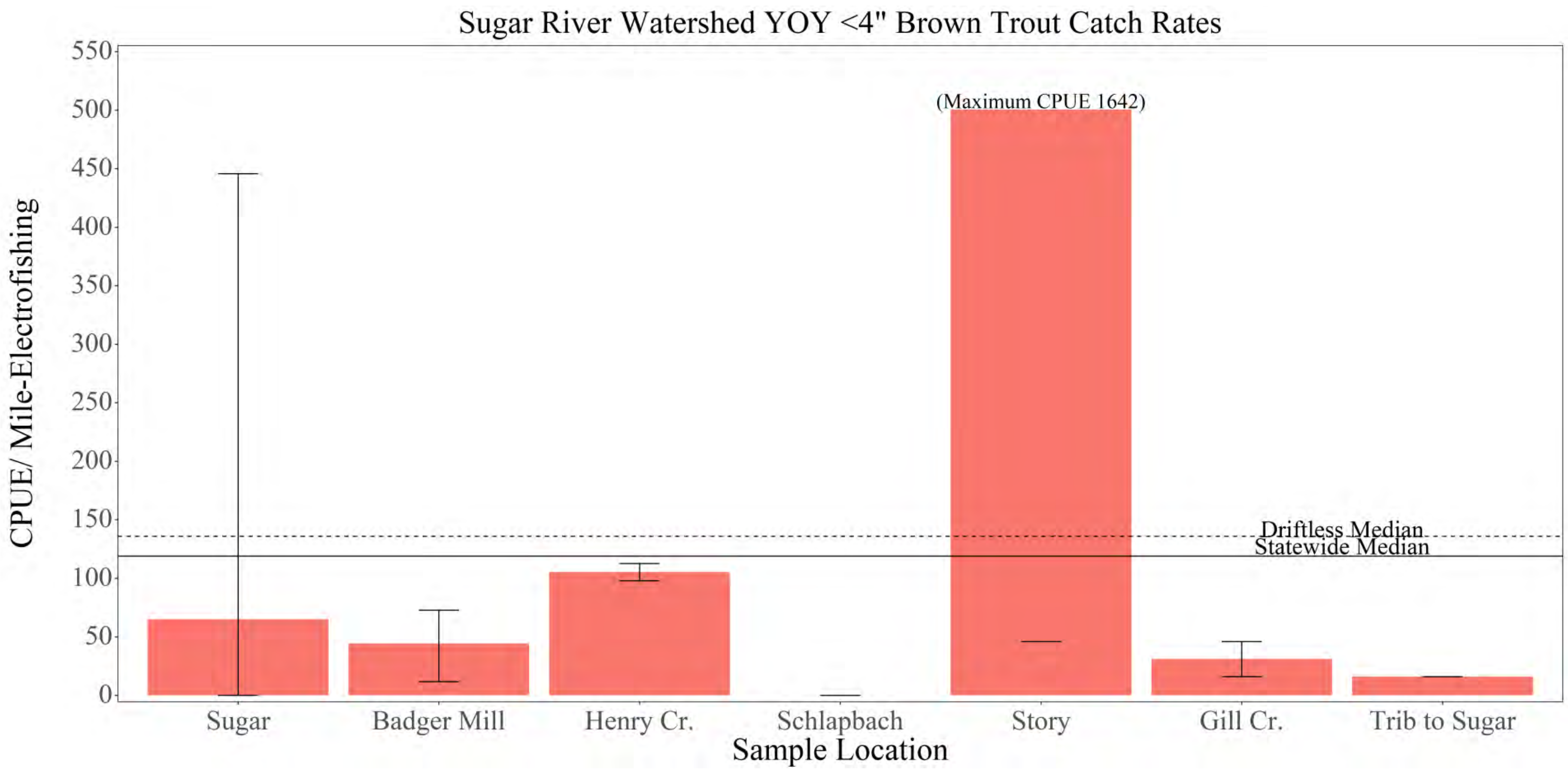


Figure 4. Average young-of-year Brown Trout catch rates (<4 inches) across all survey sites for each stream. Error bars represent minimum and maximum catch rates observed in the survey.

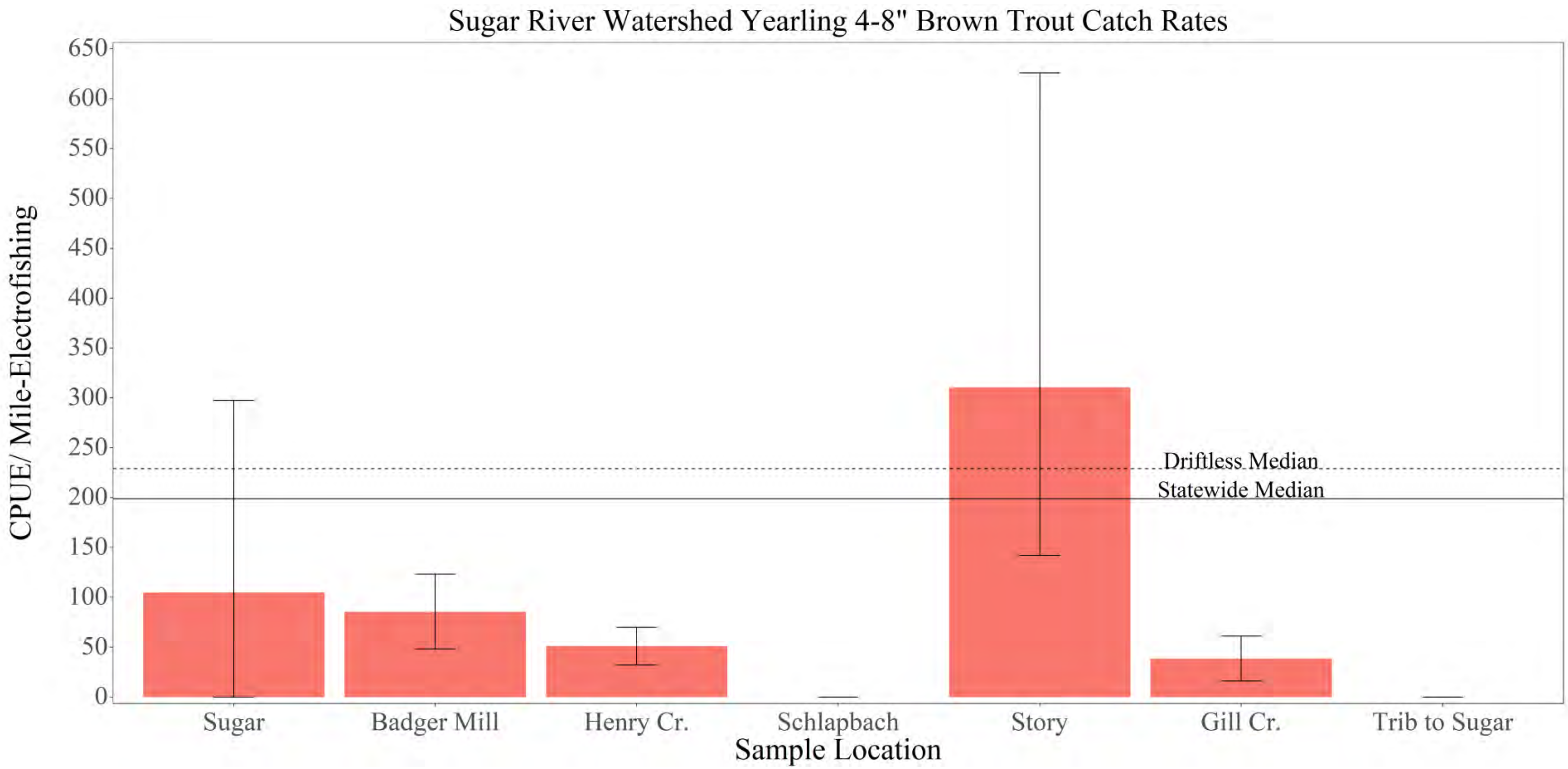


Figure 5. Average yearling Brown Trout catch rates (>4 & <8 inches) across all survey sites for each stream. Error bars represent minimum and maximum catch rates observed in the survey.

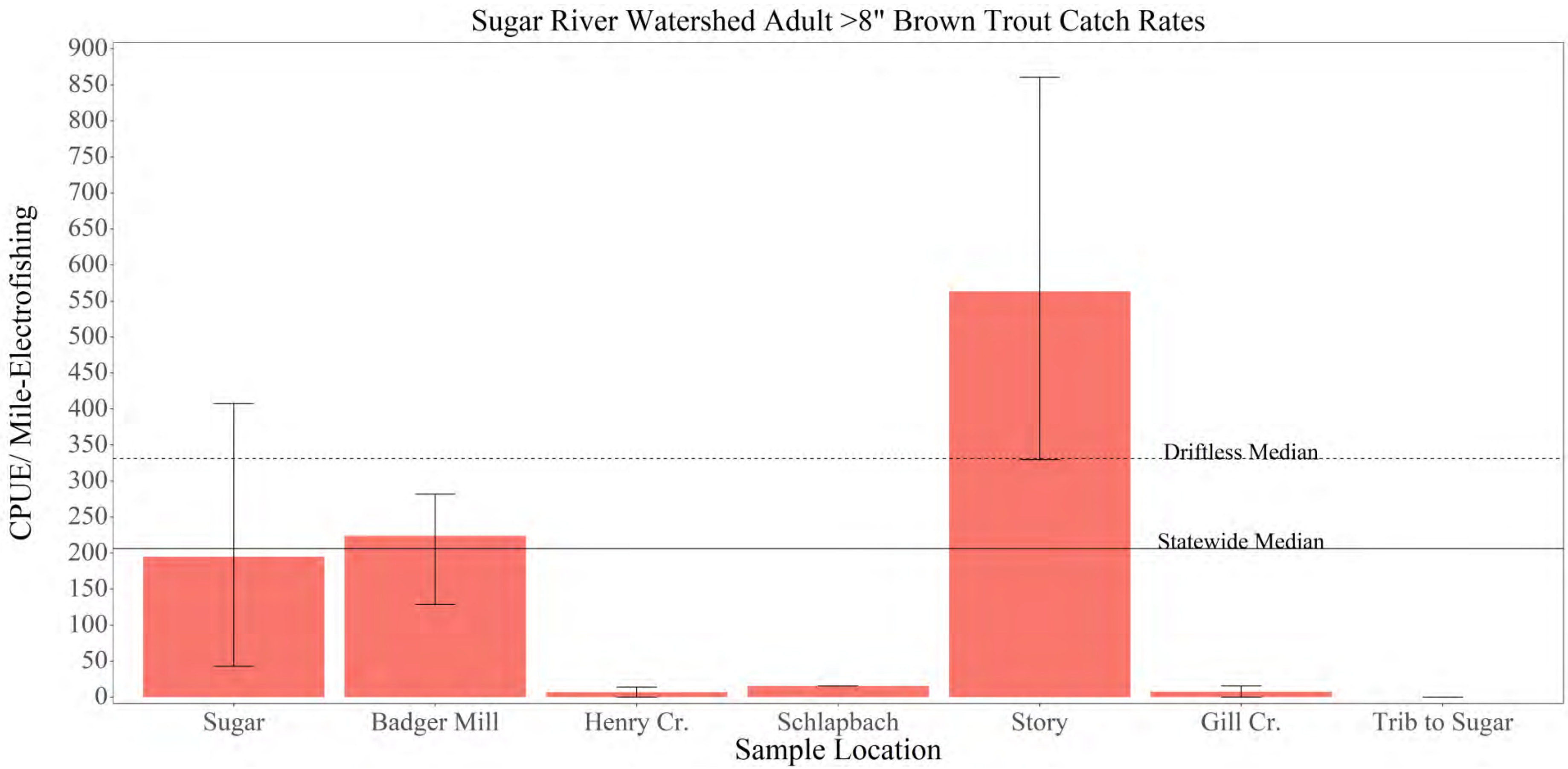


Figure 6. Average adult Brown Trout catch rates (>8 inches) across all survey sites for each stream. Error bars represent minimum and maximum catch rates observed in the survey.

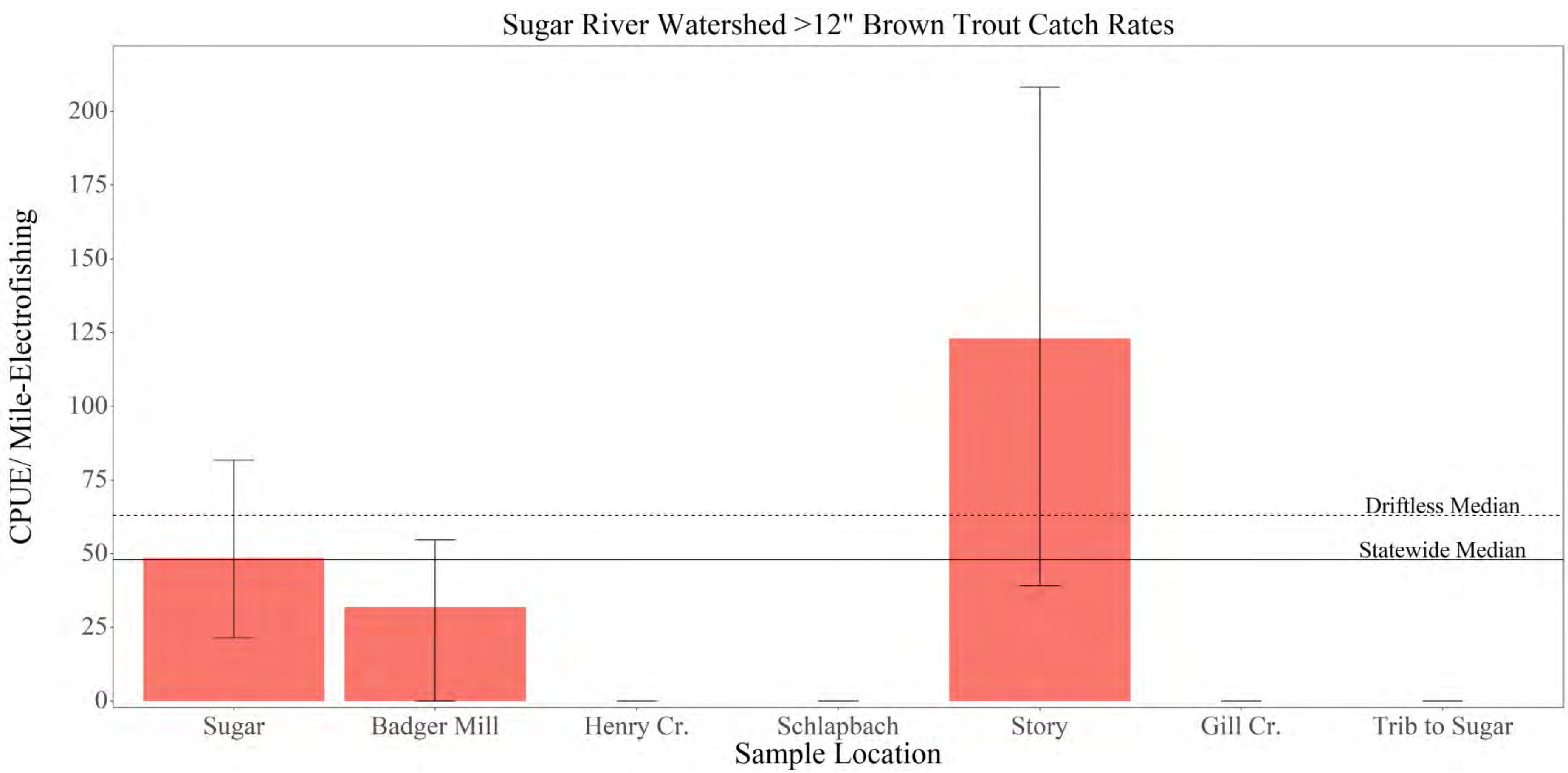


Figure 7. Average preferred Brown Trout catch rates (>12 inches) across all survey sites for each stream. Error bars represent minimum and maximum catch rates observed in the survey.

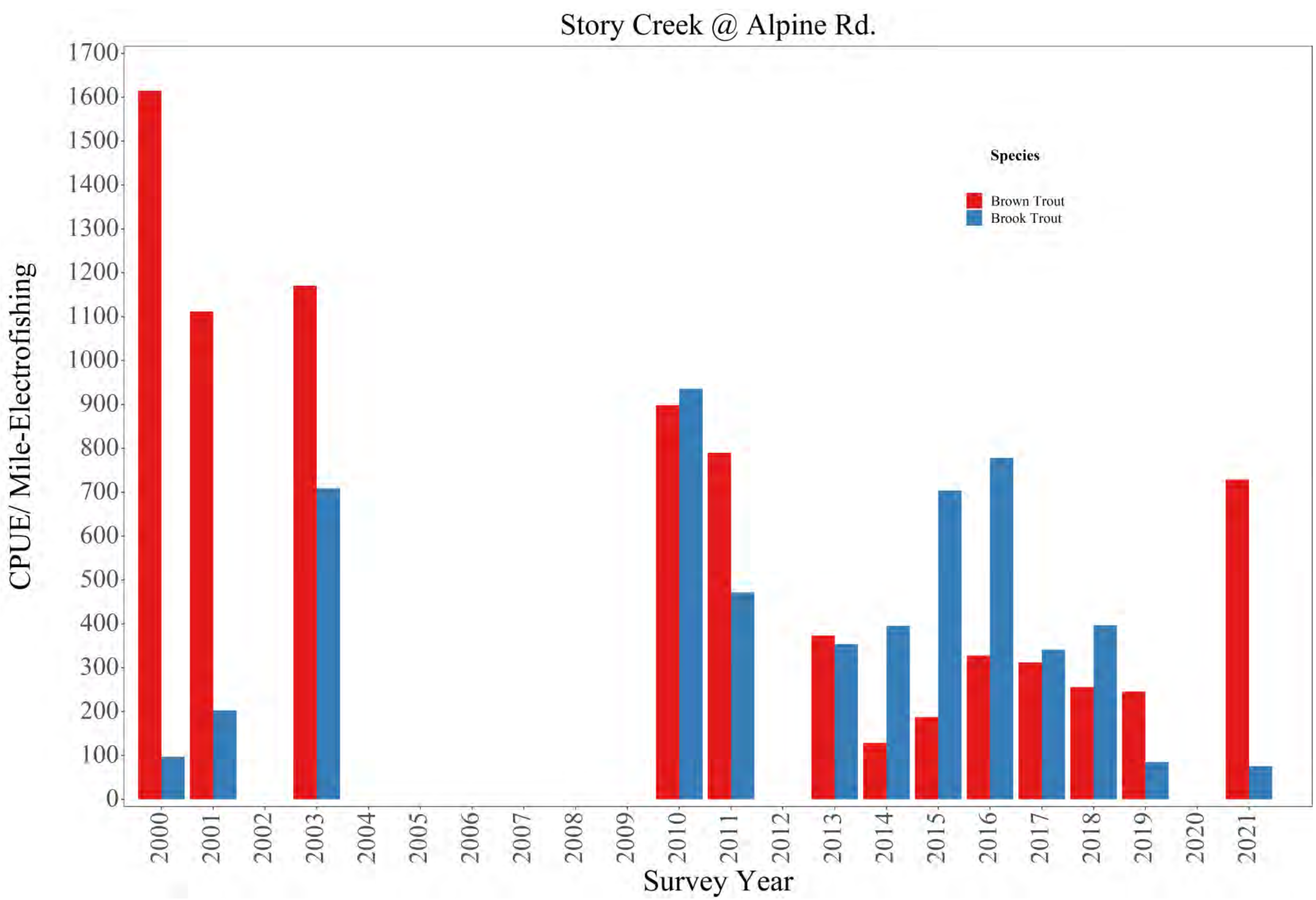


Figure 8. Total catch rates for Brown and Brook Trout at the Story Creek trend survey site at the upper end of the Alpine Road Habitat Area.

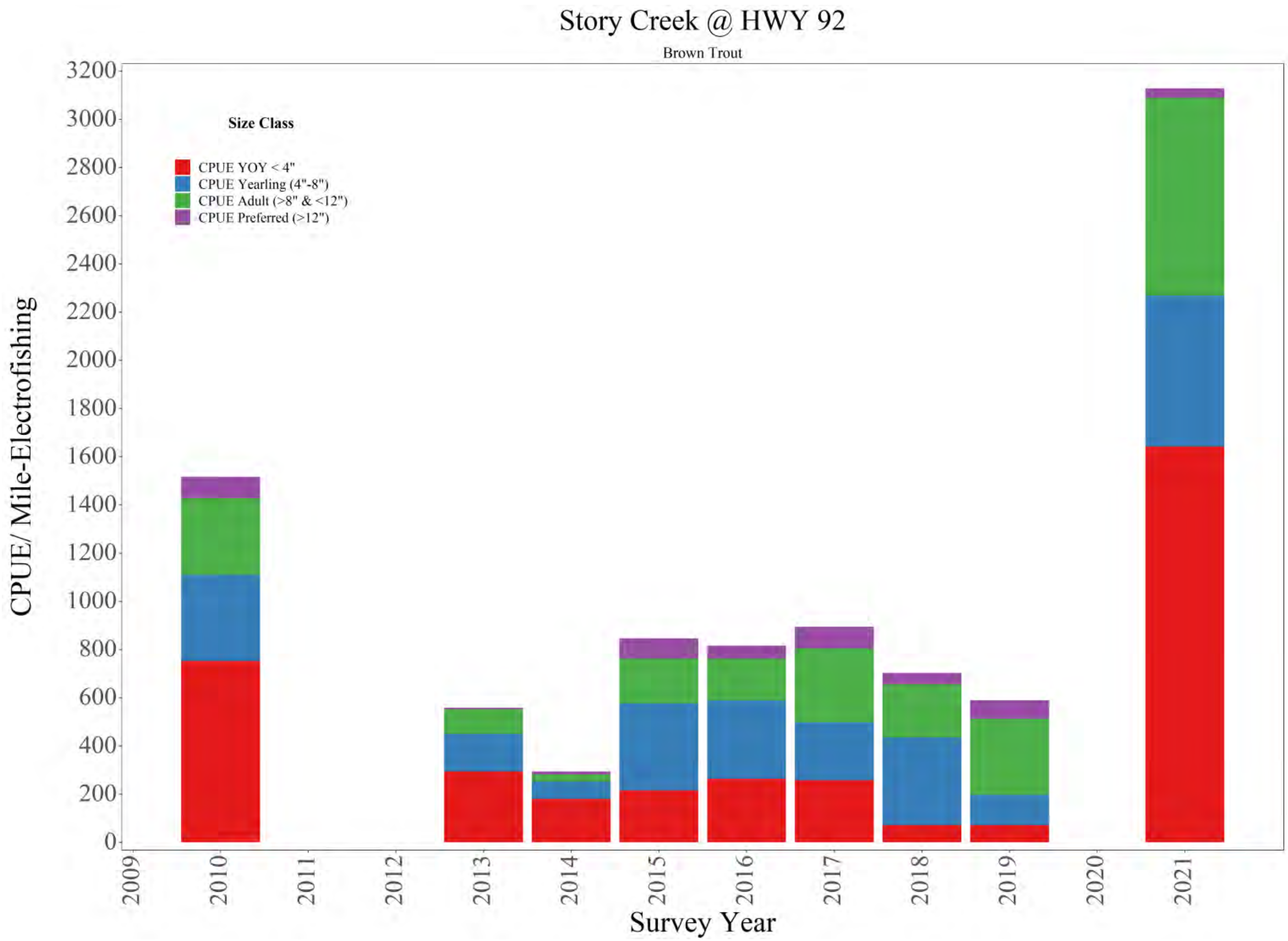


Figure 9. Size specific catch rates for Brown Trout at the Story Creek trend survey site at the HWY 92 road crossing.

MADISON METROPOLITAN SEWERAGE DISTRICT

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Jon W. Schellpfeffer
Chief Engineer & Director

Protecting Public Health and the Environment

July 26, 2010

Commissioners
Madison Metropolitan
Sewerage District
Madison, WI 53713

Subject: **Sugar River Effluent Limits and Resulting Recommendations**

Commissioners:

The Master Plan analyzed a number of different alternatives for providing service in the Sugar River watershed in the future. The recommended approach was to continue centralized treatment at Nine Springs with effluent being returned to Badger Mill Creek and the Sugar River. This recommendation was based on an estimated cost for a Sugar River treatment plant of $40 million. If the costs for a Sugar River treatment plant were lower than this, it might be more cost-effective to construct a treatment plant in the Sugar River watershed, which would reduce or delay costs associated with the District's Nine Springs Valley Interceptor system, including upgrades to Pump Stations 11 and 12.

The 2010 Capital Projects budget includes funds to perform a more detailed facilities plan for a Sugar River treatment plant to determine if the $40 million was a reasonable estimate. Before soliciting proposals to perform this work, the District requested that the Department of Natural Resources calculate effluent limits for discharges to both Badger Mill Creek and the Sugar River. If the Sugar River effluent limits could be achieved with today's conventional advanced treatment processes, the cost of this plant might be less than $40 million. If the effluent limits would require more expensive and sophisticated treatment processes, the $40 million estimated cost is probably accurate.

In response to the District's request, the Department of Natural Resources has provided their determination of the required effluent limits for discharges to Badger Mill Creek and the Sugar River for two scenarios presented in the Master Plan. The limits are summarized in the following table and were calculated based on the assumption that a portion of Badger Mill Creek and the Sugar River will be classified as cold water fisheries.

metrogro

Parameter	Badger Mill Creek Existing Discharge	Badger Mill Creek Future Discharge	Sugar River Future Discharge
Design Flow (MGD)	3.6	4.02	3.42
BOD Summer Weekly Average (mg/L)	7.0	5	5
BOD Winter Weekly Average (mg/L)	16.0	10	10
TSS Summer Monthly Average (mg/L)	10	10	10
TSS Winter Monthly Average (mg/L)	16	10	10
NH4-N Year – Round Daily Max (mg/L)	11	11	11
NH4-N Summer Weekly Average (mg/L)	3.2	4.3 – 5.5	5.8 – 7.1
NH4-N Summer Monthly Average (mg/L)	1.3	1.7 – 2.2	2.8 – 3.7
NH4-N Winter Weekly Average (mg/L)	9.1	6.1	7.7
NH4-N Winter Monthly Average (mg/L)	4.0	2.4	3.3
Minimum Daily Dissolved Oxygen (mg/L)	5.0	7.0	7.0
pH Range (s.u.)	6.0 – 9.0	6.0 – 9.0	6.0 – 9.0
Chloride (mg/L)	Monitor	400	210
Total Phosphorus (mg/L)	1.5	0.075	0.075

With the exception of the Sugar River chloride limit, and possibly the phosphorus limit, all of the other limits could be met with today's conventional advanced treatment processes. To meet the required chloride effluent limit of 210 mg/L for a discharge to the Sugar River, it would be necessary to use reverse osmosis; an extremely sophisticated and expensive process with limited operational applications. The phosphorus limit will require the use of chemical addition and membrane filtration, or chemical addition and a more conventional filtration process together with trading. The construction and operating costs for a treatment plant incorporating such advanced processes would undoubtedly be at or higher than the $40 million estimated in the Master Plan. Therefore, there is no need to perform additional studies for providing service in the Sugar River watershed, and the approach defined in the Master Plan should guide the District's planning for providing service in that watershed.

Respectfully submitted,

Jon W. Schellpfeffer
Chief Engineer and Director

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Madison Metropolitan Sewerage District

Review of Master Plan Findings and Recommendations for Service in the Sugar River Watershed

Prepared by

Jon Schellpfeffer

January, 2010

Introduction

The Master Plan analyzed six alternatives for providing wastewater service in the Sugar River watershed in the future. The costs for alternatives that accomplish full watershed balancing are similar, given the cost estimation techniques used in the master planning process. These costs are substantially higher than the cost associated with the base alternative, which involves centralized treatment with partial watershed balancing. Assumptions were made concerning the required level of treatment at various times and discharge locations. These assumptions impacted the relative costs of the alternatives. To develop better information on which to make a decision, a more detailed report should be prepared that addresses both the required treatment levels for the various effluent discharge locations and the cost of the facilities necessary to convey and treat the wastewater under each alternative. The commission will need to decide how important maintaining full watershed balancing is, since alternatives that accomplish this will result in added costs.

Current Service in the Sugar River Watershed

Areas served in the City of Verona, the Town of Middleton, and the Town of Verona are all entirely within the Sugar River watershed. Portions of the City of Madison and the City of Fitchburg are also within the Sugar River watershed. Total wastewater flows from this area currently average 3.6 mgd. The City of Verona contributes 0.9 mgd, the City of Madison 2.6 mgd, with minor contributions from the other entities.

The Sugar River watershed is served by the Nine Springs Valley Interceptor (NSVI) system, including Pump Stations 11, 12 and 17. These facilities are all approaching the end of their design lives and will require major rehabilitation and capacity upgrades in the next ten to twenty years.

Future Service Requirements in the Sugar River Watershed

The Capital Area Regional Planning Commission (CARPC) projected wastewater flows throughout the District as part of the Master Plan process. Total wastewater flows from areas served in the Sugar River watershed are estimated to increase to 5.63 mgd by 2030 and to 8.79 mgd by 2060.

Future Service Alternatives

If the current centralized treatment with effluent return model is continued, the following infrastructure will be required:

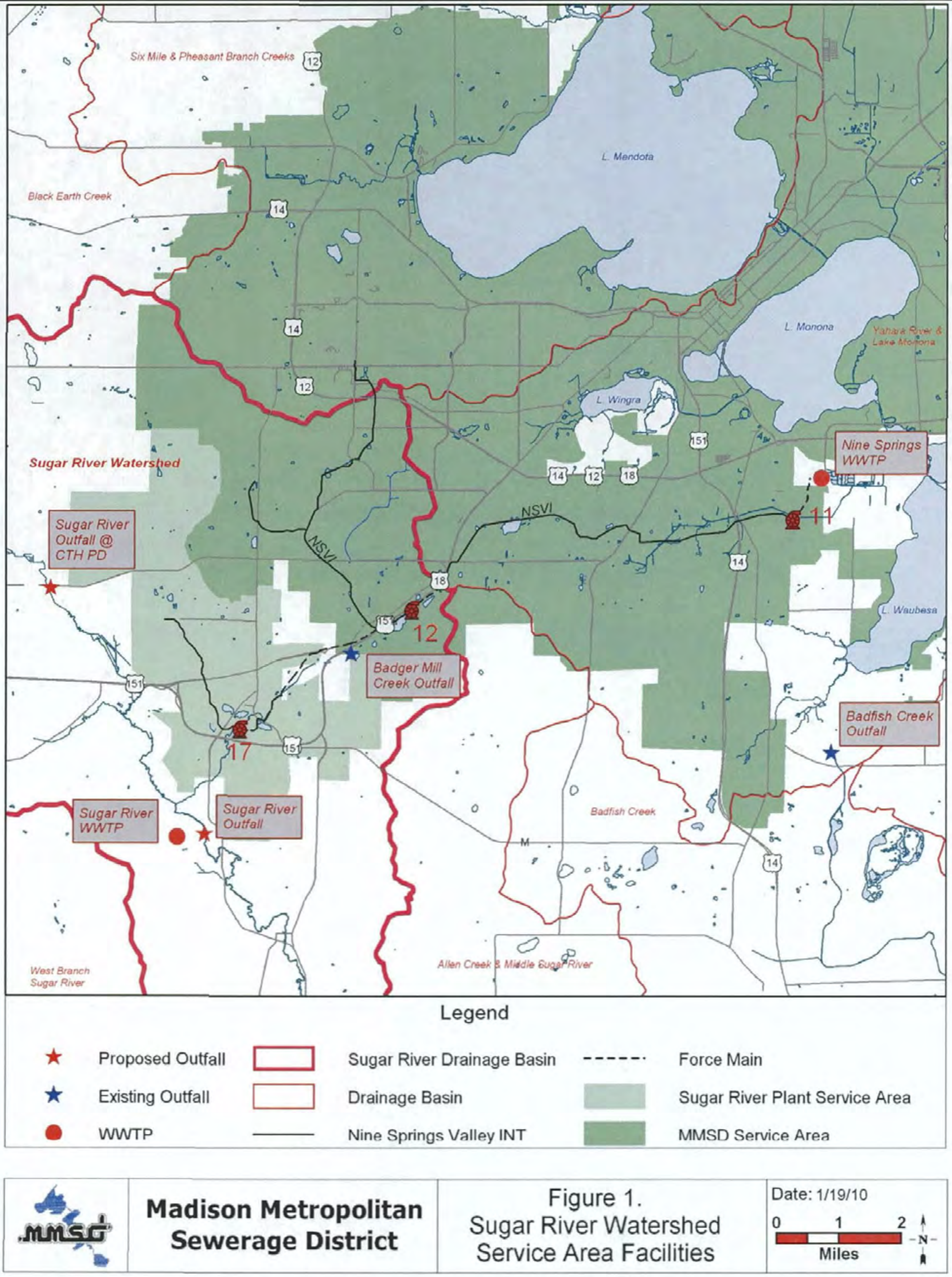
- The NSVI system will require capacity expansion beginning in 2013. The various phases of improvements to this system would continue over ten to fifteen years. The total cost of these improvements in 2009 dollars is $47 million.
- New pumps would be required at Nine Springs to pump additional effluent to Badger Mill Creek. These pumps would cost $0.5 million and be placed in service in 2013.
- It is expected that future discharges to Badger Mill Creek or the Sugar River will require a higher quality effluent. If such a plant were constructed at Nine Springs with capacity to treat flows from the Sugar River watershed in excess of 3.6 mgd, it would cost $17 million. It would be constructed between 2017 and 2019 and would be placed in service in 2020.

- If it were determined that Badger Mill Creek could not handle the full effluent return flow to the Sugar River watershed, an effluent booster pump station would be constructed near the site of the current Badger Mill Creek discharge location with a force main to a point on the Sugar River. These facilities would cost $6.5 million and would be placed in service in 2020.

If a new treatment plant were constructed in the Sugar River watershed to treat all of the wastewater generated in the Sugar River watershed, except for the portion generated in the Upper Badger Mill Creek basin (Pump Station 12 service area), the capacity expansion of the NSVI system could be avoided. Certain rehabilitation work would still be necessary at the pump stations, and the existing interceptor would require lining to prolong its useful life. Effluent would still be returned to Badger Mill Creek from Nine Springs to mitigate the inter-basin transfer of flows from the Pump Station 12 service area. The following infrastructure would be required:

- Pump Stations 11 and 12 will require rehabilitation. This work would be completed between 2013 and 2015 at a cost of $8 million.
- Pump Station 17 would be upgraded, including the construction of a new force main to the site of the Sugar River treatment plant. This work would be completed between 2014 and 2016 at a cost of $5 million.
- Design of the Sugar River treatment plant would begin in 2017, and the plant would be placed in service in 2020. The cost is estimated to be $42 million.
- The Nine Springs Valley Interceptor would be relined between 2020 and 2021 at a cost of $10 million.

The Master Plan included 6 alternatives that encompassed the two base options described above. The six alternatives are described in more detail in the following paragraphs. Figure 1 shows the locations of the facilities associated with these options. Four of the alternatives involve centralized treatment, including a base alternative that does not address mitigation of inter-basin flow transfers beyond what is currently being done. Two alternatives were based on a de-centralized treatment plant model.



Madison Metropolitan Sewerage District

Figure 1.
Sugar River Watershed
Service Area Facilities

Date: 1/19/10

- **Alternative MP-1A** – This alternative represents the current operation by MMSD and serves as the base alternative. This alternative includes returning 3.6 mgd of effluent from the NSWTP to Badger Mill Creek through the existing outfall in Badger Prairie Park.
- **Alternative MP-1B** – This alternative includes returning a total of 7.9 mgd of effluent to Badger Mill Creek through the existing outfall in Badger Prairie Park. A portion of the effluent (3.6 mgd) consists of regular effluent generated by the existing treatment processes, while the remaining 4.3 mgd would consist of high quality effluent generated by a small scale advanced effluent treatment system. The regular effluent and the high quality effluent will be blended and pumped to the Badger Mill Creek outfall location through the existing effluent force main. This alternative returns an equal volume of water to the watershed from where it was withdrawn.
- **Alternative MP-1C** – This alternative includes returning 7.9 mgd of effluent to the Badger Mill Creek outfall location through the existing force main with 3.6 mgd being discharged to Badger Mill Creek directly and 4.3 mgd being discharged downstream of the confluence of Badger Mill Creek and Sugar River through a new pumping station and a new force main in the vicinity of the existing Badger Mill Creek outfall. The regular effluent and the high quality effluent will be blended and pumped to the Badger Mill Creek outfall location through the existing effluent force main. Like Alternative MP-1B, this alternative returns an equal volume of water to the watershed from where it was withdrawn, but splits the discharge between Badger Mill Creek and the Sugar River to more closely match the stream base flows in both water bodies. This alternative could achieve similar watershed balance benefits as the decentralized alternative MP-2A discussed later.
- **Alternative MP-1D** – This alternative includes returning 7.9 mgd of effluent to the Badger Mill Creek outfall location through the existing force main with 3.6 mgd being discharged to Badger Mill Creek directly and 4.3 mgd being discharged to the Sugar River at County Highway PD (CTH PD) through a new effluent pumping station and a new force main in the vicinity of the existing Badger Mill Creek outfall. It is identical to Alternative MP-1C, except for the Sugar River discharge point.
- **Alternative MP-2A** – This alternative includes construction of a new Sugar River advanced secondary wastewater treatment plant by 2020 with discharge to the main branch of the Sugar River downstream of the confluence with Badger Mill Creek. Average day flows in 2060 will be 4.3 mgd. An average daily flow of 3.6 mgd of treated effluent would continue to be pumped from the NSWTP to Badger Mill Creek.
- **Alternative MP-2B** – This alternative includes construction of a new Sugar River advanced secondary wastewater treatment plant by 2020 with discharges to the main branch of the Sugar River downstream of the confluence with Badger Mill Creek and to the headwaters of Sugar River near CTH PD northwest of Verona. Average daily flows in 2060 will be 2.5 mgd and 1.8 mgd, respectively, at these two locations. An average daily flow of 3.6 mgd of treated effluent would continue to be pumped from the NSWTP to Badger Mill Creek.

Evaluation of Inter-Basin Flow Impacts

Since the City of Verona was annexed to the District in 1993, the inter-basin transfer of water from the Sugar River watershed to the Yahara River watershed has been a concern of the District, CARPC, DNR, and others, including citizens in the Sugar River watershed. This issue was addressed with the construction of the Badger Mill Creek effluent return force main and aerator located in Badger Prairie Park, adjacent to Upper Badger Mill Creek, a tributary of the Sugar River. Since 1998 a volume of effluent has been returned to Badger Mill Creek equal to the volume of wastewater generated in the Sugar River watershed. That volume is currently 3.6 mgd, which coincidently is the flow upon which the District's WPDES discharge permit for this location is based.

Table 1 shows the base flow impacts in Badger Mill Creek and the Sugar River under each alternative. Except for Alternative MP-1A, all of the alternatives evaluated in the Master Plan would continue to fully mitigate the inter-basin transfer of water between the Sugar River watershed and the Yahara River watershed. Under Alternative MP-1A, 3.6 mgd of effluent would continue to be returned to Badger Mill Creek. This is sufficient to offset the loss of base flow in Badger Mill Creek through 2035. By 2060 base flow in Badger Mill Creek would be reduced by about 20 percent. The base flow loss in the Sugar River would be 4 percent in 2010, increase to 17 percent by 2030, and increase further to 45 percent by 2060.

Table 1

Analysis of Wastewater Services in the Sugar River Watershed

Base Flow Impacts in Badger Mill Creek and the Sugar River

	Badger Mill Creek	Badger Mill Creek		Badger Mill Creek Effluent Return and Resulting					
	Badger Mill Creek	Base Flow Reduction		Percent of Historic Base Flow in Badger Mill Creek					
	Historic Base Flow	without Mitigation		Alternative MP-1A		Alternative MP-1B		Alternatives MP-1C, MP-1D, MP-2A and MP-2B	
Year	(mgd)	(mgd)	(%)	(mgd)	(%)	(mgd)	(%)	(mgd)	(%)
2010	4.52	2.67	59.0	3.40	116.1	3.86	126.3	2.67	100.0
2030	4.52	3.41	75.4	3.60	104.2	5.63	149.1	3.41	100.0
2060	4.52	4.52	100.0	3.60	79.6	8.79	194.3	4.52	100.0
		Sugar River		Sugar River Effluent Return and Resulting Percent of Historic Base Flow in the Sugar River					
	Sugar River	Base Flow Reduction		(includes effluent returned to Badger Mill Creek from table above)					
	Historic Base Flow	without Mitigation		Alternative MP-1A		Alternative MP-1B		Alternatives MP-1C, MP-1D, MP-2A and MP-2B	
Year	(mgd)	(mgd)	(%)	(mgd)	(%)	(mgd)	(%)	(mgd)	(%)
2010	11.63	3.86	33.2	3.40	96.0	3.86	100.0	3.86	100.0
2030	11.63	5.63	48.4	3.60	82.6	5.63	100.0	5.63	100.0
2060	11.63	8.79	75.6	3.60	55.4	8.79	100.0	8.79	100.0

Historic base flow for Badger Mill Creek and the Sugar River from draft USGS report received by email from USGS on January 11, 2010.

Badger Mill Creek base flow measured at Bruce Street - site has continuous flow data since October, 1996.

Sugar River base flow measured at Highway 69 bridge south of Verona - site has continuous flow data since May, 2009, and spot checks since 1962.

Evaluation of Capital Costs

Table 2 shows the year-by-year costs and the accumulated costs for the infrastructure improvements required under each of the six alternatives. The project descriptions are color-coded to make it easier to see the multi-year expenditures for the same project.

Figures 2 through 5 show various combinations of the cost information presented in Table 2. Figure 2 shows the accumulating costs of the six alternatives. Note that the costs for Alternatives 1C and 1D are identical.

Figure 3 shows the accumulated costs for the four centralized treatment alternatives. The difference between Alternative 1A and 1B reflects the cost of the Nine Springs High Quality Effluent Plant. The difference between Alternatives 1B and 1C/1D reflects the cost of the booster pump station and force main to the Sugar River.

Figure 4 shows the accumulated costs for the two decentralized treatment alternatives. The difference between Alternatives 2A and 2B reflects the cost of the effluent pump station and force main necessary to achieve a split discharge on the Sugar River.

Figure 5 shows the accumulated costs for the two alternatives, 1C/1D and 2A that result in identical split discharges between Badger Mill Creek and the Sugar River.

Table 2
Sugar River Watershed Service Alternatives
Related Capital Project Costs

		Alternative MP-1A		Alternative MP-1B		Alternative MP-1C		Alternative MP-1D		Alternative MP-2A		Alternative MP-2B	
Year	Project Description	Annual Cost	Accumulated Cost	Annual Cost	Accumulated Cost	Annual Cost	Accumulated Cost	Annual Cost	Accumulated Cost	Annual Cost	Accumulated Cost	Annual Cost	Accumulated Cost
2013	PS 11 and 12 Upgrades	520,000	520,000	520,000	520,000	520,000	520,000	520,000	520,000	500,000	500,000	500,000	500,000
2013	Upgrade BMC Effluent Pumps		520,000	500,000	1,020,000	500,000	1,020,000	500,000	1,020,000		500,000		500,000
2014	PS 11 and 12 Upgrades	4,000,000	4,520,000	4,000,000	5,020,000	4,000,000	5,020,000	4,000,000	5,020,000	3,800,000	4,300,000	3,800,000	4,300,000
2014	PS 17 and PS 17 Force Main Upgrades	382,000	4,902,000	382,000	5,402,000	382,000	5,402,000	382,000	5,402,000	382,000	4,682,000	382,000	4,682,000
2015	PS 11 and 12 Upgrades	4,000,000	8,902,000	4,000,000	9,402,000	4,000,000	9,402,000	4,000,000	9,402,000	3,800,000	8,482,000	3,800,000	8,482,000
2015	PS 17 and PS 17 Force Main Upgrades	4,750,000	13,652,000	4,750,000	14,152,000	4,750,000	14,152,000	4,750,000	14,152,000	4,750,000	13,232,000	4,750,000	13,232,000
2016	PS 17 and PS 17 Force Main Upgrades	20,000	13,672,000	20,000	14,172,000	20,000	14,172,000	20,000	14,172,000	20,000	13,252,000	20,000	13,252,000
2017	NSVI - PS 11 to MH 11-111A	350,000	14,022,000	350,000	14,522,000	350,000	14,522,000	350,000	14,522,000		13,252,000		13,252,000
2017	NSVI - PS 12 to MH 12-110	170,000	14,192,000	170,000	14,692,000	170,000	14,692,000	170,000	14,692,000		13,252,000		13,252,000
2017	Nine Springs High Quality Effl Plant		14,192,000	2,400,000	17,092,000	2,400,000	17,092,000	2,400,000	17,092,000		13,252,000		13,252,000
2017	Sugar River Treatment Plant		14,192,000		17,092,000		17,092,000		17,092,000	5,600,000	18,852,000	5,600,000	18,852,000
2018	NSVI - PS 11 to MH 11-111A	5,200,000	19,392,000	5,200,000	22,292,000	5,200,000	22,292,000	5,200,000	22,292,000		18,852,000		18,852,000
2018	NSVI - PS 12 to MH 12-110	2,440,000	21,832,000	2,440,000	24,732,000	2,440,000	24,732,000	2,440,000	24,732,000		18,852,000		18,852,000
2018	Nine Springs High Quality Effl Plant		21,832,000	7,250,000	31,982,000	7,250,000	31,982,000	7,250,000	31,982,000		18,852,000		18,852,000
2018	Sugar River Treatment Plant		21,832,000		31,982,000		31,982,000		31,982,000	18,200,000	37,052,000	18,200,000	37,052,000
2019	NSVI - PS 11 to MH 11-111A	1,532,500	23,364,500	1,532,500	33,514,500	1,532,500	33,514,500	1,532,500	33,514,500		37,052,000		37,052,000
2019	NSVI - PS 12 to MH 12-110	982,450	24,346,950	982,450	34,496,950	982,450	34,496,950	982,450	34,496,950		37,052,000		37,052,000
2019	NSVI - MH 11-111A to MH 11-137	600,000	24,946,950	600,000	35,096,950	600,000	35,096,950	600,000	35,096,950		37,052,000		37,052,000
2019	NSVI - MH 11-161E to MH 11-171	120,000	25,066,950	120,000	35,216,950	120,000	35,216,950	120,000	35,216,950		37,052,000		37,052,000
2019	Nine Springs High Quality Effl Plant		25,066,950	7,250,000	42,466,950	7,250,000	42,466,950	7,250,000	42,466,950		37,052,000		37,052,000
2019	Sugar River Treatment Plant		25,066,950		42,466,950		42,466,950		42,466,950	18,200,000	55,252,000	18,200,000	55,252,000
2019	Sugar River Effluent Pump Station [redacted]		25,066,950		42,466,950	200,000	42,666,950	200,000	42,666,950		55,252,000	200,000	55,452,000
2019	Sugar River Effluent Force Main [redacted]		25,066,950		42,466,950	387,500	43,054,450	387,500	43,054,450		55,252,000	200,000	55,652,000
2020	NSVI - MH 11-111A to MH 11-137	9,000,000	34,066,950	9,000,000	51,466,950	9,000,000	52,054,450	9,000,000	52,054,450		55,252,000		55,652,000
2020	NSVI - MH 11-161E to MH 11-171	1,800,000	35,866,950	1,800,000	53,266,950	1,800,000	53,854,450	1,800,000	53,854,450		55,252,000		55,652,000
2020	NSVI - Reline after SRTP in Service		35,866,950		53,266,950		53,854,450		53,854,450	5,080,000	60,332,000	5,080,000	60,732,000
2020	Nine Springs High Quality Effl Plant		35,866,950	300,000	53,566,950	300,000	54,154,450	300,000	54,154,450		60,332,000		60,732,000
2020	Sugar River Treatment Plant		35,866,950		53,566,950		54,154,450		54,154,450	1,000,000	61,332,000	1,000,000	61,732,000
2020	Sugar River Effluent Pump Station [redacted]		35,866,950		53,566,950	1,300,000	55,454,450	1,300,000	55,454,450		61,332,000	1,300,000	63,032,000
2020	Sugar River Effluent Force Main [redacted]		35,866,950		53,566,950	4,600,000	60,054,450	4,600,000	60,054,450		61,332,000	2,700,000	65,732,000
2021	NSVI - MH 11-111A to MH 11-137	2,638,275	38,505,225	2,638,275	56,205,225	2,638,275	62,692,725	2,638,275	62,692,725		61,332,000		65,732,000
2021	NSVI - MH 11-161E to MH 11-171	522,600	39,027,825	522,600	56,727,825	522,600	63,215,325	522,600	63,215,325		61,332,000		65,732,000
2021	NSVI - Reline after SRTP in Service		39,027,825		56,727,825		63,215,325		63,215,325	5,080,000	66,412,000	5,080,000	70,812,000
2022			39,027,825		56,727,825		63,215,325		63,215,325		66,412,000		70,812,000
2023			39,027,825		56,727,825		63,215,325		63,215,325		66,412,000		70,812,000
2024	PS 11 Force Main Upgrade	70,000	39,097,825	70,000	56,797,825	70,000	63,285,325	70,000	63,285,325		66,412,000		70,812,000
2024	NSVI - MH 11-145 to MH 11-161A	330,000	39,427,825	330,000	57,127,825	330,000	63,615,325	330,000	63,615,325		66,412,000		70,812,000
2025	PS 11 Force Main Upgrade	980,000	40,407,825	980,000	58,107,825	980,000	64,595,325	980,000	64,595,325		66,412,000		70,812,000
2025	NSVI - MH 11-145 to MH 11-161A	4,600,000	45,007,825	4,600,000	62,707,825	4,600,000	69,195,325	4,600,000	69,195,325		66,412,000		70,812,000
2026	NSVI - MH 11-145 to MH 11-161A	1,761,475	46,769,300	1,761,475	64,469,300	1,761,475	70,956,800	1,761,475	70,956,800		66,412,000		70,812,000
2027			46,769,300		64,469,300		70,956,800		70,956,800		66,412,000		70,812,000
2028			46,769,300		64,469,300		70,956,800		70,956,800		66,412,000		70,812,000
2029			46,769,300		64,469,300		70,956,800		70,956,800		66,412,000		70,812,000
2030			46,769,300		64,469,300		70,956,800		70,956,800		66,412,000		70,812,000

Figure 2

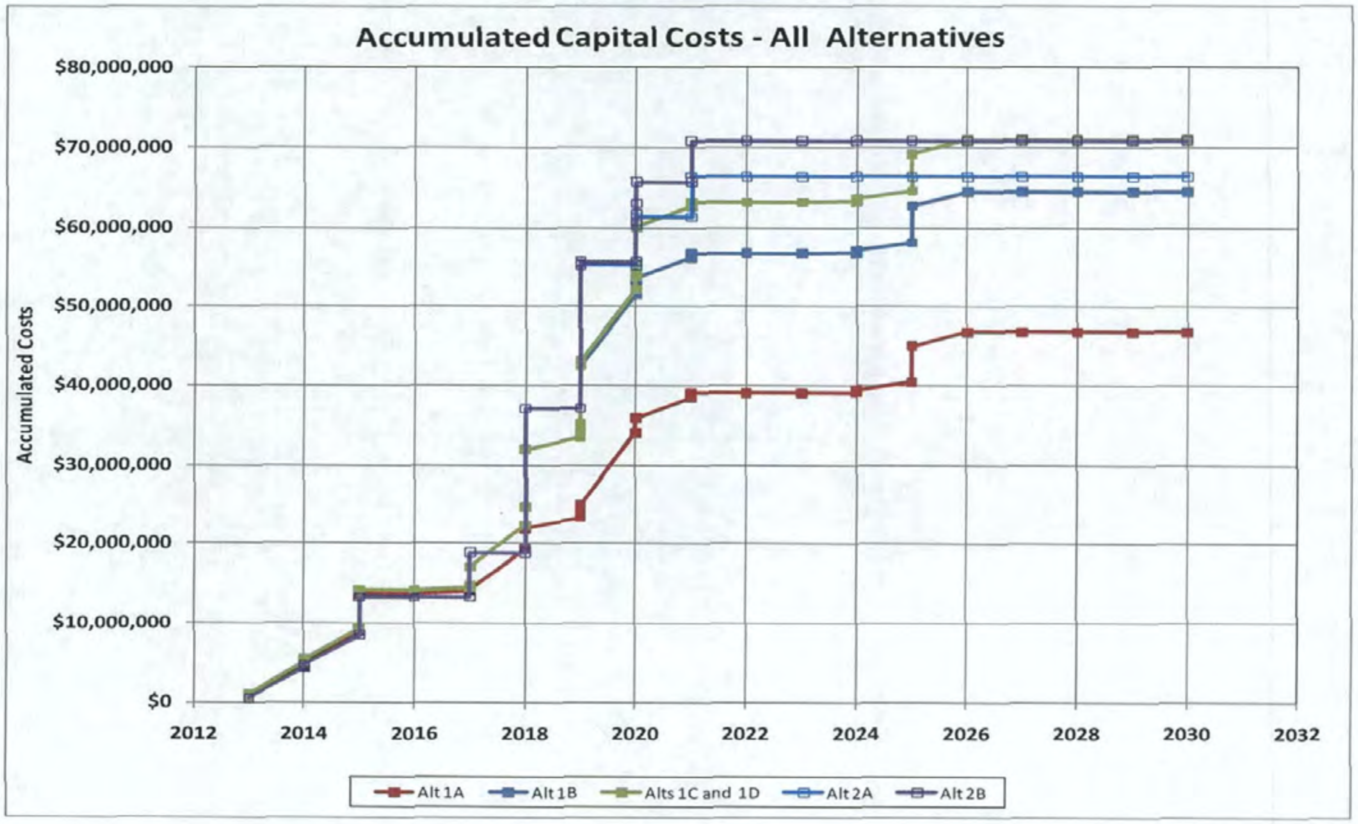


Figure 3

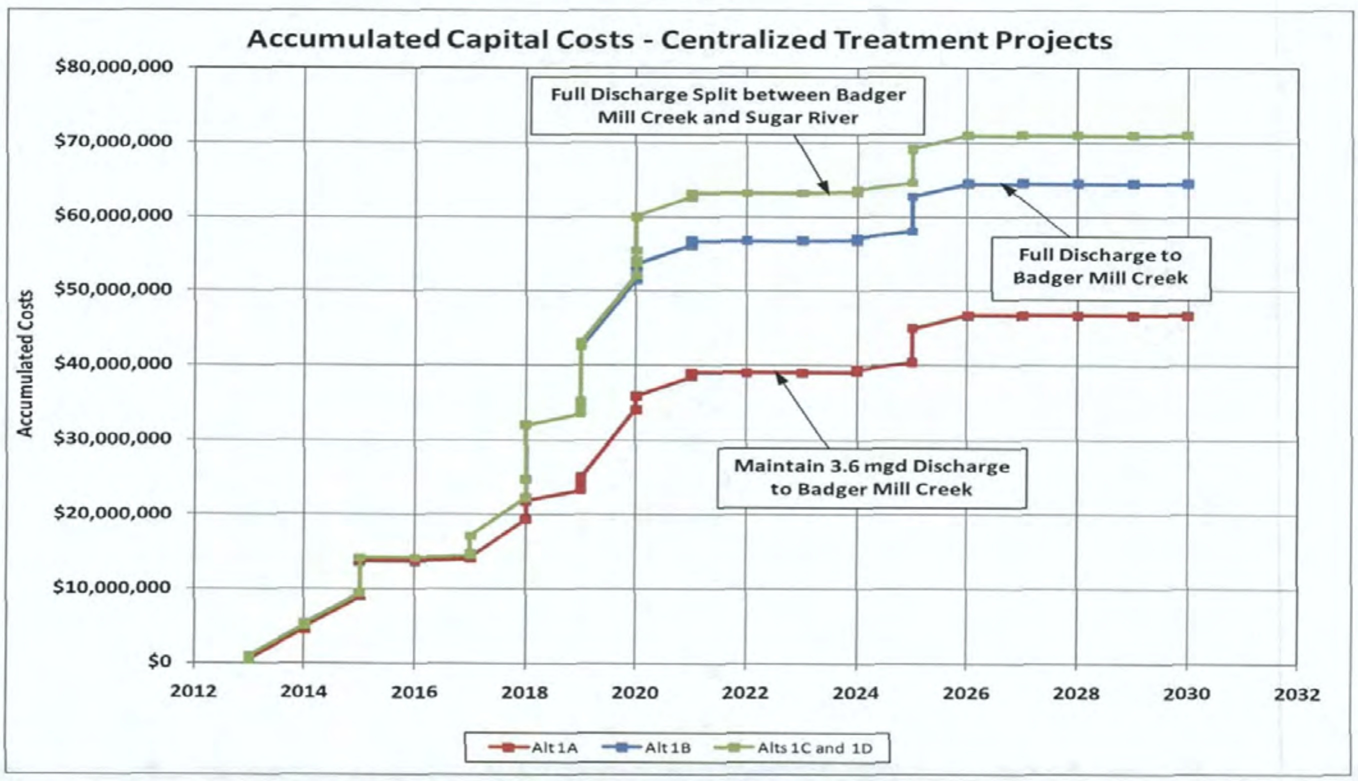


Figure 4

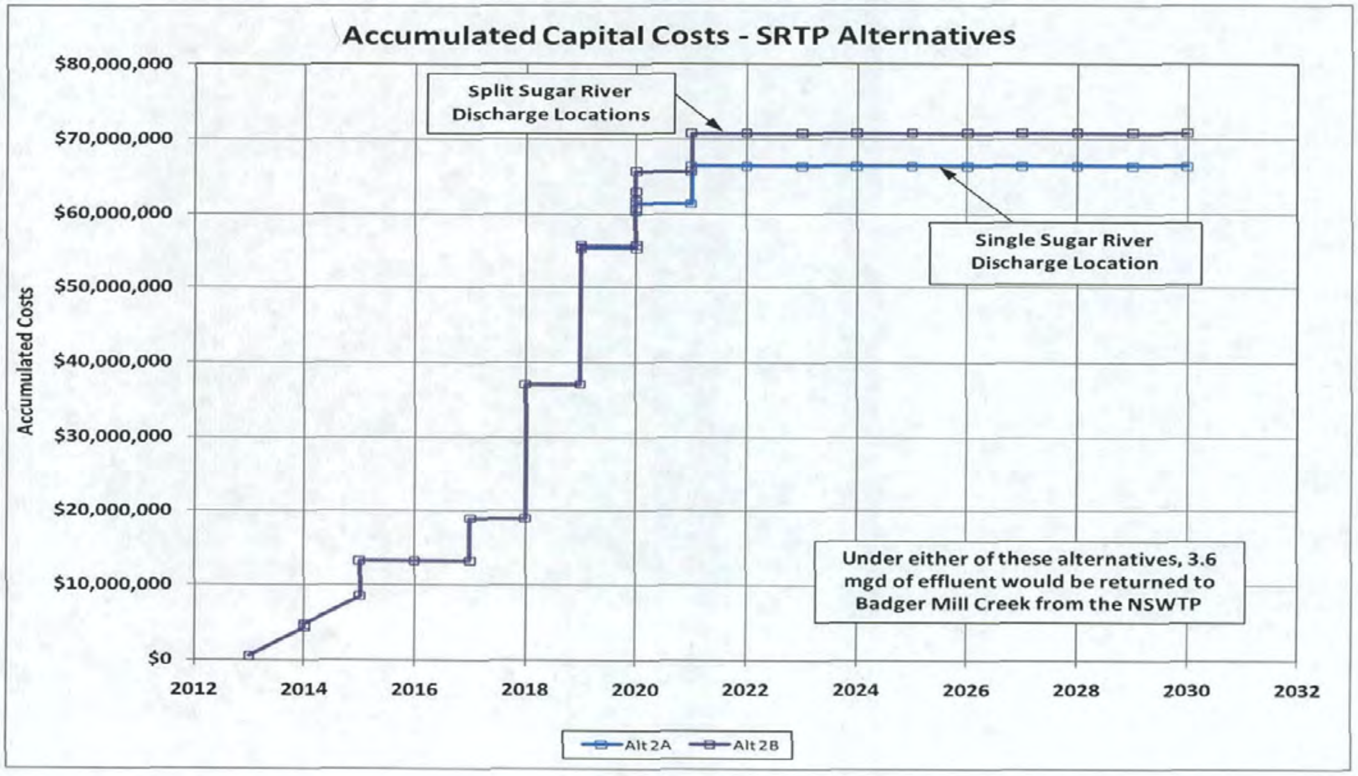
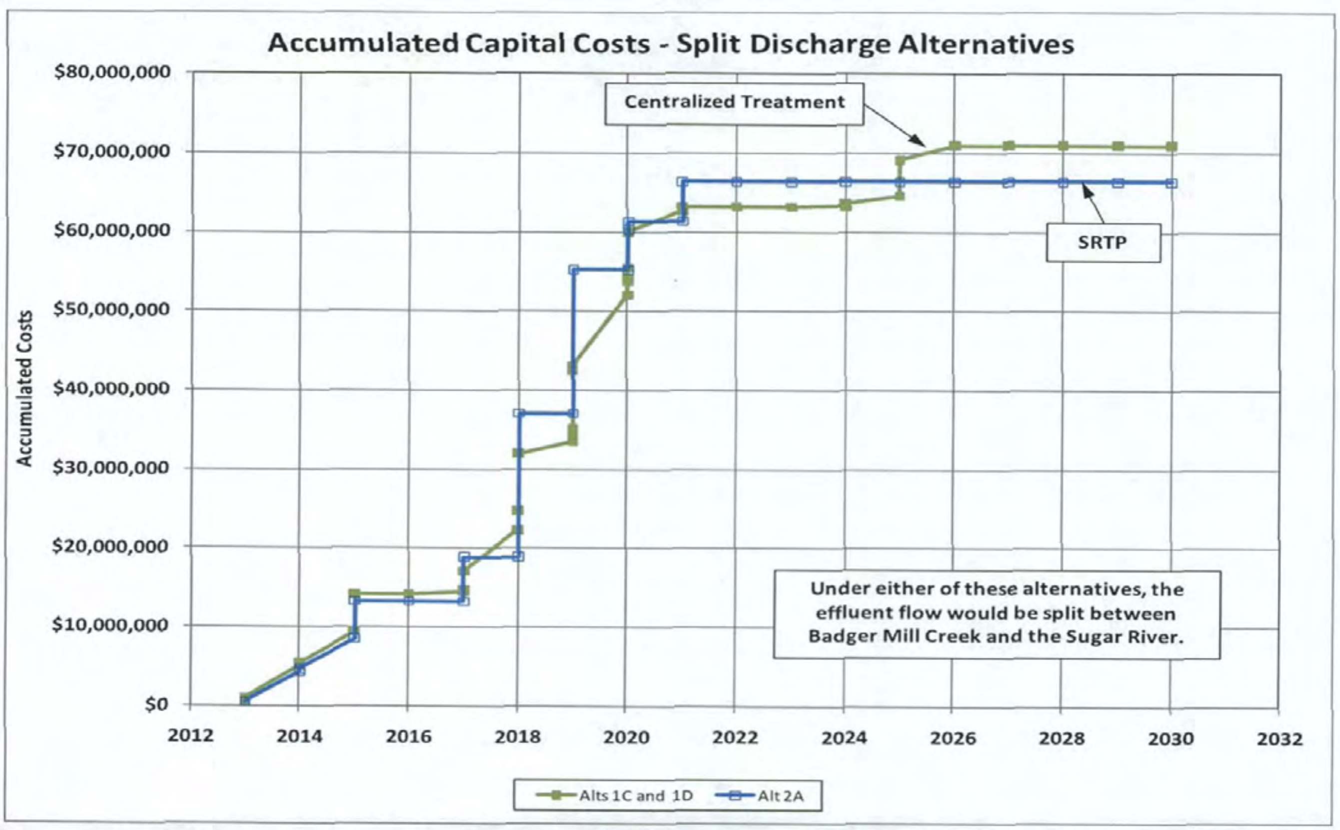


Figure 5



Evaluation of Other Non-Economic Criteria

In addition to watershed flow balancing and life-cycle costs, the Master Plan included eight other criteria that were used in the alternative evaluation process. Each of these criteria was assigned an importance weighting factor based on input from the technical advisory committee, District staff and the consultants. The criteria included:

Regulatory Constraints The regulatory requirements associated with an alternative may be easier or more difficult to meet, depending on a number of factors. For example, the regulatory requirements associated with an effluent discharge to the Sugar River, an Exceptional Resource Water (ERW), would be more stringent than those associated with discharge to a warm water stream.

Proven Effectiveness This criterion is used to evaluate alternatives for their reliability in providing required service. For example, fifteen years ago, biological phosphorous removal was not as proven a technology for removing phosphorous as chemical addition. As such, it would not have been considered to be as well "proven" as chemical addition.

Flexibility, Expandability, and Compatibility This criterion is used to rank alternatives for their potential to meet the following requirements:

- Can the alternative be readily modified to meet potential future needs such as re-routing wastewater, meeting more stringent future permit limits and regulations?
- Can it be readily expanded to meet future flows and loadings?
- Is the alternative compatible with the existing collection system and treatment facilities?
- Does it maximize continued use of existing facilities?
- Can it be phased into connection with the existing system?
- Is it compatible with adopted regional plans?

Ease of Operation This criterion considers the level of complexity involved in operating the facilities included in the alternative. For example, operation of a facility utilizing membrane filtration would be more difficult than operating the District's current facility.

Public Acceptance This criterion ranks all the alternatives for the likelihood of being accepted or resisted by the public.

Staffing Implications This criterion considers the staffing requirements for each alternative. Alternatives may have different staffing requirements, both in terms of staffing level and required skills. For example, operation of multiple plants may be more labor intensive than operation of a centralized system. In addition, operating an advanced treatment (tertiary) system may require a more skilled workforce than operating a secondary treatment system.

Opportunities for Effluent Reuse This criterion considers the potential of each alternative to reuse effluent. Effective effluent reuse could reduce the need for groundwater withdrawals from the Madison area aquifers. Available effluent reuse options include turf irrigation, groundwater recharge, and industrial water use. Some alternatives may present greater opportunity to beneficially reuse effluent because of location of facilities and/or the level or treatment.

Carbon Footprint This criterion was used to rank all the alternatives for the magnitude of their carbon footprint. Carbon footprint is a measure of the impact that the alternative has on the environment in terms of the amount of the greenhouse gases produced.

The results of the criteria evaluation are shown in Table 3.

Table 3 - Other Non-Economic Criteria Evaluation

	Sugar River Watershed Service Alternatives					
Evaluation Criteria	1A	1B	1C	1D	2A	2B
Regulatory Constraints						
Ranking Score	9	7	4	3	4	3
Level of Importance	9					
Weighted Score	**81**	**63**	**36**	**27**	**36**	**27**
Proven Effectiveness						
Ranking Score	8	6	4	4	4	4
Level of Importance	8					
Weighted Score	**64**	**48**	**32**	**32**	**32**	**32**
Flexibility/Expandability/Compatibility						
Ranking Score	5	6	8	8	8	8
Level of Importance	9					
Weighted Score	**45**	**54**	**72**	**72**	**72**	**72**
Ease of Operation						
Ranking Score	10	7	6	6	3	2
Level of Importance	5					
Weighted Score	**50**	**35**	**30**	**30**	**15**	**10**
Public Acceptance						
Ranking Score	8	9	6	5	4	3
Level of Importance	13					
Weighted Score	**104**	**117**	**78**	**65**	**52**	**39**
Staffing Implications						
Ranking Score	10	9	8	8	5	5
Level of Importance	5					
Weighted Score	**50**	**45**	**40**	**40**	**25**	**25**
Effluent Reuse						
Ranking Score	6	7	8	8	7	8
Level of Importance	9					
Weighted Score	**54**	**63**	**72**	**72**	**63**	**72**
Carbon Footprint						
Ranking Score	8	6	5	5	10	9
Level of Importance	5					
Weighted Score	**40**	**30**	**25**	**25**	**50**	**45**
Total	**488**	**455**	**385**	**363**	**345**	**322**
Relative Total	**100**	**93**	**79**	**74**	**71**	**66**

With the exception of carbon footprint, all of these criteria favored the centralized treatment alternatives over the decentralized alternatives.

Conclusions

1. With the exception of Alternate MP-1A, all alternatives will adequately mitigate the inter-basin transfer of water between the Sugar River watershed and the Yahara River watershed.

2. Other water resource management agencies, including DNR and CARPC, and the majority of citizens in the Sugar River watershed will favor the full mitigation of the inter-basin transfer.

3. The benefit of mitigating the inter-basin transfer of water between the Sugar River watershed and the Yahara River watershed is regional in nature, and as such, it is appropriate that if the District constructs such facilities, all District customers share in the cost to construct and operate these facilities.

4. The costs of similar alternatives are nearly equal. Since the cost estimation techniques used in the Master Plan were not very detailed, the range of expected costs for any of the

alternatives is probably ± 30 to 50 percent. Because of this, it is not possible to determine which of these alternatives is best from a cost standpoint.

5. All non-economic criteria, except energy use (carbon footprint), favor continued centralized treatment.
6. Without further study, Alternative MP-1A with future transitions to Alternatives MP-1B and then either Alternative MP-1C or MP-1D would seem to be the best approach to provide continued wastewater services in the Sugar River watershed.
7. Implementation of either de-centralized treatment alternative would require a major commitment of time and resources and would result in a dramatic change in the District's operations.

Recommendations

1. Future service in the Sugar River watershed should include facilities to assure full mitigation of the inter-basin transfer of water between the Sugar River watershed and the Yahara River watershed. This will continue the District's approach to this water resources management issue and is likely to be supported by DNR, CARPC, and the public.
2. To develop better information on which to make a decision for providing service in the Sugar River watershed, it is recommended that a more detailed report be prepared that addresses the required treatment levels for the various effluent discharge locations, including management of biosolids, and the cost of the facilities necessary to convey and treat the wastewater under each alternative.
3. The District should solicit proposals to prepare the recommended study within 30 days with the goal of having the study completed by the end of this year.

Madison Metropolitan Sewerage District

Sugar River Basin Effluent Discharge Study

November 1995

MONTGOMERY WATSON

MADISON METROPOLITAN SEWERAGE DISTRICT

;10 Moorland Road
Madison, WI 53713-3398
Telephone (608) 222-1201
Fax (608) 222-2703

James L. Nemke
Chief Engineer & Director

August 23, 2001

Department of Natural Resources
3911 Fish hatchery Road
Fitchburg, WI 53711-5397

Attn: Mr. Matthew J. Zine
State Natural Areas Biologist

RE: Impact of Water Diversion on Sugar River Basin

Dear Matt:

Thanks for taking the time to meet with us and the other parties interested in maintaining natural areas near the Sugar River. It is critical that there be a good understanding of everyone's objectives and needs if cooperative efforts can eventually work to everyone's advantage.

During the meeting I offered to provide data and information that was used to make the decision to return treated effluent to the Sugar River basin. Originally I was going to send some key excerpts from the Sugar River Basin Effluent Discharge Study. However, it seems like you might want to look at the entire report, which is enclosed. Since we have a limited number of these reports, please return the report after you are finished with it.(No Rush).

I did check on the actual and projected diversion volumes relative to both Badger Mill Creek and the Sugar River. You'll recall I was trying to remember the statistics. While they are contained in the report, I thought it might be easier if I spelled them out. These projections were made in 1995, prior to construction of the effluent return line.

BADGER MILL CREEK

Average Baseflow –	3.0 cfs
7Q10	0.18 cfs
Total water diversion as of 1996	3.4 cfs
Estimated water diversion by 2017	5.6 cfs
Estimated actual diversion 2001	4.6 cfs

SUGAR RIVER EFFLUENT DISCHARGE STUDY

For:

Madison Metropolitan Sewerage District
1610 Moorland Road
Madison, WI 53713-3398

By:

Montgomery Watson
Waterford Park
505 U.S. Highway 169, Suite 555
Minneapolis, Minnesota 55441

In Association With:

Applied Technologies, Inc.
Aquatic Resources Consultants
Caldwell & Associates
Carroll, Franck & Associates
Environmental Engineering Consultants

November 1995

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Executive Summary

MONTGOMERY WATSON

EXECUTIVE SUMMARY

This report is a follow-up study to the Ninth Addition Facility Plan Update for the Madison Metropolitan Sewerage District (MMSD). The purpose of this study was to determine whether a volume of treated effluent equivalent to the volume of wastewater generated in the Upper Sugar River Basin could be returned to the basin in an environmentally sound way, and if so, to identify the best means of doing so.

PROJECT BACKGROUND

The Verona Wastewater Treatment Plant (WWTP) currently treats the wastewater generated in the Verona Urban Service Area (USA) and discharges the treated effluent to the Sugar River at its confluence with Badger Mill Creek. Because of capacity problems and regulatory changes, in the future wastewater from the Verona WWTP will be pumped to the Nine Springs WWTP for treatment and treated effluent will be returned to the Sugar River Basin. In addition, treated effluent from areas of the Sugar River Basin served by MMSD outside the Verona USA will be returned to the basin. This study analyzed how to return the effluent in an environmentally sound way.

RETURN EFFLUENT EVALUATION

The effects of returning effluent were evaluated to determine the potential beneficial and negative impacts on the following:

- Water quantity and quality of the Sugar River and Badger Mill Creek
- Natural, endangered, and archaeological resources along potential transmission lines
- Stream hydraulics and hydrology of Badger Mill Creek
- The fishery habitat and stream temperature in Badger Mill Creek
- Recreational resources

Effluent quality and stream characteristics were evaluated to determine effluent discharge limits that will protect aquatic life in both the Sugar River and Badger Mill Creek. The project also evaluated ways to beneficially use the effluent to restore or create wetlands, and identified complimentary stream and watershed improvements for overall stream and fishery improvement. In all cases, the return effluent was found to have either a beneficial or neutral impact.

The study also found that Badger Mill Creek is currently impacted by channelization, sedimentation, lack of instream habitat, and low flows. Flow augmentation using the return effluent will not create significant improvements to the aquatic community of Badger Mill Creek by itself. Storm runoff and stream corridor management practices are necessary to significantly improve the resources and protect the investment made by MMSD to return effluent. The financial mechanisms and infrastructure for completing such improvements will be created by the Sugar River Priority Watershed Project scheduled to begin planning in 1997 and with implementation in 1999.

RECOMMENDED ACTIONS

The recommended actions consist of constructing an effluent pumping system and forcemain to convey the effluent to a cascade aerator constructed at the discharge location to Badger Mill Creek. Instream monitoring would determine whether additional efforts are necessary. Stream corridor improvement demonstrations would also be completed if partnerships can be formed with other local agencies for implementation. Below is a summary of the advantages of the recommended actions:

- Maintains flexibility for future management of all wastewater generated in portions of the Sugar River Basin served by MMSD

- Protects aquatic life and has a lower present worth cost than other options

- Enhances Badger Mill Creek baseflows and low flows, increases potential fish habitat for 25,000 feet of the creek, and improves fish habitat for 1,500 feet of creek

- Demonstrates stream improvement technologies, promotes the Priority Watershed Program, and has the potential to enhance cross-agency cooperation for the benefit of the resource

- Has no known long-term impacts on natural or archaeological resources, and has the potential to improve the Military Ridge and Capital City Trails and recreational uses of Badger Mill Creek

- Has strong public and local government support

Additional strategies and improvements such as proactive stormwater management are necessary to significantly improve Badger Mill Creek and the Sugar River. The Priority Watershed Project will provide the necessary plans and infrastructure to continue the improvements begun by implementing this alternative.

The total present worth cost of the recommended alternative is $5,700,000 and results in an annual service charge increase of $2 per residential user. Portions of the transmission line can be constructed in 1996 to coordinate with trail improvements already scheduled to begin then; channel improvements will be completed prior to flow augmentation. The facility improvements are expected to be operational in 1997, with 1998 being the first full year of operation.

Section 1

MONTGOMERY WATSON

SECTION 1

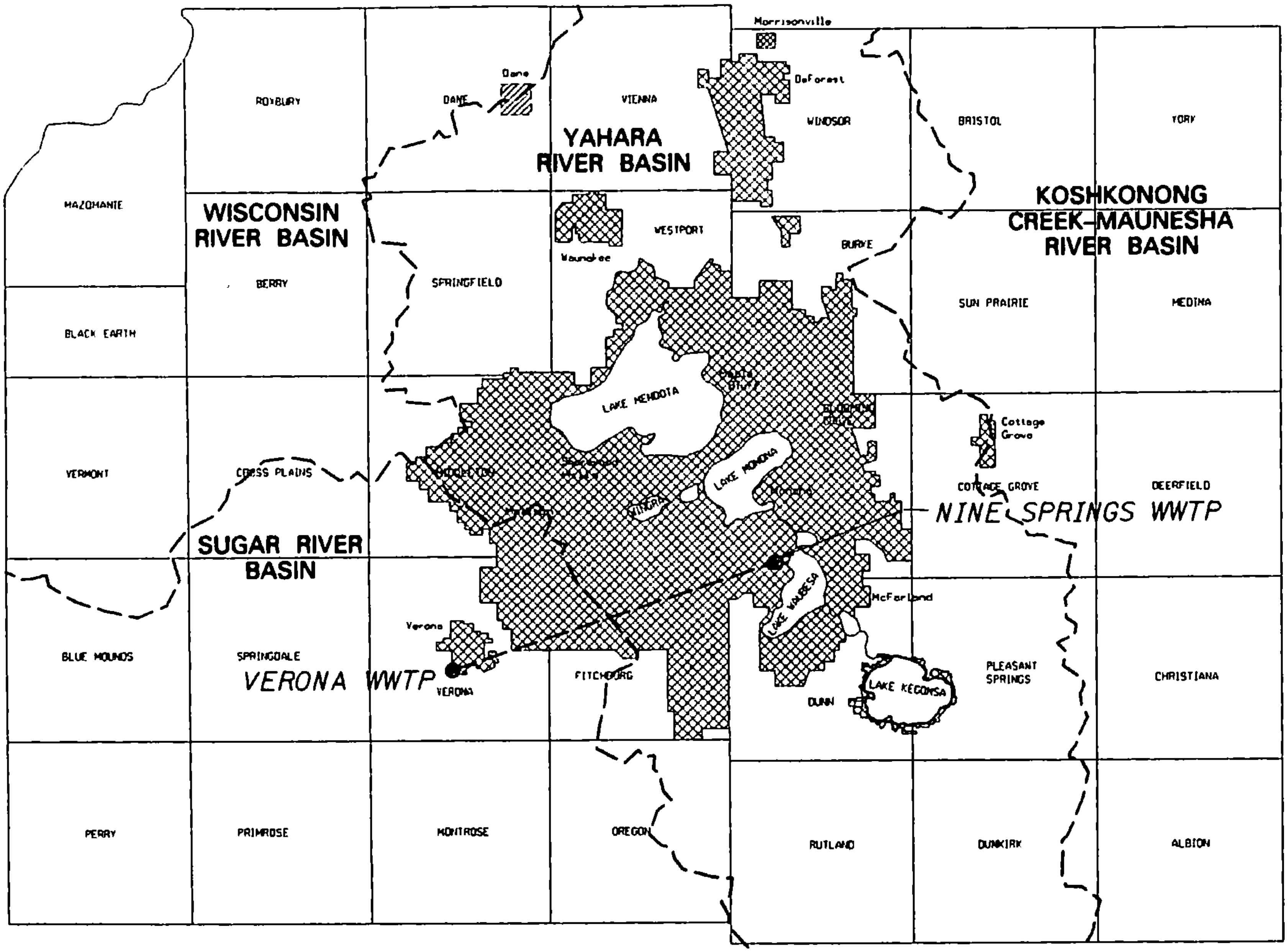
INTRODUCTION

This report presents the findings of a follow-up project to the Ninth Addition Facility Plan Update (Facility Plan) for the Madison Metropolitan Sewerage District (MMSD). The Facility Plan was completed in October 1994. One aspect of this plan was selection of a wastewater management strategy for the Verona Urban Service Area. Based on the Facility Plan as well as support expressed at public hearings, MMSD selected the alternative of treating all wastewater generated in the Sugar River Basin at the Nine Springs Wastewater Treatment Plant (NSWWTP) and returning an equal volume of effluent. The Facility Plan did not detail how returning this effluent might be accomplished in an environmentally sound way. This project is a follow-up study to determine whether treated effluent can be returned to the Upper Sugar River Basin and returned in an environmentally sound way, and, if so, to identify the best means of returning effluent.

PROJECT BACKGROUND

The Verona Wastewater Treatment Plant (WWTP) treats the wastewater generated in the Verona USA (Figure 1-1). The treated effluent is discharged to the Sugar River at the confluence of the Sugar River and Badger Mill Creek. The NSWWTP operated by MMSD treats wastewater generated in the Greater Madison Metropolitan Area, including a large portion of the wastewater generated in the Upper Sugar River basin. Treated effluent from NSWWTP is discharged to the Yahara River Basin by way of Badfish Creek.

MMSD annexed the Verona USA on September 13, 1993 and took over operation of the Verona WWTP in January 1995. The Verona WWTP is currently operating at capacity and in recent years has occasionally exceeded the permitted effluent limits. The Wisconsin Department of Natural Resources Rule NR 217 requiring phosphorus limits has resulted in a reissued permit requiring phosphorus limitations be met by March 31, 1998. The proposed reclassification of the Sugar River to a Cold Water Fishery will eventually place additional performance constraints on the plant.



LEGEND (cross-hatched) REPRESENTS EXISTING MMSD BOUNDARY

(diagonal hatched) REPRESENTS POSSIBLE FUTURE MMSD BOUNDARY INCORPORATION

— — - EFFLUENT RETURN LINE CORRIDOR

SOURCE: DANE COUNTY REGIONAL PLANNING COMMISSION

Figure 1-1
Service Area
Nine Springs WWTP

MMSD FACILITIES PLAN UPDATE

Several earlier studies were done concerning the Verona WWTP. These include the 1993 Verona Facilities Plan, an Environmental Assessment of the Verona Facilities Plan completed in 1994 by the Dane County Regional Planning Commission, and the 1994 Ninth Addition Facility Plan Update for MMSD. These studies are summarized below.

Verona Facilities Plan

A Facilities Plan Amendment was completed for the City of Verona in March 1993 (Rust 1993). The study examined three alternatives for wastewater treatment from the Verona USA:

1. Upgrade the existing treatment facility at Verona for treating projected future flows generated within the Verona USA.

2. Abandon the existing Verona WWTP and divert all flow to MMSD for treatment at the NSWWTP.

3. Construct a new regional WWTP at Verona to treat all wastewater generated in the Upper Sugar River basin, which includes the Verona USA and a portion of MMSD's service area.

A cost analysis for the three alternatives resulted in a recommended plan to abandon the existing Verona WWTP and divert all flow to MMSD for treatment at the NSWWTP.

Verona WWTP Environmental Assessment

In 1994 the Dane County Regional Planning Commission (DCRPC) completed an Environmental Assessment of the Verona Facilities Plan Amendment alternatives (DCRPC 1994). This assessment evaluated the hydrologic, water quality, and biological impacts of the three alternatives on the Sugar River and Badger Mill Creek. Alternative 2 would have the positive effect of reducing pollutant loading in the Sugar River, but the projected wastewater diversion out of the watershed would be large enough to affect stream fishery habitat negatively during dry weather. This would affect Badger Mill Creek, and to a lesser extent, the Sugar River.

The Environmental Assessment suggested the following alternatives to mitigate impacts to base flow in Badger Mill Creek and the Sugar River:

- Discharge treated effluent under Alternative 1 to Badger Mill Creek rather than the Sugar River. This had been done in the past but was discontinued in the 1980s.

- Return and discharge treated effluent from MMSD to the headwaters of Badger Mill Creek.

- Provide a deep well to augment stream flow in Badger Mill Creek and the Sugar River only during drought periods when stream flows fall below minimum levels needed to support the fishery.

Ninth Addition Facility Plan Update for MMSD

The Verona Facilities Plan Amendment was submitted to the WDNR for approval and was under review when the MMSD and the City of Verona agreed to proceed with annexation of the Verona USA to the MMSD. Because of the potential environmental concerns with the recommended alternative and associated transfer of water from the Sugar River basin to the Yahara River basin, MMSD conducted an additional alternatives evaluation as part of the Ninth Addition Facility Plan Update.

The primary conclusion of the Facility Plan was for MMSD to maintain the highest degree of flexibility in the future for handling the Verona effluent. It was recommended that MMSD adopt a wastewater management plan for Verona that would minimize the investment in the existing Verona WWTP while retaining an outfall and the associated discharge permit for the Sugar River. Two alternatives had the potential to meet the recommendation:

- Alternative 2C which would upgrade the Verona WWTP and treat and discharge a portion of the wastewater generated in the Verona USA to the Sugar River, while diverting the remaining wastewater to MMSD for treatment and subsequent discharge to the Yahara River basin.

- Alternative 3B would divert the wastewater generated in the Sugar River basin to MMSD for treatment and return an equal volume of effluent to the Sugar River basin by discharging to Badger Mill Creek.

Both alternatives would maintain an outfall and associated discharge permit for the Sugar River Basin. Alternative 3B would have the added benefit of eliminating the transfer of water from the Sugar River basin to the Yahara River basin that is already occurring. Additionally, there is significant local concern about the future of Badger Mill Creek with the trend toward lower baseflows, reduced fish habitat, and declining groundwater levels due to the diversion of water out of the watershed. By contrast, Alternative 2C would do nothing to reduce or reverse this trend. If water return and flow augmentation in Badger Mill Creek are determined to be an environmental benefit, adopting Alternative 3B would bring treated effluent back for this purpose and eliminate the need for further investment in the Verona WWTP.

Alternative 2C had a lower present worth cost than Alternative 3B, but both would require a transfer pump station and force main to divert wastewater to the NSWWTP for treatment. It was therefore recommended that the pump station and force main be constructed as a first phase of the ultimate solution for wastewater management in the Sugar River watershed. The Facility Plan also recommended further study of Alternative 3B to address the following issues:

- Hydraulics/hydrology of Badger Mill Creek

- Environmental impacts on Badger Mill Creek

- Effluent limitations

- Public acceptance

Public comment on the Ninth Addition Facility Plan Update was solicited through public hearings, meetings, and write-in comments. All public responses received as a result of these solicitations supported either returning the effluent to the Sugar River basin or further study of the potential to return effluent. These comments were received from a wide range of the public including Trout Unlimited, Audubon Society, Dane County Conservation League, Village of Belleville, Town of Exeter, and residents of the Sugar River Basin.

PROJECT DESCRIPTION

This study is a follow-up study to the Ninth Addition Facility Plan Update and specifically addresses the alternative of returning treated effluent to the Sugar River basin in an environmentally sound manner. The project area includes the Badger Mill Creek watershed, the Verona USA, and the area between Verona and NSWWTP where the effluent return line could be routed (Figure 1-1). The study covers a number of key questions and objectives and a specific planning period. Guidance for the overall project was provided by an advisory committee which is also described in this section.

Key Questions

The study addresses the following key issues:

- What should the requirements be for effluent return through discharge to Badger Mill Creek?

- Are there opportunities for wetland creation to improve water quality for aquatic life and provide wildlife habitat, and would such a discharge be environmentally sound?

- What are the hydraulic constraints in Badger Mill Creek for discharging effluent?

- How would effluent be transmitted from NSWWTP to the Badger Mill Creek area?

- What types of fisheries considerations would be appropriate for the various discharge locations and volumes?

- Are there opportunities for stream improvements that would complement the effluent return and discharge, and improve the Badger Mill Creek fishery?

- What are the temperature considerations of effluent return and discharge? Do they need to be controlled, and if so, how?

- How would the effluent resource interact with other resources in the area such as wetlands and recreational facilities?

- Are there opportunities that would complement the effluent return and discharge, and improve the recreational potential of Badger Mill Creek?

- How important is it to control nonpoint source pollution from urban runoff and agriculture to improve and protect recreational uses and the fishery of Badger Mill Creek, and the public investment in effluent return?

- Are there nonpoint source pollution control strategies that would help protect the water quality and fishery of Badger Mill Creek?

Project Objectives

The two primary project objectives were as follows:

- Identify and evaluate the necessary actions to return effluent to the Sugar River Basin in an environmentally sound way.

- Identify stream, fishery, wetland, stormwater, recreation, and watershed management activities that will complement the effluent return and provide additional improvement to Badger Mill Creek and the Sugar River.

For the remainder of the study, these two primary objectives and the alternatives identified for meeting these objectives will be referred to as necessary actions to return effluent, and added-value improvements, respectively.

Specific objectives related to the key questions were developed for both the necessary actions to return effluent and the added-value improvements. The specific objectives for the necessary actions to return effluent are as follows:

- **Effluent Discharge Limits:** Determine the necessary effluent discharge quality to meet the receiving water quality standards for Badger Mill Creek and the Sugar River.

- **Stream Hydraulics and Hydrology:** Determine the hydraulic constraints and receiving stream improvements necessary to accommodate the volume of effluent discharged.

- **Effluent Transmission:** Evaluate alternatives and design the selected alternative for transmitting the effluent from the NSWWTP to the Sugar River Basin.

- **Fisheries:** Determine the existing and potential fishery conditions of Badger Mill Creek, with and without effluent return.

- **Temperature:** Evaluate temperature control options and design a scenario which will achieve temperature goals for sustaining aquatic ecology in Badger Mill Creek.

- **Wetland Opportunities:** Identify and evaluate opportunities for, and the feasibility of, using wetlands to provide wildlife habitat and additional effluent water quality improvement prior to discharging to Badger Mill Creek.

The specific objectives for added value improvements are as follows:

- **Stream Improvement Opportunities:** Identify and evaluate stream improvement concepts and design selected concepts that will complement the elimination of interbasin transfers and protect and improve the recreational and fish habitat value of the Badger Mill Creek system.

- **Recreational Facility Improvements:** Identify and evaluate recreational facility improvement concepts that will complement effluent return and elimination of interbasin transfers and improve the recreation values of the Badger Mill Creek area.

- **Watershed Improvement Opportunities:** Identify natural resource and nonpoint source pollution control concepts that will complement the elimination of interbasin transfers and protect and improve the resource value of the Badger Mill Creek system.

Planning Period

This project covers the same planning period as the Ninth Addition Facility Plan Update, the 20 years from 1997 to 2016. Construction activities for effluent transmission and hydraulic improvements to the stream will be completed by 1997, with the first full year of operation in 1998. Construction of additional treatment facilities will be phased, based on the need to provide treatment over the planning period. Preliminary schedules for recreational, stream, and fishery improvements are discussed in the Implementation Plan presented in Section 8.

While the planning period is 1997 to 2016, water transfers from one basin to another may have much longer-term implications. This study therefore discusses and evaluates implications beyond the normal 20-year planning period.

Advisory Committee

This project was initiated because of the overwhelming public support for returning effluent from the NSWWTP to the Sugar River basin. Since the project also involves a number of agencies and policy decisions, an advisory committee was formed to guide the project and facilitate discussions among the various agencies and stakeholder groups. The committee was comprised of representatives of state, county, and city governments, interested citizens, and experts from the University of Wisconsin. The advisory committee had input on all aspects of the project and met six times. Advisory committee meeting minutes are included in Appendix A.

Section 2

Section 2

MONTGOMERY WATSON

SECTION 2

METHODOLOGY

This section presents the methodology used to determine the current situation, define conditions associated with the effluent discharge, and identify and evaluate alternatives. Methods are presented and organized by project topic.

RECEIVING WATER CHEMISTRY AND FLOW

Historical water quality monitoring data for Badger Mill Creek were compiled from multiple sources. These sources included STORET, Dane County Regional Planning Commission (DCRPC 1989), United States Geological Survey (USGS) Water Data Reports, monitoring completed for the Dane County Landfill, the University of Wisconsin, ongoing monitoring by the Madison Metropolitan Sewerage District (MMSD), and temperature, dissolved oxygen, and flow data collected by the project team.

EFFLUENT DISCHARGE CHARACTERISTICS

The characteristics of effluent discharged from both the Verona and Nine Springs WWTPs were determined for comparison with the effluent discharge limits for Badger Mill Creek and the Sugar River.

Verona WWTP

Existing effluent discharge characteristics for the Verona WWTP were based on the limits in the existing WPDS permit. The exception was a total phosphorus (TP) limit which was not specified in the permit. Existing average TP concentration was therefore based on grab samples collected during completion of the Ninth Addition Facility Plan Update. The TP concentrations for this period ranged from 4 to 6 mg/L; 4 mg/L was used for this analysis.

Nine Springs WWTP

Existing effluent discharge characteristics for the NSWWTP were based on effluent monitoring data from August 1992 through December 1994. The exception was TP. Historic effluent TP characteristics for the existing treatment plant do not reflect the addition of enhanced biological phosphorus removal (EBPR). To represent future concentrations, the average concentration of 0.88 mg/L TP from pilot testing of EBPR at NSWWTP was used.

EFFLUENT DISCHARGE LIMITS

Effluent discharge limits are typically calculated by the permitting agency, in this case the Bureau of Water Resources Management of the Wisconsin Department of Natural Resources (WDNR). However, methods employed by WDNR are typically conservative with respect to protecting aquatic life because site-specific factors are not routinely considered. Consideration and proof of alternative methods are the responsibility of the permittee. This study considers the WDNR method and alternatives for determining limits that protect aquatic life.

WDNR Limits

Methods used by the WDNR are presented with their calculations in Appendix G. One of the most important input considerations made by the WDNR for calculating limits was the stream classification. Badger Mill Creek is currently classified as a limited forage fish community (intermediate) in NR 104. However, Badger Mill Creek is proposed to be reclassified as a warm water forage fish community and will be removed from NR 104. In addition, NR 102 will also be updated in the next two years and the Sugar River is proposed to be reclassified as a cold water community. Therefore, effluent limitations were calculated by the WDNR for both the current and proposed reclassifications.

The WDNR currently sets effluent BOD_5 limits for small streams based primarily on standardized formulas. These include the 13 lb rule for cold water communities and the 26 lb rule for warm water communities.

The same methods and input values were used in this study to calculate alternative limits for a direct discharge to the Sugar River. Acute and chronic criteria for selected metals were also calculated. In addition, a receiving water model was developed to determine how site-specific factors influence the assimilative capacity of Badger Mill Creek. The methodologies used to determine alternative discharge limits, metals criteria, and site-specific considerations are described below.

Direct Discharge to the Sugar River

The WDNR calculations were done for a discharge to Badger Mill Creek. Limits protecting the Sugar River were completed without a mixing zone at the outlet of Badger Mill Creek. This was done by applying cold water fisheries standards to the 7Q10 flow for Badger Mill Creek with receiving water characteristics of the Sugar River.

This study calculated alternative limits for a direct discharge to the Sugar River using cold water fisheries standards and Sugar River receiving characteristics, but with the 7Q10 from the Sugar River. All other input values used were the same as those used by the WDNR. The 7Q10 used for the Sugar River was 7.8 cfs while the 7Q10 for Lower Badger Mill Creek was 0.18 cfs.

Ammonia Toxicity

The WDNR methods for determining discharge limits for ammonia specifies constant chronic toxicity criteria for un-ionized ammonia of 0.016 mg/L for cold water classification and 0.04 mg/L for warm water. However, the toxicity of un-ionized ammonia varies with pH and temperature. Therefore, alternative ammonia limits were calculated using a more current EPA approach which addresses the varying toxicity of un-ionized ammonia with pH and temperature, as well as the fraction of un-ionized ammonia which varies with pH and temperature (EPA 1986).

Metals Criteria

Acute and chronic metals toxicity criteria were calculated for copper, lead, and zinc using Wisconsin Administrative Code Chapter 105. Badger Mill Creek criteria were calculated using equations for warm water sport fish while Sugar River criteria were calculated using the equations for cold water. Hardness values were calculated as the geometric mean of historical creek monitoring data for chronic criteria, and the geometric mean of effluent characteristics for acute criteria.

Site-Specific Modeling

A comprehensive receiving water quality model was developed to assess site-specific factors that influence the capacity of Badger Mill Creek and the Sugar River to assimilate the return effluent discharges. The 13 and 26 lb rules used by WDNR assume a fixed DO, constant reaeration rate, temperature, and BOD_5 decay. These rules are not as accurate since they do not consider site specific conditions such as stream slope, cross-section and stream shading. As indicated in the WDNR Report of the 10/10 Committee (June 1992), the 26 lb rule was not sensitive to many site-specific variables such as temperature and channel geometry. Consequently, a water quality model was developed to evaluate site-specific stream assimilative capacity and provide additional information from which to set limits.

The site-specific model was developed using the EPA enhanced stream water quality model QUAL2E (EPA 1991). Information in the following five technical areas was compiled and evaluated to accurately and effectively perform the water quality simulations of Badger Mill Creek and the Sugar River confluence:

- Receiving water flow and background quality data
- Channel characteristics including cross-sections and slopes
- Selecting conservative but reliable rate coefficients
- Climate data to evaluate the stream heat balance and adjust rate coefficients
- Effluent flow and quality data

Receiving Water Flow and Quality: Background water quality data were compiled from multiple sources including STORET, USGS, the University of Wisconsin, Dane County, and ongoing monitoring by the Madison Metropolitan Sewerage District (MMSD). Instream flows (7Q10) were the same as those used by WDNR (0.0 cfs for upper Badger Mill Creek and 0.18 cfs for lower Badger Mill Creek). The Sugar River has an established 7Q10 of 7.8 cfs.

Channel Characteristics: Seven water quality reaches were used for the analysis. Channel geometry sections were derived from cross sections in the HEC-2 water surface profile model of Badger Mill Creek. Figure 2-1 shows the locations of the water quality reaches in relation to stream length and profile. Channel invert elevations were obtained from the HEC-2 model and USGS topographic maps. Reach characteristics are summarized in Table 2-1.

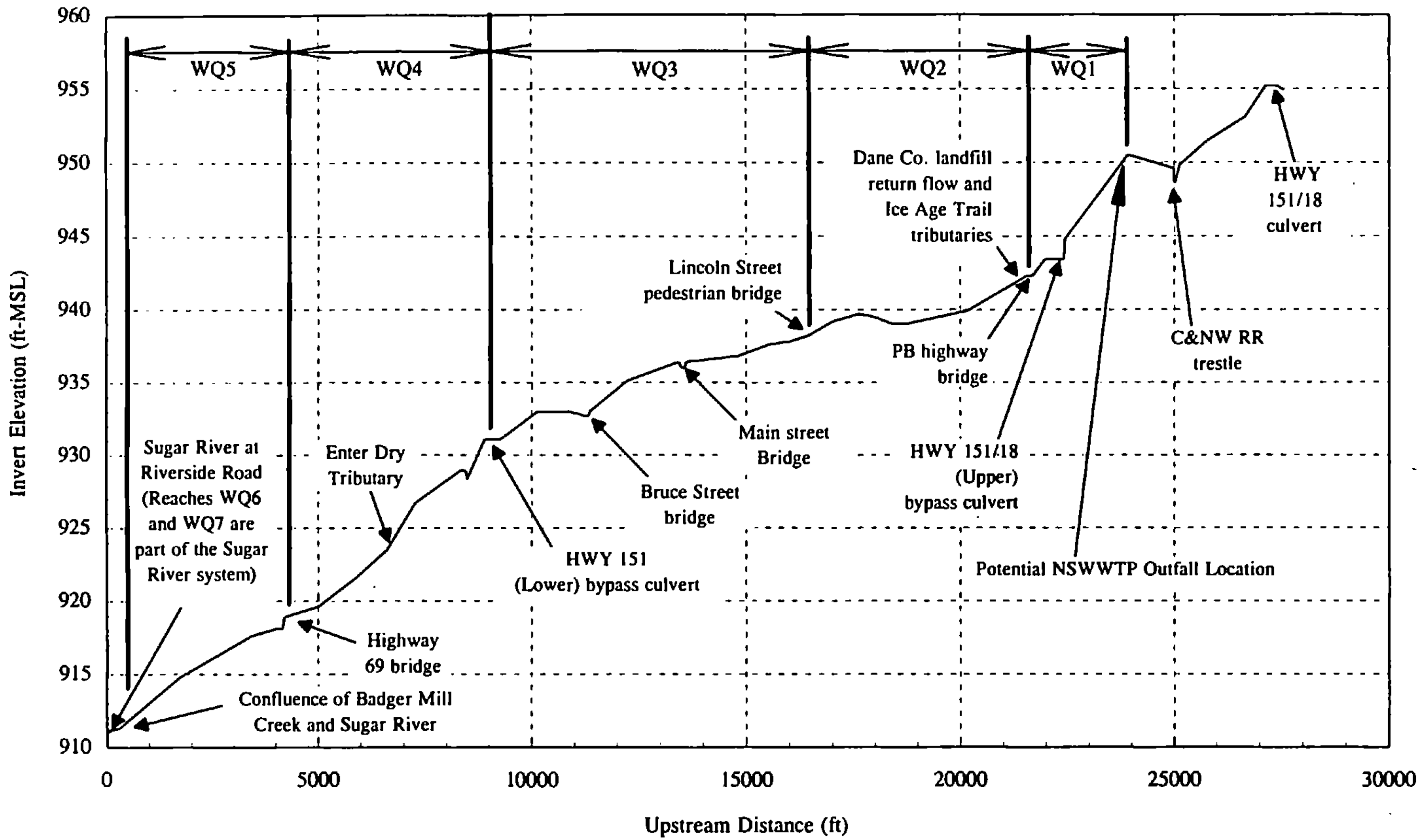


Figure 2-1. Badger Mill Creek: Existing Channel Invert Elevations Showing QUAL2E Model Water Quality Reaches (WQ#)

Climate Data: Climate affects the instream heat balance and biological activity. Warm season (June-October) and cold season (November-May) conditions were simulated using the climate data presented in Table 2-2.

Rate Coefficients: The EPA QUAL2E model is a steady state water quality model capable of simulating reach-variable conditions. These include constituent reactions and interrelationships for algae, the phosphorus and nitrogen cycles, carbonaceous BOD, total suspended solids (TSS), and temperature. A summary of the important rate coefficients used in the model is presented in Table 2-3. Conservative rate coefficients were used to develop the model.

Effluent Flow and Quality Data: Effluent return flows used in the model include the proposed rates for the beginning and end of the planning period, 2.2 mgd (3.4 cfs) and 3.6 mgd (5.5 cfs), respectively. Effluent characteristics were based on the historic performance of NSWWTP. The methodology for characterizing NSWWTP effluent is described above.

STREAM HYDRAULICS AND HYDROLOGY

Badger Mill Creek is part of the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA). The USGS under contract with FEMA recently updated the HEC-II flood profile model of the creek to reflect the floodplain interactions and hydraulic structures associated with the Highway 18/151 bypass. The model focused on the length of Badger Mill Creek between Highway 151/Nesbitt Road and its confluence with the Sugar River. A copy of this model was obtained from the USGS and used to evaluate potential hydraulic impacts associated with returning effluent to Badger Mill Creek.

TABLE 2-1

QUAL2E MODEL WATER QUALITY REACHES FOR BADGER MILL CREEK

Reach	WQ ID	Reach Length (mi)	Reach Slope (ft/ft)
Highway 18/151 to PB Road	WQ1	0.6	0.0026
PB Road to Lincoln Street Pedestrian Bridge	WQ2	1.0	0.0008
Lincoln Street Bridge to Highway 151 Bypass	WQ3	1.4	0.0010
Highway 151 Bypass to Highway 69	WQ4	0.9	0.0027
Highway 69 to Sugar River Confluence	WQ5	0.7	0.0018
Upstream Sugar River to Badger Mill Creek Confluence	WQ6	0.2	0.0007
Badger Mill Creek Confluence to Downstream Sugar River	WQ7	0.2	0.0007
	Total	4.9	

TABLE 2-2

QUAL2E MODEL METEOROLOGICAL DATA FOR MADISON, WISCONSIN[1]

Parameter	Warm Season (Average July Daily Minimum Value)	Cold Season (Average January Daily Minimum Value)
Air Temperature, °F	82.4	7.2[2]
Barometric Pressure, in Hg	29.1	29.3
Humidity, %	71.5	60.0
Windspeed, ft/sec	11.9	11.9

[1] From Wisconsin State Climatology Office, Normal Means and Extremes for Madison Wisconsin, Years 1947 through 1991

[2] Cold season temperatures between 35° and 40°F where used rather than monthly minimum since they were more conservative for DO modeling

TABLE 2-3

IMPORTANT WATER QUALITY RATE COEFFICIENTS[1]

Rate Parameter	QUAL2E Variable	Formulation Used	Typical Rate Range (1/day)	Rates Applied in Model
Oxygen Reaeration	K_a	Tsivoglou and Wallace (1972) $K_2 = (3600*24)*C*S_e*4$	0.0-100	2-18
BOD Decay	K_d	Hydroscience (1971) $K_d = 0.3*(depth/8)^{-0.434}$	0.02-3.4	0.3-0.9
TSS Settling	K_s	Stoke's Law	0.33-32.8 times depth	0.33 times depth

[1] Additional rate coefficients are defined in technical Appendix B

The flow rates for the 10- and 100-year events were initially modeled using the USGS base HEC-II deck to determine flood conditions without effluent added to the stream. The model was then altered to include effluent flow rates of 2.2 mgd (3.4 cfs) and 3.6 mgd (5.5 cfs) discharged at Nesbitt Road. The flow rates used in the model for each minor tributary to Badger Mill Creek were left unchanged. Model outputs were used to identify where flood elevations and channel velocities increased with effluent addition.

The USGS base model included duplicate stretches of Badger Mill Creek for analysis of split flow conditions which may occur in the channel if the banks are overtopped during flooding. For the official FEMA model, flow rates and tailwater elevations were balanced by trial and error between each side of the flow split. The accuracy of the split flow analysis was not high. Comparison of the 100-year flow condition showed variations of up to 1.31 feet in the flood elevations for opposite sides of the split. Because the split flow analysis was crude and the effluent discharges comprised a very small percentage of the total flow in the creek, the split flow analysis was not performed for the effluent flows. Model continuity was satisfied by including the entire effluent discharge on the dominant side of the flow split.

EFFLUENT TRANSMISSION

The Ninth Addition Facility Plan Update described a transmission system for returning highly treated effluent from the NSWWTP to Badger Mill Creek. The proposed system included a tap into the existing effluent transmission pipeline to Badfish Creek, 6,900 feet of force main, and 37,000 feet of gravity sewer. The route chosen for the transmission line parallels the existing Nine Springs Valley Interceptor (NSVI).

The Ninth Addition Facility Plan Update served as the basis for initial study planning. USGS topographic maps were used to identify alternative routes that would reduce impacts on wetlands and minimize required easement acquisitions, pipeline length, and energy requirements. The alternate routes were preliminarily screened through field inspections and meetings with local municipal and Dane County officials. The route was then divided into nine segments to compare selected alternative routes within each segment.

Plan and profile maps for the proposed alignments were generated from existing USGS mapping and verified using April 1995 aerial photography. Hydraulic analyses for the alternative pipeline routes were performed to determine the requirements for the transmission system. These analyses were used to prepare construction and operating cost estimates for each of the proposed alignments.

ARCHAEOLOGICAL SITES

The presence of archaeological sites in relation to potential project activities was investigated by Archaeological Resource Consultants and by reference to earlier studies completed by the Wisconsin DOT for the Verona highway bypass. The methods used for these studies are described in the respective reports which are attached as Appendix C.

THREATENED AND ENDANGERED SPECIES

The potential presence of threatened and endangered species was investigated by obtaining a search of the Natural Heritage Database for the project area. Areas with potential sightings were then investigated using maps, aerial photographs, and field reconnaissance to determine if project activities have the potential to affect these areas. Correspondence is attached as Appendix D.

FISHERIES

An assessment of fisheries conditions was completed as three elements:

- Stream inventory to assess existing conditions
- Review of fisheries inventories
- Habitat modeling

Methods for each of these are described below.

Stream Inventory

On April 3-4, 1995, two inventory teams of two people each walked approximately 25,240 feet of Badger Mill Creek from its confluence with the Sugar River to Highway 18/151 east of the city of Verona near Nesbitt Road. Approximately 5,300 feet of private property between Highway 69 and the Verona WWTP were not inventoried because access was not obtained.

The inventory teams observed and measured bank heights, channel widths and depths, habitat types, substrate, riparian vegetation, water temperature (mainstream and tributary), and significant features such as culverts, tributaries, and bank damage. Flow volumes and velocities were also measured at multiple locations for calibration of the habitat model.

For purposes of the inventory the stream was divided into five reaches. These reaches, based primarily on stream gradient, are shown in Table 2-4.

Two 1,000-foot longitudinal profiles were collected using standard rod and level methods for determining differential elevations. One profile was upstream from the mouth of Badger Mill Creek and the other was downstream from the Lincoln Street footbridge.

Fish Inventory

Fisheries inventories were completed by MMSD on October 4, 1994 and June 21, 1995. These inventories along with previous inventories completed by WDNR were reviewed and discussed as part of establishing existing conditions for Badger Mill Creek and the Sugar River (Marshall 1989 and Marshall and Stewart 1993).

TABLE 2-4

BADGER MILL CREEK HABITAT STREAM REACHES

Stream Reach	Reach Length (ft)
Mouth of Badger Mill Creek to Highway 69	4,330
Highway 69 to Verona WWTP	6,927[1]
Verona WWTP to Main Street	2,677
Main Street to PB Road	8,091
PB Road to Highway 18/151	3,195

[1] Includes approximately 5,300 feet of private property that was not inventoried

Habitat Modeling

An instream flow study using the Instream Flow Incremental Methodology (IFIM) was used to investigate the changes in available fish habitat with changes in flow (Bovee 1982). Hydraulic and habitat models from the Physical Habitat Simulation (PHABSIM) program library (Milhous and others 1989) were used to evaluate the effect of two effluent return flows on the fish habitat for both warmwater fish and brown trout in Badger Mill Creek.

A major assumption in focusing primarily on stream flow is that other habitat variables such as lack of escape cover, poor quality or limited spawning areas, water temperature, or other water quality parameters are not limiting fish production. This may not be entirely true. If flow can be minimized as a major limiting factor, the resource analysis can then shift emphasis to other factors.

The model output, Weighted Usable Area (WUA) versus flow (Q), is a weighted index of the change in stream habitat (i.e., stream volume) with changes in flow. It is calculated by matching predicted water depths and velocities with the habitat preferences of fish species present in each reach.

Two hydraulic models were constructed for PHABSIM modeling. Thirteen transects were established in the 4-mile study reach between the Sugar River confluence and CTH PB (Figure 2-2). At each transect, the channel cross section (including water depth and velocity), substrate type, and water surface slope were measured. Transects 1-6, the mouth of Badger Mill Creek upstream to the City of Verona WWTP, were used in the brown trout model. All 13 transects were used in the warmwater fish model.

The location and description of the 13 transects used in this analysis are shown in Figure 2-2 and Table 2-5, respectively. Habitat modeling was done on the stream reach between the Sugar River and CTH PB. It was assumed that water level conditions observed in April 1995 were low enough to represent both summer and winter base flow conditions, and that the patterns of gradual inflow increases were typical of year-round inflow patterns.

Habitat preference criteria for brown trout and warmwater fish were developed to produce the final habitat index. Brown trout preference criteria were developed from recently available field data and literature information for trout of similar size to those found in the Sugar River (Blum 1995, Stoltz and Schnell 1991). The warmwater fish preference criteria were developed from available information on white sucker habitat preferences (Towmey and Nelson 1984) and on the swimming abilities of suckers and other warmwater species found in Badger Mill Creek (sculpins, darters, sticklebacks, creek chub) (Bell 1991). Development of habitat preference criteria are discussed in detail in Appendix E in the calibration report.

The range of flows modeled for this analysis (2-25 cfs) was chosen to analyze the potential effect of two discharges (2.2 and 3.6 mgd) on low and medium flow conditions. Inflows along the reach of Badger Mill Creek from CTH PB to the Sugar River confluence were calculated from field observations. Habitat at each cross section was calculated for an appropriate range of flows and inflows. The final habitat index is an aggregate of the predicted habitat in all reaches indexed to flows at Highway 69. For instance, available habitat at the index flow of 6.6 cfs at Highway 69 includes habitat at 4.1 cfs near the Verona STP, at 2.5 cfs in reaches upstream of the Lincoln pedestrian bridge, and at flows less than 1 cfs at CTH PB.

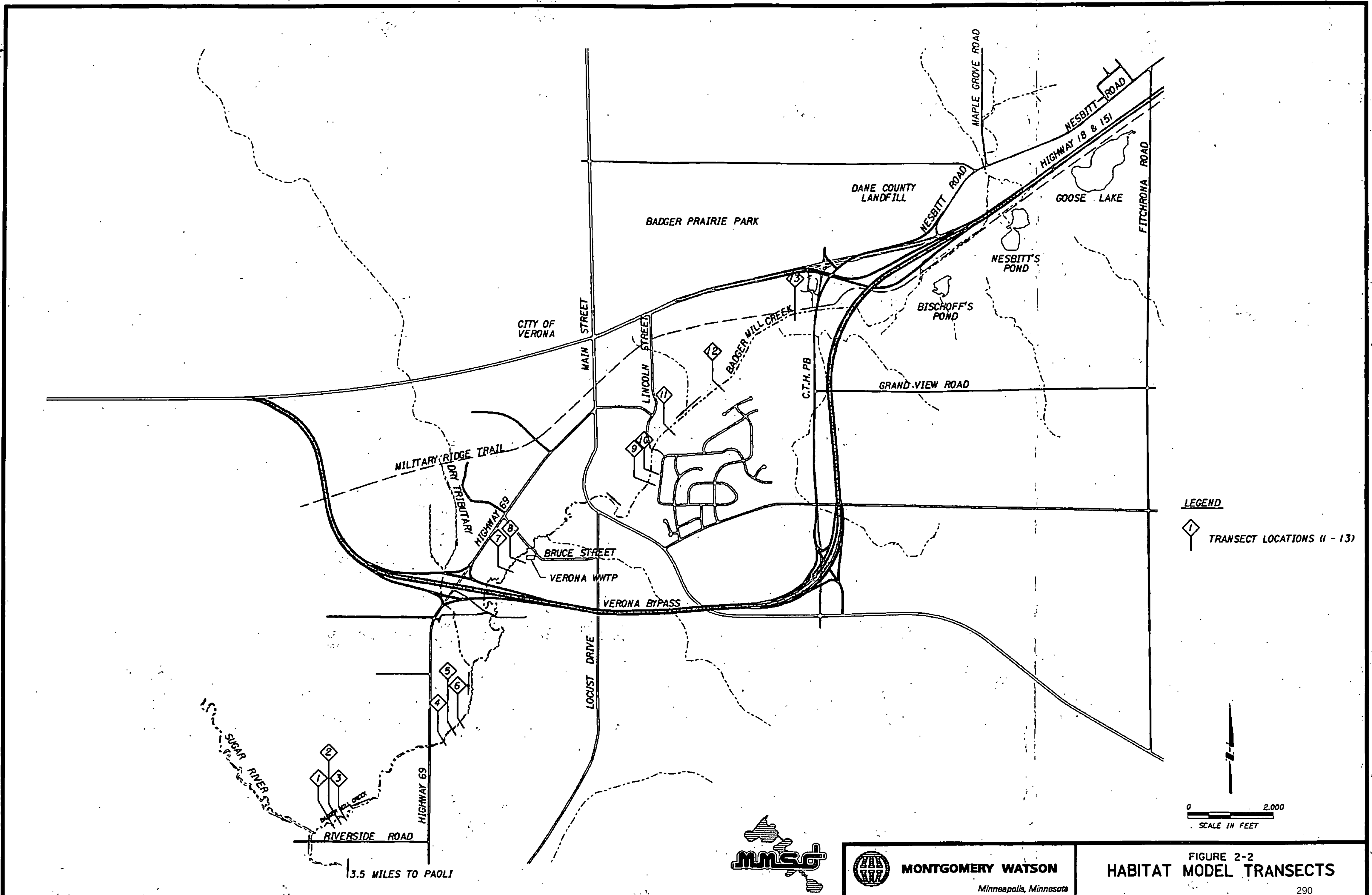


FIGURE 2-2
HABITAT MODEL TRANSECTS

TABLE 2-5

LOCATION, HABITAT TYPE, AND MEASURED BASEFLOW FOR 13 TRANSECTS IN BADGER MILL CREEK

Reach	Transect	Location (RM)[1]	Habitat Type	Measured Flow (cfs)[2]
Mouth to Highway 69	1	0.05	Corner Pool	6.6
	2	0.05	Glide	6.4
	3	0.05	Riffle	7.0
Highway 69 to Verona WWTP	4	0.82	Riffle	7.0
	5	0.86	Main Channel Pool	6.0
	6	0.87	Glide	6.4
Verona WWTP to Main Street	7	2.2	Glide	8.5[3]
	8	2.2	Glide	10.0[3]
Main Street to PB Road	9	3.2	Glide	2.6
	10	3.2	Glide	2.6
	11	3.3	Glide	2.0
	12	3.4	Glide	2.1
	13	4.1	Glide	0.34[4]

[1] River Mile (RM) 0.0 is the confluence of Badger Mill Creek with the Sugar River

[2] Measured flows are considered the same if they are within 10% of each other; thus, transects 1-3 and 4-6 were measured at a similar flow

[3] Flows were measured after a rain event; an estimated baseflow of 4.1 cfs apportioned from lineal distance was used in estimating accretion flow for these transects

[4] This transect is upstream of the pond outlet near the Military Ridge Trail; the flow downstream of the pond outlet (i.e., the pond and stream combined) was 1.4 cfs

Methods used in the hydraulic and habitat modeling for developing habitat preference criteria, calculating inflows, and allocating flows for each group of cross sections is described in Appendix E in the calibration report.

TEMPERATURE

Temperature impacts of returning effluent to Badger Mill Creek were evaluated with the QUAL2E model. The model was developed based on existing flows and then used to evaluate potential impacts of the two return effluent flow volumes. The model was also used to evaluate various design levels and approaches for enhancing instream temperature conditions. The two primary structural features considered were moderating effluent temperatures and simulating varying amounts of riparian shading. QUAL2E simulates Badger Mill Creek stream temperatures influenced by a combination of groundwater flow temperatures and meteorological conditions affecting surface flow.

The effect of the long transmission line on moderating temperatures was also discussed. The proposed effluent transmission line conveying effluent from NSWWTP to Badger Mill Creek provides an excellent opportunity for feasibly moderating effluent temperatures. Conceptually, the passage of piped effluent through the ground tends to slightly moderate temperatures; this is achieved through thermal conductance that cools in the summer and warms in the winter. Since the proposed outfall pipe would convey effluent over a considerable distance, effluent temperature moderation is a realistic factor.

Analysis of the transmission line's effect on temperature was completed using the thermal conductivity of potential pipe materials. The thermal conductivity used was 0.050 $(watts/mm^2)/(^{\circ}C/mm)$ for steel and 0.0010 $(watts/mm^2)/(^{\circ}C/mm)$ for concrete.

STREAM IMPROVEMENT OPPORTUNITIES

Methods for identifying stream improvement opportunities included stream reconnaissance, habitat evaluation, identification of problems and limiting conditions, and discussions with the advisory committee.

WETLAND OPPORTUNITIES

The approach for identifying and evaluating opportunities for wetland enhancement or creation using the return effluent consisted of two steps: site inventory, evaluation, and screening; and a feasibility assessment.

Site Inventory, Evaluation, and Screening

The first step was to identify and screen potential sites according to basic criteria. The general wetland performance was first evaluated to determine if the wetland had the potential to meet project objectives. Sites were initially screened on a pass/fail basis to determine if any fatal flaws existed and the degree to which the site met the following basic criteria:

- Adequate size
- Location relative to the desired functions of the potential system
- Topography conducive to wetland functions
- Potential land availability
- Public acceptance
- Absence of regulatory fatal flaws

The following additional criteria were used to evaluate the sites surviving the initial screening:

- Soils
  - Infiltration potential
  - Potential as a wetland soil
- Regulatory requirements
- Topography related to design objectives
- Groundwater impact potential
- Size and availability
- Proximity to existing public use areas

The screening evaluation was completed using a weighted Site Evaluation Matrix given in Appendix F.

Feasibility Assessment

The pollutant removal capabilities of the various wetland options were determined with procedures available in the published literature (Reed et al. 1995). The pollutants of major concern in this project were biochemical oxygen demand (BOD), total suspended solids (TSS), ammonia nitrogen (NH_3), and total phosphorus (TP).

Most BOD and NH_3 are removed in biological reactions supported by the microbial populations in the wetland. They can be described by simple first order, plug flow, design models with appropriate temperature-dependent rate constants. The basic model takes the following form:

$$C_e/C_o = e^{-KT(t)}$$

where: C_e = Effluent concentration, mg/L

C_o = Influent concentration, mg/L

KT = Temperature-dependent rate constant, d^{-1}

t = Detention time in wetland, d

TSS is removed using physical entrapment and filtration of the wastewater particulate matter. The design model used to remove TSS is a function of the hydraulic loading rate on the wetland. Wetlands are a unique treatment process in that both BOD and TSS are generated in the wetland because of decomposition of the naturally present organic matter such as plants. As a result, there will always be an irreducible residual of both BOD and TSS leaving the wetland. The concentration of these residuals will vary on a seasonal basis and may range from 2 mg/L to about 8 mg/L. These residual concentrations are due to naturally present wetland organic materials and not to any untreated wastewater pollutants.

Phosphorus in wetlands is removed using a combination of plant uptake, adsorption, and precipitation reactions. Much of the phosphorus initially removed by the plants is recycled to the water as the plants die back seasonally. Phosphorus removal is therefore a dynamic process and at present can be estimated only as an annual average. Excursions from that annual average will occur at various times of the year. The effluent concentrations predicted by the other models for BOD, TSS, and NH_3 are valid as monthly averages with excursions from those levels possible at shorter time intervals.

The mass removal calculations in this report are based on these average concentrations, an assumed 20-acre wetland area, and an assumed steady-state flow equal to the wastewater input. The final determination of effluent concentrations and mass removals must consider water losses and gains from precipitation, evapotranspiration, and seepage. The impact of these factors can be assessed only after the final area of the wetland is determined.

RECREATIONAL FACILITIES

Methods for determining recreational facility impacts and improvement opportunities consisted of compiling information on existing recreational facilities in the project area and overlaying the alternative project activities. Opportunities for improving recreational facilities were identified for the alternatives in conjunction with the advisory committee.

WATERSHED IMPROVEMENT OPPORTUNITIES

Methods for identifying watershed improvement opportunities to control nonpoint source pollution in the Badger Mill Creek watershed included watershed reconnaissance, discussions with the advisory committee, and discussions with Madison and Verona city staffs. Watershed reconnaissance consisted of reviewing aerial photographs and topographic maps, and field verification.

Section 3

Section 3

MONTGOMERY WATSON

SECTION 3

CURRENT SITUATION

This section presents the current characteristics of effluent discharge, Badger Mill Creek, and the watershed. Effluent discharge qualities are for the Verona Wastewater Treatment Plant (WWTP) and NSWWTP. Existing conditions for Badger Mill Creek include hydraulics, hydrology, stream corridor, fisheries, water quality, wetlands, and recreational facilities. Watershed characteristics include drainage and drainage divides, shallow groundwater drainage divides, and potential source areas for nonpoint source pollution.

EFFLUENT DISCHARGE CHARACTERISTICS

The current effluent discharge characteristics for the Verona WWTP were included in the Ninth Addition Facilities Plan and are summarized in this section. The current effluent discharge characteristics from the Nine Springs WWTP were evaluated based on historic data and are also presented in this section.

Verona WWTP

The Verona WWTP is a secondary treatment plant with a nominal average flow capacity of 625,000 gpd. The overall liquid treatment process includes grit removal, primary clarification, conventional activated sludge, and chlorine disinfection. Treated effluent flows by gravity to an outfall on the Sugar River located about 1.7 miles southwest of the plant site.

The Verona WWTP met monthly effluent TSS limits over the study period for the Ninth Addition Facilities Plan, but periodically exceeded BOD_5 effluent limits. The discharge to the Sugar River was regulated by a WPDES permit issued by the DNR on June 2, 1988. This permit expired March 31, 1993. New permit conditions were included in a revised permit issued to MMSD on September 21, 1995.

Table 3-1 summarizes the current effluent limitations for the Verona WWTP with discharge to the Sugar River. Table 3-1 also summarizes the effluent limitations for three future design flow scenarios that were evaluated for the Verona Facilities Plan (RUST 1993).

TABLE 3-1

SUMMARY OF CURRENT AND POSSIBLE FUTURE DISCHARGE LIMITS FOR THE VERONA WWTP SUGAR RIVER DISCHARGE FROM PREVIOUS STUDIES

	Average Effluent Limitations			
Effluent Characteristic	**Current**	**Future (Scenario 1)[1]**	**Future (Scenario 2)[1]**	**Future (Scenario 3)[1]**
Permit Flow Basis, mgd (maximum monthly flow)	0.625[2]	1.23	4.24	8.71
BOD_5, mg/L (monthly)	30	--	--	--
BOD_5, mg/L summer (weekly)	45	14	6	5
BOD_5, mg/L winter (weekly)	45	26	11.2	10
TSS, mg/L (monthly)	30			
TSS, mg/L summer (weekly)	45	14	10	10
TSS, mg/L winter (weekly)	45	26	11.2	10
NH_3-N, mg/L summer (weekly)	None	2.0	2.2	2.1
NH_3-N, mg/L winter (weekly)	None	8.6	9.5	9.1
Total Residual Chlorine, mg/L (daily maximum)	0.037	0.037	0.037	0.037
Fecal Coliforms, colonies/100 mL (monthly geometric mean)	400	400	400	400
Disinfection Period	5/1-9/30	5/1-9/30	5/1-9/30	5/1-9/30
Total Phosphorus, mg/L	1.0[3]	1.0[3]	1.0[3]	1.0[3]
Dissolved Oxygen, mg/L	None	None	None	7.0

[1] Scenarios by RUST, 1993
[2] Average daily flow
[3] Under these conditions an alternate discharge limit for biological phosphorus removal would most likely apply; compliance with a phosphorus limit is required by March 31, 1998

Nine Springs WWTP

The NSWWTP is an advanced secondary treatment plant with a nominal average flow capacity of 50 mgd. The liquid treatment process includes grit removal, primary clarification, single-stage nitrification, UV disinfection, and effluent piping to the outfall on Badfish Creek 5 miles south of the plant. Solids handling includes screening and degritting of primary sludge, separate thickening of primary and waste-activated sludges, anaerobic digestion, digested sludge thickening, sludge storage, and land application. Treatment performance at the NSWWTP has been excellent, with the plant achieving BOD, TSS, and TKN removals of better than 95%. Effluent concentrations for these constituents have consistently been well below the discharge permit values.

The Ninth Addition Facilities Plan Update covered the 20-year planning period of 1997-2016. Construction resulting from the facilities plan will be completed during 1997. The first full year of operation of the new facilities will be 1998. The major facility improvements include enhanced biological phosphorus removal (EBPR) and effluent disinfection using a new ultraviolet system. These will affect future effluent discharge characteristics of NSWWTP.

The current and future performance of NSWWTP is important in determining if the current effluent characteristics will meet limitations for Badger Mill Creek and the Sugar River, or whether additional facility improvements will be necessary. The historic performance of NSWWTP relative to effluent characteristics for BOD_5, DO, NH_3, TSS, TP, temperature, assorted metals, and effluent bioassay monitoring is presented and discussed below. The historic performance of NSWWTP over a 2.5-year period from August 1992 to December 1994 is summarized in Table 3-2.

Biochemical Oxygen Demand. Figure 3-1 shows the historic performance of the NSWWTP for BOD_5 relative to percent exceedence. This figure shows that warm season BOD_5 exceeds 5 mg/L less than 8% of the time on a weekly average, while cold season BOD_5 exceeds 10 mg/L less than 10% of the time on a weekly average.

TABLE 3-2

HISTORIC EFFLUENT DISCHARGE CHARACTERISTICS FOR NSWWTP

Parameter	Season Average			
	Daily Warm (mg/L)	Daily Cold (mg/L)	Maximum Warm (mg/L)	Maximum Cold (mg/L)
BOD_5	3.8	7.3	6.6 (weekly)	15.3 (weekly)
TSS	6.1	8.3	10.8 (monthly)	12.3 (monthly)
NH3	0.25	0.73	1.38 (weekly)	1.97 (weekly)

The relationship between effluent total BOD_5, nitrogenous BOD (NBOD), and carbonaceous BOD (CBOD) was investigated for NSWWTP. Recent (September 1993 to February 1995) BOD_5 and CBOD concentrations in the NSWWTP effluent were evaluated. Table 3-3 shows the breakdown of monthly average effluent CBOD and BOD_5. BOD_5 includes both NBOD and CBOD. Measured 5-day CBOD has eliminated the effects of NBOD. Measured BOD_5 over CBOD ratios were calculated to indicate the relative seasonal exertion of NBOD on effluent samples. These ratios are presented in Table 3-3 and were used to develop sample-adjusted BOD_u/BOD_5 ratios. These ratios were used for the site-specific modeling described in Section 4.

Ammonia. The exceedence curves in Figure 3-2 summarize the weekly effluent ammonia (NH_3) data for the monitoring period of August 1992 through December 1994. This figure shows that warm season (June through October) exceedence values are low with about 90% of all concentrations under 0.50 mg/L and 95% of all values under 0.65 mg/L. The 95th percentile value compares well with the most stringent warm season ammonia limit of 0.7 mg/L that could be applied (based on the WDNR's Final Report of the Ammonia Workgroup).

Cold season (November through May) exceedence values are also relatively low with about 85% of all concentrations under 1.40 mg/L and 95% of all values under 1.75 mg/L. The existing cold season 85th percentile value reasonably compares with the most stringent cold season ammonia limit of 1.4 mg/L that could be applied (*Final Report of the Ammonia Workgroup*).

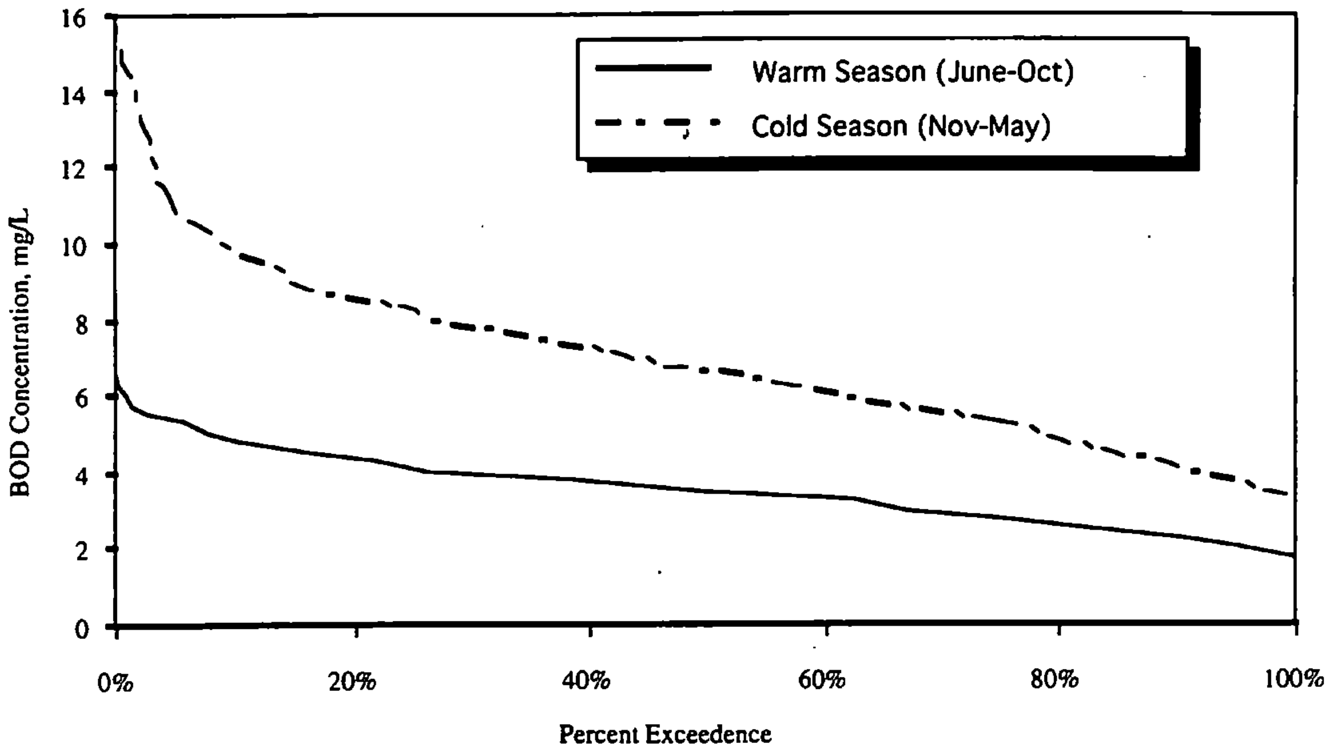


Figure 3-1. Nine Springs WWTP Weekly Average BOD Characteristics
(August 1992 - December 1994)

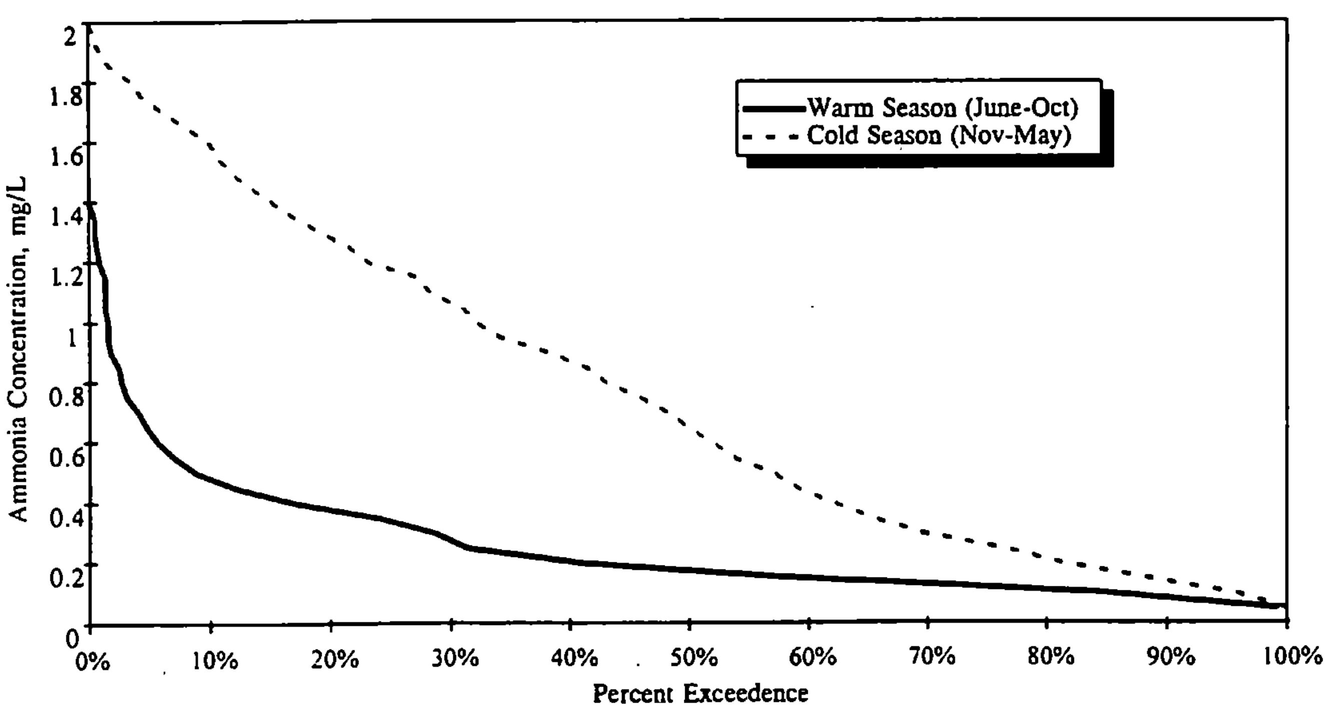


Figure 3-2. Historical Nine Springs WWTP Weekly Average Ammonia Concentrations
(August 1992 - December 1994)

TABLE 3-3

RATIO COMPARISON OF ULTIMATE BOD OVER 5-DAY TOTAL BOD (BOD_u/BOD_T)
Based on Measured NSWWTP MMSD Monthly Average Effluent BOD

Date	Measured Total BOD_5 (mg/L)	Measured Carbonaceous CBOD (mg/L)	Nitrification[c] Cold Season CBOD/BOD_5 Ratio	Nitrification[c] Warm Season CBOD/BOD_5 Ratio	Initial Overall[d] BOD_u/BOD_5 Ratio	Sample Adjusted[e] Cold Season BOD_u/BOD_5 Ratio	Sample Adjusted[e] Warm Season BOD_u/BOD_5 Ratio
Sep 93	3.83	2.70	--	0.70	2.1	--	1.53
Oct 93	5.45	3.29	--	0.60	2.1	--	--
Nov 93	5.60	3.73	0.67	--	2.1	1.62	--
Dec 93	6.74	4.97	0.74	--	2.1	1.47	--
Jan 94	8.65	5.83	0.67	--	2.1	1.60	--
Feb 94	10.71	5.93	0.55	--	2.1	1.95	--
Mar 94	7.77	4.00	0.51	--	2.1	2.10	--
Apr 94	6.50	4.24	0.65	--	2.1	1.66	--
May 94	3.16	2.81	0.89	--	2.1	1.22	--
Jun 94	4.03	3.23	--	0.80	2.1	--	1.35
Jul 94	2.35	2.13	--	0.90	2.1	--	1.20
Aug 94	2.71	2.26	--	0.83	2.1	--	1.30
Sep 94	2.33	2.13	--	0.91	2.1	--	1.18
Oct 94	4.13	2.94	--	0.71	2.1	--	1.52
Nov 94	4.37	3.33	0.76	--	2.1	--	--
Dec 94	7.35	5.45	0.74	--	2.1	--	--
Jan 95	5.68	4.39	0.77	--	2.1	--	--
Feb 95	8.68	6.50	0.75	--	2.1	--	--
Seasonally Averaged Values			0.70	0.78	--	1.66	1.35

[a] Measured 5-day total BOD (BOD_5) includes both nitrogenous BOD (NBOD) and carbonaceous BOD (CBOD)

[b] Measured 5-day carbonaceous BOD (CBOD) has elimianted effects of nitrogenous BOD (NBOD)

[c] Calculated nitrification ratio based on measured 5-day BOD_T over CBOD indicates the relative seaonal exertion of NBOD on effluent samples; a ratio of 1.0 indicates total nitrification with decreasing ratio values reflecting proportionally reduced nitrification, typically during colder weather conditions

[d] The initial overall ultimate BOD versus total BOD ratio of 2.1 was recommended by WDNR; it includes the effects of both CBOD and NBOD; it does not reflect the significant seasonal reduction in NBOD characterized by the measured effluent samples, typically during warm weather conditions; therefore, the intial overall ratio requires adjustment to actual effluent conditions that reflect nitrification at the MMSD NSWWTP

[e] The sample adjusted ratio of ultimate BOD over total BOD includes the actual effects of both CBOD and NBOD on MMSD NSWWTP effluent with seasonal nitrification; it was calculated by multiplying the worst case BOD_u/BODT ratio (of 2.1) by the ratio of the sample worst case nitrification ratio of 0.51 (March 1994) and the sample nitrification ratio; the sample adjusted BOD_u/BOD_T calculation is therefore [Worst Case BOD_u/BOD_T)*[Worst Case CBOD/BOD_T]/[Sample CBOD/BOD_T]; a sample calculation of the adjusted BOD_u/BOD_T ratio, based on August 1994, would be 2.1*0.51/0.83 = 1.3; note that the sample adjusted, worst case BOD_u/BOD_T ratio does, in fact, equal 2.1 for March 1994 as recommended by WDNR.

Total Suspended Solids. Figure 3-3 shows the historic performance of the NSWWTP for TSS relative to percent exceedence of monthly averages. This figure shows that warm season TSS concentrations exceed 10 mg/L less than 7% of the time, while cold season TSS concentrations exceed 10 mg/L less than 15% of the time on a monthly average. Monthly averages are presented since TSS limits are regulated on that basis.

Dissolved Oxygen. Figure 3-4 illustrates warm and cold season exceedence curves for dissolved oxygen (DO) at the existing NSWWTP outfall to Badfish Creek. The outfall is located below the effluent aerator but upstream of the discharge point to Badfish Creek. The data which form the basis of the exceedence curves were collected monthly by MMSD from August 1992 through December 1994. These data were generally collected in the early morning and probably reflect the best case (highest DO) for the day. Effluent DO values generally ranged from about 5.0 mg/L to 8.6 mg/L during the warm season. During the cold season, effluent DO values ranged from about 5.0 mg/L to 10.3 mg/L. The exceedence curves vary only slightly between the warm and cold seasons. In addition, the curves are moderately flat suggesting that there is no decisive break point below which DO values vary rapidly. Thus, the 90th percentile values are only 5.3 mg/L for the warm season and 5.6 mg/L for the cold season.

All except one of the daily recorded DO values met or exceeded the minimum effluent DO limit of 5.0 mg/L set for the NSWWTP. However, continuous DO sampling has indicated that during high facility flow conditions DO may slip slightly below the 5.0 mg/L minimum limit. This condition was investigated in the Ninth Addition Facility Plan Update and recommendations for improving effluent DO were developed. A stepwise approach, based on an increasing degree of unit improvement is currently being employed to implement the recommendations.

Figure 3-5 compares effluent DO values upstream and downstream of the effluent step aerator. The graphic demonstrates that the aerator significantly improves effluent DO above the 5.0 mg/L minimum limit. However, the data used in this comparison were collected by a monthly grab sample. Continuous recorded DO concentrations downstream of the step aerator were evaluated as part of the Ninth Addition Facilities Plan (Technical Memorandum No. 8A). This evaluation showed that the downstream DO decreased to approximately 4.6 mg/L on several occasions when flows were greater than 50 mgd and the aeration basin DO conditions were 2.5 mg/L. However, DO concentrations

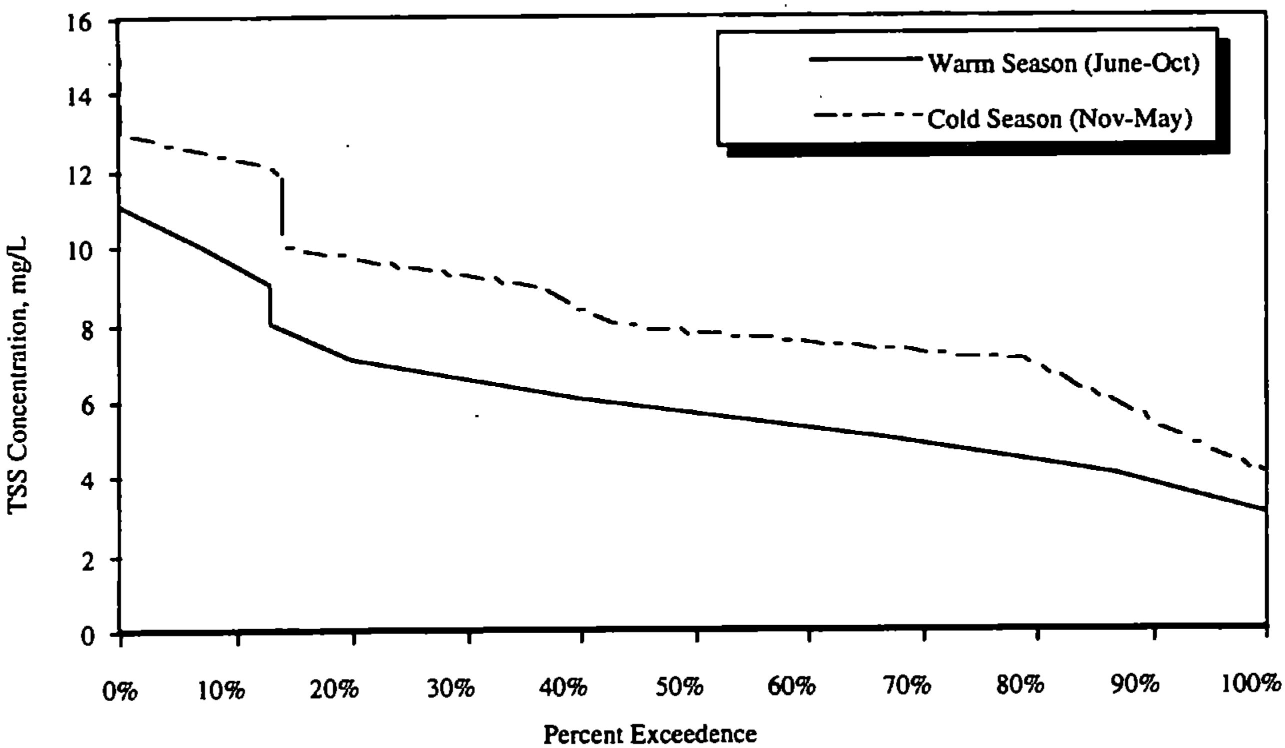


Figure 3-3. Historical Nine Springs WWTP Monthly Average TSS Characteristics (August 1992-December 1994)

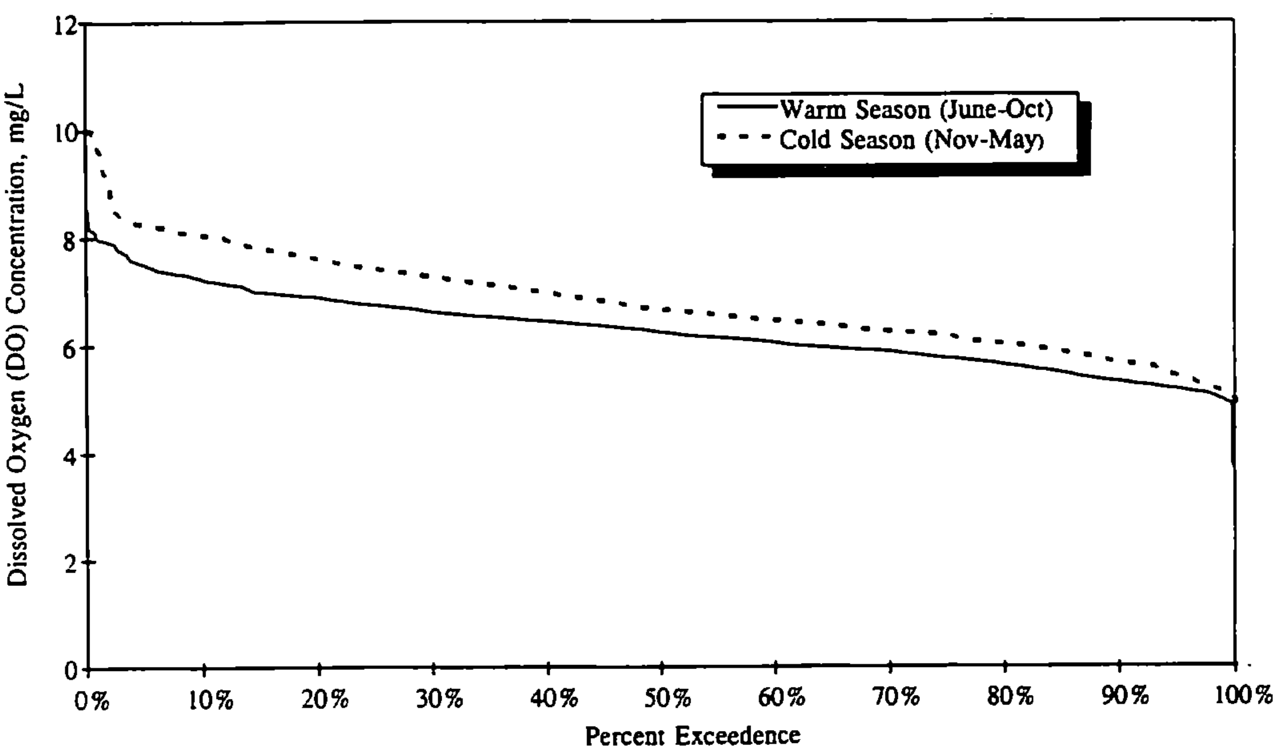


Figure 3-4. Historical Nine Springs WWTP Daily DO Concentrations (August 1992 - December 1994)

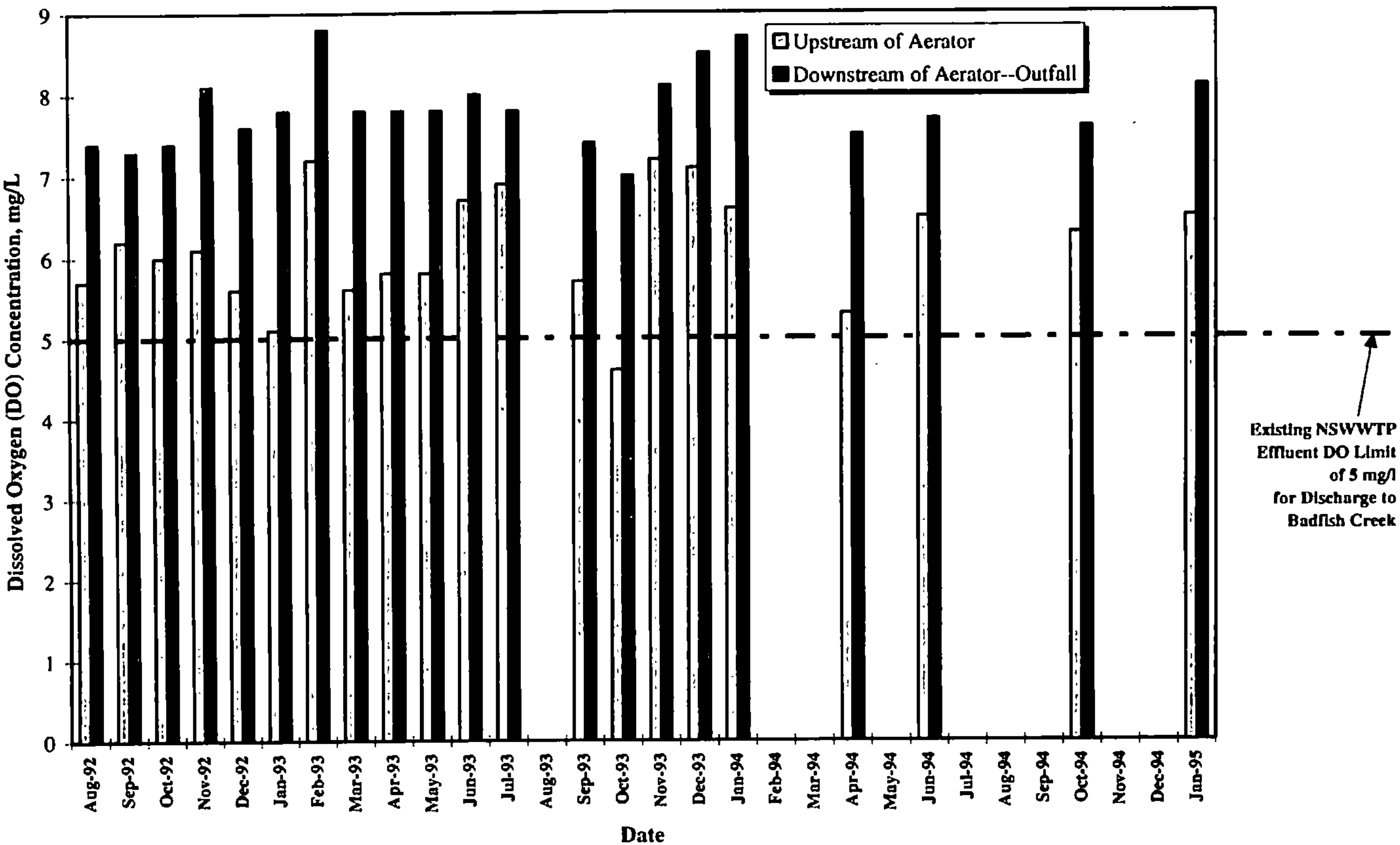


Figure 3-5. Nine Springs WWTP Daily DO Concentrations Sampled Monthly Up and Down Stream of the Effluent Aerator (August-1992 -- January 1995)

downstream of the aerator below 5 mg/L occur only rarely. Even when the condition does arise, the DO deficit from 5 mg/L is relatively small, less than 0.5 mg/L.

The Ninth Addition Facility Plan evaluated potential measures for enhancing effluent DO. The valuable experience of implementing effluent DO enhancements, derived from the NSWWTP effluent discharge to Badfish Creek, offers design guidance for the proposed NSWWTP discharge to Badger Mill Creek. Simulation has indicated that effluent DO of about 5 mg/L is highly desirable for the NSWWTP discharge to Badger Mill Creek. This would help prevent a BOD_5-induced DO sag below minimum instream requirements in Badger Mill Creek.

Future DO conditions in the effluent with the addition of EBPR will likely be lower than the monitored concentrations observed at the top of the aerator to Badfish Creek. With EBPR, DO concentrations will be minimized out of the aeration tanks. This means that any future aerator at an outfall to Badger Mill Creek will need to be oversized relative to existing conditions and/or constructed such that it can be easily modified.

Total Phosphorus. The Ninth Addition Facilities Update to the NSWWTP includes installing EBPR capabilities in 1997. The alternative TP limit of 1.5 mg/L has already been applied for by MMSD and was approved by WDNR. This limit is facility-specific and will therefore apply to NSWWTP discharges to Badger Mill Creek. For this study, effluent TP discharged from NSWWTP to Badger Mill Creek were taken as 0.88 mg/L. This overall average is based on the results of the EBPR pilot testing performed for the Ninth Addition Facility Plan Update.

Temperature. Effluent temperature below the step aerator was sampled as part of MMSD's ongoing biological monitoring of Badfish Creek. Monthly sampling data presented in Figure 3-6 show the seasonal variability of effluent temperatures. The curve displayed in Figure 3-7 indicates that effluent temperatures are evenly spread throughout the exceedence interval (i.e., no rapid changes occur at the extreme ends of the curve).

The data set presented in Figures 3-6 and 3-7 ranges from an effluent temperature of 10.4°C to 21.4°C. While characterizing effluent temperatures, the small data set does not allow definitive conclusions to be drawn about effluent temperature extremes. For comparison, existing Badger Mill Creek instream temperatures may range from 0°C to over 26.0°C. However, this range is also based on a data set that is quite small.

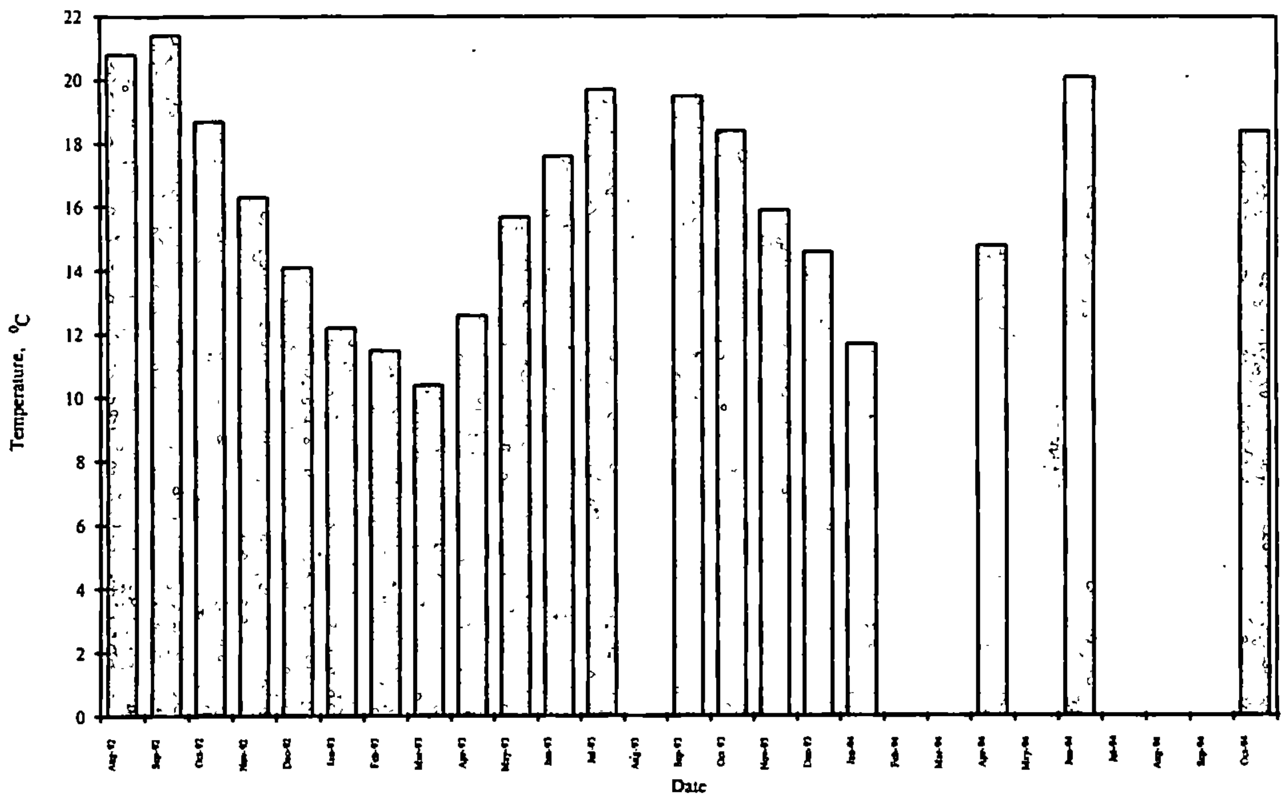


Figure 3-6. Nine Springs WWTP Daily Temperature Sampled Monthly Downstream of the Effluent Aerator (August 1992 - October 1994)

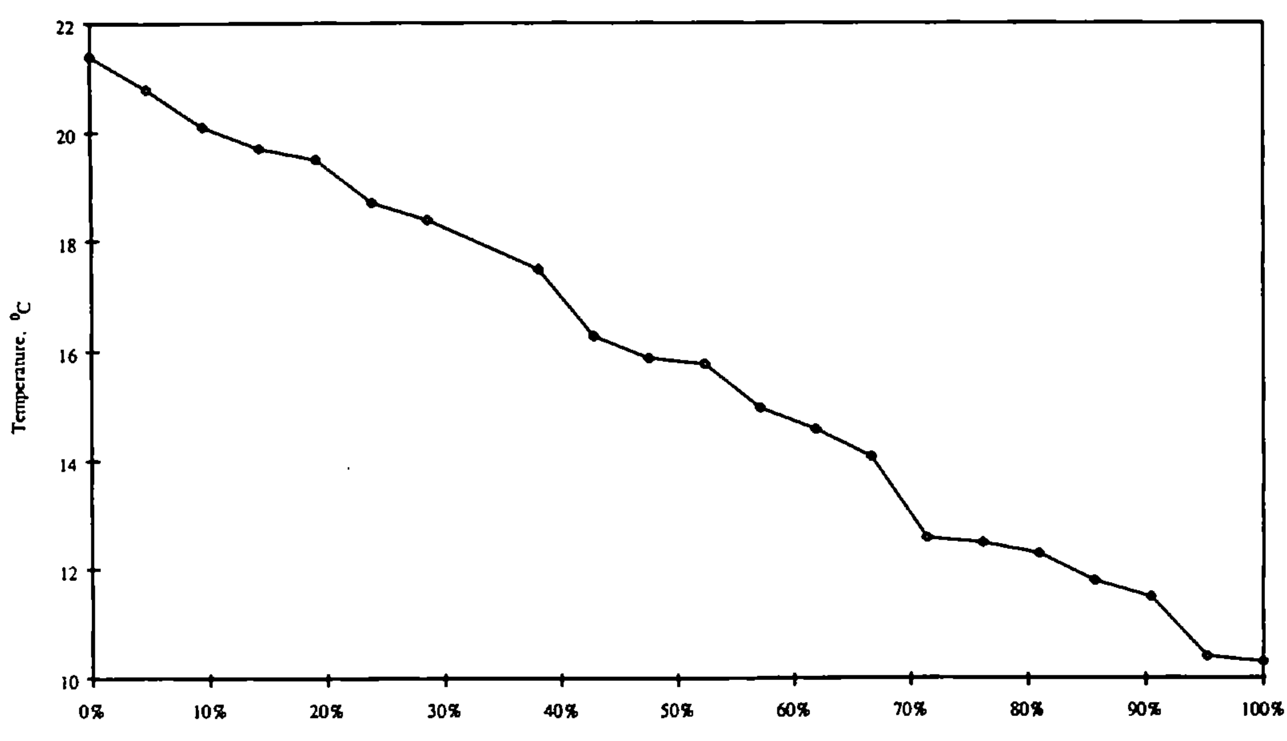


Figure 3-7. Nine Springs WWTP Daily Temperature Exceedence Values Sampled Monthly Downstream of the Effluent Aerator (August 1992 - October 1994)

The data presented in Figure 3-6 exhibit effluent temperature changes that occur when the piped effluent passes through the existing buried effluent pipeline. The pipeline distance is greater than 5 miles and may moderate effluent temperatures. No temperature data currently exist from a sampling location prior to the effluent entering the upstream end of the outfall pipeline. Consequently, the upstream effluent temperatures cannot be compared to temperatures taken below the aerator. Otherwise, the magnitude of effluent temperature moderation due to thermal contact with the ground could be evaluated.

Metals. Figures 3-8, 3-9, and 3-10 show the historic discharge characteristics of NSWWTP effluent relative to common metals copper, zinc, and lead. These also show the acute and chronic criteria calculated for Badger Mill Creek. These criteria have not been exceeded in effluent from the NSWWTP. Concentrations given in the graphs are total metals while criteria are total recoverable metals. Thus, metals performance is probably even better than that shown in the figures.

Effluent Bioassay Monitoring. The NSWWTP has been conducting effluent bioassay monitoring since 1989 and has not had any bioassay test failures over this period. During the first five years of monitoring, tests were completed using 100% effluent. For the last year tests were completed using 93% effluent. Both chronic and acute tests are performed. Chronic tests are performed using one invertebrate species, *Ceriodaphnia dubia*, and one vertebrate fish species, fathead minnow (*Pimpephales promelas*). Acute tests are performed using two invertebrate species, *Ceriodaphnia dubia* and *Daphnia magna*, and one vertebrate fish species, fathead minnows. Consistently passing the tests over the past six years demonstrates that NSWWTP effluent is of high quality and is not toxic to the test species.

BADGER MILL CREEK WATERSHED CHARACTERISTICS

Existing hydraulics and hydrology, hydrogeology, water quality, stream corridor, and fisheries conditions were inventoried to establish a baseline condition to which the effects of returning effluent can be compared. Existing hydraulics and hydrology are important for determining whether returning effluent will influence flood levels or streambank erosion. Hydrogeology is important for determining the transbasin flow diversions. Historic water quality data are important receiving water conditions for calculating effluent limits, stream

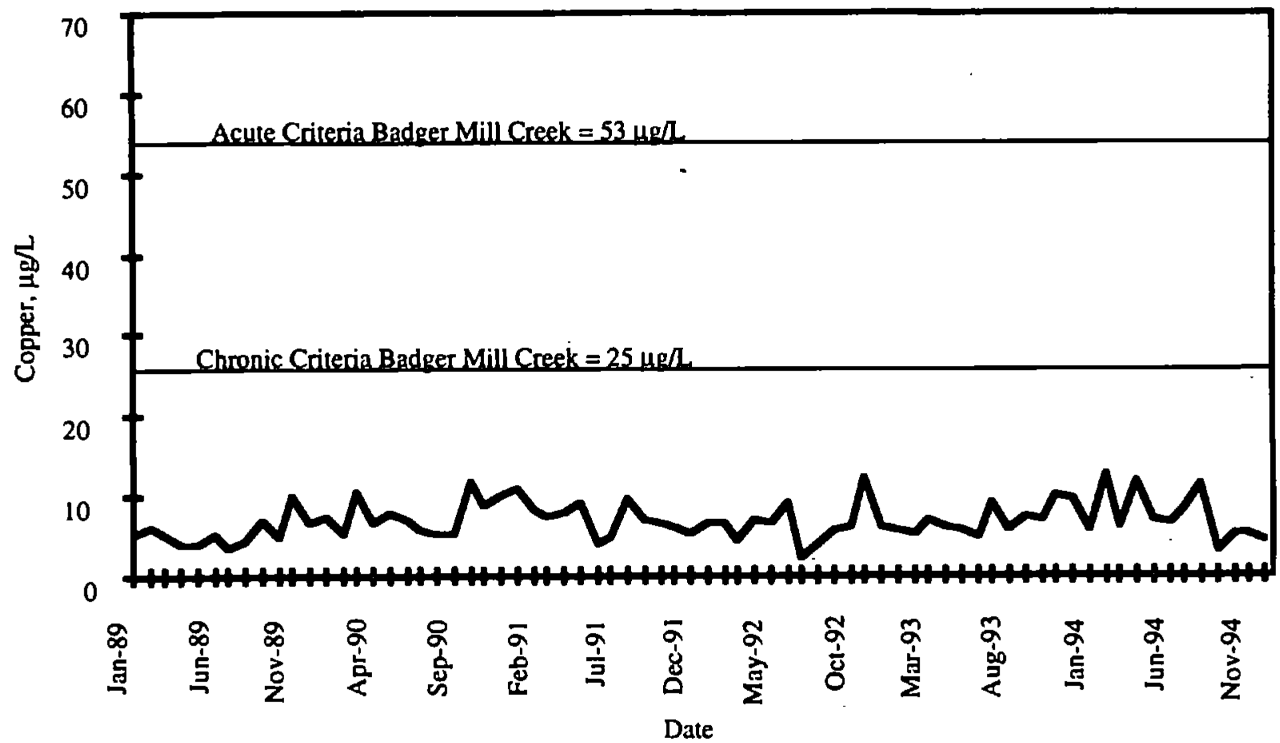


Figure 3-8. Copper Concentrations in NSWWTP Effluent
and Badger Mill Creek Criteria

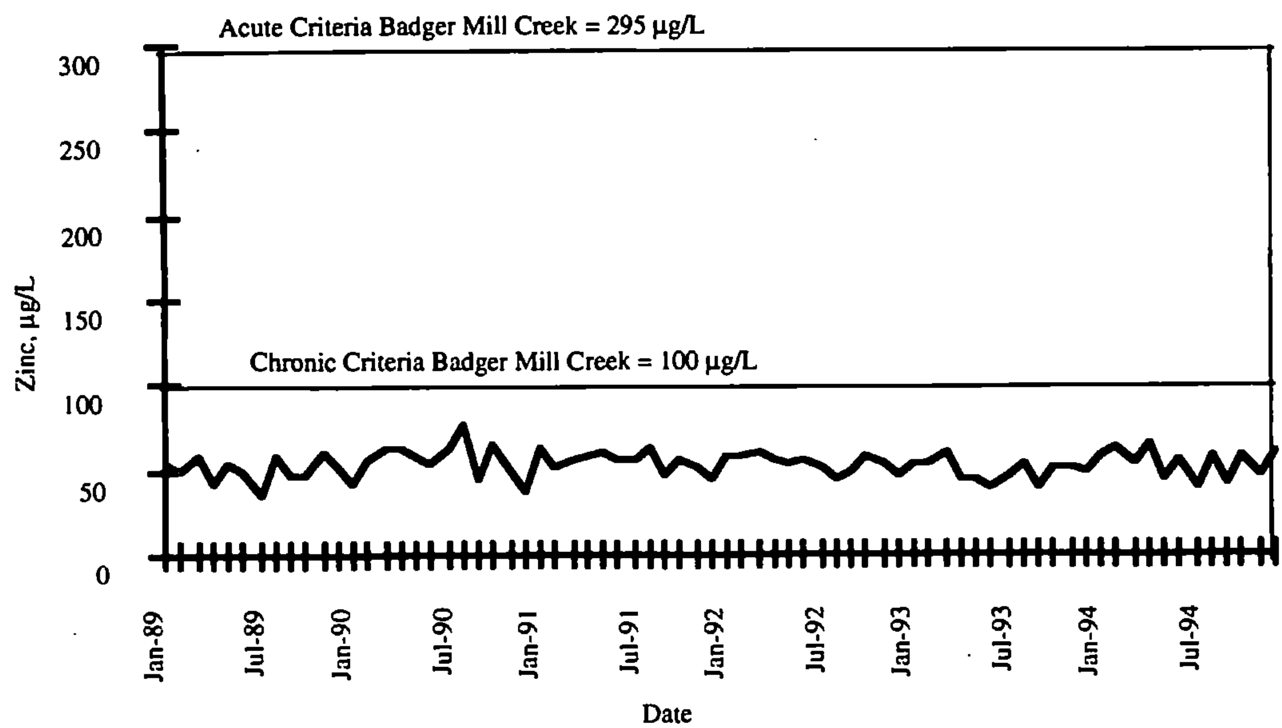


Figure 3-9. Zinc Concentrations in NSWWTP Effluent
1989 through 1994

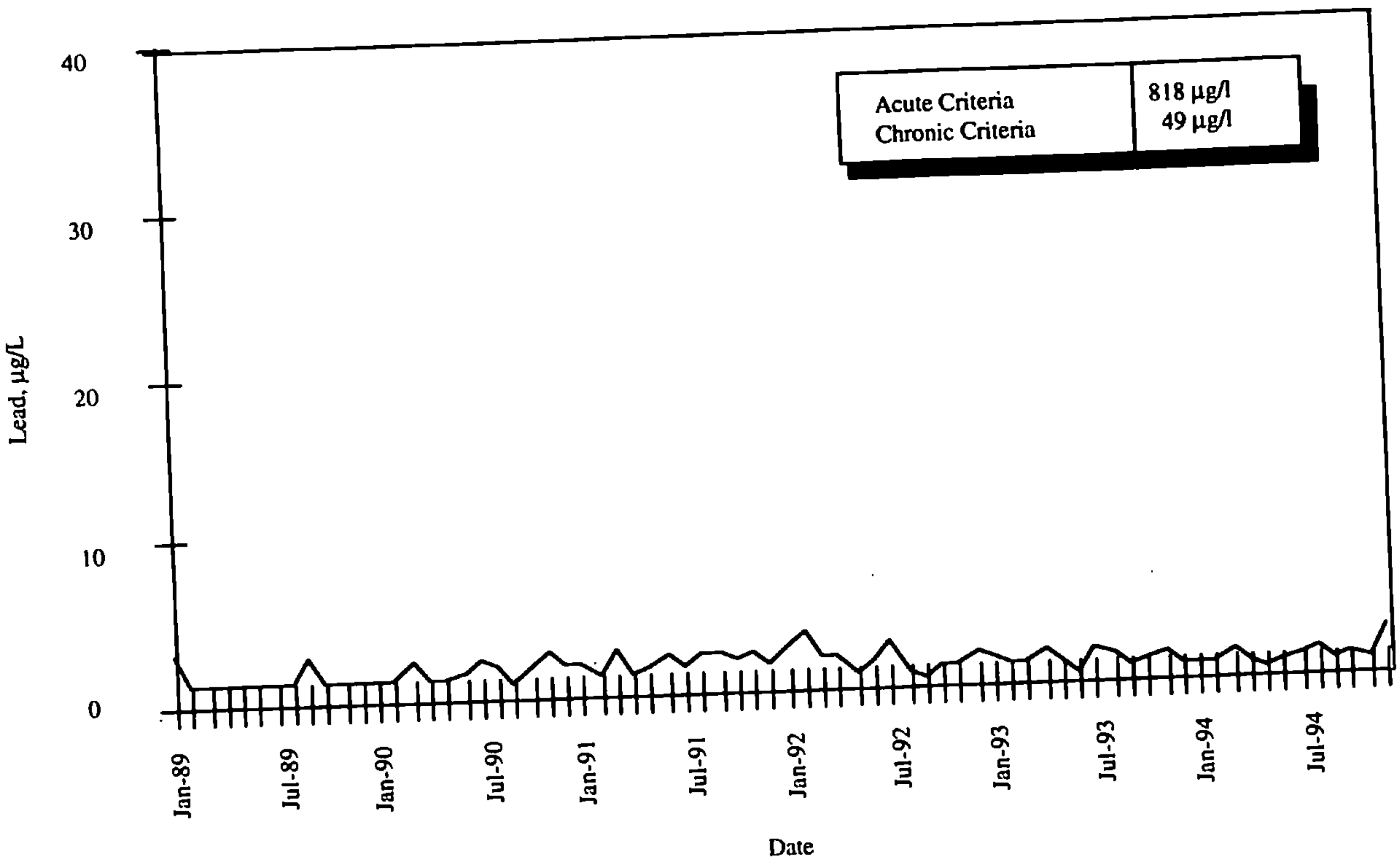


Figure 3-10. Lead Concentrationations in NSWWTP Effluent

corridor, and fishery conditions and are used to determine what factors currently limit the fisheries and the biological integrity of Badger Mill Creek.

Stream Hydraulics and Hydrology

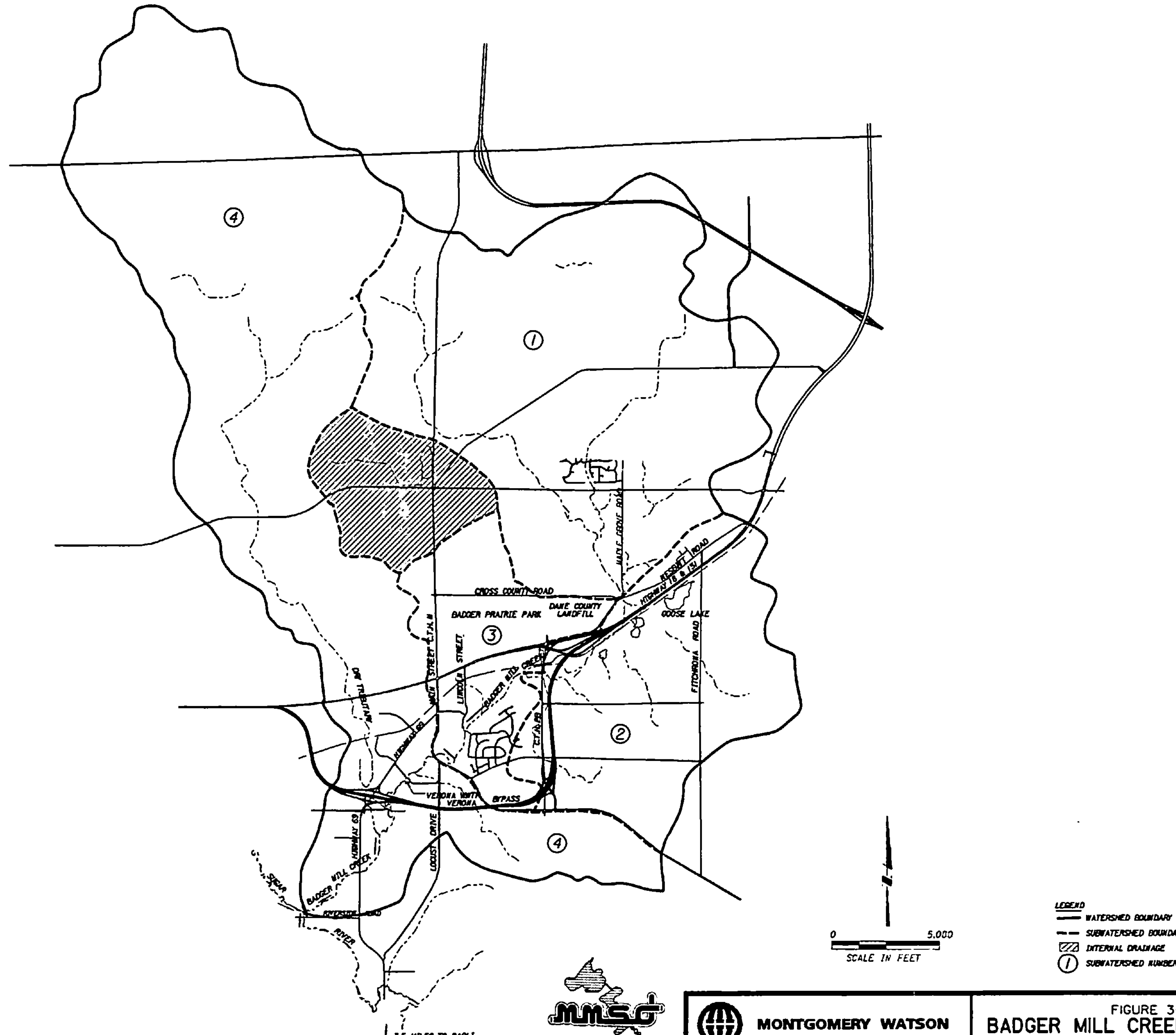
Hydrology. Badger Mill Creek drains a 32.6 square mile (sq mi) watershed southwest of the city of Madison. The watershed was divided into four subwatershed areas for study purposes (Figure 3-11). Subwatershed 1 (10.8 sq mi) is the drainage area of Upper Badger Mill Creek north of Nesbitt Road and encompasses the southwestern portion of the city of Madison. Subwatershed 2 (5.2 sq mi) contains the drainage area of an unnamed tributary which lies generally south of Highway 151 and east of CTH PB. Subwatershed 3 (2.6 sq mi) is located immediately west of Subwatershed 2 and contains drainage areas from another unnamed tributary east of CTM M and most of the eastern portion of the city of Verona. Subwatershed 4 (14 sq mi) includes the drainage areas of the dry tributary and lower reaches. This subwatershed contains western Verona and a large portion of the town of Middleton. In addition to the four subwatersheds, a large portion (1.6 sq mi) in the middle of the watershed drains internally.

The USGS prepared a hydrologic analysis of the headwaters of Badger Mill Creek for Federal Emergency Management Agency (FEMA) flood studies. The analysis used by the USGS is outlined in Water Resources Investigations Report 86-4005 (USGS 1991). The technique uses empirical equations which are functions of watershed area, average land slope, and intensity of rainfall. The flow rate of Badger Mill Creek at Nesbitt Road was predicted as 1,395 cfs and 2,280 cfs for the 10- and 100-year storms, respectively.

In a similar study, Short, Elliot, Hendrickson, Inc. (SEH) compiled a TR-20 hydrologic model for the Badger Mill Creek subwatershed 1. The SEH study found the flow rates at Nesbitt Road were 950 cfs and 1,920 cfs, respectively, for the 10- and 100-year storms.

As evidenced by the differing flow values predicted by the USGS and SEH, there is an uncertainty in predicting flood flow rates. The different techniques predicted flow rates which deviated as much as 47%.

The U.S. Army Corps of Engineers (Corps) HEC-II model (with the empirically calculated USGS flows) was used by USGS to identify the 100-year flood elevations for Badger Mill Creek as it flows from Madison through Verona to the Sugar River. Floodplain maps



MONTGOMERY WATSON

Minneapolis, Minnesota

FIGURE 3-11
BADGER MILL CREEK WATERSHED AND SUBWATERSHED DIVIDES

generated from the model results show that the floodplain for the creek is very narrow in most spots and closely follows the alignment of the creek with only small spurs at tributary ditches. From inspection of the floodplain maps, it appears that there may only be one location where buildings are jeopardized by the 100-year flood elevation of the creek. This location is on a small cul-de-sac (Holiday Court) extending east at the eastern border of Verona.

Channel Velocities. Badger Mill Creek has a length of 27,700 feet between Nesbitt Road and the Sugar River. The river loses approximately 44 feet of elevation across this distance, giving the channel an average slope of 0.0016 ft/ft.

The maximum velocity in the channel predicted by the HEC-II model for the 10-year storm is 11.9 ft/sec and occurs immediately downstream of Highway 69. The next highest velocity, 11.0 ft/sec, occurs immediately downstream of Bruce Street. Other than these two locations, the velocity in the channel for the 10-year storm generally stays between 2 and 5 ft/sec.

There are four locations in the channel where the velocity is exceptionally high during the 100-year storm. The velocity reaches 12.4 ft/sec at Highway 18/151, 12.2 ft/sec at Highway 69, 12.0 ft/sec at the Highway 151 bypass, and 11.5 ft/sec at Bruce Street. Other than at these locations, the velocity in the channel for the 100-year storm stays in the 3-6 ft/sec range.

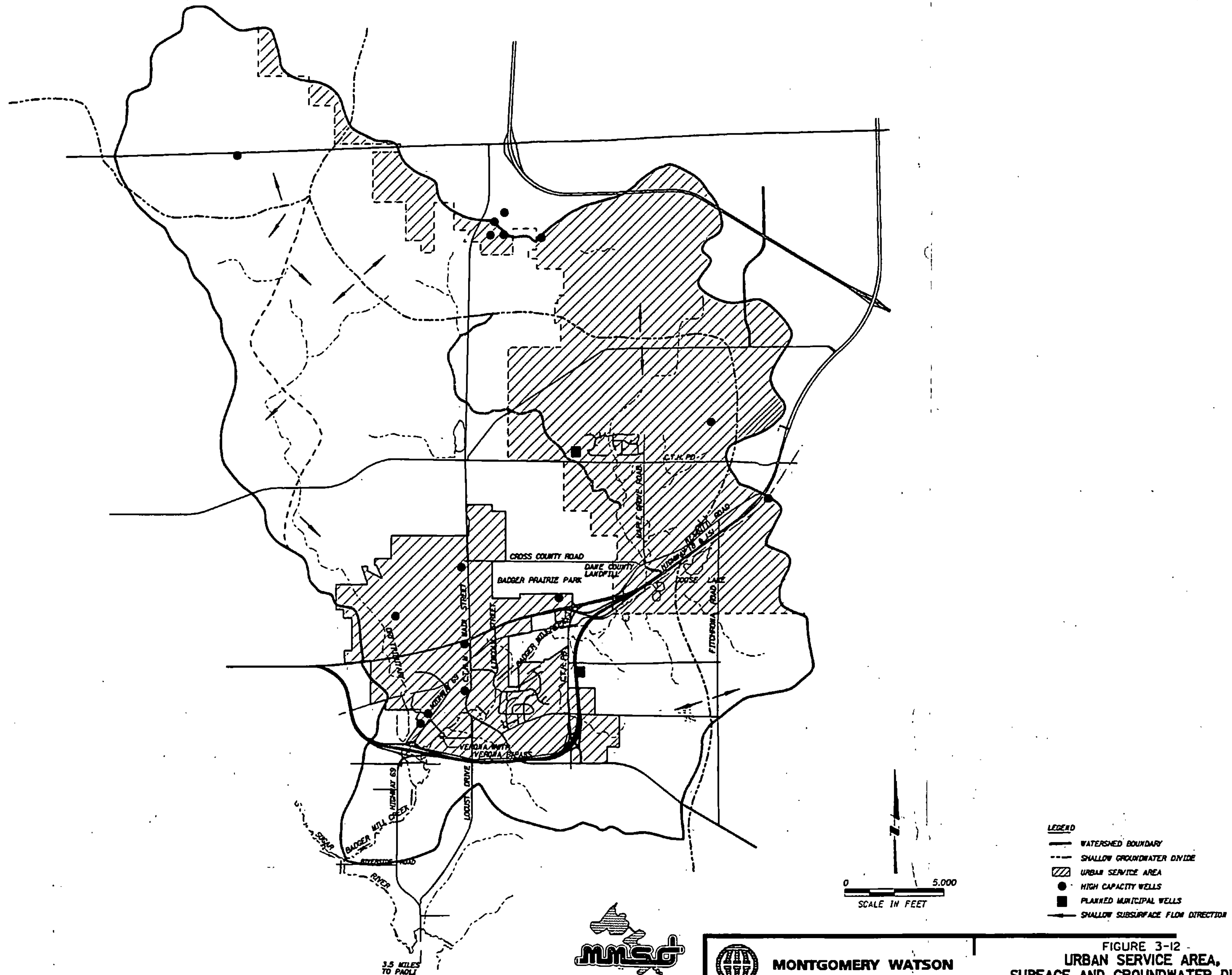
Hydrogeology

The Badger Mill Creek watershed is located at the western extent of the glaciated region of Wisconsin. The western edge of the Badger Mill Creek watershed extends west of the Johnstown Moraine which marks the western extent of the recent glaciation in this part of Wisconsin. The Badger Mill Creek channel is comprised of glacial outwash consisting of sand and gravel deposited by glacial meltwater. The Badger Mill Creek channel is mapped as having a high potential for sand and gravel production (Mickelson 1983). The sand and gravel outwash deposits are common in the area, and several nearby gravel pits actively mine these deposits.

A simplified geologic profile for the area near Verona consists of unconsolidated glacial deposits extending from the ground surface to a depth of 70 to 170 feet below the ground surface. The youngest bedrock unit logged at these wells is Ordovician aged sandstone including the St. Peter Sandstone which ranges in depth from 0 to 200 feet thick. Beneath the St. Peter Sandstone, the Prairie du Chien dolomite (0 to 200 feet thick) and the Cambrian-age Trempealeu Formation (30 to 125 feet thick) sandstone and dolomite units are present. The next oldest unit is the Eau Claire Sandstone (50 to 310 feet thick). The Eau Claire Formation also contains a shaley layer in the western part of Dane County. Current research by the Wisconsin Geologic and Natural History Survey (WGNHS) and the United States Geological Survey (USGS) indicates that the shaley portion of the Eau Claire Sandstone may act as a confining bed for those units below it. A review of working drawings being prepared as a part of this study indicates that the shaley portion of the Eau Claire Sandstone is present within the watersheds of concern for this study. The thickness of this shaley potential confining unit ranges from less than 10 feet north of Mid Town Road to more than 40 feet south of the point where Badger Mill Creek crosses County Highway M. Beneath the Eau Claire Formation, the Mt. Simon Sandstone Formation is present. The Mt. Simon Formation ranges in thickness from 220 to 455 feet. The Mt. Simon Formation is the basal aquifer. Precambrian crystalline rocks are present below the Mt. Simon Formation.

Based on a review of geologic logs for public water supply and industrial production wells in and near Verona, water supply wells withdraw water from bedrock aquifers including Ordovician and Cambrian-age sandstone and dolomite units. Geologic logs were obtained for five water supply wells: three City of Verona public water supply wells, a well installed at the Dane County Farm, and a well installed at Coating Place, Inc. formerly Verona Redi-Mix Co. The three public water supply wells extend to depths of 771 feet (Well No. 1), 1153 feet (Well No. 2) and 1030 feet (Well No. 3). The unconsolidated glacial outwash deposits are cased off at each well. The depth of the casing ranges from 114 feet (Well No. 1) to 170 feet (Well No. 2). Each well is an open borehole into the bedrock units below the casing depth. Water is withdrawn from all the rock units below the bottom of the casing to the bottom of the well.

The shallow groundwater table in Dane County has recently been mapped by the Dane County Regional Planning Commission and the Wisconsin Geologic and Natural History Service (DCRPC 1995). Shallow groundwater divides in relation to the Badger Mill Creek watershed are shown in Figure 3-12. An inspection of the divides on Figure 3-12 showed that the shallow groundwater area with gradients to Badger Mill Creek is much smaller than the surface watershed. The surface watershed is 32.6 sq mi while the shallow groundwater



MONTGOMERY WATSON

Minneapolis, Minnesota

FIGURE 3-12
URBAN SERVICE AREA, SURFACE AND GROUNDWATER DIVIDES, AND HIGH CAPACITY WELLS

area is 19.5 sq mi. This may explain the relatively low baseflows observed in Badger Mill Creek relative to the surface watershed size. The University of Wisconsin Watershed Monitoring and Assessment Class (UW 1995) found a baseflow to surface watershed area ratio of 0.24 cfs/sq mi on February 24, 1995 compared to a ratio of 0.43 cfs/sq mi for the Sugar River on the same date. Recalculating the ratio using the shallow groundwater divide area of 19.5 sq mi for Badger Mill Creek instead of the surface watershed area gives a ratio of 0.4 cfs/sq mi which is very similar to the ratio for the Sugar River.

Differences between the surface water and shallow groundwater divides are located along the northwest, north, and eastern sides of the watershed. On the northwest side the difference is natural and is due to the Johnstown Moraine. Inspection of the shallow groundwater maps shows that the area has underflow west to the Sugar River Basin. The University of Wisconsin Watershed Monitoring and Assessment Class (UW 1995) found that the Johnstown Moraine was a groundwater discharge area for several of the headwater streams in the Sugar River Basin.

On the east and northeast side of the watershed the differences between the two divides may be natural, or may be due to heavy groundwater usage and pumping in the Madison area causing the shallow groundwater divide to migrate westward. A number of studies and reports (DCRPC 1994; Cline 1965; McLeod 1978; USGS 1993) have suggested that pumping from existing municipal and industrial wells followed by wastewater diversion is affecting surface and groundwater bodies within particular watersheds in Dane County.

Figure 3-12 also shows the existing wastewater urban service boundaries within the Badger Mill Creek watershed. Two service areas are shown, one in the northeastern portion of the watershed and one serving the City of Verona. Wastewater generated within the northeastern service area is currently diverted to the NSWWTP for treatment and subsequent discharge to Badfish Creek. Estimates of the current volume diverted to MMSD include 3.67 mgd (DCRPC 1995), and 1.6 mgd (MMSD 1994; Ninth Addition Facility Plan Update; Technical Memorandum 3, Table 3-2, Figure 3-4). The DCRPC estimate is based on populations and estimated use while the MMSD estimates are based on observed flows at pump stations leading from the project area to the NSWWTP.

Wastewater from the service area surrounding Verona currently flows to the Verona WWTP at a volume of 0.57 mgd. This volume will be diverted to NSWWTP once the force main currently under construction is completed. Thus, estimates of the total volume of diversion are 0.57 mgd plus the estimates given above unless the effluent is returned. These volumes are 4.3 mgd using the DCRPC estimate and 2.2 mgd using the MMSD estimate.

Future volumes that could be diverted will increase due to population increases projected for the area. The estimated diversion for the year 2020 using DCRPC is 6.35 mgd, while the MMSD estimate for the year 2017 is 3.6 mgd. The MMSD estimate was based on the existing volume diverted (2.2 mgd) plus the future volume increase estimated using population projections and estimated household use volumes. The differences in the estimates from MMSD and DCRPC are due primarily to the difference in the existing diversion volumes. However, the two estimates show that the amount of diversion is expected to increase significantly over the next 20 to 30 years unless the effluent is returned to the Badger Mill Creek watershed.

Water Quality

Table 3-4 presents water quality data for Badger Mill Creek compiled from various sources. Locations of the sampling points are shown in Figure 3-13. The volume of data is limited and its usefulness is further constrained by lack of flow data. Additional data from the 1970s and early 1980s are available from the STORET database but are not presented since they do not reflect existing conditions. The STORET data reflect conditions when the Badger Prairie Health Care Center and Verona WWTPs discharged to Badger Mill Creek. Conditions have improved in Badger Mill creek since the elimination of these two discharges.

The existing water quality of Badger Mill Creek is still degraded. Visual observations made during the stream inventory confirm some of the water quality problems suggested by the limited data. These problems include sedimentation as evidenced by high TSS concentrations of 113 mg/L on 6/16/93 and 168 mg/L on 2/2/94. The stream inventory found sediment accumulation along most of the creek with deposits approaching 2 feet deep in the upper reaches.

Fecal coliform counts in Badger Mill Creek are also high, frequently exceeding 1,000 col/100 mL. High counts would be expected given the urbanized nature of the watershed and livestock in the area.

TABLE 3-4

EXISTING WATER QUALITY DATA FOR BADGER MILL CREEK

			Water Quality Parameter											
Location	Agency/ Site[1]	Date	Flow cfs	Temp °C	pH SU	DO mg/L	BOD mg/L	COD mg/L	NH_3-N mg/L	TKN mg/L	TP mg/L	FC col/ 100 mL	TSS mg/L	Hardness mg/L
Nesbitt Road	DCLF	06/09/89			7.7			191						137
		09/12/89			8.12			56						98
		03/06/90			8.26			52						58
	MMSD:BM-3	04/28/94		6.7	7.6	8.3	3		0.09	0.9	0.18	<80	11	
		06/16/94		23.3	6.7	1.4	4		0.31	1.2	<0.17	560	15	
PB Road	DCLF	03/07/89			8.06			<20						372
		06/08/89			7.55			39						353
		09/12/89			7.81			<20						364
		12/13/89			7.94			<20						371
		03/06/90			7.75			<20						168
		06/27/90			7.24									
		09/20/90			6.5			<20						364
		12/13/90			7.55									412
		03/07/91			7.35									81
		06/04/91			7.85									361
		09/04/91			7.33									371
		12/03/91			6.89									177
		03/18/92			7.78									286
		06/11/92		19	7.44									382
		09/14/92		18	6.92									333
		12/14/92		5	7.46									360
		03/16/93		2	6.7									48
		06/14/93		21	6.6									78
		09/08/93		13	6.69									325
		12/06/93		5	6.56									315
		03/07/94		3.5	6.74									85
		06/24/94		18.5	6.48									89
		09/13/94		22	7.14									282
Bruce Street	MMSD:BM-7	02/02/94		2.3	7.63	11.6	<2		0.11	0.94	0.2	<130	113	
		04/28/94		6.6	7.8	9.9	<2		<0.03	0.28	0.06	290	5	
		06/16/94		15	7.7	8.5	<2		0.06	0.39	<0.17	>1,360	22	
		10/13/94												
Hwy 169	USGS	06/29/92	2.7	18	8.4	14.6		15	0.3	0.07		9,700		
		07/30/92	3.4	14	7.9	8.8		<10	<0.2	0.05		17,000		
		08/21/92	2.9	20.5	8.1	10.1		<10	0.2	0.08		1,200		

TABLE 3-4

EXISTING WATER QUALITY DATA FOR BADGER MILL CREEK (Continued)

Location	Agency/ Site[1]	Date	Water Quality Parameter Flow cfs	Temp °C	pH SU	DO mg/L	BOD mg/L	COD mg/L	NH_3-N mg/L	TKN mg/L	TP mg/L	FC col/ 100 mL	TSS mg/L	Hardness mg/L
	WRMP	05/25/93		14.6		12.6			0.085		0.1		4	
	MMSD:BM-9	06/16/93		13	8	10.7	<1		0.05	0.66	0.11	690	168	
		02/02/94		0.3	7.46	12.2	<2		0.1	1.32	0.25	330	15	
		04/28/94		6.2	8	10.2	<2		<0.03	0.25	0.06	68	5	
		06/16/94		16.2	7.6	9.5	<2		0.12	0.62	<0.17	>2,000	30	
		10/13/94		8.8	7.91	11.2	<2		0.03	0.3	0.09	3,750	17	
Millpond	DCLF	03/07/89			7.38			<20						417
		06/08/89			8.05			39						349
		09/12/89			9.08			<20						232
		12/13/89			9.1			28						338
		03/06/89			8.73			<20						248
		06/27/90			7.21									
		09/20/90			7.5			58						308
		12/13/90			8.55									294
		03/07/91			7.9									170
		06/04/91			8.59									254
		09/04/91			7.8									311
		12/03/91			6.94									422
		03/18/92			7.64									418
		06/11/92		26	7.51									411
		09/14/92		19	7.03									385
		12/14/92		9	7.14									430
		03/16/94		9	7.22									424
		06/14/93		17	6.95									390
		09/08/93		11.5	6.48									410
		12/06/93		9.5	6.38									414
		03/07/94		9	7.02									411
		06/24/94		14.5	6.7									422
		09/13/94		18	7.02									396

[1] DCLF Dane County Landfill
MMSD Madison Metropolitan Sewerage District
USGS United States Geological Survey
VMP University of Wisconsin

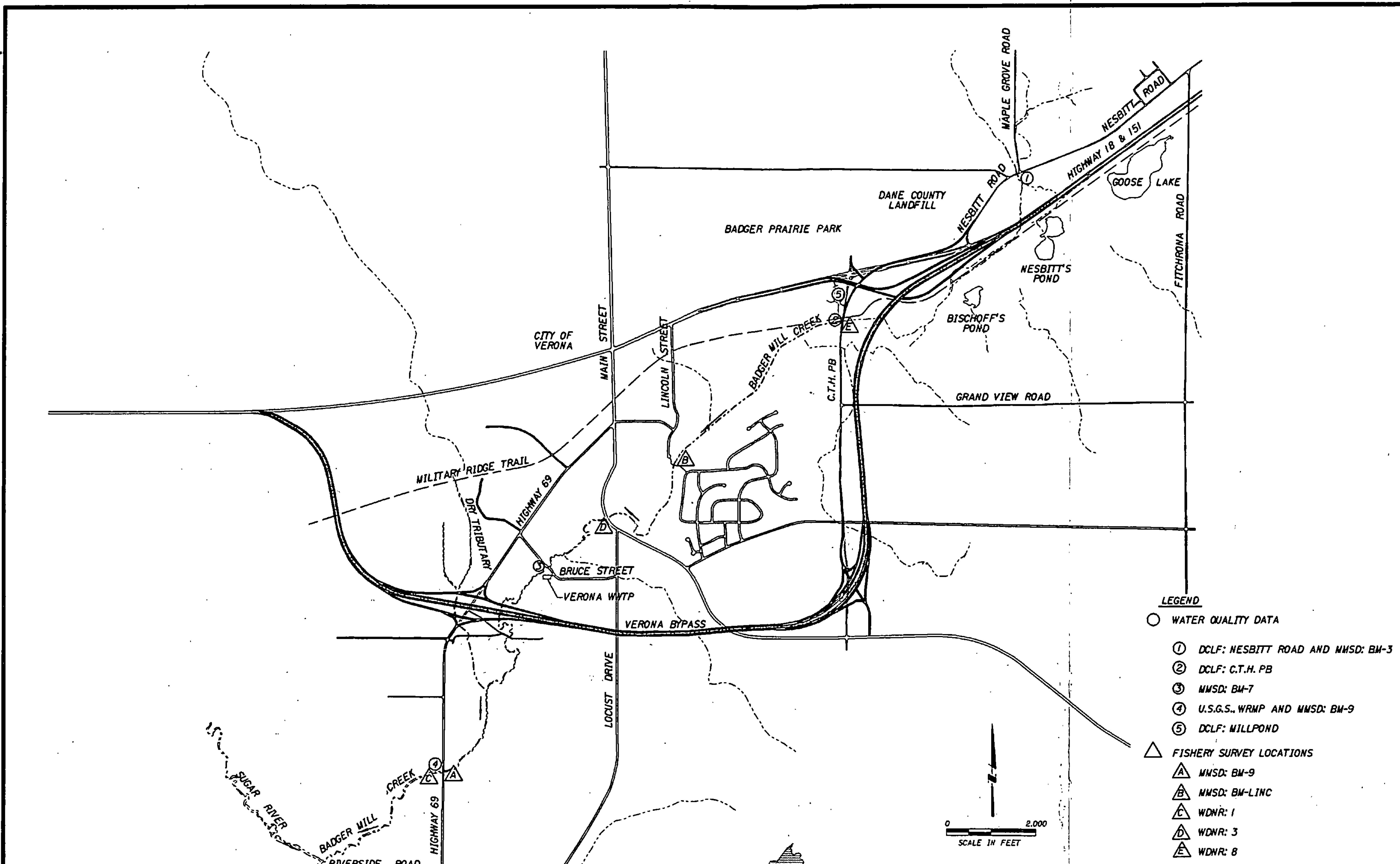


FIGURE 3-13
HISTORIC DATA POINTS

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Temperatures have also been high, exceeding 20°C on some occasions. These temperatures reflect the lack of riparian shading and low baseflows.

Stream Corridor

Badger Mill Creek is typical of many streams in urbanizing areas. The land use along the creek varies from pasture, wooded corridors, and wetland to residential neighborhoods. Although some areas are forested, large woody vegetation in the riparian corridor is limited along much of the stream.

Over most of its length, Badger Mill Creek is wide, shallow, and relatively straight; it appears that much of the stream has been channelized. As a consequence, fish habitat is very uniform with limited diversity; most of the existing habitat is glide. Definitions of the habitat types found in Badger Mill Creek are listed below (adapted from Moor and Jones 1994).

- **Glides (GLD):** A wide uniform channel bottom. Flow with low to moderate velocities lacking pronounced turbulence. Substrate usually consists of cobble, gravel, and sand.
- **Riffle (RFL):** Shallow reaches with swiftly flowing, turbulent water with some partially exposed substrate. Gradient is usually 0.5 to 2%. Substrate is usually cobble and gravel-dominated.
- **Run (RUN):** Swiftly flowing reaches with little surface agitation and no major flow obstructions. Often appears as flooded riffles. Typical substrates are gravel, cobble, and boulders.
- **Corner Pool (CP):** Lateral scour pools formed at a bend in the channel. These pools are common in lowland valley bottoms where streambanks consist of alluvium and lack hard obstructions.
- **Lateral Scour Pool (LSP):** Formed by flow impinging against one streambank or against a partial channel obstruction, log, root wad, or bedrock. Asymmetrical cross section. Includes corner pools in meandering lowland or valley bottom streams.
- **Main Channel Pool (MCP):** Formed by mid-channel scour. Generally has a broad scour hole and a symmetrical cross-section. A riffle section is often just downstream.

The stream inventory divided Badger Mill Creek into five reach lengths. These reaches were established based on channel slope and habitat characteristics. A description of each reach is given below and the location of each is shown in Figure 3-14.

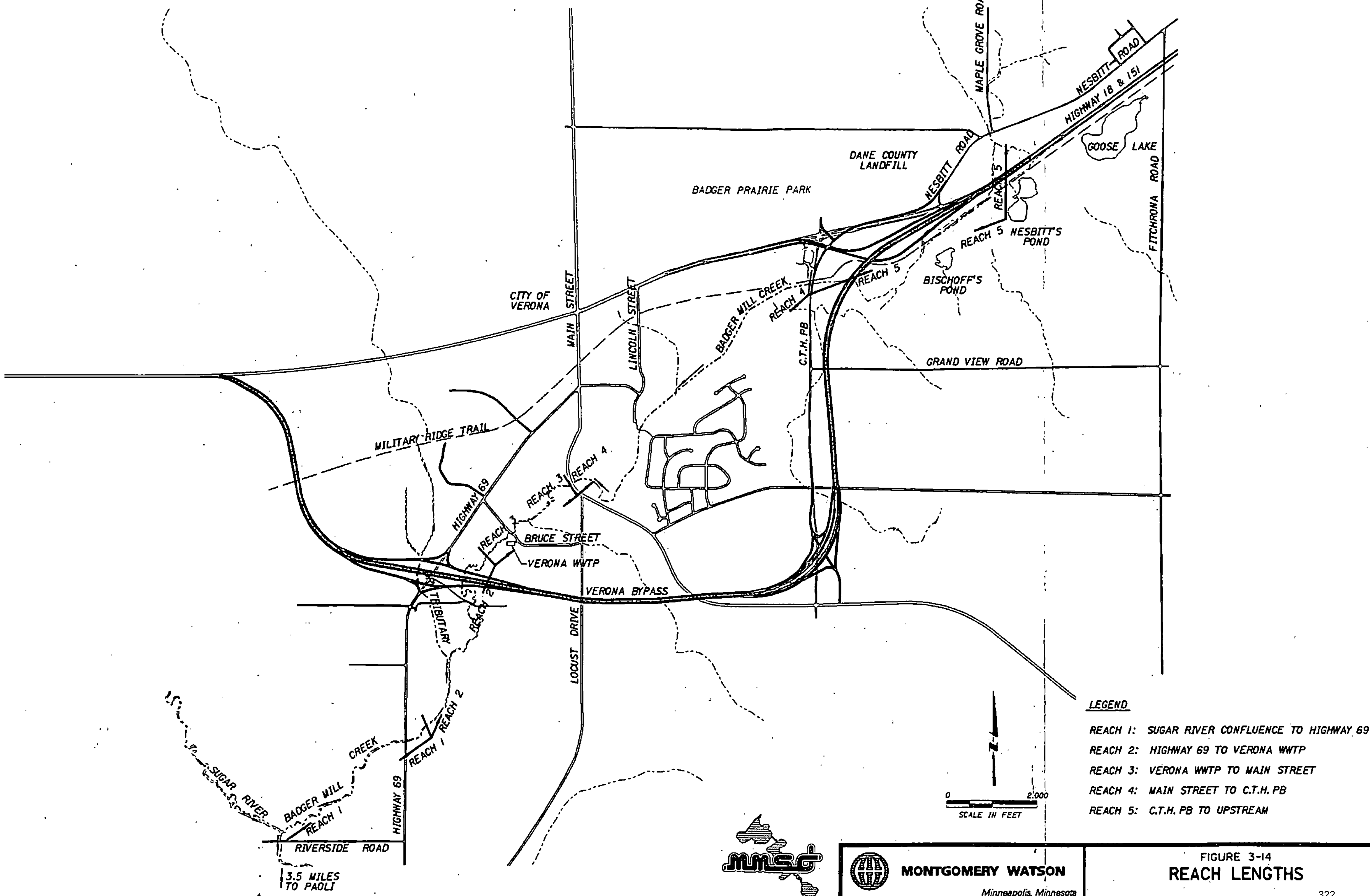

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FIGURE 3-14
REACH LENGTHS

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Reach 1, Sugar River Confluence to Highway 69: In general, this reach has the best potential for trout habitat of all reaches studied. The creek meanders through a pasture that is fenced on both banks, which prevents livestock access to the riparian area. The stream has numerous small, shallow pools interspersed between riffles and glides. Compared with other reaches, width between banks is narrower and the substrate is much coarser (predominantly gravels and sand). Although there is some bank erosion, the banks are generally intact. Large woody riparian vegetation is almost nonexistent throughout the reach. Some overbank areas have been planted but the trees are generally one-foot or less, and it will be a number of years before these plantings provide either shading or stream structure. Approximately 500 feet of stream downstream from the Highway 69 bridge have been channelized.

Most of the pools in this reach are small and shallow. The median residual pool depth of eight pools in the first 1,000 feet upstream of the Sugar River is 0.75 feet (range: 0.2-2.2 ft) (Figure 3-15). Only three of the eight pools have a residual depth of 1.0 foot or more. The lack of deeper pools could potentially limit rearing and refuge habitat in this reach.

Reach 2, Highway 69 Upstream to Verona WWTP: While this reach is similar to the reach downstream, more of the reach appears to have been channelized. The habitat is primarily glide with occasional short riffles. The right bank is pasture; the left bank alternates between steep hillside and small farm properties. While the left bank is forested for the first 800 feet, the right bank has only sparse trees and brush. The stream substrate is primarily silt with frequent pockets of gravel and sand.

The stream banks along approximately 500 feet of the stream (between 1,000 and 1,500 feet upstream from Highway 69) have been broken down by livestock access. The inventory of this reach ended 1,712 feet upstream from Highway 69 because access permission was not obtained.

Reach 3, Verona WWTP to Main Street: This reach is wide, shallow, and relatively straight. The stream banks range from 1 to 3 feet in height. Both banks are moderately forested on the downstream half of this reach with 50-75% overhead canopy cover. The upstream half of the reach closer to Main Street flows through a grass meadow. The banks are flat with a flood-prone area of 25-50 feet on each side of the stream channel. The streambed substrate is primarily silt that ranges in depth from 0.25 to 1 foot over

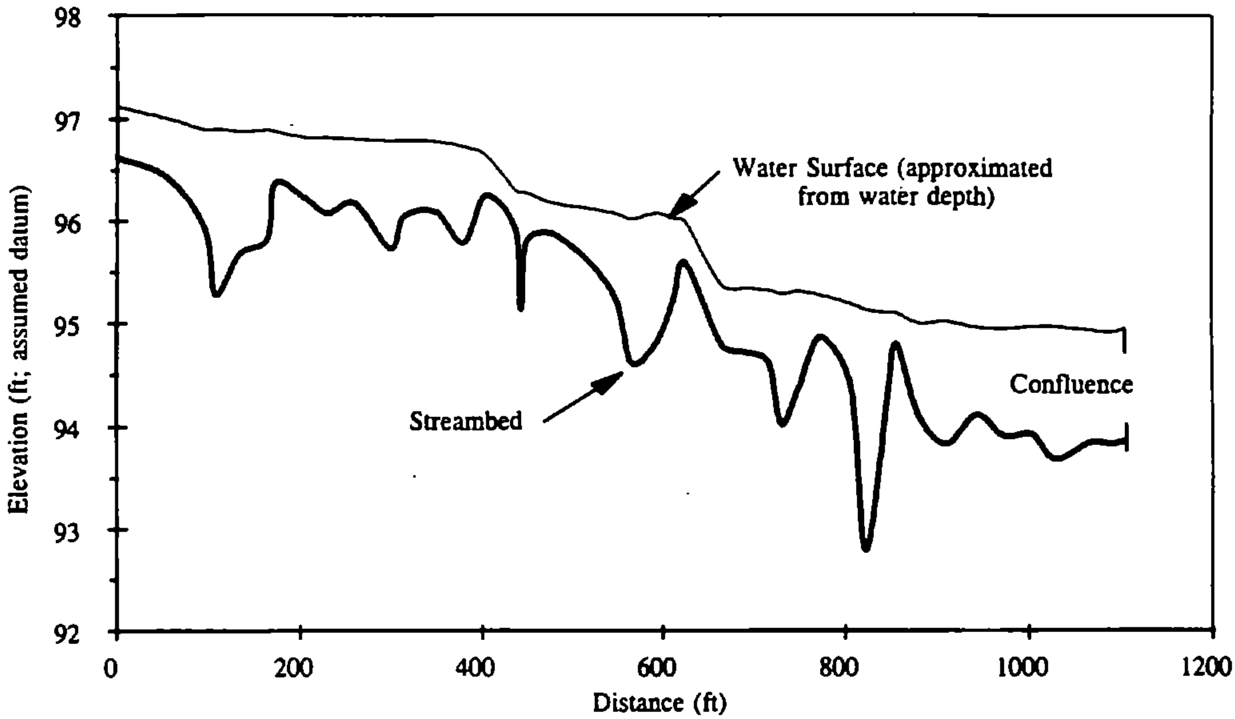


Figure 3-15. Water surface and streambed profiles in Badger Mill Creek upstream of the Sugar River, Reach 1.

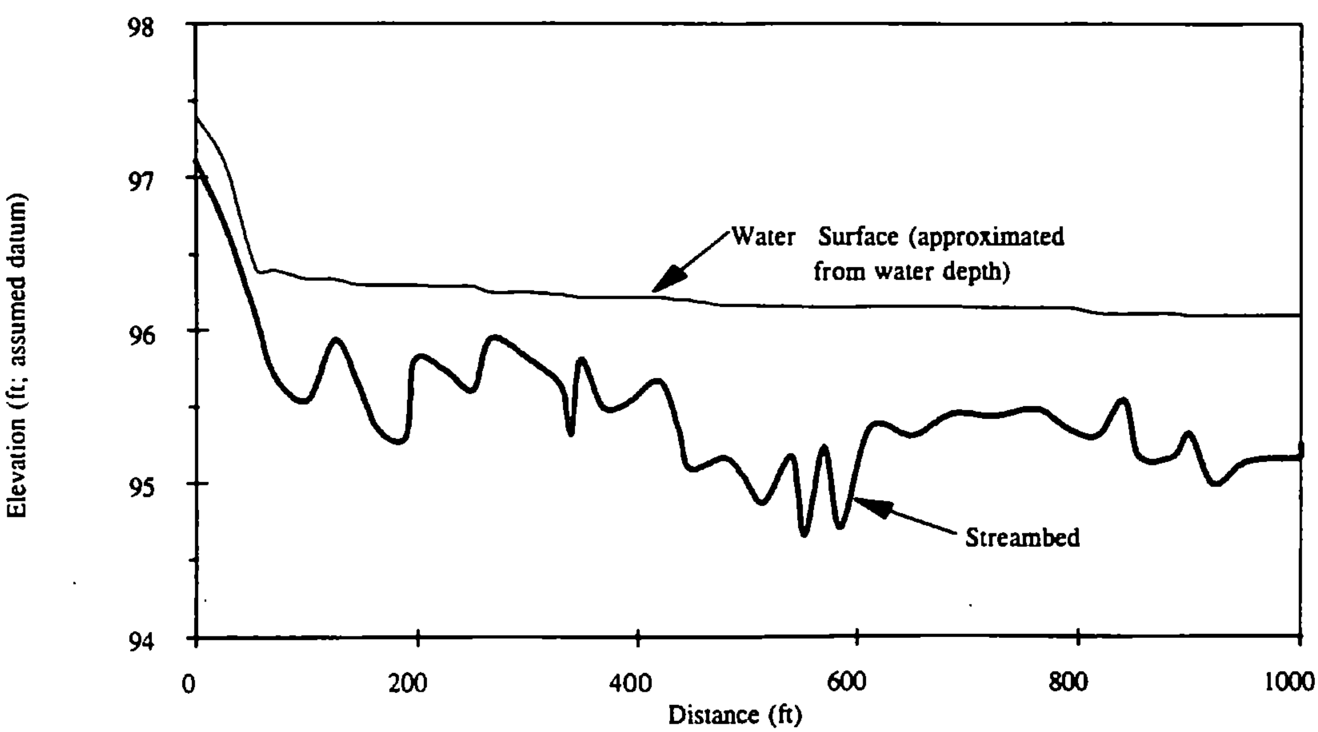


Figure 3-16. Water surface and streambed profiles in Badger Mill Creek downstream of the Lincoln Street foot-bridge.

gravel and cobble. The instream habitat is primarily glide with occasional riffles and shallow pools.

Reach 4, Main Street to CTH PB: The majority of this reach has been channelized and is constrained by levees on both sides. The levees contain sewer lines on both sides of the creek and were not constructed for flood control. The Ice Age Trail (IAT) parallels the creek starting at CTH PB. Three pedestrian bridges cross the creek in this reach. The first is near CTH PB, a second about halfway between CTH PB and Main Street, and the third at the end of Lincoln Street. The second bridge is part of the IAT. The riparian vegetation is sparse, especially upstream of the Lincoln Street footbridge (0-25% overhead canopy cover). The substrate, especially in the most upstream portions of this reach, is almost exclusively silt that is up to 1.75 feet deep.

The habitat in this reach is mostly glide and very uniform. The six pools with residual depth identified in the 1,000 feet downstream of the Lincoln Street foot bridge are small undulations in the substrate (Figure 3-16). The median residual depth of these pools is 0.4 feet (range: 0.2-0.9 feet). The existing rearing and refuge habitat is very limited.

A small pond is located near the Military Ridge Trail parking lot at CTH PB. This pond is not on Badger Mill Creek. However, the pond receives discharge from a spring and discharges the water to Badger Mill Creek. This discharge marks the start of baseflow in the creek. Flow gauging found that the discharge from the spring was generally 1-2 cfs.

Reach 5, CTH PB to Highway 151: The majority of the stream in this reach appears to have been channelized. The stream crosses under the Highway 151 bypass in three 9 by 8-ft culverts that have large concrete aprons both upstream and downstream. The channel is confined by riprap areas near and along the Highway 151 bypass.

At the time of the inventory the flow was limited to intermittent in places. The width of flood-prone area adjacent to the stream varies widely, from 2 feet to approximately 100 feet. The substrate is mostly silt (as much as 1 foot deep in places) with some clay.

Most of the riparian area along this reach consists of wetlands with extensive growths of reed canary grass. Large woody vegetation and overhead canopy cover are limited. While there appears to be very limited fisheries habitat in this reach, it seems very suitable for wildlife, especially small mammals and waterfowl.

Fishery

Badger Mill Creek is currently classified as a limited forage fish community (intermediate) in NR 104. However, NR 104 is to be updated within the next two years and Badger Mill Creek will be removed from NR 104 and reclassified as a warm water forage fish community. More recent findings include the consideration of reclassifying the lower portions of Badger Mill Creek from the Verona WWTP to the confluence with the Sugar River as a cold water community. The Sugar River is classified as a warm water community and an Exceptional Resource Water. However, NR 102 will also be updated within the next two years and the Sugar River is proposed to be reclassified as a cold water community.

These changes were recommended by classification surveys of the Sugar River (Marshall and Stewart 1993) and Badger Mill Creek (Marshall 1989). Fisheries surveys have also been conducted by MMSD on October 4, 1994 and June 21, 1995 for the Sugar River and Badger Mill Creek. Results of the Badger Mill Creek surveys are summarized in Table 3-5. Site locations are shown on Figure 3-13.

All fish species observed in Badger Mill Creek are either tolerant or intermediately tolerant of environmental stress. This is probably a result of the poor water quality, lack of habitat diversity, and poor riparian conditions along much of the stream corridor. In general, the most common species was the tolerant white sucker. Other commonly found species include the brook stickleback, mottled sculpin, creek chub, and darters. Habitat modeling criteria for fish in Badger Mill Creek were developed from information on these species.

Habitat Modeling. An instream flow study using the Instream Flow Incremental Methodology (IFIM) was used to investigate the changes in available fish habitat with changes in flow (Bovee 1982). Hydraulic and habitat models from the Physical Habitat Simulation (PHABSIM) program library (Milhous et al. 1989) were used to evaluate the effect of two effluent return flows on the fish habitat for both warmwater fish and brown trout in Badger Mill Creek.

A major assumption in focusing primarily on stream flow is that other habitat variables such as lack of escape cover, poor quality or limited spawning areas, water temperature, or other water quality parameters are not limiting fish production. If flow can be minimized as

TABLE 3-5

SUMMARY OF FISHERY SURVEY RESULTS FOR BADGER MILL CREEK

Fish	Tolerance[1,2]	Number Observed by Location						
		MMSD BM-9 10/94	MMSD BM-9 6/95	MMSD BM-7 6/95	MMSD BM-LINC 6/95	WDNR: 3 8/9/88	WDNR: 1 7/74	WDNR: 8 7/74
Black Bullhead	It							1
Blacknose Dace	T	1						
Blackside Darter	It	3						
Bluegill	It	1						
Brook Stickleback	It	94	6		2	Abundant	42	99
Brown Trout	It	5	6			2		
Central Mud Minnow	T	1			1		1	29
Central Stoneroller	It	4	4		1		99	99
Common Shiner	It						1	
Creek Chub	T	7	24	4	20	Common	31	99
Fantail Darter	It	7	34	4			1	
Fathead Minnow	T	3					24	99
Green Sunfish	T	7	4		2			
Johnny Darter	It	9	8	4	2	Common		
Largemouth Bass	It	1					1	
Mottled Sculpin	It	83	22	14		Abundant		
Northern Redbelly Dace								2
White Sucker	T	333	191	28	30		99	99

[1] Plafkin, et al., 1989

[2] In Intolerant
It Intermediate
T Tolerant

a major limiting factor, however, then the resource analysis can shift emphasis to other factors.

The model output, weighted usable area (WUA) versus flow (Q), is a weighted index of the change in stream habitat (i.e., stream volume) with changes in flow. It is calculated by matching predicted water depths and velocities with the habitat preferences of fish species present in each reach.

Two hydraulic models were constructed for PHABSIM modeling. Thirteen transects were established in the 4-mile study reach between the Sugar River confluence and CTH PB (Figure 2-2). At each transect, the channel cross section (including water depth and velocity), substrate type, and water surface slope were measured. Transects 1-6, the mouth of Badger Mill creek upstream to the Verona WWTP, were used in the brown trout model. All 13 transects were used in the warmwater fish model.

The location and description of the 13 transects used in this analysis are shown in Figure 2-2 and Table 3-6, respectively. The habitat modeled was the stream reach between the Sugar River and CTH PB. It was assumed that water level conditions observed in April 1995 were low enough to represent both summer and winter base flow conditions; and that the patterns of gradual inflow increases were typical of year-round inflow patterns.

Habitat preference criteria for brown trout and forage fish were used to produce the final habitat index. Brown trout preference criteria were developed from recent field data and literature information for trout similar in size to those found in the Sugar River (Blum 1995, Stoltz and Schnell 1991). The forage fish preference criteria were developed from available information on white sucker habitat preferences (Towmey and Nelson 1984) and based on the swimming abilities of both suckers and other forage species (sculpins, darters, sticklebacks, creek chub) found in Badger Mill Creek (Bell 1991). Development of habitat preference criteria are discussed in detail in Appendix C in the calibration report.

The habitat model was also used to evaluate water velocities for baseflow at four transects on Badger Mill Creek (Table 3-7). Only one of the baseflow velocities exceeded 1.0 ft/sec and none approached erosive velocities. This information supports the observations of limited streambank erosion along Badger Mill Creek.

TABLE 3-6

LOCATION, HABITAT TYPE, AND MEASURED BASEFLOW FOR 13 TRANSECTS IN BADGER MILL CREEK

Reach	Transect	Location (RM)[1]	Habitat Type	Measured Flow (cfs)[2]
Mouth to Highway 69	1	0.05	Corner Pool	6.6
	2	0.05	Glide	6.4
	3	0.05	Riffle	7.0
Highway 69 to Main Street	4	0.82	Riffle	7.0
	5	0.86	Main Channel Pool	6.0
	6	0.87	Glide	6.4
Verona WWTP to Main Street	7	2.2	Glide	8.5[3]
	8	2.2	Glide	10.0[3]
Main Street to PB Road	9	3.2	Glide	2.6
	10	3.2	Glide	2.6
	11	3.3	Glide	2.0
	12	3.4	Glide	2.1
	13	4.1	Glide	0.34[4]

[1] River Mile (RM) 0.0 is the confluence of Badger Mill Creek with the Sugar River

[2] Measured flows are considered the same if they are within 10% of each other; thus, transects 1-3 and 4-6 were measured at a similar flow

[3] Flows were measured after a rain event; an estimated baseflow of 4.1 cfs apportioned from lineal distance was used to estimate accretion flow for these transects

[4] This transect is upstream of the pond outlet near the Military Ridge Trail; the flow downstream of the pond outlet (i.e., the pond and stream combined) was 1.4 cfs

TABLE 3-7

AVERAGE MEASURED AND MAXIMUM PREDICTED WATER VELOCITIES AT FOUR TRANSECTS IN BADGER MILL CREEK UNDER EXISTING CONDITIONS

Transect	Measured Baseflow (cfs)	Predicted Baseflow Velocities (ft/sec)	
		Avg	Max
2	6.6	0.6	1.2
7	4.1[1]	0.2	0.4
10	2.8	0.6	0.8
12	2.5	0.3	0.4

[1] Estimated baseflow; actual flow measurement after rain event

Wetlands

Opportunities to enhance or create wetlands using the return effluent were identified and screened using the methodology described in Section 2 and the site evaluation matrix in Appendix F. Sites were initially identified based on proximity to Badger Mill Creek (1/4 mile) and a size of 10 acres or more.

Thirteen sites were initially identified (Figure 3-17). Six of these were eliminated because of fatal flaws, while sites C and F were combined as one site for subsequent evaluations. The following six sites were eliminated with fatal flaws:

- Site D: Off-Ramp Site
- Site E: Maple Grove Road Site
- Site G: Airport Site
- Site H: North Badger Mill Creek
- Site L: East View Heights
- Site N: Goose Lake Area

Site D, the Off-Ramp Site, and Site G, the Airport Site, were eliminated because construction of the Verona bypass has decreased the available area and fragmented the

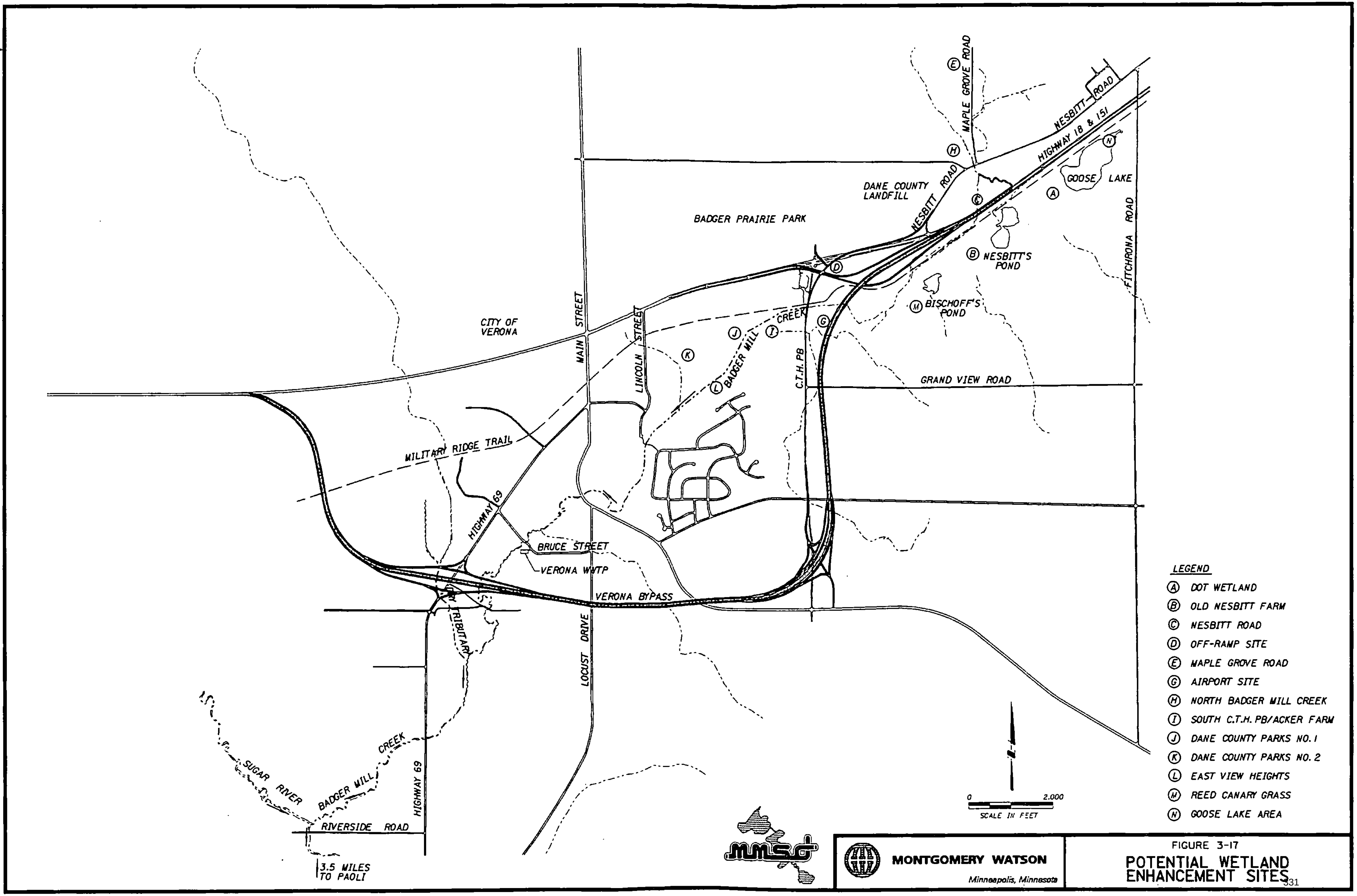


FIGURE 3-17
POTENTIAL WETLAND ENHANCEMENT SITES

JOB No. ______ 11/29/95 ______ FILE No. /usr/proj/verona/ ______ DATE ______ property. Site E, Maple Grove Road Site, and Site H, North Badger Mill Creek, were eliminated because of the transmission line needed to reach these sites. Site L, East View Heights, and Site N, Goose Lake Area, were eliminated because of proximity to urban development and potential public opposition, as well as concerns about nutrient migration to the lake.

The remaining sites were as follows:

- Site A: DOT Wetland
- Site B: Old Nesbitt Farm
- Site C: Nesbitt Road
- Site I: South PB Road
- Site J: Dane County Parks 1
- Site K: Dane County Parks 2
- Site M: Reed Canary

These sites were evaluated using criteria in a feasibility screening matrix as described below. The screening narrowed the number of sites to the two best sites, to be evaluated in greater detail.

Soils. The greatest weight in the matrix was given to soil characteristics through soil infiltration/percolation potential and soil potential for wetland use. Information to address these criteria was obtained from the Dane County Soil Survey (Glocker and Putzer 1978). Additional information on groundwater and soils for Site A, DOT Wetland, was obtained from the wetland mitigation plan by CH2M HILL (1992).

Most of the potential sites had similar soils. Only four soil series were identified as occupying the sites; these and their characteristics are listed in Table 3-8. The Batavia silt loam was the preferred soil type because of the deeper water table and greater potential for infiltration. Batavia silt loam soils are only shown on Site A, DOT Wetland, and Site B,

TABLE 3-8

SOIL SERIES AT POTENTIAL WETLAND SITES

Series	Permeability	Hydric	Drainage	Seasonal High Water Table Depth	Comment
Batavia silt loam, gravelly substratum	Moderate (0.63-2.0 in/hr)	No	Well-drained and moderately well-drained soils	>5 ft	Substratum has rapid permeability
Orion silt loam, wet	Moderate (0.63-2.0 in/hr)	Yes	Somewhat poorly drained soils	0-1 ft	Seasonally flooded
Wacousta silty clay loam	Moderate (0.63-2.0 in/hr)	Yes	Poorly drained soils	0-1 ft	Frequently flooded
Troxel silt loam	Moderate (0.63-2.0 in/hr)	Yes	Well-drained and moderately well-drained soils	>3-5 ft	Frequently flooded

Old Nesbitt Farm. Orion silt loam and Wacousta silty clay loam dominated the remainder of the sites. Troxel silt loam soils only occupied a small portion of Site A, DOT Wetland.

Borings completed on April 27, 1995 at Site I, South PB Road Site, and Site J, Dane County Parks 1 site confirmed the fine-textured soils at these sites and shallow water tables. The water table at Site 1, South PB Road, was 2.7 feet deep near Badger Mill Creek and 0.8 feet deep near the middle of the site further from Badger Mill Creek. The water table at Site J, Dane County Parks 1 site, was 3.0 feet deep but mottling started at 1 foot. This indicated the depth of the seasonally high water table. Soils at these sites are shown as either Orion silt loam or Wacousta silty clay loam. The primary conclusion from these borings was that little if any infiltration potential existed for these soils given their fine texture and shallow water table depth.

Soil potential for wetland use was evaluated based on whether the soils were hydric. The presence of hydric soils indicates that wetland hydrology is currently or historically present, which in turn, indicates good potential for restoring or enhancing wetland functions. Hydric soils should also contain wetland plant seeds that could germinate following restoration or enhancement of wetland hydrology.

Size. The size criteria ranged from one to five points with a weighting factor of three. Size categories and points was as follows:

- 10-14 acres 1 point
- 15-19 acres 2 points
- 20-24 acres 3 points
- 25-29 acres 4 points
- >30 acres 5 points

Shape (3D). Shape was considered for topography conducive to wetland functions to minimize earthmoving during construction. The basic need is to have a wetland surface which is 5 feet or more above the summer elevation of Badger Mill Creek. The topography should be appropriate for a shallow wetland with a minimum of additional berms and hydraulic control features.

Lateral Groundwater Movement to Badger Mill Creek. Following infiltration, lateral groundwater movement to Badger Mill Creek is preferred. The screening evaluation of potential for lateral groundwater movement to Badger Mill Creek was completed by estimating the shallow groundwater flow direction and water table elevation relative to Badger Mill Creek. Shallow groundwater flow directions and water table elevations were identified from Dane County water table surface maps (WGNHS 1995). Soil characteristics, permeability, and substrata descriptions given in the soil survey were also considered. The mitigation report (CH2M HILL 1992) included water table elevations, soil boring logs, and hydraulic conductivity test results for Site A, DOT Wetland. This information showed that over most of the site the shallow groundwater gradient was toward Badger Mill Creek and that hydraulic conductivity rates were fairly high to moderate at 0.013-0.0012 cm/sec.

Access Potential. This criterion considered the availability of nearby access for construction, operation, and maintenance.

Land Acquisition Potential. This criterion considered land availability with land already in public ownership considered the most available; the number of landowners involved was also determined. In addition, numerous prehistoric archaeological sites are known to exist on Site B, Nesbitt Farm.

Proximity to Public Use Areas. Since the wetland is to complement resources in the area and have a high public profile, proximity to existing recreational use areas was considered an advantage. All sites except Site C, Nesbitt Road, are adjacent to the Military Ridge Trail and thus have good access potential to public use areas.

Wildlife Potential. This criterion considered adjacent/nearby areas and the benefits of additional wetland habitat.

Safe Edge Shape. This criterion gave the highest rating for sites where shallow areas could be maintained around the edge of the entire site.

Results of the feasibility screening are given in Table 3-9. Site A, DOT Wetland, and Site J, Dane County Park 1, received the highest scores. The feasibility of enhancing these sites using the return effluent is discussed in greater detail in Section 5. Other sites such as Site M, Reed Canary, Site I, South PB Road, and Site C, Nesbitt Road, have greater potential for improving stormwater runoff. Restoration or enhancement of these wetlands is suggested for consideration as a stormwater management strategy.

TABLE 3-9

WETLAND OPPORTUNITY SITE EVALUATION MATRIX CRITERIA SCORES

Site	Soil Infiltration Potential	Soil Potential for Wetland	Size	Shape	Lateral Groundwater Movement	Access Potential	Land Acquisition Potential	Proximity to Public Use Areas	Wildlife Potential	Safe Edge Shape	Total Score
Site A: DOT Wetland	Good: 5	Not hydric but used by DOT for wetland: 4	24 acres: 3	Good: 4	Fair: 3	Good: 5	Good: 5	Good: 5	Good: 5	Good: 5	70
Site B1: Old Nesbitt Farm	Good: 5	Not hydric: 3	6 acres: 0	Fair: 3	Good: 5	Good: 5	Poor; archaeologic sites: 1	Good: 5	Poor; better upland potential: 1	Good: 5	52
Site B2: Old Nesbitt Farm	Good: 5	Not hydric: 3	13 acres: 1	Good: 5	Good: 5	Good: 5	Poor; archaeologic sites: 1	Good: 5	Better upland potential: 3	Good: 5	61
Site C: Nesbitt Road	Poor: 2	Hydric: 5	28 acre: 4	Good: 5	Poor: 2	Good: 5	Private: 2	Good: 4	Good: 5	Good: 5	66
Site I: South PB Road	Poor: 1	Hydric: 5	32 acres: 5	Good: 5	Poor: 2	Good: 5	Good but two property owners: 4	Good 5	Good: 5	Good: 5	66
Site J: Dane Co. Parks 1	Poor: 2	Hydric: 5	35 acres: 5	Good: 5	Poor: 2	Good: 5	Good: 5	Good: 5	Good: 5	Good: 5	67
Site K: Dane Co. Parks 2	Poor: 1	Hydric: 5	22 acres: 3	Good: 4	Poor: 2	Good: 5	Good but two property owners: 4	Good: 5	Good: 5	Good: 5	58
Site M: Reed Canary	Poor: 2	Hydric: 5	10 acres: 1	Good: 5	Poor: 2	Fair: 3	Fair, three property owners: 3	Good: 5	Good: 5	Good: 5	52

Nonpoint Source Pollution

Nonpoint source pollution in the Badger Mill Creek watershed comes from both urban and agricultural sources. No significant areas of channel erosion along Badger Mill Creek were observed.

Urban Nonpoint Source Pollution. Urban sources include portions of the City of Madison in the northeast portion of the watershed, and the City of Verona in the central portions of the watershed. The City of Fitchburg has some area which drains to Badger Mill Creek; however, a large portion of this area first drains to a retention basin east of Fitchrona Road, which if it ever overflowed would discharge to Goose Lake. Goose Lake would then have to overflow as would a depressional wetland area west of Goose lake before the runoff would reach Badger Mill Creek. The frequency of overflows reaching Badger Mill Creek is low. In such cases, a combination of retention area, lake and wetland ponding would provide good sedimentation of pollutants prior to discharge to Badger Mill Creek. Therefore, discharges from this area of Fitchburg were not considered a significant source of pollution.

The primary pollutant of concern from the urban areas is sediment and possibly sediment-associated toxics. Sources of urban sediment include build-up and washoff from impervious surfaces such as streets, roofs, and driveways, and construction erosion.

Large areas of the eastern and northeastern portions of the watershed are under construction. These include large areas east and west of Maple Grove Road and south of CTH PD. The City of Madison has a Construction Erosion Control ordinance and enforcement program which require all plats to install sedimentation basins as part of their erosion control. The area east of Maple Grove Road and south of CTH PD has three basins (Fries 1995). Enforcement of the erosion control program is handled by the Engineering Department until plats are accepted. This controls construction erosion during site grading and street and utility installation activities. Once plats are approved enforcement is taken over by the Inspections Department.

The city also has a detention ordinance which requires post-development peak runoff rates for the 1-, 2-, 5-, and 10-year storms to equal pre-development rates. Compliance with this ordinance generally requires the construction of either retention or detention basins. Plats that are over 80 acres are required to have retention with a wet pond area. These are sized to maximize the available area rather than for specific water quality functions and sedimentation rates. The retention basins are sized for runoff rate control for the 1-, 2-, 5-, and 10-year storms. Retention basins may be the same ones used as sedimentation basins for construction erosion control. However, the city requires excavation of accumulated sediment and maintenance prior to dedication to the City and subsequent maintenance of the basin. For example, the three sedimentation basins currently part of the construction east of Maple Grove Road and south of CTH PD will be cleaned out following construction and maintained as wet ponds (Fries 1995).

Other activities by the City of Madison that may affect water quality in the watershed over the next few years include growth of the city to the south and west, conversion of a dry retention basin to a wet pond, installation of a small pond along Badger Mill Creek, and construction of a defined drainageway. The dry detention basin is located north of CTH PD and east of Maple Grove Road. Conversion of this dry basin to a wet pond will improve the removal of particulate pollutants. The installation of a 1-acre pond along Badger Mill Creek south of CTH PD near the confluence of the two main tributaries will provide little additional water quality benefit. This pond is not designed for water quality, and its size is limited by existing wetlands and sewer lines in the area. This pond is being built for wetland/channel mitigation (Fries 1995).

The construction of a defined drainageway along the east side of Maple Grove Road may allow more efficient drainage to Badger Mill Creek. Currently areas east of Maple Grove Road do not have a defined drainageway to Badger Mill Creek. Runoff currently flows south and west into farm fields west of Maple Grove Road where much of it infiltrates. However, this runoff will be treated in the three sedimentation ponds/retention basins and the converted basin that are in this drainage area.

The City of Verona also has runoff rate control and construction erosion control ordinances. The city also has three existing dry detention basins and one planned basin. The three existing basins are located on storm sewer networks that drain to the dry tributary of Badger Mill Creek on the west side of the city.

Agricultural Nonpoint Source Pollution. Agricultural activities are scattered throughout the watershed and consist of row crops, dairy and hog farming, and livestock grazing. Agricultural activities in the northeastern portion of the watershed between

Highways 18/151 and the advancing urban development to the north will decline over the planning period as urban development from Madison moves south toward Nesbitt Road.

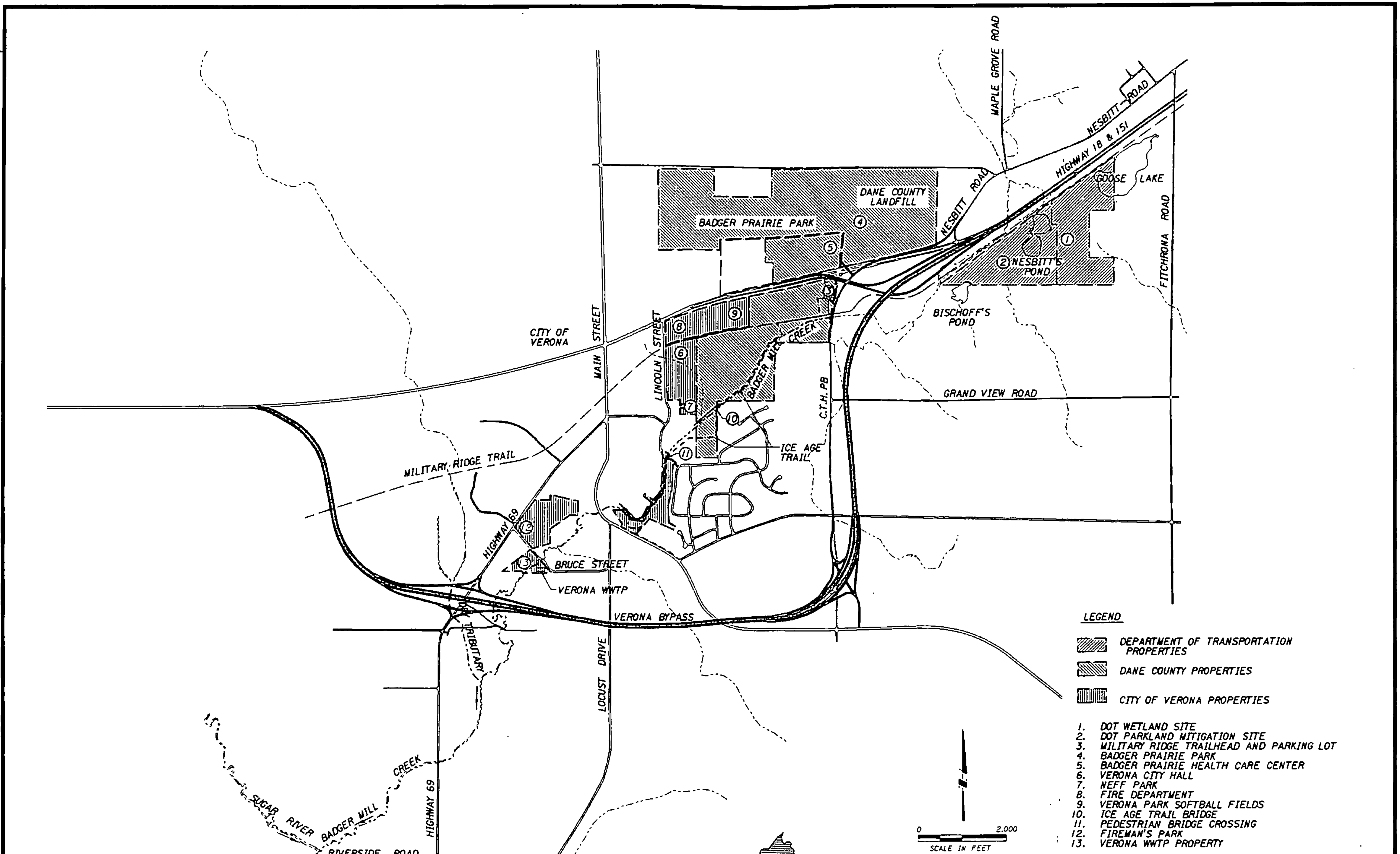
The subwatershed of the dry tributary on the western side of the watershed and areas south of the City of Verona are dominated by agricultural land uses. Livestock grazing dominates along Badger Mill Creek from the Verona WWTP to the confluence with the Sugar River. However, the reach from Highway 69 downstream to the Sugar River Confluence is fenced to exclude livestock; this protects the stream banks and has minimized erosion in this reach. Portions of the reach between Highway 69 and the Verona WWTP are also fenced; however, about 500 feet of the reach are not fenced, and livestock have direct access to the creek. The creek banks along this reach are slightly damaged and show some signs of erosion.

Recreational Facilities

A number of public lands and recreational facilities are located in the project area. These properties include county and city parkland, Wisconsin Department of Transportation (DOT) property, state and regional trails, and city-owned property. Figure 3-18 identifies public lands, recreational areas, and recreational trails in the project area. These resources are described below.

DOT Wetland Site. The DOT wetland site is located east of Goose Lake and immediately south of Highways 18/151. This parcel was originally designated as a wetland mitigation site for the Verona bypass project; however, the property was determined to be unsuitable for this and alternative areas were used to satisfy the mitigation requirements for DOT. The DOT created some seasonal wetlands by grading the site and seeded the area with a natural prairie seed mixture. The Dane County Parks Department will assume ownership of the property in the future. The Military Ridge Trail provides recreational access to the property and forms the northern property boundary.

DOT Parkland Mitigation Site. The DOT parkland mitigation site is located immediately west of the DOT wetland site and is owned by the DOT. The DOT acquired this property for mitigation of parkland lost due to construction of the Verona bypass. The Dane County Parks Department will assume ownership of the property in the future. Recreational access to the property is provided by the Military Ridge Trail that forms the northern boundary. No formal plans have been developed by the Dane County Parks



MONTGOMERY WATSON
Minneapolis, Minnesota

FIGURE 3-18
PUBLIC LANDS

JOB No. 10/6/95 FILE No. /usr/proj/veronoe/ DATE

Department for use of this property; however, preliminary concepts include natural restoration of native plant communities and possible passive recreation such as cross-country ski trails.

Military Ridge State Recreational Trail. The Military Ridge State Recreational Trail consists of 39.6 miles of trail along the abandoned Chicago and Northwestern rail line through Dane and Iowa Counties. The trail is used primarily for biking and is also suitable for hiking, plant and wildlife observation, cross-country skiing, and snowmobiling. A gravel parking lot and trail booth are located at CTH PB. The trail continues east from the project area connecting with the Capitol State Trail and into the City of Madison. To the west, the Military Ridge Trail connects with the Glacial Drumlin Trail.

Ice Age National Scenic Trail. The IAT was authorized by Congress in 1980 as a National Scenic Trail in Wisconsin. The proposed trail route through the project area is part of a larger trail system that generally follows the terminal moraines of Wisconsin's glacial landscape. As shown in Figure 3-19, the trail will generally traverse in a north-south direction. In addition to hiking and backpacking, permitted uses on the portion of the IAT through the project area will include cross-country skiing and snowmobiling.

Easements for the construction of the IAT through Badger Prairie County Park and along CTM M have already been obtained from the Dane County Parks Commission and Dane County Highway Department. An IAT junction area project plan was prepared by the Dane County Parks Commission and adopted by the Dane County Board of Supervisors on November 4, 1993. This project plan includes a strategy for acquisition priorities (Figure 3-20) and a habitat and recreation development plan (Figure 3-19).

The IAT junction area project plan defines the project boundary and preliminary development plan for the trail junction area. The project boundary is an acquisition boundary within which Dane County, in partnership with state, federal, and private agencies, will purchase land rights from willing sellers. The preliminary concept plan indicates how land in the project boundary will be used and where recreational trails or other facilities will likely be located. Because land acquisition depends on willing sellers, the development plan will evolve over time as land or land rights are acquired and as detailed facility plans are prepared. The project plan is guided by three sets of objectives addressing recreational trail development, resource protection, and community development and identity.

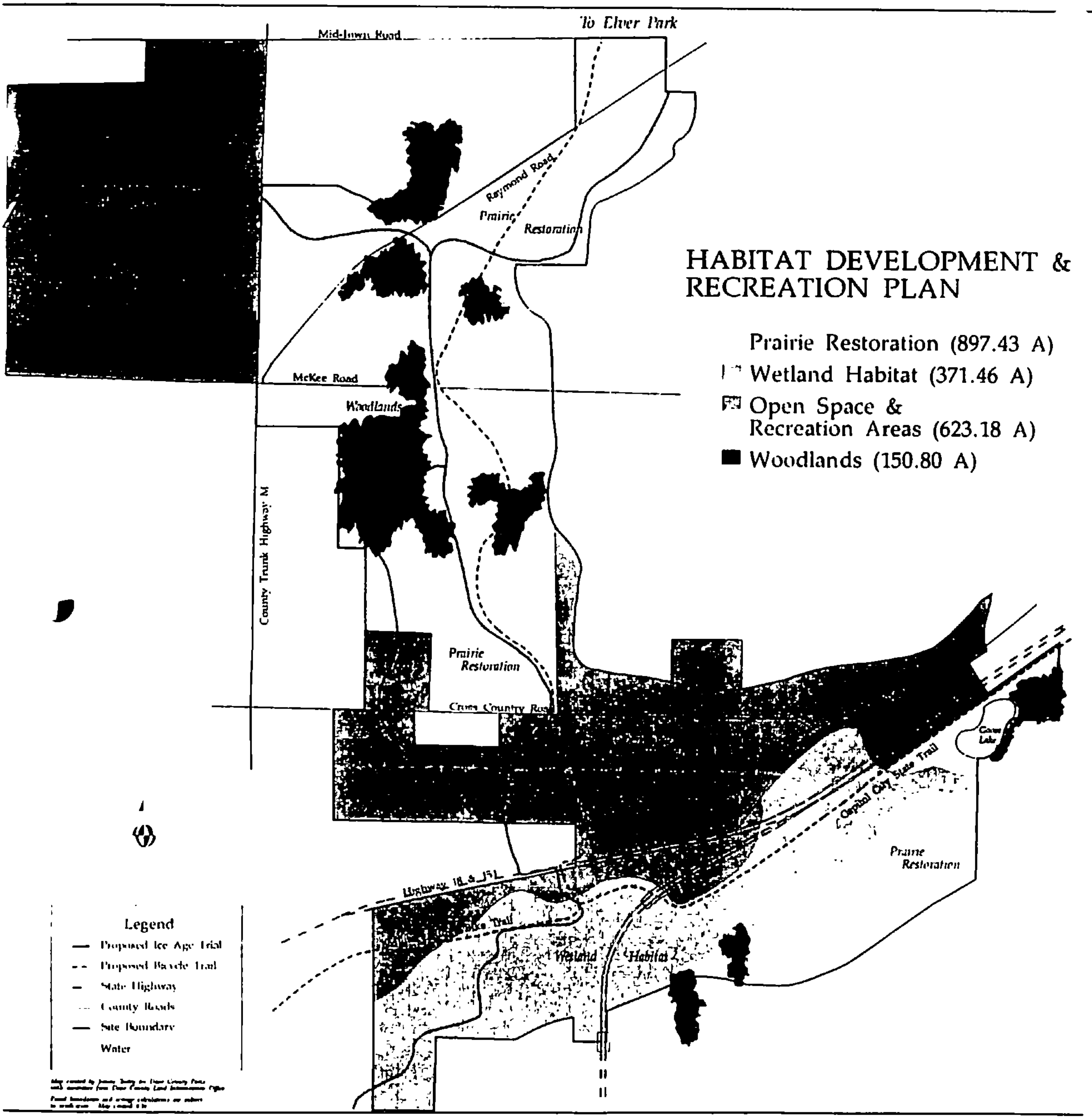
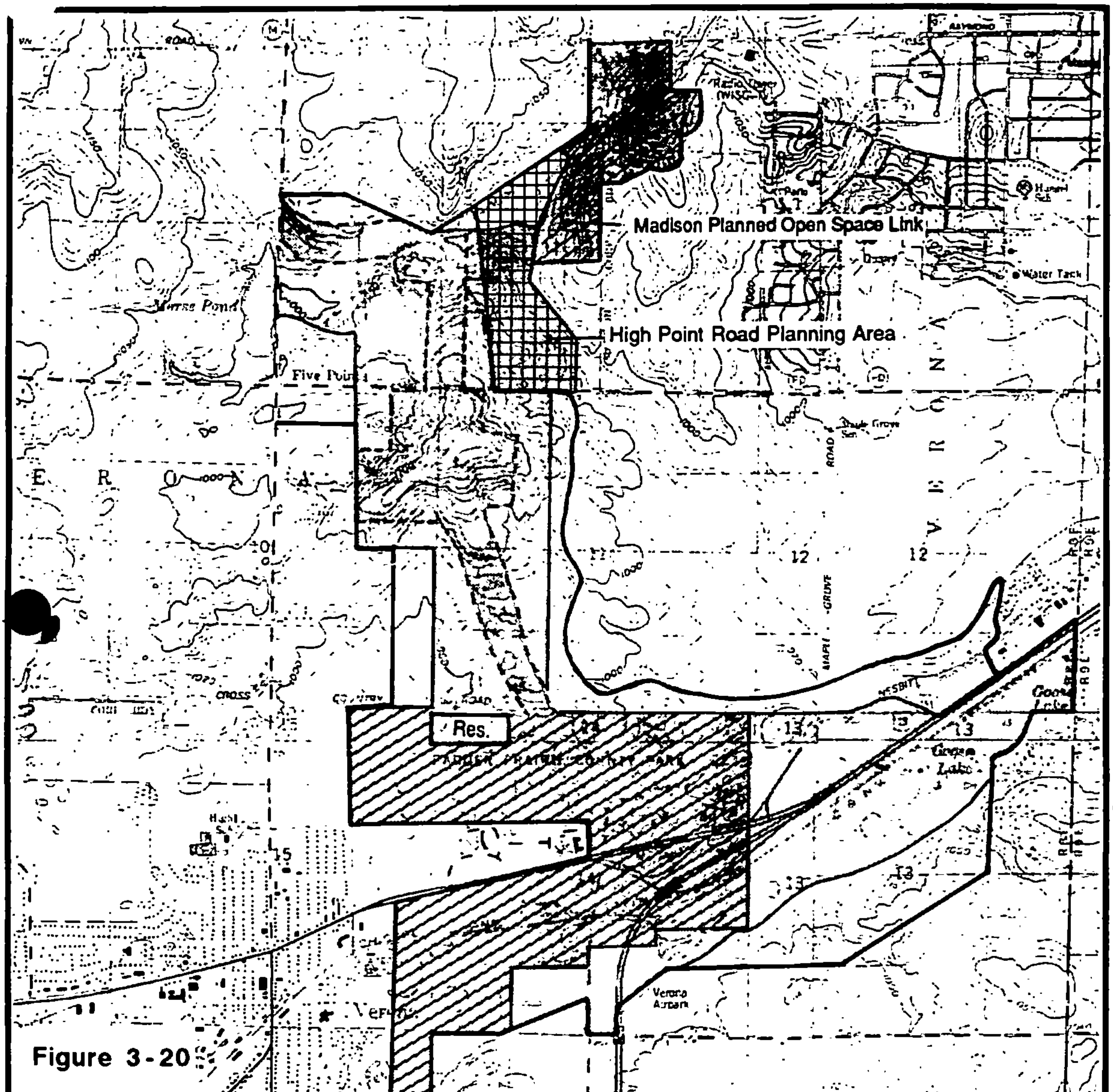


Figure 3-19 ICE AGE TRAIL JUNCTION AREA

1995 STATE STEWARDSHIP FUNDING PROPOSAL

Source: Ice Age Trail Junction Plan

DANE COUNTY
WISCONSIN



Trail Junction Area: Project Boundary and Acquistion Priorities

- Project Boundary
- First Priority Acquisition
- Second Priority Acquisition
- Third Priority Acquisitions/Easements
- Existing Public Ownership
- High Point Road Planning Area

7/26/93

Prepared by: THE DANE COUNTY REGIONAL PLANNING COMMISSION

Source: Ice Age Trail Junction Plan

Negotiations are in progress for acquisition of lands north of Badger Prairie County Park although no properties have been acquired to date.

Badger Prairie County Park. Badger Prairie County Park occupies approximately 500 acres, including 160 acres of a sanitary landfill and farmland previously used by the Dane County Hospital and Home (now the Badger Prairie Health Care Center). The park lies directly east of Verona and spans USH 18/151. The park includes some of the wetlands south of USH 18/151, a recreational and picnic area north of the highway, part of the IAT route, and a junction with the Ice Age and Military Ridge State Park Trails.

County-owned lands south of USH 18/151 and west of CTH PB are leased by the Wisconsin Department of Natural Resources (DNR) for use as a trailhead for the Military Ridge State Recreational Trail. Facilities include a gravel parking lot and trail information booth. A small pond has also been constructed. The pond is spring fed and discharges south to Badger Mill Creek.

Community Park. Community Park, owned and operated by the City of Verona, is located south of USH 18/151 and west of Badger Prairie County Park. The Military Ridge Trail forms the southern boundary of the park. The park occupies approximately 39 acres. Current development in the park includes a 200 care parking lot, two softball fields, one baseball field, a small soccer field, an outdoor hockey rink, and an indoor hockey rink. The Verona City Hall is located on the property south of the Military Ridge Trail and Community Park. Access to City Hall and open parkland space south of City Hall is off Lincoln Street.

Neff Park. Neff Park is a small city park located south of Community Park at the end of Holiday Court. No development has occurred in the park except for placement of a picnic table.

Firemen's Park. Firemen's Park, owned and operated by the City of Verona, is located at the corner of Highway 69 and Bruce Street. The park is approximately 12 acres. Recreational facilities include a swimming beach and picnic tables. Nonmotorized boating and fishing are allowed in the old gravel quarry.

Verona WWTP Property. The Verona WWTP property is located off Bruce Street in the southwest area of the City of Verona. The portion of this property on which the

WWTP is located is currently owned by the Madison Metropolitan Sewerage District with the understanding that the property will be given back to the City of Verona should the WWTP be abandoned. The property includes approximately 10 acres. Badger Mill Creek flows through the middle of the property with the WWTP situated on the eastern side of the creek.

Miscellaneous City Property. The City of Verona owns properties adjacent to Badger Mill Creek beginning at the Lincoln Street pedestrian bridge and continuing downstream along the creek to approximately CTM M. No recreational improvements have been made in this area with the exception of the Lincoln Street pedestrian bridge and the IAT. Public access is provided to the area from Lincoln Street, Melody Lane, and CTM M.

SUMMARY

This section consisted of an inventory and review of the current effluent discharge and watershed characteristics. Important findings of the inventory and review are given below by subject heading.

Effluent Discharge Characteristics

- Treatment performance at the NSWWTP is excellent with the plant achieving BOD, TSS, and NH_3 removals of better than 95%.
- Future treatment performance at NSWWTP will be further improved with the addition of EBPR and a new ultraviolet disinfection system.
- Concentrations of copper, lead, and zinc in NSWWTP effluent are less than the acute and chronic criteria calculated for Badger Mill Creek.
- Effluent bioassay monitoring has been conducted for six years at NSWWTP without a failure, indicating the high quality of the effluent.

Watershed Characteristics

- Badger Mill Creek has a length of 27,700 feet between Nesbitt Road and the Sugar River. The river loses approximately 44 feet of elevation across this distance, giving the channel an average slope of 0.0016 ft/ft.

- Badger Mill Creek Watershed is located in the glaciated region of Wisconsin and the creek channel lies on glacial outwash comprised of sand and gravel.

- The surface watershed for Badger Mill Creek is 32.6 sq mi while the shallow groundwater area draining to the creek is 19.5 sq mi.

- Water supply wells in and near Verona withdraw water from bedrock aquifers including Ordovician and Cambrian aged sandstone and dolomite units.

- Currently 0.57 mgd of effluent is discharged to the Sugar River while 1.6 mgd of wastewater is diverted to NSWWTP from the Badger Mill Creek watershed.

- The future (year 2017) volume of wastewater generated in the Sugar River urban service areas is estimated as 3.6 mgd.

- Water quality data for Badger Mill Creek are limited. However, the creek appears degraded, particularly by sediment.

- Over most of its length Badger Mill Creek is wide, shallow, and relatively straight; it appears that much of the stream has been channelized.

- Fish habitat in Badger Mill Creek is very uniform with limited diversity.

- Based on screening criteria, Site A, DOT Wetland, and Sites J/K, Dane County Parks 1 and 2, have the greatest potential for using the return effluent to enhance or create wetlands. Other sites have potential for improving stormwater runoff.

- Nonpoint source pollution in the Badger Mill Creek Watershed comes from both urban and agricultural sources. The most significant sources appear to be construction erosion and livestock grazing along the channel.

- Large acreages surrounding Badger Mill Creek upstream of the treatment plant are in public ownership. These lands offer significant recreational opportunities, access opportunities for channel improvements, and opportunities for cross-agency partnerships. The lower reaches of Badger Mill Creek are privately owned.

Section 4

Section 4

MONTGOMERY WATSON

SECTION 4

RETURN EFFLUENT EVALUATION

The purpose of this section is to determine the potential beneficial and negative impacts of returning effluent to the Sugar River basin, the regulatory implications of meeting effluent limits, and the needs for either additional treatment or mitigation.

TRANSBASIN DIVERSIONS

One of the impacts of returning effluent to the Sugar River Basin is the elimination of transbasin diversions. At the beginning of the planning period this diversion consists of the 1.6 mgd currently being diverted, and an additional 0.57 mgd that are currently being discharged to the Sugar River by the Verona WWTP, for a total volume of 2.2 mgd. The estimated diversion volume at the end of the planning period in 2017 is 3.6 mgd. Estimates have not been completed beyond the end of the planning period, however the amount of diversion is expected to continue to increase as development expands in the watershed.

The future effects of the diversion are unknown. DCRPC (1994, 1995) has suggested that the diversion could affect groundwater elevations and/or baseflows. The existing average baseflow in Badger Mill Creek is only 3.0 cfs, and the 7Q2 flow of 0.49 cfs and 7Q10 flow 0.18 cfs are both less than the potential diversion volumes of 3.4 and 5.6 cfs. In addition, Badger Mill Creek may be susceptible to losses of baseflow because of its relatively small shallow groundwater drainage area.

The shaley portion of the Eau Claire Formation is located at a depth of more than 400 feet where it is present. The impact of the potential confining nature of the shaley portion of the Eau Claire may not directly affect the hydrogeology of the area of this study since the water supply wells in question withdraw water over thicknesses ranging from 103 to 1153 feet below the ground surface. The aquifers which provide water include the Ordovician and Cambrian sandstones and dolomites which are located above the Eau Claire Formation, and have a close hydrogeologic connection with the shallow ground water. Thus, it appears that baseflow in Badger Mill Creek, and subsequently in the Sugar River, could be influenced by wastewater diversions out of the watershed. However, it is uncertain if the volume of the diversions will be large enough to impact baseflows significantly or noticeably. Analysis of water management scenarios by the hydrogeologic study in progress by the Wisconsin Geologic and Natural History Survey (WGNHS) will provide additional information on this impact. However, diverting the 0.57 mgd (1 cfs) that are currently discharged to the Sugar River will reduce Sugar River flow. Returning the effluent will eliminate this impact. This diversion represents 13% of the 7Q10 low flow and 6% of the average baseflow (18 cfs) of the Sugar River.

Returning the effluent and discharging to Badger Mill Creek will increase flows. The impacts of these increases are evaluated below in relation to stream hydrology, flooding, channel erosion, fisheries habitat, stream temperature, and effluent limits that protect aquatic life.

EFFLUENT DISCHARGE LIMITS

The calculation of effluent limits for a discharge to Badger Mill Creek is subject to the provisions of chapters NR 102, 104, 210, and 207 of the Wisconsin Administrative Code. Chapters 102 and 104 relate to stream classifications and standards. Effluent limits for small streams are typically calculated by WDNR to meet the stream standards using the 13-lb rule for cold water communities and the 26-lb rule for warm water forage fish communities. Chapter NR 207 is the antidegradation rule and applies since an increased discharge to the Sugar River is proposed. These rules are analyzed below as they relate to the determination of effluent limits.

Antidegradation Rule NR 207

The Antidegradation Rule NR 207 applies to new or increased discharges. Discharge to Badger Mill Creek is not a new discharge but a relocation of the existing Verona WWTP discharge. The proposed discharges of 2.2 mgd at the beginning of the planning period and 3.6 mgd at the end of the planning period are increases in the discharges to the Sugar River Basin over the existing Verona WWTP discharge of 0.57 mgd. However, the proposed discharges will be treated at the NSWWTP and will have much lower effluent concentrations than the existing Verona WWTP effluent. The increased discharges in NR 207 apply to mass loads. Therefore, existing and proposed mass loads of BOD_5, TSS, NH_3-N and TP were calculated to determine if increased mass discharges would be proposed.

The most recent WPDES permit for the Verona WWTP which expired on March 31, 1993 does not contain mass limits. Therefore, existing mass loads for the Verona WWTP were calculated using the WPDES permit effluent concentrations and a design flow of 0.57 mgd. Proposed mass loads of BOD_5, TSS, and NH_3-N were calculated for design flows of 2.2 and 3.6 mgd using the average effluent concentrations (Table 3-2) for August 1992 through December 1994 from the NSWWTP. The proposed mass load of TP was calculated using the two design flows and an average TP concentration of 0.88 mg/L; the concentration of 0.88 mg/L was obtained from pilot testing and represents the performance of the NSWWTP following implementation of advanced phosphorus removal. These loads are shown graphically in Figure 4-1.

Figure 4-1 shows that the proposed discharges will significantly reduce the mass loads discharged to the Sugar River and will improve its water quality for all parameters except TP. The antidegradation rule is met at the beginning of the planning period. However, the mass of TP at the end of the planning period as shown in Figure 4-1 is very similar to the existing mass estimated in the discharge to the Sugar River (i.e., 9,750 lbs/yr proposed versus 9,500 lbs/yr existing). This difference is much less than the uncertainty involved in calculating the estimates. The proposed mass was based on pilot testing, while the mass currently discharged from Verona WWTP was estimated from a limited number of grab samples. Thus, existing information is not sufficient to conclude that there will be a future increase. Compliance later in the planning period would be determined once the EBPR is operating and actual performance is determined. In determining discharge limits, WDNR concurs that antidegradation appears to be satisfied for the proposed discharge, but future interpretation would be based on mass loadings. WDNR states the following (WDNR 1995):

> *Although there is an increase in discharge, the recommended effluent limitations for protection of Sugar River for both, warm water and cold water are much lower than those in the existing permit, thus there is no increase in concentration limits, there is no way to determine if the new discharge will result in an increase in mass loadings. Based on this information, mass limits are recommended to be used for future implementation of NR 207.*

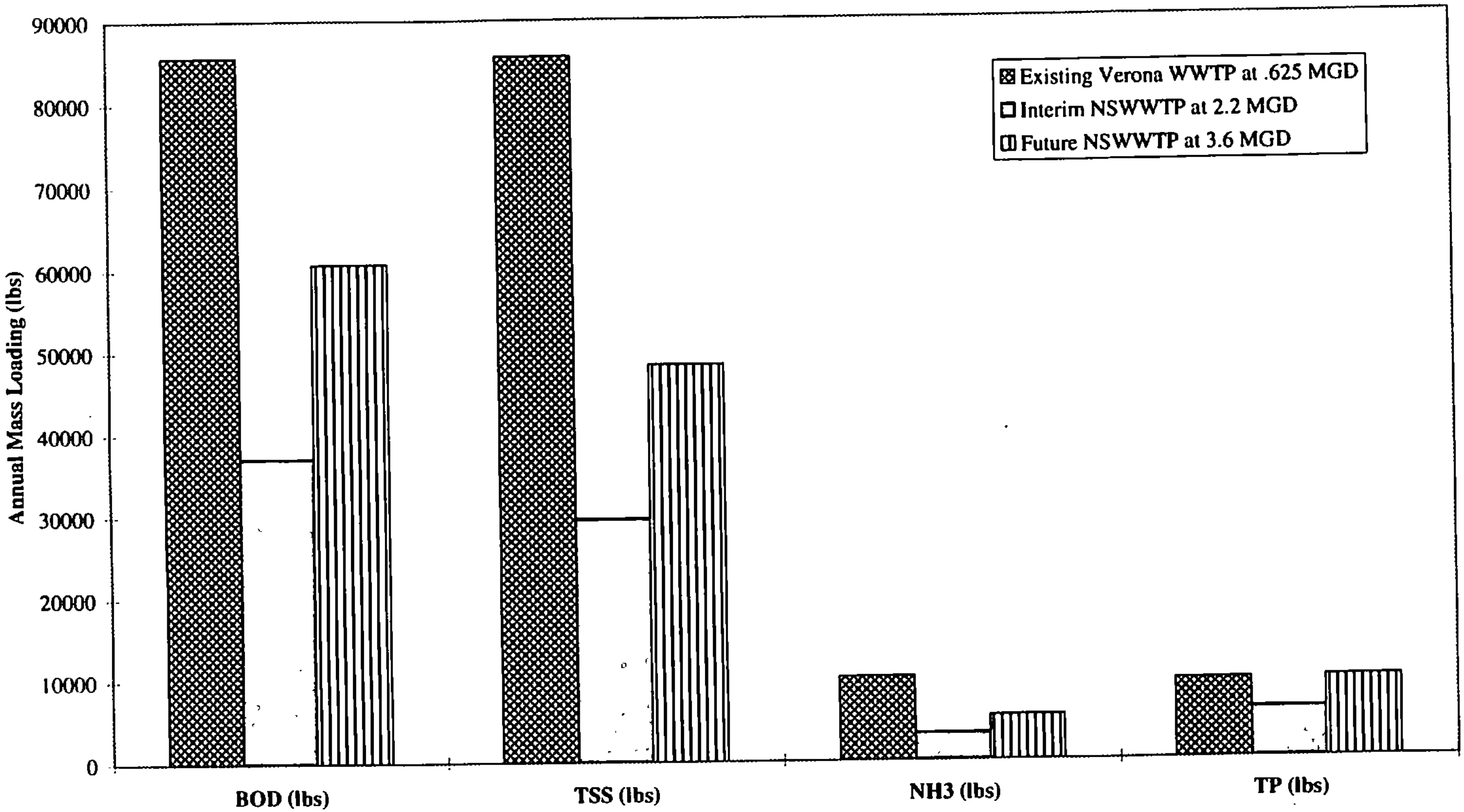


Figure 4-1. Comparison of Annual Mass Loadings to the Sugar River

Based on Existing Verona versus NSWWTP Effluent Quality

13- and 26-LB Rules

The 13- and 26-lb rules relate to the WDNR methodology usually used to determine effluent BOD_5 and DO limits for discharges to small streams. However, these rules are based on dilution, do not consider the assimilative capacity or the site-specific characteristics of the receiving stream, and can lead to overly conservative effluent limits.

In addition, effluent limits calculated by WDNR applied the 13-lb rule to Badger Mill Creek because a mixing zone at the confluence with the Sugar River is not allowed. This is a very conservative approach. For comparison, the 13-lb rule was used to calculate alternative limits for a direct discharge to the Sugar River. Limits calculated by WDNR as well as the alternative limits for a direct discharge to the Sugar River are presented below.

WDNR Calculated Limits. WDNR calculated limits for a discharge applying both the 13- and 26-lb rules to Badger Mill Creek with the more stringent limits controlling. A copy of WDNR calculations is attached as Appendix G. The calculated limits are presented in Table 4-1.

TABLE 4-1

EFFLUENT LIMITS FOR A 2.2 AND 3.6 MGD DISCHARGE TO BADGER MILL CREEK DETERMINED BY WDNR

Parameter	Warm Season	Cold Season
BOD_5 Weekly Average (mg/L)	5	10
TSS Monthly Average (mg/L)	10	10
NH_3-N Weekly Average (mg/L)	0.7	1.5

Comparing the limits with the historic performance of NSWWTP (Figures 3-1, 3-2, and 3-3) shows that these limits will generally be met. However, effluent from NSWWTP occasionally has concentrations which exceed these limits. Table 4-2 summarizes the percent of the time that NSWWTP effluent has exceeded these limits. These excursions must be reduced in order to meet the WDNR calculated limits.

TABLE 4-2

PERCENT EXCEEDENCE OF BOD_5, TSS, AND NH_3-N CONCENTRATIONS IN NSWWTP EFFLUENT ABOVE WDNR EFFLUENT LIMITS AT CURRENT OPERATING LEVELS

Parameter	Warm Season (%)	Cold Season (%)
BOD_5 Weekly Average	7	8
TSS Monthly Average	7	14
NH_3-N Weekly Average	4	11

Sugar River Discharge Limits. Alternative limits for a direct discharge to the Sugar River instead of Badger Mill Creek were calculated using the 13-lb rule and the same background values and methods as used by WDNR for the discharge to Badger Mill Creek but with the 7Q10 for the Sugar River. The calculated limits are presented in Table 4-3.

TABLE 4-3

EFFLUENT LIMITS FOR 2.2 AND 3.6 MGD DISCHARGED TO THE SUGAR RIVER

Parameter (mg/L)	2.2 mgd		3.6 mg	
	Warm Season	Cold Season	Warm Season	Cold Season
BOD_5 Weekly Average	9.0	17.1	6.6	12.6
TSS Monthly Average	10	17.1	10	12.6
NH_3-N Weekly Average	0.8	8.0	0.7	5.9

Table 4-4 shows the percent of the time that NSWWTP effluent discharged directly to the Sugar River would exceed the limits. These excursions must be reduced in order to meet limits for a direct discharge to the Sugar River.

TABLE 4-4

PERCENT EXCEEDENCE OF BOD_5, TSS, AND NH_3-N CONCENTRATIONS IN NSWWTP EFFLUENT OF SUGAR RIVER LIMITS

Parameter	2.2 mgd		3.6 mgd	
	Warm Season (%)	Cold Season (%)	Warm Season (%)	Cold Season (%)
BOD_5 Weekly Average	0	0	0	3
TSS Monthly Average	7	0	7	4
NH_3-N Weekly Average	3	0	4	0

Comparing the limits calculated for a direct discharge to the Sugar River to the WDNR calculated limits for discharge to Badger Mill Creek shows that much higher limits would be allowed for a direct discharge to the Sugar River. Either of these limits would protect aquatic life in the Sugar River. The WDNR limits are much more conservative because a mixing zone was not allowed at the confluence with the Sugar River rather than because of standards protecting aquatic life in the Sugar River. The requirement to not allow a mixing zone is an administrative requirement. The limits for a direct discharge to the Sugar River demonstrate that it is not necessary for protecting aquatic life.

If a mixing zone is allowed, alternative limits for a discharge to Badger Mill Creek would be the more stringent of the 13-lb rule limits calculated for the Sugar River and the 26-lb rule limits calculated for Badger Mill Creek. These limits are presented in Table 4-5 and percent exceedence of these limits is presented in Table 4-6.

These limits are only slightly higher than those calculated by WDNR. However, they show that existing effluent characteristics from the NSWWTP will meet BOD_5 limits protective of aquatic life in both the Sugar River and Badger Mill Creek with only rare excursions. The TSS concentrations will be met on average, but reducing the frequency and magnitude of excursion will be necessary to meet limits, particularly during the cold season. Ammonia limits would also be met on average with only rare excursions during the warm season.

TABLE 4-5

EFFLUENT LIMITS FOR 2.2 AND 3.6 MGD DISCHARGE TO BADGER MILL CREEK WITH A MIXING ZONE AT THE SUGAR RIVER

Parameter (mg/L)	2.2 mgd		3.6 mgd	
	Warm Season	Cold Season	Warm Season	Cold Season
BOD_5 Weekly Average	6.3	10.9	6.1	10.7
TSS Monthly Average	10	10.9	10	10.7
NH_3-N Weekly Average	0.8	8.0	0.7	5.9

TABLE 4-6

PERCENT EXCEEDENCE OF BOD_5, TSS, AND NH_3-N CONCENTRATIONS IN NSWWTP EFFLUENT FOR LIMITS TO BADGER MILL CREEK WITH A MIXING ZONE AT THE SUGAR RIVER

Parameter	2.2 mgd		3.6 mgd	
	Warm Season (%)	Cold Season (%)	Warm Season (%)	Cold Season (%)
BOD_5 Weekly Average	<1	5	1	5
TSS Monthly Average	7	14	7	14
NH_3-N Weekly Average	3	0	4	0

While TSS appears to have the largest deviation of the effluent characteristics, it is interesting to note that, even without further treatment, the NSWWTP will improve the long-term TSS conditions of Badger Mill Creek and the Sugar River. As shown in Figure 4-1, return effluent from NSWWTP will reduce the existing load discharged to the Sugar River by more than 16,000 kg annually. In addition, the average daily TSS concentrations (6.1 mg/L warm season and 8.3 mg/L cold season) are less than all but 3 of the 11 historical TSS measurements taken from Badger Mill Creek (Table 3-4). The maximum monthly average TSS concentrations for NSWWTP effluent (10.8 mg/L warm season and 12.3 mg/L cold season) are also generally lower than the historical TSS concentrations in Badger Mill Creek. Badger Mill Creek is currently affected by sediment as evidenced by the sediment deposits observed during the stream reconnaissance. The effluent discharge, even without additional treatment, would provide long-term improvements to TSS conditions in Badger Mill Creek and the Sugar River.

There may be a short-term increase in TSS loading for Badger Mill Creek to the Sugar River with the addition of effluent. Effluent addition may increase stream velocities in Badger Mill Creek and accelerate the migration of the accumulated sediment already in the upper reaches of the creek and migrating toward the Sugar River. This potential impact is evaluated in greater detail in the stream hydraulics, and channel velocities discussion later in this section.

Ammonia Toxicity

Alternative ammonia limits were calculated for Badger Mill Creek and the Sugar River using EPA criteria (EPA 1986). Limits for Badger Mill Creek were calculated for both warm water and cold water classifications. Sugar River Limits were calculated for a cold water classification. Input values for temperature and background NH_3-N were the same as those used by WDNR. Since Badger Mill Creek would be effluent-dominated, a pH of 7.5 was used for Badger Mill Creek.

The calculated limits for Badger Mill Creek are presented in Table 4-7 for both cold water and warm water classifications, and Sugar River limits are presented in Table 4-8.

TABLE 4-7

AMMONIA LIMITS FOR 2.2 AND 3.6 MGD DISCHARGE TO BADGER MILL CREEK USING EPA CRITERIA (EPA 1986)

	2.2 mgd		3.6 mgd	
Classification	Warm Season (mg/L)	Cold Season (mg/L)	Warm Season (mg/L)	Cold Season (mg/L)
Warm Water	1.8	2.1	1.8	2.1
Cold Water	1.6	2.1	1.6	2.1

TABLE 4-8

AMMONIA LIMITS FOR 2.2 AND 3.6 MGD DISCHARGE TO THE SUGAR RIVER USING EPA CRITERIA (EPA 1986)

2.2 mgd		3.6 mgd	
Warm Season (mg/L)	Cold Season (mg/L)	Warm Season (mg/L)	Cold Season (mg/L)
1.8	3.1	1.3	2.3

The maximum historical weekly average NH_3-N concentrations for NSWWTP effluent of 1.38 mg/L warm season and 1.97 mg/L cold season are generally less than the limits shown in Tables 4-7 and 4-8. The exception is the warm season limit of 1.3 mg/L for the Sugar River under the 3.6 mgd future flow scenario, but the exceedence of this limit is only 1 to 2% (Figure 3-2). Discharge to Badger Mill Creek 4 to 5 miles above the confluence with the Sugar River will allow some attenuation of the effluent NH_3-N concentration through oxidation. This means that EPA's NH_3-N limits to protect aquatic life will be met. The probability of exceedence in either the Sugar River or Badger Mill Creek is close to zero. The magnitude of NH_3-N attenuation was investigated with the site-specific modeling discussed below.

Another approach to evaluating ammonia toxicity involves interpreting the application of the no mixing zone requirement. The WDNR approach did not allow a mixing zone at the confluence with the Sugar River. WDNR used the pH from the Sugar River with the flows from Badger Mill Creek to determine limits. However, if there is no mixing, the pH used in this calculation should be the pH for Badger Mill Creek. Since Badger Mill Creek would be effluent-dominated, the pH would be 7.5. Table 4-9 presents the ammonia limits calculated for Badger Mill Creek as a cold water community using the WDNR approach and a pH of 7.5. These limits could be met with NSWWTP effluent without additional treatment.

TABLE 4-9

AMMONIA LIMITS FOR BADGER MILL CREEK AS A COLD WATER COMMUNITY USING WDNR APPROACH AND A pH OF 7.5

2.2 mgd		3.6 mgd	
Warm Season	Cold Season	Warm Season	Cold Season
1.6 mg/L	4.8 mg/L	1.6 mg/L	4.7 mg/L

Site-Specific Modeling

The EPA QUAL2E model was used to determine if existing NSWWTP effluent quality would have an adverse impact on Badger Mill Creek water quality and aquatic life. Conservative methods and site-specific data were used in the QUAL2E model runs. The most critical effluent and instream constituents (DO, BOD_5, BOD_u, NH_3-N, and TSS) were investigated in detail. Instream temperature, the nitrogen cycle including NBOD, and the phosphorus cycle were also simulated.

Eight instream water quality simulations were performed. Both average and critical conditions were evaluated. Average conditions were represented using average NSWWTP effluent characteristics and average baseflow. Critical conditions were represented using historical maximum NSWWTP effluent characteristics (Table 3-2) and 7Q10 low flows. The broad factors affecting Badger Mill Creek water quality that were used in the model are summarized in Table 4-10. Detailed model inputs and outputs are presented in Appendix B, Model Results.

At WDNR's recommendation, the BOD/DO simulation was performed in terms of BOD_u. The WDNR recommended using a BOD_u/BOD_5 ratio of 2.1. This ratio, however, represents a worst-case condition for a facility without nitrification. The NSWWTP has nitrification which reduces NBOD. NBOD typically degrades slower than CBOD exerting oxygen demand after five days and is a portion of the demand represented by BOD_u values. With nitrification, NBOD is reduced and therefore the BOD_u/BOD_5 ratio is reduced. The greatest reduction in the ratio would occur during the warm season due to greater biological decay activity. When the NSWWTP is fully nitrifying during warm conditions, very low BOD_u/BOD_5 should result. BOD_u/BOD_5 ratios were developed and evaluated in Section 3. Based on the evaluation, a ratio of 2.1 (as recommended by WDNR) was used for cold season simulations, while a ratio of 1.35 was used for the warm season simulations.

TABLE 4-10

BROAD FACTORS AFFECTING BADGER MILL CREEK WATER QUALITY[1]

Modeled Condition	Seasonal Effluent and Weather Conditions		Stream Flow Conditions	Facility Flow Rate		BOD		Effluent DO
	Cold	Warm		Interim	Ultimate	Cold	Warm	
Critical	Air Temp of 40°F	Air Temp of 82°F	BMC Flow of 0-0.18 cfs	2.2 mgd	3.6 mgd	BOD_u/ BOD_5 ratio of 2.1	BOD_u/ BOD_5 ratio of 1.35	5 mg/L
	Sugar R. and BMC Temp of 40°F	Sugar R. and BMC Temp of 68°F	Sugar R. Flow of 7.8 cfs					
	Winter Effluent Characteristics: Effl. Temp of 50°F	Summer Effluent Characteristics: Effl. Temp of 71.6°F						
Average	Air Temp of 40°F	Air Temp of 54.5°F	BMC Flow of 3-6 cfs	2.2 mgd	3.6 mgd	BOD_u/ BOD_5 ratio of 2.1	BOD_u/ BOD_5 ratio of 1.35	6 mg/L
	Sugar R. and BMC Temp of 43.4°F	Sugar R. and BMC Temp of 63.3°F	Sugar R. Flow of 18 cfs					
	Winter Effluent Characteristics: Effl. Temp of 56°F	Summer Effluent Characteristics: Effl. Temp of 65.9°F						

[1] Additional effluent and stream characteristics are provided in the detailed model output (see Model Results appendix)

Instream conditions from the eight Badger Mill Creek simulations are presented in Tables 4-11 and 4-12. These results were extracted from the model output files in Appendix B. The results presented in the tables were extracted from the output files for the point just above the Sugar River confluence. However, the DO concentrations for both worst-case and average conditions were at or above 5 mg/L for all reaches of Badger Mill Creek.

TABLE 4-11

QUAL2E SIMULATED INSTREAM CONCENTRATIONS RESULTING FROM WORST CASE EFFLUENT FROM NSWWTP[1]

Parameter (mg/L)	2.2 mgd		3.6 mgd	
	Warm Season	Cold Season	Warm Season	Cold Season
DO	7.4	10.5	7.4	10.3
BOD_5	4.4	12.7	4.6	13
TSS	9.8	11.5	9.9	11.6
NH_3-N	0.8	1.7	0.9	1.8

[1] Reported concentrations are the simulated concentrations in Badger Mill Creek at the confluence with the Sugar River

TABLE 4-12

QUAL2E SIMULATED INSTREAM CONCENTRATIONS RESULTING FROM AVERAGE EFFLUENT CONDITIONS FROM NSWWTP[1]

Parameter (mg/L)	2.2 mgd		3.6 mgd	
	Warm Season	Cold Season	Warm Season	Cold Season
DO	10.3	11.3	9.9	11.1
BOD_5	2.9	4.1	2.9	4.7
TSS	5.3	6.5	5.4	6.8
NH_3-N	0.2	0.41	0.2	0.48

[1] Reported concentrations are the simulated concentrations in Badger Mill Creek at the confluence with the Sugar River

Comparison of the model simulations with WDNR calculated limits (Table 4-1) shows that average conditions always meet the limits. For critical conditions (i.e., maximum NSWWTP characteristics and low flow), cold season BOD_5, TSS, and NH_3-N WDNR limits are exceeded for both the 2.2 and 3.6 mgd facility flow rates. However, DO was always above 6 mg/L at the confluence with the Sugar River, and 5 mg/L in Badger Mill Creek. Badger Mill Creek may be classified as a warm water forage fish community which has a DO standard of 5 mg/L. The Sugar River, which will be classified as a cold water community, has a DO standard of 6 mg/L. Therefore, the critical conditions modeled meet the DO standards for the Sugar River and Badger Mill Creek. This means that BOD_5 and TSS standards are also met. BOD_5 limits are typically set in order to maintain desired DO concentrations while TSS limits are set based on the BOD_5 limit.

Ammonia concentrations for the critical conditions model scenarios slightly exceed the WDNR limits. Based on the historic performance of NSWWTP relative to ammonia (Figure 3-2) the frequency of these exceedences is low.

Badger Mill Creek Reclassification to Cold Water Community

The WDNR is currently considering reclassifying the lower portions of Badger Mill Creek from the Verona WWTP to the Sugar River confluence as a cold water community. This change would not affect the WDNR limits presented in Table 4-1, since the limits were calculated for a cold water community with a 7Q10 from Badger Mill Creek. Tables 4-13 and 4-14 present worst-case and average conditions model results for Badger Mill Creek near the Verona WWTP (Bruce Street). These results show that NH_3-N limits calculated for Badger Mill Creek as a cold water community will be met by the time the stream flow reaches the Verona WWTP for either EPA limits (Table 4-7) or WDNR limits (Table 4-9). Results also show that the cold water community DO limit of 6 mg/L is met for all scenarios expect the warm season 2.2 mgd discharge with worst-case effluent. However, the simulated instream concentration of 5.9 mg/L is very close to the limit. Given the very conservative reaeration rate used in the model and worst-case effluent conditions, the simulated concentration essentially meets the limit.

TABLE 4-13

QUAL2E SIMULATED INSTREAM CONCENTRATIONS IN BADGER MILL CREEK NEAR THE VERONA WWTP RESULTING FROM WORST-CASE EFFLUENT FROM NSWWTP

Parameter (mg/L)	2.2 mgd Warm Season	2.2 mgd Cold Season	3.6 mgd Warm Season	3.6 mgd Cold Season
DO	5.9	7.1	6.0	7.1
BOD_5	5.1	13.7	5.3	13.7
TSS	10.2	11.8	10.3	11.9
NH_3-N	1.0	1.8	1.1	1.8

TABLE 4-14

QUAL2E SIMULATED INSTREAM CONCENTRATIONS IN BADGER MILL CREEK NEAR THE VERONA WWTP RESULTING FROM AVERAGE CONDITIONS EFFLUENT FROM NSWWTP

Parameter (mg/L)	2.2 mgd Warm Season	2.2 mgd Cold Season	3.6 mgd Warm Season	3.6 mgd Cold Season
DO	8.4	8.8	8.3	8.6
BOD_5	3.1	4.9	3.2	5.4
TSS	5.5	7.0	5.6	7.3
NH_3-N	0.2	0.5	0.2	0.6

Proposed Permit Effluent Limits

The previous discussion presented alternative approaches for determining discharge limits that protect aquatic life in Badger Mill Creek and the Sugar River. WDNR-calculated limits do not consider site-specific characteristics and are conservative. The site-specific modeling is more accurate even with conservative inputs. The modeling shows that even worst case NSWWTP effluent characteristics for BOD_5 and TSS are protective of warm water forage fish communities in upper Badger Mill Creek, cold water communities in the lower portions of the creek, and cold water communities in the Sugar River.

During extreme critical conditions NH_3-N concentrations slightly exceed the WDNR calculated limits. However, calculation of limits for Badger Mill Creek as effluent-dominated, and review of EPA techniques for determining NH_3-N limits, demonstrate that no toxic effects are expected to occur for the worst-case NSWWTP effluent NH_3-N characteristics.

Based on the site-specific modeling and alternative approaches, the effluent discharge limits presented in Table 4-15 protect aquatic life and are proposed for the discharge to Badger Mill Creek. Aeration at the outfall would be needed to meet the DO standard. However, additional treatment relative to BOD_5, TSS, and NH_3-N would not be necessary.

TABLE 4-15

PROPOSED EFFLUENT DISCHARGE LIMITS

Parameter (mg/L)	2.2 mgd Warm Season	2.2 mgd Cold Season	3.6 mgd Warm Season	3.6 mgd Cold Season
BOD_5 Weekly Average[1]	7	16	7	16
TSS Monthly Average[1]	11	16	11	16
NH_3-N Weekly Average[2]	1.6	2.1	1.6	2.1

[1] Based on site-specific modeling

[2] Based on EPA approach and WDNR approach applied to Badger Mill Creek as presented in Table 4-9

Verona Landfill Discharge Permit

The Dane County Landfill located north of the intersection of CTH PB and Highway 18/151 recently received a WPDES permit to discharge to Badger Mill Creek. The permit is for a 0.2 mgd discharge from a groundwater treatment system. The proposed treatment consists of a stripping tower for the removal of VOCs. Effluent limits primarily focus on VOCs and toxics. No overlap is expected with the conventional parameters for BOD, TSS, and NH_3-N associated with the potential municipal outfall for this project.

EFFLUENT TRANSMISSION

Optional transmission line routes A, B, and C are shown in Figures 4-2 and 4-3. A detailed description of the routes is given in Section 5. The impact evaluation of the routes included an archaeological investigation and a review of threatened and endangered species. The results of these investigations are presented below.

Archaeological Investigation

The archaeological investigation was initiated by requesting a database review from the State Historical Society of Wisconsin. This revealed numerous records of archaeological materials within a mile of the potential transmission line corridor so an archaeological investigation was required by the Historical Society.

The archaeological investigation was completed by Archaeological Consulting Services of Verona, Wisconsin. A copy of their report is included in Appendix C. Their study focused on the preferred transmission line route C, the combination option, and consisted of a pedestrian survey and excavation of 313 shovel test units and various shovel probes.

The survey discovered two Native American sites. In one, three pieces of debitage (i.e., chert flakes) scattered on the surface of an agricultural field in a line about 210 meters long; another small, disturbed site was discovered about 60 meters south of the project corridor. Euro-American materials consisted of surface finds of recent age or which were not temporally diagnostic (i.e., not time-specific). No further archaeological work is recommended for this project because none of the sites is eligible for protection or inclusion on the National Register of Historic Places.

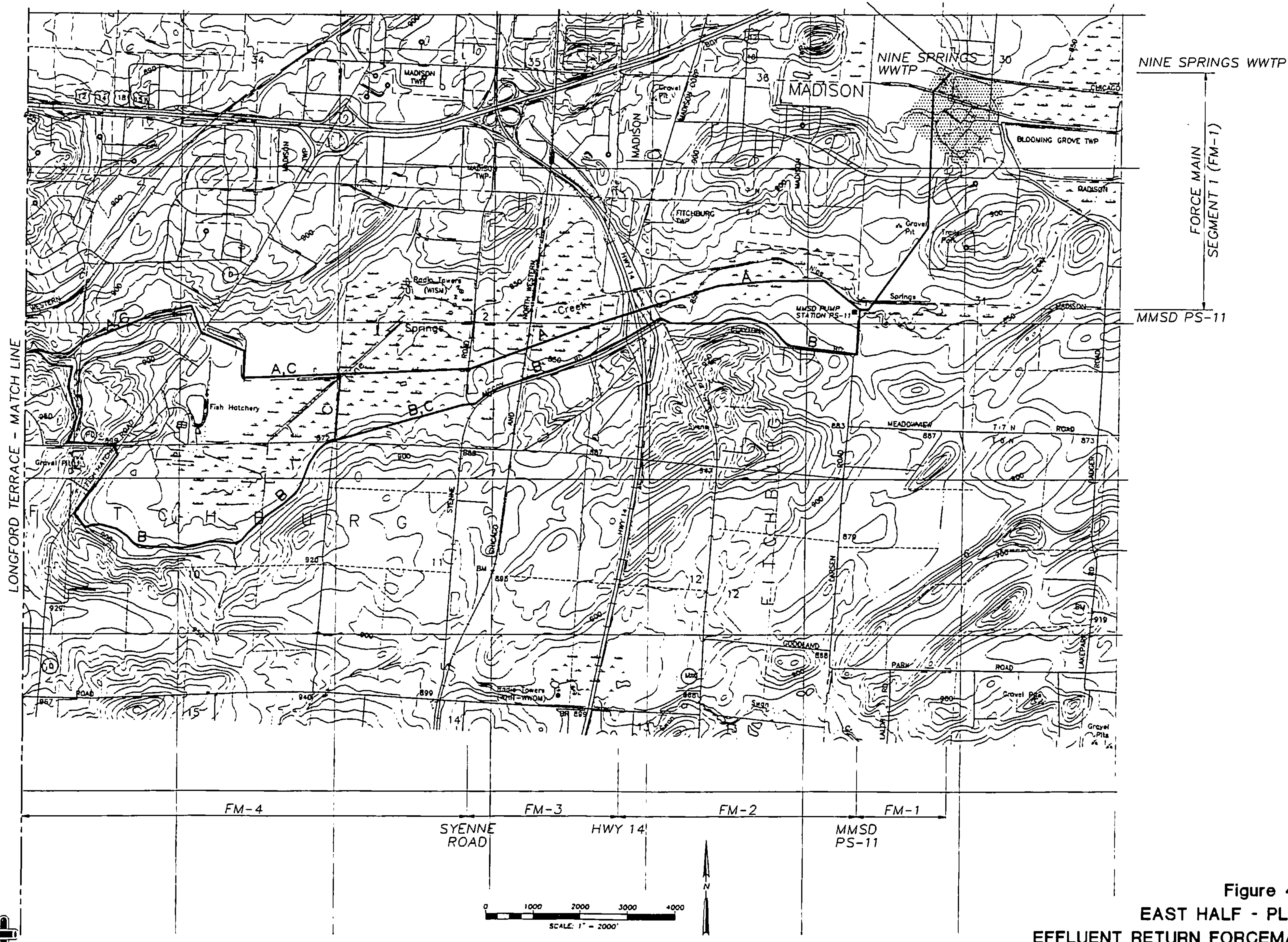


Figure 4-2
EAST HALF - PLAN
EFFLUENT RETURN FORCEMAIN

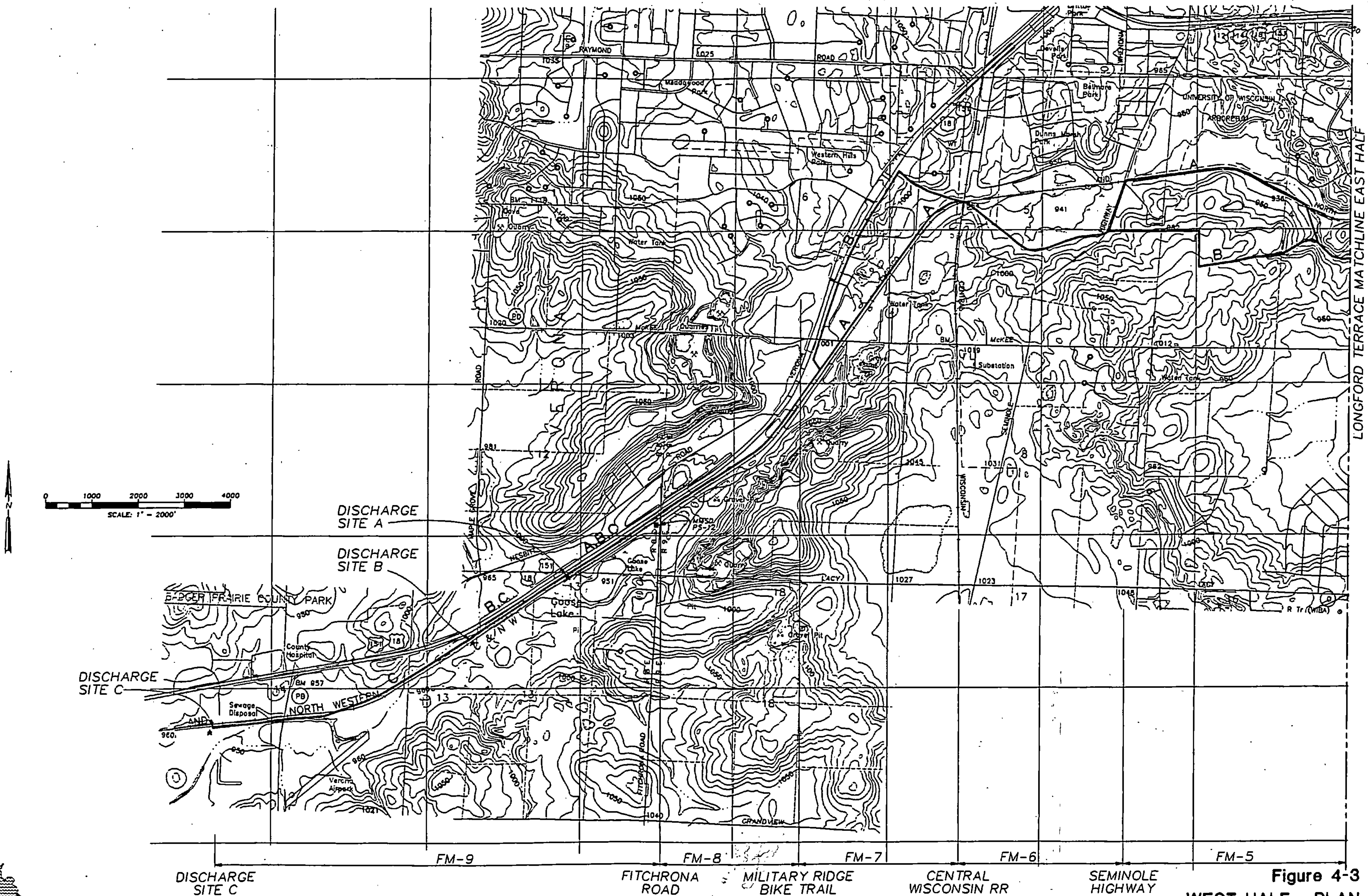


Figure 4-3
WEST HALF - PLAN
EFFLUENT RETURN FORCEMAIN

Threatened and Endangered Species

The threatened and endangered species investigation was initiated by requesting a Natural Heritage Database review from the WDNR (Appendix D). This uncovered a number of natural communities and threatened species within one mile (five miles for aquatic species) of the project's location. Information from WDNR along with the habitat information was then reviewed to determine if the sighting occurred within the project area or if appropriate habitats occur in the project area near the sitings.

Endangered resources recorded in the database that occur within or near the project site include the following:

Gentia alba (yellowish gentian), a plant listed as threatened in Wisconsin, occurs in Section 7 of T6N R9E. The observation date for this occurrence record is 1989. In Wisconsin this species has been observed in wet, sandy railroad prairie; thin soil on open and wooded ridges and bluff tops; wooded ravines in clay soils; and damp roadsides on edges of woods. Blooming occurs from mid-August through early October.

Plantanthera leucophaea (prairie white-fringed orchid), a plant listed as Threatened at the federal level and endangered in Wisconsin, occurs in Section 4 of T6N R9E. The observation date for this occurrence record is 1981. This species prefers wet prairies, wet meadows, bogs, and other open, grassy places. Blooming occurs during June and July.

Lower Mud Lake (Dunn) Natural Area is located in parts of the E1/2 SW1/4 of Section 10, the S1/2 of Section 11, the NW1/4 of Section 15, and the NE1/4 of Section 16 in T6N R10E, Dane County. This large wetland complex (approximately 400 acres) lies east and southwest of Lower Mud Lake, a widening of the Yahara River. The shallow marsh and sedge meadow are interspersed with deeper marsh and shrub carr. Many submerged aquatics are found in the lake and the area is used extensively by migrating waterfowl.

Nine Springs Meadows Natural Area is located in Sections 2, 3, and 10 of T6N R9E, Dane County. This approximately 130-acre site contains occurrences of scrub carr, southern sedge meadow, and a slow, hard, warm-water stream.

Agastache nepetoides (giant yellow hyssop), a plant listed as threatened in Wisconsin, occurs in Section 19 of T7N R10E. The observation date for this occurrence record is 1991. This species prefers oak woodlands and woodland edges and rich thickets. Blooming occurs from July through September.

Colias cesonia (dog-face butterfly), listed as a special concern species in Wisconsin, occurs in Section 4 of T6N R9E. Special Concern (Watch) species are suspected but not proven to have some problem of abundance or distribution. This category focuses attention on certain species before they become endangered or threatened. The observation date for this record is 1991. This species prefers open dry areas such as hot, dry scrub groves, short grass prairie hills, and open woodlands. It migrates north from south and breeds most summers in the midwest. Host plants include herbs of the peak family.

The data files also contained an historical record (generally records 25 years old or older) of a rare species known to occur within the vicinity of the project site. Unfortunately, the Bureau does not have more current survey information documenting the continued existence of this species in this area and noted below:

Nothocalais cuspidata (prairie dandelion), is listed as a special concern plant in Wisconsin and has been known to occur in T6N R9E. The species prefers dry areas and dry sand prairies. Blooming occurs from April through May.

Map and field inspections related to the sitings of the endangered resources determined the following:

- The yellowish gentian occurring in Section 7 of T6N R9E is noted in the Verona Bypass EIS (USDT 1989) as occurring in a small prairie remnant area located 500-600 feet south of the project area. Since the transmission line follows the dry, disturbed rail line in Section 7 of T6N R9E, there are no other areas with appropriate habitat for the yellowish gentian associated with the project in this section. The Verona Bypass EIS found an additional area of remnant prairie in Section 13 of T6N R8E along the rail line, but no threatened or endangered species were found in this remnant. Regardless, disturbance of this remnant should be avoided.

- Field reconnaissance of areas in Section 4 T6N R9E found that the project in this area does not affect habitat types listed for the prairie white fringed orchid or dog-faced butterfly. Project activities in these areas are confined to the Chicago and Northwest Rail Line and an agricultural field south of the rail line that is currently planted with soybeans.

- The project goes south around Dunn's Marsh in Section 5 of T6N R9E so it is not affected. Lower Mud Lake is well outside the project area and is not affected.

- Optional transmission line route A has 12,000 ft of pipeline located in the Nine Springs Meadows Natural Area. This route follows the existing easement for the Nine Springs Valley Interceptor (NSVI). Optional transmission line route B avoids the natural area by going south of the wetland following the proposed Capital City Bike Trail, Clayton Road, and McCoy Road. Optional route C initially avoids the wetland by following the same route as optional route B along Clayton and McCoy Roads, but then the alignment for route C turns north and cuts through the wetland approximately 3,000 ft west of the intersection of Syenne and McCoy Roads. Route C then proceeds north through the wetland about 1,400 ft before intersecting with the existing NSVI, becoming the same as route A which follows the existing easement for the NSVI. In total, route C affects a linear distance of approximately 4,000 ft of the wetland. Wetland impacts caused by optional routes A and C are temporary. Once the pipeline is installed conditions can be restored and no future disturbance will be necessary.

- Sitings of giant yellow hyssop in Section 19 of T7N R10E are well north of the project area.

These findings showed that with the exception of the temporary wetland impacts associated with transmission routes A and C, known impacts to threatened and endangered resources are avoided.

STREAM HYDRAULICS AND HYDROLOGY

Results from the HEC-II model with and without effluent discharge were evaluated to determine the hydrologic and hydraulic implications of returning effluent to Badger Mill Creek.

Watershed Hydrology

Flow rates for Badger Mill Creek calculated by the USGS at Nesbitt Road were 1,395 cfs for 10-year flows and 2,280 cfs for 100-year flows. At the confluence of the Sugar River, the 10-year flow in Badger Mill Creek is 2,000 cfs and the 100-year flow is 4,100 cfs. The effluent return project proposes a maximum effluent discharge of 3.6 mgd (5.5 cfs). For the 10-year storm, this would represent increases of 0.39% at Nesbitt Road and 0.28% at the confluence with the Sugar River. For the 100-year storm, the flow would increase 0.24% at Nesbitt Road and 0.13% at the Sugar River. This level of discharge increase is negligible. Referring to the accuracy of the hydrologic models discussed in Section 3, which identified predicted flow deviations of as much as 47%, the additional effluent flows are less than the range of error of the existing natural flow predictions.

Stream Hydraulics

The base HEC-II model used to predict the flood behavior of Badger Mill Creek was obtained from the USGS; FEMA used the same model to predict flood hazards for the Verona and Madison areas. The model was recently updated to reflect the floodplain interactions and hydraulic structures associated with the Highway 18/151 Bypass. The model focused on the length of Badger Mill Creek between Highway 151/Nesbitt Road and its confluence with the Sugar River. The flow rates (hydrology) used in the model for each minor tributary to Badger Mill Creek were kept the same. The flow rates used by FEMA represent existing conditions for the creek system. To estimate the effects of effluent on flood elevation and flow velocity, additional discharges of 2.2 mgd (3.4 cfs) and 3.6 mgd (5.5 cfs) were added to the flows at Nesbitt Road.

Flood Elevations. Under 10-year flow conditions, an addition of either 2.2 mgd or 3.6 mgd of effluent caused a maximum increase in flood elevation of 0.02 feet.

Under 100-year flow conditions, an addition of 3.6 mgd of effluent resulted in a peak flood elevation increase of 0.03 feet. Addition of 2.2 mgd of effluent resulted in a flood rise of 0.02 feet. Wisconsin state flood regulations do not permit projects whose construction or operation result in more than a 0.01-foot flood stage increase for upstream or downstream reaches of a stream. To determine the maximum allowable effluent discharge under 100-year flood conditions, the HEC-II model was altered to model a range of discharge rates. It was found that an effluent discharge of 1.94 mgd would keep 100-year flood level increases at or under 0.01 feet. Therefore, no hydraulic improvements would be necessary if an operational procedure is outlined which keeps the discharge to 1.94 mgd or less during wet weather.

Channel Velocities. Under 10-year flow conditions, an addition of 3.6 mgd of effluent caused a maximum velocity increase of 0.05 ft/sec; 2.2 mgd increased the velocity 0.04 ft/sec.

Under 100-year flow conditions, an addition of 3.6 mgd of effluent caused a peak flow velocity increase of 0.02 ft/sec; 2.2 mgd increased velocity by 0.01 ft/sec.

The increase in stream velocities under baseflow conditions was analyzed using the habitat model. The average measured velocity at baseflow was compared with calculated velocities at the baseflow plus 2.2 and 3.6 mgd and the highest modeled flow at four transects (Table 4-16). The transects chosen were typical of the entire stream reach downstream of CTH PB. No water velocities greater than 2.0 ft/sec were predicted at any of the flows modeled.

Erosion Potential. It is not likely that streambank erosion would be increased with these small velocity increases caused by effluent addition, although it is possible that some of the high sediment load present in places along the stream reach may be removed with these slightly higher water velocities. However, none of the baseflow velocities approach velocities that are considered erosive.

TABLE 4-16

COMPARISON OF THE AVERAGE MEASURED AND MAXIMUM PREDICTED WATER VELOCITIES AT FOUR TRANSECTS IN BADGER MILL CREEK

Transect	Baseflow (cfs)	Baseflow (ft/sec)		Baseflow +2.2 (mgd)		Baseflow +3.6 (mgd)		Highest Modeled Flow[2]	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max
2	6.6	0.6	1.2	0.7	1.3	0.7	1.4	0.8	1.7
7[1]	4.1	0.2	0.4	0.4	0.7	0.4	0.8	0.9	1.6
10	2.8	0.6	0.8	0.8	0.4	0.9	1.8	1.1	2.0
12	2.5	0.3	0.4	0.4	1.0	0.6	1.4	0.8	1.7

[1] Estimated baseflow; actual flow measurement after rain event

[2] Highest modeled flow for transects 2 and 7 = 25 cfs; and for transects 10 and 12 = 10 cfs

FISHERIES

Potential fish habitat impacts for the 2.2 and 3.6 mgd effluent return scenarios were evaluated using the habitat model for warm water fish habitat and brown trout habitat.

Forage Fish Habitat

A benefit of flow augmentation to forage fish would be a longer reach of stream with baseflows in the preferred range. The Wisconsin Department of Natural Resources (WDNR) stream classifications define a desired baseflow for supporting forage fish as greater than 5 cfs (Ball 1982). The measured baseflow in upper Badger Mill Creek nearCTH PB was 0.3 cfs (1.4 cfs downstream of the pond), and 2.5 cfs at the Lincoln St. pedestrian bridge. With either proposed discharge, a greater portion of the upstream reaches of Badger Mill Creek would approach or exceed the 5 cfs threshold. The amount of increase depends on the discharge volume and location.

TABLE 4-17

ESTIMATED AVAILABLE HABITAT AT MEASURED AND PREDICTED BASEFLOWS AT 13 TRANSECTS IN BADGER MILL CREEK[1]

Stream Reach	Transect Number	Flow Volume (cfs) at: Baseflow	BF + 3.4 (cfs)	BF + 5.5 (cfs)	Weighted Useable Volume at:[2] Baseflow	BF + 3.4 (cfs)	BF + 5.5 (cfs)
Mouth to Highway 69	1-3	6.6	10.4 (58)	12.1 (83)	32[1]	50 (56)	54 (69)
Highway 69 to Verona WWTP	4-6	7.0	10.8 (54)	12.5 (78)	28	46 (64)	56 (100)
Verona WWTP to Main St.	7-8	4.1	7.9 (93)	9.6 (134)	20	28 (40)	30 (50)
Main St.	9-11	2.4	6.2 (158)	7.9 (229)	15	22 (47)	24 (60)
to	12	2.1	5.9 (181)	7.6 (262)	6	8 (28)	8 (31)
CTH PB	13	1.4	5.2 (271)	6.9 (393)	4	6 (71)	7 (100)

[1] Percent change from baseflow is listed in parentheses
[2] Weighted useable volume is an indexed habitat value expressed in cubic feet of habitat per 1,000 feet of stream

The volume of stream flow at various transects increases from 53 to 271 percent above existing conditions with 2.2 mgd and from 78 to 393 percent with 3.6 mgd (Table 4-17). With this increase in stream volume, the potential habitat for forage fish increases from 33 to 71 percent above existing conditions with 2.2 mgd and from 50 to 100 percent with 3.6 mgd (Figure 4-4).

Brown Trout Habitat

The base flow near Highway 69 is approximately 6 cfs. In the lower reach of Badger Mill (transects 1-6), the estimated useable brown trout habitat continually increases with flows up to 25 cfs (Figure 4-5). Flow augmentation in this reach would raise the baseflow and thus the potential habitat. The potential habitat increase for brown trout ranges from 58 percent with 2.2 mgd to 105 percent with 3.6 mgd additional flow. This modeling effort does not address whether additional habitat benefits to brown trout could be realized by adding instream cover structures or increasing riparian shading.

Limiting Factors Observed

The major focus of this analysis has been on the effects of flow augmentation on the fisheries resources of Badger Mill Creek. Simply stated, regardless of the amount of available habitat, if there is no water, there are no fish. A major assumption in focusing primarily on flow is that other habitat variables such as lack of cover, poor quality or limited spawning areas, water temperature, or other water quality parameters are not limiting fish production. If flow can be altered so it is no longer a major limiting factor, then the emphasis can shift to other factors.

As noted, baseflow appears to limit the fisheries resource over much of the stream reach upstream of Main Street. Lincoln Street upstream to CTH PB (1 mile of stream) has limited baseflow. Increasing the amount of water removes the major limiting factor, but other factors also appear to be limiting the fisheries resource. Because much of the stream has been channelized and straightened, there is a lack of habitat diversity and channel structure along most of the stream; the channel is wide and shallow with limited woody debris.

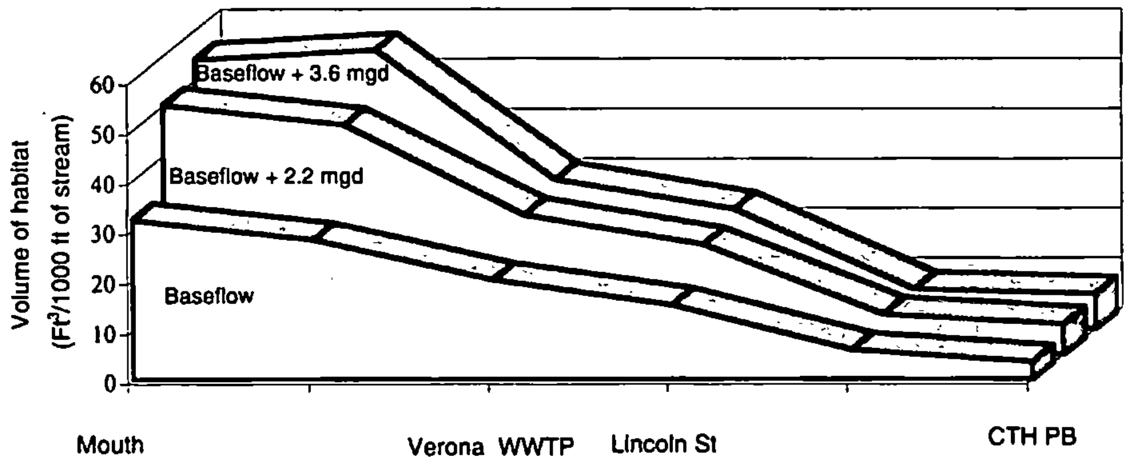


Figure 4-4. Effects of flow augmentation on the volume of forage fish habitat in different reaches of Badger Mill Creek

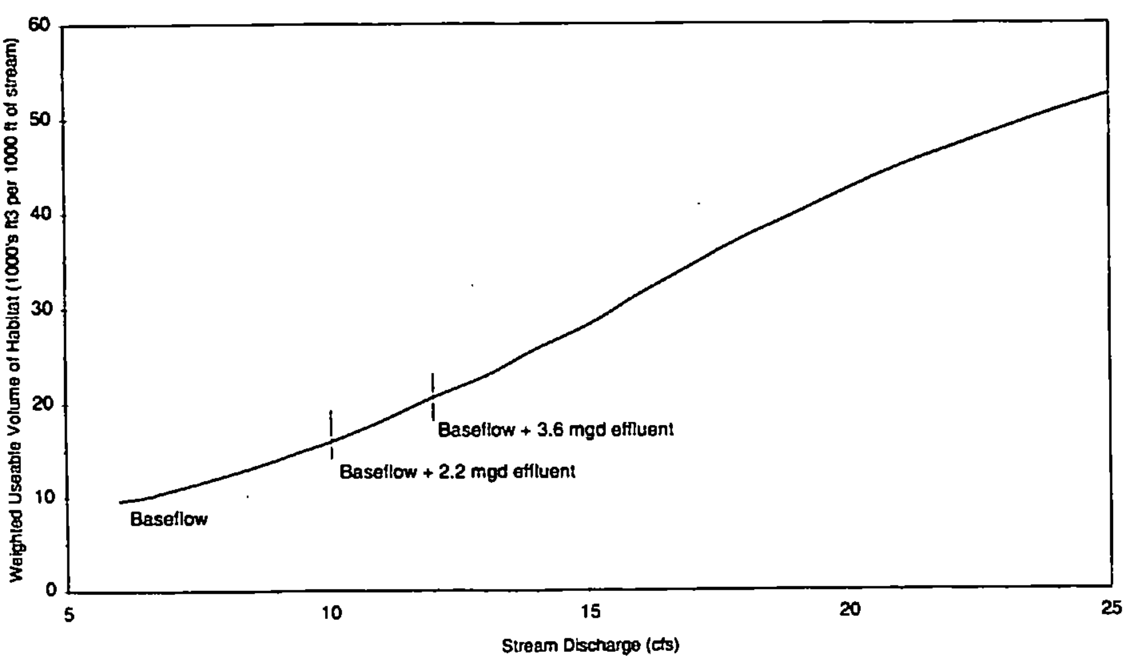


Figure 4-5. Estimated available habitat for Brown Trout at different flows in Badger Mill Creek

In addition, in much of the stream reach, particularly upstream of Lincoln Street, riparian vegetation is providing little shading. This could increase water temperatures and affect even the warmwater fish species present in this reach.

Sediment, more than 1 foot deep in places, covers stream substrates in much of Badger Mill Creek. High levels of sediment can decrease fish spawning success, as well as reduce food availability for fish by lowering invertebrate production and filling in pools, which limits rearing habitat.

TEMPERATURE

Temperatures in Badger Mill Creek were evaluated using the QUAL2E site-specific model. Only warm season results are presented since only high temperatures are of concern. Both critical low flow with worst case effluent discharge, and average stream flow with average effluent discharge temperatures were simulated.

Effluent temperatures in the model were based on monitored temperatures downstream of the effluent aerator on Badfish Creek. These temperatures reflect the temperature of the effluent discharged from the NSWWTP, and the temperature loss/gain from the transmission line to the ground along the 5-mile transmission line. This existing line is concrete. The proposed transmission line for the discharge to Badger Mill Creek is approximately 8.5 miles and will be constructed of ductile iron that has a thermal conductivity about 50 times that of concrete. The combination of the longer travel distance and higher thermal conductivity means that the proposed transmission line will have greater heat transfer to and from the ground than the existing transmission line to Badfish Creek. Warm season temperatures for the outfall to Badger Mill Creek will likely be lower than those observed at the outfall to Badfish Creek. Since the temperature difference cannot be reliably estimated, the temperatures from Badfish Creek were used as a conservative high temperature condition.

Critical conditions during the warm season (i.e., low flow and worst case effluent temperature) were dominated by the effluent temperature. Simulation of the critical conditions showed the temperature at the outfall increasing from 22°C to 23°C at the confluence with the Sugar River for both the 2.2 mgd and 3.6 mgd discharge rates. Existing monitored temperatures for Badger Mill Creek are limited and it is not possible to determine if the proposed discharge creates a temperature change during low flow.

However, low flows under existing conditions are 0-0.18 cfs. These flows would be subject to large diurnal temperature fluctuations because of the small volume of water and relatively shallow flow depths. The effluent discharge would help minimize this variation by providing a greater heat sink.

Warm season average temperature conditions (i.e., average flow and effluent temperature) for the 2.2 mgd and 3.6 mgd discharge rates are shown on Figure 4-6. Under these conditions the effluent discharge temperature does not dominate stream temperature as is the case for the critical low flow. Instead, temperatures cool rapidly, and downstream temperatures are controlled primarily by meteorological and riparian conditions.

The literature reports temperature requirements for various life stages of different fish species. The variations are due to different results from laboratory and field studies, and differences in fish temperature tolerances as a function of the temperature to which fish were acclimated before experimentation. Different subgroups within some trout species also have different temperature tolerances (Coutant 1977, Easton et al. 1995, Trotter 1987, Groot and Margolis 1991).

Preferred temperatures for trout and salmon are usually reported in the 12-14°C range, with upper lethal temperatures between 24 and 29°C. Upper lethal temperatures for brown trout (*Salmo trutta*) are reported at or near 25°C, with fish growth stopping as temperatures increase over 18°C (Easton et al. 1995, Coutant 1977). Average simulated conditions with effluent are below these temperatures, particularly in the lower reaches which have trout potential. Critical low flow conditions with effluent are above the growth-stopping temperature but below the lethal temperature. However, this condition with the added effluent is probably better than the low flow condition without effluent because the volume of water without effluent under this condition is essentially zero.

Forage fish observed in Badger Mill Creek includes mottled sculpins (*Cottus bairdi*), sticklebacks (*Gasterosteus spp.*), darters (*Etheostoma spp.*), and creek chub (*Semotilus atromaculatus*) (Table 3-5). White suckers (*Catostomus commersoni*) have also been observed in high numbers. Preferred temperatures for white suckers are reported in the 22-24°C range, with fish growth stopping over 26°C and lethal temperatures at or near 30.5°C (Twomey et al. 1984). The other members of this species assemblage exhibit similar temperature tolerances (Easton et al. 1995). Simulated critical and average

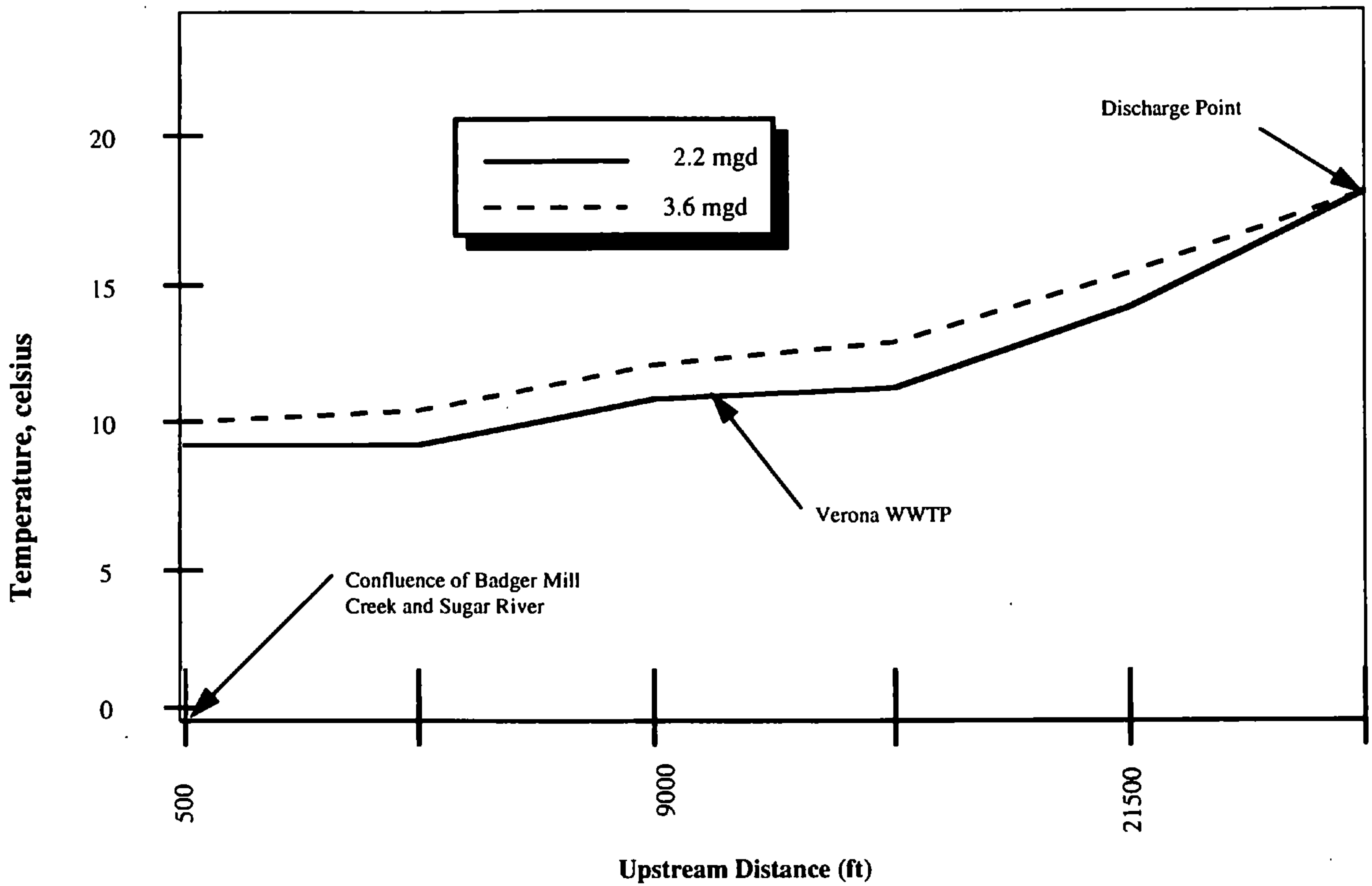


Figure 4-6. Simulated Average Conditions Temperatures for

Badger Mill Creek with Effluent Discharge Rates of 2.2 and 3.6 mgd conditions temperatures with effluent are lower than the growth stopping and lethal temperatures for white suckers.

The proposed effluent discharge, based on the model simulations, will not have negative impacts. In addition, ductile iron pipe for the transmission line will maximize effluent temperature reductions. This means that actual temperatures after construction should be lower than simulated. Further reductions in stream temperature, if desirable, would be best obtained by managing the riparian corridor.

RECREATION

Potential impacts on recreational facilities and activities of returning effluent are generally positive. The transmission line routes generally follow bike trails, including the Military Ridge Trail, Capital City Trail, and the Nine Springs E-Way. Routes B and C parallel a significant portion of the Capital City Bike Trail. Construction of the transmission line would provide clearing and grubbing for the trail. All three routes follow the Military Ridge Trail at the western end of the transmission line. Construction of the transmission line in this area would provide brush clearing for the trail. Realization of the potential benefits to the trails depends on the timing of the transmission line construction. Improvements are already planned for both trails and benefits would be maximized if transmission line construction could be coordinated with the trail improvements.

SUMMARY

Table 4-18 summarizes the impacts of returning effluent to Badger Mill Creek and potential solutions or mitigation activities. Returning the effluent will not have significant negative impacts. In fact the effluent return will improve the water quality of the Sugar River and will increase the forage and brown trout fishery potential of Badger Mill Creek. Other factors will continue to limit the fishery potential of the creek, but at least returning effluent eliminates flow as a limiting factor. Additional water quality and stream corridor improvements will be necessary to improve the aquatic biology and fishery of Badger Mill Creek significantly.

Alternatives solutions and mitigation activities are identified and defined in Section 5, and Section 6 evaluates these alternatives.

TABLE 4-18

IMPACT SUMMARY

Impact Topic	Impact Summary	Potential Solutions/ Mitigation Activities
Sugar River Water Quality	Quality will improve due to decreased mass loads	No mitigation needed
13 lb and 26 lb Rule	Occasional exceedences	Reduction of excursions and outfall aerator needed
Ammonia Toxicity	Current NSWWTP effluent NH_3-N concentrations are protective of aquatic life per EPA approach	No mitigation needed
Site-Specific Modeling	Current NSWWTP effluent characteristics are protective of aquatic life	Outfall aerator needed
Archaeological Sites	No sites were encountered which might be eligible for the National Register of Historic Places	No mitigation needed
Threatened and Endangered Species	No known locations within the construction area	No mitigation needed
Natural Areas	Route A has 12,000 lin ft (8.3 acres) Route C has 3,000 ft (2.1 acres) of temporary construction impact to Nine Springs Meadows natural area Prairie remnant area northwest of Goose Lake	Minimize disturbance with preferred route as route C; avoid prairie remnant area
Flood Elevations	Proposed effluent return volumes create 100-year flood level increases greater than 0.01 ft	Develop operational procedure to limit discharges to 1.94 mgd or less during wet weather
Channel Velocities/Erosion Potential	Small velocity changes will not increase bank erosion	No mitigation needed

TABLE 4-18

IMPACT SUMMARY
(Continued)

Impact Topic	Impact Summary	Potential Solutions/ Mitigation Activities
In-Stream Sediment	Baseflow velocities are too low to significantly accelerate migration of accumulated sediment	No mitigation needed
Fisheries	Increases fisheries potential by removing low base flows as a limiting condition	No mitigation needed
Temperature	Critical low flow temperatures will likely be improved with effluent discharge; average temperature conditions with effluent will generally be lower than the growth stopping and lethal temperatures for brown trout and white suckers	No mitigation needed
Recreation	Transmission line construction has potential to provide clearing and grubbing for planned trail improvements	No mitigation needed but construction timing is important to maximize benefits

Section 5

MONTGOMERY WATSON

SECTION 5

ALTERNATIVES DEFINITION

This section identifies and defines alternatives for discharging of effluent originating from the Sugar River Basin. Evaluation of the alternatives is presented in Section 6.

The Ninth Addition Facilities Plan Update for MMSD evaluated a number of alternatives for handling the Verona effluent. However, only two alternatives had the potential to retain an outfall and associated discharge permit to the Sugar River once it was determined that the concept of a regional facility in the Sugar River Basin was not cost effective:

- Alternative 2C would upgrade the Verona WWTP and treat and discharge a portion of the wastewater generated in the Verona USA to the Sugar River; the remaining wastewater would be diverted to MMSD for treatment and subsequent discharge it to the Yahara River Basin.

- Alternative 3B would divert the wastewater generated in the Sugar River basin to MMSD for treatment and return an equal volume to the Sugar River basin by discharging it to Badger Mill Creek.

Alternative 2C was evaluated as part of the Ninth Addition Facilities Plan Update. This current study is a detailed evaluation of Alternative 3B. The alternatives defined in this section therefore reflect various ways to implement Alternative 3B. A no-action alternative with respect to returning effluent was already evaluated and rejected as part of the Ninth Addition Facilities Planning effort and is not evaluated further in this study.

ALTERNATIVES IDENTIFICATION

The alternatives may have options, techniques, or strategies. Options are site- or approach-specific means of meeting the goals for the alternative. Techniques are technologies that can be used with the various options. Strategies are actions that can be used with the various options to provide added value to the alternative. For improvements determined to be "necessary", techniques support options which in turn allow an alternative to be implemented. For improvements which are "added value", techniques and/or strategies support options and then an alternative.

The two alternatives are:

Alternative I: Return effluent

Alternative II: Return effluent with water quality and stream corridor improvement

Alternative I is designed to address the necessary improvements identified in Section 4 for returning the effluent and meeting conditions that protect aquatic life. Alternative II contains added value improvements that build upon the necessary improvements contained in Alternative I. The added value improvements are designed to address some of the watershed and stream corridor problems identified in Section 3 and include a total resource management perspective to complement returning the effluent. The following sections define each alternative in detail.

ALTERNATIVE I: RETURN EFFLUENT

The return effluent alternative consists of providing necessary improvements or the basic infrastructure to return the effluent and protect aquatic life. Actions necessary to complete this alternative consist of building the transmission line along one of three possible routes, and protecting aquatic life either by improvements to meet WDNR-calculated effluent discharge limits or WDNR acceptance of alternative discharge limits. Options and techniques for Alternative I are summarized in Figure 5-1. The two necessary actions (i.e., transmission line and protecting aquatic life) for implementing Alternative I are evaluated in detail below.

A detailed evaluation of transmission line routes and techniques is included in Appendix H. Optional routes are briefly described below.

Transmission Line

The transmission pipeline would deliver highly treated effluent from the NSWWTP to a discharge site on the Badger Mill Creek, a distance of about 10 miles. The forcemain would be sized to transmit effluent flows ranging from 2.2 to 3.6 mgd. Alternative routes for the transmission line were identified using the following screening criteria:

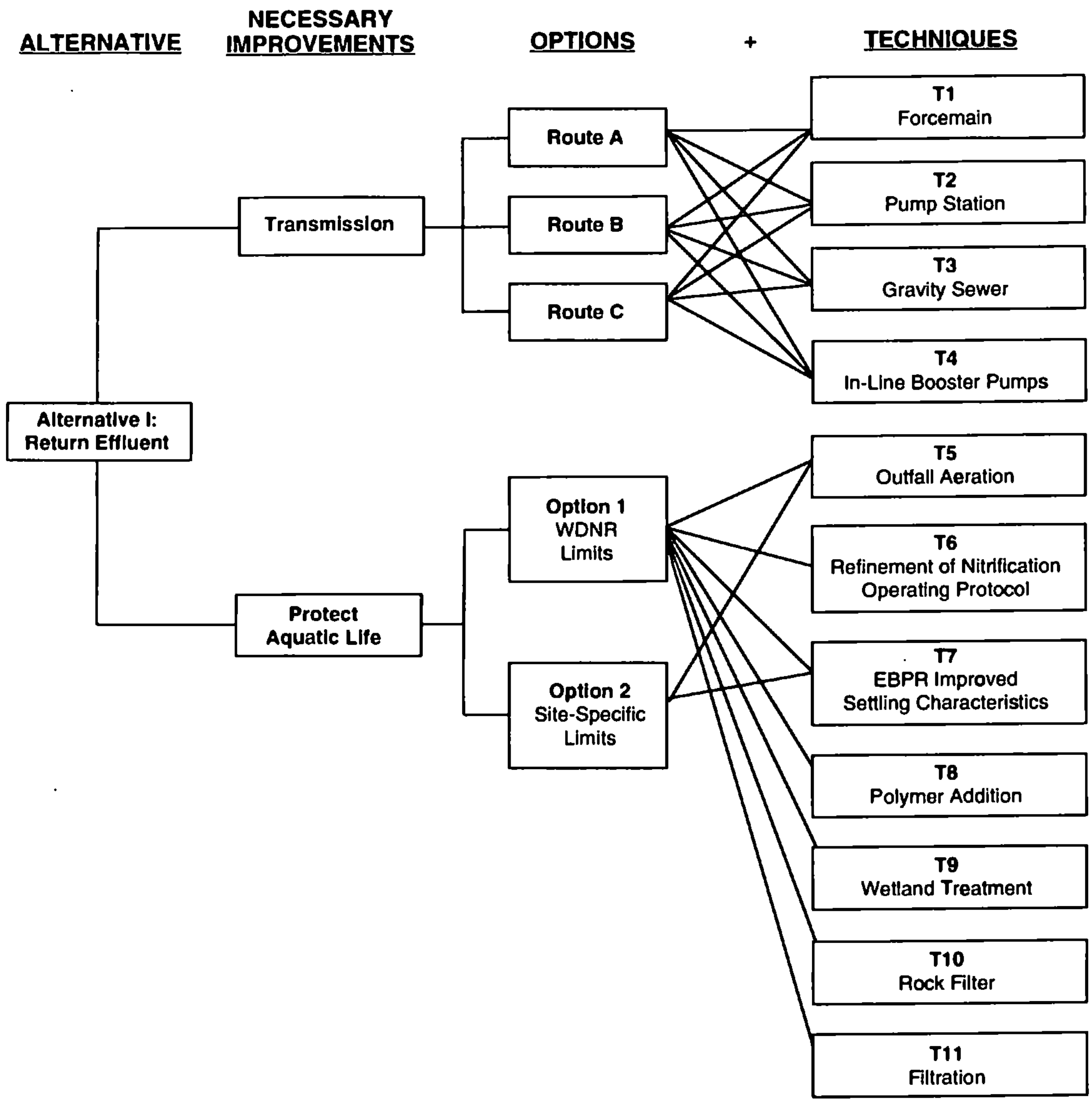


FIGURE 5-1: DEFINITION OF ALTERNATIVE I OPTIONS AND TECHNIQUES

- Maximize use of existing utility corridors
- Maximize use of road right-of-way
- Choose routes along property lines
- Avoid road and railway crossings
- Avoid heavily wooded and residential areas
- Avoid wetlands and other environmentally sensitive areas
- Minimize peaks and valleys in the pipeline profile
- Maximize cost effectiveness

A preliminary screening of forcemain options was conducted to evaluate the effluent transmission system proposed in the Ninth Addition Facility Plan Update. It was concluded that using the existing effluent transmission system to divert to Badger Mill Creek would require adding booster pumping. The preliminary screening evaluated three optional forcemain configurations, each with an optional route. The selected option included a direct tap of MMSD's 54-inch effluent forcemain at MMSD's pumping station 11 site, a booster pump station adjacent to pump station 11, an 18-inch forcemain for 33,000 feet, and a 30-inch gravity sewer for the remaining 12,000 feet to the discharge location. Three alternative pipeline routes were developed for the selected options.

Subsequent review of the preliminary screening effort determined that the selected option included the following undesirable features:

- The booster pump station would be subjected to variable suction head conditions (depending on the residual head in the existing 54-inch effluent transmission line), making flow control to Badger Mill Creek more difficult and complex.

- An independent pumping system would more flexibly accommodate additional future treatment units for aeration or filtration.

- Directly tapping the existing 54-inch effluent forcemain would require an expensive, risky construction operation on piping that has been in service 37 years. The risk was deemed to be highly undesirable because of the critical need to maintain effluent transmission from the NSWWTP to Badfish Creek.

Because of these disadvantages, the selected option in the Ninth Addition Facility Plan Update was modified to include installation of independent effluent pumps at the NSWWTP and a forcemain from the NSWWTP to the various routes to the Badger Mill Creek.

A review of the route options in the preliminary screening analysis indicated that the proposed 10-mile forcemain would traverse several "sensitive" areas requiring careful review and planning. Selecting a forcemain route will require integration with Dane County and WDNR plans for developing recreational parks and trails as well as private residential development in Fitchburg. Meetings with Dane County, WDNR, and the City of Fitchburg were held to discuss route options and selection. Field inspections of route options were conducted to verify current land uses and construction conditions. These efforts resulted in the selection of final route options to be considered.

For the purposes of this study, the forcemain from the NSWWTP to Badger Mill Creek will be divided into nine segments labeled FM-1 through FM-9. The proposed alignments are depicted on Figures 4-2 and 4-3, and the ground profiles for the alignments are shown on Figures 5-2 and 5-3. The segments are summarized as follows:

FM-1 NSWWTP to MMSD PS-11

Proposed route is parallel to the existing alignment for PS-11 forcemain on MMSD property.

FM-2 MMSD PS-11 to USH 14

Proposed routes are in two options:

FM-2A - Follows existing easement for Nine Springs Valley Interceptor (NSVI) in MMSD and Dane County property parallel to Nine Springs Creek. This route is mainly in wetlands.

FM-2B - Follows proposed Capital City Bike Trail along Clayton Road in MMSD, Dane County and private property, as well as existing road right of way (ROW).

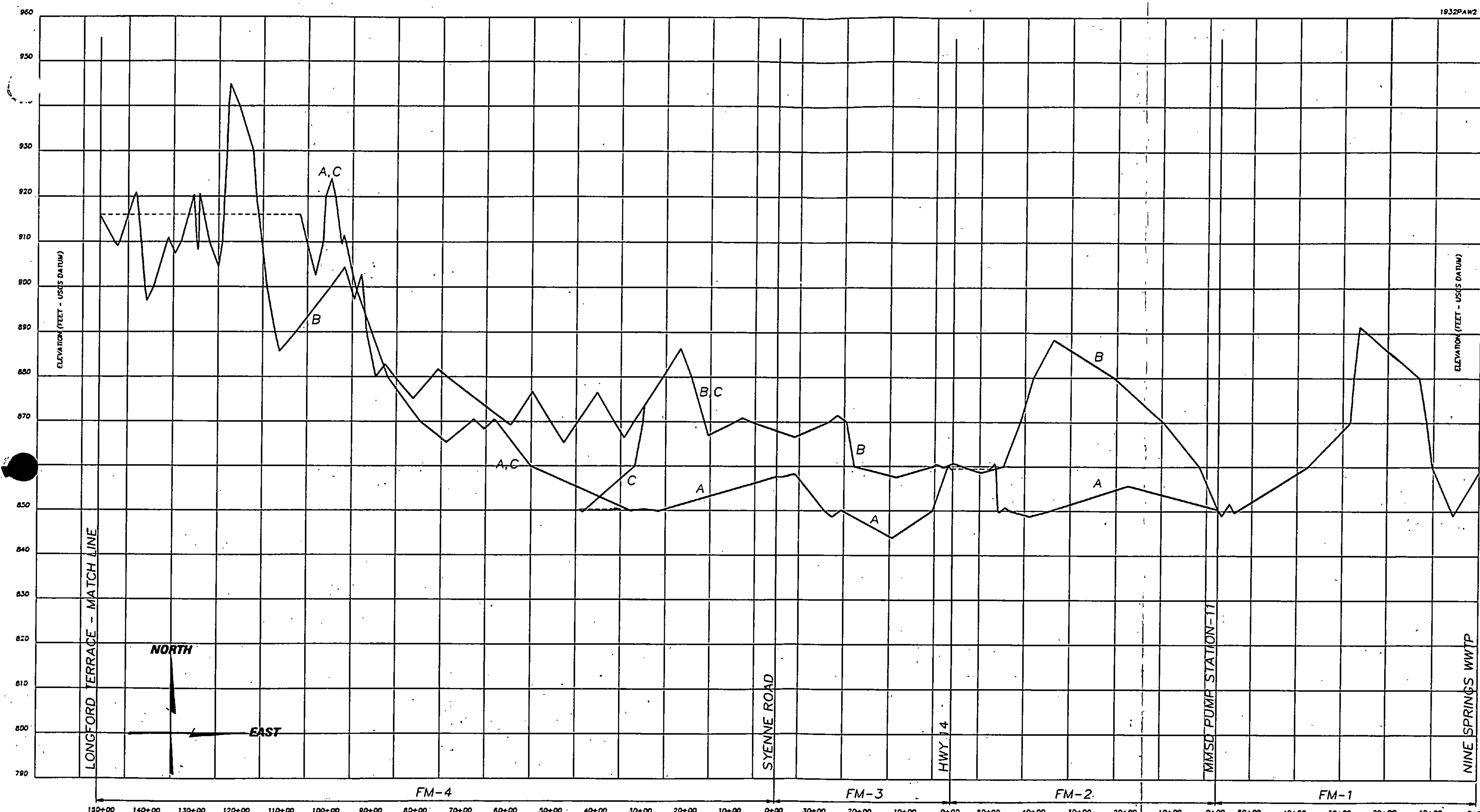


Figure 5-2
EAST HALF - GROUND PROFILE
EFFLUENT RETURN FORCEMAIN

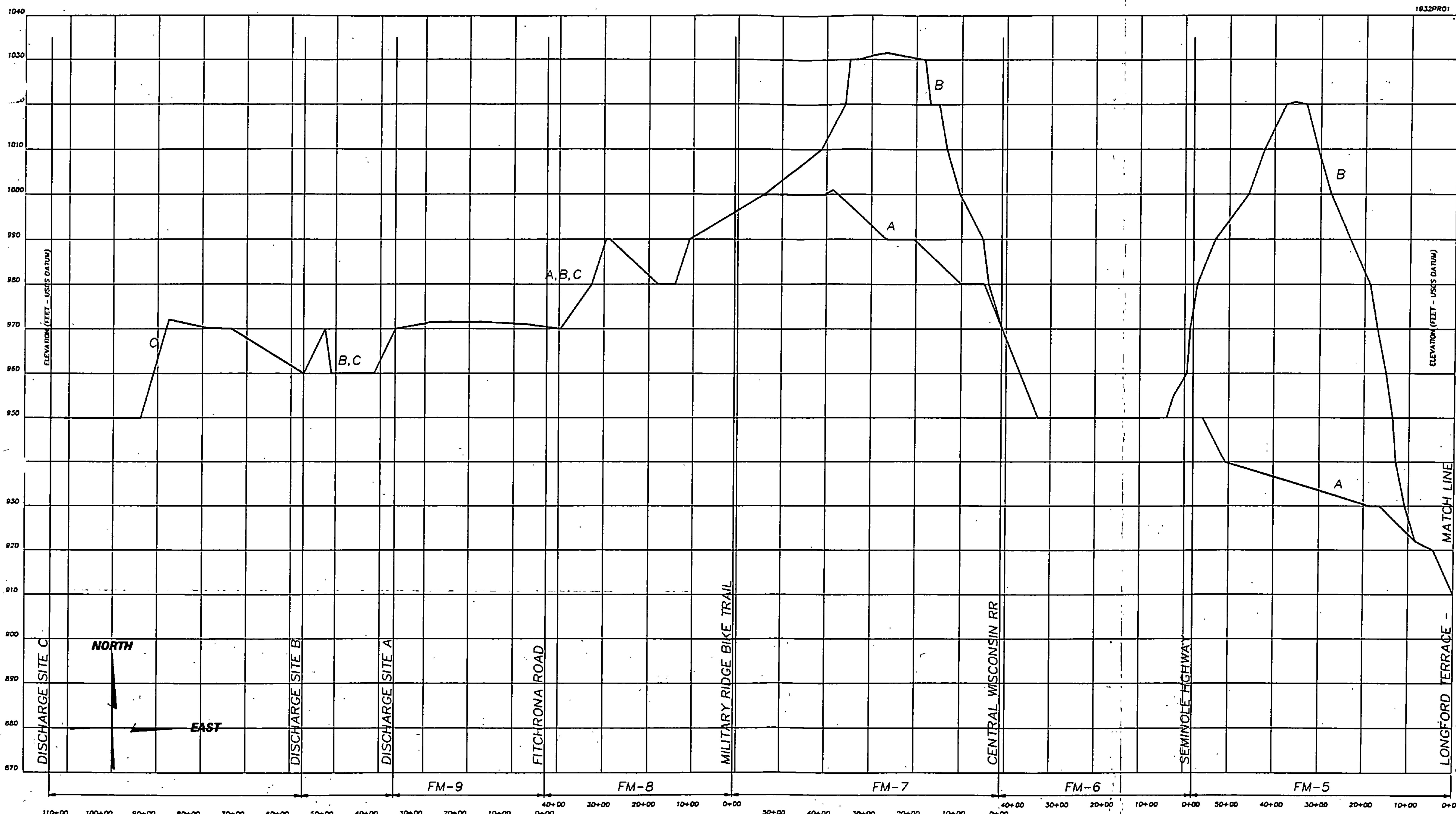


Figure 5-3
WEST HALF - GROUND PROFILE
EFFLUENT RETURN FORCEMAIN

FM-3 USH 14 to Syenne Road

Proposed routes are in two options:

FM-3A - Follows existing easement for NSVI along Nine Springs Creek, mainly in Dane County property. This route is in wetlands.

FM-3B - Follows proposed Capital City Bike Trail along McCoy Rd., mainly in existing road ROW.

FM-4 - Syenne Road to Longford Terrace (Highlands of Seminole Subdivision)

Proposed routes are in three options:

FM-4A - Follows existing easement for NSVI up to Highlands of Seminole Subdivision, then in the road ROW for proposed Longford Terrace. This route includes wetlands in Dane County property, approximately 4,000 feet of private easement acquisition, 3,000 feet in a City of Fitchburg golf course, and 1,400 feet in proposed road ROW in Highlands of Seminole Subdivision.

FM-4B - Follows proposed Capital City Bike Trail southwest to Fish Hatchery Road, McKee Road, up to Longford Terrace. This route includes Dane County property, 3,400 feet of easement in WDNR property, and about 4,200 feet of private easements. The route also includes about 2,000 feet of difficult construction in a heavily wooded ravine adjacent to Yarmouth Greenway Drive.

FM-4C - Follows proposed Capital City Bike Trail (same as 4B) to western edge of Dane County property in Section 2, then north through wetlands on Dane County property to the same alignment as 4A for the remainder of the segment.

FM-5 - Longford Terrace (Highlands of Seminole Subdivision) to Seminole Highway

Proposed routes are in two options:

FM-5A - Follows existing easement for NSVI to Seminole Highway, then south to the highway crossing location in the highway ROW. This route includes 1,400 feet in a public outlot in Highlands of Seminole, 4,200 feet of easement in Chicago & Northwestern (C&NW) Railroad ROW.

FM-5B - Follows proposed Capital City Bike Trail westward to Seminole Highway within a public outlot and an existing ROW.

FM-6 Seminole Highway to Central Wisconsin RR

Proposed route follows proposed Capital City Bike Trail south around Dunn's Marsh in City of Fitchburg, Dane County, and City of Madison properties.

FM-7 Central Wisconsin Railroad to Military Ridge Bike Trail

Proposed routes are in two options:

FM-7A - Follows existing easement for NSVI along C&NW Railroad ROW to the head of the Military Ridge Bike Trail south of McKee Road. This route includes about 5,100 feet of easement in C&NW Railroad ROW.

FM-7B - Follows proposed Capital City Bike Trail westward to Verona Road then connects with the Military Ridge Bike Trail. This route includes about 800 feet of private easements, 900 feet in City of Fitchburg property, and 4,500 feet in highway ROW.

FM-8 Military Ridge Bike Trail Head to Fitchrona Road

Proposed route follows existing Military Ridge Bike Trail in abandoned railroad ROW and includes about 4,300 feet of easements in WDNR Bike Trail.

FM-9 Fitchrona Road to discharge sites

Proposed routes are in three options:

FM-9A - Follows existing Military Ridge Bike Trail in abandoned railroad ROW to discharge site A, immediately southwest of Goose Lake.

FM-9B - Follows existing Military Ridge Bike Trail in abandoned railroad ROW to discharge site B near Badger Mill Creek highway crossing.

FM-9C - Follows existing Military Ridge Bike Trail in abandoned railroad ROW to discharge site C on county property south of the Bike Trail and west of CTH PB.

Three main route options were developed by combining the line segments identified above. In addition to route options, several techniques were identified for use with the routes. These include technique Tl, forcemain, or T3, gravity sewer, and either techniques T2, effluent pumping, or T4, in-line booster pumps. These routes and techniques are briefly described below.

Route A. This route was labeled the Nine Springs Valley Interceptor (NSVI) Route because it would generally follow MMSD's NSVI from the NSWWTP to MMSD pump station 12 on Fitchrona Road. On Figures 4-2 and 4-3 this route is composed of line segments FM-1, -2A, -3A, -4A, -5A, -6, -7A, 8, and 9, A, B, or C, depending on discharge location. Segment 9 would be routed within the abandoned railroad right-of-way occupied by the Military Ridge Bike Trail. As shown on Figures 5-2 and 5-3 the highest ground surface elevation for Route A is about 1,000 feet (USGS datum).

Route B. This route was labeled the Capital City Trail route because it would generally follow the proposed Capital City Trail being developed by Dane County. The route would follow the trail from MMSD pump station 11 to pump station 12. On Figures 4-2 and 4-3 this route is composed of line segments FM-1, -2B, -3B, -4B, -5B, -6, -7B, 8, and 9, A, B, or C, depending on discharge location. As shown on Figures 5-2 and 5-3, Route B has two main peaks at about 1,020 and 1,030 feet (USGS datum).

Route C. This route was labeled the Combination route because it would contain segments from both the NSVI and Capital City routes. The route would follow the NSVI in line segments FM-1, -7A, and 8. The route would follow the Capital City Trail alignment in line segments FM-2B, -3B, 5B, and 6. This alternative includes route C in FM-4 (See Figure 4-2) and FM-9 along the Military Ridge Trail. As shown on Figures 5-2 and 5-3 Route C the highest elevation for Route C is at about 1,020 feet (USGS datum).

Technique 1: Forcemain. The proposed effluent transmission line will be a forcemain constructed with ductile iron piping wrapped in plastic. The diameter will be 16-20 inches, depending on the hydraulic and economic analyses presented in Section 6. The transmission line will be buried about 6 feet deep, and will be equipped with air/vacuum release valves at all high points in the pipeline profile.

Technique 2: Effluent Pumping. The effluent will be pumped from the existing Effluent Building at the NSWWTP by installing two centrifugal pumps in an existing space in the Pump Room in the Effluent Building. The sizing and characteristics of the new effluent pumps are presented in Section 6.

Technique 3: Gravity Sewer. Gravity sewer could be used for certain portions of the transmission system, utilizing gravity to reduce the energy requirements of the transmission system. Gravity sewer would need a pipe diameter larger than the forcemain to accommodate a given flow, and would need to be buried deeper to achieve the required slope.

Technique 4: In-line Booster Pumps. Booster pumps installed at intermediate points could be used to decrease the pipeline size. Booster pumps could also be used to shorten the length of the line by pumping from a direct tap into the existing 54-inch effluent forcemain near MMSD pump station 11.

Protecting Aquatic Life

Protecting aquatic life consists of selecting discharge limits and treatment techniques that ensure consistent treatment plant operation that meets the selected limits. Options for protecting aquatic life and meeting the discharge limits depend on the volume of effluent, the characteristics of the NSWWTP effluent and receiving water, and WDNR acceptance of alternative approaches for determining limits. Section 4 presented a number of different approaches for determining limits and protecting aquatic life. The following options are based on either the WDNR approach or WDNR acceptance of the approaches presented in Section 4.

Option 1: WDNR-Calculated Limits. This option consists of accepting the WDNR-Calculated limits presented in Table 4-1 of Section 4. Acceptance of these limits means that effluent characteristics will need to be improved. This could be done by reducing the frequency and magnitude of BOD_5, TSS, and NH_3-N excursions in NSWWTP effluent.

Option 2: Site-Specific Proposed Limits. This option consists of obtaining WDNR approval of the site-specific modeling and alternative ammonia limit presented in Section 4. This modeling showed that NSWWTP effluent is currently of sufficient quality to protect the aquatic life in

Badger Mill Creek and the Sugar River, while EPA methods and approaches specific to Badger Mill Creek showed that worst case NSWWTP effluent ammonia characteristics are not toxic. Limits presented in Table 4-15 would be accepted with approval of the modeling and alternative approaches. With this alternative the frequency and magnitude of excursions would not have to be reduced. However, an outfall aerator would be needed to maintain dissolved oxygen (DO) levels.

A number of techniques can be used to meet the optional effluent limits above. The overall organization of the techniques and options is summarized in Figure 5-1. A brief description of each technique is given below.

Technique 5: Outfall Aeration. Aeration will be needed to meet initial DO limits for all four discharge limit options regardless of other techniques utilized. Aeration would consist of a cascade aerator, steep inclined aerator, or manufacturer-supplied aerator.

Technique 6: Refinement of Nitrification Operating Protocol. This refines the operating criteria to achieve the required level of nitrification and meet effluent limits. This technique would be used with Option 1.

Technique 7: EBPR Improved Settling Characteristics. This would wait to see how much the addition of EBPR will improve BOD_5 and TSS characteristics before completing other improvements. Enhanced biological phosphorus removal processes have been shown to provide improved performance in BOD_5 and TSS removal over normal activated sludge processes. EBPR is already being added to the capabilities of NSWWTP and will therefore provide benefits under both discharge limit options.

Technique 8: Polymer Addition. This option would add polymer at NSWWTP to increase the removal of TSS and possibly BOD_5. If the goal is primarily to reduce the TSS excursions, polymer need be added only when TSS is a problem. Since TSS limits are regulated as a monthly average, problems could be identified and polymer addition started in a timely manner. This technique could be used with discharge limit Option 1, and could also be used as a sequential improvement to be tried after completing Technique 7, EBPR Improved Settling Characteristics.

Technique 9: Wetland Treatment. This would construct a wetland as part of the treatment system. The two identified locations for wetland treatment systems are: Site A, DOT Wetland and Site J/K, Dane County Parks 1. This technique could be used in conjunction with Option 1.

Technique 10: Rock Filter Outlet. Another technique to help improve the wetland performance is a rock filter outlet to filter out residual plant materials, BOD_5, and TSS prior to discharging to Badger Mill Creek.

Technique 11: Effluent Filtration. This technique would filter effluent at NSWWTP. This technique could be used with Options 1 and 2, or as a sequential improvement based on the success of techniques 5, 6, and 7.

ALTERNATIVE II: RETURN EFFLUENT WITH WATER QUALITY, AND STREAM CORRIDOR IMPROVEMENTS

This alternative includes necessary improvements for the transmission line route and protection of aquatic life options and techniques presented above for Alternative I, with added value options and strategies for additional water quality and stream corridor improvement. Transmission and discharge limit options and techniques are the same as Alternative I except for the wetland systems. For Alternative II constructed wetlands would not be part of the treatment system. Limits would be met prior to discharge into the wetlands, and the wetlands would be used only for additional effluent polishing or wildlife improvement. Options for additional improvement include wetland creation and/or restoration, improved stormwater management, improved erosion control practices, and channel improvements. Options and techniques for Alternative II are summarized in Figure 5-4.

The added value improvement options are presented as strategies and are not necessarily part of the traditional role that MMSD provides. Some of the strategies are better implemented by other agencies or the greater Madison community as part of the Priority Watershed Project planned for the Sugar River in 1997. This section discusses the implementation responsibility of each strategy. Those where responsibility could or should be with MMSD are evaluated in greater detail in Section 6 along with the necessary improvements. Those strategies where responsibility is not with MMSD or would be better implemented through the Priority Watershed Project are not evaluated further, but are suggested as strategies to be further investigated and refined as part of that plan.

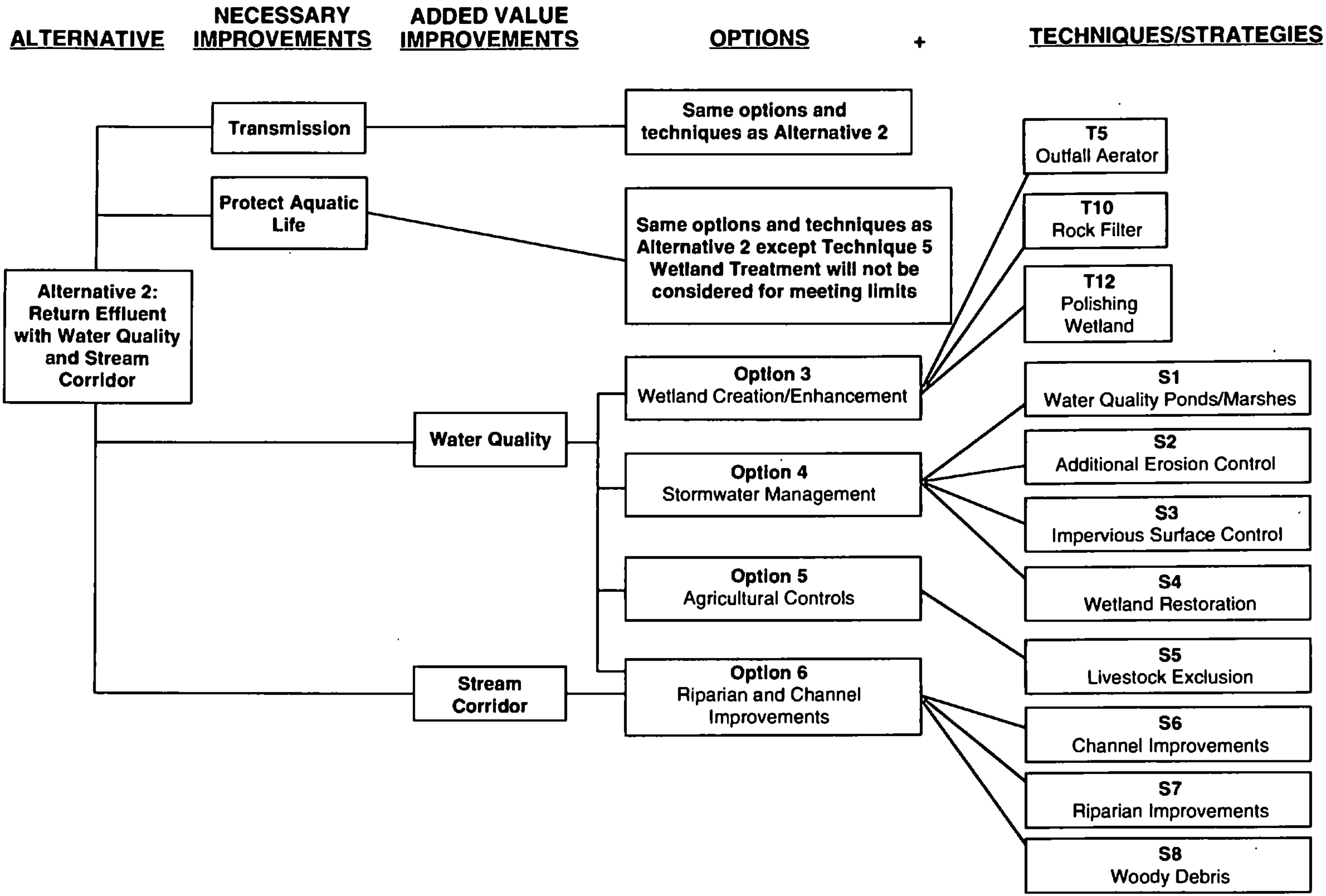


FIGURE 5-4: DEFINITION OF ALTERNATIVE II OPTIONS, TECHNIQUES, AND STRATEGIES

Water Quality Improvements

Water quality improvements include the four options and seven strategies presented below.

Option 3: Wetland Creation/ Enhancement. This option would use a portion of the Site A DOT wetland or Sites J/K Dane County Park Sites to create a wetland using the effluent as the water source. Potential techniques for use with this options include T12, Polishing Wetland; T5, Outfall Aerator; and T10, Rock Filter Outlet. Techniques T5 and T10 were previously defined under Alternative I. Technique T12, Polishing Wetland, is defined below and is different from technique T9, Treatment Wetland, since effluent limits would be met prior to discharge into the polishing wetland and the primary goal would be additional effluent treatment.

Technique 12: Polishing Wetland. MMSD would be responsible for implementing this technique. While not part of the official treatment system, effluent would be the water source and the primary implementation goal would be additional effluent treatment. Polishing benefits could be realized primarily for TSS, TP, and NH_3-N. Effluent BOD_5 would already be near the residual wetland concentration. Since this is a polishing wetland with no regulatory discharge limits, any size could be used.

The primary differences between wetlands for this alternative and treatment wetlands are the goals discussed above, and the regulatory requirements. WDNR currently requires a liner for treatment wetlands; this would not be required for a polishing wetland that is not part of the treatment system.

Since effluent limits are met prior to discharge, an additional aerator (Technique 5) at the outlet of the wetland would be optional and would probably benefit the aquatic life of Badger Mill Creek. A rock filter (Technique 10) to remove residual BOD would also be optional and may be beneficial.

The primary difference between the two wetland sites is the length of the transmission line and the ability to route the transmission line past the new interchange for Highway 18/151 east of Verona. Costs associated with this difference are presented and discussed in Section 6.

Option 4: Stormwater Management. This option consists of strategies to improve the quality of stormwater runoff. These added value improvements are not under the control of MMSD, but would either benefit Badger Mill Creek and the Sugar River, or protect MMSD's effluent return investment. These strategies could be implemented by area cities or the county with assistance from the Priority Watershed Program, and should be investigated further during development of that plan.

Stormwater management strategies are based on observations during the field work and discussions with the Madison and Verona city personnel. The primary concerns regarding stormwater management are the large sediment deposits observed in Badger Mill Creek and the rapid urban development in the upper portions of the Badger Mill Creek watershed.

Both the cities of Madison and Verona have stormwater management ordinances, erosion control programs, and strategies that are described in Section 3.

Additional strategies which would target sedimentation in the creek as well as other pollutants associated with sediment include the following:

Strategy 1: Additional Water Quality Ponds/Marshes. This strategy would construct water quality ponds or marshes to treat sediment and nutrients in stormwater runoff. The potential locations observed are shown on Figure 5-5 and include the following:

- The northeast corner of intersection of Maple Grove Road and Nesbitt Road
- South of Nesbitt Road and north of Highway 18/151
- West of Bischoff's Pond
- The old SCS grade control structure
- The City of Verona planned detention pond at the intersection of Silent Street and Enterprise Drive
- The Verona city park enclosed by Harriet and Mary Lou Streets
- Within the DOT interchange of CTH PB and Highway 18/151 bypass

Strategy 2: Additional Erosion Control Protection. Large areas along CTH PD and Maple Grove in the City of Madison are currently being developed. While erosion control measures (sedimentation ponds) are in place, a large amount of land was denuded at the same time. The Verona bypass construction also exposed a great deal of soil to erosion, much of which was not stabilized over the 1994-95 winter. Standard erosion control practices are not 100% efficient and typically degrade over winter such that the first few spring rains can cause significant erosion and sediment transport. The single most effective improvement that could be made would be to limit the amount of soil exposed at one time. This can be done by requiring

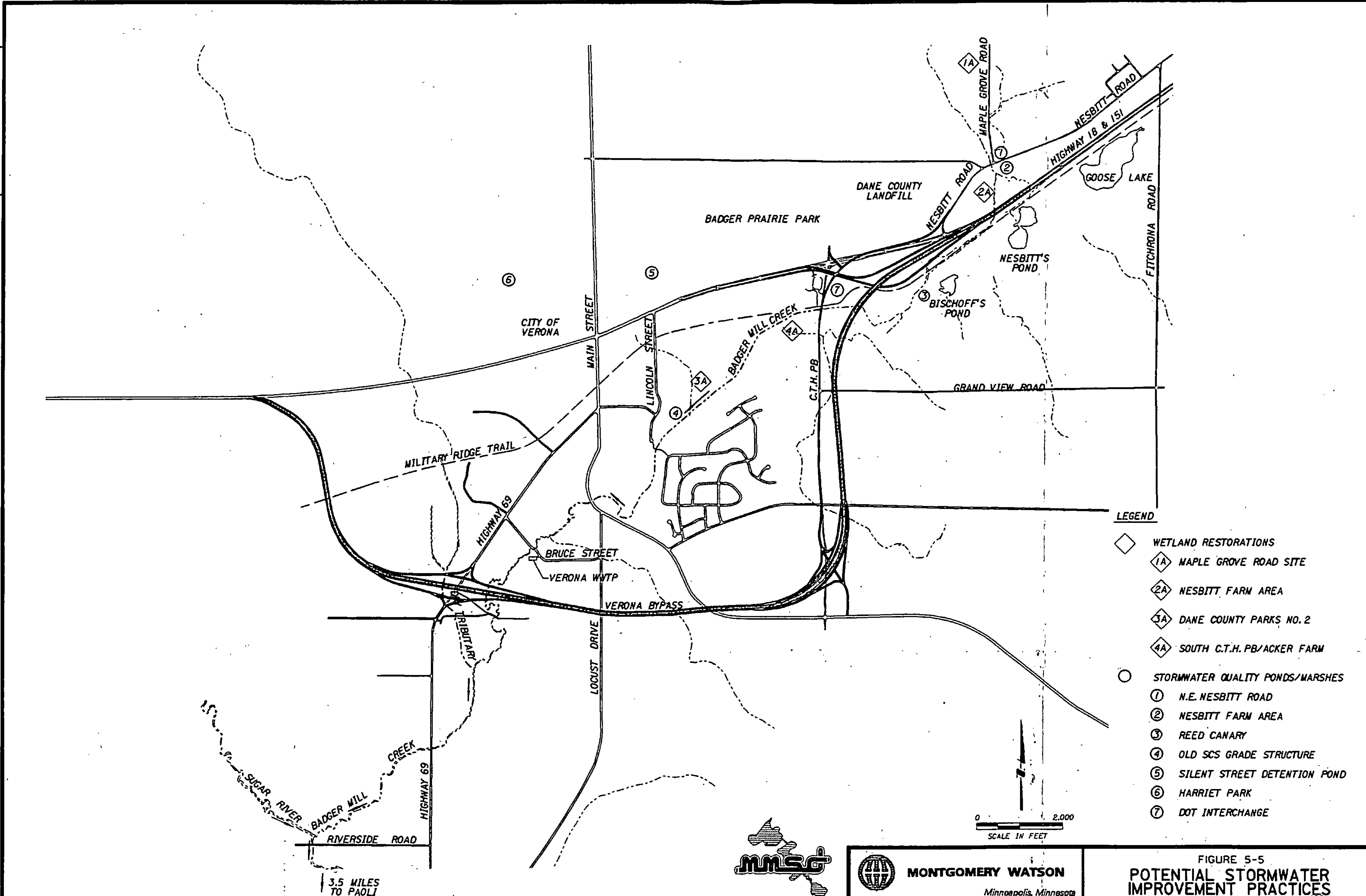


FIGURE 5-5
POTENTIAL STORMWATER IMPROVEMENT PRACTICES

JOB No. ______ FILE No. /usr/proj/verona/ ______ DATE 10/6/95 and enforcing provisions for any area of denuded land to be stabilized prior to winter with vegetation, and/or requiring any denuded area without activity for a specified period to be stabilized with vegetation.

Recent erosion control measures in the project area have degraded over the 1994-95 winter. Erosion control would have been more effective with earlier erosion control practices in the spring and/or temporary stabilization of areas with vegetation prior to winter. Potential actions for erosion control improvement include the following:

- Seasonal "window" for construction
- Maximum road prism widths
- Maximum percent of area exposed
- Maximum time of exposure (30-60-90 days)

Strategy 3: Impervious Surface Control. In an urban environment where most of the post-construction pollution comes from impervious surfaces, minimizing the amount of impervious surface can help water quality. One means of minimizing impervious surfaces is through zoning. However, much of the upper watershed area is already planned and zoned. Little opportunity exists for upgrading zoning to larger lot sizes. However, the Dane County Parks department has a greenway corridor plan (Ice Age Trail Junction Plan) for much of the area in the upper watershed north of Highway 18/151. Implementation and support of this plan will help preserve open space and limit impervious surfaces. Other strategies which could help control the amount of impervious area are density transfers to lower priority areas, or bonuses for lower impervious construction. Runoff from impervious surfaces can also be controlled by promoting sump areas with no outlet and infiltration areas.

Strategy 4: Wetland Restoration. Wetland restoration through reestablishing wetland hydrology (not using effluent) and vegetation can help improve water quality by restoring areas for filtration and sedimentation, and by slowing down or storing runoff. Potential wetland restoration sites are shown in Figure 5-5 and include the following:

- Maple Grove Road Site
- Nesbitt Farm area
- Dane County Park area west of model airplane field
- Portion of Acker Farm (old Badger Mill Creek alignment)

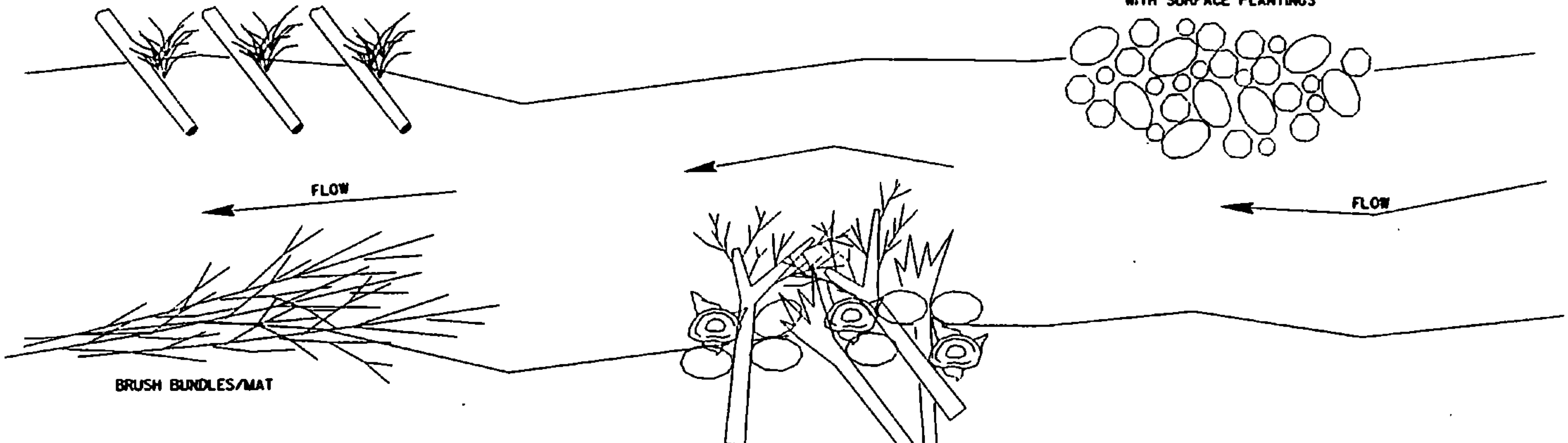
The water quality performance can be improved and future maintenance activities simplified by excavating a pretreatment sedimentation area at the upstream end of the wetland.

Option 5: Agricultural Nonpoint Source Controls. This option would promote agricultural nonpoint source controls. Observations made during the field reconnaissance found that about 500 feet of channel in the lower reaches of Badger Mill Creek is affected by livestock access. These added value improvements are not under the control of MMSD, but would either benefit Badger Mill Creek and the Sugar River or protect MMSD's return effluent investment. MMSD does not have the infrastructure to coordinate agricultural management practices with farm producers, but could work through the Soil and Water Conservation District or the Priority Watershed Project to promote these practices.

Strategy 5: Livestock Exclusion. Livestock exclusion could be promoted along those portions of Badger Mill Creek where livestock have access. The WDNR already has a riparian easement acquisition program. This program could be promoted as a means of acquiring easements with additional funds obtained from either the priority watershed program or the USDA ACP program for fencing and livestock crossings. The WDNR easement program could also be made more attractive to property owners by having local sponsors supplement the easement payments. This would spread the cost around, take advantage of, and leverage existing programs.

Option 6: Channel and Riparian Improvements. This option consists of channel alternations and riparian plantings to improve water quality and the stream corridor. Channel alterations in reaches 4 (Main Street to CTH PB) and 5 (upstream of CTH PB) have the potential to improve both dissolved and TSS loads, while riparian planting in almost all reaches has the potential to improve stream temperatures. MMSD, the City of Verona, and WDNR could all participate in these improvements. While not in the traditional focus of MMSD these improvements could be completed as part of installing a direct discharge to the creek.

Strategy 6: Channel Improvements. Channel improvements in reaches 4 and 5 have the potential to improve both DO and TSS. Portions of these reaches have low slopes and are overwidened. This combination creates a wide shallow flow area with low velocities where sediment accumulates and DO reaeration is low. Channel improvements (Figure 5-6) to narrow the low flow channel could increase velocities, increase DO reaeration, and prevent sediment deposition. Narrowing the channel could also improve stream temperatures by reducing the surface area exposed to solar radiation. Warm water fish habitat diversity would also be



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	MONTGOMERY WATSON Minneapolis, Minnesota	TYPICAL STRUCTURES FOR FISH HABITAT IN THE MIDDLE AND UPPER REACHES OF BADGER MILL CREEK	Figure 5-6

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improved. These improvements could be constructed within the existing channel. Construction of the channel improvements as shown in Figure 5-6 would also create sediment bars which could be stabilized with vegetation to store the sediment in the channel and slow the migration of existing sediment deposits.

Strategy 7: Riparian Improvements. This strategy includes planting trees and shrubs or seeding grasses as part of improving the riparian areas along Badger Mill Creek. Temperature reduction would be the primary water quality benefit of this strategy. Motivated volunteers from the Dane County Conservation League and the Ice Age Trail maintenance group would reduce costs for this strategy.

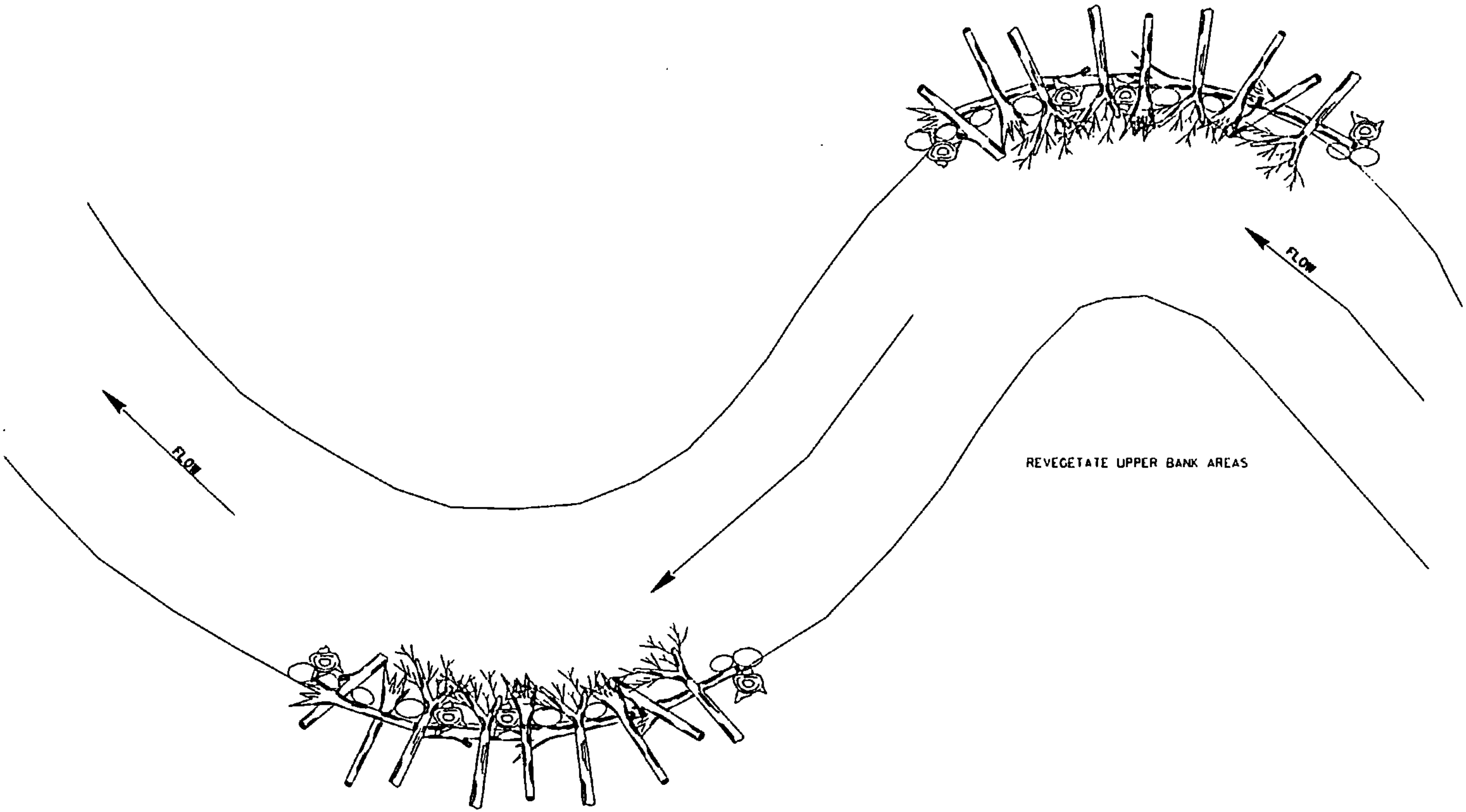
There has been considerable discussion by the advisory group concerning the appropriate vegetation. The natural vegetation in the driftless area near the month of the creek was prairie. However, the creek has been significantly altered from its natural condition and other types of vegetation may be appropriate. In fact most of the lower reach has already been planted with spruce seedlings. This strategy should be discussed further and would be best implemented as part of the priority watershed project.

Stream Corridor Improvements. These improvements include strategies 6 and 7 discussed above, and strategy 8, Woody Debris, described below.

Strategy 8: Woody Debris. This strategy includes strategically incorporating woody debris in the creek. This debris would provide structure and greater variety of habitat types. An example of the use of debris in the lower reaches is shown in Figure 5-7.

CONCLUSION

This section identified and defined two alternatives for returning effluent along with strategies to improve water quality and the stream corridor. These strategies require further evaluation and refinement. Strategies that are best implemented by organizations other than MMSD should be refined through the priority watershed project. Added value techniques and strategies that could be implemented by MMSD (T12, Polishing Wetland; S6, Channel Improvements; and S8, Woody Debris) are evaluated in Section 6 along with the necessary improvements.



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EXAMPLE PLACEMENT OF ROCK AND WOODY DEBRIS FOR HABITAT AND BANK STABILIZATION IN THE LOWER REACHES OF BADGER MILL CREEK

Figure 5-7

Section 6

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SECTION 6

ALTERNATIVES EVALUATION

This section documents the evaluation of the alternatives, options, techniques, and strategies identified in Section 5 to meet regulatory constraints, mitigate impacts for the project elements identified in Section 4, and remedy the existing watershed and fisheries problems identified in Section 3. Each of the options, techniques and strategies was evaluated as to its technical feasibility, regulatory considerations, benefit, and cost. The evaluation is organized by the two alternatives identified and developed in Section 5:

- Alternative I: Return Effluent
- Alternative II: Return Effluent with Water Quality and Stream Corridor Improvement

ALTERNATIVE I: RETURN EFFLUENT

The return effluent alternative consists of providing necessary improvements or the basic infrastructure to return the effluent and protect aquatic life. Actions necessary to complete this alternative consist of building the transmission line and either improvements to meet effluent discharge limits or WDNR acceptance of alternative discharge limits.

Transmission Line

Three routes for the effluent return transmission line were presented in Section 5 as well as four techniques. Detailed description and evaluation are presented in a technical memorandum for the transmission line included as Appendix I. Two of the four techniques were eliminated because of technical considerations. T3, gravity sewer piping was eliminated because larger pipe diameters are required to accommodate a given flow, and because greater burial depths would be required to achieve the required slope. The topography of the routes and the hydraulic grade line are such that the use of gravity sewers would not be economically attractive. The additional construction costs of gravity sewers would far outweigh any energy savings.

The second technique eliminated was T4, the use of in-line booster pumps to reduce the forcemain size and length. In-line booster pumps would be located at sites remote from the NSWWTP. The remote location and variable system head conditions would make it difficult to operate and maintain the booster pump station(s). Booster pump stations would also introduce undesirable control complexity that would make flow rate control of the effluent return system less reliable.

The two remaining techniques, T1, forcemain piping from the NSWWTP to Badger Mill Creek and T2, effluent pumping at the NSWWTP, would be employed for all three proposed routes. A key to both of these techniques is forcemain sizing.

The pipe size chosen for technique T1, forcemain, was based on hydraulic and cost considerations. There are practical tradeoffs between construction costs and energy requirements. Table 6-1 illustrates the costs associated with four pipe sizes considered. The comparison is shown for a flowrate of 3.6 mgd, the maximum flow projected for the study period. The additional material costs for larger pipe sizes are generally not offset by the energy savings. A pipe size of 20 inches was selected for the cost analysis to keep the pump discharge pressure less than 100 psi and provide reserve capacity beyond the 20-year study period.

TABLE 6-1

COMPARISON OF FORCEMAIN COSTS

Pipe Size (inches)	Flow Velocity[1] (ft/sec)	Total Dynamic Head[2] (ft)	Annual Pumping Costs ($)	Pipe Material Costs[3] ($)
16	3.6	314	72,000	935,000
18	2.9	243	56,000	1,143,000
20	2.3	207	48,000	1,335,000
24	1.6	174	40,000	1,780,000

[1] Based on a flow of 3.6 mgd
[2] Includes static head of 150 feet and frictional losses through 52,000 feet of pipe
[3] For 52,000 feet of pipe, excluding installation costs

Once the forcemain sizing was determined, the transmission line route options were evaluated in terms of construction and operational costs and feasibility of construction. The cost estimates were based on a pipeline burial depth of 6 feet and a 20-inch diameter pipe. Each of the pipeline alignments resulted in a different point of highest elevation with corresponding static head requirement which affected operating costs. Each alignment also resulted in a different length of pipeline which affected capital and operation costs. Table 6-2 summarizes the hydraulic characteristics of the three routes and Table 6-3 summarizes the costs.

New effluent pumps (technique T2) will be installed at the NSWWTP to deliver treated effluent through the transmission main. If filtration is not required, the new pumps would be installed in the existing Effluent Building adjacent to MMSD's existing effluent pumps. If filtration is required, the new pumps would be installed in the new Filtration Building, pumping from a filtered effluent wet well.

There are adequate space and power available to install two centrifugal pumps in the Effluent Building. Routing the new discharge line out of the building will be difficult because of interference with the existing 54-inch effluent pipe outside the building. The pumps would be sized for a flow range of 2.2 to 3.6 mgd, with brake horsepower requirements of about 200 hp. Variable flow could be provided with variable speed controls or a flow control valve arrangement to control releases at 1.94 mgd or less during high flow conditions. The preferred control will be determined during design. A single pump would deliver the required flow and the second pump would serve as backup. The estimated cost to install the effluent pumps is $175,000.

Techniques T1, forcemain and T2, effluent pumping will be used for all three possible routes. These routes are evaluated below.

Route A. The Nine Springs Valley Interceptor (NSVI) Route was described in Section 5 and is shown on Figures 4-2, 4-3, 5-2, and 5-3.

Technical Feasibility. Route A is the shortest of the alternatives, with the lowest pump head requirements. This route would traverse about 12,000 feet of wetlands along the Nine Springs Creek and would also have the most roadway and railway crossings, as well as easement acquisition.

TABLE 6-2

TRANSMISSION LINE HYDRAULIC COMPARISON

Route	Total Length[1] (ft)	Highest Elevation (ft)	Static Head (ft)	Total Pump Head (ft) at 2.2 mgd	at 2.9 mgd	at 3.6 mgd
A, NSVI	50,100	1,002	151	174	189	207
B, Capital City	56,200	1,032	182	207	224	245
C, Combination	50,900	1,020	170	193	208	227

[1] Transmission line length assumes discharge site B on Badger Mill Creek

TABLE 6-3

TRANSMISSION LINE COST SUMMARY

Route	Construction Cost[1] ($)	Total Project Cost[2] ($)	Annual Pumping Cost[3] ($) at 2.2 mgd	at 2.9 mgd	at 3.6 mgd	Present Worth Cost[4] ($)
A, NSVI	4,500,000	4,900,000	22,000	31,000	42,000	5,100,000
B, Capital City	4,600,000	5,000,000	27,000	38,000	52,000	5,300,000
C, Combination	4,200,000	4,600,000	24,000	33,000	44,000	4,900,000

[1] Construction cost includes 20% contingency
[2] Total project cost includes 10% engineering and administrative
[3] Assumes 81% overall pump/motor efficiency
[4] 8.25% interest rate, 20-year period, salvage value not deducted

Regulatory Considerations. The main concern of this route is the potential temporary disturbance of the wetlands in the Nine Springs Meadows Natural Area. Once the pipeline was installed, however, conditions could be restored and no future disturbance would be necessary. A U.S. Army Corps of Engineers 404 Permit would be needed, and the project should be eligible for a Nationwide Permit 19. Other necessary permits include construction erosion control and a WDNR Chapter 30 Permit for stream crossings.

Benefits. Route A would provide the effluent return capacity with the lowest energy consumption.

Estimated Cost. The estimated costs for the transmission line on Route A are shown in Table 6-3. The construction costs for this route reflect the difficulties associated with wetland construction and easement acquisitions, so although it is the shortest and lowest head alternative, Route A is not the lowest cost.

Route B. The Capital City Trail Route was described in Section 5 and is shown on Figures 4-2, 4-3, 5-2, and 5-3.

Technical Feasibility. Route B is the longest of the alternatives with the highest pump head requirements. This route would avoid the wetlands along the Nine Springs Creek and would parallel roadways and follow bike trails for most of the route. This route would be difficult to construct along McKee Road west of Fish Hatchery Road because of roadway and utility congestion. The route would also require construction in a steep, wooded ravine along the east side of the Forsythe Green Park. Construction difficulties in this area could be severe enough to make this section of Route B unfeasible.

Regulatory Considerations. Necessary permits include construction erosion control and a WDNR Chapter 30 Permit for stream crossings. A U.S. Army Corps of Engineers 404 Permit for small wetlands and stream crossings would be needed, and the project should be eligible for a Nationwide Permit 19.

Benefits. Constructing Route B would disturb wetlands the least and require the fewest private easements.

A significant benefit of this route is that it would parallel Dane County's Capital City Bike Trail. Constructing the transmission main would provide the clearing and grubbing required for the trail.

Estimated Cost. The estimated cost for the transmission line on Route B in Table 6-3 shows that this alternative would have the highest cost. Construction costs for this route reflect the greater forcemain length (about 6,000 feet longer than Route A) and the higher energy requirements (30 feet more static head than Route A).

Route C. The Combination Route was described in Section 5 and is shown on Figures 4-2, 4-3, 5-2, and 5-3.

Technical Feasibility. Route C is about 1,000 feet longer than Route A, with pump head requirements between those of Routes A and B. This route would avoid most of the wetlands along Nine Springs Creek (about 4,000 feet in wetlands) and would avoid the high peak in Route B. Route C would also avoid the difficult construction conditions near the intersection of McKee and Fish Hatchery Roads.

Regulatory Considerations. The main concern of this route is the potential temporary disturbance of the wetlands in the Nine Springs Meadows Natural Area. Once the pipeline was installed, however, conditions could be restored and no future disturbance would be necessary. A U.S. Army Corps of Engineers 404 Permit would be needed, and the project should be eligible for a Nationwide Permit 19. Other necessary permits include construction erosion control and a DNR Chapter 30 Permit for stream crossings.

Benefits. Route C is a compromise between Routes A and B, significantly reducing the disturbance to wetlands in Route A yet avoiding the highest peak of Route B. Route C would provide the clearing and grubbing required to construct a significant portion of the Capital City Bike Trail.

Estimated Cost. The estimated cost for the transmission line on Route C in Table 6-3 shows that this alternative would have the lowest construction and present worth costs.

Summary of Transmission Options. Three routes were identified for the effluent return transmission line from the NSWWTP to the discharge site on Badger Mill creek.

The transmission line would be about 10 miles long and would cost about $5 million to construct. Annual operating costs range from $25,000 to $50,000. Route C was identified as the preferred route for the transmission line. In addition to being the lowest cost alternative, Route C would avoid most of the wetlands construction and the highest peaks in the profile. It would parallel Dane County's proposed Capital City Bike Trail for a significant distance, providing clearing for the trail. One refinement was made to the selected route: In force main segment FM-5 (between Longford Terrace and Seminole Highway) the route will follow the Route A instead of Route B, running along the south side of the railroad right-of-way. This will avoid the elevation peak at 1,020 feet in Route B in this segment and a heavily wooded area.

Protecting Aquatic Life

Under Alternative I, Return Effluent, two options were evaluated for setting effluent discharge limits that protect aquatic life. Option 1 is to accept the WDNR-calculated limits, and Option 2 is to obtain WDNR approval of site-specific limits. Both sets of limits would be met by the average characteristics of NSWWTP effluent, but an outfall aerator would be needed in either case to maintain DO concentrations at stream standards. In addition, Option 1 would require facility improvements to reduce the frequency and magnitude of concentrations at the high end of the range historically observed for NSWWTP effluent.

Techniques for an outfall aerator and for reducing these excursions are evaluated below.

Technique 5: Outfall Aeration. Outfall aeration is required to raise the DO concentration in the discharge to Badger Mill Creek to a level which meets WPDES requirements. Both the type and location of the aerator are important issues with regard to the feasibility of Alternative I: Returning Effluent. Options for both of these issues are discussed below.

Type of Outfall Aerator. The three types of aerators investigated were a cascade aerator, a steep inclined aerator, and a manufacturer-supplied aerator. A cascade aerator is similar to the existing NSWWTP aerator and has consecutive weirs and pools to entrain air and promote oxygen transfer. A steep inclined aerator transfers oxygen through turbulence at the air-water interface created in the flow as the flow travels an inclined plane. Parkson Corporation, a manufacturer of wastewater treatment units, provides an Oxycharger unit designed to promote reaeration of WWTP effluent. It uses concentric tubes of 304 stainless steel with perforations at the top of alternating tubes to create a condition similar to that of the cascade aerator in which turbulent overflows which cause oxygen transfer and entrain air bubbles are followed by flow areas which allow oxygen transfer from the bubbles to the liquid stream. Conceptual designs of the aerators shown in Figures 6-1 through 6-3 are based on the following conservative criteria:

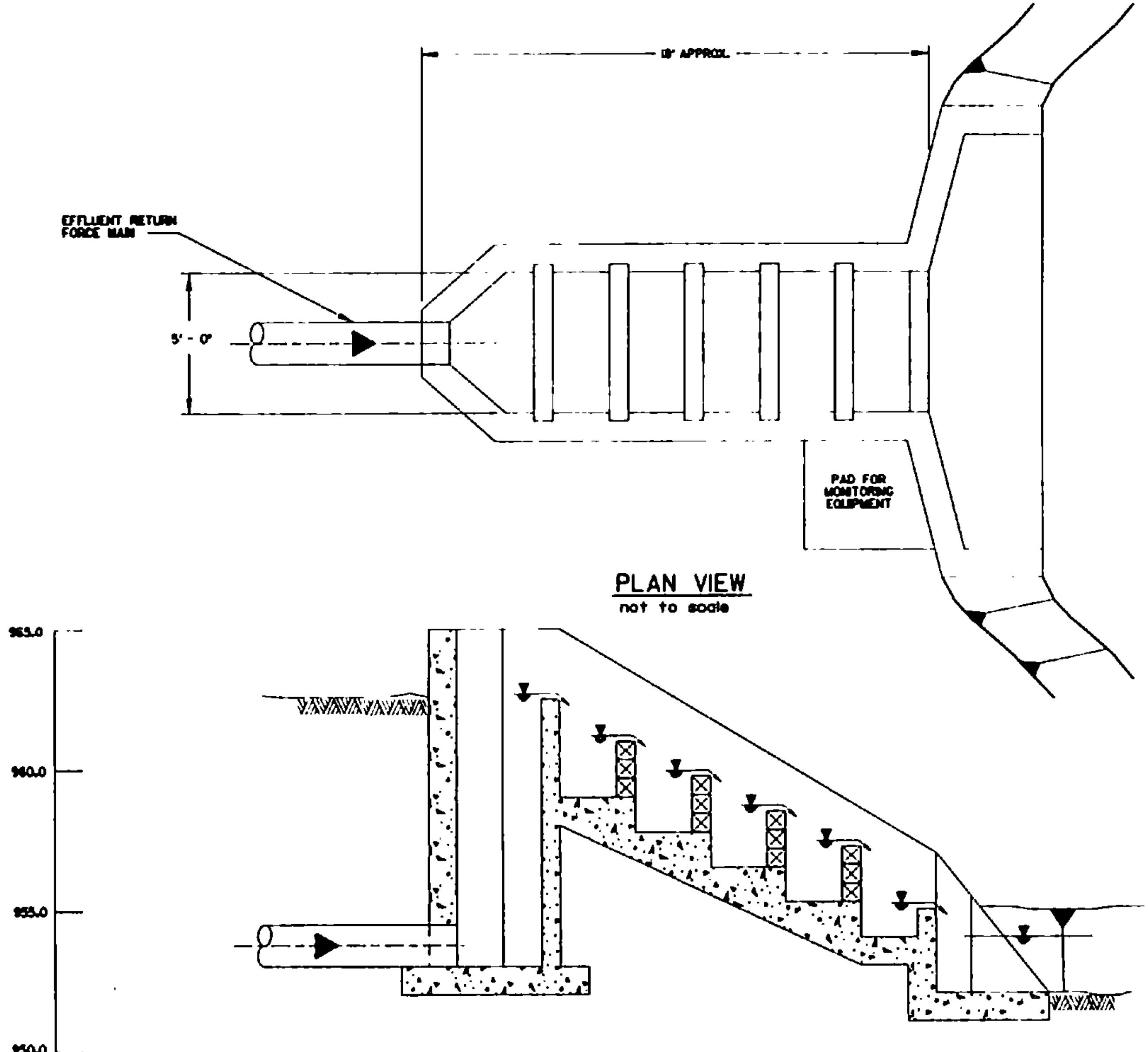
• Flow	3.6 mgd
• Upstream DO Concentration	2.0 mg/L
• Target DO Concentration	6.0 mg/L
• Maximum Temperature	22°C
• Minimum Temperature	10°C

These criteria are based on review of existing NSWWTP effluent information. The types of aerators investigated are compared below for technical feasibility, regulatory considerations, benefits, and estimated cost.

Technical Feasibility. Each of the potential types of outfall aerators is technically feasible and will provide adequate oxygen transfer to meet discharge limits if properly designed. The Oxycharger system may be considered the most proven. It has been used successfully at numerous installations, has the support of a manufacturer's research and development experience, and is fully guaranteed.

Given the existing cascade aerator's success in aerating effluent at the NSWWTP outfall, a cascade type aerator is also a proven system for use with NSWWTP effluent. Previous analysis has shown that available empirical equations describe oxygen transfer at the existing cascade aerator to some degree (NSWWTP Ninth Addition Facilities Plan Update TM 8A). However, in developing and designing a new cascade aerator for the Badger Mill Creek outfall, the existing aerator should be further analyzed to understand thoroughly the existing system and ensure that the new system will meet the process goals.

A steep, inclined aerator is less proven than the other two options. The conceptual development provided in this analysis has a theoretical basis. To implement this technology confidently at the Badger Mill Creek outfall a more detailed investigation, including review of existing facilities, a literature search, and potentially prototype testing, would be required.



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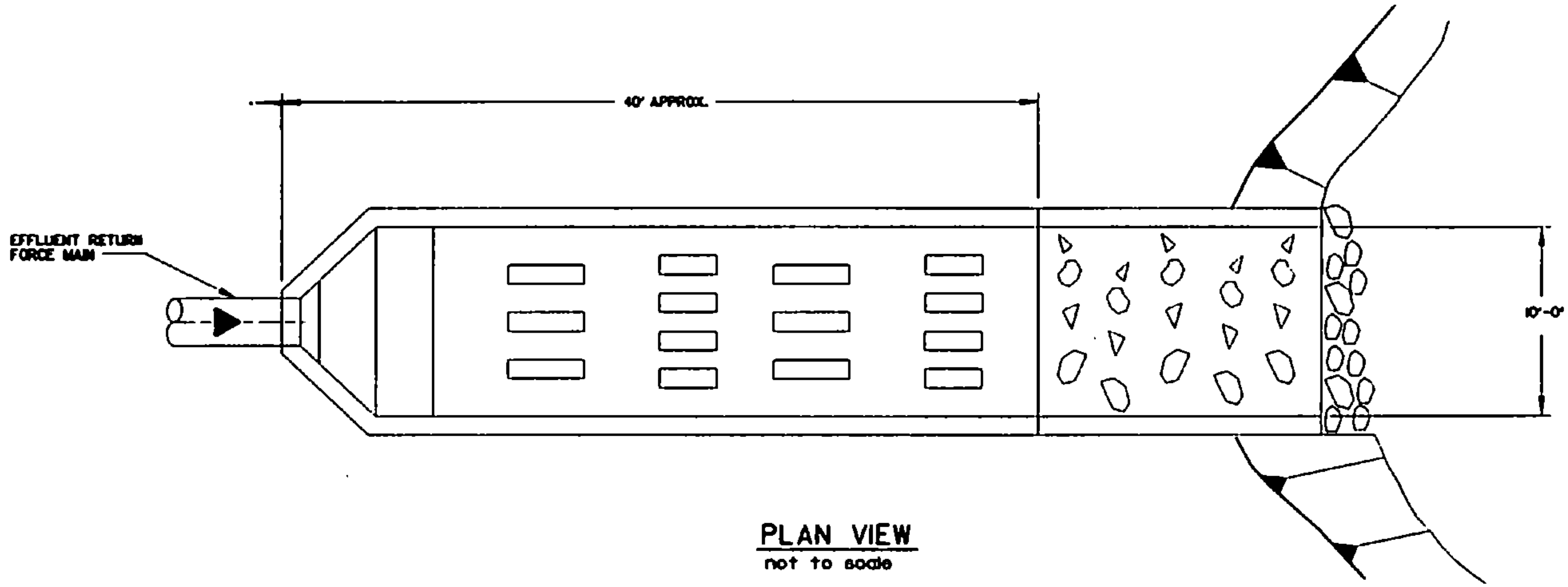
CASCADE AERATOR CONCEPTUAL DESIGN

Figure 6-1



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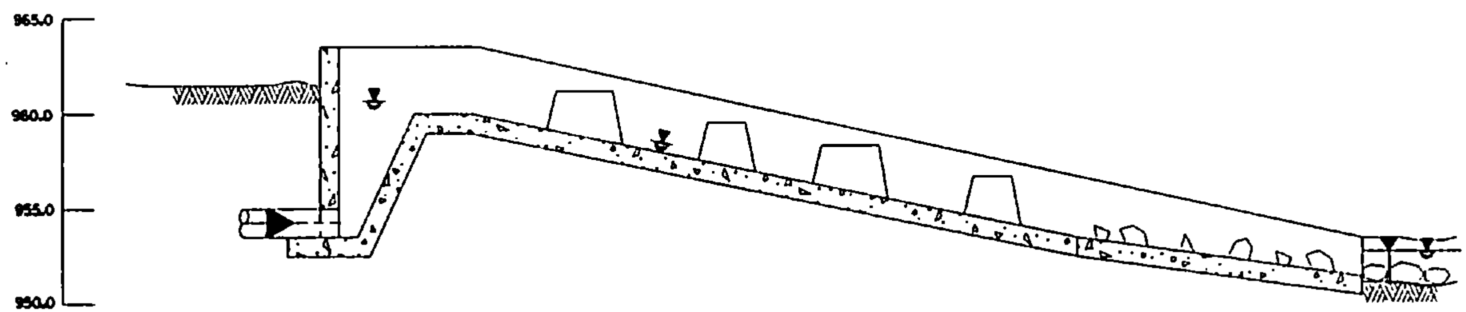

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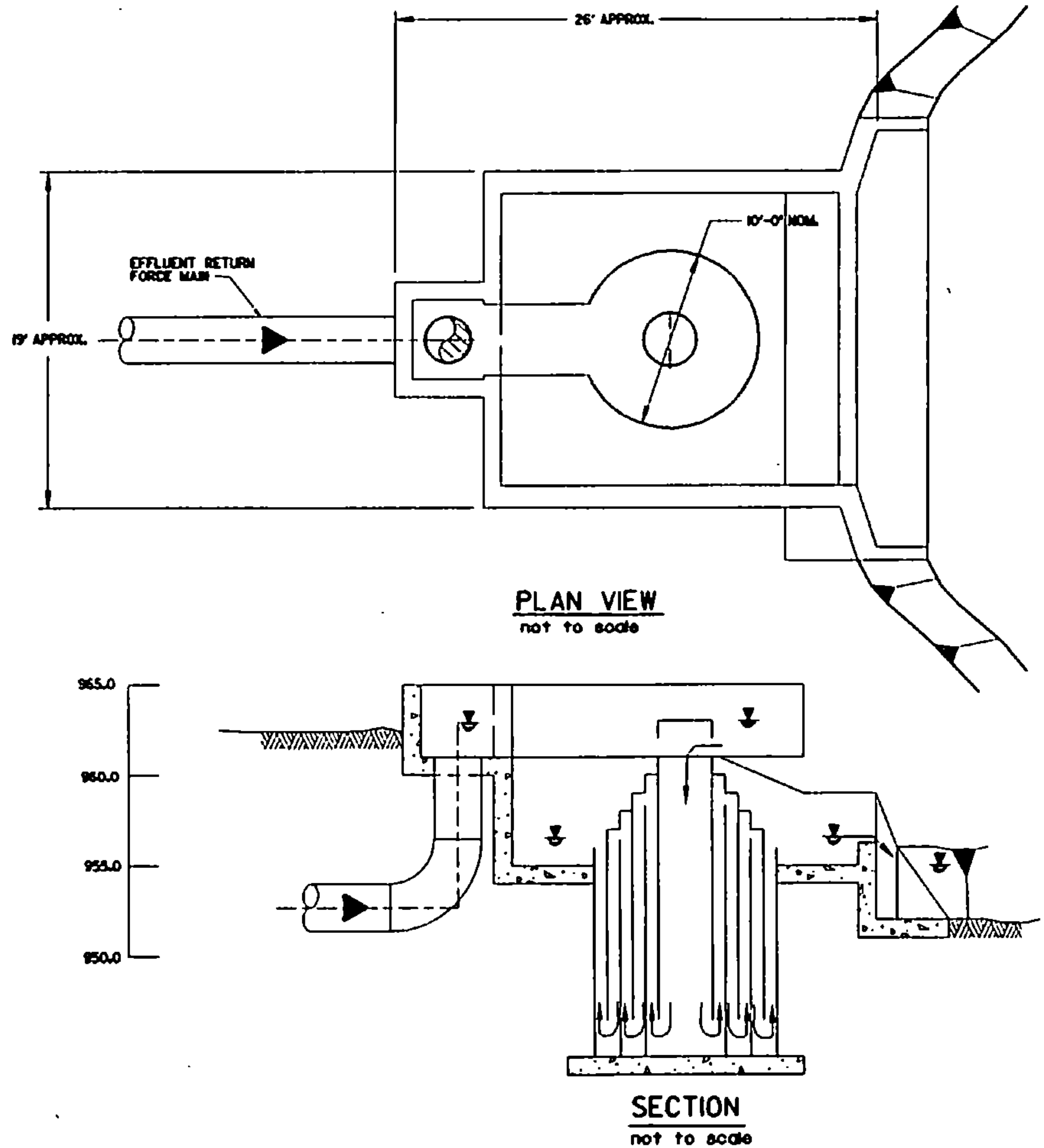
STEEP INCLINED AERATOR
CONCEPTUAL DESIGN

Figure
6-2



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MANUFACTURER SUPPLIED AERATOR
CONCEPTUAL DESIGN

Figure
6-3

Regulatory Considerations. An outfall aerator is required at Badger Mill Creek to meet the DO discharge limit. Given the technical feasibility of each aerator type given above and assuming that the system is developed and designed to provide adequate aeration, all three options are capable of complying with the regulatory requirements for this process.

Benefits. The cascade and Oxycharger aerators can be provided in relatively compact structures. The steep, inclined aerator requires more length to achieve similar process performance and could appear larger than the other options.

The steep, inclined aerator can be more easily adapted to available ground contours and therefore could be designed with a lower ground profile. Depending on the grade at the aerator site, both the cascade and Oxycharger aerators could have significant amount of structure above grade and be readily apparent from the surrounding area. The cascade and steep inclined aerators would be concrete structures similar to many common hydraulic structures seen along drainage channels. These aerators could also be constructed with natural materials such as river rock and landscaped to improve their aesthetic appearance. The Oxycharger's stainless steel unit would be installed in a concrete structure. The steel portion of the system would be readily apparent and would have an unusual appearance; it could also be reflective, causing a greater visual impact than the other options.

The cascade aerator and steep inclined aerator would be constructed of reinforced concrete and have a useful life of approximately 40 years. A major portion of the Oxycharger would be constructed of 304 stainless steel; the manufacture suggests its useful life is approximately 20 years.

Both the cascade and the Oxycharger aerators have hydraulic compartments of significant depth built into them which create easily utilized volumes of aerated effluent for sampling and monitoring. The steep inclined aerator uses a more sheet-like flow pattern and monitoring and sampling could be more difficult.

Estimated Costs. Estimated costs for the three aerators are given in Tables 6-4 through 6-6. Allowances for preliminary investigations are included in the estimates for the cascade aerator and the steep inclined aerator to account for the analysis required to address issues discussed above in the technical feasibility subsection. A useful life of 40 years was used

TABLE 6-4

ESTIMATED COSTS FOR A CASCADE AERATOR

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
Excavation	CY	4	144	576
Hauling	CY	6	144	864
Backfill	CY	10	120	1,200
Reinforced Concrete - Slabs	CY	225	11	2,475
Reinforced Concrete - Walls	CY	430	20	8,600
Inlet Pipe Connection	LS	5,000	1	5,000
Stream Transition	LS	5,000	1	5,000
Stop Logs	MBF	3,000	0.20	600
Final Grading and Landscaping	SY	30	312	9,360
Fencing	LF	25	230	5,750
Access Road	SY	20	134	2,680
Miscellaneous	LS	5,000	1	5,000
Monitoring Equipment	LS	15,000	1	15,000
Subtotal				62,105
Construction Contingency		15%		9,316
Total Construction				71,421
Preliminary Engineering Investigations		5%		3,571
Engineering and Administration		10%		7,142
Total Capital Cost				82,134
Salvage Value at End of Planning Period				35,710
Salvage Value Present Worth				7,317
Operations and Maintenance				
Annual Maintenance		1% of Construction		714
Weekly Inspections/Monitoring Data	Hr	15.00	208	3,120
Fringe Benefits		0.42		1,310
Vehicle Usage	Mile	0.30	520	156
Additional Pumping Head Over Lowest Alt.	kwh	.042	10,863	456
TOTAL O&M COSTS				5,757
Present Worth				**$130,313**
Annualized Worth				**$13,518**

TABLE 6-5

ESTIMATED COSTS FOR STEEP INCLINED AERATOR

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
Excavation	CY	4	254	1,016
Hauling	CY	6	254	1,524
Backfill	CY	10	170	1,700
Reinforced Concrete - Slabs	CY	225	28	6,300
Reinforced Concrete - Walls	CY	430	34	14,620
Inlet Pipe Connection	LS	5,000	1	5,000
Energy Dissipation Riprap	SY	60	20	1,200
Stream Transition	LS	5,000	1	5,000
Final Grading and Landscaping	SY	30	710	21,300
Fencing	LF	25	318	7,950
Access Road	SY	20	134	2,680
Miscellaneous	LS	5,000	1	5,000
Monitoring Equipment	LS	15,000	1	15,000
Subtotal				88,290
Construction Contingency		15%		13,244
Total Construction				101,534
Preliminary Engineering Investigations		10%		10,153
Engineering and Administration		10%		10,153
Total Capital Cost				121,840
Salvage Value at End of Planning Period				50,767
Salvage Value Present Worth				10,402
Operations and Maintenance				
Annual Maintenance		1% of construction		1,015
Weekly Inspections/Monitoring Data	Hr	15.00	208	3,120
Fringe Benefits		0.42		1,310
Vehicle Usage	Mile	0.30	520	156
Additional Pumping Head Over Lowest Alt.	KWH	.042	21,727	913
TOTAL O&M COSTS				6,514
Present Worth				**$174,236**
Annualized Worth				**$18,074**

TABLE 6-6

ESTIMATED COSTS FOR OXYCHARGER AERATOR

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
Excavation	CY	4	440	1,760
Hauling	CY	6	440	2,640
Backfill	CY	10	228	2,280
Reinforced Concrete - Slabs	CY	225	32	7,200
Reinforced Concrete - Walls	CY	430	24	10,320
Inlet Pipe Connection	LS	5,000	1	5,000
Stream Transition	LS	5,000	1	5,000
Manufacturer's Unit, Installed	LS	96,000	1.00	96,000
Final Grading and Landscaping	SY	30	405	12,150
Fencing	LF	25	246	6,150
Access Road	SY	20	134	2,680
Miscellaneous	LS	5,000	1	5,000
Monitoring Equipment	LS	15,000	1	15,000
Subtotal				171,180
Construction Contingency		15%		25,677
Total Construction				196,857
Engineering and Administration		10%		19,686
Total Capital Cost				216,543
Salvage Value at End of Planning Period				0
Salvage Value Present Worth				0
Operations and Maintenance				
Annual Maintenance		1% of construction		1,960
Weekly Inspections/Monitoring Data	Hr	15.00	208	3,120
Fringe Benefits		0.42		1,310
Vehicle Usage	Mile	0.30	520	156
Additional Pumping Head Over Lowest Alt.	KWH	.042	0	0
TOTAL O&M COSTS				6,555
Present Worth				**$279,733**
Annualized Worth				**$29,018**

for the cascade and steep inclined aerators and 20 years for the Oxycharger. The energy cost difference due to the required pumping head is included in the annual and present worth costs. It is estimated the Oxycharger would have the lowest head requirement. The cascade aerator would require an additional 1.5 feet, and the steep inclined aerator would require an additional 3 feet.

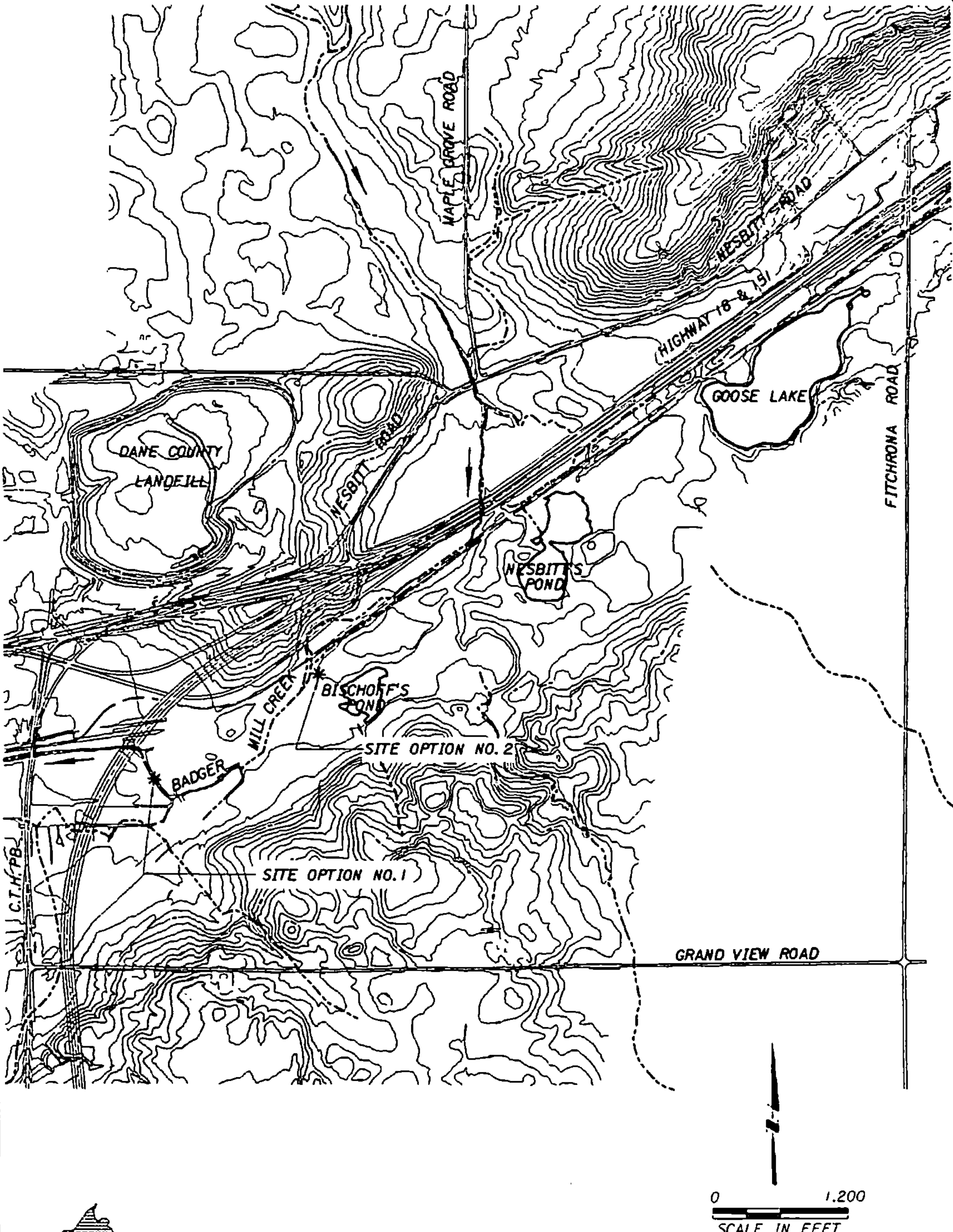
The cascade aerator has the lowest estimated capital and present worth costs. The steep inclined aerator has the second lowest estimated capital and present worth costs. The estimated capital cost of the steep inclined aerator is approximately 48% greater than that of the cascade aerator and the estimated present worth cost is approximately 34% greater. The Oxycharger has the highest estimated capital and present worth costs. The estimated capital cost of the Oxycharger is approximately 163% greater than that of the cascade aerator and the estimated present worth cost is approximately 115% greater.

Based on the above analysis the cascade aerator was selected as the preferred aerator type.

Location of Aerator. Two potential locations for the outfall aerator were examined and are shown on Figure 6-4. Both sites are located east of County Highway PB and southeast of the Highway 18/151 bypass interchange. These site options are compared below for technical feasibility, regulatory considerations, benefits, and estimated cost.

Technical Feasibility. Implementation at either site is technically feasible. The grade at Site 2 has a greater slope and would allow easier implementation of an outfall aerator.

Regulatory Considerations. Site 2 is adjacent to prehistoric archaeological sites identified in the Environmental Impact Statement for the Verona Bypass. A more detailed examination may be necessary to determine if sites are eligible for the National Register of Historic Places. Site 1 requires approximately 2,000 more feet of effluent forcemain and therefore 2,000 more feet of easement and permitting issues would need to be addressed.



MONTGOMERY WATSON

Minneapolis, Minnesota

FIGURE 6-4

AERATOR SITE OPTIONS

As discussed above, the grade at Aerator Site 2 is steeper and more conducive to aerator installation. This is of particular importance if the cascade or Oxycharger aerator is used. At Site 2 these types of aerators could be installed with minimal regrading and only a small portion of the structure would extend above grade. If Site 1 is used, structures for these types of aerators could extend 8-10 feet above grade.

Both sites are accessible from the Highway 18/151 bypass and the Military Ridge Trail.

Site 2 would be visible from the Military Ridge Trail but visibility could be reduced with landscaping. Site 1 would not be visible from the trail.

The streambed slope downstream of Site 1 is relatively steep. This indicates it would be a good location for effluent discharge because the creek would flow relatively fast below the discharge, resulting in shorter detention and greater turbulence and associated oxygen transfer. The streambed downstream of Site 2 has less slope and the creek flows through a marshy area. This results in longer detention times and less oxygen transfer opportunity.

Estimated Costs. Due to the shorter forcemain length and lower earthwork requirements, Site 2 has an estimated capital cost $145,000 less than Site 1. The additional costs associated with the use of Site 1 rather than Site 2 are given in Table 6-7. The major factor in this cost difference is the cost of the forcemain. Annual operational cost differences between the sites option are insignificant. Although Site 1 requires an additional 2,000 ft of forcemain with associated friction loss and pumping head, it also allows discharge at a lower elevation and the net effect on pumping head is minor.

Due to lower costs Aerator Site 2 was selected. Therefore, the preferred aeration system is a cascade aerator located at Site 2.

Technique 6: Refine Nitrification Operating Protocol. The nitrification process is currently operated at the NSWWTP to achieve a warm weather monthly limit of 2.7 mg/L ammonia and a cold weather monthly limit of 5.0 mg/L. However, actual performance is much better with average daily warm season and cold season concentrations of 0.25 and 0.73 mg/L, respectively. Maximum weekly warm season and cold concentrations are 1.38 and 1.97 mg/L, respectively. To achieve the weekly WDNR calculated Badger Mill Creek ammonia effluent limit of 0.7 mg/L in the warm season and

TABLE 6-7

ADDITIONAL COSTS ASSOCIATED WITH THE USE OF AERATOR SITE OPTION 1

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
Additional Backfill	CY	10	200	2,000
Additional Access Road	SY	20	134	2,680
Additional Forcemain Length	LF	55	2,000	110,000
Subtotal				114,680
Construction Contingency		15%		17,202
Total Construction				131,882
Engineering and Administration		10%		13,188
Total Capital Cost				145,070
Salvage Value at End of Planning Period				79,129
Salvage Value Present Worth				16,214
Operations and Maintenance				
Annual Maintenance		1% of construction		1,319
Weekly Inspections/Monitoring Data	Hr	15.00	52	780
Fringe Benefits		0.42		328
Vehicle Usage	Mile	0.30	52	16
Additional Pumping Head Over Lowest Alt.	KWH	.042	(28,971)	(1,217)
TOTAL O&M COSTS				1,225
Present Worth				**$140,668**
Annualized Worth				**$14,592**

1.5 mg/L in the cold season, refinements in the operating criteria will have to be made to achieve the required level of nitrification.

Technical Feasibility. The most important operating criteria to change would be the aerobic mean cell residence time (MCRT) and aeration capacity. Both of these parameters may have to be increased to achieve the lower effluent ammonia concentrations required for discharge to Badger Mill Creek. The exact amounts would be determined after testing and analyzing the full-scale system. An important point to note with this technique is that the potential increase in MCRT to achieve lower ammonia concentrations may have a detrimental effect on phosphorus removal performance. Therefore, these criteria, along with others related to EBPR, will be investigated extensively at the startup of the EBPR retrofit of the NSWWTP Ninth Addition to optimize ammonia and phosphorus removal performance.

System operation at a longer aerobic MCRT and/or with additional aeration may result in higher solids loadings to the clarifiers. Therefore, implementation of this modification throughout the planning period may be limited by the plant's existing aeration and clarification capacity. Although at current loadings the existing aeration is sufficient to accommodate an increase in MCRT, as future loadings increase the existing plant's ability to operate at the longer MCRT may be exceeded, and other alternatives would have to be implemented.

Since the return flow volume to the Sugar River is only a small portion of the total flow treated at the NSWWTP, a way of optimizing this technique would be to provide the additional nitrification at a single train (plant) of the facility such as Plant 4. This would produce lower operation costs because the refined operating protocol would only be implemented at a portion of the facility and may simplify pumping or the implementation of additional treatment.

Regulatory Considerations. It should be possible to achieve the Badger Mill Creek effluent ammonia limits, but this cannot be verified until the new system is on-line.

Benefits. Refining the nitrification operating protocol will help the NSWWTP meet the Badger Mill Creek ammonia limit and also the BOD limit. The proposed BOD effluent limit is based on the total BOD test; a reduction in ammonia concentration will also reduce total BOD.

Estimated Cost. As noted above, the additional aeration required to operate at a longer aerobic MCRT could result in additional operating cost. However, operation at a longer MCRT also reduces biosolids production and associated treatment and reuse costs. Given the relatively minor adjustment to meet the Badger Mill Creek effluent limits, and the savings from biosolids reduction, no significant cost impact is anticipated.

Technique 7: EBPR Improved Settling Characteristics. Enhanced biological phosphorus removal (EBPR) processes have been shown to better remove BOD and TSS compared to normal activated sludge processes.

Technical Feasibility. Comparing one year of simultaneous testing of a step-feed activated sludge system and an EBPR system showed that average CBOD and TSS removal were higher for the EBPR system (Montgomery Watson 1994). Sludge volume index measurements for the simultaneously tested systems also showed that the EBPR solids settled better. Although no direct comparisons were made in the NSWWTP pilot testing program, the NSWWTP pilot planning effort generally supports the concept that EBPR systems have comparably better settling characteristics.

Regulatory Considerations. While improved TSS and BOD performance can be anticipated at the NSWWTP, full-scale testing is required because the effluent levels are already very low. Thus, the ability of this technique to meet the WDNR-calculated limits is uncertain. Even if proven effective, enough operational flexibility must be maintained to consistently meet the effluent limits.

Benefits. The primary benefit of this technique is that it is currently being implemented to meet future phosphorus discharge limit requirements at the NSWWTP, and no additional efforts are required.

Estimated Cost. There are no costs beyond those currently required for implementation of the Ninth Addition to NSWWTP.

Technique 8: Polymer Addition. Adding polymer to the mixed liquor is often used to help floc settle and to provide more consistent solids removal rates.

Technical Feasibility. Adding polymer to increase TSS and possibly BOD removal at the NSWWTP may be cost-effective, since polymer feed facilities already exist at the plant. Refurbishing and changing the polymer feed piping would be required to make the system operational and are estimated to cost $80,000. Operating costs will be the deciding factor with polymer. To effect a significant change in effluent TSS, a fairly large dose of up to 5 mg/L of polymer may be required. However, doses as low as 1-2 mg/L have shown improved settling performance with EBPR solids (Montgomery 1994). Given the polymer cost, it should be used only when the system is susceptible to poorer removals, such as portions of the winter. In addition, because each waste stream has unique characteristics which determine the type and dose of polymer required and the ability of polymer to improve removals, full-scale system testing is recommended before final selection of this alternative as a dependable treatment option. Many types of polymers are on the market and one can be selected that avoids toxicity.

As with Technique 6, since the return flow volume to Sugar River is only a small portion of the total flow treated at the NSWWTP, it would be prudent to implement this technique on a single train (plant) of the NSWWTP, such as Plant 4. This would lower operating costs because only a portion of the total plant flow would be treated and may simplify pumping or the implementation of additional treatment.

Regulatory Considerations. Because the system would be added to an existing facility the ability of this technique to meet the WDNR calculated limits is uncertain.

Benefits. The primary benefit of this technology is its relatively low capital cost. However, polymer is expensive so operating costs are relatively high.

Estimated Costs. As an order of magnitude estimate of costs, with a dosage of 2 mg/L, unit cost of $2.20/lb, average daily flow of 45.8 mgd (the estimated 2016 plant influent from the facilities plan update) and a 50% recycle, the polymer would cost $2,520/day. For a 5 mg/L dose the cost would be approximately $6,300/day. Assuming use of a 2 mg/L dose for 15% of the year and a 5 mg/L dose for 5% of the year, the annual operating costs for polymer addition would be approximately $253,100 with a present worth of $2,551,200 (Table 6-8). Electrical costs for polymer mixing and pumping would be less than $300/year for a 50 hp total load running 20% of the year.

TABLE 6-8

ESTIMATED COSTS FOR TECHNIQUE 7: POLYMER ADDITION[1]

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
System Improvements and Pipe Distribution System Modifications	Lump	80,000	1	80,000
Construction Contingency		15%		12,000
Total Construction				92,000
Engineering and Administration		10%		9,200
Total Capital Cost				101,200
Operations and Maintenance				
Polymer at 2 mg/L (15% of yr)	lb	2.20	62,739	138,026
Polymer at 5 mg/L (5% of yr)	lb	2.20	52,283	115,023
Total Polymer				253,049
Annual Maintenance		1% of Construction		800
Electricity for 5-hp Pump Connected Load (20% of yr)	kwh	0.042	6,532	300
TOTAL O&M COSTS				254,149
Present Worth				**$2,551,200**
Annualized Worth				**$264,650**

[1] Assumed flow on 45.8 mgd and 50% recycle

Technique 9: Wetland Treatment. Both wetland treatment performance and the location of a treatment wetland are important to the feasibility of this technique. Options for both of these are discussed below.

Treatment Performance. Pollutant removal capabilities of the various wetland options were determined with procedures available in the published literature (Reed et al. 1995). The results of these analyses are presented and discussed below.

Technical Feasibility. The water temperature in a wetland is an important design parameter since all biological reactions are temperature dependent. Weather records from 1948-92 at the Madison Airport indicate that 1976 was the coldest year, so 1976 was used as the base year for design. The average monthly air temperatures, assumed WWTP effluent temperatures, and calculated average water temperature in a wetland are presented in Table 6-9. The assumed WWTP effluent temperatures for the proposed outfall are slightly lower than monitored temperatures at the existing outfall to Badfish Creek. The small difference does not affect results.

TABLE 6-9

AVERAGE MONTHLY TEMPERATURES
(°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Air (1976)	-9	-2	2	10	12	20	23	20	14	7	-2	-10
WWTP Effluent (Assumed)	7	7	9	16	16	17	18	19	17	15	10	9
Wetland Water (Calculated)	4	4	6	15	16	17	18	19	17	14	8	4
Wetland Effluent (Calculated)	1	1	3	15	16	17	17	19	17	14	5	1

Ice cover on a wetland is also an important parameter since ice reduces the volume available for flow and moderates water temperature by acting as an insulating barrier. Ice formation in a cold winter in mid-November and continues through mid-March; it is usually gone by early May. A calculated estimate of ice depth on a wetland in the Madison area is presented in Table 6-10.

TABLE 6-10

ICE THICKNESS
(Inches)

Nov	Dec	Jan	Feb	Mar	Apr	May
3	8	10	11	12	5	0

Based on the water quality and temperature conditions defined above, a preliminary series of calculations was performed to determine the minimum size of a treatment wetland to meet the required discharge standards for BOD, TSS, and NH_3. These results are presented in Table 6-11.

TABLE 6-11

PRELIMINARY WETLAND SIZE CALCULATIONS

		Flow Rate (mgd)	
		2.2	3.6
BOD	Summer	3 ac	6 ac
	Winter	12 ac	20 ac
TSS	Summer	0.5 ac	0.9 ac
	Winter	0.6 ac	1.0 ac
NH_3	Summer	14 ac	57 ac
	Winter	52 ac	84 ac

About 20 acres are available at Site A, the DOT Wetland, to develop a treatment wetland. This would satisfy BOD and TSS requirements at both flow rates. Ammonia is the limiting parameter. There is insufficient land at either Site A, DOT wetland or Site J/K, Combined Dane County Parks 1 and 2, to achieve the desired summer or winter ammonia limit at the 3.6 mgd flow rate, or the winter limit at the 2.2 mgd flow rate. The most economical solution is to ensure that ammonia limits are met at the WWTP so a treatment wetland can be designed for BOD and TSS only. In this case, BOD is the limiting design parameter and a 20-acre site would be required. Polishing would still occur for ammonia and phosphorus.

A unique characteristic of wetlands is that they actually produce BOD and TSS as a result of decomposing the naturally occurring organic materials in the wetland. As a result, there will always be a residual BOD and TSS in the effluent from these systems. These residual concentrations may range from 2 to 7 mg/L and are typically about 5 mg/L for BOD and 6 mg/L for TSS. These are all natural residuals and are not related to the wastewater BOD or TSS.

Monthly values for treatment wetland effluent BOD concentrations and mass removals are presented in Table 6-12.

TABLE 6-12

EFFLUENT BOD CONCENTRATIONS FOR A 20-ACRE WETLAND SYSTEM[1]

	Effluent Concentration (mg/L)	
	2.2 mgd	3.6 mgd
Jan	8.5	10
Feb	8.5	10
Mar	7.3	10
Apr	5[2]	5[2]
May	5[2]	5[2]
Jun	5[2]	5[2]
Jul	5[2]	5[2]
Aug	5[2]	5[2]
Sep	5[2]	5[2]
Oct	5[2]	5[2]
Nov	5[2]	5[2]
Dec	7	7
Annual Average	5.9	6.4

[1] Based on worst case, maximum NSWWTP effluent as wetland influent
[2] These are the nonreducible residual concentrations

The TSS effluent concentrations from a 20-acre treatment wetland are presented in Table 6-13. Effluent concentrations will be the same at either flow rate because such a small area is required for TSS removal. All of the effluent TSS concentrations are nonreducible residual levels.

It is assumed that the discharge limits for ammonia are met at the WWTP. There will, however, be some further polishing in the wetland below the permits limits of 0.7 mg/L for the warm season and 1.5 mg/L cold season. These effluent values and mass removals are presented in Table 6-14.

TABLE 6-13

EFFLUENT TSS CONCENTRATIONS FOR A 20-ACRE WETLAND SYSTEM[1]

	TSS Concentration[2] (mg/L)
Jan	3
Feb	3
Mar	3
Apr	5
May	5
Jun	6
Jul	6
Aug	6
Sep	6
Oct	5
Nov	3
Dec	3
Average Annual	4.5

[1] Based on worst case, maximum NSWWTP effluent as wetland influent
[2] These are the nonreducible residual concentrations

Assuming phosphorus limits are met at the WWTP, there will still be some polishing benefits achieved by the wetland. Monthly wetland effluent concentrations will vary by season and seasonal calculation techniques are not yet available. The annual average wetland effluent phosphorus concentration from a 20-acre wetland can be calculated, however, at 1.2 mg/L. That represents an annual mass removal of about 2,000 pounds per year based on an influent concentration of 1.5 mg/L.

The calculations above show a total ice depth on a wetland of almost 11 inches given 1976 air temperature conditions and the assumed wastewater temperatures and flow rates. Greater ice depth could result during a more extreme winter or if WWTP effluent temperatures are lower than the assumed values.

TABLE 6-14

WETLAND EFFLUENT AMMONIA CONCENTRATIONS ASSUMING LIMITS ARE MET IN THE WETLAND INFLUENT[1]

	Effluent Concentration (mg/L)	
	2.2 mgd	3.6 mgd
Jan	1.3	1.4
Feb	1.3	1.4
Mar	1.3	1.3
Apr	0.3	0.5
May	0.3	0.5
Jun	0.3	0.5
Jul	0.3	0.5
Aug	0.3	0.5
Sep	0.3	0.5
Oct	0.3	0.5
Nov	0.3	1.2
Dec	1.3	1.4
Average Annual	0.63	0.85

[1] Influent concentrations of 0.7 mg/L warm season and 1.5 mg/L cold season

Ice on a wetland reduces the flow volume and therefore the detention time in the wetland. If, for example, the wetland were designed with a fixed operating depth of 12 inches, a winter ice cover of 11 inches would require termination of wetland operations from December through March.

This winter ice formation can be accommodated if the final effluent structures include an adjustable weir to control of the water level in the wetland. These effluent structures should be located about 100 feet apart along the end of the wetland bed. The weir should be raised to set a water level of 2 feet in the wetland on about November 15 of each year. This permits an under-ice water depth of about 1.2 feet. The lower detention time associated with this minimal water depth has been included in the calculations tabulated above. About April 15 of each year, these weirs can be lowered to set a water depth of 1 to 1.5 feet for the warm season. The calculations above were based on 1.5 feet, but a 1-foot depth would produce essentially the same results since effluent BOD and TSS are residual wetland organics during the warm weather season.

Regulatory Considerations. Regulatory considerations for wetland treatment performance relate to the ability of the system to meet effluent limits. Ammonia limits cannot be met with a wetland system given the available land area and therefore must be met at the NSWWTP. Wetland effluent BOD and TSS concentrations given in Tables 6-12 and 6-13 appear to meet the WDNR limits. However, most of these concentrations are average nonreducible residual concentrations. Since BOD residual concentrations may range from 2 to 7 mg/L, BOD limits will be exceeded on occasion due to these residuals. These exceedences would not pose a health risk since they would be due to decomposition of naturally occurring organic materials in the wetland rather than the wastewater influent. However, WDNR may still consider these levels an effluent limit violation.

Benefits. Wetland systems can have negative impacts on treatment performance as well as benefits. Treatment performance benefits include additional polishing for TP and ammonia. Negative impacts may include increased mass loadings of BOD. Because of nonreducible residual levels of BOD, a wetland treatment system may actually contribute higher mass loads to Badger Mill Creek than a direct discharge with existing NSWWTP effluent. The average daily BOD concentration in NSWWTP effluent is lower than the residual wetland concentrations. Annual mass loads of BOD and TSS to Badger Mill Creek for a direct discharge versus a wetland discharge are presented in Table 6-15.

TABLE 6-15

MASS BOD AND TSS DIRECT DISCHARGE TO BADGER MILL CREEK VERSUS WETLAND DISCHARGE

Parameter	Direct Discharge[1] 2.2 mgd	Direct Discharge[1] 3.6 mgd	20-Acre Wetland[2] 2.2 mgd	20-Acre Wetland[2] 3.6 mgd
BOD_5 (lb/yr)	38,700	63,400	39,400	69,900
TSS (lb/yr)	48,260	78,970	28,440	46,540

[1] Assuming average daily concentrations for NSWWTP effluent
[2] Assuming residual concentrations of 5 mg/L BOD and average annual concentrations of 5.9 and 6.4 mg/L for 2.2 mgd and 3.6 mgd, respectively, and 3 to 6 mg/L TSS or 4.25 mg/L average annual concentration

Estimated Cost. Estimated costs for a 20-acre wetland treatment system are presented in Table 6-16. The most significant costs are for construction and land acquisition. Monitoring and analytical costs were also included since the wetland would be part of the treatment system with the point of compliance at the wetland discharge point.

TABLE 6-16

ESTIMATED COSTS FOR A 20-ACRE WETLAND TREATMENT SYSTEM

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
Construction	acre	35,000[1]	20	700,000
Construction Contingency		15%		105,000
Total Construction				805,000
Engineering and Administration		10%		80,500
Total Capital Cost				885,500
Operations and Maintenance				
Inspections and Sample Collection	hr/yr	15.00	730	10,950
Water Level Control Operation	hr/hr	15.00	64	960
Benefits		42%		5,002
Annual Maintenance		1% of Construction		8,050
Sample Analysis	$/day	50.00	365	18,250
Total Operations and Maintenance Cost				43,212
Present Worth				**$1,302,066**
Annualized Worth				**$ 115,802**

[1] $30,000/acre for wetland construction with liner; $5,000/acre for land acquisition

Wetland Location. The two locations identified in Section 3 as having the best potential for wetlands are evaluated in greater detail below. These are Site A, DOT Wetland, and Sites J/K, Dane County Parks 1 and 2.

Technical Feasibility. Construction of either site is feasible. However, as discussed under estimated costs below, the ability to reach Sites J/K with the transmission line is more complex because of the recently constructed Verona Bypass.

Regulatory Considerations. Construction at Site A, DOT Wetland, would need to avoid prehistoric archaeological sites and existing wetlands. This should not be a problem and about 20 acres are available at this site, not including wetlands and archaeological areas. Sites J/K, Dane County Parks 1 and 2, do not contain archaeological sites. Sites J/K were previously drained for agriculture, and the property is currently used by Dane County Parks as a model airplane airfield.

Benefits. Elements benefiting wildlife can be incorporated with a wetland system at either site. The Site A DOT Wetland, has already been graded by the DOT to create seasonally wet ponds and seeded with prairie mix. Thus, restoration and/or enhancement of the highly altered Sites J/K would likely provide greater wildlife benefit. However, some wildlife improvements to Sites J/K are already being planned. The Dane County Parks Department and the U.S. Fish and Wildlife Service are planning to restore wetlands on the western half of the site. Thus, while use of this site would create greater wildlife benefit than at Site A, a portion of the site is already scheduled for restoration.

Estimated Cost. The cost differences between the two sites are significant because of differences in the length of the transmission line. An additional 10,000 feet of transmission line would be needed to reach Sites J/K. In addition, the line would probably need to be jacked under the recently constructed Verona Bypass. At a minimum, not including jacking costs, the additional cost at $55/LF would be $550,000.

Technique 9: Rock Filter Outlet. A rock filter outlet consists of a weir constructed of riprap with washed stone/gravel facing on the upstream side. The rock filter would operate by allowing the wetland effluent to travel through the voids in the gravel and riprap, capturing algae and wetland plant materials.

Technical Feasibility. Rock filters are easy to construct. Wetland effluent could be directed to one outlet where a filter would be constructed. Multiple outlets with rock filters could be constructed, allowing alternating use of the filters. Alternately taking rock filters off line would allow accumulated organic material to oxidize, thereby reducing the potential for clogging.

Regulatory Considerations. Rock filter outlets are not a proven technology and their ability to help meet the effluent limits is unknown.

Benefits. The principal advantages of rock filter outlets are their relatively low construction costs and simple operation.

Estimated Cost. The cost to install rock filter outlets depends on the design configuration of the wetland system and number of filters incorporated. For planning purposes a cost of approximately $5,000 to $10,000 per filter was assumed.

Technique 10: Effluent Filtration. Returning highly treated effluent from the NSWWTP to Badger Mill Creek may require compliance with stringent discharge standards. Under certain future scenarios, effluent filtration may be needed to meet the discharge limits.

Technical Feasibility. Due to concerns relating to the operation and maintenance of the proposed filters, the preferred location for the filter equipment would be at one of two possible sites at the NSWWTP. One site is northeast of the Effluent Pump Station between the Effluent Building and Storage Building No. 1. This site would facilitate gravity flow to the filters and avoid the existing effluent forcemain and electrical duct banks on the west side of the effluent building. The backwash from the filter system at this site would be pumped to the wet well of MMSD Pump Station 3.

A second site is at the south end of the plant, directly south of the west digester complex and adjacent to the water storage tank currently owned by the Madison water utility. The Madison water utility plans to abandon the water storage tank and turn it over the MMSD. It is possible that the tank could be used as a wet well for the filter and thus save construction cost. Locating the filter at this site would involve tapping the existing 54-inch effluent forcemain to feed the filters. This location would save approximately 1,700 feet of forcemain to Badger Mill Creek compared to the other site. The backwash from the filter located at this site would be pumped to the grit chamber effluent channel.

The effluent filters would be four-cell gravity type filters with gravel/sand/anthracite media, an underdrain system, and an air scouring system. The packaged filter systems would have automatic controls and be located in a building which would also house the filtered effluent pumps, chlorination equipment (chlorine for sand bed cleaning), air compressors, and backwash tanks and pumps as required.

Regulatory Considerations. Filtration is a proven technology for reducing BOD and TSS in treated wastewater effluent. Filtration would not affect ammonia concentrations.

Benefits. Effluent filtration would consistently reduce BOD and TSS concentrations to below proposed limits. Filtration is an established, proven technology with demonstrated reliability.

Estimated Costs. Estimated costs for filtration are presented in Table 6-17. The construction cost of a filtration facility at the NSWWTP would be approximately $1,700,000, with annual O&M costs of approximately $10,000 and a present worth of $1,400,000.

Summary of Techniques

A summary of the techniques evaluation is presented in Table 6-18. This evaluation was used to screen the techniques for further consideration. Based on the evaluation, techniques T3, T4, the Oxycharger in T5, T8, T9, and T10 were eliminated from further consideration, as explained below:

- T3 - Gravity Sewer: Eliminated because of cost
- T4 - In-Line Booster Pumps: Eliminated because of complexity
- T5 - Oxycharger Aerator: Eliminated because of cost
- T8 - Polymer Addition: Eliminated because of high cost for a technique with uncertain results
- T9 - Wetland Treatment: Eliminated because of uncertainty with consistently meeting effluent limits, possible negative impacts of BOD mass loads, and high cost
- T10 - Rock Filter Outlet: Eliminated because of uncertainty of meeting effluent limits and dependence upon Technique T9

The remaining techniques were given further consideration for refining Alternative I as discussed below.

TABLE 6-17

ESTIMATED COSTS FOR AN EFFLUENT FILTRATION FACILITY

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
Filter Building	SF	170	3,600	612,000
Excavation	CY	10	2,600	26,000
Forcemain Connection	LS	85,000	1	85,000
Control Valve	LS	5,000	1	5,000
Influent Piping (24-inch)	LF	75	400	30,000
Effluent Piping (20-inch)	LF	55	400	22,000
Backwash Piping (6-inch)	LF	30	550	17,000
Filter Package System	LS	450,000	1	450,000
Spent Backwash Pumps	LS	5,000	2	10,000
Filter Effluent Pumps	LS	25,000	2	50,000
Disinfection System	LS	5,000	1	5,000
Subtotal				1,312,000
Construction Contingency		20%		262,000
Engineering and Administration		10%		131,000
Total Capital Cost				1,705,000
Salvage Value Present Worth				398,000
Operations and Maintenance				
Annual Labor	Hr	21	208	4,430
Annual Maintenance		1% of Equipment Cost		5,150
Total Annual O&M Costs				9,580
Present Worth				**$1,400,000**
Annualized Worth				**$145,228**

TABLE 6-18

EVALUATION SUMMARY OF ALTERNATIVE I TECHNIQUES

Technique	Technical Feasibility	Regulatory Considerations	Benefits	Estimated Cost[1] ($1,000s)
Transmission:				
T1 - Forcemain	Good	404 Nationwide 19, Construction Erosion Control, and Chapter 30 permits needed	Smaller pipe size and ease of construction	$4,900-$5,300
T2 - Pump Station	Good	None unique to this technique	Location at NSWWTP and reliable flow rate control	(2)
T3 - Gravity Sewer	Greater burial depths required	None unique to this technique	Lower energy costs	Not estimated because of significantly greater construction costs
T4 - In-Line Booster Pumps	Complex flow rate control system required	None unique to this technique	None unique to this technique	Not estimated because of undesirable technical feasibility

TABLE 6-18

EVALUATION SUMMARY OF ALTERNATIVE I TECHNIQUES (Continued)

Technique	Technical Feasibility	Regulatory Considerations	Benefits	Estimated Cost[1] ($1,000s)
Protection of Aquatic Life: T5 - Outfall Aerator				
Cascade	Good	Capable of meeting DO limits	Proven technology and compact size	$130
Steep Inclined	Good, although less proven technology	Capable of meeting DO limits	Adaptable to available ground contours but largest size	$174
Manufacturer Supplied	Good	Capable of meeting DO limits	Proven technology, manufacturer guaranteed, and compact size	$280
T6 - Refinement of Nitrification Operating Protocol	Good, although future performance may be constrained by existing aeration, clarification, and phosphorus removal capacity	Ability to achieve limits is possible, but until new system is on-line, cannot be verified	Will also reduce BOD	No significant cost impact is expected with operational modifications
T7 - EBPR Improved Settling	Good, already scheduled for implementation	TSS and BOD is expected to improve, but until new system is on-line, cannot be verified	No additional efforts are required for implementation	No additional cost beyond improvements already planned

TABLE 6-18

EVALUATION SUMMARY OF ALTERNATIVE I TECHNIQUES (Continued)

Technique	Technical Feasibility	Regulatory Considerations	Benefits	Estimated Cost[1] ($1,000s)
T8 - Polymer Addition	Full-scale testing needed	Ability to meet limits is uncertain	Relatively low capital costs but high operation and maintenance costs	$1,775
T9 - Wetland Treatment	Good at Site A, DOT Wetland; complicated at Site J/K, Dane County Parks because of Verona bypass	Ammonia limits would need to be met at NSWWTP; residual BOD and TSS concentrations could exceed limits	Additional polishing for TP and NH_3-N but could increase BOD mass loads over a direct discharge	$1,302
T10 - Rock Filter Outlet	Good	Not a proven technology	Low construction costs and simple operation	$5 to $10 per filter
T11 - Filtration	Good	Proven technique that will meet BOD and TSS limits; will not assist with meeting NH_3-N limits	Proven/reliable technology	$1,400

[1] Present worth
[2] Included with costs of forcemain

Summary of Alternative I Evaluation

Implementing Alternative I requires a basic infrastructure to transport the effluent and ensure that effluent discharge limits are met. Based on the evaluation of techniques, the transmission system will consist of a pump station and effluent forcemain. The preferred transmission line route is Route C with a modification in segment FM-5.

The need for improvements to meet discharge limits depends on the two options for setting effluent discharge limits. An outfall aerator would be needed under either option, and the best choice appears to be a cascade aerator at Site 2. This combination has the lowest present worth.

Option 1 to protect aquatic life based on WDNR-calculated limits will require treatment in addition to aeration. The techniques evaluation indicated that only techniques T6, T7, and T11 remain viable. These techniques are needed only to reduce the magnitude and frequency of high effluent concentrations. Effluent from NSWWTP meets the WDNR-calculated limits 85-90% of the time. A tremendous cost saving is possible if operational modifications associated with techniques T6 (refine nitrification operating protocol) and T7 (EBPR improved settling characteristics) at the NSWWTP can address the remaining 10-15% of the time, thereby avoiding filtration. A sequencing approach is, therefore, proposed for implementing additional treatment. This approach consists of implementing techniques T6 and T7 prior to considering the structural modifications associated with technique T11, Filtration.

Implementation of Techniques T6 and T7 could be staged beginning with refining the operating protocol for nitrification system (T6) and then the activated sludge system modification for EBPR (T7). Once the NSWWTP Ninth Expansion is complete, techniques T6 and T7 can be evaluated and instream effects can be monitored. If results are not satisfactory, then technique T11, Filtration, could be implemented.

Option 2, Site-Specific Limits for protecting aquatic life, would not require additional treatment beyond aeration. These limits can be consistently achieved by NSWWTP.

The estimated costs for Alternative I and its options are presented in Table 6-19. If the operational sequencing approach is successful the costs for the two options are essentially the same at $5 million.

TABLE 6-19

ESTIMATED PRESENT WORTH
ALTERNATIVE I: RETURN EFFLUENT

Necessary Improvement	Option 1 WDNR Limits ($1,000s)	Option 2 Site-Specific Limits ($1,000s)
Transmission System, Route C	4,900	4,900
Cascade Aerator	130	130
Sequencing Operational Improvements	NA[1]	NA
Filtration	1,400	NA
Total	6,430	5,030

[1] No significant additional costs are expected with techniques T6 and T7

ALTERNATIVE II: RETURN EFFLUENT WITH WATER QUALITY AND STREAM CORRIDOR IMPROVEMENT

This alternative includes the transmission line and protecting aquatic life options and techniques presented above for Alternative I, with added value options and strategies for additional water quality and stream corridor improvement. Transmission and discharge limits options and techniques are the same as Alternative I except that constructed wetlands would not be part of the treatment system. Effluent limits would be met prior to discharge into the wetland and the wetlands would be used only for additional effluent polishing or wildlife improvement. Strategies for additional water quality polishing and stream corridor improvement include wetland creation and/or restoration, improved stormwater management, improved construction erosion control practices, livestock exclusion, and riparian and channel improvements.

Most of the added value options, techniques, and strategies are not under the control or the traditional focus of MMSD. These include Option 3, Wetland Creation/Restoration; Option 4, Stormwater Management; Option 5, agricultural controls; Option 6, Riparian and Channel Improvements; and the strategies associated with these options. These options should be implemented by the agencies best suited for their completion, taking advantage of the skill base across multiple agencies. Options and strategies that are best implemented by other organizations should be refined and implemented as part of an overall watershed program such as the Priority Watershed Program scheduled to begin in the Sugar River Basin in 1997. Added value techniques and strategies that could be implemented by MMSD include T12, Polishing Wetland; S6, Channel Improvements; and S8, Woody Debris. These techniques and strategies are evaluated below.

Technique 12: Polishing Wetland

This option is similar to the wetland treatment technique T9 evaluated with Alternative I except that effluent limits would be met prior to discharge into the wetland. The primary purpose of the wetland would be additional effluent polishing and wildlife habitat. Either Site A, DOT Wetland, or Sites J/K, Dane County Parks, could be used with effluent as the water source.

Technical Feasibility. The technical feasibility of constructing a wetland at either site is good. Since the wetland is for effluent polishing and wildlife habitat, any size could be used.

Regulatory Considerations. Existing wetlands in the area could be incorporated in the new wetland if it can be demonstrated that their use will result in either enhancement or restoration. A wetland functional value assessment would be needed to make this determination. In addition, both a U.S. Army Corps of Engineers 404 Permit and State Wetland Water Quality Certification NR 103 would be needed if an existing wetland was used as part of the system.

The future administrative jurisdiction over the created wetland is a concern with the creation of a polishing wetland that would not be part of the official wastewater treatment system. If the created wetland is considered jurisdictional by permitting agencies, MMSD may be obligated indefinitely to maintain the wetland with effluent. This may constrain future flexibility for managing effluent in the Sugar River Basin.

Benefits. The polishing benefits of a wetland where limits are not met prior to discharge into the wetland would be the same as those presented earlier for technique T9. These included mass load reductions for TSS, ammonia, and TP but an increase in BOD mass loading to Badger Mill Creek compared to a direct discharge. Effluent polishing benefits for a 20-acre wetland assuming that the WDNR limits will be met prior to discharge into the wetland are presented below. The polishing benefit for other wetland sizes will be approximately proportional to the area used, compared to the 20-acre base for these calculations. The BOD discharge concentrations for a 20-acre polishing/habitat wetland are presented in Table 6-20. Warm season concentrations for the polishing wetland discharge are generally higher than the average warm season concentration (3.8 mg/L) in the NSWWTP effluent. Cold season concentrations from the wetland are lower than the average NSWWTP cold season concentrations (7.3 mg/L). However, the assumption that limits would be met through treatment means that the average concentrations from the NSWWTP could be slightly lower than the existing average NSWWTP concentrations. Therefore, the net annual mass reduction in BOD from a polishing wetland is probably negligible. Seasonally, the polishing wetland would increase mass BOD loads during the warm season and decrease loads during the cold season.

TABLE 6-20

BOD EFFLUENT CONCENTRATIONS FOR A 20-ACRE POLISHING WETLAND

	Effluent Concentration (mg/L)	
	2.2 mgd	3.6 mgd
Jan	6	7
Feb	6	7
Mar	5	6
Apr	5[1]	5[1]
May	5[1]	5[1]
Jun	5[1]	5[1]
Jul	5[1]	5[1]
Aug	5[1]	5[1]
Sep	5[1]	5[1]
Oct	5[1]	5[1]
Nov	5	6
Dec	6	6
Average Annual	5.2	5.6

[1] Nonreducible residual concentrations

The TSS removed in a polishing/habitat wetland is presented in Table 6-21 and is the same for both 2.2 and 3.6 mgd flows. These concentrations would reduce TSS mass loads to Badger Mill Creek compared to a direct discharge.

TABLE 6-21

TSS EFFLUENT CONCENTRATIONS FOR A 20-ACRE POLISHING WETLAND

	Concentration (mg/L)
Jan	3
Feb	3
Mar	3
Apr	5
May	5
Jun	6
Jul	6
Aug	6
Sep	6
Oct	5
Nov	3
Dec	3
Average Annual	4.5

The ammonia and phosphorus removals in this 20-acre polishing/habitat wetland would be the same as previously calculated for the treatment wetland, technique T9 in Alternative I (Table 6-15), since the assumption was that limits would be met at the NSWWTP.

In summary, a polishing wetland would have a negligible effect on BOD loads discharged to Badger Mill Creek but would have polishing benefits for TSS, ammonia, and TP.

Estimated Cost. The estimated cost for a 20-acre polishing wetland system is presented in Table 6-22. The primary cost difference between a treatment wetland and polishing wetland is the liner required for a treatment wetland.

Strategy S6: Channel Improvements

Typical channel improvements considered for implementation are shown on Figure 5-6.

TABLE 6-22

ESTIMATED COSTS FOR A 20-ACRE POLISHING WETLAND

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
Construction	acre	29,000		580,000
Construction Contingency		15%		87,000
Total Construction				667,000
Engineering and Administration		10%		66,700
Total Capital Cost				733,700
Operations and Maintenance				
Inspections and Sample Collection	hr/yr	15.00	104	1,560
Water Level Control Operation	hr/yr	15.00	64	960
Benefits		42%		1,058
Annual Maintenance		1% of Construction		5,800
Total Operations and Maintenance Cost				9,378
Present Worth				**$824,108**
Annualized Worth				**$ 69,524**

[1] $24,000/acre for wetland construction without liner; $5,000/acre for land acquisition

Technical Feasibility. The typical channel improvements are simple, easy to install, and made of commonly available materials. The design and installation processes will need to attend to the stability of materials placed in the channel, as well as possible erosion and flooding issues. As part of the design process , a HEC-2 flood profile analysis will need to be completed to assure that improvements do not affect flood levels. No-rise conditions with the improvements are possible if the structures are low enough to compress only the baseflow channel and not significantly change flood flow channel areas.

Regulatory Considerations. Implementing channel improvements would require a WDNR Chapter 30 Permit, local flood permits, and compliance with the National Flood Insurance Program (NFIP). For compliance with the NFIP, the HEC-2 flood profile analysis must show no rise in the 100-year floodplain or the project must obtain a Letter of

Map Revision. To obtain a Letter of Map Revision, public hearings must be held and revised flood maps developed and approved.

A state wetland water quality certification, NR 103, may also be needed since the creek is a riparian wetland. However, since the improvements are designed to improve conditions for the aquatic biota in the creek, these efforts should be compatible with NR 103.

Benefits. Channel improvements in reaches 4 and 5 have the potential to improve water quality and fish habitat. Water quality would improve because increased velocities would improve reaeration and reduce sediment accumulation. Low flow temperatures would also improve because of the reduced surface area exposed to solar radiation. The channel improvements may also help stabilize sediment already accumulated in the creek. This could be accomplished by seeding or planting areas that accumulate sediment in and around the stream structures.

Fish habitat would improve because of the greater variety of stream structure, cover, and water depths created by the improvement.

Estimated Costs. Costs for channel improvements depend on the length of channel to be modified. Typical construction costs for the types of structures considered for this project are $30-50 per linear foot. Additional costs would be incurred for the HEC-2 flood profile modeling and permit negotiation.

Strategy S8: Woody Debris

The primary goals for this strategy would be to increase fish habitat and stabilize streambanks.

Technical Feasibility. As with S6, Channel Improvements, it is easy to install woody debris.

Regulatory Considerations. Regulatory considerations are the same as those for Strategy S6, Channel Improvements.

Benefits. Benefits from the installation of woody debris include fish habitat and streambank stabilization. Streambanks are stabilized because the debris forces the higher velocities away from the bank and downward so that scouring creates pools. These pools increase the variety of fish habitat in terms of cover and structure.

Estimated Costs. Costs to install woody debris depend on the length of channel to be modified. Typical construction costs based on similar projects are $50-70 per linear foot. Additional costs would be incurred for the HEC-2 flood profile modeling and permit negotiation.

Summary of Alternative II Evaluation

Implementing Alternative II includes the Alternative I options and techniques with added value improvements. Added value improvements considered include a polishing wetland, channel improvements, and woody debris. A polishing wetland would provide TSS, ammonia, and TP benefits but the amount of BOD benefit is uncertain and is likely negligible. A polishing wetland may also have the negative impact of increasing temperature and reducing DO prior to discharge into Badger Mill Creek. For these reasons, a direct discharge into Badger Mill Creek was preferred.

Stream corridor improvements could be implemented through a partnership between MMSD and other organizations. One of the best mechanisms for this is the Priority Watershed Program (PWP) which is scheduled to begin planning in 1997 with implementation starting in 1999. There is some debate about how the stream corridor will be managed; this debate can be resolved as part of the PWP planning. However, the interim period provides an excellent opportunity for demonstrating the suggested channel improvement and woody debris technologies. The most successful technologies could then be expanded as part of the PWP. Therefore; Alternative II was refined to include the necessary improvements from Alternative I and a channel improvement demonstration project as an added value improvement.

A distance of 1,500 linear feet was selected for demonstration. The locations for demonstrations have not yet been selected and will depend on goals established by a steering committee. Approximately 1,000 feet in reaches 4 or 5 would be constructed using Strategy S6, Channel Improvement, as shown in Figure 5-5. About 500 feet in reaches 1 and 2 would be improved with woody debris as shown in Figure 5-6. The estimated cost for the 1,500-foot demonstration is presented in Table 6-23. The capital cost for the demonstrations is $110,600 with a present worth of $121,600.

TABLE 6-23

ESTIMATED COSTS FOR A 1,500-FOOT CHANNEL IMPROVEMENT DEMONSTRATION

Description	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Capital				
Instream Structures	LF	40	1,000	40,000
Debris Structures	LF	60	500	30,000
Subtotal				70,000
Construction Contingency		15%		10,500
Total Construction				80,500
Engineering and Administration		15%		12,075
Permit Contingency	Lump	7,500	1	7,500
Total Capital Cost				110,575
Easements/Land	acre	5,000	0	0
Operations and Maintenance				
Annual Maintenance		1% of Construction		805
Semi-Annual Inspections	hr	15.00	16	240
Fringe Benefits		0.42		101
Total Operations and Maintenance Cost				1,146
Present Worth				**$121,622**
Annualized Worth				**$ 12,616**

Total costs for Alternative II are summarized in Table 6-24 and include both the necessary improvements from Alternative I and the channel improvement demonstration.

TABLE 6-24

ESTIMATED PRESENT WORTH FOR ALTERNATIVE 2: RETURN EFFLUENT WITH WATER QUALITY AND STREAM CORRIDOR IMPROVEMENT

Improvement	Option 1[1] ($1,000s)	Option 2[2] ($1,000s)
Necessary Improvements		
Transmission System, Route C	4,900	4,900
Cascade Aerator	130	130
Sequencing Operational Improvements	NA[3]	NA
Filtration	1,400	NA
Subtotal	6,430	5,030
Added Value Improvements		
Channel Improvement Demonstration	122	122
Total	6,552	5,152

[1] WDNR limits
[2] Site-specific proposed limits
[3] No significant additional costs are expected

Section 7

Section 7

SECTION 7

SCREENING AND PLAN SELECTION

Section 5, Alternatives Definition, and Section 6, Alternatives Evaluation, presented and evaluated alternatives for handling effluent from the Sugar River Basin. These sections covered numerous options, techniques, and strategies, and narrowed selection to the following five alternatives:

Alternative I: Return Effluent, Option 1 WDNR Limits

- Transmission Line

  Option: Route C

  Techniques:
  - T1: Forcemain
  - T2: Effluent pumping
- Protect Aquatic Life

  Option 1: WDNR Limits

  Techniques:
  - T5: Cascade aerator at Site 2
  - Sequenced operational improvements consisting of T6, refine the nitrification operating protocol, T7, EBPR improved settling characteristics, and if necessary T11, effluent filtration

Alternative I: Return Effluent, Option 2 Site-Specific Limits

- Transmission Line

  Option: Route C

  Techniques:
  - T1: Forcemain
  - T2: Effluent pumping
- Protect Aquatic Life

  Option 2: Site-Specific Limits

  Techniques:
  - T5: Cascade aerator at Site 2 with monitoring of instream characteristics to determine if additional efforts are necessary.

Alternative II: Return Effluent with Water Quality and Stream Corridor Improvement, Option 1 WDNR Limits

- Transmission Line

  Option: Route C

  Techniques:

  - T1: Forcemain
  - T2: Effluent pumping
- Protect Aquatic Life

  Option 1: WDNR Limits

  Techniques:

  - T5: Cascade aerator at Site 2
  - Sequenced operational improvements consisting of T6, refine the nitrification operating protocol, T7, EBPR improved settling characteristics, and if necessary T11, effluent infiltration
- Water Quality and Stream Corridor Improvements

  Option: Stream corridor improvements

  Strategies:

  - S6: Channel improvement demonstrations
  - S8: Woody debris demonstrations

- **Alternative II: Return Effluent with Water Quality and Stream Corridor Improvements, Option 2, Site-Specific Limits**

  - Transmission Line

    Option: Route C

    Techniques:

    - T1: Forcemain
    - T2: Effluent pumping
  - Protect Aquatic Life

    Option 2: Site-Specific Limits

    Techniques:

    - T5: Cascade aerator at Site 2 with monitoring of instream characteristics to determine if additional efforts are necessary
  - Water Quality and Stream Corridor Improvements

    Option: Stream corridor improvements

    Strategies:

    -S6: Channel improvement demonstrations
    -S8: Woody debris demonstrations

Alternative Option 2C was described and evaluated in the Ninth Addition Facilities Plan. This alternative is also a potential solution for handling effluent from the Sugar River Basin. This alternative would upgrade and operate the existing Verona WWTP to meet effluent permit requirements while pumping a portion of the wastewater to the NSWWTP.

This section evaluates the economic and noneconomic aspects of the above alternatives, which forms the basis for selecting and recommending an alternative. The following criteria were used to compare the alternatives:

- Present worth cost
- Environmental impact
- Flexibility and operation
- Public support

A summary of the alternatives comparison is presented in Table 7-1.

COST COMPARISON

The comparison of present worth costs for the alternatives is summarized in Table 7-1. Estimated costs for the effluent return system (i.e., transmission line and effluent pumping) are slightly higher than the costs used for comparing routes in Section 6 because of refinements. The most significant refinement included the addition of 1,000 feet of line to reach the preferred discharge Site 2. The refined effluent return system present worth cost is $5,400,000.

Alternative Option 2C is the least expensive. The next lowest, Alternative I, Option 2, has a present worth 2.3 times the least cost alternative. Alternative II, Option 1 is the most expensive at three times the cost of the least cost alternative.

ENVIRONMENTAL IMPACT COMPARISON

The criteria used to compare the environmental impacts of the alternatives include the following and are discussed below:

- Water quantity
- Water quality

TABLE 7-1

SUMMARY COMPARISON OF ALTERNATIVES

Alternative	Present Worth Cost ($ millions)	Environmental Impact					Flexibility and Operation	Public Support
		Water Quantity	Water Quality	Fisheries	Natural and Archaeological Resources	Recreation		
Alternative I, Option I	6.9	Enhances Sugar River and Badger Mill Creek baseflows and low flows, and minimizes the potential for future flow reductions by eliminating diversions out of the watershed	Protects aquatic life and improves water quality of the Sugar River	Increases the potential for forage fish and trout in Badger Mill Creek	No long-term adverse impacts	Potential to improve Military Ridge and Capital City Trails, and for improved recreational uses of Badger Mill Creek	Maintains flexibility for the future management of all wastewater generated in portions of the Sugar River Basin served by MMSD	Public support is strong
Alternative I, Option 2	5.5	Same as Alternative I, Option I	Same as Alternative I, Option I	Same as Alternative I, Option 1	Same as Alternative I, Option I	Same as Alternative I, Option 1	Same as Alternative I, Option I	Public support is strong
Alternative II, Option 1	7.1	Same as Alternative I, Option 1	Demonstrates channel improvement techniques for stabilizing sediment, improving reaeration, and reducing solar heating	Improves fisheries habitat for 1,500 feet of Badger Mill Creek and demonstrates technologies for coordinated implementation with the Priority Watershed Program	Same as Alternative I, Option 1	Same as Alternative I, Option 1	Same as Alternative I, Option 1	Public support is strong
Alternative II, Option 2	5.7	Same as Alternative I, Option I	Same as Alternative II, Option I	Same as Alternative II, Option I	Same as Alternative I, Option I	Same as Alternative I, Option 1	Same as Alternative I, Option 1	Public support is strong
Alternative Option 2C	2.4	Reduces Sugar River flow by 0.5 cfs for 10 years and does not address the potential for future reductions or diversions from areas outside the Verona USA	Same as Alternative I, Option 1	Existing conditions continue in Badger Mill Creek	Same as Alternative I, Option 1	Does not affect trails or recreational uses	Maintains flexibility for the future management of wastewater generated in the Verona USA, but does not provide a solution for wastewater generated in other portions of the Sugar River Basin served by MMSD Need to operate two plants	Public concern about 0.5 cfs loss of flow in the Sugar River

- Fisheries
- Natural and archaeological resources
- Recreation

Water Quantity

Alternatives I and II with either option would return treated water to the Sugar River Basin. The return volumes would enhance existing Sugar River baseflows and minimize potential future reductions in baseflow due to increased diversions. Sugar River flows would be enhanced because the proposed discharges of 2.2 mgd and 3.6 mgd at the beginning and end of the planning period are greater than the existing discharge of 0.6 mgd. These increases are 1.4 mgd (2.4 cfs) and 2.6 mgd (4.6 cfs). These flows would increase Sugar River baseflows by 13-25% and low flows by 30-59%. The increased flows are due to the return of a volume of effluent equivalent to the wastewater generated in areas outside the Verona USA but inside the Sugar River Basin and the MMSD USA. Thus, Alternatives I and II provide a solution for the duration of the planning period for all the wastewater generated in portions of the Sugar River Basin served by MMSD.

Alternative Option 2C would keep an estimated 0.3 mgd discharge into the Sugar River Basin, resulting in an immediate decrease in discharge to the Sugar River of 0.3 mgd or 0.5 cfs. This flow reduction would continue until the plant is completely upgraded in 10 years as part of the alternative. This upgrade would be designed to handle wastewater generated in the Verona USA and would not accommodate wastewaters generated in other portions of the Sugar River Basin served by MMSD. These flows would continue to be diverted to the NSWWTP for treatment and discharge to Badfish Creek.

The immediate reduction in discharge to the Sugar River of 0.5 cfs is a 3 percent decrease in baseflow and 6 percent decrease in low flow. Alternative Option 2C would also do nothing over the first 10 years to minimize the potential for future reductions in baseflow due to increased diversions. When the plant is upgraded in 10 years, diversions from the Verona USA would be reduced. The plant capacity would be increased from 0.32 mgd to 0.84 mgd. However, 2.72 mgd from other areas of the Sugar River Basin would still be diverted to the NSWWTP without return. The source of this diversion water is groundwater and it is uncertain if its diversion would create a significant reduction in baseflow. However, the review of the county's hydrologic study and City of Verona well logs in Section 4 showed that there is a potential connection between the source groundwater and shallow groundwater which supplies baseflow. Thus, Alternative Option 2C provides only a partial or temporary solution to wastewater management in the Sugar River Basin.

Alternatives I and II will also enhance baseflows in Badger Mill Creek. The enhanced flow volumes would be 3.4 cfs at the beginning of the planning period and 5.5 cfs at the end. The existing baseflow volume is about 3 cfs. Low flow at the mouth of Badger Mill Creek is 0.18 cfs. Alternatives I and II would also minimize the potential for future baseflow reductions due to increased diversions. Badger Mill Creek is more susceptible to baseflow reductions than the Sugar River because most of the groundwater that would be diverted comes from areas underlying the Badger Mill Creek watershed. In addition, shallow groundwater area draining to Badger Mill Creek is relatively small compared to the surface watershed area for Badger Mill Creek.

Alternative Option 2C would not enhance the baseflows in Badger Mill Creek or protect the creek from future baseflow reductions.

Water Quality

Alternatives I and II with either option would improve the water quality of the Sugar River due to decreased mass loads. Effluent from the NSWWTP is of much better quality than effluent from the Verona WWTP, and even though the volume of discharge would be greater, the quality of the NSWWTP effluent would reduce the mass of pollutants discharged. Option 1 with either Alternative I or II would produce slightly better discharge characteristics if effluent filtration were implemented after the sequenced operational improvements.

Alternative Option 2C would also improve the water quality of the Sugar River due to the decreased discharge volume and improved effluent characteristics following improvements at the Verona WWTP. This alternative would not affect the water quality of Badger Mill Creek.

Existing water quality data for Badger Mill Creek are limited, and it is not possible to conclude that Alternatives I and II would affect Badger Mill Creek's water quality by comparison with existing conditions data. However, effluent quality under the alternatives would meet either the WDNR proposed limits (Option 1) or site-specific limits (Option 2). Both of these limits protect aquatic life and meet stream standards.

Badger Mill Creek is currently affected by sediment. Alternative II addresses some of these sediment problems by demonstrating methods to stabilize sediment already in the creek. Alternative II may also help resolve some of the sediment problem by increasing public awareness and promoting the Priority Watershed Project.

Alternatives I and II may also improve Badger Mill Creek during low flows by providing a greater heat sink to buffer high temperatures. Under average warm season conditions, effluent discharges under Alternatives I and II are not expected to have negative effects due to high temperatures.

Fisheries

The proposed effluent quality for Alternatives I and II is sufficient to support the warm water and cold water stream classifications. The quality of effluent discharges to Badger Mill Creek under Alternatives I and II meets limits that protect aquatic life; effluent temperatures are always below the lethal and generally below the growth-stopping temperatures for brown trout. The best evidence that effluent from NSWWTP is of sufficient quality to support a fishery is the presence of brown trout below the existing outfall to Badfish Creek.

The enhanced baseflows in Badger Mill Creek under Alternatives I and II increase the fishery potential. Habitat modeling showed that enhanced flows have the potential to increase the amount of usable habitat in Badger Mill Creek for forage fish and brown trout. However, other factors are limiting the fishery productivity in Badger Mill Creek. Flow augmentation by itself as proposed in Alternative I may not provide much fishery benefit. Alternative II provides additional fisheries benefit by addressing some of the other limiting factors through a channel improvement demonstration project that improves 1,500 linear feet of channel as well as providing demonstrations for further improvement through the Priority Watershed Project.

Alternative Option 2C does not provide any fishery benefit to Badger Mill Creek.

Natural and Archaeological Resources

Long-term negative impacts on natural or archaeological resources from construction were not identified for any of the alternatives. Temporary wetland impacts due to the construction of the transmission line would occur for Alternatives I and II. These temporary impacts are not significant.

Recreation

Alternatives I and II have the potential to improve recreational resources. Improvements are possible to the Military Ridge and Capital City Trails during construction of the transmission line. Stream corridor and fisheries improvements completed as part of Alternative II have the potential to improve the recreational uses of Badger Mill Creek.

Alternative Option 2C has no effect on recreation, while Alternatives I and II have the potential to reduce the cost of trail improvements.

FLEXIBILITY AND OPERATION

All the alternatives maintain a discharge point in the Sugar River Basin. However, the volume of discharge under Alternative Option 2C accommodates only the volume generated in the Verona USA. This provides only a partial or temporary solution for the wastewater generated in portions of the Sugar River Basin served by MMSD. As infrastructure in the area grows, it will become increasingly difficult to develop solutions for all the wastewater generated within the Sugar River Basin. This is particularly true for a return effluent line.

Alternative Option 2C would also require MMSD to operate two plants instead of just the NSWWTP. This imposes a noneconomic operational burden on MMSD in addition to the operation, maintenance, and staff costs associated with the continued operation of the Verona WWTP.

Alternatives I and II would maintain flexibility for the future management of all wastewater generated in portions of the Sugar River Basin served by MMSD.

PUBLIC SUPPORT

Two public meetings have been held by MMSD regarding the facilities planning effort. The first was held as part of the Ninth Addition Facilities Plan, and the second as part of the current effort. Public comment expressed at the hearings has unanimously supported keeping a volume of water equal to the volume of wastewater generated in the Sugar River Basin in the basin. Furthermore, the public appears to support the concept of returning effluent with a discharge to Badger Mill Creek despite its higher cost. This is due to concerns over the flows in the Sugar River and the potential beneficial impacts associated with returning effluent to Badger Mill Creek. A transcript of the second public hearing is attached as Appendix I, and a transcript of the first hearing is included with the Ninth Addition Facilities Plan Update.

PLAN SELECTION

Based on the evaluation criteria, Alternative II, Option 2 as described on page 7-2 was selected for implementation. Justification for selecting this alternative is as follows:

- Alternative II, Option 2 maintains flexibility for future management of all wastewater generated in portions of the Sugar River Basin served by MMSD.

- Alternative II, Option 2 protects aquatic life and has a lower present worth cost than Alternative II, Option 1.

- Alternative II, Option 2 enhances Badger Mill Creek baseflows and low flows, increases potential fish habitat for 25,000 feet of the creek, and improves fish habitat for 1,500 feet of creek.

- Alternative II, Option 2 demonstrates stream improvement technologies, promotes the Priority Watershed Program, and has the potential to enhance cross-agency cooperation for the benefit of the resource.

- Alternative II, Option 2 has no known long-term impacts on natural or archaeological resources, and has the potential to improve the Military Ridge and Capital City Trails and recreational uses of Badger Mill Creek.

- Public and local government support is strong for this alternative.

Additional strategies and improvements such as proactive stormwater management are necessary to significantly improve Badger Mill Creek and the Sugar River. However, through the Priority Watershed Project the necessary plans and infrastructure will be developed to continue the improvements started by selecting and implementing this alternative by the MMSD. Section 8 provides information on implementing the selected alternative.

Section 8

SECTION 8

PLAN IMPLEMENTATION

This section describes the program required to implement the selected alternative, Alternative 2: Return Effluent with Water Quality and Stream Corridor Improvement with Option 2, Site-Specific Limits. Implementation considerations include additional actions, project costs, impacts on service charge rates, and schedule.

ADDITIONAL ACTIONS

The following additional actions are needed to complete the planning to implement the selected alternative.

- Develop an operational protocol for regulating effluent discharge at or below 1.9 mgd during periods of flooding on Badger Mill Creek. This protocol can be developed as part of design, and should include mechanisms for tracking rainfall and criteria for determining when the protocol should be implemented.

- Determine goals and responsibilities for the stream corridor improvement demonstrations. MMSD has approved the demonstrations if other agencies and organizations will form a partnership to complete the channel improvements. Possible partnerships could include engineering and materials funding by MMSD with construction assistance from City of Verona crews or others. Goals for the improvement demonstrations also need to be established so that the improvements can be sited along the creek and a measurable result identified against which the success of the demonstrations can be evaluated.

- A more detailed archaeological evaluation needs to be completed at Site 2 for the outfall aerator.

PROJECT COSTS

Total project costs are summarized in Table 8-1. Costs shown in Table 8-1 are for new facilities in this plan and do not include costs of the forcemain from the Verona WWTP to the MMSD collection system. This forcemain has already been approved and is under construction.

TABLE 8-1

ESTIMATED PROJECT COSTS ($)

Facilities	Initial Project Cost ($)	Annual O&M Cost ($/yr)
Forcemain and Pumping	4,700,000	25,000[1] to 49,000[2]
Cascade Aerator	82,100	5,800
Stream Improvements	110,100	1,200
Total	4,892,200	32,000 to 56,000

[1] Pumping at 2.2 mgd
[2] Pumping at 3.6 mgd

IMPACTS ON SERVICE CHARGE RATES

The Ninth Addition Facilities Plan Update included a detailed discussion of the District's service charge rate structure. Since the costs associated with the return of effluent to the Sugar River Basin estimated in that plan update are nearly identical to cost estimates for the selected alternative, there is no reason to repeat the detailed analysis. Table 8-2 summarizes the service charge effects of the selected alternative. Implementation of the selected alternative results in an annual increase of about $2 or 1.6% to the average residential user.

TABLE 8-2

IMPACT OF PROJECT COSTS ON AVERAGE RESIDENTIAL SERVICE CHARGES

Year	Rate Structure Basis	Average Residential Service Charge (MMSD and Community) ($/yr)
1995	Current	133
1998	Base	145
1997	Ninth Addition Incremental Charge	13
1997	Sugar River Incremental Charge	2
Total		160

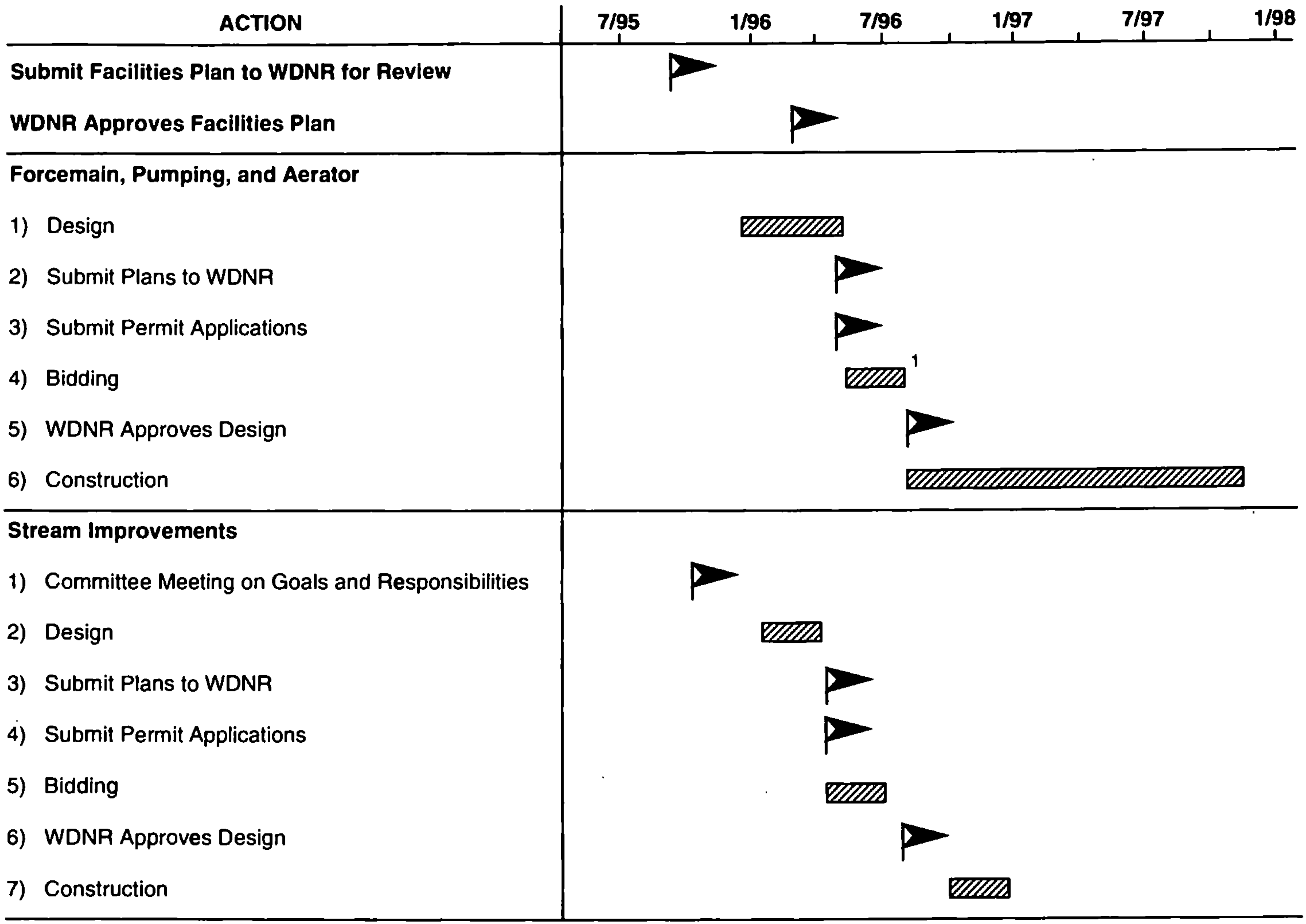
PROJECT IMPLEMENTATION SCHEDULE

The implementation plan is shown on Figure 8-1. The plan contains two main projects:

- Construction of the forcemain, effluent pumps, and aerator
- Construction of the channel improvements

Forcemain construction will provide maximum recreation benefits if coordinated with improvements already planned for the Military Ridge and Capital City Trails. These improvements are scheduled to begin in 1996, but may be delayed until 1997. Therefore, this implementation plan has an accelerated schedule for transmission line design so that if trail improvements occur as planned in 1996, the forcemain construction could be bid during the summer of 1996 and key segments constructed in conjunction with the trail improvements.

Construction of the channel improvements is also accelerated so that the improvements and channel work can be completed prior to augmentation of flow. This would allow installation during lower flows and provide time for vegetation and structures to become established before flow augmentation.



[1] If needed to coordinate with trail improvements

FIGURE 8-1

PLAN IMPLEMENTATION SCHEDULE

Section 9

Section 9

MONTGOMERY WATSON

SECTION 9

REFERENCES

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Appendix

MONTGOMERY WATSON

Appendix A

MONTGOMERY WATSON

File 3.3.2

M E M O R A N D U M

MONTGOMERY WATSON

To:	Jim Nemke	**Date:**	January 26, 1995
From:	Paul Nelson PN Tom Davis	**Reference:**	4248.0011/3.1.2
Subject:	Advisory Committee Meeting Minutes		

SUGAR RIVER BASIN EFFLUENT DISCHARGE STUDY
ADVISORY COMMITTEE MEETING MINUTES
JANUARY 19, 1995

The Advisory Committee meeting was kicked off by Jim Nemke with introductions. Those in attendance at the meeting are listed on the attached attendees list. Mr. Nemke also discussed the Advisory Committee structure and organization, noting that regulatory agency personnel need not participate in any voting with the Advisory Committee but are encouraged to participate as they feel comfortable. He gave a project background about the annexation of the Verona Wastewater Treatment Plant and the analysis and alternatives that have led up to the current study. Mr. Nemke then introduced Paul Nelson from Montgomery Watson.

Mr. Nelson stated Montgomery Watson's desire to have a good working relationship and open discussions throughout the project with the Advisory Committee and participating agencies, and that the project would work best without any preconceived paradigms. Mr. Nelson then reviewed the project scope of work stating there were 12 tasks and reviewed each task. Review started with Task 2 - Hydraulic Analysis. Mr. Nelson explained this task would look at whether there would be any hydraulic constraints for discharging effluent into Badger Mill Creek. An analysis of hydraulic constraints is necessary because Badger Mill Creek is mapped as part of the Federal Flood Insurance Program. He stated that we did not anticipate there would be any hydraulic constraints because the volume of effluent discharged is much smaller than storm flows in Badger Mill Creek. Mr. Nelson stated that the hydraulic analysis will be based on the HEC-2 study recently completed by USGS for the National Flood Insurance Program.

Mr. Nelson discussed Task 3 - Determination of Effluent Discharge. He stated that Montgomery Watson would be using model-determined environmentally sensitive effluent limits based on a process described in the flow chart in the scope of work. This process is iterative starting with conservative assumptions in comparison with the abilities of technologies to meet certain effluent characteristics. Mr. Nelson stated this task is where Montgomery Watson needs some assistance from the Advisory Committee in terms of looking for water quality data for Badger

Mill Creek. Montgomery Watson has already pulled data from the STORET system and found a very limited amount of data. Bill Lane suggested that the *Dane County Water Index* would be the place to start looking for additional data. Mr. Lane also pointed out that the hospital had a discharge to Badger Mill Creek through approximately 1978. Bonnie Goodweiler suggested that we contact Dave Marshall from DNR regarding surveys of Badger Mill Creek and others suggested reviewing Ken Potter's work on the Sugar River.

Mr. Nelson then reviewed Task 4 - Transmission System. He stated there are two efforts regarding transmission. The first was to get the effluent from Verona to the Nine Springs Wastewater Treatment Plant, which is already underway. The second, which is a part of this study, is how to return effluent from Nine Springs to Badger Mill Creek.

Mr. Nelson then moved on to reviewing Task 5 - Stream Improvements, stating that stream improvements were being examined at two levels. The first level was what types of stream improvements would be necessary to accommodate additional effluent. The second level was to look at what types of additional improvements could be made to Badger Mill Creek to improve it as a resource for the community. Steve Fix asked if Montgomery Watson anticipated monitoring any storm flows. Mr. Nelson responded that we did not anticipate monitoring storm flows. Ken Potter stated that he did not feel a detailed analysis of storm flows was worthwhile since the volume of effluent is such a small part of any storm flow, and the HEC-2 model would provide limited insight on any velocities and erosion concerns. He felt that effort was better spent looking at possible future changes in the quality and quantity of storm flows. Ed Brick concurred with Ken Potter stating he did not think that the HEC-2 model would provide much insight since it was not really set up to analyze stream conditions as much as hydraulic structures. Mr. Nelson stated that Montgomery Watson concurred that limited efforts should be placed on analysis of storm events, stating that a bulk of the velocity and stream analysis would be done with the IFIM modeling approach. Mr. Brick concurred that the IFIM approach is the best approach. Mr. Nelson explained the IFIM approach.

Mr. Potter then reiterated his concern about future stormwater runoff conditions impacting the creek. This was followed by a discussion of the entire group that rapid development in the upper reaches of Badger Mill Creek will further change the water quantity and quality characteristics of the creek. Mr. Nelson stated that we had anticipated these types of changes and will discuss them as part of the study since investments made to improving Badger Mill Creek with the effluent or stream improvements should be protected from these future stormwater changes. Mr. Nemke concurred stating that we anticipated looking at surrounding land use development plans and discussing how ongoing surrounding development will impact the creek. He stated that control of these future types of impacts are not within the jurisdiction of MMSD. This was followed by a group discussion of responsibility for stormwater runoff changes by cities in the project area and that while MMSD is not responsible for stormwater runoff changes, this report should point out the possible implications of stormwater runoff changes and opportunities for infiltration or stormwater management in the project area. Mr. Nelson stated that it was understanding that SEH has done a detailed hydrologic study of the area north of the highway in the City of Madison. Carol Terrel suggested contacting Larry Nelson, City of Madison engineer, to obtain a copy of the report.

Mr. Potter stated that he felt there was a lot of potential for infiltration in the glacial outwash in the area, and that infiltration would be a beneficial way of introducing effluent back into the area. Bill Lane and Mr. Fix then discussed opportunities for using wetlands for stormwater treatment. Mr. Fix expressed some concern on the DNR's part for using wetlands without some prior pretreatment of the runoff.

Russ Hefty then asked if there was any intention at looking at reestablishing the original meander of Badger Mill Creek. Mr. Nelson responded that looking at what stream improvements are possible is wide open and this could potentially be looked at, however, it was his understanding that a reach immediately west of PB Road had effluent transmission lines on either side of the creek which would limit the ability to establish a meander. Mr. Nemke concurred and expanded on this constraint. However, others pointed out that there is a possibility of reestablishing the meanders or original streambed areas east of PB Road.

Mr. Nelson then asked if there was any additional discussion on Task 5 and proceeded to describe Task 6 - Fisheries Considerations. Mr. Nelson stated that under fisheries conditions, Montgomery Watson would be using the IFIM model along with detailed stream reconnaissance to determine the amount of available fish habitat for various flow regimes. Mr. Lane expressed some concern about only analyzing specific flow regimes and expressed a desire for the report to also determine what the optimum amount of return flow would be.

Mr. Nelson then discussed the approach for Task 7 - Wetland Opportunities, stating that the task included several subtasks, the first subtask being screening of potential sites so that we do not waste effort on sites that have fatal flaws. In the second subtask, we would be working with Sherwood Reed, a national expert on the performance of wetland systems for removing pollutants. Mr. Nemke pointed out, however, that we would not be relying on a wetland treatment system to meet effluent limits; rather, we are looking at using the effluent as an opportunity for creating or restoring wetlands as a resource improvement in the area. Gerry Novotny stated that at wetlands as opportunity rather than as treatment would be a better approach from a DNR permitting perspective. Mr. Nemke stated that was an intention and that we felt we could meet effluent limits for Badger Mill Creek without relying on wetland treatment systems. This project was for additional improvement.

Paul Nelson then moved onto Task 8 - Temperature, stating that it is a potentially difficult effluent parameter to meet. Mr. Brick stated that he did not feel that was necessarily true and that brown trout could survive in effluent temperatures from the Nine Springs Wastewater Treatment Plant. Mr. Nemke concurred stating that brown trout are found in Badfish Creek where the Nine Springs effluent is currently discharged. Mr. Nelson stated that the problem may arise more from stream classification than from the actual fish in Badger Mill and Sugar River and that reviewing the fisheries survey information from Sugar River showed that most of the species found in the survey would be considered either cool or warm water fish. However, current regulations only recognize two stream classifications: cold water and warm water fisheries. Ms. Goodweiler pointed out that the DNR currently has a committee looking at stream temperature classifications. Ms. Terrel and Jeff Stevens on the Advisory Committee are members of this other temperature committee. Mr. Nelson pointed out that some of the means we are looking at for controlling the temperature of the discharge include mitigation and improvements to the riparian zone of Badger Mill Creek, and looking at employing high conductance pipe material in the effluent transmission line.

Mr. Nelson then discussed the approach for task 9 - Resource Interplay. He stated that a number of recreational resources are centered in the project area. Mr. Nemke and he had met the previous day with representatives of the Ice Age Trail, Military Ridge Trail, City of Verona, and Dane County Parks to discuss plans for the area. Efforts for this task will look at for ways or concepts for using this project to complement what is being planned for the other recreational resources in the area.

Mr. Nelson then discussed the project schedule shown in the scope of work stating that the important dates will be completion of field in late March or early April, selection of alternatives in mid-May, production of a draft report in mid-July, and a final report by the end of August. There will be additional Advisory Committee meetings with the next one occurring the first week of March, at which point we will be able to present and discuss findings of the hydraulic and effluent discharge analysis. We will have another Advisory Committee meeting during the first week of April to correspond with the completion of the field work. At this time, most of the project team will be in town and it will be a good point to have a meeting. Thursday afternoons were determined to be a good time for meetings.

Mr. Nelson then asked if there were any other issues the group wanted to discuss prior to leaving. George Osipoff pointed out we should be aware that there is a draft discharge permit currently being developed by the DNR for the Verona Landfill that will discharge to Badger Mill Creek. The discharge will be treated groundwater at 216,000 gallons per day. The permit writer is Tom Harpt. He should be contacted regarding permit conditions. Mr. Nelson asked if anyone knew if a feasibility study had been completed as this may contain more water quality data, particularly for the spring. It was suggested that we contact Ken Kossic of the Dane County Public Works to obtain a copy of any feasibility study work.

...gar River - Advisory Cm. 1/19/95

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Kevin Connors	266-4757	266-9054
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BILL LANE	608-266-4417	266-9117
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File 3.3.3

M E M O R A N D U M

MONTGOMERY WATSON

To: Jim Nemke, MMSD | Date: March 17, 1995

From: Paul Nelson PMN | Reference: 4248.0011/3.3.3

Subject: Advisory Committee Meeting Minutes
March 9, 1995

SUGAR RIVER BASIN EFFLUENT DISCHARGE STUDY
ADVISORY COMMITTEE MEETING - MARCH 9, 1995

Meeting Attendees:

Robert Belle
Ed Brick
Steve Fix
Greg Fries
Russ Hefty
Bill Lane
Jim Mueller
Paul Nelson
Jim Nemke
Gerry Novotny
Ron Rieder
Jeff Steven
Dave Taylor

1. Jim Nemke asked Greg Fries of the City of Madison Engineering Department to introduce himself. Asked for any changes to minutes and briefly described DNR/MMSD consensus letter.

2. Paul Nelson talked about hydraulic modeling. Indicated that the maximum impact was 0.02 feet in elevation and 0.03 fps in velocity. "No noticeable impact."

   Handed out modeling information consisting of a streambed profile. Noted where velocity exceeded 5 fps. May have to look more closely at these for erosion protection.

   Bill Lane suggested we need to see what variation in elevation will trigger regulatory input or constraints.

3. Paul handed out limited amount of numerical data on Badger Mill Creek (Attachment A). Answered questions. Bill Lane suggested it would be helpful to have more flow data. Paul indicated he would hope to develop a stage-discharge curve that then could be used during future sampling.

   Jeff Steven explained what sampling he has done relative to macroinvertebrates on Bader Mill Creek and fish surveys. October samples not yet analyzed.

   Fish data is available. Found 24 species of fish.

   Worked with Bill Ryan from DNR on fish sampling.

Fish surveys revealed similar types of fish as previous DNR surveys.

Will fish sample in spring and fall.

4. Effluent discharge standards. Talked about mass loading from existing Verona permit versus existing MMSD effluent quality. Showed that the proposed discharge of effluent from NSWWTP to Badger Mill Creek would not increase mass loadings to the Sugar River Basin.

   Talked about 13 lb rule and 26 lb rule. WDNR is in the process of calculating effluent limits based on these rules. Montgomery Watson used the rules to calculate preliminary estimates of the limits. Comparison of these estimates with the quality of effluent from NSWWTP showed that the NSWWTP effluent was very close to the quality anticipated for a discharge to Badger Mill Creek. Because the quality is so close, modeling will be beneficial.

   Gerry Novotny suggested that Montgomery Watson check with DNR modeling people to make sure the modeling will be accepted.

   Showed NSWWTP effluent discharge data on BOD, NH_3, and metals versus preliminary effluent limits and criteria (Attachment B)

   Landfill permit was discussed briefly. There would not be much overlap.

   Will take a closer look through modeling.

5. Brainstorming.

   Paul Nelson organized a silent brainstorming session. Attendees were asked to record the elements of the study and elements for final implementation of this project they thought were important. The individual ideas were recorded on a separate piece of paper. All ideas from the entire group were then posted on the blackboard in the front of the room.

   Paul asked the attendees to each select the three elements they considered most important and to move then to the other end of the board. All the elements identified by the group are presented in Attachment C. With the most important elements listed as "Priority Elements" and the remaining elements listed as "Other Elements." This breakdown serves to help Montgomery Watson and MMSD identify those project elements that are most important to the Advisory Committee.

   Paul then asked the committee to think ahead and to take the priority elements and place them in circles of influence consisting of the Great Madison Community and MMSD. Paul explained that the purpose of this exercise was not to determine what should be within MMSD's study, but to start the committee thinking about whether successful implementation of the various elements will require commitment and cooperation from groups in addition to MMSD. The breakdown developed by the group is shown on Attachment D.

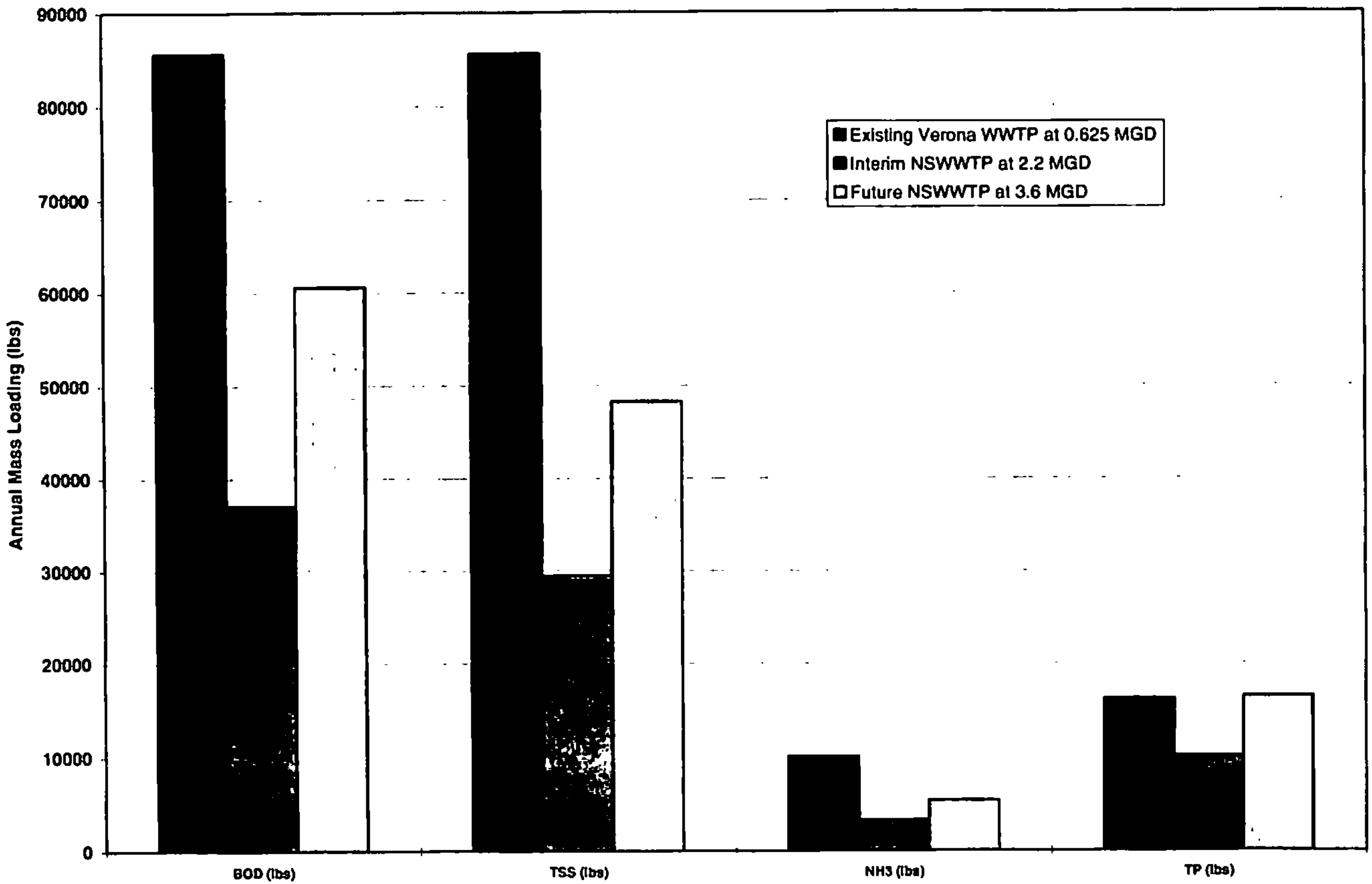
ATTACHMENT A

Input: PAN 2/2/95 — Badger Mill Creek WQ Data

Data Source:Site	Date	Flow cfs	Temp Deg-C	pH SU	DO mg/l	BOD mg/l	COD mg/l	NH3-N mg/l	TKN mg/l	PO4 mg/l	TP mg/l	ALK mg/l	FC /100 ml	TSS mg/l	Hardn mg/l	Cu mg/l
MMSD:BM-7	6/16/93															
	2/2/94		2.3	7.63	11.6	<2		0.11	0.94	<.02	0.2	310	<130	113		
	4/28/94		6.6	7.8	9.9	<2		<.03	0.28	<.1	0.06	311	290	5		
	6/16/94		15	7.7	8.5	<2		0.06	0.39	<.1	<.17	313	>1360	22		
	10/13/94															
MMSD:BM-9	6/16/93		13	8	10.7	<1		0.05	0.66	<.1	0.11	302	690	168		
	2/2/94		0.3	7.46	12.2	<2		0.1	1.32	<.02	0.25	305	330	15		
	4/28/94		6.2	8	10.2	<2		<.03	0.25	<0.1	0.06	311	68	5		
	6/16/94		16.2	7.6	9.5	<2		0.12	0.62	0.1	<.17	303	>2000	30		
	10/13/94		8.8	7.91	11.2	<2		0.03	0.3	<.1	0.09	314	3750	17		
MMSD:BM-3	4/28/94		6.7	7.6	8.3	3		0.09	0.9	<.1	0.18	61	<80	11		
	6/16/94		23.3	6.7	1.4	4		0.31	1.2	0.1	<.17	78	560	15		
	10/13/94		8	6.96	5.5	3		0.44	1.5	0.2	0.37	53.9	25	24		
USGS:Hwy 69	6/29/92	2.7	18	8.4	14.6		15	0.3		0.04	0.07		9700			
	7/30/92	3.4	14	7.9	8.8		<10	<.2		0.03	0.05	305	17000			
	8/21/92	2.9	20.5	8.1	10.1		<10	0.2		0.08	0.08	304	1200			
WRMP:SC	5/25/93		14.6		12.6			0.085		0.075	0.1			4		
DCLF:Down	3/7/89			8.06			<20					283			372	<0.01
	6/8/89			7.55			39					281			353	
	9/12/89			7.81			<20					299			364	
	12/13/89			7.94			<20					294			371	
	3/6/90			7.75			<20					150			168	
	6/27/90			7.24												
	9/20/90			8.5			<20					300			364	
	12/13/90			7.55								294			412	
	3/7/91			7.35								82			81	
	6/4/91			7.65								292			361	
	9/4/91			7.33								307			371	
	12/3/91			6.89								158			177	
	3/18/92			7.78								220			286	
	6/11/92		19	7.44								323			382	
	9/14/92		18	8.92								295			333	
	12/14/92		5	7.46								288			360	
	3/16/93		2	6.7								216			46	
	6/14/93		21	6.6								56			78	
	9/8/93		13	6.69								272			325	
	12/6/93		5	6.56								262			315	
	3/7/94		3.5	6.74								40			85	
	6/24/94		18.5	6.48								59			89	
	9/13/94		22	7.14								194			282	
DCLF: Millpond	3/7/89			7.38			<20					311			417	<0.01
	6/8/89			8.05			39					279			349	
	9/12/89			9.08			<20					166			232	
	12/13/89			9.1			26					256			338	
	3/6/89			8.73			<20					202			248	
	6/27/90			7.21												
	9/20/90			7.5			58					250			308	
	12/13/90			8.55								205			294	
	3/7/91			7.9								92			170	
	6/4/91			8.59								206			254	
	9/4/91			7.8								254			311	
	12/3/91			6.94								372			422	
	3/18/92			7.64								326			418	
	6/11/92		26	7.51								334			411	
	9/14/92		19	7.03								327			385	
	12/14/92		9	7.14								336			430	
	3/16/93		9	7.22								342			424	
	6/14/93		17	6.95								325			390	
	9/8/93		11.5	6.48								326			410	
	12/6/93		9.5	6.38								333			414	
	3/7/94		9	7.02								325			411	
	6/24/94		14.5	6.7								351			422	
	9/13/94		18	7.02								328			396	
DCLF: Upstream	6/9/89			7.7			191					332			137	
	9/12/89			8.12			56					116			98	
	3/6/90			8.26			52					76			58	
MW:Lin Peb Br.	1/18/95	5.1	4		8.7											
	2/2/95	3.2	5.5		8.4											
MW:PB Bridge	1/18/95	0.36	4		7											
	2/2/95	0.33	3		8.3											
MW:PB Pond	1/18/95	0.63	9		6.1											
	2/2/95	0.63	8.5		6.9											
MW: Hwy 69	2/2/95	4.9	6		11											
MW: Sug Riv	2/2/95	29.4	4.5		9.6											

Comparison of Annual Mass Loadings to Badger Mill Creek

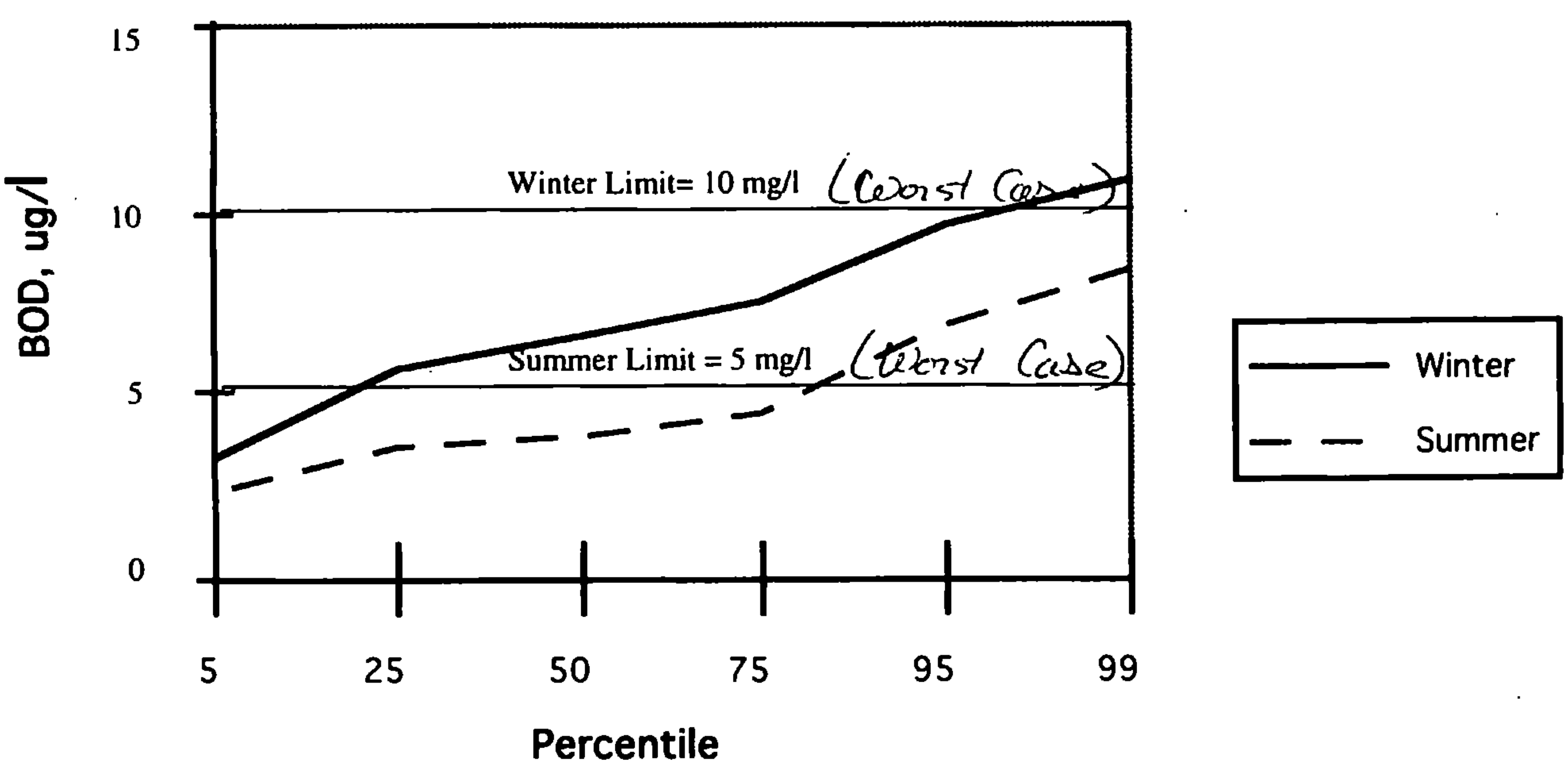
Based on Existing Verona versus NSWWTP Effluent Quality for Design Flow Cases



ATTACHMENT B

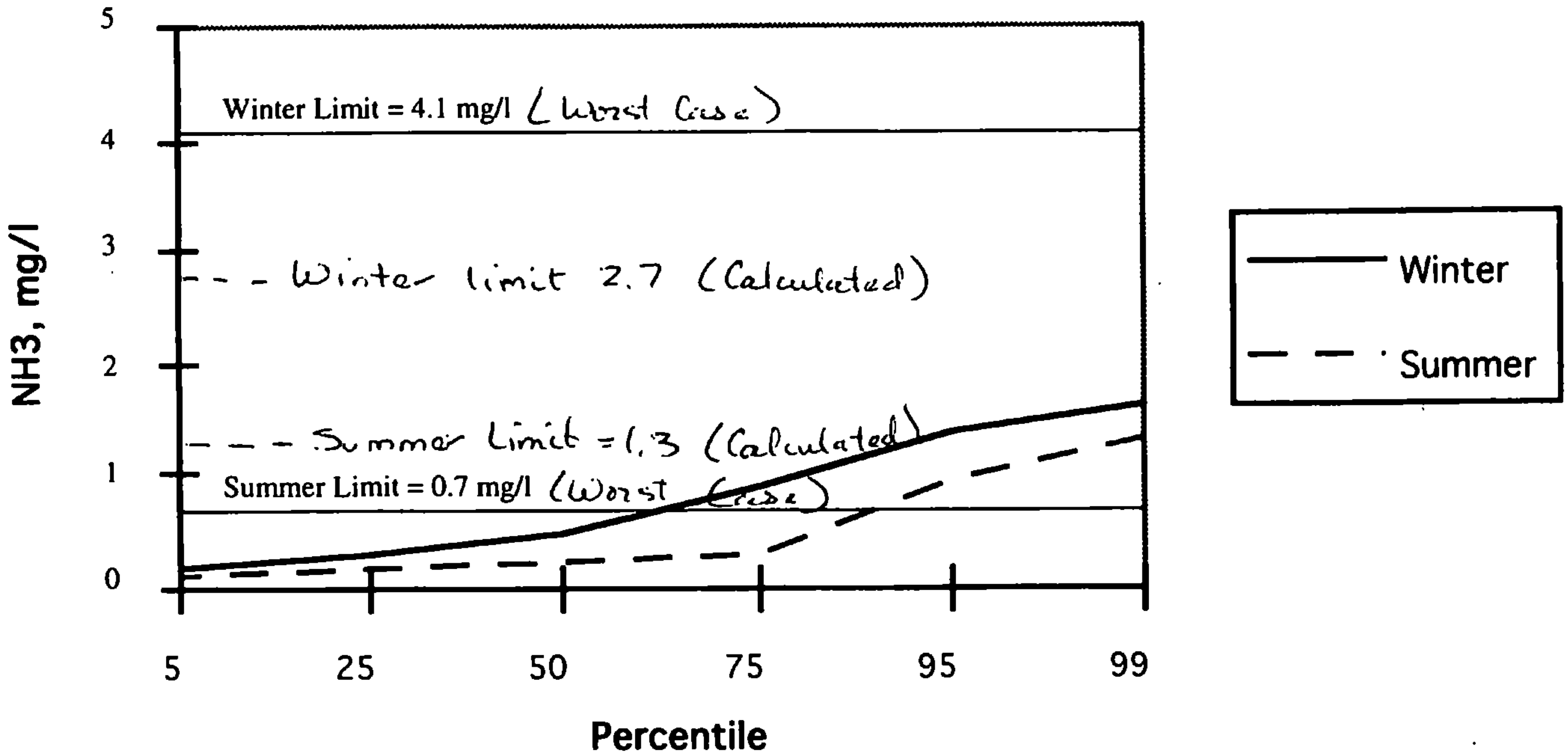
Figure X - Monthly Average BOD Percentiles for NSWWTP

Effluent, 1989 through 1994



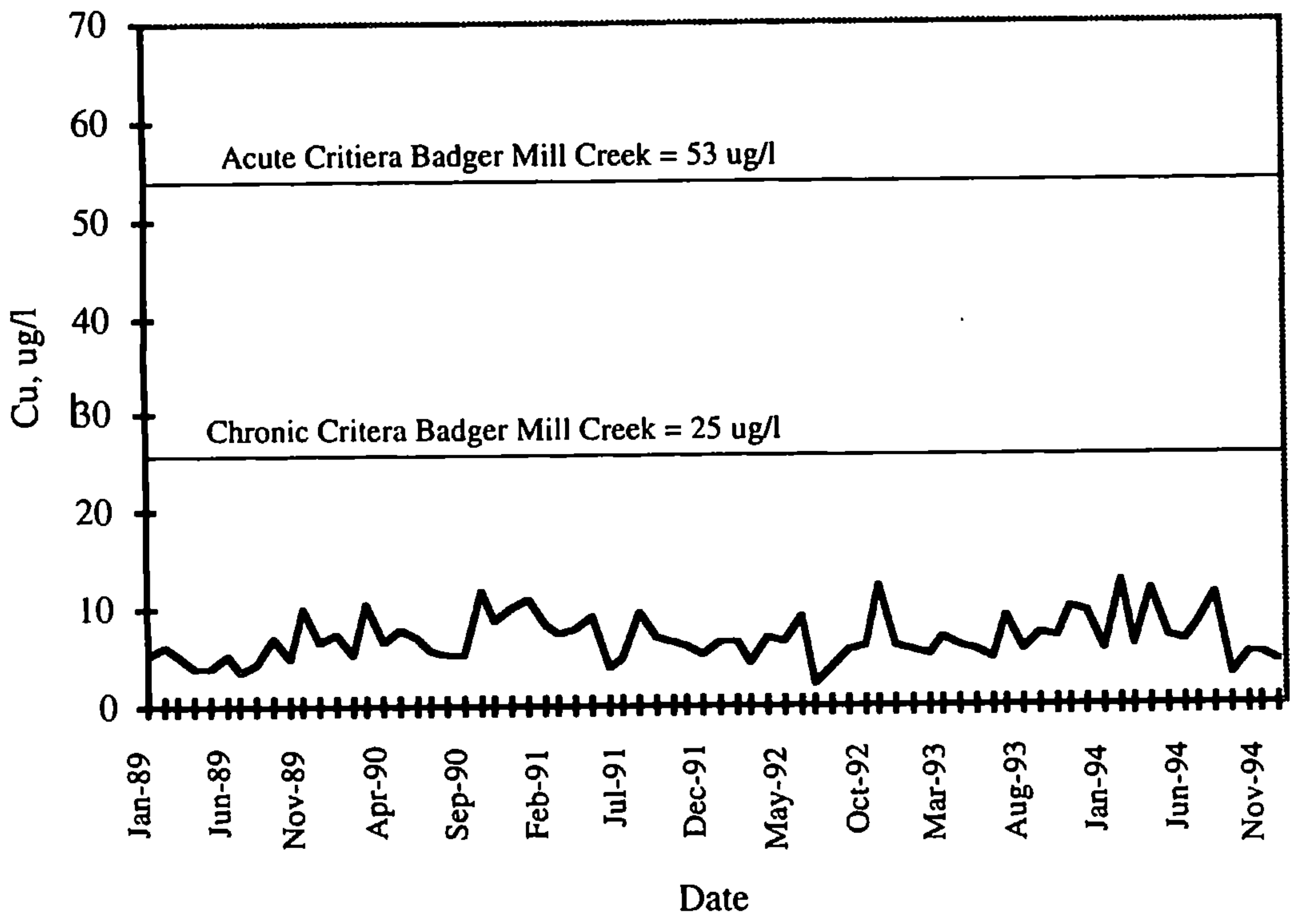
ATTACHMENT B

Figure x. Monthly Average NH3 Percentiles for NSWWTP Effluent, 1989 through 1994



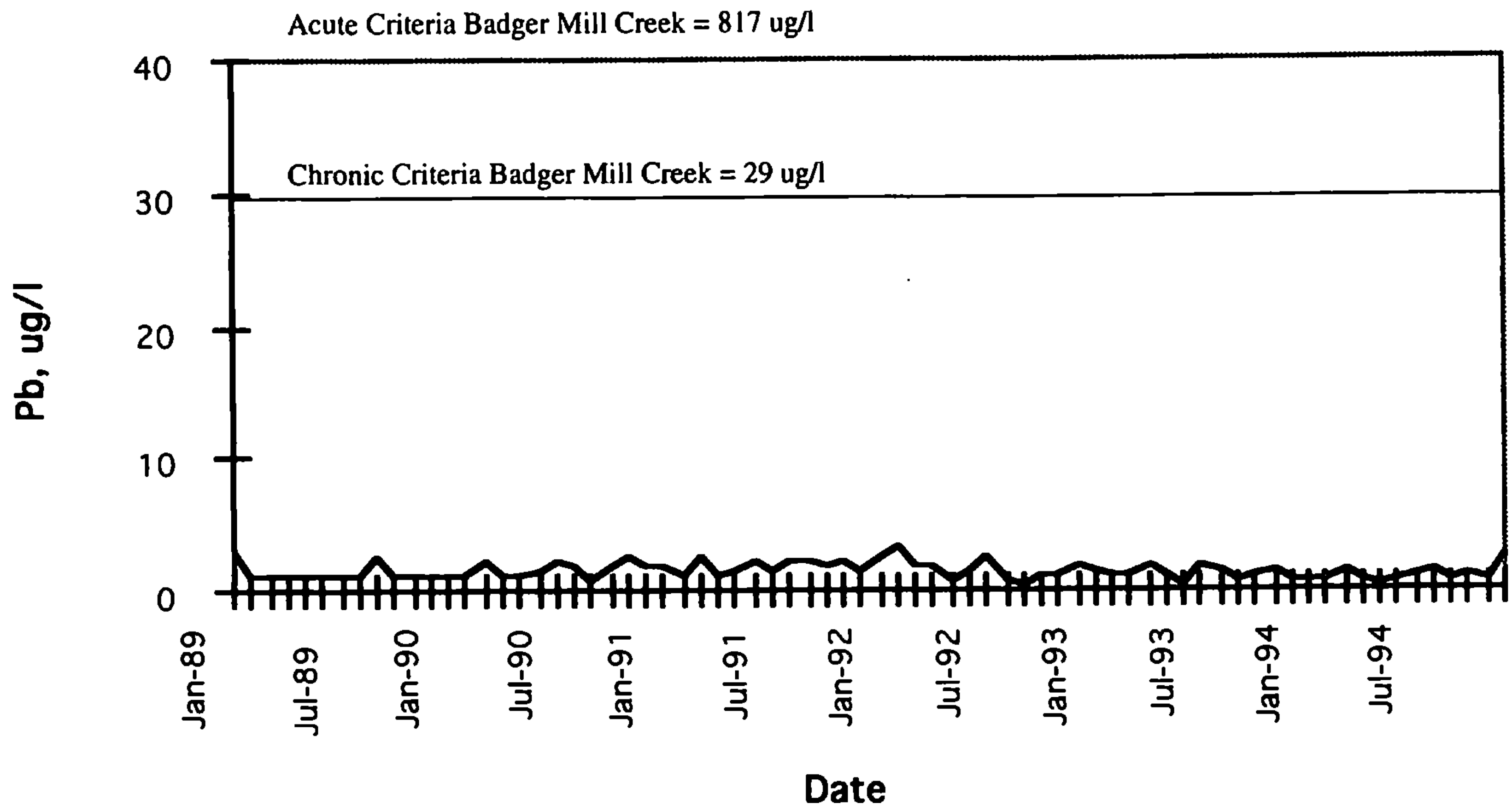
ATTACHMENT B

Figure X. Copper Concentrations in NSWWTP Effluent and Badger Mill Creek Criteria



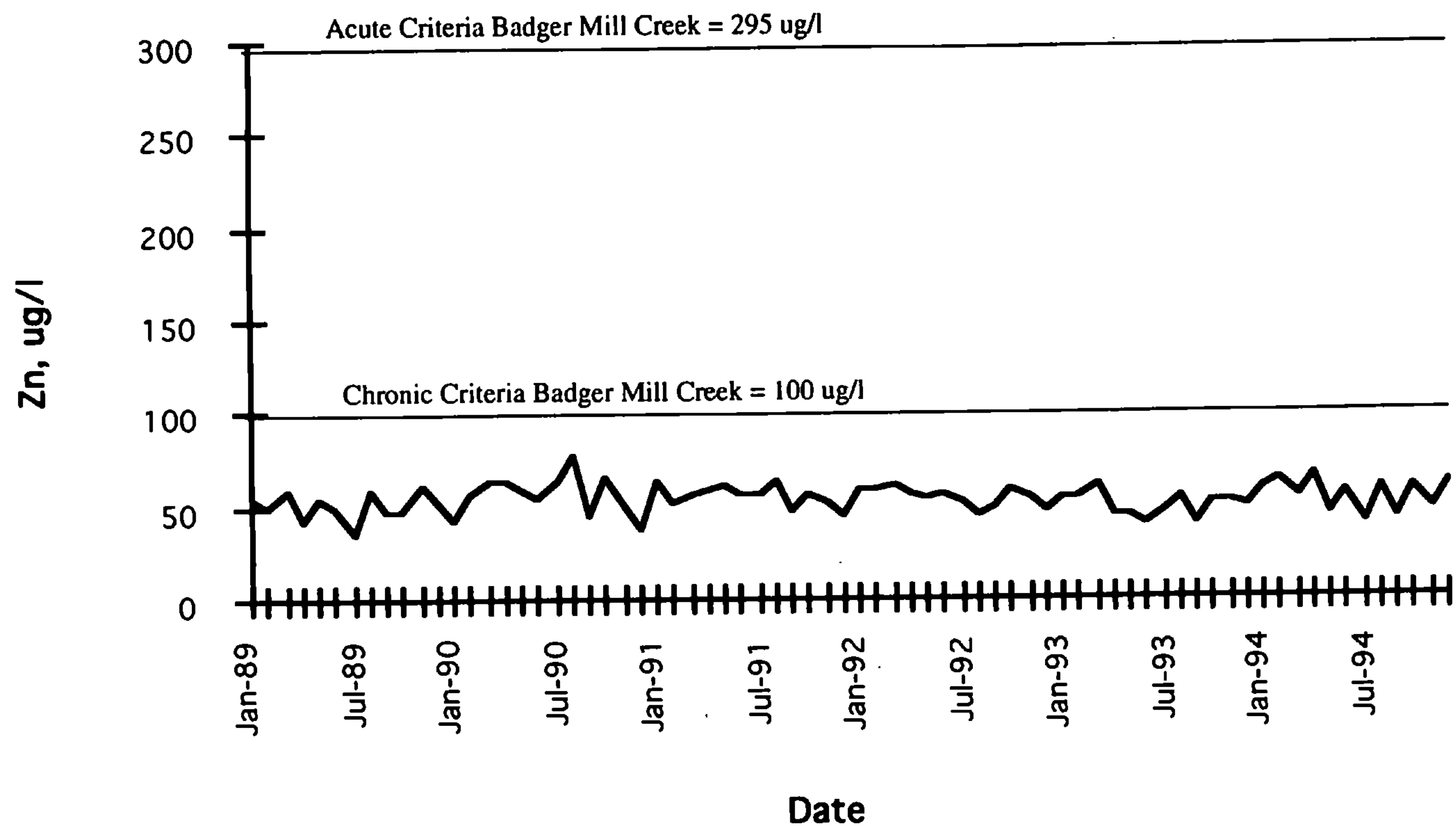
ATTACHMENT B

Figure X. Lead Concentrations in NSWWTP Effluent, 1989 through 1994



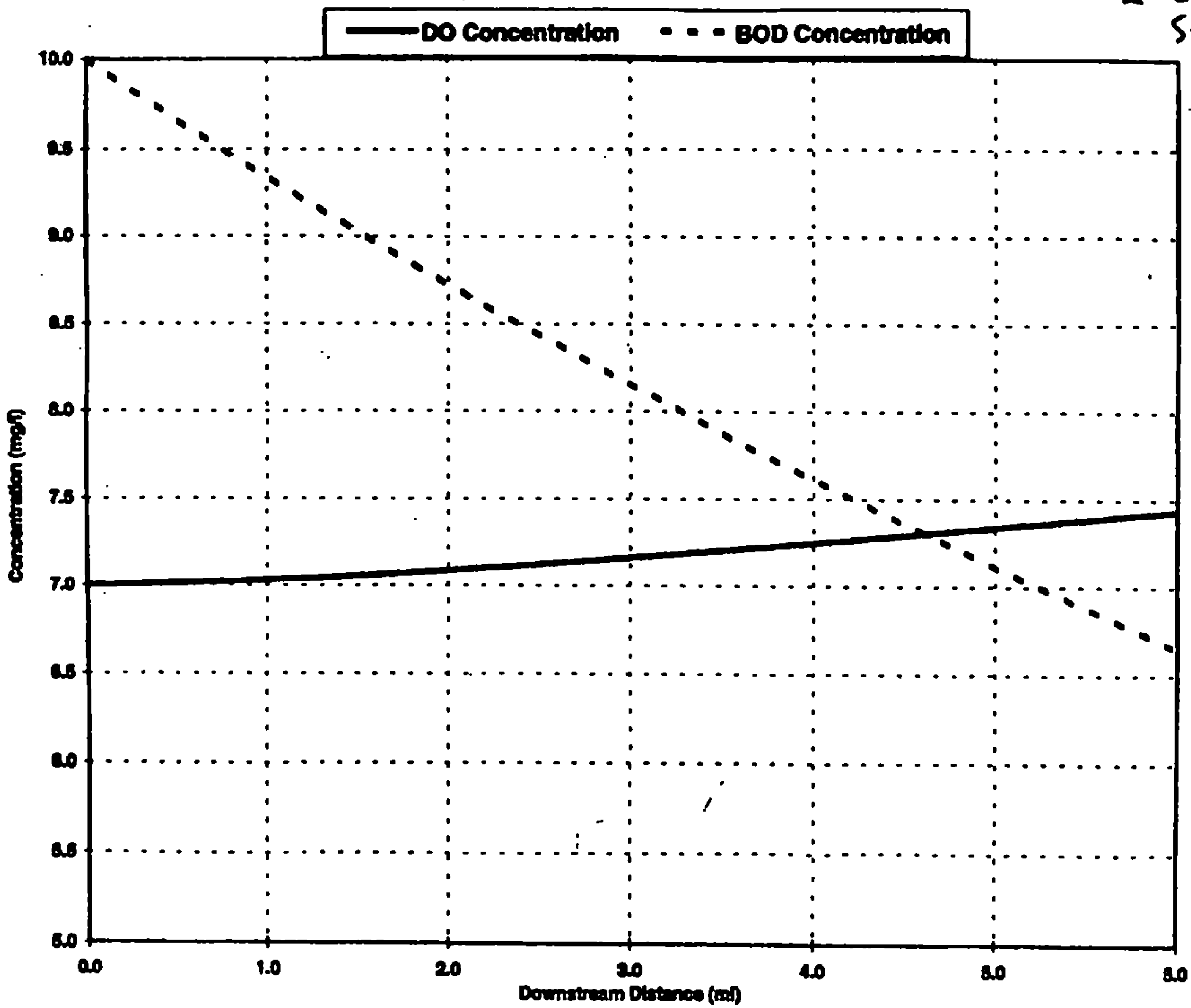
ATTACHMENT B

Figure X. Zinc Concentrations in NSWWTP Effluent 1989 through 1994



ATTACHMENT B

MMSD Discharge to Badger Mill Creek DO and BOD Concentrations with Distance Downstream ← Calculated using Streeter-Phelps DO s In-stream model.



Ka = 4.087 1/day

Kd = 0.843 1/day

Qeff = 3.6 mgd

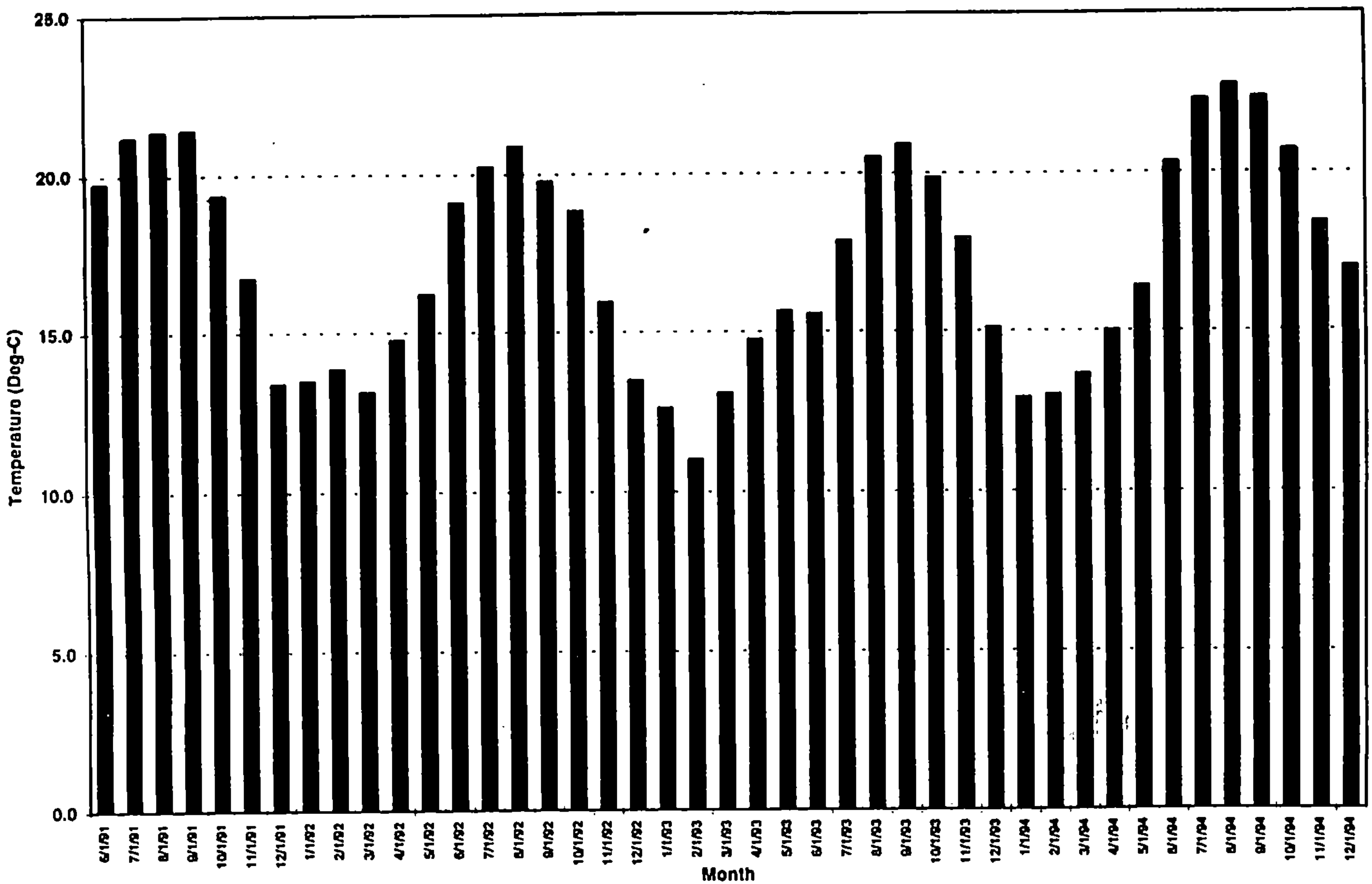
BODeff = 10.0 mg/l

Temp = 20.00 Deg-C

DOeff = 7.00 mg/l

ATTACHMENT B

MMSD Monthly Average Effluent (Mixed Liquor) Temperatures



Attachment 3

ATTACHMENT C

DESIRED/IMPORTANT PROJECT ELEMENTS

Priority Elements

- Wetland recreation for water treatment (effluent and/or stormwater)
- Feasibility of constructed wetlands for polishing and infiltration
- Restore/sustain optimum flow regime
- Provide flexibility in operation
- Satisfy public concerns
- Study changes in stream morphology -- normal flow
- Location of outfall
- Methods to minimize summer temperature increase
- Study should look at wetland restoration
- Provide concept plans for longer-term projects
- Plan: Recreational improvements to Badger Mill Creek corridor
- Optimize balance of multiple public purposes/uses
- Investigate potential wetland restoration
- Assess stormwater flow from "fully developed" watershed
- Study should look at improving the fishery
- Integrate with other watershed issues
- Create a better fishery
- Wisely use public funds
- Financing
- Maximize natural/biological approach
- Maintain or improve resource potential - recreation and "other"
- Preserve or enhance existing fisheries
- Recreate stream meanders on Upper Badger Mill Creek
- Minimize temperature impacts on Badger Mill Creek and Sugar River

Other Elements

- Improve habitat of Badger Mill Creek
- Increase recreational opportunities
- Rough fish control
- Wellhead restoration
- Fish stocking
- Route options
- Explore effluent infiltration possibilities
- Examine possibility of cooling effluent temperature
- Study should look at stream creation
- Water-spread effluent in restored wetlands -- summer
- Maximize stream dissolved oxygen
- Provide "double" effluent return route
- Provide reliable long-term operation of system
- Evaluate pre- and post-stream quality -- biological and other
- Develop models
- Focus public attention on Badger Mill Creek and Sugar River
- Identify other threats to water quality
- Improve warm water fishery habitat (use increased flows as benefit)
- Wetland recreation on Upper Badger Mill Creek (wildlife)
- Study should look at upland restoration

ATTACHMENT C

DESIRED/IMPORTANT PROJECT ELEMENTS

Other Elements (Continued)

- Eliminate Verona Treatment Plant
- Point discharge effluent at 18/151 bridge -- winter
- Restore 18/15 downstream PB wetland
- Evaluate present sample sites based on existing data
- Check legality of flood regulations with proposed increases in flow
- Provide a consistent water resource
- Put in staff gauges at monitoring sites

ATTACHMENT D

PRIORITY ELEMENTS AND AREAS OF INFLUENCE

Plan: Recreation Improvements to Badger Mill Creek corridor
Optimize balance of multiple public purposes/uses
Investigate potential wetland restoration

Assess stormwater flow from "fully developed" watershed
Integrate with other watershed issues
Study should look at improving the fishery

COMMUNITY

Create a better fishery
Wisely use public funds
Financing
Maximize natural/biological approach

Maintain or improve resource potential -- recreation and "other"
Preserve or enhance existing fisheries
Recreate stream meanders on Upper Badger Mill Creek
Minimize temperature impacts on Badger Mill Creek and Sugar River

File 3.3.3

Advisory Committee Meeting Agenda

Sugar River Basin Effluent Discharge Study

April 6, 1995

Introductions

Follow-up Items From March Meeting

- Hydraulics & Hydrology
- Brain Storming Themes
- Effluent Discharge

Alternatives Assessment

- Alternatives Organization
- Alternatives Definition
- Evaluation Criteria

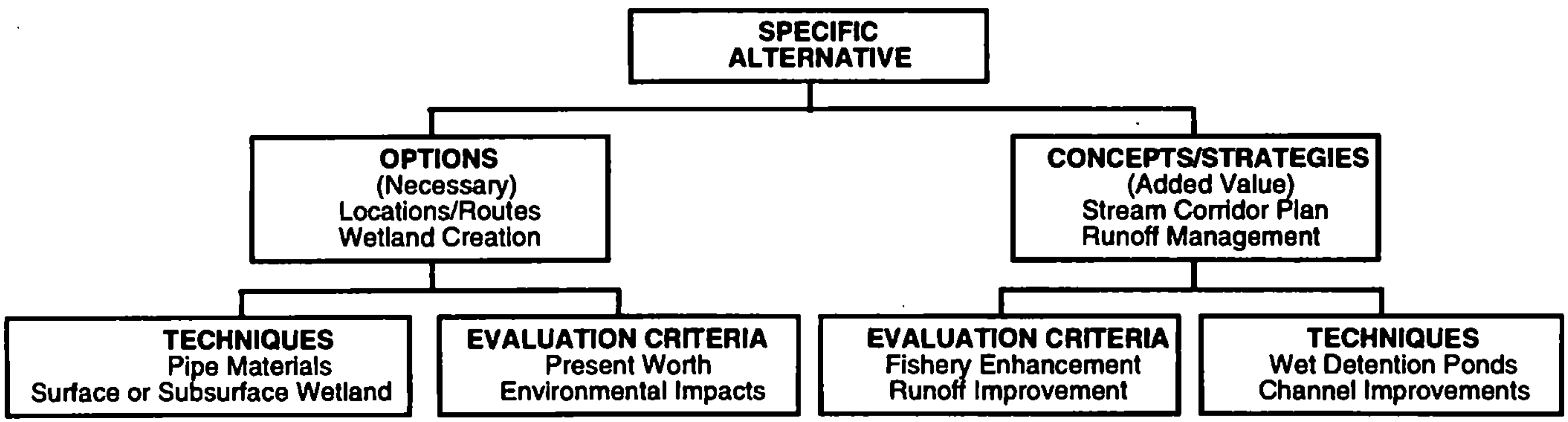
Stream Corridor Assessment

Fisheries Assessment

Runoff Management

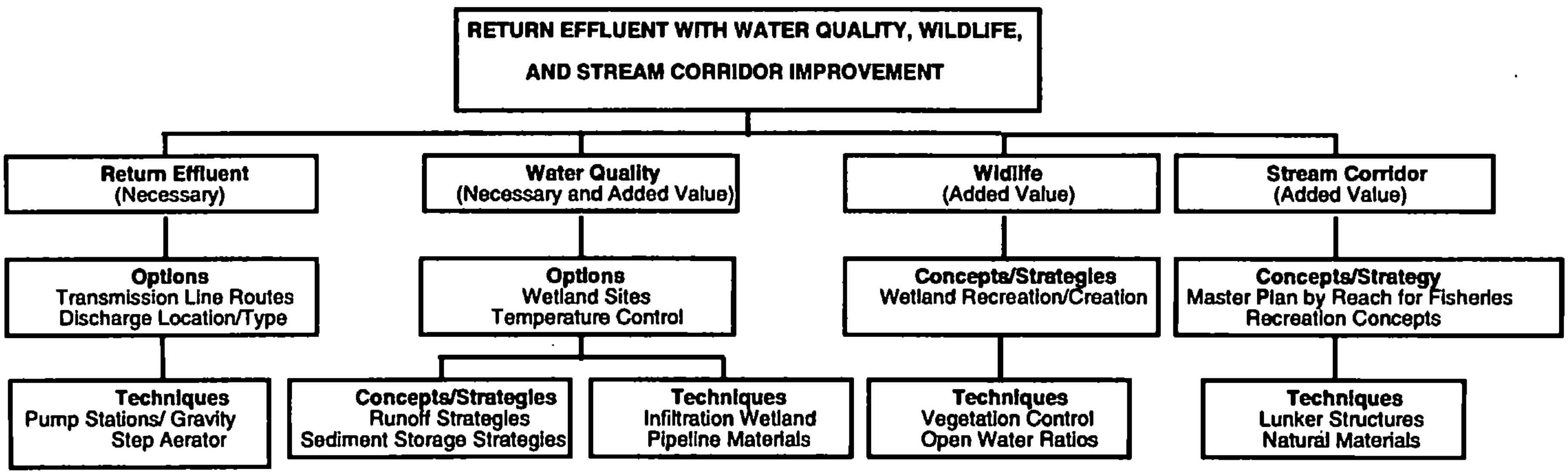
Wetland Assessment

ALTERNATIVES ASSESSMENT



ALTERNATIVES

- **No Action (Existing Conditions)**
- **Return Effluent**
- **Return Effluent with Water Quality and Wildlife Improvement**
- **Return Effluent with Water Quality, Wildlife and Stream Corridor Improvement**


RETURN EFFLUENT WITH WATER QUALITY, WILDLIFE, AND STREAM CORRIDOR IMPROVEMENT
Return Effluent (Necessary)
Water Quality (Necessary and Added Value)
Widlife (Added Value)
Stream Corridor (Added Value)
Options
Transmission Line Routes
Discharge Location/Type
Options
Wetland Sites
Temperature Control
Concepts/Strategies
Wetland Recreation/Creation
Concepts/Strategy
Master Plan by Reach for Fisheries
Recreation Concepts
Techniques
Pump Stations/ Gravity
Step Aerator
Concepts/Strategies
Runoff Strategies
Sediment Storage Strategies
Techniques
Infiltration Wetland
Pipeline Materials
Techniques
Vegetation Control
Open Water Ratios
Techniques
Lunker Structures
Natural Materials

EVALUATION CRITERIA

- Present worth cost
- Flexibility in operation
- Phasing for future flows
- Land requirements
- Safety of operation
- Public concerns
- Wetland recreation/creation
- Aquatic life protection/enhancement (Temperature, sediment and water quality)
- Fishery enhancement
- Protection/Improvement of recreational resources
- Regulatory requirements

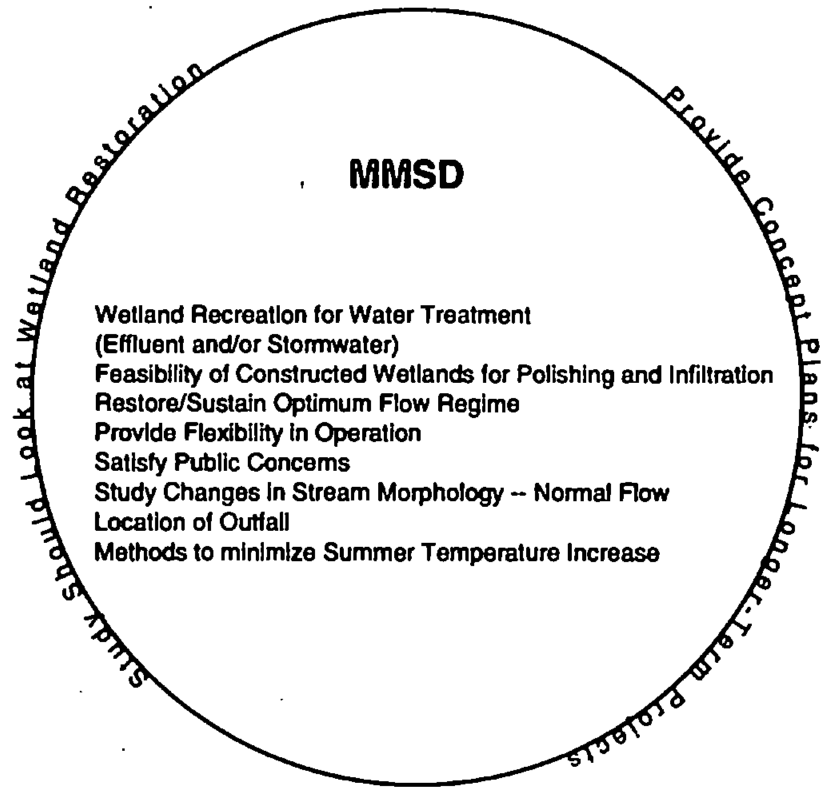
ATTACHMENT D

PRIORITY ELEMENTS AND AREAS OF INFLUENCE

Plan: Recreation improvements to Badger Mill Creek corridor
Optimize balance of multiple public purposes/uses
Investigate potential wetland restoration

Assess stormwater flow from "fully developed" watershed
Integrate with other watershed issues
Study should look at improving the fishery

COMMUNITY



Create a better fishery
Wisely use public funds
Financing
Maximize natural/biological approach

Maintain or improve resource potential -- recreation and "other"
Preserve or enhance existing fisheries
Recreate stream meanders on Upper Badger Mill Creek
Minimize temperature impacts on Badger Mill Creek and Sugar River

what we've completed

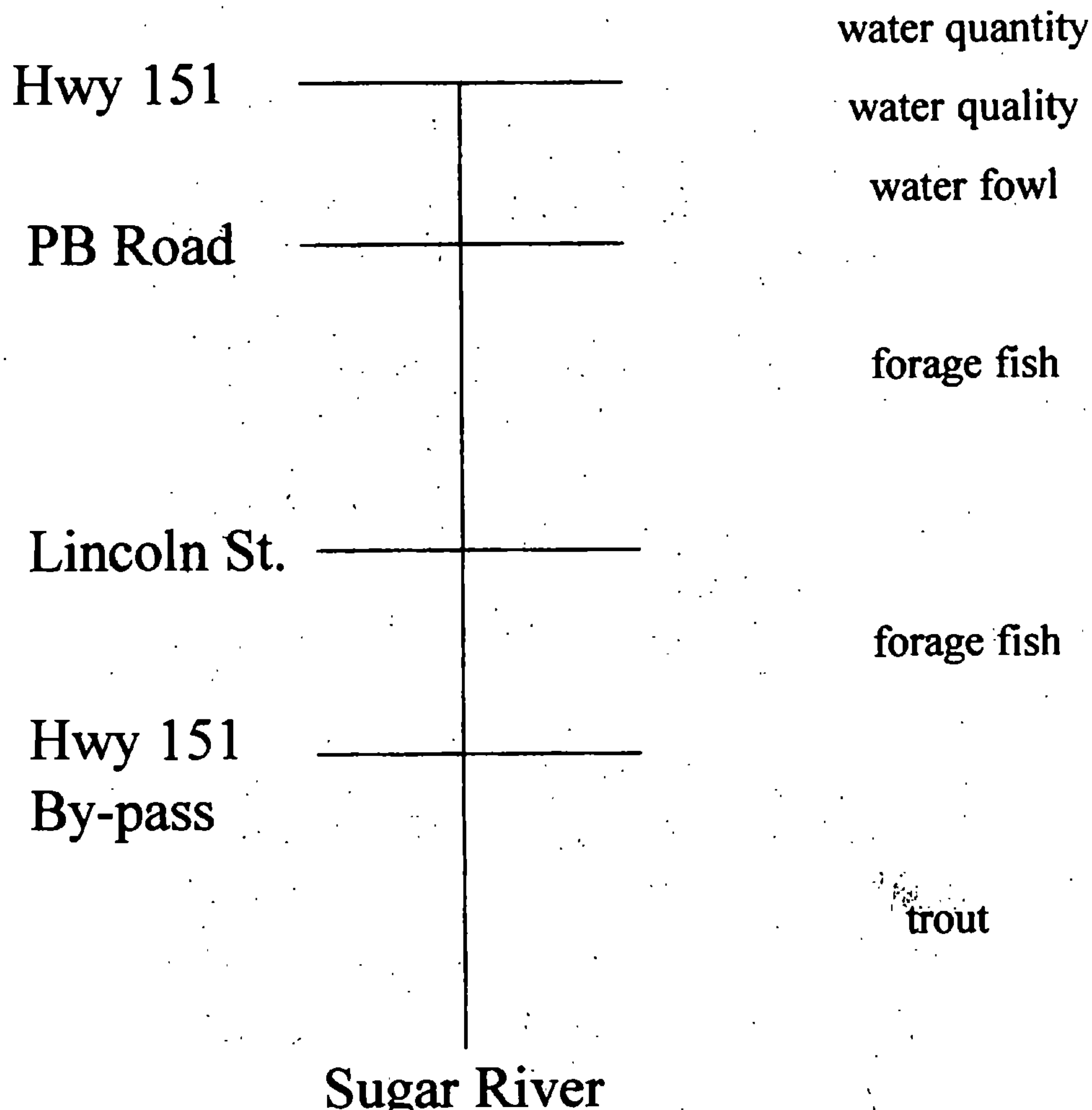
- walked all accessible portions (approx. 4.5 miles)
- what we've measured
- cross sections/profile

You can observe a lot just by looking around.

Yogi Berra

what we've found

- four reaches
- potential exists for:
  - forage fish
  - trout


water quantity
water quality
water fowl
Hwy 151
PB Road
forage fish
Lincoln St.
forage fish
Hwy 151
By-pass
trout
Sugar River

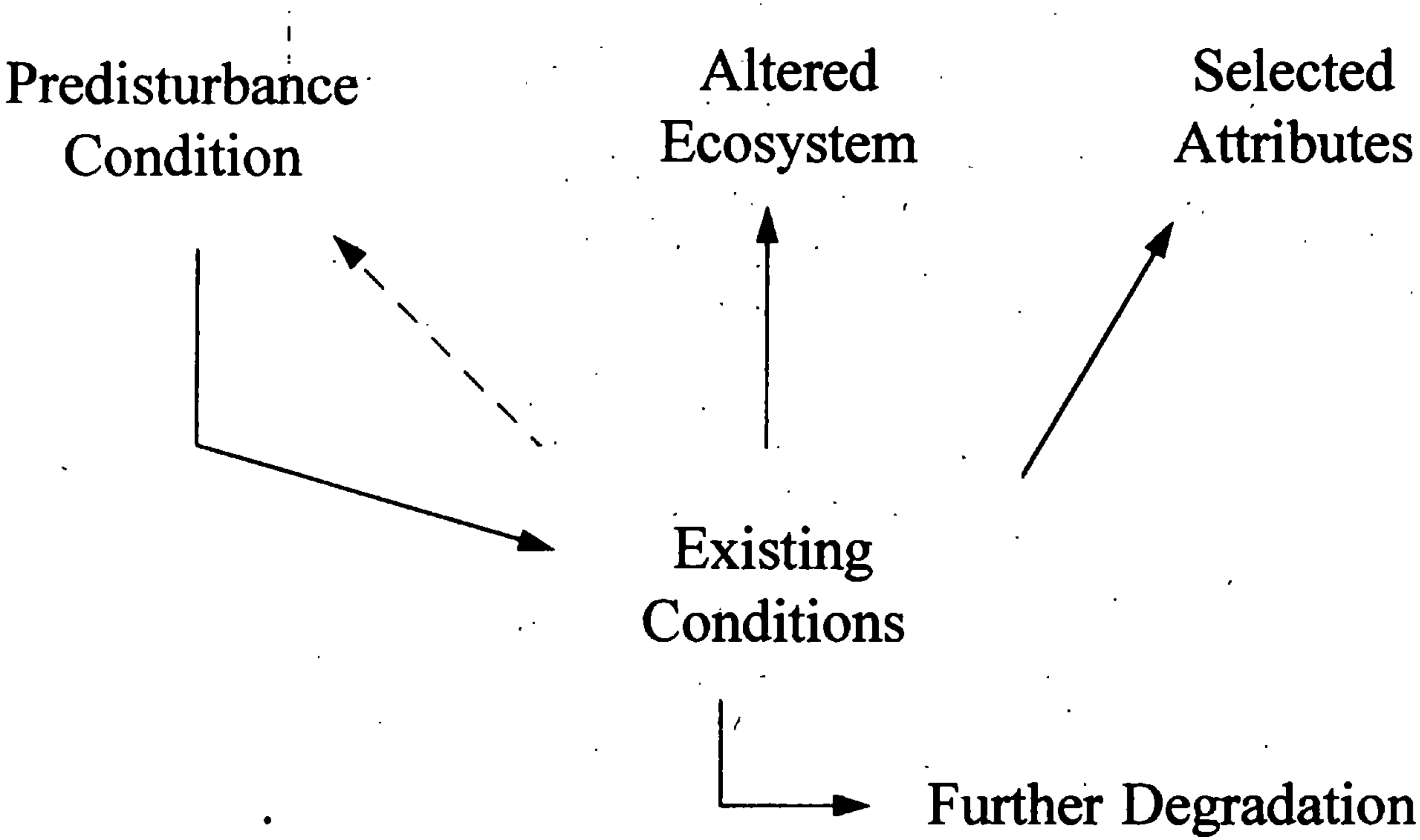
Basic needs of fish

- water
  - quantity
  - quality
- shelter
- food
- ability to reproduce
- access

Factors limiting fisheries resource in Badger Mill Creek

- lack of cover
- excess sediment
- flows/channel morphology
- water temperature
- water quality

Options for Stream Management



what are our options

- leave stream as is
- augment flows
- augment flows and modify habitat

Options for habitat modification

- control sediment inputs
- add cover
- re-establish channel morphology
- add vegetation to streamside corridor

SITE EVALUATION MATRIX
MADISON METROPOLITAN SEWERAGE DISTRICT
POTENTIAL WETLAND CONSTRUCTION/ENHANCEMENT SITES

DRAFT 3/95
FACILITY SITE NUMBER:____
NAME:________________

INITIAL SCREENING	YES	NO
At least 10 Acres available	______	______
Within 1/4 mile of Badger Mill Creek	______	______
"Bowl" shape with<1000' of 10' berm required	______	______
No history of significant public opposition to change in use	______	______
Regulatory conditions not prohibitory	______	______
No significant flood damage impact on structures	______	______
No history of containing hazardous materials	______	______
No known P/other pollutant contribution potential from soils	______	______

NOTE: Any NO above eliminates the site from further consideration

FEASIBILITY SCREENING	Value Range Low	Value Range High	Weight Factor	Assigned Value	Weighted Value	Max Value
A) Infiltration/percolation potential	1	5	2			10
B) P/pollutant removal potential of the soils	1	5	3			15
C) Soil potential for wetland use	1	5	1			5
D) Size	1	5	3			15
E) Shape (3-D)	1	5	2			10
F) Lateral groundwater movement to Badger Mill Creek	1	5	3			15
G) Access Potential	1	5	1			5
H) Land Aquisition Potential	1	5	2			10
I) Close to public use areas	0	5	1			5
J) Wildlife Potential	0	5	1			5
K) Safe Edge Shape	0	5	1			5
TOTAL POINTS:						100

A) Infiltration/percolation should generally be in the mid range-specifically ________ ________ ________ ________ and ________ in descending preference.

B) Acceptable soils (surface and up to 30' depth) include in descending preference.

C) In descending order of preference these soils include ________ ________ ________ ________ and ________.

D) 10 to 15 acres - 1
15 to 20 acres - 2
20 to 25 acres - 3
25 to 30 acres - 4
> 30 acres - 5

E) Ideal would involve - length to width ratio = >2
- maximum water depth = 6'
- average water depth = 18"
- > 1/3 surface area < 6" deep

F) Definite shallow flow path to Badger Mill Creek with < 10 day travel time =5

G) Main access road now exists - 5
> 2 miles of access road required - 1

H) Available public land - 5
Eager seller - 4
Tough potential seller - 1

I) Within one mile - 5
Over five miles - 1

J) Subjective - Consider adjacent/nearby wildlife area needs for complementery habitat.

K) Highest rating for sites where a perimiter depth of < 6" can be easily provided for 10' into wetland around entire edge.

MADISON METROPOLITAN SEWERAGE DISTRICT

.610 Moorland Road
Madison, WI 53713-3398
Telephone (608) 222-1201
Fax (608) 222-2703

James L. Nemke
Chief Engineer & Director

MEMORANDUM

TO: Sugar River/Verona Facilities Planning Group

FROM: James L. Nemke
Chief Engineer & Director Jim

DATE: June 21, 1995

SUBJECT: Tour of Potential Effluent Discharge Locations

Montgomery Watson has been working hard at evaluating all the potential discharge locations for the treated effluent. As you recall from an earlier meeting, approximately fifteen sites had been identified as possibilities for use in the return of highly treated effluent to the Badger Mill Creek area. That list of fifteen has now been reduced to three prime candidates.

We have tentatively scheduled a field trip for July 21, 1995 at 1:00 p.m. We intend to rent a bus and take a driving/walking trip to the area where the personnel working on selection of the sites can explain the pluses and minuses of various discharge options. Please mark you calendar for the afternoon of July 21, 1995 if you would like to accompany us on this field trip. Your input relative to the potential discharge locations will be very helpful in preparing the final report and recommendation.

:dms
cc: Paul Nelson ✓

File: 3.3.3

Minutes of the Sugar River Basin Effluent Discharge Study Advisory Committee Meeting Held on August 24, 1995, at 1:30 p.m.

In Attendance: See attached sign up sheet.

1. Paul Nelson indicated that the District would like to schedule a public hearing on the draft facilities plan amendment on September 28, 1995. After discussion, it was agreed by the committee that the appropriate place to hold the meeting would be the City of Verona's City Hall. Ron Rieder indicated that he would check on the availability of the City Hall for Thursday evening, September 28.

2. Paul Nelson reviewed the modeling work that had been done relative to Badger Mill Creek to determine whether the existing effluent quality from the Nine Springs Wastewater Treatment Plant could meet the proposed effluent limits at the confluence with the Sugar River. The data is attached. Paul indicated that during summer conditions if you used the maximum weekly discharge that has occurred at the Nine Springs Wastewater Treatment Plant over the last two year period, all of the water quality requirements would be met at the confluence of Badger Mill Creek and the Sugar River except for ammonia which would be 0.8 milligrams per liter as opposed to 0.7 per liter. There would be a slight exceedence of the DO standards at the 3.6 MGD flow rate with a DO of 5.8 at the confluence, as opposed to the required 6.0 milligram per liter concentration. Using average discharge conditions over the past two years, all of the water quality standards could be easily met as shown on attached Table 5.

   It was pointed out that no specific attempt was made at the treatment facility to keep the ammonia level at the lowest possible level since the District's permit conditions to discharge to Badfish Creek are higher than those anticipated for the discharge to Badger Mill Creek.

   The data showed that for critical cold season conditions the maximum concentrations from Nine Springs Wastewater Treatment Plant would exceed the proposed BOD, total suspended solids, and ammonia nitrogen limits at the Sugar River (Tables 7 and 8) but that the DO requirements would be met. Paul indicated that the BOD and suspended solids levels are normally set to accomplish a certain DO level. The modeling shows that even though the BOD and suspended solids are slightly higher than determined by the thirteen pound rule, the DO conditions would be met based on the Qual 2E modeling. The information showed that during average discharge conditions over the last two years, the requirements at the confluence of Badger Mill Creek and the Sugar River would be met, with the exception of ammonia which would slightly exceed the proposed limits. Using average cold season conditions over the past two years, all of the water quality standards could be easily met as shown on attached tables 9 and 10

3. Paul Nelson discussed what he called *impact topics* and the potential solutions or mitigation activities necessary to deal with those impact areas (Please refer to Table 4 attached). Paul indicated that he had talked to the archeologist doing the archeological survey and had been informed that there were no significant archeological finds along the pipeline route. There were a few things that needed to be checked out further relative to threatened and endangered species. Paul indicated that it was clear that an outfall aeration device was necessary and, under the 13 pound and 26 pound rules, there would be occasional exceedences of the limits as currently proposed by the Department of Natural Resources. He also indicated that during flood periods the flow would have to be limited to 1.94 MGD or less to prevent violation of the requirement that the flood level not increase greater than 0.01 feet. As shown in attached Table 4, the other areas of concern would not be adversely impacted by the effluent discharge. There was considerable discussion by committee members regarding various items such as in-stream sediment loads, fishery potential, and temperature effects.

4. Paul Nelson indicated that there were a number of factors limiting the fishery resource in Badger Mill Creek. Other than low flow they included lack of cover, excess sediment, low flows and channel morphology, water temperature, and water quality.

5. Paul Nelson then reviewed the alternatives under consideration as part of this facilities planning update. Those alternatives and the significance of each are included in the attachments. There was a general understanding on the part of the committee members that for effluent return to have positive impacts, there would need to be significant commitments from other agencies and stake holders to make other improvements that are outside the realm of the District's responsibility. Paul Nelson discussed a number of the non-point pollution control strategies that would need to be looked at in a broader based study. The summary of those non-point pollution control strategies is attached. There was a general discussion of some of the types of activities that could occur in the area between Goose Lake and the City of Verona. There was a general consensus on the part of the committee that there were a number of areas that could effectively be used for stormwater control and wetland redevelopment through use of stormwater rather than through use of effluent. The committee seemed to agree that the key was to provide a system that would provide flexibility by maintaining certain control strategies that might allow regulation of both stormwater and use of effluent for wetland creation or maintenance.

6. Paul Nelson indicated that the most likely discharge point for the District's effluent would be into Badger Mill Creek just east of the new Hwy. PB interchange. That location is close to the Military Ridge bike path which would allow easy access for

construction. The gradient downstream from that location is significant enough to provide reaeration, and there would not be the need to deal with private land [illegible]

7. Paul Nelson led a discussion on the advantages and disadvantages of discharging into the existing Badger Mill channel and making channel improvements, or in creating a totally new effluent channel that would run from east of PB through the old culvert located south of the existing channel and reconnecting with Badger Mill Creek farther to the west. After significant discussion, the committee agree that it appeared to be the most reasonable to modify the existing channel to increase grass cover and improve hydraulics rather than build a new effluent dominated channel. It was felt that the best method to rehabilitate the existing channel would be to place certain structures in the stream that would encourage the trapping of sediments and allow the growing of grasses along the stream which would provide a more efficient, deeper channel that would have some natural shading from the reestablished grasses.

8. Paul Nelson presented a cost matrix that showed some of the costs associated with various activities to accomplish this project. He indicated that the pipeline costs would be in the neighborhood of 4.5 million dollars. Caryl Terrell suggested that the costs be presented in relationship to each alternative. Paul indicated that would be done in the draft report. The cost matrix is attached.

9. Caryl Terrell indicated that the Commission would be interested in knowing what other commitments will be made to protect the Badger Mill Creek area if the District is to invest significant money in returning effluent and making in-stream habitat improvements. Steve Fix indicated that he felt that the Sugar River pilot study would be approved by EPA and would be ready to proceed this fall. There was general discussion regarding the timing of the priority watershed project which might begin in 1997. Jim Nemke indicated that, even if this project should proceed, construction to allow effluent return would not be completed until late 1997. It appeared that there will be a certain degree of coordination of work relative to efforts in the upper Sugar River Basin. The committee as a whole felt that it was very critical to take the information that will be generated by this effort and build on it for future actions. It was felt that the District could be leading the way towards a much more expansive and coordinated effort

MMSD Sugar River
Advisory Committee Meeting
8/24/05

Paul Nelson	Montgomery Watson	
Ed Bride	(608) 845-8059 Citizen	
Jeff Steven	MMSD	
Dave Taylor	MMSD	222-1201 Ext 270
Jon Fellows	DCLL	244-1983
Steve Fix	WDNR	275-3280
Russ Hefty	City of Madison	267-[illegible]
Jim Nemke	MMSD	222-1201 Ext. 253
Ron Rieder	City of Verona	845-6695
Gerry Novotny	DNR	267-7625
George Osipoff	DNR	273-5969
Jim Mueller	Co. Parks	246-3893
Bill Lane	RPC	266-4417
John Exo	D.C. Lakes & Watershed Div.	267-0118
Caryl Terrell	MMSD Commissioner	2560585

Appendix B

MONTGOMERY WATSON

Madison Metropolitan Sewerage District

EPA QUAL2E Instream WQ Model Results for NSWWTP Discharge to Badger Mill Creek

December 1995

MONTGOMERY WATSON

EPA QUAL2E Instream WQ Model Results for MMSD NSWWTP Discharge to Badger Mill Creek

Submitted to:
Madison Metropolitan Sewerage District
1610 Moorland Road
Madison, WI
53713-3398

Prepared by:
Montgomery Watson
Waterford Park
505 US Highway 160, Suite 555
Minneapolis, MN
55441

Deccember 5, 1995

TABLE OF CONTENTS

ATTACHMENTS

Summary

The EPA QUAL2E model was used to determine if existing NSWWTP effluent quality would have an adverse impact on Badger Mill Creek (BMC) water quality (WQ) and aquatic life. Conservative methods and site specific data were used in the QUAL2E model runs. All of the major effluent and in-stream WQ constituent parameters were evaluated using QUAL2E. The most critical effluent and instream constituents (DO, BOD_5 [BOD_U], and NH_3 and TSS) were investigated in detail. In-stream temperature, the nitrogen cycle including NBOD and the phosphorus cycle were also simulated (see *EPA QUAL2E Model Input and Results Attachments*).

Eight (8) separate detailed instream water quality simulations were performed in this investigation. Both typical average and critical conditions were evaluated. The broad factors affecting Badger Mill Creek water quality are summarized in Table 1. Table 2 evaluates the important relation between NSWWTP site specific ultimate BOD and total 5-day BOD. Detailed model inputs and outputs are also presented in the *Attachments* to this report.

The simulations were sensitive to site specific conditions such as temperature and stream geometry. By comparison, using the nominal WDNR 13-lb and 26-lb rules for BOD_5 and TSS there was no similar site sensitivity. Tables 3 and 4 below offer a concise summary of the key (NPDES permitted) effluent parameters generated from the model runs.

The model results, at 2.2 MGD and 3.6 MGD, indicate that no adverse impact should be anticipated from the proposed NSWWTP discharge to BMC. This is primarily because of the high effluent quality currently discharged by NSWWTP. Under typical average operating conditions, the NSWWTP discharge is well below potential effluent limits.

During extreme critical conditions some downstream concentrations very slightly exceed the most stringent possible Wisconsin Department of Natural Resources (WDNR) effluent limits. These were ammonia during both cold and warm seasons, BOD_5 in the cold season and TSS in the cold season. However, a review of EPA techniques for determining ammonia limits, with varying temperature and pH, demonstrates that no toxic effects are predicted to occur at the most stringent possible WDNR limits.

Similarly, although the BMC simulations demonstrated that BOD_5 was slightly above the most stringent possible WDNR limits, DO stayed well above the cold water criteria in all most all cases. This is based on applying a potential cold water criteria of 6 mg/l-DO at two BMC characteristic locations. One upstream site at the existing Verona WWTP (at Bruce St.) and the other immediately upstream of the Sugar River confluence. Under critical case summer conditions, DO at the Bruce Street site was slightly below (5.9 mg/l-DO) or right at 6 mg/l-DO. However, given the conservative inputs going into the critical case summer simulations, these minor differences are not considered significant.

At WDNR's recommendation, the BOD/DO simulation was performed in terms of BOD_U. Accordingly, an evaluation of NSWWTP effluent BOD_U/BOD_5 ratios was performed for this investigation. Particularly, while a BOD_U/BOD_5 ratio of 2.1 (as suggested by WDNR) may be appropriate for winter conditions with little or no nitrification, a ratio of 1.35 can be reasonably applied for summer conditions when full nitrification is occurring. This technical memorandum also emphasizes and reports the inclusion of the BOD_U analysis as it relates to QUAL2E modeling of instream DO.

Also at WDNR's recommendation, the DO simulation was performed was conservatively performed using the Tsivoglou and Wallace (1972) formulation for instream reareration (K_2) rates. Rates used in this study ranged from about 2/day to 18/day based on site specific stream flow and channel geometry conditions. Typical K_2 values range between 0.0/day and 100/day and the QUAL2E analysis values can be seen to be conservatively low by comparison.

The BOD_U/BOD_5 ratio evaluation revealed the close relationship that exists between the ratio and seasonal temperature conditions. The ratio clearly increases, on average as high as 1.66, for cold temperature conditions indicating reduced biological decay activity. Conversely, the BOD_U/BOD_5 ratio dramatically decreases for warm season conditions due to greater biological decay activity. When the NSWWTP is fully nitrifying during warm conditions, very low BOD_U/BOD_5 ratios, between 1.18 and 1.35, typically result. Therefore, a ratio of 2.1 (as recommended by WDNR) was used in the cold weather simulations while a ratio of 1.35 was used for the warm weather simulations. The 1.35 ratio used in the warm weather simulations is conservative, and consistent, with facilities similar to NSWWTP that nitrify and have ratios less than 1.30.

Objective

The stream water quality model, EPA QUAL2E, was employed to simulate the effect of Nine Springs WWTP effluent discharge on Badger Mill Creek (BMC). The primary objective of this study was to determine if current NSWWTP effluent discharge concentrations of permitted water quality parameters will have an adverse impact on BMC. The key results of the model simulation are presented in this report. Full technical details are contained in the model output presented in the Attachments.

Method

The broad factors affecting Badger Mill Creek water quality are summarized in Table 1. Accordingly, a variety of analysis requirements were evaluated in detail for assessing instream water quality conditions with a NSWWTP discharge in Badger Mill Creek. These requirements included a detailed evaluation of NSWWTP effluent concentrations, BMC channel geometry, local climatological data and instream background BMC WQ data.

The EPA QUAL2E instream WQ model was used to perform the analysis. The association between biochemical oxygen demand (BOD) and dissolved oxygen (DO) received particular attention in this analysis. The relationship between ultimate BOD over total 5-day BOD (BOD_U/BOD_5) was thoroughly investigated with reference to NSWWTP specific data and conditions (see Table 2). The very important instream reaeration rate (K_2) was also evaluated and conservatively applied, in all the model runs, using the Tsivoglou and Wallace (1972) formulation.

NSWWTP Effluent Concentrations

Evaluation of NSWWTP effluent concentration data and BMC water quality were performed to site specifically simulate the proposed NSWWTP discharge to BMC. The most recently available NSWWTP effluent data (August 1992 through January 1995) were analyzed to determine critical maximum concentrations to be used in the model. These critical maximum concentrations are listed as appropriate in Tables 3 and 4.

Table 1. Broad Factors Affecting Badger Mill Creek Water Quality[a]

Seasonal Effluent and Weather Conditions		Stream Flow Conditions		Facility Flow Rate		BOD	
Cold	Warm	Average	Critical	Interim	Ultimate	Cold	Warm
<u>Critical</u> Air Temp =40 °F Sugar R. and BMC Temp =40 °F Winter Effluent Characteristics: Effl. Temp =50 °F	<u>Critical</u> Air Temp =82 °F Sugar R. and BMC Temp =68 °F Summer Effluent Characteristics: Effl. Temp =71.6 °F		BMC flow= 0 to 0.18 cfs Sugar R. flow= 7.8 cfs	2.2 MGD	3.6 MGD	BOD_U $/BOD_5$ Ratio= 2.1	BOD_U $/BOD_5$ Ratio= 1.35
<u>Average</u> Air Temp =40 °F Sugar R. and BMC Temp =43.4 °F Winter Effluent Characteristics: Effl. Temp =56 °F	<u>Average</u> Air Temp=54.5 °F Sugar R. and BMC Temp=63.3 °F Summer Effluent Characteristics: Effl. Temp =65.9 °F	BMC flow= 3 to 6 cfs Sugar R. flow= 18 cfs		2.2 MGD	3.6 MGD	BOD_U $/BOD_5$ Ratio= 2.1	BOD_U $/BOD_5$ Ratio= 1.3

[a] Additional effluent and stream characteristics are too lengthy to display here but are provided in the tables which follow and in the detailed model output.

BMC Channel Geometry

BMC channel geometry was developed from the detailed floodplain cross-sectional information available from the *Dane County Flood Insurance Study* (1974). This channel geometry was land surveyed and prepared by the USGS in cooperation with the Dane County Regional Planning Commission. Although this study was performed in 1974, no extensive channel alterations have been performed since then and the detailed data development is relevant to current BMC conditions. All of the channel sections and channel invert elevations, used in the FIS, were evaluated for this project. This data is presented in Attachment A. A profile of channel invert elevations is presented in Figure 2-1. [Note that the source of this figure (and number) is the *Sugar River Effluent Discharge Study*, 1995.]

Badger Mill Creek, and the Sugar River Confluence, were divided up into seven (7) distinct Water Quality reaches based on the evaluation results of the FIS channel cross-sections and invert elevations. Division of the WQ reaches is based on broad changes in channel invert slope and channel geometry. These reaches effectively characterize those segments of Badger Mill Creek, and the Sugar River, required for the accurate QUAL2E instream WQ analysis. Charts of the channel cross-sections applied in the QUAL2E modeling are presented Attachment A. [Note that the land surveyed natural channel cross-sections (dashed line) were converted into the trapezoidal sections (solid bold line) used by QUAL2E.] BMC channel geometry is presented in the QUAL2E output files presented in Attachments B and C.

Local Climatological Data

Meteorological data was obtained from the Wisconsin State Climatology Office. Conservative values were used to characterize warm and cold weather conditions as presented in Table 1. Local climatological data are also presented in the QUAL2E output files presented in Attachments B and C.

Instream Background BMC WQ Data

Background stream flow and water quality data for the Sugar River and Badger Mill Creek was developed from available sources including the USGS, Dane County, WDNR and MMSD. Background BMC WQ data are presented in the QUAL2E output files presented in Attachments B and C.

EPA QUAL2E Instream WQ Model

The QUAL2E model development used conservative rate coefficients for DO, BOD_5 (BOD_U), NH3 and TSS to assess the impact of the effluent discharge on these Badger Mill Creek water quality parameters. The collection of available data, its development and its utilization in this study are discussed in detail in the main body of the report.

Other WQ parameters such as temperature, nutrients such as nitrogen and phosphorus, and algae were also simulated. The results of these water quality parameters are not summarized here since they are not as critical as the previously mentioned permitted WQ parameters. However, the model results Attachments B and C contain the full QUAL2E output files for all eight of the model runs and provides a complete listing of all variables, rate coefficients and parameters simulated during the study.

The three (3) broad factors generally affecting instream water quality are: seasonal effluent and weather conditions; BMC and Sugar River stream flow conditions; and future interim and ultimate facility flow rates. A fourth category is included to reflect the BOD_U/BOD_5 ratios used in the analysis since this is also an important factor. Values used for each of these conditions is presented in Table 1. Seasonal factors are divided up into warm (June through October) and cold (November through May) periods.

BMC Dissolved Oxygen Reaeration Rate (K_2)

As noted in the previous section, instream DO was simulated for this investigation. A key component in assessing instream DO concentrations is in estimating the instream reaeration (K_2) rate for each WQ reach. A very conservative approach was taken in modeling instream DO reaeration by applying the Tsivoglou and Wallace (1972) estimation approach (Option 8 in QUAL2E). This method assumes that (K_2) is proportional to the change in elevation of the water surface and inversely proportional to the flow time through the reach. As determined by QUAL2E:

$$K_2 = (3600 \times 24) * c * S_e * U$$

where

c = escape coefficient, 1/ft

S_e = slope of energy gradient (ft/ft) as calculated by QUAL2E

U = mean reach velocity (fps) as calculated by QUAL2E

For this analysis, a very low, i.e., conservative, escape coefficient of 0.110/ft was used for uncalibrated small streams (Tsivoglou and Neal,1976). For the QUAL2E DO simulation, reaeration rates were temperature sensitive, varied by reach and ranged between about 2/day to 18/day. Typical K_2 values are between 0.0/day and 100/day and the QUAL2E analysis values can be seen to be conservatively low by comparison.

Ultimate BOD over Total 5-Day BOD (BOD_U/BOD_5)

For simulating DO, internal QUAL2E calculations are performed in terms of ultimate BOD (BOD_U). In addition, although QUAL2E simulates BOD_U in the general case, the user may choose to use the input and output values for the total 5-day BOD (BOD_5). However, for his investigation, BOD_U inputs and outputs were used.

The relationship between effluent BOD_5 and effluent BOD_U was evaluated for this study. Recent (Sept. 1993 to Feb. 1995) BOD_5 and CBOD data recorded at the NSWWTP was analyzed (see Table 2). Measured 5-day total BOD (BOD_5) includes both nitrogenous BOD (NBOD) and carbonaceous BOD (CBOD). The measured 5-day carbonaceous BOD (CBOD) eliminated the effects of NBOD. The calculated nitrification ratio based on measured 5-day BOD_5 over CBOD indicates the relative seasonal exertion of NBOD on effluent samples. A ratio of 1.0 indicates complete nitrification. Decreasing ratio values reflect proportionally reduced nitrification, typically during colder weather conditions.

The initial overall ultimate BOD versus 5-day total BOD ratio of 2.1 was recommended by WDNR. However, this ratio includes the effects of both CBOD and NBOD. It does not reflect the significant seasonal reduction in NBOD characterized by the measured effluent samples and calculated nitrification ratios. Therefore, the initial overall ratio required adjustment to actual effluent conditions that reflect nitrification at the MMSD NSWWTP.

The sample adjusted ratio of ultimate BOD over total BOD includes the actual effects of both CBOD and NBOD on MMSD NSWWTP effluent with seasonal nitrification. It was calculated by multiplying the worst case BOD_U/BOD_5 ratio (of 2.1) by the ratio of the sample worst case nitrification ratio of 0.51 (March 1994) and the sample nitrification ratio. The sample adjusted BOD_U/BOD_5 calculation is therefore: [Worst Case BOD_U/BOD_5]*[Worst Case $CBOD/BOD_5$] / [Sample $CBOD/BOD_5$]. A sample calculation of the adjusted BOD_U/BOD_5 ratio, based on August 1994, would be: 2.1*0.51/0.83 = 1.30. Note that the sample adjusted, worst case BOD_U/BOD_5 ratio, does in fact equal 2.1 for March 1994 as recommended by WDNR.

For warm weather, the average sample adjusted BOD_U/BOD_5 ratio was 1.35 for the recent period with a maximum of 1.53 (in September). During the seasonally warmest months, the ratio ranged from a very low 1.18 to 1.53. Since low BOD_U/BOD_5 ratios are directly associated with higher seasonal temperatures, the average warm weather value was taken as the average warm weather ratio of 1.35. This value most appropriately characterizes warm weather conditions in the field and simulated in the model. The 1.35 ratio used in the warm weather simulations is conservative, and consistent, with facilities similar to NSWWTP that nitrify and have ratios less than 1.30.

Table 2. Ratio Comparison of Ultimate BOD over Total 5-Day BOD (BOD_U/BOD_5) Based on Measured NSWWTP MMSD Monthly Average Effluent BOD

Date	Measured Total [a] BOD_5 mg/l	Measured Carbonaceous[b] CBOD mg/l	Nitrification[c] Cold Season $CBOD/BOD_5$ ratio	Nitrification[c] Warm Season $CBOD/BOD_5$ ratio	Initial Overall [d] BOD_U/BOD_5 ratio	Sample Adjusted [e] Cold Season BOD_U/BOD_5 ratio	Sample Adjusted [e] Warm Season BOD_U/BOD_5 ratio
Sep-93	3.83	2.70		0.70	2.1		1.53
Oct-93	5.45	3.29		0.60	2.1		
Nov-93	5.60	3.73	0.67		2.1	1.62	
Dec-93	6.74	4.97	0.74		2.1	1.47	
Jan-94	8.65	5.83	0.67		2.1	1.60	
Feb-94	10.71	5.93	0.55		2.1	1.95	
Mar-94	7.77	4.00	0.51		2.1	2.10	
Apr-94	6.50	4.24	0.65		2.1	1.66	
May-94	3.16	2.81	0.89		2.1	1.22	
Jun-94	4.03	3.23		0.80	2.1		1.35
Jul-94	2.35	2.13		0.90	2.1		1.20
Aug-94	2.71	2.26		0.83	2.1		1.30
Sep-94	2.33	2.13		0.91	2.1		1.18
Oct-94	4.13	2.94		0.71	2.1		1.52
Nov-94	4.37	3.33	0.76		2.1		
Dec-94	7.35	5.45	0.74		2.1		
Jan-95	5.68	4.39	0.77		2.1		
Feb-95	8.68	6.50	0.75		2.1		
Seasonally Averaged Values =			**0.70**	**0.78**		**1.66**	**1.35**

[a] Measured total 5-day BOD (BOD_5) includes both nitrogenous BOD (NBOD) and carbonaceous BOD (CBOD).

[b] Measured 5-day carbonaceous BOD (CBOD) has eliminated effects of nitrogenous BOD (NBOD).

[c] Calculated nitrification ratio based on measured 5-day BOD_5 over CBOD indicates the relative seasonal exertion of NBOD on effluent samples. A ratio of 1.0 indicates total nitrification with decreasing ratio values reflecting proportionally reduced nitrification, typically during colder weather conditions.

[d] The initial overall ultimate BOD versus total BOD ratio of 2.1 was recommended by WDNR. It includes the effects of both CBOD and NBOD. It does not reflect the significant seasonal reduction in NBOD characterized by the measured effluent samples, typically during warm weather conditions. Therefore, the initial overall ratio requires adjustment to actual effluent conditions that reflect nitrification at the MMSD NSWWTP.

[e] The sample adjusted ratio of ultimate BOD over total BOD includes the actual effects of both CBOD and NBOD on MMSD NSWWTP effluent with seasonal nitrification. It was calculated by multiplying the worst case BOD_U/BOD_5 ratio (of 2.1) by the ratio of the sample worst case nitrification ratio of 0.51 (March 1994) and the sample nitrification ratio. The sample adjusted BOD_U/BOD_5 calculation is therefore: [Worst Case BOD_U/BOD_5]*[Worst Case $CBOD/BOD_5$]/[Sample $CBOD/BOD_5$]. A sample calculation of the adjusted BOD_U/BOD_5 ratio, based on August 1994, would be: 2.1*0.51/0.83 = 1.3 Note that the sample adjusted, worst case BOD_U/BOD_5 ratio, does in fact equal 2.1 for March 1994 as recommended by WDNR.

Summary Model Results

Model results from the eight (8) Badger Mill Creek simulations are presented in Tables 3 and 4. These results were extracted from the EPA QUAL2E instream WQ output files presented in the Attachments: *EPA QUAL2E Model Input and Results.* Attachment B displays the four (4) cold season simulations and Attachment C presents the four (4) warm season simulations. Table 5 presents the output file naming convention and definition applied to the Badger Mill Creek output files. These filenames are labeled on the lower right-hand corner of the output file pages.

Maximum and average seasonal effluent values, inputted to the model, are presented in the summary tables. For comparison, the most stringent limits that WDNR could potentially apply are also listed in each of the tables. The nominal limits assume the most stringent case where cold water criteria are applied to BMC water quality without Sugar River mixing. QUAL2E simulated BMC WQ values were extracted from the output files for the two BMC characteristic locations. One upstream site at the existing Verona WWTP (at Bruce St.) and the other immediately upstream of the Sugar River confluence.

The first 3 pages of each model run, presented in the Attachments, present the input data as defined variables so that the reader can see all the values and rates used in the simulation. Page 10 or page 11 (it varies) present the key output values by reach and downstream distance.

Table 3. Winter Conditions--QUAL2E Simulated Water Quality Effects of Potential NSWWTP Effluent Discharges to Badger Mill Creek

WQ Parameter	Effluent Conc. [a] (mg/l)	Potential Limit [b] (mg/l)	QUAL2E Simulated Cold Season Values at Characteristic Locations: BMC Near Existing Verona WWTP [c] (mg/l)	BMC Upstream of Sugar River [d] (mg/l)
Critical Interim Facility Flow of 2.2 MGD (QUAL2E File BWCIU.OUT in Attachment B)				
DO	5.0	6.0	7.1	10.5
BOD5 (BODU)	15.3 (32.1)	10.0 (21.0)	13.5 (28.4)	12.7 (26.7)
TSS	12.3	10.0	11.8	11.5
NH_3	1.97	1.50	1.81	1.74
Average Interim Facility Flow of 2.2 MGD (QUAL2E File BWAIU.OUT in Attachment B)				
DO	6.0	6.0	8.8	11.3
BOD5 (BODU)	7.3 (15.3)	10.0 (21.0)	4.9 (10.4)	4.1 (8.6)
TSS	8.3	10.0	7.0	6.5
NH3	0.73	1.50	0.50	0.41
Critical Ultimate Facility Flow of 3.6 MGD (QUAL2E File BWCUU.OUT in Attachment B)				
DO	5.0	6.0	7.1	10.3
BOD5 (BODU)	15.3 (32.1)	10.0 (21.0)	13.7 (28.8)	13.0 (27.3)
TSS	12.3	10.0	11.9	11.6
NH3	1.97	1.50	1.81	1.76
Average Ultimate Facility Flow of 3.6 MGD (QUAL2E File BWAUU.OUT in Attachment B)				
DO	6.0	6.0	8.6	11.1
BOD5 (BODU)	7.3 (15.3)	10.0 (21.0)	5.4 (11.4)	4.7 (9.8)
TSS	8.3	10.0	7.3	6.8
NH3	0.73	1.50	0.55	0.48

[a] Existing NSWWTP Effluent Maximum Weekly Cold Season Concentration.

[b] Nominal WDNR Permit Effluent Limits for the Cold Season Applied to BMC without Sugar River Mixing Zone.

[c] QUAL2E Simulated Cold Season Values--BMC Near the Existing Verona WWTP at Bruce Street.

[d] QUAL2E Simulated Cold Season Values--BMC Immediately Upstream of Sugar River Confluence.

Table 4. Summer Conditions--QUAL2E Simulated Water Quality Effects of Potential NSWWTP Effluent Discharges to Badger Mill Creek

			QUAL2E Simulated Warm Season Values at Characteristic Locations	
WQ Parameter	Effluent Conc. [a] (mg/l)	Potential Limit [b] (mg/l)	BMC Near Existing Verona WWTP [c] (mg/l)	BMC Upstream of Sugar River [d] (mg/l)
Critical Interim Facility Flow of 2.2 MGD(QUAL2E File BSCIU.OUT in Attachment C)				
DO	5.0	6.0	5.9	7.4
BOD5 (BODU)	6.6 (8.6)	5.0 (6.5)	5.1 (5.9)	4.4 (5.9)
TSS	10.8	10.0	10.2	9.8
NH3	1.38	0.70	1.00	0.84
Average Interim Facility Flow of 2.2 MGD (QUAL2E File BSAIU.OUT in Attachment C)				
DO	6.0	6.0	8.4	10.3
BOD5 (BODU)	3.8 (4.9)	5.0 (6.5)	3.1 (5.9)	2.9 (3.9)
TSS	6.1	10.0	5.5	5.3
NH3	0.25	0.70	0.20	0.18
Critical Ultimate Facility Flow of 3.6 MGD (QUAL2E File BSCUU.OUT in Attachment C)				
DO	5.0	6.0	6.0	7.4
BOD5 (BODU)	6.6 (8.6)	5.0 (6.5)	5.3 (5.9)	4.6 (6.3)
TSS	10.8	10.0	10.3	9.9
NH3	1.38	0.70	1.06	0.91
Average Ultimate Facility Flow of 3.6 MGD (QUAL2E File BSAUU.OUT in Attachment C)				
DO	6.0	6.0	8.3	9.9
BOD5 (BODU)	3.8 (4.9)	5.0 (6.5)	3.2 (5.9)	2.9 (4.0)
TSS	6.1	10.0	5.6	5.4
NH3	0.25	0.70	0.21	0.19

[a] Existing NSWWTP Effluent Maximum Weekly Warm Season Concentration.

[b] Nominal WDNR Permit Effluent Limits for the Warm Season Applied to BMC without Sugar River Mixing Zone.

[c] QUAL2E Simulated Warm Season Values--BMC Near the Existing Verona WWTP at Bruce Street.

[d] QUAL2E Simulated Warm Season Values--BMC Immediately Upstream of Sugar River Confluence.

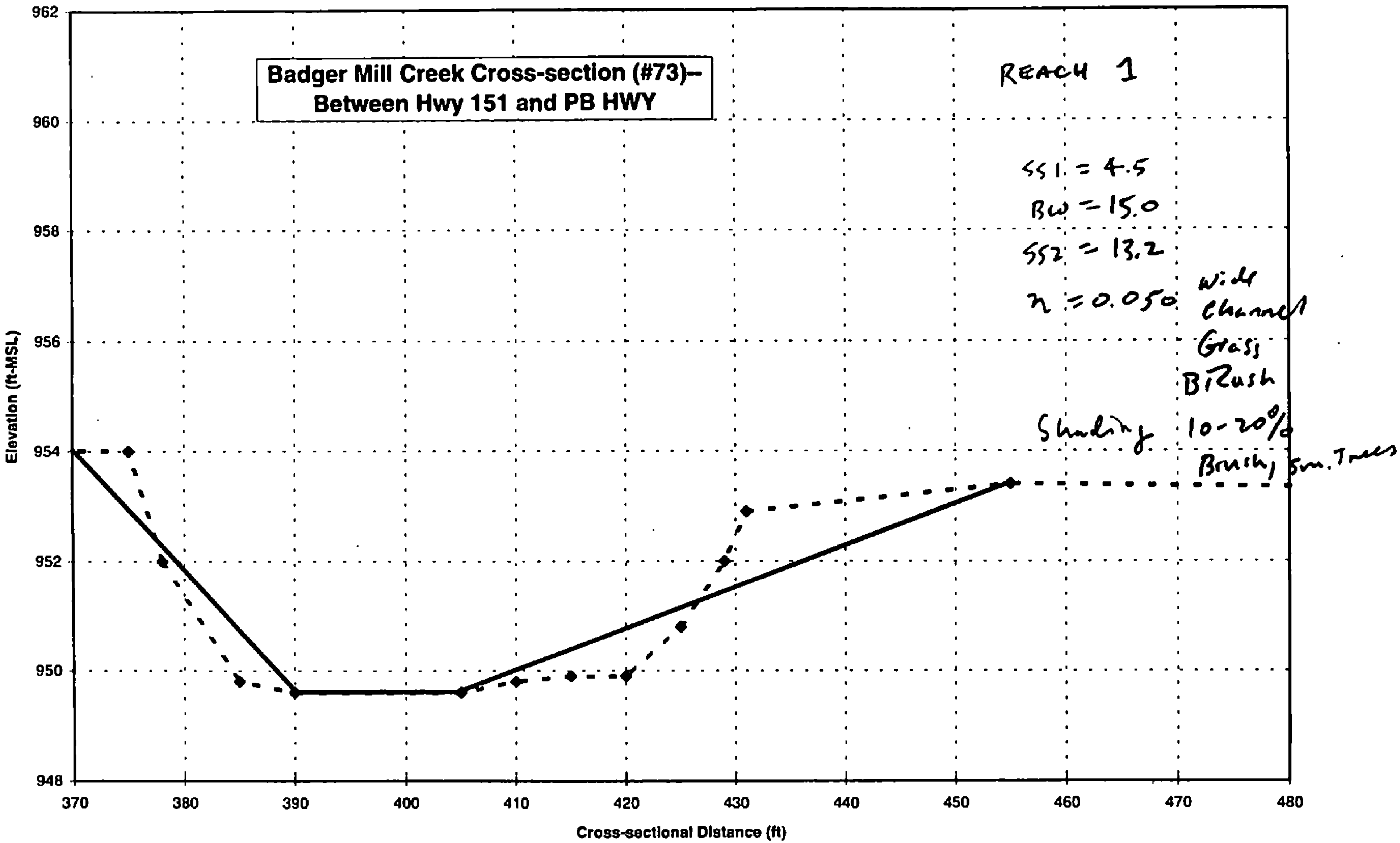
Table 5. Output File Naming Convention for EPA QUAL2E Instream WQ Model for Badger Mill Creek

QUAL2EU Filename	Season		Case		Facility Flow Rate Using Ultimate BOD	
Condition=	Winter	Summer	Average	Critical	Interim Flow	Ultimate Flow
Abbreviation=	W	S	A	C	IU	UU
Cold (W--Winter) Season Simulations are in Attchment B						
BWCIU.OUT	W			C	IU	
BWAIU.OUT	W		A		IU	
BWCUU.OUT	W		C			UU
BWAUU.OUT	W			A		UU
Warm (S--Summer) Season Simulations are in Attachment C						
BSCIU.OUT		S		C	IU	
BSAIU.OUT		S	A		IU	
BSCUU.OUT		S	C			UU
BSAUU.OUT		S		A		UU

The Interim (I) Facility Flow Rate is 2.2 MGD (3.40 cfs).
The Ultimate (U) Facility Flow Rate is 3.6 MGD (5.57 cfs).

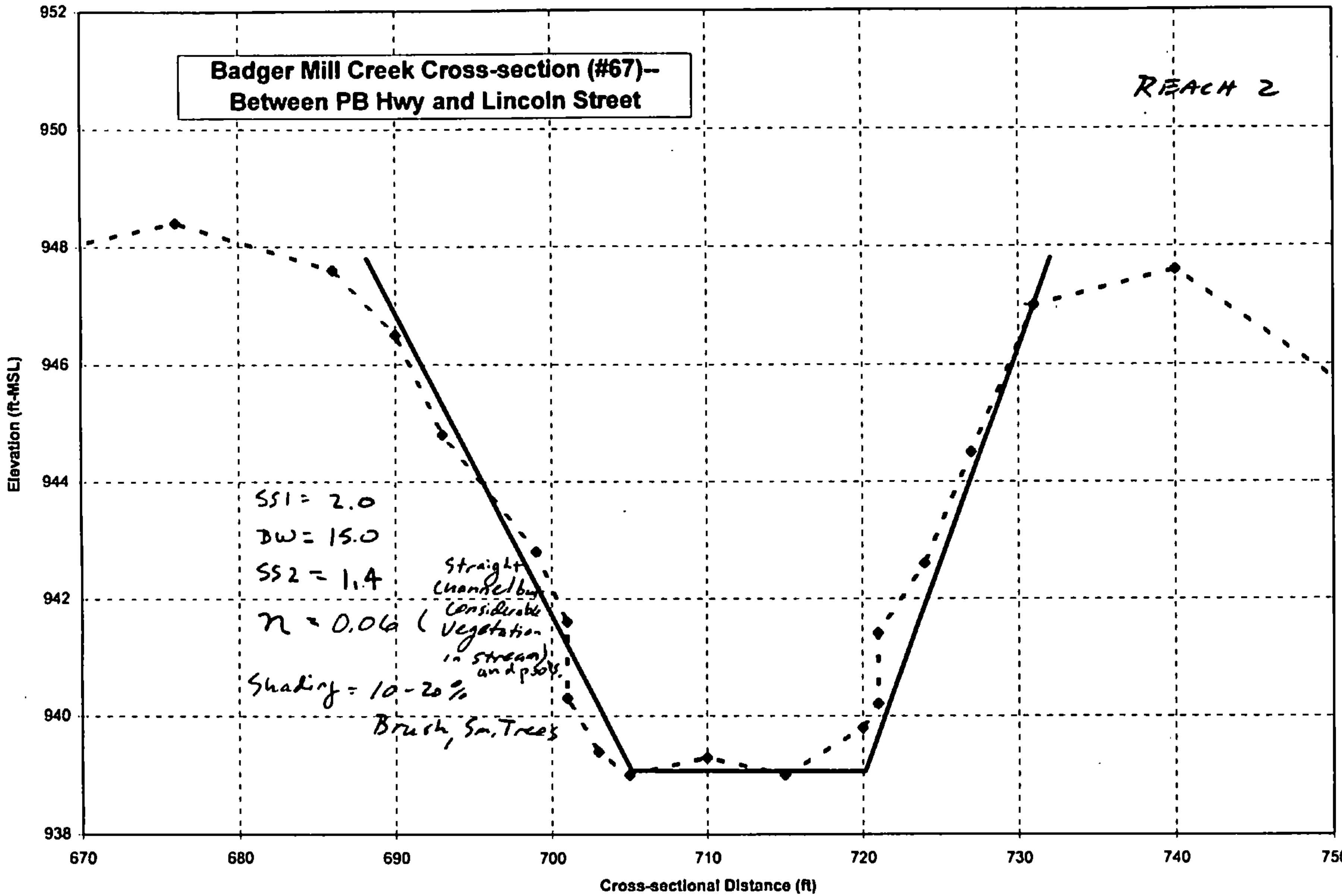
Attachment A

Badger Mill Creek Cross-Section Data
Developed from Dane County Flood Insurance Study



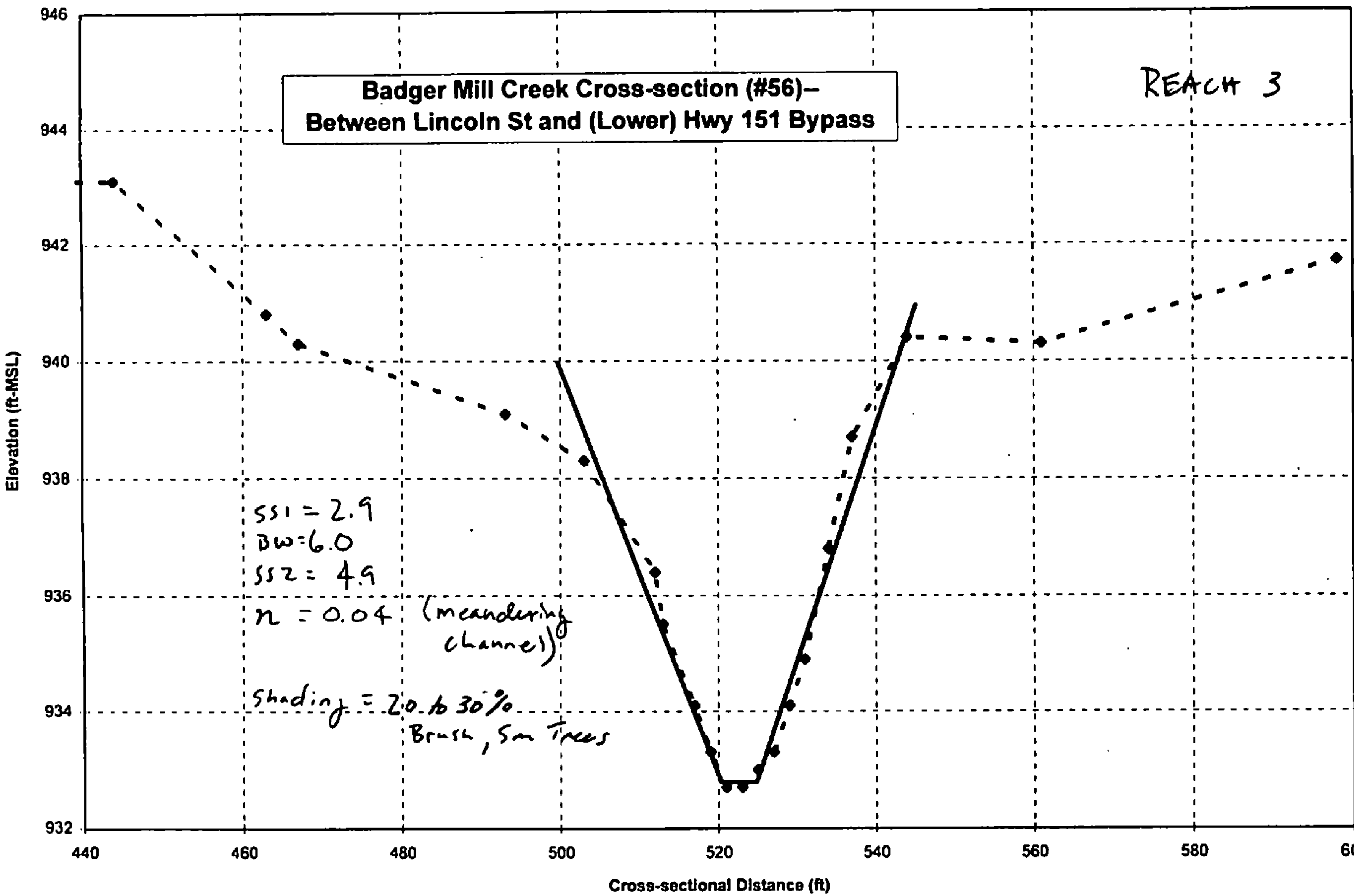
7/20/95

BMC Cross-sections Chart 62



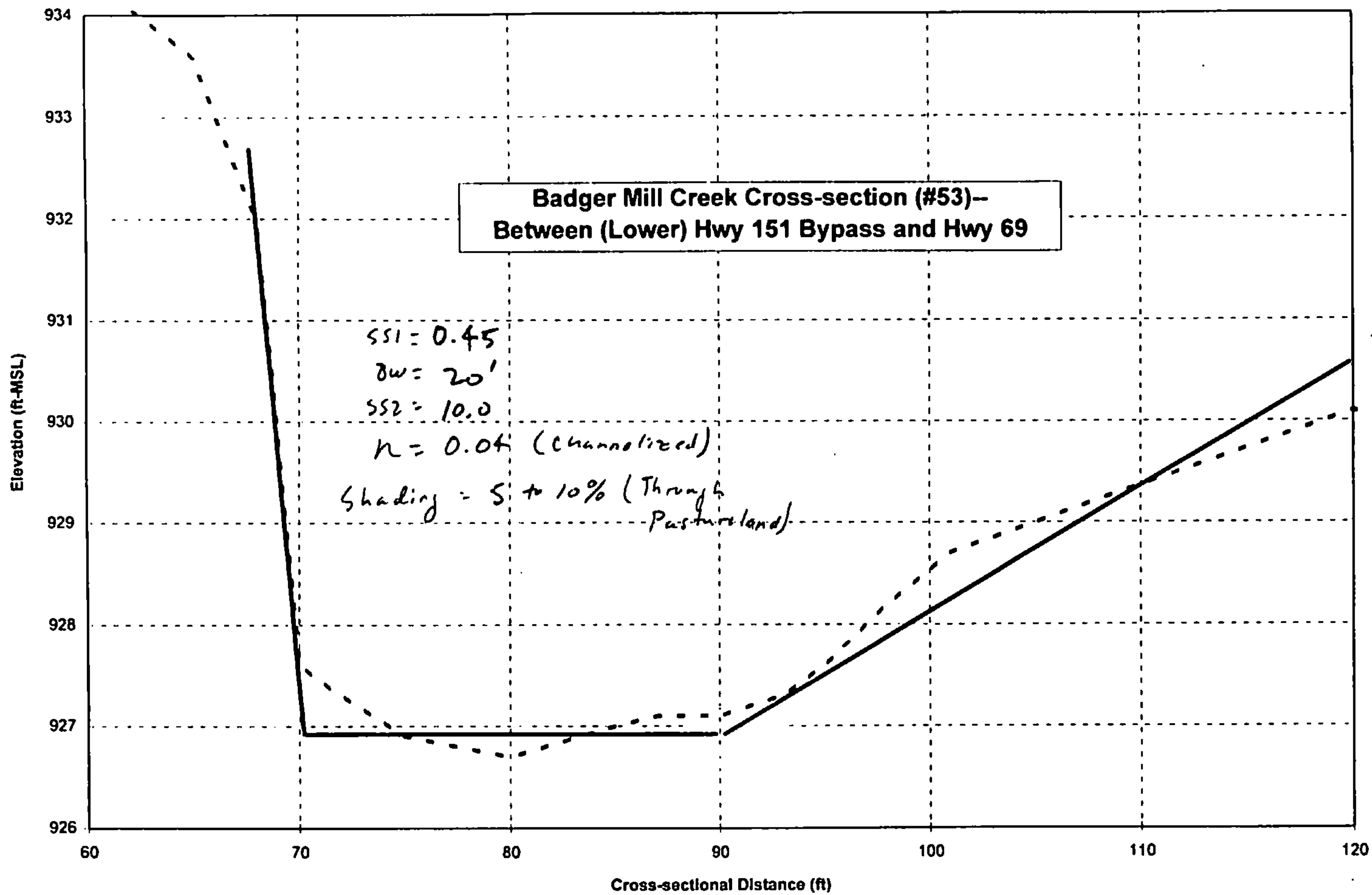
7/8/95

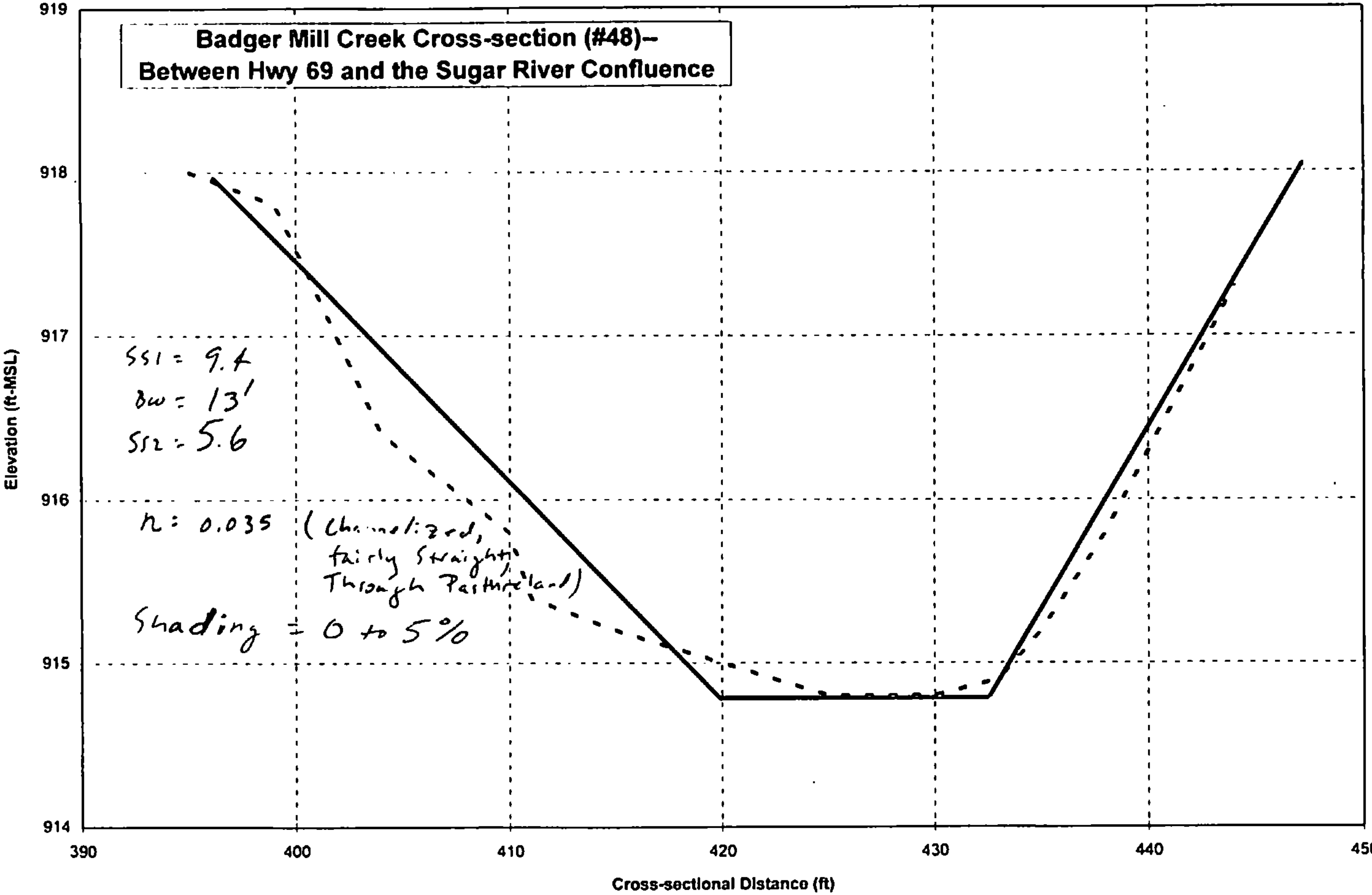
* BMC Cross-sections Chart 60

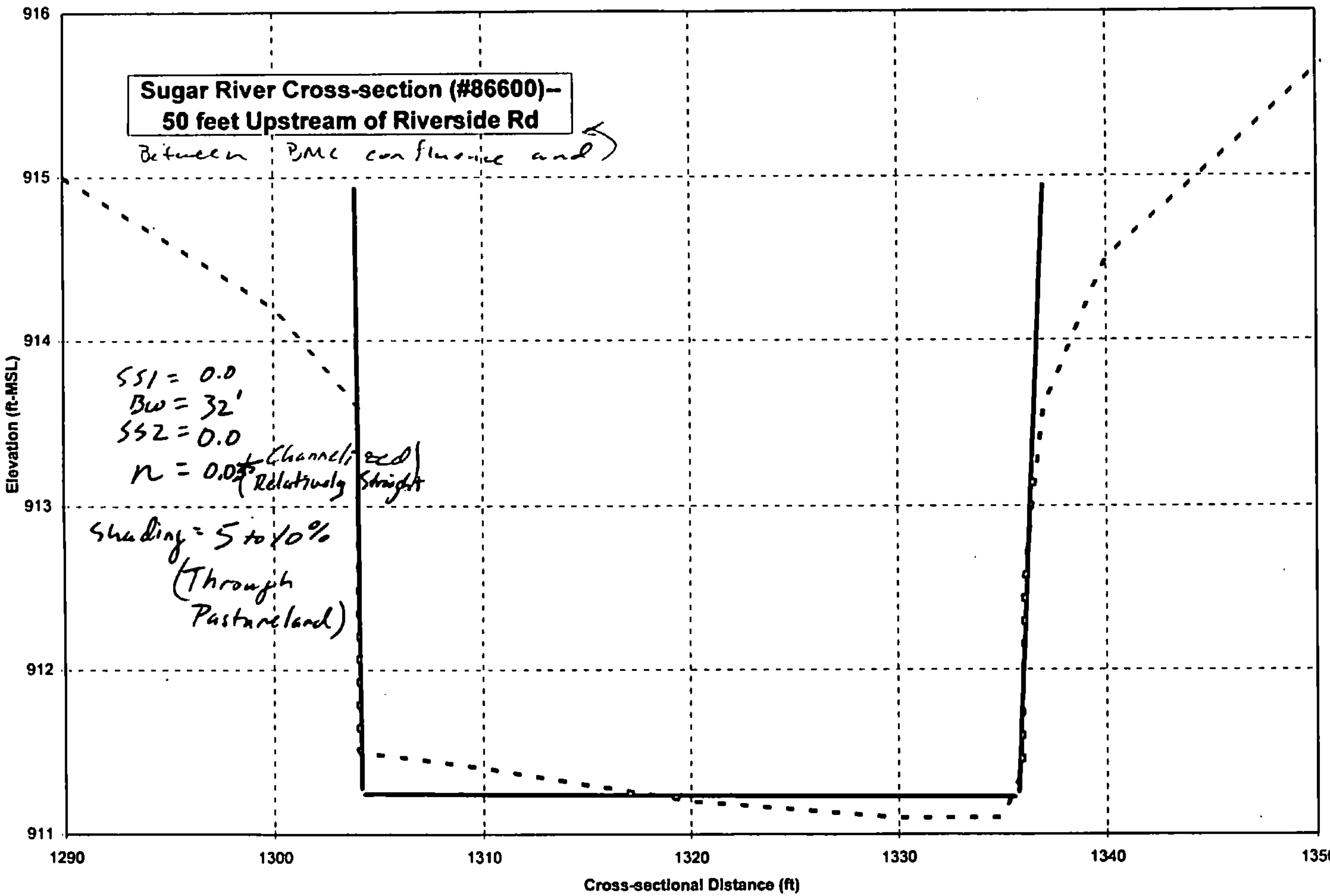


Badger Mill Creek Cross-section (#56)–
Between Lincoln St and (Lower) Hwy 151 Bypass
REACH 3
Elevation (ft-MSL)
946
944
942
940
938
936
934
932
440
460
480
500
520
540
560
580
600
Cross-sectional Distance (ft)
SS1 = 2.9
BW = 6.0
SS2 = 4.9
n = 0.04 (meandering channel)
Shading = 20 to 30%
Brush, Sm Trees

7/7/95


Badger Mill Creek Cross-section (#53)--
Between (Lower) Hwy 151 Bypass and Hwy 69
934
933
932
931
930
929
928
927
926
Elevation (ft-MSL)
60
70
80
90
100
110
120
Cross-sectional Distance (ft)
SS1 = 0.45
Bw = 20'
SS2 = 10.0
n = 0.04 (channelized)
Shading = 5 to 10% (Through Pastureland)


Badger Mill Creek Cross-section (#48)--
Between Hwy 69 and the Sugar River Confluence
919
918
917
916
915
914
390
400
410
420
430
440
450
Elevation (ft-MSL)
Cross-sectional Distance (ft)
SS1 = 9.4
bw = 13'
SS2 = 5.6
n: 0.035 (Channelized, fairly Straight Through Pastureland)
Shading = 0 to 5%



Sugar River Cross-section (#86600)--
50 feet Upstream of Riverside Rd
Between BMC confluence and
SS1 = 0.0
Bw = 32'
SS2 = 0.0
n = 0.035 (Channelized Relatively Straight)
Shading = 5 to 10% (Through Pastureland)
916
915
914
913
912
911
Elevation (ft-MSL)
1290
1300
1310
1320
1330
1340
1350
Cross-sectional Distance (ft)

* CROSS SECTION [illegible] FROM 1983 RIDGE DANE CO. STUDY ON SUGAR RIVER. SECTION IS
* 80' US OF RIVERSIDE ROAD BRIDGE ON SUGAR RIVER.

Section Number= [illegible]
Number of X-Sec Points= 32

sta (ft)	el(ft)		
160	[illegible]		
250	[illegible]		
320	[illegible]		
[illegible]	[illegible]		
640	[illegible]		
740	920.6		
815	920.4		
[illegible]	[illegible]		
[illegible]	919		
[illegible]	919		
1235	917.8		
1240	915		
1250	914.4		
1270	914.1		
1280	914.9		
1290	915		
1300	914.2		
1304	913.6	SS1(run/rise)=	0.0
1304	911.8		
1310	911.4		
1320	911.2		
1330	911.1		
1335	911.1	BW (ft)=	32.0
1336	911.4		
1336	912.5		
1337	913.6		
1340	914.5		
1353	916		
1530	918		
1680	920	SS2(run/rise)=	0.0
1710	922		
1900	[illegible]		

*
* SECTION 48X, CONFLUENCE WITH THE SUGAR RIVER. USE SECTION 48, LOWER
* ELEVATIONS BY 3.5 FEET TO MATCH THALWEG OF PREVIOUS STUDY.
* ENCROACH ON LOB AND ROB FOR CONTRACTION INTO RIVERSIDE ROAD BRIDGE.
* CHANGE TO DISCHARGES FOR BADGER MILL CREEK.
*

Section Number= 1.0
Number of X-Sec Points= 32.0

sta (ft)	el(ft)
12	922
74	918.1
[illegible]	918.1
132	914.9
[illegible]	915.1
346	915.8
[illegible]	915.4
375	913.6
387	913.6
395	914.5
398	914.3
404	912.9
410	912.3
411	911.9
415	911.7
420	911.5
425	911.3
430	911.3
433	911.4
435	911.7
436	912.3
444	913.6
446	915.4
448	916.3
546	917.1
630	915.5
709	917.1
814	918.7
819	920.6
1000	921
1146	921.6
1146	923

*
* CROSS SECTION A. SECTION 48. ENCROACH ROB FOR EFFECTIVE FLOW
*

Section Number= 2.0

Number of X-Sec Points= 32.0

12	925.5		
74	922.6		
98	919.6		
132	918.4		
240	918.6		
345	919.3		
[illegible]	918.9		
375	917.1		
387	917.1		
395	918		
398	917.8		
404	918.4	SS1(run/rise)=	0.37500
410	918.6		
411	915.4		
415	915.2		
420	915		
425	914.6	BW (ft)=	12
430	914.8		
433	914.9		
436	915.2		
438	915.6		
444	917.3		
446	918.9		
448	919.6	SS2(run/rise)=	5.0000
546	920.6		
630	919		
709	920.6		
814	922.2		
819	924.3		
1000	924.5		
1146	925.1		
1146	926.5		

*
* CROSS SECTION B. SECTION 49
*

Section No. [illegible] 3.0

Number of X-Sec Points 32.0

0	[illegible].7
[illegible]	[illegible]
147	[illegible]
[illegible]	[illegible]
[illegible]	921
381	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	921.4
[illegible]	921
[illegible]	[illegible]
570	922.4
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	922.4
[illegible]	921.6
[illegible]	920.4
[illegible]	919
[illegible]	918.2
[illegible]	919
[illegible]	919
[illegible]	919
[illegible]	917.9
[illegible]	917.6
[illegible]	917.9
[illegible]	918.7
[illegible]	919
[illegible]	921
700	924
750	926
[illegible]	927.1
[illegible]	929

*
* EXIT SEC TION TO HWY [illegible] BRIDGE. USE BRIDGE GEOMETRY FOR CHANNEL, [illegible] CO
* TOPO FOR OVERBANKS. NOT ENCROACHED ON LOB DUE TO STEEPNESS OF BANK.
*

Section No. [illegible] 4.0

Number of X-Sec Points 18.0

0	[illegible]
30	[illegible]
60	[illegible]
120	[illegible]
180	[illegible]
200	[illegible]
210	[illegible]
220	918.9
[illegible]	918.1
[illegible]	918.8
230	918.9
[illegible]	919
241	918.9
243	919
250	920.2
260	922
270	924
[illegible]	[illegible]

*
* DS FACE HWY [illegible] BRIDGE. CHANNEL GEOMETRY FROM SURVEY NOTES ON [illegible],
* OVERBANK S APPROXIMATED FROM CROSS SECTION [illegible]. CHANNEL N VALUE RAISED
* TO REPRE SENT ROCK RIPRAP. CONTRACTION AND EXPANSION COEFFICIENTS SET
* AND [illegible] TO REPRESENT THE MAJOR CONSTRICTION OF BRIDGE.
*

Section No. [illegible] 5.0

Number of X-Sec Points [illegible]

15	942.5
67	932.6
[illegible]	927.3
114	926.1
118	923.9
[illegible]	[illegible]
131	925.7
[illegible]	924.7
143	[illegible]
146	[illegible]
151	918.8
[illegible]	918.9
161	919
[illegible]	920.2
[illegible]	922
171	[illegible]
[illegible]	923.9
[illegible]	922.3
[illegible]	[illegible]
[illegible]	922.2
[illegible]	921.6
[illegible]	922.1
[illegible]	[illegible]
[illegible]	922.7
430	923.8
[illegible]	924.9
[illegible]	[illegible]
[illegible]	[illegible]

*
*
* US FACE OF HWY [illegible] BRIDGE. REPEAT DS FACE.
*

Section No. [illegible] 6.0

Number of X-Sec Points= 30

19	842.5	842.5
67	832.6	833.1
86	827.3	832.9
114	828.1	832.8
118	825.9	836.4
120	828.5	836.4
126	828.9	836.4
131	828.6	836.4
138	828.6	836.3
143	828.8	835.3
148	828.6	836.3
151	828.7	836.3
156	828.7	836.1
161	828.8	836.1
164	828.6	836
168	828.6	836
171	828.6	835
176	828.5	834.9
178	825.9	834.9
180	822.3	834.9
182	822.8	832.1
183	822.2	832.1
204	821.6	831.7
208	822.1	831.5
262	822.8	830.6
364	823.7	830.3
430	823.9	830.1
588	824.9	828.5
664	826.4	828.6
880	828.5	828.6

*

* CROSS SE CTION C. SECTION 80 APPROACH SECTION TO HWY 69 BRIDGE. NOT

* ENCROACH ED ON LOB BECAUSE OF STEEPNESS OF BANK

*

Section Nu mber= 7.0

Number of X-Sec Points= 30.0

19	842.5
67	832.6
86	827.3
119	822.8
136	821.8
140	821.4
146	820.4
147	819.9
148	819.2
150	818.5
156	818.5
158	819.2
160	819.6
161	819.9
162	820.3
168	820.7
171	820.9
174	820.7
179	820.1
180	821
188	822.3
192	822.8
193	822.2
204	821.6
262	822.6
430	823.6
588	824.9
660	826.5
800	830
1750	830

* CROSS SE CTION D SECTION 81 ENCROACHED FOR EFFECTIVE FLOW

*

Section Nu mber= 8.0

Number of X-Sec Points= 31.0

52	827.7
67	826.6
161	825.1
270	824
274	823.8
277	823.3
280	821.6
280	820.4
282	820.1
286	819.8
290	820
296	820.4
297	820.8
298	821.2
300	821.7
307	822.7
314	822.9
328	821.9
337	822.1
345	824.1
348	824.7
431	824.3
632	825.8
631	827.8
1004	829.1
1210	829.1
1308	829.7
1325	828.5
1328	829.1

*

* CROSS SE CTION E SECTION 82 ENCROACHED FOR EFFECTIVE FLOW OVERFLOW F

* 69 RETUR NS HERE USED NH CARD TO EXCLUDE FLOW FOR "SHADOW" OF ISLAND

*

Section Nu mber= 9.0

Number of	X-Sec Points= [illegible]
128	827.3
150	829.7
222	826.1
280	824.7
350	825.8
386	825.8
392	825.1
393	823.3
397	822.5
398	821.8
408	821.6
410	821.6
412	821.6
415	822.5
417	822.9
420	824.4
427	825.2
442	824.9
452	824.9
520	824.9
544	823.8
666	823.8
708	827.7
800	828
1040	829.2
1400	830

*
* INTERPOL ATED CROSS SECTION BETWEEN 53 AND 53 JUST UPSTREAM FROM THE
* CONFLUEN CE WITH THE DRY TRIBUTARY TO BADGER MILL CREEK. OVERBANKS FRO
* CONTOUR TOPO. SECTION INCLUDES BOTH CHANNELS. ASSUME FULL DISCHARGE.
*

Section No. above 10.0

Number of	X-Sec Points= 23.0
0	838.2
110	834
228	832
310	830
420	828
460	826
470	825.4
480	824.7
485	824.1
491	823.5
495	823.7
500	823.7
503	823.7
507	824.3
511	824.7
520	825.4
750	826
800	828
900	829.5
1000	830
1080	832
1420	834
1430	834.4

*
* CROSS SE CTION F, SECTION 53.
* DECREASE DISCHARGE FOR LOSS OF INFLOW FROM THE TRIBUTARY AND FOR LOSS
* OVER HWY 69. A SPLIT FLOW ANALYSIS USING THE HEC-2 SF RECORD WAS USED.
* LOSSES O VER HWY 69 WERE AS FOLLOWS: 10-YEAR -0 CFS, 50-YEAR -30 CFS, 1
* -140 CFS ; 500-YEAR -680 CFS.
*
*

Section Number= 11

Number of X-Sec Points= 26					
25	844				
35	842				
40	840				
45	838			EC1(units?)=	0.45435
57	834.9				
65	833.9				
68	833				
70	827.8				
73	827.3		BW (ID=		20
75	828.3				
80	828.7				
85	827				
87	827.1				
88	827.1				
90	827.3				
95	827.8			EC2(units)=	10.00000
98	828.2				
101	828.7				
120	830.1	830.6			
135	829.5				
177	829.5				
261	829.9				
337	829.9				
370	830				
570	831.2				
630	832				

*
* EXIT SEC TION FOR PRIVATE ROAD. ENCROACHED ON LOB FOR EFFECTIVE FLOW
*

Section No. above 12.0

Number of	X-Sec Points= 12.0
1000	840
1050	836
1140	838
1240	834
1430	832
1450	830
1456	828
1515	829
1520	830

1800	933
1820	934
2080	936

*
* DS FACE OF PRIVATE ROAD. EDIT SECTION FOR OVERBANKS, BRIDGE GEOM FOR C
* REMOVED X3.10 OPTION IN ORDER TO MAKE FLOWS THROUGH BRIDGE CONSISTENT
* OUTPUT F ROM SPECIAL BRIDGE ROUTINE. USED X3.4 AND X3.8 OPTION INSTEAD
*

Section Nu mber= 12.0

Number of X-Sec Points= 12.0

1385	933.3
1415	932.3
1430	932
1450	930
1470	929.8
1485	929.9
1500	930.4
1520	930
1535	930.4
1600	932
1620	933.3
1880	934

*
*
* US FACE OF PRIVATE ROAD. REPEAT DS FACE SECTION
* REMOVED X3.10 OPTION IN ORDER TO MAKE FLOWS THROUGH BRIDGE CONSISTENT
* OUTPUT F ROM SPECIAL BRIDGE ROUTINE. USED X3.4 AND X3.8 OPTION INSTEAD

BRIDGE Se ction Number= 14.0

BRIDGE Nu mber of X-Sec Points= 13.0

1385	932.3	934.7
1415	932.3	934.6
1430	932	934.5
1450	930	936
1470	929.8	936.3
1470	933.6	936.3
1485	933.6	936.3
1500	933.7	936.4
1500	930.4	935.4
1520	930	933.8
1535	930.4	932.6
1600	932	932.6
1620	933.2	934

Section N umber= 14.0

Number of X-Sec Points= 13.0

1385	932.3
1415	932.2
1430	932
1450	930
1470	929.8
1485	929.9
1500	930.4
1520	930
1535	930.4
1600	932
1620	933.2
1880	934

*
* CROSS SE CTION G SECTION 94 APPROACH SECTION FOR PRIVATE ROAD
* ENCROACH ED ON ROB FOR EFFECTIVE FLOW FROM CULVERT.
*

Section Nu mber= 15.0

Number of X-Sec Points= 47.0

0	936.3
70	936.1
140	936.4
167	933.8
208	934.9
230	934.4
242	933.4
250	934.8
267	936
273	934.8
290	933.8
316	933.8
330	932.8
348	933.6
358	933.3
375	932.7
375	930.8
382	929.8
386	929.6
388	929.3
393	929.4
398	929.6
400	929.9
406	929.8
413	929.7
430	929.8
443	930
448	930.9
480	931.1
540	931.9
580	932.3
643	932.8
660	932.8
680	933.1
700	934.3
720	935.5
726	936.4
768	935.2
807	934.8
822	936

987	938.9
1014	936.2
1082	936.5
1144	936.5
1223	936.5
1310	936.5
1368	936.5

*

* EXIT SEC TION FOR PROPOSED HWY 151 BYPASS CULVERT.
* USE 2' T OPO FOR OVERBANKS, BARRIENTOS CULVERT PLAN MAP FOR CHANNEL.
* ENCROACH ED FOR 4:1 EXPANSION OF FLOW. LEAVE CONTRACTION AND EXPANSION
* COEFFICI ENTS AT .3 AND .5

*

Section Nu mber= 16.0

Number of X-Sec Points= 8.0

1000	934
1305	932
1308	931.1
1345	931.1
1348	932
1350	934
1380	934
1520	936

*

* DS FACE OF HWY 151 BYPASS CULVERT. REPEAT EXIT SECTION.

*

Section Nu mber= 17.0

Number of X-Sec Points= 8.0

1000	934
1305	932
1308	931.1
1345	931.1
1348	932
1350	934
1380	934
1520	936

*

*

* US FACE OF HWY 151 BYPASS CULVERT. REPEAT EXIT SECTION.

*

Section Nu mber= 18.0

Number of X-Sec Points= 8.0

*

* APPROACH SECTION FOR HWY 151 BYPASS CULVERT.
* USE 2' T OPO FOR OVERBANKS, BARRIENTOS CULVERT PLAN FOR CHANNEL.
* ENCROACH ED FOR EFFECTIVE FLOW. DECREASE DISCHARGE FOR ROAD OVERFLOW

*

*

Section Nu mber= 19.0

Number of X-Sec Points= 8.0

830	938.5
1000	936
1180	934
1185	931.3
1225	931.3
1230	934
1260	936
1640	938

*

* CROSS SE CTION IN SECTION 16. USE 2' TOPO FOR OVERBANKS, BARRIENTOS CU
* PLAN FOR CHANNEL. ENCROACHED OVERBANKS FOR 4:1 EXPANSION OF FLOW FROM
* UPSTREAM . CHANGE DISCHARGE FOR ROAD OVERFLOW BASED ON SPLIT FLOW ANALY

*

*

Section Nu mber= 20.0

Number of X-Sec Points= 16.0

835	944
905	942
1000	940
1246	938
1380	936
1385	934
1400	933
1415	933
1420	934
1430	935
1600	935
1630	936
1700	936
1750	936
1920	938
2000	938.5

*
* SECTION INSERTED ON FLOOD MAP
* USE 2' TOPO FOR OVERBANKS, BARRIENTOS CULVERT PLAN EXTENDED FOR CHANNE
* ENCROACHED OVERBANKS FOR 4:1 EXPANSION OF FLOW FROM UPSTREAM.
* INCREASE DISCHARGE TO FULL AMOUNT.
*
*

Section Number= 21.0

Number of X-Sec Points= 12.0

710	944
880	942
1000	940
1020	938
1270	936
1300	934
1310	933
1320	933
1340	934
1400	936
1420	938
1700	940

*
* CROSS SECTION L SECTION 56 EXIT SECTION FOR BRUCE STREET BRIDGE
* LEFT OVERBANK CHANGED SLIGHTLY DUE TO RECENT SURVEY DATA
* ENCROACHED ON ROB FOR EXPANSION OF FLOW FROM BRIDGE.
* LEFT OVERBANK NOT ENCROACHED DUE TO ROAD OVERFLOW.
*

Section Number= 22.0

Number of X-Sec Points= 47.0

	85	945.6			
	113	945.8			
	119	945.8			
	137	944.3			
	177	944			
	212	942.5			
	253	942.5			
	257	942.5			
	304	943.1		SS1 (ps/ftmel)=	2.8
	323	943.1			
	340	943.1			
	373	943.1			
	415	943.1			
	444	943.1			
	483	940.8			
	487	940.3			
800	490	938.1	940		
	503	936.3			
	512	936.4			
	513	935.5			
	517	934.1			
	519	933.3			
	521	932.7			
	523	932.7			
	525	933		BW (ft)=	6.0
	527	933.3			
	529	934.1			
	531	934.9			
	534	936.8			
	537	938.7			
	544	940.4			
	581	940.3		SS2(ps/ftmel)=	4.8
	599	941.7			
	640	940.7			
	686	939.9			
	728	939.9			
	742	939.9			
	780	940.1			
	813	940.8			
	815	940.8			
	820	940.5			
	816	941.7			
	848	941.7			
	980	941.4			
	989	941.2			
	990	940.7			
	1084	941.1			

*
* DS FACE OF BRUCE STREET BRIDGE.
* REPEAT EXIT SECTION, CHANGE N VALUES AND CHANNEL STATIONS
* ROAD OVERFLOW IS NOT POSSIBLE ON RIGHT SIDE.
* REMOVED X3.10 OPTION IN ORDER TO MAKE FLOWS THROUGH BRIDGE CONSISTENT
* OUTPUT FROM SPECIAL BRIDGE ROUTINE. USED X3.4 AND X3.6 OPTION INSTEAD
*

Section Number= 23.0

Number of X-Sec Points= 47.0

85	945.6
113	945.6
119	945.8
137	944.3
177	944
212	943.5
253	942.5
257	942.5
304	943.1
323	943.1
340	943.1
373	943.1
415	943.1
444	943.1
483	940.8
487	940.3
490	938.1
503	936.3
512	936.4
513	935.5
517	934.1

519	933.3
521	933.7
523	933.7
525	933
527	933.3
529	934.1
531	934.9
534	936.8
537	938.7
544	940.4
[illegible]	940.3
[illegible]	941.7
640	940.7
[illegible]	939.9
738	939.9
742	939.8
780	940.1
813	940.5
815	940.5
[illegible]	940.5
918	941.7
948	941.7
983	941.4
[illegible]	941.3
[illegible]	940.7
1084	941.1

*
*
* US FACE OF BRUCE STREET BRIDGE. REPEAT OS SECTION.
* ROAD OVE RFLOW IS NOT POSSIBLE ON RIGHT SIDE.
* REMOVED X3.10 OPTION IN ORDER TO MAKE FLOWS THROUGH BRIDGE CONSISTENT
* OUTPUT F ROM SPECIAL BRIDGE ROUTINE. USED X3.4 AND X3.8 OPTION INSTEAD
*

Section No. mbom= 54.0

Number of X-Sec Points= [illegible]

113	945.8	945.8
119	945.8	945.8
137	944.2	944.2
177	944	944
212	943.8	943.3
253	942.5	942.8
257	942.8	942.8
304	943.1	943.1
320	943.1	943.1
340	943.1	943.3
373	943.1	943.7
415	943.1	944.3
444	943.1	944.8
463	940.8	944.8
467	940.3	944.8
480	939.1	945
500	938.3	945
512	938.4	945.1
513	938.8	946.1
513	942.9	945.1
517	942.9	946.1
519	942.9	946.1
521	942.9	946.1
523	942.9	946.1
525	942.9	945.1
527	943.9	945.1
529	942.9	945.1
531	943.9	945.1
531	934.9	943.1

*
* CROSS SE CTION J. SECTION 57, APPROACH SECTION FOR BRUCE STREET BRIDGE
* ENCROACH ED ROS FOR CONTRACTION INTO BRIDGE. LEFT OVERBANK NOT ENCROAC
* TO ROAD OVERFLOW
*

Section No. mbom= 55.0

Number of X-Sec Points= 38.0

16	946.4
39	944.8
65	944
90	943.7
135	942.9
159	942.1
191	941.3
239	940.5
277	938.3
324	939.2
367	939.5
380	939
383	937.4
384	938.9
386	935.8
388	934.3
399	933.3
400	933.3
402	933
404	933.1
406	933.2
408	933.5
410	934.2
412	936.7
416	937.3
424	938.9
440	938.1
456	939.7
470	942.5
490	941.3
526	941.1
564	943
587	943
615	944.4
635	946.6
684	947.4

*
* CROSS SE CTION K. SECTION 58 MODIFIED SLIGHTLY TO MATCH TOPO MAP

Section Number= 28.0

Number of X-Sec Points= 52.0

0	946
53	943.8
81	943.8
100	944
120	946
150	945.2
177	943.5
200	943.5
224	943.7
260	943.4
286	942.9
322	943.1
346	943.2
366	943.1
384	943.1
417	943.7
440	944.1
454	945
470	945.5
486	945.4
501	945.1
517	944.1
528	943.7
539	943.3
550	942
559	938.2
560	937.3
566	936.6
570	935.5
573	935.2
576	935.2
579	936.1
581	936.7
583	938.6
590	938.5
605	938.6
620	938.8
632	939.3
653	939.3
675	938.6
688	938.7
713	938.7
731	939.5
757	938.8
777	939.4
823	939
875	939.6
889	940.7
919	941.7
939	942.7
955	944.2
979	945.5

*

* CROSS S ECTION L. SECTION 99 EXIT SECTION FOR MAIN STREET BRIDGE.

* ENCROAC HED OVERBANKS FOR 4:1 EXPANSION OF FLOW

*

Section Number= 27.0

Number of X-Sec Points= 22.0

0	946
20	944
42	942
90	941.8
184	940.5
200	939.4
203	936.4
216	937.7
220	937.7
222	936.4
224	936.5
226	936.5
228	936.8
229	938
240	939.1
246	939.7
253	940.3
320	940
360	942
370	944
380	946
410	948

*

* DS FACE OF MAIN STREET BRIDGE.

* USE EXI T SECTION FOR OVERBANKS, BRIDGE GEOMETRY FOR CHANNEL.

* USE CON TRACTION AND EXPANSION COEFFICIENTS OF .4 AND .6

*

Section Number= 26.0

Number of X-Sec Points= 22.0

0	946
20	944
42	942
90	941.8
184	940.5
200	939.4
203	936.4
207	937.7
208	936
219	936.8
230	936.8
240	936.1
241	936.1
246	939.7
253	940.3

330	940
360	942
370	944
380	946
410	948

*
* US FACE OF MAIN STREET BRIDGE
* REPEAT DS FACE SECTION
*

Section No. above 29.0

Number of X-Sec Points .0

*
* CROSS SECTION M. SECTION 60. APPROACH SECTION FOR MAIN STREET BRIDGE
* ENCROACHED FOR CONTRACTION OF FLOW.
*

Section No. above 30.0

Number of X-Sec Points 21.0

910	950
1027	941.5
1030	940.3
1037	938.6
1039	937.8
1040	937.7
1042	937.2
1048	936.9
1088	936.9
1090	936.4
1095	936.5
1097	936.9
1098	937.7
1100	937.5
1101	939
1103	939.7
1180	943.4
1208	944.8
1237	946.4
1264	946.6
1281	947.6

*
* CROSS SECTION N. SECTION 61.
*

Section No. above 31.0

Number of X-Sec Points 34.0

63	954.3
73	951.3
79	947.6
83	944.4
86	943.5
87	943.2
92	940.7
94	940.4
98	938.1
101	938.4
102	937.8
105	937.2
107	936.8
112	936.9
114	937.7
116	939
124	939.9
127	944
148	944.6
175	944.6
195	944.8
221	944.8
251	944.4
273	946.5
287	947.2
309	946.6
333	946.4
366	946.4
382	946.2
404	946.8
418	946.4
434	950.7
457	953.5
483	953.1

*
* CROSS SECTION O. SECTION 62
*

Section No. above 32.0

Number of X-Sec Points 23.0

46	955.1
64	952.9
77	948.9
98	948.4
122	946.4
151	947.2
171	946.2
188	942.9
190	941.8
194	939.4

196	936.7
198	936.3
200	937.6
203	937.6
206	937.9
209	938.4
210	939
216	939.4
217	940
223	940.4
231	941.9
250	944.1
264	946.6
276	950.3
301	953.7
314	958.2

* CROSS SE CTION P SECTION 63

Section Nu mber= 33.0

Number of X-Sec Points= 33.0

13	959.4
20	954.9
30	949.5
39	946.4
40	943.4
64	945.8
80	944
94	946
105	945.6
121	946
135	946
154	946.6
158	943.6
162	940.9
166	938.6
168	939
169	938.6
170	938.2
172	937.8
175	939
180	938.1
182	939.3
186	938.6
188	939.6
190	942
199	944
211	946
220	946
232	948.6
240	952.1
250	954.5
259	957
284	960.3

* CROSS SE CTION Q SECTION 64

Section Nu mber= 34.0

Number of X-Sec Points= 33.0

46	961.2
52	960
63	956.8
71	952.1
81	948.8
98	947.2
113	945.4
132	945.8
147	944.6
157	942.6
158	941.6
162	939.9
166	938.5
167	939.9
169	938.5
171	938.8
176	938.7
177	938.5
178	938.2
182	939.8
186	939.1
188	939.6
187	939.6
187	941.1
193	944.3
208	946.4
220	946.8
231	946.6
271	948.2
280	950.1
294	953.7
310	956.8
330	956.2
360	960.6
381	961.4

* CROSS SE CTION R SECTION 65

Section Nu mber= 35.0

Number of X-Sec Points= 62.0

304	952.9
312	956.6
319	956.9

[illegible]	[illegible]
[illegible]	951.1
[illegible]	[illegible]
[illegible]	943.7
417	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	947.2
[illegible]	[illegible]
616	947.2
[illegible]	[illegible]
[illegible]	941.4
[illegible]	940.5
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	940.5
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	947.8
[illegible]	944.9
[illegible]	[illegible]
[illegible]	943.6
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
714	[illegible]
729	943.4
743	944.6
[illegible]	943
761	[illegible]
[illegible]	947
815	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	947.4
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
1012	[illegible]
1031	951.9
[illegible]	951.9
1071	952.7
[illegible]	951.1
1112	950.9
[illegible]	950.9
1162	[illegible]
[illegible]	952.5
[illegible]	952.0
[illegible]	[illegible]
1251	[illegible]
1267	[illegible]
1279	[illegible]

* CROSS SE CTION S SECTION [illegible]

Section Nu mbers: 38.0

Number of X-Sec Points: 48.0

79	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
134	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
701	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
742	[illegible]
747	[illegible]
749	[illegible]
754	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
814	[illegible]
[illegible]	[illegible]
843	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
1411	951.7

* SECTION [illegible] - APPROVED FILL SECTION

Section Nu mbers 37.0

Number of X-Sec Points= 27.0

0	957.4
60	960.9
213	960.9
233.5	948.6
300	948.2
400	948
500	946.1
580	947.3
582.5	945.1
585	943.8
590	940.6
595	939.6
600	939.5
605	939.3
610	940.7
615	943
617.5	945.9
700	946.4
800	947.6
900	947.5
1000	947.5
1100	947.7
1200	948.4
1300	946.1
1400	948.9
1500	951.4
1600	953.8

*
* CROSS SE CTION T, SECTION 67.
*

Section Nu mbers 38.0

Number of X-Sec Points= 50.0

81	958.5		
105	957.6		
134	956.8		
158	954.1		
188	952.1		
240	949.7		
258	948.2		
270	947.3		
280	944.4		
298	944.4		
302	947.4		
312	947.8		
329	947.6	SS1(pumps)=	2.0
371	947.8		
413	947		
430	946.4		
466	948.4		
542	946.5		
581	947		
620	947		
662	947.6		
676	948.4		
686	947.6		
690	946.3		
693	944.8		
698	942.8		
701	941.6		
701	940.3		
703	939.4	BW (X)=	15.0
706	939		
710	939.3		
715	939		
720	939.8		
721	940.2		
721	941.4		
724	942.6	SS2(pumps)=	21.0
727	944.6		
731	947		
740	947.8		
751	945.6		
780	945.6		
868	947.2		
947	947.8		
1080	947.8		
1168	947		
1340	947.2		
1410	948		
1580	950		
1700	952		
1720	954		

*
* UPSTREAM CORPORATE LIMITS. REPEAT LAST SECTION 170 FEET UPSTREAM
*

Section Nu mbers 39.0

Number of X-Sec Points= 0

*
* CROSS SE CTION U. SECTION 66. RIGHT OVERBANK EXTENDED FROM 2' CI TOPO
* NH CARD USED TO EXCLUDE FLOW FROM "SHADOW" OF UPSTREAM ISLAND
* CHANGED SECTION REFERENCE DIFFERENCE FROM PREVIOUS STUDY
*

Section Nu mbers 40.0

Number of X-Sec Points= 17.0

30	961.6
50	958.2
74	957
100	954.1
120	951.7

194	948.7
286	948.4
336	948.4
482	948.4
530	948.4
600	948.5
663	948
679	950.1
686	948.8
698	947.7
700	946.4
708	940
710	941.6
710	940
711	939.5
713	939.2
715	939
717	938.2
720	939.4
723	939.7
725	939.8
729	940.3
739	942.1
730	943.3
736	944.1
741	946.5
752	950.3
828	947.5
860	948.5
928	948.6
978	950
1070	952
1180	952
1200	950
1250	948
1300	946
1400	948.8
1500	946
1600	948
1670	950
1730	952
1800	954

*
* CROSS SE CTION V SECTION 60 - AT CONFLUENCE WITH UNNAMED TRIBUTARIES -
* DOWNSTRE AM SECTION FOR SPLIT FLOW ANALYSIS. MAIN NORTHERN CHANNEL
* CHANGED SECTION REFERENCE DIFFERENCE FROM PREVIOUS STUDY
*

Section No mbers 41.0

Number of X-Sec Points 70.0

76	960.8
123	957.6
172	956
221	952.5
316	950.7
389	951.1
416	951.1
424	950.7
438	949.8
444	949.8
478	949.9
523	951.0
589	951.9
667	952.7
724	951.8
786	950.5
860	950.9
914	951.9
983	950.2
1022	949.9
1080	949.3
1135	949.9
1179	948
1214	946
1237	946.2
1240	946.4
1244	946.5
1251	946.7
1256	946.8
1263	946
1330	946.9
1342	948.2
1382	948
1385	946.6
1408	946.6
1418	946.6
1425	946.6
1433	946.6
1435	946.4
1441	945.1
1446	944
1448	942.5
1450	941.3
1453	941.2
1454	940.2
1458	939.9
1460	939.9
1462	940.5
1466	941.3
1468	943.8
1473	944.8
1475	946.5
1481	946.1
1484	946.7
1486	950.1
1514	948.8
1582	946.6
1676	946.6
1780	946.6
1888	947.2
1900	948.4
1910	951.1
1919	953.3
1942	952.5
2049	952.5
2134	952.7
2203	953.3
2248	957.8
2271	960.6
2314	961

* SECTION 70. EXIT TO HWY P8 BRIDGE, ABOVE CONFLUENCE WITH UNNAMED TRIB
* CHANGED DISCHARGES FOR LOSS OF FLOW. USED BARRIENTOS 2' TOPO MAP FOR
* ENCROACH ED FOR EXPANSION OF FLOW. SECTION WAS MODIFIED FOR TRIBUTARY A
* SECTION REFERENCE CHANGED FROM PREVIOUS STUDY.
*
*

Section Nu mber= 42.0

Number of X-Sec Points= 17.0

1000	960
1050	951
1070	950
1073	948
1076	946
1082	944
1086	943.7
1090	943.6
1096	942.4
1098	942.3
1101	943.3
1103	944
1108	946
1119	948
1143	950
1154	950.9
1165	951.6

*
* DS FACE OF HWY P8 BRIDGE.
*

Section Nu mber= 43.0

Number of X-Sec Points= .0

*
*
* US FACE HWY P8 BRIDGE.
*

Section Nu mber= 44.0

Number of X-Sec Points= 19

1000	960	963.3
1050	951	963
1070	950	962.9
1073	948	962.9
1076	946	962.9
1076	960.2	962.9
1082	960.2	962.9
1085	960.2	962.9
1090	960.2	962.9
1095	960.2	962.9
1098	960.2	962.9
1101	960.2	962.9
1103	960.2	962.9
1106	960.2	962.9
1108	946	962.9
1119	948	962.8
1143	950	962.8
1154	950.9	962.9
1165	951.6	962.8

*
* APPROACH TO HWY P8 BRIDGE. BRIDGE GEOM FOR CHANNEL, 2' TOPO FOR
* OVERBANK S. ENCROACHED FOR CONTRACTION OF FLOW
*

Section Nu mber= 45.0

Number of X-Sec Points= 17.0

1000	960
1050	951
1070	950
1073	948
1076	946
1082	944
1086	943.7
1090	943.6
1096	942.4
1098	942.3
1101	943.3
1103	944
1108	946
1119	948
1143	950
1154	950.9
1165	951.6

*
* EXIT TO CULVERT. BARRIENTOS 2' CONTOUR TOPO MAP FOR CHANNEL AND OVERS
* ENCROACH ED FOR EXPANSION OF FLOW
*

Section Nu mber= 46.0

Number of X-Sec Points= 6.0

1000	965

1080	948.5
1140	948.8
1140	949
1188	943.4
1205	943.4
1210	948
1280	951.6

*

* DS FACE OF CULVERT. USE SECTION 46.

*

Section No rdsno= 47.0

Number of X-Sec Points= 8

*

*

* US FACE OF CULVERT. REPEAT DS FACE.

*

Section No rdsno= 48.0

Number of X-Sec Points= 8

*

* MODIFIED SECTION 71. APPROACH TO CULVERT. BARRIENTOS MAP OVERBANKS, C

* PLANS FO R CHANNEL. ENCROACHED FOR CONTRACTION

*

Section No rdsno= 49.0

Number of X-Sec Points= 15.0

1000	960
1040	960.1
1088	960
1110	960
1125	960.8
1148	960
1135	948
1150	948
1138	944.8
1168	944.8
1168	948
1168	948
1220	948
1280	960
1275	951.6

* CROSS SE CTION W. SECTION 72. COMMON UPSTREAM SECTION FOR SPLIT FLOW A

* CHANGE D ISCHARGES TO MATCH UPSTREAM STUDY AND MATCH ELEVATIONS FOR SOU

* CHANNEL

*

*

Section No rdsno= 50.0

Number of X-Sec Points= 44.0

105	964.1
138	961.7
179	960.4
214	958.4
332	964.8
410	965
437	968.8
464	966.4
488	969
516	967
588	953.1
600	951.5
603	950.9
605	951
615	951.2
620	950.8
625	950.5
627	950.8
628	951.8
629	952.3
638	951.8
648	952.1
738	951.9
748	952.5
774	952.5
781	951.9
788	951.1
812	951.1
828	951.3
856	951.7
881	953.9
900	958.4
980	968
1000	969
1080	968
1110	966
1130	964
1140	963
1158	963
1160	962
1170	964
1280	966
1310	969
1380	960

* CROSS SE CTION X SECTION 73. APPROACH TO RR BRIDGE. NOT ENCROACHED DUE
* OVERFLOW .
*

Section Nu mbers 51.0

Number of X-Sec Points 29.0

0	959.6		
180	958		
231	958		
[illegible]	956.3		
[illegible]	956.2		
313	955		
330	954.9		
346	954.1		
375	954	SS1(run/rise)=	4.6
376	952		
[illegible]	948.9		
390	948.6		
405	949.6	BW (ft)=	15.0
410	949.8		
415	949.9		
420	949.9		
425	950.8		
429	952		
431	952.2	SS2(run/rise)=	13.2
435	953.4		
487	953.3		
509	954.6		
525	956.4		
541	954.1		
[illegible]	954.3		
[illegible]	956.8		
605	959.6		
624	961.4		

*
* DS FACE OF RR BRIDGE
*

Section Nu mbers 52.0

Number of X-Sec Points 29.0

1250	954.5
1290	954.3
1320	954
1350	953.7
1350	952.9
1357	952
1361	950.7
1363	950.2
1366	949.6
1368	949.4
1373	948.8
1374	948.7
1376	948.6
1378	948.9
1380	948.7
1387	948.7
1389	948.6
1393	948
1399	949.5
1401	949.8
1409	950.7
1413	951.4
1414	951.5
1421	952.2
1422	953.3
1423	952.7
1425	953.7
1630	953.2

*
* 1 FOOT I NSIDE DS FACE OF RR BRIDGE. MOST OF THE FLOW IS PASSING OVER T
* TRACKS R ATHER THAN UNDER THE BRIDGE, AND MUCH OF THIS WATER IS NOT FLO
* PERPENDI CULAR TO THE SECTIONS ANYWAY, THE ENDPOINTS OF THESE CROSS SEC
* WERE CHO SEN TO APPROXIMATE THE TOPWIDTHS OF THE APPROACH AND EXIT SECT
*

BRIDGE Sec tion Numbers 53.0

BRIDGE Num ber of X-Sec Points 40.0

1290	954	954.3
1320	953.7	954
1350	953.7	954.7
1350	953.7	954.7
1357	953.7	954.7
1361	953.7	954.6
1361	950.7	954.6
1363	950.2	954.6
1363	953.7	954.6
1366	953.7	954.6
1368	953.7	954.6
1373	953.7	954.5
1374	953.7	954.5
1374	948.7	954.5
1376	948.6	954.5
1378	953.7	954.5
1378	953.7	954.5
1380	953.7	954.5
1387	953.7	954.5
1387	948.7	954.5
1389	949	954.4
1389	953.7	954.4
1393	953.7	954.4
1399	953.7	954.4
1399	949.5	954.4
1401	949.8	954.4
1401	953.7	954.4
1401	953.7	954.4

1408	963.7	964.3
1413	963.7	964.3
1413	961.4	964.3
1414	961.5	964.3
1414	962.7	964.3
1421	962.7	964.2
1421	962.2	964.2
1422	962.2	964.2
1422	963.7	964.2
1425	963.7	964.2
1425	962.7	964.2
1430	962.2	964.2

*
* 1 FOOT I   NSIDE US FACE OF RR BRIDGE.
*

Section Nu   mber= 54.0

Number of   X-Sec Points= 0

*
* US FACE   OF RR BRIDGE. REPEAT DS FACE.
*

Section Nu   mber= 55.0

Number of   X-Sec Points= 0

*
* CROSS SE   CTION Y, SECTION 74. APPROACH TO RR BRIDGE. BRIDGE GEOMETRY FO
* CHANNEL,   BARRIENTOS 2' CONTOUR TOPO FOR OVERBANKS
*

Section Nu   mber= 56.0

Number of   X-Sec Points= 21.0

0	980
33	968
65	966
130	964
151	964.7
158	964.7
180	964
230	962
300	963
340	962
350	961.2
352	960
354	949.6
359	948.9
365	949.6
370	962
380	964
400	966
425	968
450	980
500	986

*
* CROSS SE   CTION Z, SECTION 75. CROSS SECTION EXTENDED FROM TOPO MAP
*

Section Nu   mber= 57.0

Number of   X-Sec Points= 26.0

300	983
320	980
330	968
370	966
400	964.5
440	967.6
460	966.4
450	964.3
463	964
468	962.4
477	963.1
480	963.6
481	963.1
484	961.9
486	961.6
487	961.3
489	961.4
501	961.7
503	961.7
504	961.8
507	962.8
511	963.2
521	963.7
536	966.8
545	966.6
600	969.8

*
* CROSS SE   CTION AA. SECTION 76. CROSS SECTION EXTENDED FROM TOPO MAP
*

Section Nu   mber= 58.0

Number of   X-Sec Points= 18.0

310	988

400	[illegible]
450	[illegible]
500	[illegible]
570	[illegible]
580	[illegible].4
610	[illegible].4
630	[illegible].4
637	[illegible].4
640	[illegible].1
660	[illegible].2
675	[illegible].8
717	[illegible].1
750	964.1
757	[illegible].5
800	[illegible].1

*
* EXIT TO HWY 18/151 CULVERT. BARRIENTOS 2' CONTOUR TOPO FOR OVERBANKS,
* PLAN FOR CHANNEL. ENCROACHED FOR EXPANSION OF FLOW. RAISE CHANNEL N VA
* SLIGHTLY TO MATCH UPSTREAM STUDY AT SECTION 77.
*

Section Number= 59.0

Number of X-Sec Points= 13.0

0	[illegible]
70	[illegible]
100	[illegible]
110	[illegible]
145	[illegible]
150	[illegible].7
151	[illegible].2
170	[illegible].2
177	[illegible].7
180	[illegible]
200	[illegible]
230	[illegible]

*
* DS FACE OF HWY 18/151 CULVERT. REPEAT EXIT SECTION. RAISE CHANNEL N VA
* SLIGHTLY TO MATCH UPSTREAM STUDY AT SECTION 77
*

Section Number= 60.0

Number of X-Sec Points= 0

*
*
* US FACE OF HWY 18/151 CULVERT. REPEAT DS FACE.
*

Section Number= 61.0

Number of X-Sec Points= 0

*
* CROSS SE CTION AS SECTION 77, UPSTREAM LIMIT OF STUDY, APPROACH TO HWY
* CULVERT ENCROACHED BASED ON 1:1 CONTRACTION INTO CULVERT.
* MATCH RE CENT UPSTREAM ELEVATIONS
* 10-YEAR = 960.5, 50-YEAR = 963.4, 100-YEAR = 963.0, 500-YEAR = 963.5
*

Section Number= 62.0

Number of X-Sec Points= 19.0

1707	[illegible].2
1822	[illegible]
2049	[illegible].4
2248	[illegible]
2262	[illegible].8
2268	[illegible].3
2272	[illegible].8
2274	[illegible].9
2280	[illegible].2
2286	[illegible].8
2302	[illegible].7
2340	[illegible].4
2476	[illegible].6
2602	[illegible]
2921	[illegible].5
3180	[illegible].8
3332	[illegible].8
3457	[illegible].2
3568	973.8

*
* "ISLAND" SPLIT FLOW ANALYSIS USING TRIBUTARY FLOW OPTION. SOUTHERN SEC
* CROSS SE CTION V SECTION 59 - AT CONFLUENCE WITH UNNAMED TRIBUTARIES -
* DOWNSTRE AM SECTION FOR SPLIT FLOW ANALYSIS
*
*

Section Number= -41.0

Number of X-Sec Points= 70.0

76	[illegible].0
123	[illegible].8

172	[illegible]
231	962.5
316	960.7
389	951.1
416	951.1
424	950.7
436	949.5
444	949.8
479	949.9
522	951.9
588	951.9
607	952.7
724	951.5
795	950.5
860	950.5
914	951.9
960	950.5
1022	949.9
1090	949.3
1136	949.9
1179	949
1214	949
1232	948.3
1240	948.4
1244	948.5
1251	948.7
1259	948.8
1280	949
1300	948.8
1342	948.3
1382	949
1388	948.6
1408	948.8
1416	948.6
1423	948.8
1430	948.8
1438	948.4
1441	945.1
1446	944
1449	942.8
1450	941.3
1453	941.2
1454	940.2
1456	939.9
1460	939.9
1462	940.2
1465	941.3
1468	942.8
1473	944.5
1475	945.5
1481	948.1
1484	949.7
1488	950.1
1514	949.8
1582	949.9
1679	948.8
1780	948.8
1888	947.2
1900	948.4
1910	951.1
1919	952.5
1942	952.8
2040	952.8
2134	952.7
2200	955.3
2246	957.8
2271	960.6
2314	961

* SECTION 70 EXIT TO HWY P8 BRIDGE. USE TOPO MAP FOR OVERBANKS, BRIDG
* FOR CHAN NEL ENCROACHED FOR EXPANSION OF FLOW. CHANGE DISCHARGES FOR
* FLOW
*
*

Section Nu mbers 42.0

Number of X-Sec Points 15.0

1000	[illegible]
1488	952.6
1570	951.6
1575	951
1849	949.7
1850	949.7
1853	949.6
1856	949.3
1860	948.3
1866	949.7
1872	949.3
1873	949.3
1880	949.6
2100	960
2300	962

* DS FACE OF SOUTH HWY P8 BRIDGE. REPEAT EXIT SECTION
*

Section Nu mbers 43.0

Number of X-Sec Points 0

*
*
* US FACE OF SOUTH HWY P8 BRIDGE. REPEAT DS FACE
*

Section Nu mbers 44.0

Number of X-Sec Points 14

1435	852.6	[illegible]
1570	851.8	[illegible]
1475	851	864.6
1540	849.7	864.3
[illegible]	849.7	[illegible]
[illegible]	851.6	[illegible]
[illegible]	851.8	[illegible]
[illegible]	851.9	[illegible]
[illegible]	851.9	[illegible]
[illegible]	851.9	[illegible]
1572	851.9	[illegible]
1572	849.3	[illegible]
1573	849.3	864.3
1580	849.8	864.1

*
* APPROACH TO SOUTH HWY PS BRIDGE. REPEAT EXIT SECTION. ENCROACHED FOR
* CONTRACT ION OF FLOW.
*

Section Nu mber= 43.0

Number of X-Sec Points= 0

*
* EXIT TO CULVERT. OVERBANKS FROM TOPO, CHANNEL FROM CULVERT PLAN
* ENCROACH ED FOR EXPANSION OF FLOW
*

Section Nu mber= 46.0

Number of X-Sec Points= 6.0

1000	860.5
1050	849.5
[illegible]	846
1070	846
1080	849.5
1100	861.2

*
* DS FACE OF CULVERT, REPEAT EXIT SECTION
*

Section Nu mber= 47.0

Number of X-Sec Points= 0

*
*
* US FACE OF CULVERT, REPEAT EXIT SECTION
*

Section Nu mber= 48.0

Number of X-Sec Points= 0

*
* APPROACH TO CULVERT. REPEAT EXIT SECTION. ENCROACHED FOR CONTRACTION
*

Section Nu mber= 49.0

Number of X-Sec Points= 0

*
* MODIFIED SECTION 71, BARRIENTOS 2' CONTOUR TOPO FOR OVERBANKS AND
* INTERPOL ATED CHANNEL BOTTOM FROM UPSTREAM AND DOWNSTREAM SECTIONS *

Section Nu mber= 49.5

Number of X-Sec Points= 15.0

1000	[illegible]
1030	[illegible]
1070	[illegible]
1120	[illegible]
1240	[illegible]
1305	[illegible]
1387	[illegible]
1400	[illegible]
1410	[illegible]
1500	861.2
1540	860.6
1570	[illegible]
1580	[illegible]
1600	860.3
1900	[illegible]

* CROSS SE CTION W SECTION 72 COMMON UPSTREAM SECTION FOR SPLIT FLOW AN
* MATCH DI SCHARGES FOR UPSTREAM STUDY, AND MATCH ELEVATIONS OF THE NORTH
* CHANNEL

[illegible]

[illegible]

[illegible]	[illegible]
[illegible]	861.7
170	[illegible]
214	[illegible]
[illegible]	[illegible]
410	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	862.1
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	861
615	861.3
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	862.1
[illegible]	[illegible]
740	[illegible]
[illegible]	[illegible]
761	[illegible]
[illegible]	[illegible]
812	[illegible]
[illegible]	[illegible]
[illegible]	861.7
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
1000	[illegible]
[illegible]	[illegible]
1110	[illegible]
[illegible]	[illegible]
1140	[illegible]
[illegible]	[illegible]
1160	[illegible]
1170	[illegible]
[illegible]	[illegible]
1310	[illegible]
[illegible]	[illegible]

Attachment B

Cold Weather Badger Mill Creek Simulations Using EPA QUAL2E Instream WQ Model

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                    * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                              Ver. 3.13 - September 1991

 $$$ (PROBLEM TITLES) $$$

CARD TYPE                          QUAL-2E PROGRAM TITLES
TITLE01              BWCIU.IN - Winter, Critical, INTERIM FLOW, BODU Simulation
TITLE02              NSWTP DISCHARGE TO BADGER MILL CREEK
TITLE03   NO         CONSERVATIVE MINERAL I         IN
TITLE04   NO         CONSERVATIVE MINERAL II        IN
TITLE05   NO         CONSERVATIVE MINERAL III       IN
TITLE06  YES         TEMPERATURE
TITLE07  YES         BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)
TITLE08  YES         ALGAE AS CHL-A IN UG/L
TITLE09  YES         PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                (ORGANIC-P, DISSOLVED-P)
TITLE11  YES         NITROGEN CYCLE AS N IN MG/L
TITLE12                (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
TITLE13  YES         DISSOLVED OXYGEN IN MG/L
TITLE14   NO         FECAL COLIFORMS IN NO./100 ML
TITLE15  YES         ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l
ENDTITLE

 $$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                  CARD TYPE
LIST DATA INPUT              0.00000                                      0.00000
WRITE OPTIONAL SUMMARY       0.00000                                      0.00000
NO FLOW AUGMENTATION         0.00000                                      0.00000
STEADY STATE                 0.00000                                      0.00000
TRAPEZOIDAL X-SECTIONS       0.00000                                      0.00000
PRINT LCD/SOLAR DATA         0.00000                                      0.00000
PLOT DO AND BOD              0.00000                                      0.00000
FIXED DNSTM COND (YES=1)=    0.00000       5D-ULT BOD CONV K COEF   =     0.23000
INPUT METRIC (YES=1)    =    0.00000       OUTPUT METRIC (YES=1)    =     0.00000
NUMBER OF REACHES       =    7.00000       NUMBER OF JUNCTIONS      =     1.00000
NUM OF HEADWATERS       =    2.00000       NUMBER OF POINT LOADS    =     0.00000
TIME STEP (HOURS)       =    1.00000       LNTH  COMP  ELEMENT (DX)=      0.10000
MAXIMUM ROUTE TIME (HRS)=  288.00000       TIME INC. FOR RPT2 (HRS)=      1.00000
LATITUDE OF BASIN (DEG) =   43.10000       LONGITUDE OF BASIN (DEG)=     89.30000
STANDARD MERIDIAN (DEG) =   75.00000       DAY OF YEAR START TIME  =     15.00000
EVAP. COEFF. (AE)       =    0.00068       EVAP. COEFF. (BE)       =      0.00027
ELEV. OF BASIN (ELEV)   =  937.00000       DUST ATTENUATION COEF.  =      0.06000
ENDATA1                      0.00000                                      0.00000

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                       .  CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.5000         O UPTAKE BY NO2 OXID(MG O/MG N)=      1.2000
O PROD  BY ALGAE (MG O/MG A)   =    1.6000         O UPTAKE BY ALGAE (MG O/MG A)  =      2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0850         P CONTENT OF ALGAE (MG P/MG A) =      0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000         ALGAE RESPIRATION RATE (1/DAY) =      0.1000
N HALF SATURATION CONST  (MG/L)=    0.3000         P HALF SATURATION CONST  (MG/L)=      0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0088         NLIN SHADE(1/FT-(UGCHA/L)**2/3)=      0.0540
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000         LIGHT SAT'N COEF (BTU/FT2-MIN) =      0.0300
DAILY AVERAGING OPTION (LAVOPT)=    2.0000         LIGHT AVERAGING FACTOR (AFACT) =      0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =   10.0000         TOTAL DAILY SOLR RAD (BTU/FT-2)=    400.0000
ALGY GROWTH CALC OPTION(LGROPT)=    1.0000         ALGAL PREF FOR NH3-N (PREFN)   =      0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500         NITRIFICATION INHIBITION COEF  =      0.6000
ENDATA1A                            0.0000                                               0.0000

 $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE     RATE CODE     THETA VALUE

THETA( 1)     BOD DECA        1.047     DFLT
THETA( 2)     BOD SETT        1.024     DFLT
THETA( 3)     OXY TRAN        1.024     DFLT
THETA( 4)     SOD RATE        1.060     DFLT
THETA( 5)     ORGN DEC        1.047     DFLT
THETA( 6)     ORGN SET        1.024     DFLT
THETA( 7)     NH3 DECA        1.083     DFLT
THETA( 8)     NH3 SRCE        1.074     DFLT
THETA( 9)     NO2 DECA        1.047     DFLT
THETA(10)     PORG DEC        1.047     DFLT
THETA(11)     PORG SET        1.024     DFLT
THETA(12)     DISP SRC        1.074     DFLT
THETA(13)     ALG GROW        1.047     DFLT
THETA(14)     ALG RESP        1.047     DFLT
THETA(15)     ALG SETT        1.024     DFLT
THETA(16)     COLI DEC        1.047     DFLT
THETA(17)     ANC DECA        1.000     DFLT
THETA(18)     ANC SETT        1.024     DFLT
THETA(19)     ANC SRCE        1.000     DFLT
ENDATA1B

 $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE            REACH ORDER AND IDENT                     R. MI/KM              R. MI/KM
STREAM REACH     1.0  RCH= HWY 151-PB         FROM       10.0     TO           9.4
STREAM REACH     2.0  RCH= PB-Lincoln         FROM        9.4     TO           8.4
STREAM REACH     3.0  RCH= Lincoln-151 By     FROM        8.4     TO           7.0
STREAM REACH     4.0  RCH= 151 By-HWY 69      FROM        7.0     TO           6.1
STREAM REACH     5.0  RCH= HWY 69-Sugar R     FROM        6.1     TO           5.4
STREAM REACH     6.0  PCH= Upstrm Sugar R     FROM        5.6     TO           5.4
STREAM REACH     7.0  RCH= Dnstrm Sugar R     FROM        5.4     TO           3.4
ENDATA2          0.0                        .             0.0                  0.0

 $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE                        REACH  AVAIL HDWS TARGET    ORDER OF AVAIL SOURCES
ENDATA3                           0.         0.       0.0  0.   0.   0.   0.   0.   0.

 $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE        REACH ELEMENTS/REACH             COMPUTATIONAL FLAGS
FLAG FIELD        1.        6.          1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        2.       10.          2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        3.       14.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
```

FLAG FIELD	4.	9.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CMANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	2.	945.00	0.13	0.10	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	3.	935.00	0.13	0.20	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	4.	925.00	0.13	0.05	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	5.	915.00	0.13	0.00	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	6.	910.00	0.13	0.05	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	7.	910.00	0.13	0.05	40.00	40.00	29.10	15.40	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	40.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	2.	40.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	3.	40.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	4.	40.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	5.	40.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	6.	40.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	7.	40.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	5.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

INCR INFLOW-2	1.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	2.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	3.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	4.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	5.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC=Sugar R Confluen	46.	49.	48.
ENDATA9	0.		0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	NSWTPOutfall	3.40	50.00	5.00	32.10	0.00	0.00	0.00
HEADWTR-1	2.	Sugar River	7.80	40.00	7.00	4.00	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	12.30	0.00	0.00	0.50	1.97	0.00	1.00	0.00	0.89
HEADWTR-2	2.	10.00	0.00	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
ENDATA11A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

	DAM	RCH	ELE	ADAM	BDAM	FDAM	HDAM
ENDATA12	0.	0.	0.	0.00	0.00	0.00	0.00

$$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

CARD TYPE	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI

ENDATA13 DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P

ENDATA13A DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
1	52
2	0

TEMPERATURE — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	49.03	48.13	47.28	46.49	45.75	45.05														
2	44.44	43.89	43.37	42.88	42.42	41.99	41.58	41.19	40.83	40.49										
3	40.24	40.08	39.92	39.77	39.62	39.47	39.33	39.20	39.06	38.94	38.81	38.69	38.58	38.46						
4	38.30	38.04	37.80	37.58	37.37	37.18	37.01	36.84	36.69											
5	36.57	36.48	36.39	36.30	36.22	36.14	36.07													
6	39.74	39.49																		
7	38.34	38.22	38.10	37.98	37.87	37.76	37.65	37.55	37.45	37.36	37.27	37.18	37.10	37.02	36.94	36.86	36.79	36.72	36.65	36.59

TEMPERATURE — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	49.01	48.09	47.23	46.44	45.70	45.01														
2	44.40	43.85	43.33	42.85	42.39	41.96	41.55	41.16	40.80	40.46										
3	40.22	40.06	39.90	39.74	39.59	39.45	39.31	39.17	39.04	38.91	38.78	38.66	38.54	38.43						
4	38.27	38.00	37.75	37.52	37.31	37.11	36.92	36.75	36.59											
5	36.46	36.36	36.26	36.17	36.08	36.00	35.92													
6	39.74	39.49																		
7	38.30	38.17	38.04	37.92	37.81	37.70	37.59	37.48	37.38	37.28	37.19	37.10	37.01	36.93	36.84	36.77	36.69	36.61	36.54	36.47

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 9.2

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	0.00	9	0.00	17	0.00
2	0.00	10	0.00	18	0.00
3	0.00	11	0.00	19	0.00
4	0.00	12	0.00	20	0.00
5	0.00	13	0.00	21	0.00
6	0.00	14	0.00	22	0.00
7	0.00	15	0.00	23	0.00
8	0.00	16	0.00	24	0.00

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	31.95	31.80	31.65	31.51	31.37	31.24														
2	31.07	30.88	30.69	30.51	30.32	30.15	29.97	29.80	29.63	29.46										
3	29.32	29.22	29.12	29.02	28.93	28.83	28.73	28.63	28.54	28.44	28.35	28.25	28.16	28.07						
4	27.98	27.89	27.80	27.71	27.62	27.53	27.44	27.36	27.27											
5	27.19	27.11	27.03	26.95	26.87	26.79	26.70													
6	3.98	3.97																		
7	10.85	10.82	10.78	10.75	10.71	10.68	10.64	10.61	10.57	10.54	10.51	10.47	10.44	10.41	10.37	10.34	10.31	10.28	10.24	10.21

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	12.28	12.26	12.24	12.23	12.21	12.19														
2	12.17	12.14	12.12	12.09	12.07	12.04	12.02	12.00	11.97	11.95										
3	11.93	11.91	11.90	11.89	11.87	11.86	11.84	11.83	11.81	11.80	11.79	11.77	11.76	11.74						
4	11.73	11.72	11.70	11.69	11.67	11.66	11.65	11.63	11.62											
5	11.61	11.59	11.58	11.57	11.56	11.54	11.53													
6	9.99	9.97																		

7	10.44	10.43	10.41	10.40	10.39	10.38	10.36	10.35	10.34	10.33	10.32	10.30	10.29	10.28	10.27	10.26	10.24	10.23	10.22	10.21

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	2.70	2.70																		
7	1.88	1.89	1.89	1.89	1.89	1.89	1.90	1.90	1.90	1.90	1.90	1.90	1.91	1.91	1.91	1.91	1.91	1.91	1.92	1.92

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.89	0.89	0.89	0.89	0.89	0.89														
2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89										
3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89						
4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89											
5	0.89	0.89	0.89	0.89	0.89	0.89	0.89													
6	0.13	0.13																		
7	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.49	0.49														
2	0.49	0.49	0.49	0.49	0.49	0.49	0.48	0.48	0.48	0.48										
3	0.48	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47						
4	0.47	0.47	0.47	0.47	0.46	0.46	0.46	0.46	0:46											
5	0.46	0.46	0.46	0.46	0.46	0.46	0.46													
6	0.62	0.62																		
7	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.55	0.55	0.55	0.55	0.55

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.96	1.96	1.95	1.94	1.94	1.93														
2	1.92	1.91	1.91	1.90	1.89	1.88	1.88	1.87	1.86	1.85										
3	1.85	1.85	1.84	1.84	1.83	1.83	1.83	1.82	1.82	1.81	1.81	1.81	1.80	1.80						
4	1.79	1.79	1.79	1.78	1.78	1.78	1.77	1.77	1.77											
5	1.76	1.76	1.76	1.75	1.75	1.75	1.74													
6	0.12	0.12																		
7	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.01	0.02	0.02	0.03	0.04	0.04														
2	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.11	0.12										
3	0.13	0.13	0.13	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.17	0.18						
4	0.18	0.18	0.19	0.19	0.19	0.20	0.20	0.20	0.20											
5	0.21	0.21	0.21	0.22	0.22	0.22	0.22													
6	0.00	0.00																		
7	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	1.00	1.00	1.00	1.00	1.00														
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01										
3	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.02	1.02						
4	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02											
5	1.02	1.02	1.03	1.03	1.03	1.03	1.03													
6	2.30	2.30																		
7	1.91	1.91	1.91	1.91	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.38	5.73	6.06	6.38	6.67	6.95														
2	7.09	7.02	6.95	6.89	6.84	6.80	6.76	6.72	6.70	6.67										
3	6.70	6.74	6.79	6.84	6.89	6.94	6.99	7.04	7.08	7.13	7.18	7.23	7.27	7.32						
4	7.55	7.93	8.29	8.61	8.92	9.19	9.45	9.69	9.91											
5	10.05	10.14	10.23	10.31	10.38	10.46	10.53													
6	7.13	7.26																		
7	8.34	8.42	8.49	8.57	8.64	8.72	8.79	8.86	8.93	9.00	9.07	9.13	9.20	9.26	9.32	9.39	9.45	9.51	9.56	9.62

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	66
ALGAE GROWTH RATE	2	66
ALGAE GROWTH RATE	3	66
ALGAE GROWTH RATE	4	66
ALGAE GROWTH RATE	5	66
ALGAE GROWTH RATE	6	0
NITRIFICATION INHIBITION	1	0
ALGAE GROWTH RATE	7	0
NITRIFICATION INHIBITION	2	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:

1. LIGHT AVERAGING OPTION. LAVOPT= 2

METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

SOURCE OF SOLAR VALUES: DATA TYPE 1A
DAILY NET SOLAR RADIATION: 400.000 BTU/FT-2 (108.548 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 9.2
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): N/A
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS. LGROPT= 1

MULTIPLICATIVE: FL*FN*FP

TEMPERATURE — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	49.01	48.09	47.23	46.44	45.70	45.01														
2	44.40	43.85	43.33	42.85	42.39	41.96	41.55	41.16	40.80	40.46										
3	40.22	40.06	39.90	39.74	39.59	39.45	39.31	39.17	39.04	38.91	38.78	38.66	38.54	38.43						
4	38.27	38.00	37.75	37.52	37.31	37.11	36.92	36.75	36.59											
5	36.46	36.36	36.26	36.17	36.08	36.00	35.92													
6	39.74	39.49																		
7	38.30	38.17	38.04	37.92	37.81	37.70	37.59	37.48	37.38	37.28	37.19	37.10	37.01	36.93	36.84	36.77	36.69	36.61	36.54	36.47

DISSOLVED OXYGEN IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.38	5.73	6.06	6.38	6.67	6.95														
2	7.09	7.02	6.95	6.89	6.84	6.80	6.76	6.73	6.70	6.67										
3	6.70	6.75	6.79	6.84	6.89	6.94	6.99	7.04	7.08	7.13	7.18	7.23	7.27	7.32						
4	7.55	7.94	8.29	8.61	8.92	9.19	9.45	9.69	9.91											
5	10.05	10.14	10.22	10.31	10.38	10.46	10.53													
6	7.13	7.26																		
7	8.34	8.42	8.49	8.57	8.64	8.72	8.79	8.86	8.93	9.00	9.07	9.13	9.20	9.26	9.32	9.38	9.45	9.50	9.56	9.62

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	31.95	31.80	31.65	31.51	31.37	31.24														
2	31.07	30.88	30.69	30.51	30.32	30.15	29.97	29.80	29.63	29.46										
3	29.32	29.22	29.12	29.02	28.93	28.83	28.73	28.63	28.54	28.44	28.35	28.25	28.16	28.07						
4	27.98	27.89	27.80	27.71	27.62	27.53	27.44	27.36	27.27											
5	27.19	27.11	27.03	26.95	26.87	26.79	26.70													
6	3.98	3.97																		
7	10.85	10.82	10.78	10.75	10.71	10.68	10.64	10.61	10.57	10.54	10.51	10.47	10.44	10.41	10.37	10.34	10.31	10.28	10.24	10.21

ORGANIC NITROGEN AS N IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.49	0.49														
2	0.49	0.49	0.49	0.49	0.49	0.49	0.48	0.48	0.48	0.48										
3	0.48	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47						
4	0.47	0.47	0.47	0.47	0.46	0.46	0.46	0.46	0.46											
5	0.46	0.46	0.46	0.46	0.46	0.46	0.46													
6	0.62	0.62																		
7	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.55	0.55	0.55	0.55	0.55

AMMONIA AS N IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.96	1.96	1.95	1.94	1.94	1.93														
2	1.92	1.91	1.91	1.90	1.89	1.88	1.88	1.87	1.86	1.86										
3	1.85	1.85	1.84	1.84	1.83	1.83	1.83	1.82	1.82	1.81	1.81	1.81	1.80	1.80						
4	1.80	1.79	1.79	1.78	1.78	1.78	1.77	1.77	1.77											
5	1.76	1.76	1.76	1.75	1.75	1.75	1.74													
6	0.12	0.12																		
7	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60

NITRITE AS N IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.01	0.02	0.02	0.03	0.04	0.04														
2	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.11	0.12										
3	0.13	0.13	0.13	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.18						
4	0.18	0.18	0.19	0.19	0.19	0.20	0.20	0.20	0.20											
5	0.21	0.21	0.21	0.22	0.22	0.22	0.22													
6	0.00	0.00																		
7	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09

NITRATE AS N IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	1.00	1.00	1.00	1.00	1.00														
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01										
3	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.02	1.02						
4	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02											
5	1.02	1.02	1.03	1.03	1.03	1.03	1.03													
6	2.30	2.30																		
7	1.91	1.91	1.91	1.91	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.89	0.89	0.89	0.89	0.89	0.89														
2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89										
3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89						
4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89											
5	0.89	0.89	0.89	0.89	0.89	0.89	0.89													
6	0.13	0.13																		
7	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36

ALGAE AS CHL-A IN UG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	2.70	2.70																		
7	1.88	1.89	1.89	1.89	1.90	1.90	1.90	1.90	1.91	1.91	1.91	1.91	1.92	1.92	1.92	1.92	1.93	1.93	1.93	1.94

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	12.28	12.26	12.24	12.23	12.21	12.19														
2	12.17	12.14	12.12	12.09	12.07	12.04	12.02	12.00	11.97	11.95										
3	11.93	11.91	11.90	11.89	11.87	11.86	11.84	11.83	11.81	11.80	11.79	11.77	11.76	11.74						
4	11.73	11.72	11.70	11.69	11.67	11.66	11.65	11.63	11.62											
5	11.61	11.59	11.58	11.57	11.56	11.54	11.53													
6	9.99	9.97																		
7	10.44	10.43	10.41	10.40	10.39	10.38	10.36	10.35	10.34	10.33	10.32	10.30	10.29	10.28	10.27	10.26	10.24	10.23	10.22	10.21

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.49	0.48	0.47	0.46	0.45	0.44														
2	0.44	0.43	0.42	0.42	0.41	0.41	0.40	0.40	0.40	0.39										
3	0.39	0.39	0.39	0.39	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.37	0.37	0.37						
4	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36	0.36											
5	0.35	0.35	0.35	0.35	0.35	0.35	0.35													
6	0.30	0.30																		
7	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.37	6.37	6.37	6.37	6.37	6.37														
2	6.37	6.37	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.35										
3	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.34	6.34	6.34						
4	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34											
5	6.34	6.34	6.34	6.34	6.34	6.34	6.33													
6	4.99	4.99																		
7	5.90	5.90	5.90	5.90	5.90	5.90	5.90	5.90	5.90	5.90	5.90	5.89	5.89	5.89	5.89	5.89	5.89	5.89	5.89	5.89

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
2	1	2	9.90	9.80	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
3	1	3	9.80	9.70	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
4	1	4	9.70	9.60	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
5	1	5	9.60	9.50	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
6	1	6	9.50	9.40	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
7	2	1	9.40	9.30	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
8	2	2	9.30	9.20	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
9	2	3	9.20	9.10	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
10	2	4	9.10	9.00	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
11	2	5	9.00	8.90	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
12	2	6	8.90	8.80	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
13	2	7	8.80	8.70	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
14	2	8	8.70	8.60	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
15	2	9	8.60	8.50	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
16	2	10	8.50	8.40	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
17	3	1	8.40	8.30	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
18	3	2	8.30	8.20	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
19	3	3	8.20	8.10	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
20	3	4	8.10	8.00	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
21	3	5	8.00	7.90	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
22	3	6	7.90	7.80	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
23	3	7	7.80	7.70	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
24	3	8	7.70	7.60	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
25	3	9	7.60	7.50	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
26	3	10	7.50	7.40	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
27	3	11	7.40	7.30	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
28	3	12	7.30	7.20	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
29	3	13	7.20	7.10	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
30	3	14	7.10	7.00	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
31	4	1	7.00	6.90	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
32	4	2	6.90	6.80	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
33	4	3	6.80	6.70	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
34	4	4	6.70	6.60	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
35	4	5	6.60	6.50	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
36	4	6	6.50	6.40	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
37	4	7	6.40	6.30	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
38	4	8	6.30	6.20	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
39	4	9	6.20	6.10	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
40	5	1	6.10	6.00	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
41	5	2	6.00	5.90	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
42	5	3	5.90	5.80	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
43	5	4	5.80	5.70	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
44	5	5	5.70	5.60	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
45	5	6	5.60	5.50	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
46	5	7	5.50	5.40	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
47	6	1	5.60	5.50	7.80	0.00	0.00	0.603	0.010	0.404	32.005	6.82	17.32	12.92	0.23
48	6	2	5.50	5.40	7.80	0.00	0.00	0.603	0.010	0.404	32.005	6.82	17.32	12.92	0.23
49	7	1	5.40	5.30	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
50	7	2	5.30	5.20	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
51	7	3	5.20	5.10	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
52	7	4	5.10	5.00	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
53	7	5	5.00	4.90	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
54	7	6	4.90	4.80	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
55	7	7	4.80	4.70	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
56	7	8	4.70	4.60	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
57	7	9	4.60	4.50	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
58	7	10	4.50	4.40	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
59	7	11	4.40	4.30	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
60	7	12	4.30	4.20	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
61	7	13	4.20	4.10	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
62	7	14	4.10	4.00	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
63	7	15	4.00	3.90	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
64	7	16	3.90	3.80	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
65	7	17	3.80	3.70	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
66	7	18	3.70	3.60	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
67	7	19	3.60	3.50	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
68	7	20	3.50	3.40	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	11.13	8	9.92	0.49	0.00	0.00	0.15	0.08	0.41	0.00	0.59	0.12	0.08	0.00	0.00	0.00	0.16	0.00
1	2	11.26	8	9.80	0.48	0.00	0.00	0.15	0.08	0.40	0.00	0.58	0.12	0.08	0.00	0.00	0.00	0.15	0.00
1	3	11.39	8	9.69	0.47	0.00	0.00	0.15	0.08	0.39	0.00	0.57	0.12	0.08	0.00	0.00	0.00	0.15	0.00
1	4	11.52	8	9.59	0.46	0.00	0.00	0.14	0.08	0.38	0.00	0.56	0.12	0.08	0.00	0.00	0.00	0.15	0.00
1	5	11.63	8	9.50	0.45	0.00	0.00	0.14	0.07	0.37	0.00	0.56	0.11	0.07	0.00	0.00	0.00	0.15	0.00
1	6	11.75	8	9.41	0.44	0.00	0.00	0.14	0.07	0.36	0.00	0.55	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	1	11.84	8	5.75	0.44	0.00	0.00	0.14	0.07	0.35	0.00	0.54	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	2	11.93	8	2.14	0.43	0.00	0.00	0.13	0.07	0.34	0.00	0.53	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	3	12.02	8	2.12	0.43	0.00	0.00	0.13	0.07	0.33	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
2	4	12.10	8	2.11	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
2	5	12.18	8	2.10	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	6	12.26	8	2.09	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	7	12.33	8	2.07	0.41	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	8	12.40	8	2.06	0.40	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	9	12.46	8	2.05	0.40	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	10	12.52	8	2.05	0.40	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	1	12.57	8	2.64	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	2	12.60	8	3.23	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	3	12.63	8	3.23	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	4	12.65	8	3.22	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	5	12.68	8	3.21	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	6	12.71	8	3.21	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	7	12.73	8	3.20	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	8	12.76	8	3.19	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	9	12.79	8	3.19	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	10	12.81	8	3.18	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	11	12.83	8	3.18	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
3	12	12.86	8	3.17	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
3	13	12.88	8	3.17	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
3	14	12.90	8	3.16	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.14	0.00
4	1	12.93	8	7.13	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.14	0.00
4	2	12.98	8	11.06	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	3	13.03	8	11.03	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	4	13.07	8	10.99	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	5	13.12	8	10.96	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	6	13.16	8	10.93	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	7	13.19	8	10.91	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	8	13.23	8	10.88	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	9	13.26	8	10.86	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	1	13.28	8	8.87	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	2	13.30	8	6.89	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	3	13.32	8	6.89	0.36	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	4	13.34	8	6.88	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	5	13.36	8	6.87	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	6	13.38	8	6.86	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	7	13.39	8	6.85	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
6	1	12.66	8	2.67	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
6	2	12.70	8	2.67	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	1	12.93	8	3.93	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	2	12.95	8	3.00	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	3	12.97	8	2.99	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	4	13.00	8	2.99	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	5	13.02	8	2.98	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	6	13.04	8	2.98	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	7	13.06	8	2.97	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	8	13.08	8	2.97	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	9	13.10	8	2.97	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	10	13.12	8	2.96	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	11	13.14	8	2.96	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	12	13.16	8	2.96	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	13	13.17	8	2.95	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	14	13.19	8	2.95	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	15	13.21	8	2.95	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	16	13.22	8	2.94	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	17	13.24	8	2.94	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	18	13.25	8	2.94	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	19	13.27	8	2.93	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	20	13.28	8	2.93	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota apen	CHLA UG/L
1	1	49.01	0.00	0.00	0.00	5.38	31.95	0.50	1.96	0.01	1.00	3.47	0.00	0.89	0.89	0.00	12.28	0.00
1	2	48.09	0.00	0.00	0.00	5.73	31.80	0.50	1.96	0.02	1.00	3.47	0.00	0.89	0.89	0.00	12.26	0.00
1	3	47.23	0.00	0.00	0.00	6.06	31.65	0.50	1.95	0.02	1.00	3.47	0.00	0.89	0.89	0.00	12.24	0.00
1	4	46.44	0.00	0.00	0.00	6.38	31.51	0.50	1.94	0.03	1.00	3.47	0.00	0.89	0.89	0.00	12.23	0.00
1	5	45.70	0.00	0.00	0.00	6.67	31.37	0.49	1.94	0.04	1.00	3.47	0.00	0.89	0.89	0.00	12.21	0.00
1	6	45.01	0.00	0.00	0.00	6.95	31.24	0.49	1.93	0.04	1.00	3.47	0.00	0.89	0.89	0.00	12.19	0.00
2	1	44.40	0.00	0.00	0.00	7.09	31.07	0.49	1.92	0.05	1.00	3.47	0.00	0.89	0.89	0.00	12.17	0.00
2	2	43.85	0.00	0.00	0.00	7.02	30.88	0.49	1.91	0.06	1.00	3.47	0.00	0.89	0.89	0.00	12.14	0.00
2	3	43.33	0.00	0.00	0.00	6.95	30.69	0.49	1.91	0.07	1.00	3.47	0.00	0.89	0.89	0.00	12.12	0.00
2	4	42.85	0.00	0.00	0.00	6.89	30.51	0.49	1.90	0.08	1.00	3.47	0.00	0.89	0.89	0.00	12.09	0.00
2	5	42.39	0.00	0.00	0.00	6.84	30.32	0.49	1.89	0.08	1.00	3.47	0.00	0.89	0.89	0.00	12.07	0.00
2	6	41.96	0.00	0.00	0.00	6.80	30.15	0.49	1.88	0.09	1.00	3.46	0.00	0.89	0.89	0.00	12.04	0.00
2	7	41.55	0.00	0.00	0.00	6.76	29.97	0.48	1.88	0.10	1.00	3.46	0.00	0.89	0.89	0.00	12.02	0.00
2	8	41.16	0.00	0.00	0.00	6.73	29.80	0.48	1.87	0.11	1.01	3.46	0.00	0.89	0.89	0.00	12.00	0.00
2	9	40.80	0.00	0.00	0.00	6.70	29.63	0.48	1.86	0.11	1.01	3.46	0.00	0.89	0.89	0.00	11.97	0.00
2	10	40.46	0.00	0.00	0.00	6.67	29.46	0.48	1.86	0.12	1.01	3.46	0.00	0.89	0.89	0.00	11.95	0.00
3	1	40.22	0.00	0.00	0.00	6.70	29.32	0.48	1.85	0.13	1.01	3.46	0.00	0.89	0.89	0.00	11.93	0.00
3	2	40.06	0.00	0.00	0.00	6.75	29.22	0.48	1.85	0.13	1.01	3.46	0.00	0.89	0.89	0.00	11.91	0.00
3	3	39.90	0.00	0.00	0.00	6.79	29.12	0.48	1.84	0.13	1.01	3.46	0.00	0.89	0.89	0.00	11.90	0.00
3	4	39.74	0.00	0.00	0.00	6.84	29.02	0.48	1.84	0.14	1.01	3.46	0.00	0.89	0.89	0.00	11.89	0.00
3	5	39.59	0.00	0.00	0.00	6.89	28.93	0.48	1.83	0.14	1.01	3.46	0.00	0.89	0.89	0.00	11.87	0.00
3	6	39.45	0.00	0.00	0.00	6.94	28.83	0.47	1.83	0.15	1.01	3.46	0.00	0.89	0.89	0.00	11.86	0.00
3	7	39.31	0.00	0.00	0.00	6.99	28.73	0.47	1.83	0.15	1.01	3.46	0.00	0.89	0.89	0.00	11.84	0.00
3	8	39.17	0.00	0.00	0.00	7.04	28.63	0.47	1.82	0.15	1.01	3.46	0.00	0.89	0.89	0.00	11.83	0.00
3	9	39.04	0.00	0.00	0.00	7.08	28.54	0.47	1.82	0.16	1.01	3.46	0.00	0.89	0.89	0.00	11.81	0.00
3	10	38.91	0.00	0.00	0.00	7.13	28.44	0.47	1.81	0.16	1.01	3.46	0.00	0.89	0.89	0.00	11.80	0.00
3	11	38.78	0.00	0.00	0.00	7.18	28.35	0.47	1.81	0.16	1.01	3.46	0.00	0.89	0.89	0.00	11.79	0.00
3	12	38.66	0.00	0.00	0.00	7.23	28.25	0.47	1.81	0.17	1.01	3.46	0.00	0.89	0.89	0.00	11.77	0.00
3	13	38.54	0.00	0.00	0.00	7.27	28.16	0.47	1.80	0.17	1.02	3.46	0.00	0.89	0.89	0.00	11.76	0.00
3	14	38.43	0.00	0.00	0.00	7.32	28.07	0.47	1.80	0.18	1.02	3.46	0.00	0.89	0.89	0.00	11.74	0.00
4	1	38.27	0.00	0.00	0.00	7.55	27.98	0.47	1.80	0.18	1.02	3.46	0.00	0.89	0.89	0.00	11.73	0.00
4	2	38.00	0.00	0.00	0.00	7.94	27.89	0.47	1.79	0.18	1.02	3.46	0.00	0.89	0.89	0.00	11.72	0.00
4	3	37.75	0.00	0.00	0.00	8.29	27.80	0.47	1.79	0.19	1.02	3.46	0.00	0.89	0.89	0.00	11.70	0.00
4	4	37.52	0.00	0.00	0.00	8.61	27.71	0.47	1.78	0.19	1.02	3.46	0.00	0.89	0.89	0.00	11.69	0.00
4	5	37.31	0.00	0.00	0.00	8.92	27.62	0.46	1.78	0.19	1.02	3.46	0.00	0.89	0.89	0.00	11.67	0.00
4	6	37.11	0.00	0.00	0.00	9.19	27.53	0.46	1.78	0.20	1.02	3.46	0.00	0.89	0.89	0.00	11.66	0.00
4	7	36.92	0.00	0.00	0.00	9.45	27.44	0.46	1.77	0.20	1.02	3.46	0.00	0.89	0.89	0.00	11.65	0.00
4	8	36.75	0.00	0.00	0.00	9.69	27.36	0.46	1.77	0.20	1.02	3.46	0.00	0.89	0.89	0.00	11.63	0.00
4	9	36.59	0.00	0.00	0.00	9.91	27.27	0.46	1.77	0.20	1.02	3.46	0.00	0.89	0.89	0.00	11.62	0.00
5	1	36.46	0.00	0.00	0.00	10.05	27.19	0.46	1.76	0.21	1.02	3.46	0.00	0.89	0.89	0.00	11.61	0.00
5	2	36.36	0.00	0.00	0.00	10.14	27.11	0.46	1.76	0.21	1.02	3.46	0.00	0.89	0.89	0.00	11.59	0.00
5	3	36.26	0.00	0.00	0.00	10.22	27.03	0.46	1.76	0.21	1.03	3.46	0.00	0.89	0.89	0.00	11.58	0.00
5	4	36.17	0.00	0.00	0.00	10.31	26.95	0.46	1.75	0.22	1.03	3.46	0.00	0.89	0.89	0.00	11.57	0.00
5	5	36.08	0.00	0.00	0.00	10.38	26.87	0.46	1.75	0.22	1.03	3.46	0.00	0.89	0.89	0.00	11.56	0.00
5	6	36.00	0.00	0.00	0.00	10.46	26.79	0.46	1.75	0.22	1.03	3.45	0.00	0.89	0.89	0.00	11.54	0.00
5	7	35.92	0.00	0.00	0.00	10.53	26.70	0.46	1.74	0.22	1.03	3.45	0.00	0.89	0.89	0.00	11.53	0.00
6	1	39.74	0.00	0.00	0.00	7.13	3.98	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	9.99	2.70
6	2	39.49	0.00	0.00	0.00	7.26	3.97	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	9.97	2.70
7	1	38.30	0.00	0.00	0.00	8.34	10.85	0.57	0.61	0.07	1.91	3.17	0.00	0.36	0.36	0.00	10.44	1.88
7	2	38.17	0.00	0.00	0.00	8.42	10.82	0.57	0.61	0.07	1.91	3.16	0.00	0.36	0.36	0.00	10.43	1.89
7	3	38.04	0.00	0.00	0.00	8.49	10.78	0.57	0.61	0.07	1.91	3.16	0.00	0.36	0.36	0.00	10.41	1.89
7	4	37.92	0.00	0.00	0.00	8.57	10.75	0.57	0.61	0.07	1.91	3.16	0.00	0.36	0.36	0.00	10.40	1.89
7	5	37.81	0.00	0.00	0.00	8.64	10.71	0.56	0.61	0.07	1.92	3.16	0.00	0.36	0.36	0.00	10.39	1.90
7	6	37.70	0.00	0.00	0.00	8.72	10.68	0.56	0.61	0.07	1.92	3.16	0.00	0.36	0.36	0.00	10.38	1.90
7	7	37.59	0.00	0.00	0.00	8.79	10.64	0.56	0.61	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.36	1.90
7	8	37.48	0.00	0.00	0.00	8.86	10.61	0.56	0.61	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.35	1.90
7	9	37.38	0.00	0.00	0.00	8.93	10.57	0.56	0.61	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.34	1.91
7	10	37.28	0.00	0.00	0.00	9.00	10.54	0.56	0.61	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.33	1.91
7	11	37.19	0.00	0.00	0.00	9.07	10.51	0.56	0.61	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.32	1.91
7	12	37.10	0.00	0.00	0.00	9.13	10.47	0.56	0.60	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.30	1.91
7	13	37.01	0.00	0.00	0.00	9.20	10.44	0.56	0.60	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.29	1.92
7	14	36.93	0.00	0.00	0.00	9.26	10.41	0.56	0.60	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.28	1.92
7	15	36.84	0.00	0.00	0.00	9.32	10.37	0.56	0.60	0.08	1.92	3.16	0.00	0.36	0.36	0.00	10.27	1.92
7	16	36.77	0.00	0.00	0.00	9.38	10.34	0.55	0.60	0.09	1.92	3.16	0.00	0.36	0.36	0.00	10.26	1.92
7	17	36.69	0.00	0.00	0.00	9.45	10.31	0.55	0.60	0.09	1.92	3.16	0.00	0.36	0.36	0.00	10.24	1.93
7	18	36.61	0.00	0.00	0.00	9.50	10.28	0.55	0.60	0.09	1.92	3.16	0.00	0.36	0.36	0.00	10.23	1.93
7	19	36.54	0.00	0.00	0.00	9.56	10.24	0.55	0.60	0.09	1.92	3.16	0.00	0.36	0.36	0.00	10.22	1.93
7	20	36.47	0.00	0.00	0.00	9.62	10.21	0.55	0.60	0.09	1.92	3.16	0.00	0.36	0.36	0.00	10.21	1.94

~Bruce St.

Brk (immediate) upstream of Sugar River Confl.

***** STEADY STATE SIMULATION *****

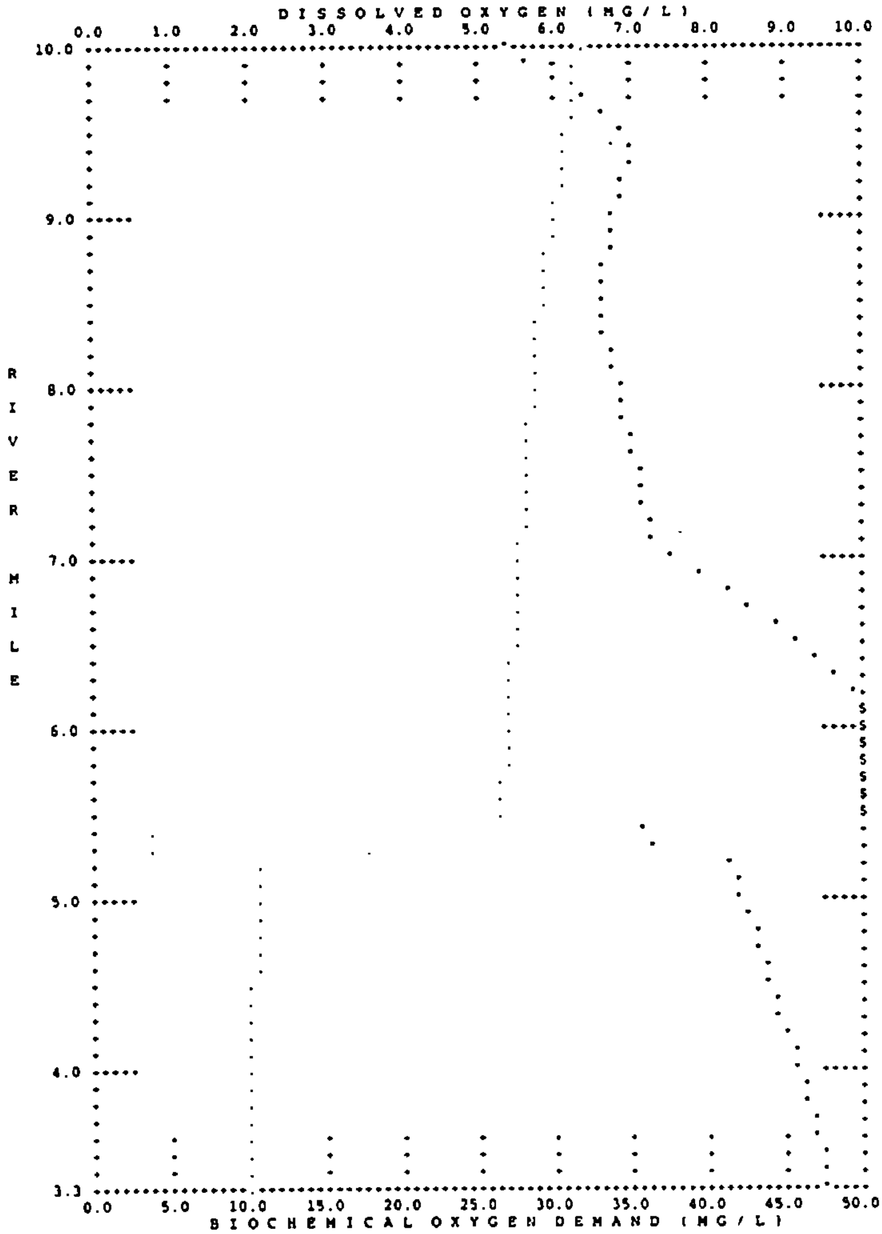
** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS: LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.00	0.49	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
2	1	2	0.00	0.48	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
3	1	3	0.00	0.47	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
4	1	4	0.00	0.46	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
5	1	5	0.00	0.45	0.06	0.07	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
6	1	6	0.00	0.44	0.06	0.07	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
7	2	1	0.00	0.44	0.05	0.07	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
8	2	2	0.00	0.43	0.05	0.07	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
9	2	3	0.00	0.42	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
10	2	4	0.00	0.42	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
11	2	5	0.00	0.41	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
12	2	6	0.00	0.41	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
13	2	7	0.00	0.40	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
14	2	8	0.00	0.40	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
15	2	9	0.00	0.40	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
16	2	10	0.00	0.39	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.91	0.96
17	3	1	0.00	0.39	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
18	3	2	0.00	0.39	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
19	3	3	0.00	0.39	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
20	3	4	0.00	0.39	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	C 96
21	3	5	0.00	0.38	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
22	3	6	0.00	0.38	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
23	3	7	0.00	0.38	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
24	3	8	0.00	0.38	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
25	3	9	0.00	0.38	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
26	3	10	0.00	0.38	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
27	3	11	0.00	0.38	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
28	3	12	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
29	3	13	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
30	3	14	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
31	4	1	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
32	4	2	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
33	4	3	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
34	4	4	0.00	0.36	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
35	4	5	0.00	0.36	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
36	4	6	0.00	0.36	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
37	4	7	0.00	0.36	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
38	4	8	0.00	0.36	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
39	4	9	0.00	0.36	0.04	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
40	5	1	0.00	0.35	0.04	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
41	5	2	0.00	0.35	0.04	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
42	5	3	0.00	0.35	0.04	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
43	5	4	0.00	0.35	0.04	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
44	5	5	0.00	0.35	0.04	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
45	5	6	0.00	0.35	0.04	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
46	5	7	0.00	0.35	0.04	0.07	6.33	0.00	0.90	0.94	0.01	0.37	0.90	0.96
47	6	1	2.70	0.30	0.05	0.07	4.99	0.02	0.90	0.32	0.14	0.37	0.89	0.76
48	6	2	2.70	0.30	0.05	0.07	4.99	0.02	0.90	0.32	0.14	0.37	0.89	0.76
49	7	1	1.88	0.35	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
50	7	2	1.89	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
51	7	3	1.89	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
52	7	4	1.89	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
53	7	5	1.90	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
54	7	6	1.90	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
55	7	7	1.90	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
56	7	8	1.90	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
57	7	9	1.91	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
58	7	10	1.91	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
59	7	11	1.91	0.34	0.05	0.07	5.90	0.02	0.90	0.74	0.11	0.37	0.89	0.90
60	7	12	1.91	0.33	0.05	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90
61	7	13	1.92	0.33	0.05	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90
62	7	14	1.92	0.33	0.05	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90
63	7	15	1.92	0.33	0.05	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90
64	7	16	1.92	0.33	0.05	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90
65	7	17	1.93	0.33	0.04	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90
66	7	18	1.93	0.33	0.04	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90
67	7	19	1.93	0.33	0.04	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90
68	7	20	1.94	0.33	0.04	0.07	5.89	0.02	0.90	0.74	0.11	0.37	0.89	0.90

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
1	1	1	49.01	11.13	5.38	5.75	0.00	0.96	512.00	57.07	-15.74	0.00	0.00	-2.84	-0.01
2	1	2	48.09	11.26	5.73	5.53	0.00	0.97	0.00	54.26	-15.30	0.00	0.00	-2.74	-0.01
3	1	3	47.23	11.39	6.06	5.33	0.00	0.97	0.00	51.68	-14.90	0.00	0.00	-2.65	-0.02
4	1	4	46.44	11.52	6.38	5.14	0.0C	0.98	0.00	49.31	-14.53	0.00	0.00	-2.56	-0.02
5	1	5	45.70	11.63	6.67	4.96	0.00	0.98	0.00	47.12	-14.20	0.00	0.00	-2.48	-0.02
6	1	6	45.01	11.75	6.95	4.79	0.00	0.98	0.00	45.09	-13.89	0.00	0.00	-2.40	-0.03
7	2	1	44.40	11.84	7.09	4.75	0.00	0.99	0.00	27.31	-13.60	0.00	0.00	-2.33	-0.03
8	2	2	43.85	11.93	7.02	4.92	0.00	0.99	0.00	10.51	-13.33	0.00	0.00	-2.26	-0.04
9	2	3	43.33	12.02	6.95	5.07	0.00	0.98	0.00	10.77	-13.08	0.00	0.00	-2.20	-0.04
10	2	4	42.85	12.10	6.89	5.21	0.00	0.98	0.00	10.99	-12.84	0.00	0.00	-2.14	-0.05
11	2	5	42.39	12.18	6.84	5.34	0.00	0.98	0.00	11.20	-12.61	0.00	0.00	-2.09	-0.05
12	2	6	41.96	12.26	6.80	5.46	0.00	0.98	0.00	11.39	-12.40	0.00	0.00	-2.04	-0.06
13	2	7	41.55	12.33	6.76	5.57	0.00	0.98	0.00	11.56	-12.20	0.00	0.00	-2.00	-0.06
14	2	8	41.16	12.40	6.73	5.67	0.00	0.98	0.00	11.71	-12.01	0.00	0.00	-1.96	-0.06
15	2	9	40.80	12.46	6.70	5.76	0.00	0.98	0.00	11.84	-11.83	0.00	0.00	-1.92	-0.07
16	2	10	40.46	12.52	6.67	5.85	0.00	0.98	0.00	11.96	-11.66	0.00	0.00	-1.88	-0.07
17	3	1	40.22	12.57	6.70	5.87	0.00	0.98	0.00	15.49	-11.54	0.00	0.00	-1.86	-0.07
18	3	2	40.06	12.60	6.75	5.85	0.00	0.98	0.00	18.91	-11.45	0.00	0.00	-1.84	-0.08
19	3	3	39.90	12.63	6.79	5.83	0.00	0.98	0.00	18.81	-11.37	0.00	0.00	-1.82	-0.08
20	3	4	39.74	12.65	6.84	5.81	0.00	0.98	0.00	18.70	-11.28	0.00	0.00	-1.81	-0.08
21	3	5	39.59	12.68	6.89	5.79	0.00	0.98	0.00	18.60	-11.20	0.00	0.00	-1.79	-0.08
22	3	6	39.45	12.71	6.94	5.77	0.00	0.98	0.00	18.50	-11.12	0.00	0.00	-1.78	-0.08
23	3	7	39.31	12.73	6.99	5.75	0.00	0.98	0.00	18.39	-11.05	0.00	0.00	-1.76	-0.09
24	3	8	39.17	12.76	7.04	5.72	0.00	0.99	0.00	18.28	-10.97	0.00	0.00	-1.75	-0.09
25	3	9	39.04	12.79	7.08	5.70	0.00	0.99	0.00	18.18	-10.90	0.00	0.00	-1.74	-0.09
26	3	10	38.91	12.81	7.13	5.68	0.00	0.99	0.00	18.07	-10.83	0.00	0.00	-1.72	-0.09
27	3	11	38.78	12.83	7.18	5.65	0.00	0.99	0.00	17.97	-10.75	0.00	0.00	-1.71	-0.09
28	3	12	38.66	12.86	7.23	5.63	0.00	0.99	0.00	17.86	-10.69	0.00	0.00	-1.70	-0.09
29	3	13	38.54	12.88	7.27	5.60	0.00	0.99	0.00	17.75	-10.62	0.00	0.00	-1.69	-0.10
30	3	14	38.43	12.90	7.32	5.58	0.00	0.99	0.00	17.65	-10.55	0.00	0.00	-1.68	-0.10
31	4	1	38.27	12.93	7.55	5.38	0.00	0.99	0.00	38.35	-10.47	0.00	0.00	-1.66	-0.10
32	4	2	38.00	12.98	7.94	5.05	0.00	0.99	0.00	55.83	-10.37	0.00	0.00	-1.64	-0.10
33	4	3	37.75	13.03	8.29	4.74	0.00	0.99	0.00	52.28	-10.27	0.00	0.00	-1.63	-0.10
34	4	4	37.52	13.07	8.61	4.46	0.00	0.99	0.00	49.03	-10.18	0.00	0.00	-1.61	-0.10
35	4	5	37.31	13.12	8.92	4.20	0.00	1.00	0.00	46.05	-10.09	0.00	0.00	-1.59	-0.10
36	4	6	37.11	13.16	9.19	3.96	0.00	1.00	0.00	43.32	-10.01	0.00	0.00	-1.58	-0.11
37	4	7	36.92	13.19	9.45	3.74	0.00	1.00	0.00	40.81	-9.93	0.00	0.00	-1.56	-0.11
38	4	8	36.75	13.23	9.69	3.54	0.00	1.00	0.00	38.51	-9.85	0.00	0.00	-1.55	-0.11
39	4	9	36.59	13.26	9.91	3.35	0.00	1.00	0.00	36.39	-9.78	0.00	0.00	-1.53	-0.11
40	5	1	36.46	13.28	10.05	3.23	0.00	1.00	0.00	28.65	-9.72	0.00	0.00	-1.52	-0.11
41	5	2	36.36	13.30	10.14	3.16	0.00	1.00	0.00	21.80	-9.67	0.00	0.00	-1.51	-0.11
42	5	3	36.26	13.32	10.22	3.10	0.00	1.00	0.00	21.33	-9.61	0.00	0.00	-1.50	-0.11
43	5	4	36.17	13.34	10.31	3.04	0.00	1.00	0.00	20.88	-9.56	0.00	0.00	-1.49	-0.11
44	5	5	36.08	13.36	10.38	2.98	0.00	1.00	0.00	20.45	-9.51	0.00	0.00	-1.49	-0.12
45	5	6	36.00	13.38	10.46	2.92	0.00	1.00	0.00	20.03	-9.47	0.00	0.00	-1.48	-0.12
46	5	7	35.92	13.39	10.53	2.86	0.00	1.00	0.00	19.64	-9.42	0.00	0.00	-1.47	-0.12
47	6	1	39.74	12.66	7.13	5.52	0.00	0.99	691.28	14.77	-1.55	0.00	0.02	-0.12	0.00
48	6	2	39.49	12.70	7.26	5.44	0.00	0.99	0.00	14.50	-1.53	0.00	0.02	-0.12	0.00
49	7	1	38.30	12.93	8.34	4.59	0.00	0.99	0.00	18.01	-4.07	0.00	0.02	-0.57	-0.04
50	7	2	38.17	12.95	8.42	4.53	0.00	0.99	0.00	13.59	-4.04	0.00	0.02	-0.57	-0.04
51	7	3	38.04	12.97	8.49	4.48	0.00	0.99	0.00	13.41	-4.01	0.00	0.02	-0.56	-0.04
52	7	4	37.92	13.00	8.57	4.43	0.00	0.99	0.00	13.23	-3.99	0.00	0.02	-0.56	-0.04
53	7	5	37.81	13.02	8.64	4.38	0.00	0.99	0.00	13.05	-3.96	0.00	0.02	-0.56	-0.04
54	7	6	37.70	13.04	8.72	4.32	0.00	0.99	0.00	12.88	-3.94	0.00	0.02	-0.55	-0.04
55	7	7	37.59	13.06	8.79	4.27	0.00	0.99	0.00	12.71	-3.92	0.00	0.02	-0.55	-0.04
56	7	8	37.48	13.08	8.86	4.22	0.00	1.00	0.00	12.54	-3.89	0.00	0.02	-0.55	-0.04
57	7	9	37.38	13.10	8.93	4.17	0.00	1.00	0.00	12.38	-3.87	0.00	0.02	-0.54	-0.04
58	7	10	37.28	13.12	9.00	4.12	0.00	1.00	0.00	12.22	-3.85	0.00	0.02	-0.54	-0.04
59	7	11	37.19	13.14	9.07	4.07	0.00	1.00	0.00	12.06	-3.83	0.00	0.02	-0.54	-0.04
60	7	12	37.10	13.16	9.13	4.03	0.00	1.00	0.00	11.90	-3.81	0.00	0.02	-0.54	-0.04
61	7	13	37.01	13.17	9.20	3.98	0.00	1.00	0.00	11.74	-3.79	0.00	0.02	-0.53	-0.04
62	7	14	36.93	13.19	9.26	3.93	0.00	1.00	0.00	11.59	-3.77	0.00	0.02	-0.53	-0.04
63	7	15	36.84	13.21	9.32	3.88	0.00	1.00	0.00	11.44	-3.75	0.00	0.02	-0.53	-0.05
64	7	16	36.77	13.22	9.38	3.84	0.00	1.00	0.00	11.30	-3.73	0.00	0.02	-0.53	-0.05
65	7	17	36.69	13.24	9.45	3.79	0.00	1.00	0.00	11.15	-3.71	0.00	0.02	-0.52	-0.05
66	7	18	36.61	13.25	9.50	3.75	0.00	1.00	0.00	11.01	-3.69	0.00	0.02	-0.52	-0.05
67	7	19	36.54	13.27	9.56	3.70	0.00	1.00	0.00	10.87	-3.67	0.00	0.02	-0.52	-0.05
68	7	20	36.47	13.28	9.62	3.66	0.00	1.00	0.00	10.73	-3.65	0.00	0.02	-0.52	-0.05



DISSOLVED OXYGEN •••••

BIOCHEMICAL OXYGEN DEMAND • . . . .

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* * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                Ver. 3.13 - September 1991

$$$ (PROBLEM TITLES) $$$

CARD TYPE                          QUAL-2E PROGRAM TITLES
TITLE01               BWAIU.IN - Winter, Average, Ultimate FLOW, BODU Simulation
TITLE02               NSWTP DISCHARGE TO BADGER MILL CREEK
TITLE03    NO         CONSERVATIVE MINERAL I          IN
TITLE04    NO         CONSERVATIVE MINERAL II         IN
TITLE05    NO         CONSERVATIVE MINERAL III        IN
TITLE06   YES         TEMPERATURE
TITLE07   YES         BIOCHEMICAL OXYGEN DEMAND ULTIMATE
TITLE08   YES         ALGAE AS CHL-A IN UG/L
TITLE09   YES         PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                 (ORGANIC-P, DISSOLVED-P)
TITLE11   YES         NITROGEN CYCLE AS N IN MG/L
TITLE12                 (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
TITLE13   YES         DISSOLVED OXYGEN IN MG/L
TITLE14    NO         FECAL COLIFORMS IN NO./100 ML
TITLE15   YES         ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l
ENDTITLE

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                    CARD TYPE
LIST DATA INPUT               0.00000                                     0.00000
WRITE OPTIONAL SUMMARY        0.00000                                     0.00000
NO FLOW AUGMENTATION          0.00000                                     0.00000
STEADY STATE                  0.00000                                     0.00000
TRAPEZOIDAL X-SECTIONS        0.00000                                     0.00000
PRINT LCD/SOLAR DATA          0.00000                                     0.00000
PLOT DO AND BOD               0.00000                                     0.00000
FIXED DNSTM COND (YES=1)=     0.00000        5D-ULT BOD CONV K COEF  =    0.23000
INPUT METRIC (YES=1)     =    0.00000        OUTPUT METRIC (YES=1)   =    0.00000
NUMBER OF REACHES        =    7.00000        NUMBER OF JUNCTIONS     =    1.00000
NUM OF HEADWATERS        =    2.00000        NUMBER OF POINT LOADS   =    0.00000
TIME STEP (HOURS)        =    1.00000        LNTH  COMP  ELEMENT (DX)=    0.10000
MAXIMUM ROUTE TIME (HRS)=   288.00000        TIME INC. FOR RPT2 (HRS)=    1.00000
LATITUDE OF BASIN (DEG) =    43.10000        LONGITUDE OF BASIN (DEG)=   89.30000
STANDARD MERIDIAN (DEG) =    75.00000        DAY OF YEAR START TIME  =   15.00000
EVAP. COEFF. (AE)       =     0.00068        EVAP. COEFF. (BE)       =    0.00027
ELEV. OF BASIN (ELEV)   =   937.00000        DUST ATTENUATION COEF.  =    0.06000
ENDATA1                       0.00000                                     0.00000

$$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                         CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.5000        O UPTAKE BY NO2 OXID(MG O/MG N)=     1.2000
O PROD  BY ALGAE (MG O/MG A)   =    1.6000        O UPTAKE BY ALGAE (MG O/MG A)  =     2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0850        P CONTENT OF ALGAE (MG P/MG A) =     0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000        ALGAE RESPIRATION RATE (1/DAY) =     0.1000
N HALF SATURATION CONST  (MG/L)=    0.3000        P HALF SATURATION CONST  (MG/L)=     0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0088        NLIN SHADE(1/FT-(UGCHA/L)**2/3)=     0.0540
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000        LIGHT SAT'N COEF (BTU/FT2-MIN) =     0.0300
DAILY AVERAGING OPTION (LAVOPT)=    2.0000        LIGHT AVERAGING FACTOR (AFACT) =     0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =   10.0000        TOTAL DAILY SOLR RAD (BTU/FT-2)=   400.0000
ALGY GROWTH CALC OPTION(LGROPT)=    1.0000        ALGAL PREF FOR NH3-N (PREFN)   =     0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500        NITRIFICATION INHIBITION COEF  =     0.6000
ENDATA1A                            0.0000                                             0.0000

$$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE     RATE CODE     THETA VALUE

THETA( 1)     BOD DECA        1.047     DFLT
THETA( 2)     BOD SETT        1.024     DFLT
THETA( 3)     OXY TRAN        1.024     DFLT
THETA( 4)     SOD RATE        1.060     DFLT
THETA( 5)     ORGN DEC        1.047     DFLT
THETA( 6)     ORGN SET        1.024     DFLT
THETA( 7)     NH3 DECA        1.083     DFLT
THETA( 8)     NH3 SRCE        1.074     DFLT
THETA( 9)     NO2 DECA        1.047     DFLT
THETA(10)     PORG DEC        1.047     DFLT
THETA(11)     PORG SET        1.024     DFLT
THETA(12)     DISP SRC        1.074     DFLT
THETA(13)     ALG GROW        1.047     DFLT
THETA(14)     ALG RESP        1.047     DFLT
THETA(15)     ALG SETT        1.024     DFLT
THETA(16)     COLI DEC        1.047     DFLT
THETA(17)     ANC DECA        1.000     DFLT
THETA(18)     ANC SETT        1.024     DFLT
THETA(19)     ANC SRCE        1.000     DFLT
ENDATA1B

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE          REACH ORDER AND IDENT                  R. MI/KM              R. MI/KM
STREAM REACH    1.0  RCH= HWY 151-PB         FROM          10.0      TO          9.4
STREAM REACH    2.0  RCH= PB-Lincoln         FROM           9.4      TO          8.4
STREAM REACH    3.0  RCH= Lincoln-151 By     FROM           8.4      TO          7.0
STREAM REACH    4.0  RCH= 151 By-HWY 69      FROM           7.0      TO          6.1
STREAM REACH    5.0  RCH= HWY 69-Sugar R     FROM           6.1      TO          5.4
STREAM REACH    6.0  RCH= Upstrm Sugar R     FROM           5.6      TO          5.4
STREAM REACH    7.0  RCH= Dnstrm Sugar R     FROM           5.4      TO          3.4
ENDATA2         0.0                                         0.0                  0.0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE                REACH  AVAIL HDWS TARGET    ORDER OF AVAIL SOURCES
ENDATA3                   0.        0.      0.0   0.   0.   0.   0.   0.   0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE        REACH ELEMENTS/REACH             COMPUTATIONAL FLAGS
FLAG FIELD         1.       6.         1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         2.      10.         2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         3.      14.         2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
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FLAG FIELD	4.	9.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CHANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	2.	945.00	0.13	0.10	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	3.	935.00	0.13	0.20	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	4.	925.00	0.13	0.05	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	5.	915.00	0.13	0.00	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	6.	910.00	0.13	0.05	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	7.	910.00	0.13	0.05	35.00	35.00	29.10	15.40	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	OR OR	EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000		0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	2.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	3.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	4.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	5.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	6.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	7.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.390	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	2.	0.650	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	3.	0.910	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	4.	0.590	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	5.	0.460	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

INCR INFLOW-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC-Sugar R Confluen	46.	49.	48.
ENDATA9	0.		0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	NSWTPOutfall	3.40	56.10	6.00	15.30	0.00	0.00	0.00
HEADWTR-1	2.	Sugar River	18.00	43.40	7.00	4.00	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	8.30	0.00	0.00	0.50	0.73	0.00	1.00	0.00	0.89
HEADWTR-2	2.	5.00	0.00	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
ENDATA11A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

	DAM	RCH	ELE	ADAM	BDAM	FDAM	HDAM
ENDATA12	0.	0.	0.	0.00	0.00	0.00	0.00

$$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

CARD TYPE	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI

ENDATA13 DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P

ENDATA13A DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
1	52
2	0

TEMPERATURE — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	54.24	52.56	51.04	49.65	48.39	47.25														
2	46.27	45.40	44.61	43.87	43.20	42.58	42.00	41.47	40.97	40.51										
3	40.20	40.00	39.81	39.63	39.45	39.29	39.13	38.98	38.84	38.70	38.57	38.44	38.32	38.21						
4	38.03	37.70	37.39	37.10	36.83	36.58	36.35	36.14	35.93											
5	35.78	35.67	35.56	35.46	35.36	35.27	35.18													
6	43.10	42.80																		
7	40.65	40.47	40.29	40.12	39.95	39.78	39.61	39.45	39.29	39.14	38.98	38.83	38.68	38.54	38.39	38.25	38.11	37.98	37.84	37.71

TEMPERATURE — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	54.17	52.44	50.89	49.49	48.23	47.08														
2	46.11	45.25	44.47	43.75	43.08	42.46	41.89	41.37	40.88	40.42										
3	40.12	39.92	39.73	39.55	39.38	39.22	39.06	38.91	38.77	38.63	38.50	38.37	38.25	38.14						
4	37.95	37.62	37.31	37.02	36.74	36.49	36.25	36.03	35.82											
5	35.66	35.55	35.43	35.33	35.22	35.13	35.04													
6	43.10	42.80																		
7	40.61	40.43	40.25	40.08	39.91	39.74	39.58	39.42	39.26	39.10	38.95	38.79	38.65	38.50	38.35	38.21	38.07	37.93	37.80	37.66

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

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DAILY NET SOLAR RADIATION =      0.000 BTU/FT-2  (     0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS =    9.2
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HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	0.00	9	0.00	17	0.00
2	0.00	10	0.00	18	0.00
3	0.00	11	0.00	19	0.00
4	0.00	12	0.00	20	0.00
5	0.00	13	0.00	21	0.00
6	0.00	14	0.00	22	0.00
7	0.00	15	0.00	23	0.00
8	0.00	16	0.00	24	0.00

BIOCHEMICAL OXYGEN DEMAND ULTIMATE — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	15.01	14.73	14.46	14.21	13.97	13.74														
2	13.50	13.26	13.04	12.82	12.61	12.40	12.21	12.02	11.84	11.66										
3	11.51	11.36	11.23	11.09	10.96	10.84	10.71	10.59	10.48	10.36	10.25	10.15	10.04	9.94						
4	9.84	9.75	9.65	9.56	9.47	9.38	9.30	9.22	9.14											
5	9.06	8.98	8.91	8.84	8.76	8.70	8.62													
6	3.99	3.98																		
7	5.19	5.17	5.16	5.15	5.13	5.12	5.11	5.10	5.08	5.07	5.06	5.05	5.03	5.02	5.01	5.00	4.99	4.97	4.96	4.95

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.22	8.15	8.08	8.02	7.95	7.89														
2	7.83	7.77	7.71	7.65	7.59	7.54	7.48	7.43	7.38	7.33										
3	7.29	7.25	7.21	7.17	7.13	7.10	7.06	7.03	6.99	6.96	6.93	6.90	6.87	6.84						
4	6.81	6.78	6.75	6.73	6.70	6.67	6.65	6.62	6.60											
5	6.58	6.55	6.53	6.51	6.49	6.47	6.45													
6	4.99	4.99																		

7	5.37	5.36	5.36	5.35	5.35	5.34	5.34	5.34	5.33	5.33	5.32	5.32	5.31	5.31	5.30	5.30	5.29	5.29	5.28	5.28

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.05	0.10	0.15	0.19	0.24	0.28														
2	0.32	0.36	0.40	0.44	0.47	0.51	0.54	0.58	0.61	0.64										
3	0.67	0.70	0.73	0.76	0.79	0.81	0.84	0.87	0.89	0.91	0.94	0.96	0.98	1.01						
4	1.03	1.05	1.07	1.09	1.10	1.12	1.14	1.16	1.18											
5	1.19	1.21	1.23	1.24	1.26	1.27	1.29													
6	2.70	2.71																		
7	2.34	2.34	2.34	2.34	2.35	2.35	2.35	2.35	2.36	2.36	2.36	2.36	2.37	2.37	2.37	2.37	2.38	2.38	2.38	2.38

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.86	0.85	0.84	0.82	0.81														
2	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71										
3	0.70	0.70	0.69	0.68	0.67	0.66	0.66	0.65	0.64	0.64	0.63	0.63	0.62	0.61						
4	0.61	0.60	0.60	0.59	0.59	0.58	0.57	0.57	0.57											
5	0.56	0.56	0.55	0.55	0.54	0.54	0.53													
6	0.13	0.13																		
7	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.51														
2	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51										
3	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.52	0.52	0.52	0.52	0.52	0.52	0.52						
4	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52											
5	0.52	0.52	0.52	0.52	0.52	0.53	0.53													
6	0.62	0.62																		
7	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.72	0.70	0.69	0.68	0.67	0.65														
2	0.64	0.63	0.62	0.61	0.60	0.59	0.59	0.58	0.57	0.56										
3	0.55	0.55	0.54	0.53	0.53	0.52	0.51	0.51	0.50	0.50	0.49	0.49	0.48	0.48						
4	0.47	0.47	0.46	0.46	0.45	0.45	0.45	0.44	0.44											
5	0.43	0.43	0.43	0.42	0.42	0.42	0.41													
6	0.12	0.12																		
7	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.01	0.01	0.01	0.01	0.02														
2	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04										
3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04						
4	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04											
5	0.04	0.04	0.04	0.04	0.04	0.04	0.04													
6	0.00	0.00																		
7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.02	1.05	1.07	1.09	1.11	1.13														
2	1.15	1.17	1.19	1.21	1.23	1.24	1.26	1.28	1.29	1.31										
3	1.32	1.34	1.35	1.36	1.38	1.39	1.40	1.41	1.42	1.43	1.45	1.46	1.47	1.48						
4	1.49	1.50	1.51	1.52	1.53	1.53	1.54	1.55	1.56											
5	1.57	1.58	1.58	1.59	1.60	1.61	1.61													
6	2.30	2.30																		
7	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.34	6.67	6.97	7.26	7.53	7.79														
2	7.95	7.96	7.97	7.99	8.02	8.05	8.08	8.11	8.15	8.19										
3	8.25	8.31	8.37	8.43	8.48	8.54	8.59	8.65	8.70	8.75	8.81	8.86	8.91	8.96						
4	9.14	9.42	9.69	9.93	10.15	10.36	10.55	10.72	10.89											
5	11.00	11.06	11.12	11.17	11.23	11.28	11.33													
6	7.12	7.25																		
7	8.40	8.50	8.59	8.67	8.76	8.85	8.93	9.01	9.10	9.18	9.25	9.33	9.41	9.48	9.55	9.63	9.70	9.77	9.84	9.90

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	66
ALGAE GROWTH RATE	2	66
ALGAE GROWTH RATE	3	66
ALGAE GROWTH RATE	4	66
ALGAE GROWTH RATE	5	46
ALGAE GROWTH RATE	6	0
NITRIFICATION INHIBITION	1	0
ALGAE GROWTH RATE	7	0
NITRIFICATION INHIBITION	2	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
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1. LIGHT AVERAGING OPTION. LAVOPT= 2

METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

SOURCE OF SOLAR VALUES: DATA TYPE 1A
DAILY NET SOLAR RADIATION: 400.000 BTU/FT-2 (108.548 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 9.2
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): N/A
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS. LGROPT= 1

MULTIPLICATIVE: FL*FN*FP

TEMPERATURE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	54.17	52.44	50.89	49.49	48.23	47.08														
2	46.11	45.25	44.47	43.75	43.08	42.46	41.89	41.37	40.88	40.42										
3	40.12	39.92	39.73	39.55	39.38	39.22	39.06	38.91	38.77	38.63	38.50	38.37	38.25	38.14						
4	37.95	37.62	37.31	37.02	36.74	36.49	36.25	36.03	35.82											
5	35.66	35.55	35.43	35.33	35.22	35.13	35.04													
6	43.10	42.80																		
7	40.61	40.43	40.25	40.08	39.91	39.74	39.58	39.42	39.26	39.10	38.95	38.79	38.65	38.50	38.35	38.21	38.07	37.93	37.80	37.66

DISSOLVED OXYGEN IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.34	6.67	6.97	7.26	7.53	7.79														
2	7.95	7.96	7.97	7.99	8.02	8.05	8.08	8.11	8.15	8.19										
3	8.25	8.31	8.37	8.43	8.48	8.54	8.59	8.65	8.70	8.75	8.81	8.86	8.91	8.96						
4	9.14	9.42	9.69	9.93	10.15	10.36	10.55	10.72	10.89											
5	11.00	11.06	11.12	11.17	11.23	11.28	11.33													
6	7.12	7.25																		
7	8.40	8.50	8.59	8.67	8.76	8.85	8.93	9.01	9.10	9.18	9.25	9.33	9.41	9.48	9.55	9.63	9.70	9.77	9.84	9.90

BIOCHEMICAL OXYGEN DEMAND ULTIMATE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	15.01	14.73	14.46	14.21	13.97	13.74														
2	13.50	13.26	13.04	12.82	12.61	12.40	12.21	12.02	11.84	11.66										
3	11.51	11.36	11.23	11.09	10.96	10.84	10.71	10.59	10.48	10.36	10.25	10.15	10.04	9.94						
4	9.84	9.75	9.65	9.56	9.47	9.38	9.30	9.22	9.14											
5	9.06	8.98	8.91	8.84	8.76	8.70	8.62													
6	3.99	3.98																		
7	5.19	5.17	5.16	5.15	5.13	5.12	5.11	5.10	5.08	5.07	5.06	5.05	5.03	5.02	5.01	5.00	4.99	4.97	4.96	4.95

ORGANIC NITROGEN AS N IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.51														
2	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51										
3	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.52	0.52	0.52	0.52	0.52	0.52	0.52						
4	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52											
5	0.52	0.52	0.52	0.52	0.52	0.53	0.53													
6	0.62	0.62																		
7	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58

AMMONIA AS N IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.72	0.70	0.69	0.68	0.67	0.65														
2	0.64	0.63	0.62	0.61	0.60	0.59	0.59	0.58	0.57	0.56										
3	0.55	0.55	0.54	0.53	0.53	0.52	0.51	0.51	0.50	0.50	0.49	0.49	0.48	0.48						
4	0.47	0.47	0.46	0.46	0.45	0.45	0.45	0.44	0.44											
5	0.43	0.43	0.43	0.42	0.42	0.42	0.41													
6	0.12	0.12																		
7	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

NITRITE AS N IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.01	0.01	0.01	0.01	0.02														
2	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04										
3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04						
4	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04											
5	0.04	0.04	0.04	0.04	0.04	0.04	0.04													
6	0.00	0.00																		
7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.02	1.05	1.07	1.09	1.11	1.13														
2	1.15	1.17	1.19	1.21	1.23	1.24	1.26	1.28	1.29	1.31										
3	1.32	1.34	1.35	1.36	1.38	1.39	1.40	1.41	1.42	1.43	1.45	1.46	1.47	1.48						
4	1.49	1.50	1.51	1.52	1.53	1.53	1.54	1.55	1.56											
5	1.57	1.58	1.58	1.59	1.60	1.61	1.61													
6	2.30	2.30																		
7	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12

ORGANIC PHOSPHORUS AS P IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											

5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.86	0.85	0.84	0.82	0.81														
2	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71										
3	0.70	0.70	0.69	0.68	0.67	0.66	0.66	0.65	0.64	0.64	0.63	0.63	0.62	0.61						
4	0.61	0.60	0.60	0.59	0.59	0.58	0.57	0.57	0.57											
5	0.56	0.56	0.55	0.55	0.54	0.54	0.53													
6	0.13	0.13																		
7	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

ALGAE AS CHL-A IN UG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.05	0.10	0.15	0.19	0.24	0.28														
2	0.32	0.36	0.40	0.44	0.48	0.51	0.55	0.58	0.61	0.65										
3	0.68	0.71	0.74	0.77	0.79	0.82	0.85	0.87	0.90	0.92	0.95	0.97	0.99	1.01						
4	1.04	1.06	1.08	1.10	1.11	1.13	1.15	1.17	1.19											
5	1.21	1.22	1.24	1.26	1.27	1.29	1.30													
6	2.70	2.71																		
7	2.34	2.34	2.35	2.35	2.35	2.36	2.36	2.36	2.37	2.37	2.37	2.37	2.38	2.38	2.38	2.39	2.39	2.39	2.40	2.40

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.22	8.15	8.08	8.02	7.95	7.89														
2	7.83	7.77	7.71	7.65	7.59	7.54	7.48	7.43	7.38	7.33										
3	7.29	7.25	7.21	7.17	7.13	7.10	7.06	7.03	6.99	6.96	6.93	6.90	6.87	6.84						
4	6.81	6.78	6.75	6.73	6.70	6.67	6.65	6.62	6.60											
5	6.58	6.55	6.53	6.51	6.49	6.47	6.45													
6	4.99	4.99																		
7	5.37	5.36	5.36	5.35	5.35	5.34	5.34	5.34	5.33	5.33	5.32	5.32	5.31	5.31	5.30	5.30	5.29	5.29	5.28	5.28

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.53	0.50	0.48	0.47	0.45	0.44														
2	0.43	0.42	0.41	0.40	0.40	0.39	0.38	0.38	0.37	0.37										
3	0.37	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.35	0.35	0.35	0.35	0.35	0.35						
4	0.35	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33											
5	0.33	0.32	0.32	0.32	0.32	0.32	0.32													
6	0.33	0.33																		
7	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32	0.32

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.98	5.98	5.98	5.99	5.99	5.99														
2	5.99	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98										
3	5.98	5.98	5.98	5.98	5.98	5.97	5.97	5.97	5.97	5.97	5.97	5.97	5.96	5.96						
4	5.97	5.96	5.96	5.96	5.96	5.96	5.96	5.96	5.95											
5	5.95	5.95	5.95	5.95	5.94	5.94	5.94													
6	4.98	4.98																		
7	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	3.47	0.00	0.06	0.630	0.010	0.310	17.744	2.90	10.84	5.50	0.27
2	1	2	9.90	9.80	3.53	0.00	0.06	0.634	0.010	0.313	17.774	2.94	10.87	5.57	0.28
3	1	3	9.80	9.70	3.60	0.00	0.06	0.638	0.010	0.317	17.803	2.98	10.90	5.64	0.28
4	1	4	9.70	9.60	3.66	0.00	0.06	0.642	0.010	0.320	17.832	3.01	10.93	5.70	0.28
5	1	5	9.60	9.50	3.73	0.00	0.06	0.645	0.009	0.323	17.860	3.05	10.97	5.77	0.29
6	1	6	9.50	9.40	3.79	0.00	0.06	0.649	0.009	0.326	17.889	3.08	11.00	5.84	0.29
7	2	1	9.40	9.30	3.86	0.00	0.06	0.445	0.014	0.545	15.926	4.58	9.06	8.67	0.37
8	2	2	9.30	9.20	3.92	0.00	0.06	0.447	0.014	0.550	15.935	4.63	9.07	8.76	0.37
9	2	3	9.20	9.10	3.99	0.00	0.06	0.450	0.014	0.555	15.944	4.68	9.08	8.86	0.38
10	2	4	9.10	9.00	4.05	0.00	0.06	0.453	0.013	0.561	15.953	4.72	9.09	8.95	0.38
11	2	5	9.00	8.90	4.12	0.00	0.06	0.455	0.013	0.566	15.963	4.77	9.10	9.04	0.39
12	2	6	8.90	8.80	4.18	0.00	0.06	0.458	0.013	0.571	15.972	4.82	9.11	9.13	0.40
13	2	7	8.80	8.70	4.25	0.00	0.06	0.461	0.013	0.577	15.980	4.87	9.12	9.22	0.40
14	2	8	8.70	8.60	4.31	0.00	0.06	0.463	0.013	0.582	15.989	4.91	9.14	9.30	0.41
15	2	9	8.60	8.50	4.38	0.00	0.06	0.466	0.013	0.587	15.998	4.96	9.15	9.39	0.41
16	2	10	8.50	8.40	4.44	0.00	0.06	0.468	0.013	0.592	16.007	5.01	9.16	9.48	0.42
17	3	1	8.40	8.30	4.51	0.00	0.07	0.756	0.008	0.687	8.678	3.15	6.09	5.96	0.51
18	3	2	8.30	8.20	4.57	0.00	0.07	0.759	0.008	0.692	8.699	3.18	6.12	6.02	0.51
19	3	3	8.20	8.10	4.64	0.00	0.07	0.762	0.008	0.697	8.719	3.21	6.14	6.08	0.52
20	3	4	8.10	8.00	4.70	0.00	0.07	0.766	0.008	0.702	8.739	3.24	6.16	6.14	0.52
21	3	5	8.00	7.90	4.77	0.00	0.07	0.769	0.008	0.708	8.760	3.27	6.18	6.20	0.53
22	3	6	7.90	7.80	4.83	0.00	0.07	0.772	0.008	0.713	8.780	3.30	6.20	6.26	0.53
23	3	7	7.80	7.70	4.90	0.00	0.07	0.775	0.008	0.718	8.800	3.34	6.23	6.32	0.54
24	3	8	7.70	7.60	4.96	0.00	0.07	0.778	0.008	0.723	8.820	3.37	6.25	6.38	0.54
25	3	9	7.60	7.50	5.03	0.00	0.07	0.781	0.008	0.728	8.839	3.40	6.27	6.43	0.55
26	3	10	7.50	7.40	5.09	0.00	0.07	0.784	0.008	0.733	8.859	3.43	6.29	6.49	0.55
27	3	11	7.40	7.30	5.16	0.00	0.07	0.787	0.008	0.738	8.878	3.46	6.31	6.55	0.56
28	3	12	7.30	7.20	5.22	0.00	0.07	0.790	0.008	0.743	8.897	3.49	6.33	6.61	0.57
29	3	13	7.20	7.10	5.29	0.00	0.07	0.793	0.008	0.748	8.917	3.52	6.35	6.67	0.57
30	3	14	7.10	7.00	5.35	0.00	0.07	0.795	0.008	0.753	8.936	3.55	6.37	6.73	0.58
31	4	1	7.00	6.90	5.42	0.00	0.07	0.827	0.007	0.304	21.586	3.46	12.35	6.55	0.28
32	4	2	6.90	6.80	5.48	0.00	0.07	0.830	0.007	0.306	21.597	3.49	12.36	6.60	0.28
33	4	3	6.80	6.70	5.55	0.00	0.07	0.834	0.007	0.308	21.609	3.51	12.37	6.65	0.29
34	4	4	6.70	6.60	5.61	0.00	0.07	0.837	0.007	0.310	21.620	3.54	12.38	6.70	0.29
35	4	5	6.60	6.50	5.68	0.00	0.07	0.841	0.007	0.312	21.631	3.56	12.40	6.75	0.29
36	4	6	6.50	6.40	5.74	0.00	0.07	0.845	0.007	0.314	21.642	3.59	12.41	6.80	0.30
37	4	7	6.40	6.30	5.81	0.00	0.07	0.848	0.007	0.316	21.653	3.62	12.42	6.85	0.30
38	4	8	6.30	6.20	5.87	0.00	0.07	0.851	0.007	0.318	21.664	3.64	12.43	6.90	0.30
39	4	9	6.20	6.10	5.94	0.00	0.07	0.855	0.007	0.321	21.675	3.67	12.45	6.95	0.30
40	5	1	6.10	6.00	6.01	0.00	0.07	0.892	0.007	0.417	16.130	3.55	10.20	6.73	0.35
41	5	2	6.00	5.90	6.07	0.00	0.07	0.895	0.007	0.420	16.150	3.58	10.22	6.78	0.35
42	5	3	5.90	5.80	6.14	0.00	0.07	0.898	0.007	0.423	16.169	3.61	10.24	6.83	0.35
43	5	4	5.80	5.70	6.20	0.00	0.07	0.901	0.007	0.425	16.188	3.63	10.26	6.88	0.35
44	5	5	5.70	5.60	6.27	0.00	0.07	0.905	0.007	0.428	16.207	3.66	10.28	6.93	0.36
45	5	6	5.60	5.50	6.33	0.00	0.07	0.908	0.007	0.430	16.226	3.68	10.30	6.98	0.36
46	5	7	5.50	5.40	6.40	0.00	0.07	0.911	0.007	0.433	16.245	3.71	10.32	7.03	0.36
47	6	1	5.60	5.50	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
48	6	2	5.50	5.40	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
49	7	1	5.40	5.30	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
50	7	2	5.30	5.20	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
51	7	3	5.20	5.10	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
52	7	4	5.10	5.00	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
53	7	5	5.00	4.90	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
54	7	6	4.90	4.80	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
55	7	7	4.80	4.70	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
56	7	8	4.70	4.60	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
57	7	9	4.60	4.50	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
58	7	10	4.50	4.40	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
59	7	11	4.40	4.30	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
60	7	12	4.30	4.20	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
61	7	13	4.20	4.10	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
62	7	14	4.10	4.00	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
63	7	15	4.00	3.90	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
64	7	16	3.90	3.80	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
65	7	17	3.80	3.70	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
66	7	18	3.70	3.60	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
67	7	19	3.60	3.50	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
68	7	20	3.50	3.40	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63

***** STEADY STATE SIMULATION *****

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** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	10.41	8	10.67	0.56	0.00	0.00	0.18	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
1	2	10.64	8	10.46	0.54	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
1	3	10.86	8	10.29	0.52	0.00	0.00	0.16	0.08	0.46	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
1	4	11.06	8	10.15	0.50	0.00	0.00	0.16	0.08	0.43	0.00	0.62	0.12	0.08	0.00	0.00	0.00	0.16	0.00
1	5	11.24	8	10.03	0.48	0.00	0.00	0.15	0.08	0.41	0.00	0.60	0.12	0.08	0.00	0.00	0.00	0.15	0.00
1	6	11.42	8	9.92	0.47	0.00	0.00	0.15	0.08	0.39	0.00	0.58	0.12	0.08	0.00	0.00	0.00	0.15	0.00
2	1	11.57	8	6.05	0.46	0.00	0.00	0.14	0.07	0.38	0.00	0.57	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	2	11.71	8	2.27	0.45	0.00	0.00	0.14	0.07	0.36	0.00	0.55	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	3	11.83	8	2.26	0.44	0.00	0.00	0.14	0.07	0.35	0.00	0.54	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	4	11.95	8	2.25	0.43	0.00	0.00	0.13	0.07	0.34	0.00	0.53	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	5	12.06	8	2.24	0.42	0.00	0.00	0.13	0.07	0.33	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
2	6	12.17	8	2.24	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.52	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	7	12.27	8	2.23	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	8	12.36	8	2.23	0.41	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	9	12.45	8	2.22	0.40	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
2	10	12.53	8	2.22	0.40	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	1	12.59	8	2.81	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	2	12.62	8	3.40	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	3	12.66	8	3.40	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	4	12.69	8	3.40	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	5	12.72	8	3.40	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	6	12.75	8	3.40	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	7	12.78	8	3.40	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	8	12.81	8	3.40	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	9	12.84	8	3.40	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
3	10	12.86	8	3.40	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
3	11	12.89	8	3.40	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
3	12	12.91	8	3.41	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
3	13	12.93	8	3.41	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
3	14	12.96	8	3.41	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	1	12.99	8	8.12	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	2	13.06	8	12.80	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	3	13.12	8	12.79	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	4	13.17	8	12.79	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	5	13.23	8	12.79	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	6	13.28	8	12.79	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	7	13.33	8	12.80	0.36	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	8	13.37	8	12.80	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
4	9	13.41	8	12.81	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	1	13.44	8	10.32	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	2	13.47	8	7.83	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.44	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	3	13.49	8	7.84	0.35	0.00	0.00	0.11	0.07	0.24	0.00	0.43	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	4	13.51	8	7.84	0.35	0.00	0.00	0.11	0.06	0.23	0.00	0.43	0.09	0.06	0.00	0.00	0.00	0.13	0.00
5	5	13.53	8	7.85	0.35	0.00	0.00	0.11	0.06	0.23	0.00	0.43	0.09	0.06	0.00	0.00	0.00	0.13	0.00
5	6	13.55	8	7.86	0.35	0.00	0.00	0.11	0.06	0.23	0.00	0.43	0.09	0.06	0.00	0.00	0.00	0.13	0.00
5	7	13.57	8	7.87	0.34	0.00	0.00	0.11	0.06	0.23	0.00	0.43	0.09	0.06	0.00	0.00	0.00	0.13	0.00
6	1	12.06	8	3.80	0.42	0.00	0.00	0.13	0.07	0.33	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
6	2	12.11	8	3.79	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
7	1	12.50	8	5.09	0.40	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	2	12.53	8	4.08	0.40	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	3	12.56	8	4.07	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	4	12.59	8	4.07	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	5	12.62	8	4.06	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	6	12.65	8	4.05	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	7	12.68	8	4.04	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	8	12.71	8	4.03	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	9	12.74	8	4.02	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	10	12.77	8	4.01	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	11	12.80	8	4.01	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	12	12.83	8	4.00	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	13	12.86	8	3.99	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	14	12.89	8	3.98	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	15	12.91	8	3.97	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	16	12.94	8	3.97	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	17	12.97	8	3.96	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	18	13.00	8	3.95	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	19	13.02	8	3.94	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	20	13.05	8	3.94	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00

STREAM QUALITY SIMULATION
QUAL-2E STREAM QUALITY ROUTING MODEL.

OUTPUT PAGE NUMBER 5
Ver. 3.13 - September 1991

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota apen	CHLA UG/L
1	1	54.17	0.00	0.00	0.00	6.34	15.01	0.50	0.72	0.00	1.02	2.24	0.00	0.88	0.88	0.00	8.22	0.05
1	2	52.44	0.00	0.00	0.00	6.67	14.73	0.50	0.70	0.01	1.05	2.26	0.00	0.86	0.86	0.00	8.15	0.10
1	3	50.89	0.00	0.00	0.00	6.97	14.46	0.50	0.69	0.01	1.07	2.27	0.00	0.85	0.85	0.00	8.08	0.15
1	4	49.49	0.00	0.00	0.00	7.26	14.21	0.50	0.68	0.01	1.09	2.29	0.00	0.84	0.84	0.00	8.02	0.19
1	5	48.23	0.00	0.00	0.00	7.53	13.97	0.50	0.67	0.01	1.11	2.30	0.00	0.82	0.82	0.00	7.95	0.24
1	6	47.08	0.00	0.00	0.00	7.79	13.74	0.51	0.65	0.02	1.13	2.31	0.00	0.81	0.81	0.00	7.89	0.28
2	1	46.11	0.00	0.00	0.00	7.95	13.50	0.51	0.64	0.02	1.15	2.32	0.00	0.80	0.80	0.00	7.83	0.32
2	2	45.25	0.00	0.00	0.00	7.96	13.26	0.51	0.63	0.02	1.17	2.33	0.00	0.79	0.79	0.00	7.77	0.36
2	3	44.47	0.00	0.00	0.00	7.97	13.04	0.51	0.62	0.02	1.19	2.35	0.00	0.78	0.78	0.00	7.71	0.40
2	4	43.75	0.00	0.00	0.00	7.99	12.82	0.51	0.61	0.03	1.21	2.36	0.00	0.77	0.77	0.00	7.65	0.44
2	5	43.08	0.00	0.00	0.00	8.02	12.61	0.51	0.60	0.03	1.23	2.37	0.00	0.76	0.76	0.00	7.59	0.48
2	6	42.46	0.00	0.00	0.00	8.05	12.40	0.51	0.59	0.03	1.24	2.38	0.00	0.75	0.75	0.00	7.54	0.51
2	7	41.89	0.00	0.00	0.00	8.08	12.21	0.51	0.59	0.03	1.26	2.39	0.00	0.74	0.74	0.00	7.48	0.55
2	8	41.37	0.00	0.00	0.00	8.11	12.02	0.51	0.58	0.03	1.28	2.40	0.00	0.73	0.73	0.00	7.43	0.58
2	9	40.88	0.00	0.00	0.00	8.15	11.84	0.51	0.57	0.03	1.29	2.40	0.00	0.72	0.72	0.00	7.38	0.61
2	10	40.42	0.00	0.00	0.00	8.19	11.66	0.51	0.56	0.04	1.31	2.41	0.00	0.71	0.71	0.00	7.33	0.65
3	1	40.12	0.00	0.00	0.00	8.25	11.51	0.51	0.55	0.04	1.32	2.42	0.00	0.70	0.70	0.00	7.29	0.68
3	2	39.92	0.00	0.00	0.00	8.31	11.36	0.51	0.55	0.04	1.34	2.43	0.00	0.70	0.70	0.00	7.25	0.71
3	3	39.73	0.00	0.00	0.00	8.37	11.23	0.51	0.54	0.04	1.35	2.44	0.00	0.69	0.69	0.00	7.21	0.74
3	4	39.55	0.00	0.00	0.00	8.43	11.09	0.51	0.53	0.04	1.36	2.45	0.00	0.68	0.68	0.00	7.17	0.77
3	5	39.38	0.00	0.00	0.00	8.48	10.96	0.51	0.53	0.04	1.38	2.45	0.00	0.67	0.67	0.00	7.13	0.79
3	6	39.22	0.00	0.00	0.00	8.54	10.84	0.51	0.52	0.04	1.39	2.46	0.00	0.66	0.66	0.00	7.10	0.82
3	7	39.06	0.00	0.00	0.00	8.59	10.71	0.51	0.51	0.04	1.40	2.47	0.00	0.66	0.66	0.00	7.06	0.85
3	8	38.91	0.00	0.00	0.00	8.65	10.59	0.52	0.51	0.04	1.41	2.48	0.00	0.65	0.65	0.00	7.03	0.87
3	9	38.77	0.00	0.00	0.00	8.70	10.48	0.52	0.50	0.04	1.42	2.48	0.00	0.64	0.64	0.00	6.99	0.90
3	10	38.63	0.00	0.00	0.00	8.75	10.36	0.52	0.50	0.04	1.43	2.49	0.00	0.64	0.64	0.00	6.96	0.92
3	11	38.50	0.00	0.00	0.00	8.81	10.25	0.52	0.49	0.04	1.45	2.50	0.00	0.63	0.63	0.00	6.93	0.95
3	12	38.37	0.00	0.00	0.00	8.86	10.15	0.52	0.49	0.04	1.46	2.50	0.00	0.63	0.63	0.00	6.90	0.97
3	13	38.25	0.00	0.00	0.00	8.91	10.04	0.52	0.48	0.04	1.47	2.51	0.00	0.62	0.62	0.00	6.87	0.99
3	14	38.14	0.00	0.00	0.00	8.96	9.94	0.52	0.48	0.04	1.48	2.52	0.00	0.61	0.61	0.00	6.84	1.01
4	1	37.95	0.00	0.00	0.00	9.14	9.84	0.52	0.47	0.04	1.49	2.52	0.00	0.61	0.61	0.00	6.81	1.04
4	2	37.62	0.00	0.00	0.00	9.42	9.75	0.52	0.47	0.04	1.50	2.53	0.00	0.60	0.60	0.00	6.78	1.06
4	3	37.31	0.00	0.00	0.00	9.69	9.65	0.52	0.46	0.04	1.51	2.53	0.00	0.60	0.60	0.00	6.75	1.06
4	4	37.02	0.00	0.00	0.00	9.93	9.56	0.52	0.46	0.04	1.52	2.54	0.00	0.59	0.59	0.00	6.73	1.10
4	5	36.74	0.00	0.00	0.00	10.15	9.47	0.52	0.45	0.04	1.53	2.55	0.00	0.59	0.59	0.00	6.70	1.11
4	6	36.49	0.00	0.00	0.00	10.36	9.38	0.52	0.45	0.04	1.53	2.55	0.00	0.58	0.58	0.00	6.67	1.13
4	7	36.25	0.00	0.00	0.00	10.55	9.30	0.52	0.45	0.04	1.54	2.56	0.00	0.57	0.57	0.00	6.65	1.15
4	8	36.03	0.00	0.00	0.00	10.72	9.22	0.52	0.44	0.04	1.55	2.56	0.00	0.57	0.57	0.00	6.62	1.17
4	9	35.82	0.00	0.00	0.00	10.89	9.14	0.52	0.44	0.04	1.56	2.57	0.00	0.57	0.57	0.00	6.60	1.19
5	1	35.66	0.00	0.00	0.00	11.00	9.06	0.52	0.43	0.04	1.57	2.57	0.00	0.56	0.56	0.00	6.58	1.21
5	2	35.55	0.00	0.00	0.00	11.06	8.98	0.52	0.43	0.04	1.58	2.58	0.00	0.56	0.56	0.00	6.55	1.22
5	3	35.43	0.00	0.00	0.00	11.12	8.91	0.52	0.43	0.04	1.58	2.58	0.00	0.55	0.55	0.00	6.53	1.24
5	4	35.33	0.00	0.00	0.00	11.17	8.84	0.52	0.42	0.04	1.59	2.59	0.00	0.55	0.55	0.00	6.51	1.26
5	5	35.22	0.00	0.00	0.00	11.23	8.76	0.52	0.42	0.04	1.60	2.59	0.00	0.54	0.54	0.00	6.49	1.27
5	6	35.13	0.00	0.00	0.00	11.28	8.70	0.53	0.42	0.04	1.61	2.59	0.00	0.54	0.54	0.00	6.47	1.29
5	7	35.04	0.00	0.00	0.00	11.33	8.62	0.53	0.41	0.04	1.61	2.60	0.00	0.53	0.53	0.00	6.45	1.30
6	1	43.10	0.00	0.00	0.00	7.12	3.99	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.70
6	2	42.80	0.00	0.00	0.00	7.25	3.98	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.71
7	1	40.61	0.00	0.00	0.00	8.40	5.19	0.59	0.20	0.01	2.12	2.92	0.00	0.24	0.24	0.00	5.37	2.34
7	2	40.43	0.00	0.00	0.00	8.50	5.17	0.59	0.20	0.01	2.12	2.92	0.00	0.24	0.24	0.00	5.36	2.34
7	3	40.25	0.00	0.00	0.00	8.59	5.16	0.59	0.20	0.01	2.12	2.92	0.00	0.24	0.24	0.00	5.36	2.35
7	4	40.08	0.00	0.00	0.00	8.67	5.15	0.59	0.20	0.01	2.12	2.92	0.00	0.24	0.24	0.00	5.35	2.35
7	5	39.91	0.00	0.00	0.00	8.76	5.13	0.59	0.20	0.01	2.12	2.92	0.00	0.24	0.24	0.00	5.35	2.35
7	6	39.74	0.00	0.00	0.00	8.85	5.12	0.59	0.20	0.01	2.12	2.92	0.00	0.24	0.24	0.00	5.34	2.36
7	7	39.58	0.00	0.00	0.00	8.93	5.11	0.59	0.20	0.01	2.12	2.92	0.00	0.24	0.24	0.00	5.34	2.36
7	8	39.42	0.00	0.00	0.00	9.01	5.10	0.59	0.20	0.01	2.12	2.92	0.00	0.24	0.24	0.00	5.34	2.36
7	9	39.26	0.00	0.00	0.00	9.10	5.08	0.59	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.33	2.37
7	10	39.10	0.00	0.00	0.00	9.18	5.07	0.59	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.33	2.37
7	11	38.95	0.00	0.00	0.00	9.25	5.06	0.59	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.32	2.37
7	12	38.79	0.00	0.00	0.00	9.33	5.05	0.59	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.32	2.37
7	13	38.65	0.00	0.00	0.00	9.41	5.03	0.58	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.31	2.38
7	14	38.50	0.00	0.00	0.00	9.48	5.02	0.58	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.31	2.38
7	15	38.35	0.00	0.00	0.00	9.55	5.01	0.58	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.30	2.38
7	16	38.21	0.00	0.00	0.00	9.63	5.00	0.58	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.30	2.39
7	17	38.07	0.00	0.00	0.00	9.70	4.99	0.58	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.29	2.39
7	18	37.93	0.00	0.00	0.00	9.77	4.97	0.58	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.29	2.39
7	19	37.80	0.00	0.00	0.00	9.84	4.96	0.58	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.28	2.40
7	20	37.66	0.00	0.00	0.00	9.90	4.95	0.58	0.20	0.02	2.12	2.92	0.00	0.24	0.24	0.00	5.28	2.40

***** STEADY STATE SIMULATION *****

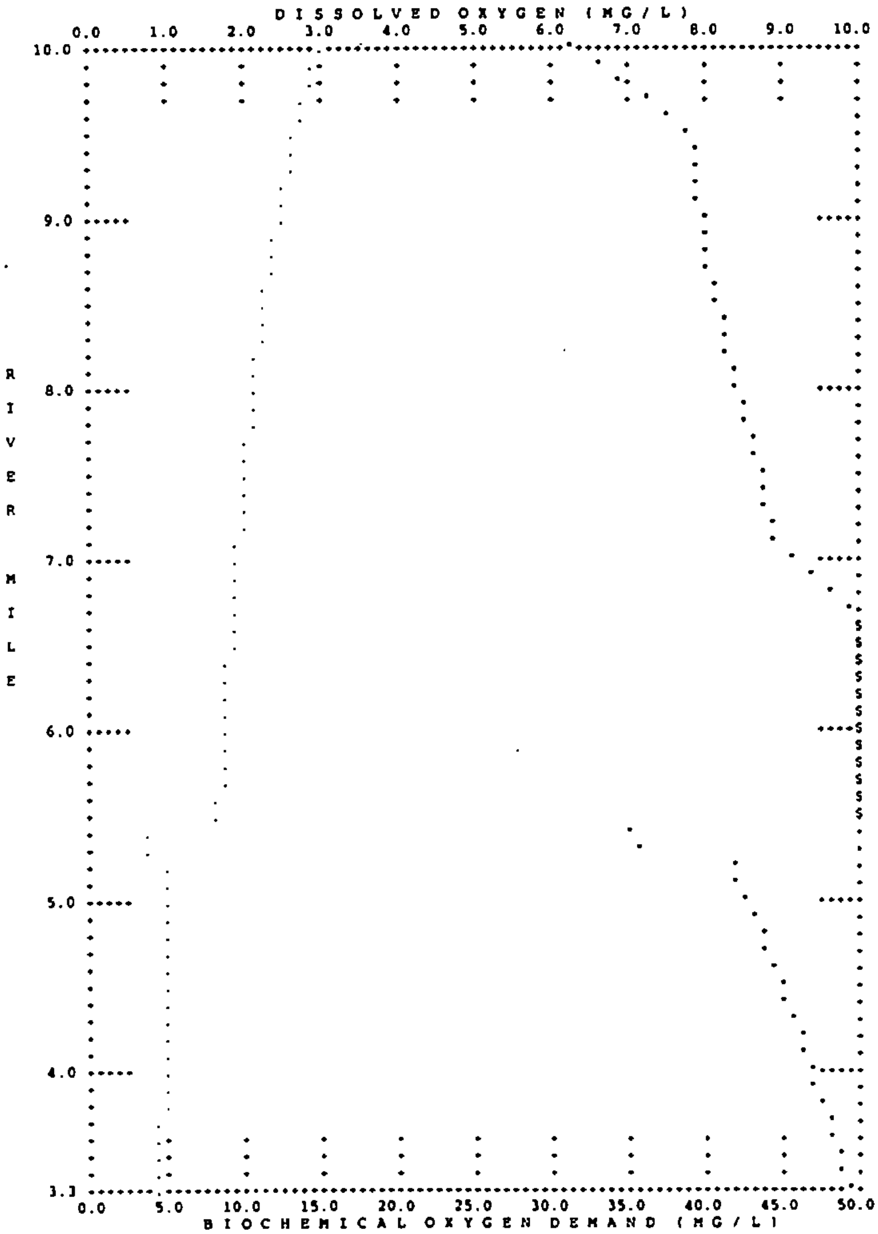
** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.05	0.53	0.07	0.08	5.98	0.00	0.90	0.86	0.02	0.37	0.85	0.96
2	1	2	0.10	0.50	0.07	0.08	5.98	0.00	0.90	0.86	0.02	0.37	0.85	0.96
3	1	3	0.15	0.48	0.06	0.08	5.98	0.00	0.90	0.85	0.03	0.37	0.85	0.95
4	1	4	0.19	0.47	0.06	0.08	5.99	0.00	0.90	0.85	0.03	0.37	0.86	0.95
5	1	5	0.24	0.45	0.06	0.08	5.99	0.00	0.90	0.84	0.03	0.37	0.86	0.95
6	1	6	0.28	0.44	0.06	0.08	5.99	0.00	0.90	0.84	0.04	0.37	0.86	0.95
7	2	1	0.32	0.43	0.06	0.07	5.99	0.00	0.90	0.83	0.04	0.37	0.86	0.95
8	2	2	0.36	0.42	0.06	0.07	5.98	0.00	0.90	0.83	0.04	0.37	0.86	0.95
9	2	3	0.40	0.41	0.05	0.07	5.98	0.00	0.90	0.82	0.04	0.37	0.86	0.95
10	2	4	0.44	0.40	0.05	0.07	5.98	0.00	0.90	0.82	0.05	0.37	0.86	0.95
11	2	5	0.48	0.40	0.05	0.07	5.98	0.01	0.90	0.82	0.05	0.37	0.86	0.95
12	2	6	0.51	0.39	0.05	0.07	5.98	0.01	0.90	0.81	0.05	0.37	0.86	0.95
13	2	7	0.55	0.38	0.05	0.07	5.98	0.01	0.90	0.81	0.05	0.37	0.86	0.95
14	2	8	0.58	0.38	0.05	0.07	5.98	0.01	0.90	0.80	0.05	0.37	0.86	0.95
15	2	9	0.61	0.37	0.05	0.07	5.98	0.01	0.90	0.80	0.05	0.37	0.86	0.95
16	2	10	0.65	0.37	0.05	0.07	5.98	0.01	0.90	0.79	0.06	0.37	0.86	0.95
17	3	1	0.68	0.37	0.05	0.07	5.98	0.01	0.90	0.79	0.06	0.37	0.86	0.95
18	3	2	0.71	0.36	0.05	0.07	5.98	0.01	0.90	0.79	0.06	0.37	0.86	0.95
19	3	3	0.74	0.36	0.05	0.07	5.98	0.01	0.90	0.78	0.06	0.37	0.86	0.95
20	3	4	0.77	0.36	0.05	0.07	5.98	0.01	0.90	0.78	0.06	0.37	0.86	0.94
21	3	5	0.79	0.36	0.05	0.07	5.98	0.01	0.90	0.78	0.06	0.37	0.86	0.94
22	3	6	0.82	0.36	0.05	0.07	5.97	0.01	0.90	0.77	0.06	0.37	0.86	0.94
23	3	7	0.85	0.36	0.05	0.07	5.97	0.01	0.90	0.77	0.07	0.37	0.86	0.94
24	3	8	0.87	0.36	0.05	0.07	5.97	0.01	0.90	0.76	0.07	0.37	0.86	0.94
25	3	9	0.90	0.35	0.05	0.07	5.97	0.01	0.90	0.76	0.07	0.37	0.87	0.94
26	3	10	0.92	0.35	0.05	0.07	5.97	0.01	0.90	0.76	0.07	0.37	0.87	0.94
27	3	11	0.95	0.35	0.05	0.07	5.97	0.01	0.90	0.75	0.07	0.37	0.87	0.94
28	3	12	0.97	0.35	0.05	0.07	5.97	0.01	0.90	0.75	0.07	0.37	0.87	0.94
29	3	13	0.99	0.35	0.05	0.07	5.96	0.01	0.90	0.75	0.07	0.37	0.87	0.94
30	3	14	1.01	0.35	0.05	0.07	5.96	0.01	0.90	0.74	0.07	0.37	0.87	0.94
31	4	1	1.04	0.35	0.05	0.07	5.97	0.01	0.90	0.74	0.07	0.37	0.87	0.94
32	4	2	1.06	0.34	0.05	0.07	5.96	0.01	0.90	0.74	0.08	0.37	0.87	0.94
33	4	3	1.08	0.34	0.05	0.07	5.96	0.01	0.90	0.73	0.08	0.37	0.87	0.94
34	4	4	1.10	0.34	0.05	0.07	5.96	0.01	0.90	0.73	0.08	0.37	0.87	0.94
35	4	5	1.11	0.34	0.05	0.07	5.96	0.01	0.90	0.73	0.08	0.37	0.87	0.94
36	4	6	1.13	0.33	0.04	0.07	5.96	0.01	0.90	0.73	0.08	0.37	0.87	0.94
37	4	7	1.15	0.33	0.04	0.07	5.96	0.01	0.90	0.72	0.08	0.37	0.87	0.93
38	4	8	1.17	0.33	0.04	0.07	5.96	0.01	0.90	0.72	0.08	0.37	0.87	0.93
39	4	9	1.19	0.33	0.04	0.07	5.95	0.01	0.90	0.72	0.08	0.37	0.87	0.93
40	5	1	1.21	0.33	0.04	0.07	5.95	0.01	0.90	0.71	0.08	0.37	0.87	0.93
41	5	2	1.22	0.32	0.04	0.07	5.95	0.01	0.90	0.71	0.08	0.37	0.87	0.93
42	5	3	1.24	0.32	0.04	0.07	5.95	0.01	0.90	0.71	0.08	0.37	0.87	0.93
43	5	4	1.26	0.32	0.04	0.06	5.95	0.01	0.90	0.71	0.08	0.37	0.87	0.93
44	5	5	1.27	0.32	0.04	0.06	5.94	0.01	0.90	0.70	0.08	0.37	0.87	0.93
45	5	6	1.29	0.32	0.04	0.06	5.94	0.01	0.90	0.70	0.09	0.37	0.87	0.93
46	5	7	1.30	0.32	0.04	0.06	5.94	0.01	0.90	0.70	0.09	0.37	0.87	0.93
47	6	1	2.70	0.33	0.05	0.07	4.98	0.02	0.90	0.32	0.14	0.37	0.89	0.76
48	6	2	2.71	0.33	0.05	0.07	4.98	0.02	0.90	0.32	0.14	0.37	0.89	0.76
49	7	1	2.34	0.34	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
50	7	2	2.34	0.34	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
51	7	3	2.35	0.34	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
52	7	4	2.35	0.34	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
53	7	5	2.35	0.34	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
54	7	6	2.36	0.34	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
55	7	7	2.36	0.34	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
56	7	8	2.36	0.33	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
57	7	9	2.37	0.33	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
58	7	10	2.37	0.33	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
59	7	11	2.37	0.33	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
60	7	12	2.37	0.33	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
61	7	13	2.38	0.33	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
62	7	14	2.38	0.33	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
63	7	15	2.38	0.32	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
64	7	16	2.39	0.32	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
65	7	17	2.39	0.32	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
66	7	18	2.39	0.32	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
67	7	19	2.40	0.32	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86
68	7	20	2.40	0.32	0.05	0.07	5.54	0.02	0.90	0.46	0.13	0.37	0.89	0.86

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
1	1	1	54.17	10.41	6.34	4.07	0.00	0.98	620.28	43.40	-8.43	0.00	0.00	-1.33	0.00
2	1	2	52.44	10.64	6.67	3.97	0.00	0.98	13.37	41.56	-7.92	0.00	0.00	-1.21	-0.01
3	1	3	50.89	10.86	6.97	3.88	0.00	0.98	13.21	39.98	-7.47	0.00	0.00	-1.11	-0.01
4	1	4	49.49	11.06	7.26	3.80	0.00	0.99	13.05	38.53	-7.09	0.00	0.00	-1.03	-0.01
5	1	5	48.23	11.24	7.53	3.71	0.00	0.99	12.90	37.20	-6.74	0.00	0.00	-0.96	-0.01
6	1	6	47.08	11.42	7.79	3.63	0.00	0.99	12.75	35.96	-6.44	0.00	0.00	-0.90	-0.01
7	2	1	46.11	11.57	7.95	3.62	0.00	0.99	8.59	21.91	-6.18	0.00	0.00	-0.85	-0.01
8	2	2	45.25	11.71	7.96	3.75	0.00	0.99	8.50	8.52	-5.94	0.00	0.00	-0.80	-0.01
9	2	3	44.47	11.83	7.97	3.86	0.00	0.99	8.41	8.73	-5.72	0.00	0.00	-0.76	-0.02
10	2	4	43.75	11.95	7.99	3.96	0.00	0.99	8.32	8.92	-5.52	0.00	0.00	-0.73	-0.02
11	2	5	43.08	12.06	8.02	4.05	0.00	0.99	8.24	9.08	-5.34	0.00	0.01	-0.69	-0.02
12	2	6	42.46	12.17	8.05	4.12	0.00	0.99	8.16	9.22	-5.17	0.00	0.01	-0.66	-0.02
13	2	7	41.89	12.27	8.08	4.19	0.00	0.99	8.08	9.35	-5.01	0.00	0.01	-0.64	-0.02
14	2	8	41.37	12.36	8.11	4.25	0.00	0.99	8.00	9.45	-4.87	0.00	0.01	-0.61	-0.02
15	2	9	40.88	12.45	8.15	4.30	0.00	0.99	7.93	9.55	-4.74	0.00	0.01	-0.59	-0.02
16	2	10	40.42	12.53	8.19	4.34	0.00	0.99	7.85	9.62	-4.61	0.00	0.01	-0.57	-0.02
17	3	1	40.12	12.59	8.25	4.34	0.00	0.99	12.50	12.18	-4.52	0.00	0.01	-0.56	-0.02
18	3	2	39.92	12.62	8.31	4.31	0.00	0.99	12.37	14.65	-4.44	0.00	0.01	-0.55	-0.02
19	3	3	39.73	12.66	8.37	4.29	0.00	0.99	12.25	14.57	-4.36	0.00	0.01	-0.54	-0.02
20	3	4	39.55	12.69	8.43	4.26	0.00	0.99	12.13	14.49	-4.29	0.00	0.01	-0.53	-0.02
21	3	5	39.38	12.72	8.48	4.24	0.00	0.99	12.01	14.40	-4.22	0.00	0.01	-0.52	-0.02
22	3	6	39.22	12.75	8.54	4.21	0.00	0.99	11.90	14.32	-4.16	0.00	0.01	-0.51	-0.02
23	3	7	39.06	12.78	8.59	4.19	0.00	0.99	11.79	14.23	-4.09	0.00	0.01	-0.50	-0.02
24	3	8	38.91	12.81	8.65	4.16	0.00	0.99	11.68	14.15	-4.03	0.00	0.01	-0.49	-0.02
25	3	9	38.77	12.84	8.70	4.13	0.00	0.99	11.57	14.06	-3.97	0.00	0.01	-0.48	-0.02
26	3	10	38.63	12.86	8.75	4.11	0.00	0.99	11.47	13.98	-3.92	0.00	0.01	-0.47	-0.02
27	3	11	38.50	12.89	8.81	4.08	0.00	0.99	11.36	13.89	-3.86	0.00	0.01	-0.46	-0.02
28	3	12	38.37	12.91	8.86	4.05	0.00	1.00	11.26	13.81	-3.81	0.00	0.01	-0.46	-0.02
29	3	13	38.25	12.93	8.91	4.03	0.00	1.00	11.17	13.72	-3.76	0.00	0.01	-0.45	-0.02
30	3	14	38.14	12.96	8.96	4.00	0.00	1.00	11.07	13.64	-3.71	0.00	0.01	-0.44	-0.02
31	4	1	37.95	12.99	9.14	3.85	0.00	1.00	11.46	31.28	-3.66	0.00	0.01	-0.43	-0.02
32	4	2	37.62	13.06	9.42	3.63	0.00	1.00	11.37	46.49	-3.59	0.00	0.01	-0.42	-0.02
33	4	3	37.31	13.12	9.69	3.43	0.00	1.00	11.29	43.88	-3.53	0.00	0.01	-0.41	-0.02
34	4	4	37.02	13.17	9.93	3.25	0.00	1.00	11.20	41.51	-3.47	0.00	0.01	-0.41	-0.02
35	4	5	36.74	13.23	10.15	3.08	0.00	1.00	11.12	39.34	-3.41	0.00	0.01	-0.40	-0.02
36	4	6	36.49	13.28	10.36	2.92	0.00	1.00	11.04	37.36	-3.36	0.00	0.01	-0.39	-0.02
37	4	7	36.25	13.33	10.55	2.78	0.00	1.00	10.96	35.54	-3.31	0.00	0.01	-0.38	-0.02
38	4	8	36.03	13.37	10.72	2.65	0.00	1.00	10.88	33.87	-3.26	0.00	0.01	-0.37	-0.02
39	4	9	35.82	13.41	10.89	2.52	0.00	1.00	10.81	32.34	-3.21	0.00	0.01	-0.37	-0.02
40	5	1	35.66	13.44	11.00	2.45	0.00	1.00	11.18	25.26	-3.17	0.00	0.01	-0.36	-0.02
41	5	2	35.55	13.47	11.06	2.41	0.00	1.00	11.10	18.88	-3.14	0.00	0.01	-0.36	-0.02
42	5	3	35.43	13.49	11.12	2.37	0.00	1.00	11.02	18.61	-3.10	0.00	0.01	-0.35	-0.02
43	5	4	35.33	13.51	11.17	2.34	0.00	1.00	10.94	18.35	-3.07	0.00	0.01	-0.35	-0.02
44	5	5	35.22	13.53	11.23	2.31	0.00	1.00	10.86	18.10	-3.04	0.00	0.01	-0.34	-0.02
45	5	6	35.13	13.55	11.28	2.27	0.00	1.00	10.79	17.86	-3.00	0.00	0.01	-0.34	-0.02
46	5	7	35.04	13.57	11.33	2.24	0.00	1.00	10.71	17.64	-2.97	0.00	0.01	-0.34	-0.02
47	6	1	43.10	12.06	7.12	4.94	0.00	0.99	959.81	18.76	-1.69	0.00	0.02	-0.14	0.00
48	6	2	42.80	12.11	7.25	4.87	0.00	0.99	0.00	18.42	-1.67	0.00	0.02	-0.14	0.00
49	7	1	40.61	12.50	8.40	4.09	0.00	0.99	0.00	20.82	-2.06	0.00	0.02	-0.20	-0.01
50	7	2	40.43	12.53	8.50	4.03	0.00	0.99	0.00	16.47	-2.05	0.00	0.02	-0.20	-0.01
51	7	3	40.25	12.56	8.59	3.97	0.00	0.99	0.00	16.20	-2.03	0.00	0.02	-0.20	-0.01
52	7	4	40.08	12.59	8.67	3.92	0.00	0.99	0.00	15.93	-2.02	0.00	0.02	-0.20	-0.01
53	7	5	39.91	12.62	8.76	3.86	0.00	0.99	0.00	15.66	-2.01	0.00	0.02	-0.20	-0.01
54	7	6	39.74	12.65	8.85	3.81	0.00	1.00	0.00	15.41	-1.99	0.00	0.02	-0.20	-0.01
55	7	7	39.58	12.68	8.93	3.75	0.00	1.00	0.00	15.16	-1.98	0.00	0.02	-0.20	-0.01
56	7	8	39.42	12.71	9.01	3.70	0.00	1.00	0.00	14.91	-1.97	0.00	0.02	-0.19	-0.01
57	7	9	39.26	12.74	9.10	3.65	0.00	1.00	0.00	14.67	-1.95	0.00	0.02	-0.19	-0.01
58	7	10	39.10	12.77	9.18	3.60	0.00	1.00	0.00	14.44	-1.94	0.00	0.02	-0.19	-0.01
59	7	11	38.95	12.80	9.25	3.55	0.00	1.00	0.00	14.21	-1.93	0.00	0.02	-0.19	-0.01
60	7	12	38.79	12.83	9.33	3.50	0.00	1.00	0.00	13.99	-1.92	0.00	0.02	-0.19	-0.01
61	7	13	38.65	12.86	9.41	3.45	0.00	1.00	0.00	13.77	-1.90	0.00	0.02	-0.19	-0.01
62	7	14	38.50	12.89	9.48	3.41	0.00	1.00	0.00	13.56	-1.89	0.00	0.02	-0.19	-0.01
63	7	15	38.35	12.91	9.55	3.36	0.00	1.00	0.00	13.35	-1.88	0.00	0.02	-0.19	-0.01
64	7	16	38.21	12.94	9.63	3.32	0.00	1.00	0.00	13.15	-1.87	0.00	0.02	-0.19	-0.01
65	7	17	38.07	12.97	9.70	3.27	0.00	1.00	0.00	12.95	-1.86	0.00	0.02	-0.18	-0.01
66	7	18	37.93	13.00	9.77	3.23	0.00	1.00	0.00	12.76	-1.85	0.00	0.02	-0.18	-0.01
67	7	19	37.80	13.02	9.84	3.19	0.00	1.00	0.00	12.57	-1.84	0.00	0.02	-0.18	-0.01
68	7	20	37.66	13.05	9.90	3.14	0.00	1.00	0.00	12.38	-1.82	0.00	0.02	-0.18	-0.01



DISSOLVED OXYGEN * * * * *

BIOCHEMICAL OXYGEN DEMAND * . . . . .

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                    * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                              Ver. 3.13 - September 1991

 $$$ (PROBLEM TITLES) $$$

CARD TYPE                           QUAL-2E PROGRAM TITLES
TITLE01              BWCUU.IN - Winter, Critical, Ultimate flow, BODU Simulation
TITLE02              NSWTP DISCHARGE TO BADGER MILL CREEK
TITLE03   NO         CONSERVATIVE MINERAL I          IN
TITLE04   NO         CONSERVATIVE MINERAL II         IN
TITLE05   NO         CONSERVATIVE MINERAL III        IN
TITLE06  YES         TEMPERATURE
TITLE07  YES         BIOCHEMICAL OXYGEN DEMAND (Ultimate)
TITLE08  YES         ALGAE AS CHL-A IN UG/L
TITLE09  YES         PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                (ORGANIC-P, DISSOLVED-P)
TITLE11  YES         NITROGEN CYCLE AS N IN MG/L
TITLE12                (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
TITLE13  YES         DISSOLVED OXYGEN IN MG/L
TITLE14   NO         FECAL COLIFORMS IN NO./100 ML
TITLE15  YES         ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS.mg/l
ENDTITLE

 $$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                      CARD TYPE
LIST DATA INPUT                 0.00000                                        0.00000
WRITE OPTIONAL SUMMARY          0.00000                                        0.00000
NO FLOW AUGMENTATION            0.00000                                        0.00000
STEADY STATE                    0.00000                                        0.00000
TRAPEZOIDAL X-SECTIONS          0.00000                                        0.00000
PRINT LCD/SOLAR DATA            0.00000                                        0.00000
PLOT DO AND BOD                 0.00000                                        0.00000
FIXED DNSTM COND (YES=1)=       0.00000        5D-ULT BOD CONV K COEF  =       0.23000
INPUT METRIC (YES=1)     =      0.00000        OUTPUT METRIC (YES=1)   =       0.00000
NUMBER OF REACHES        =      7.00000        NUMBER OF JUNCTIONS     =       1.00000
NUM OF HEADWATERS        =      2.00000        NUMBER OF POINT LOADS   =       0.00000
TIME STEP (HOURS)        =      1.00000        LNTH  COMP  ELEMENT (DX)=       0.10000
MAXIMUM ROUTE TIME (HRS)=     288.00000        TIME INC. FOR RPT2 (HRS)=       1.00000
LATITUDE OF BASIN (DEG) =      43.10000        LONGITUDE OF BASIN (DEG)=      89.30000
STANDARD MERIDIAN (DEG) =      75.00000        DAY OF YEAR START TIME  =      15.00000
EVAP. COEFF. (AE)        =      0.00068        EVAP. COEFF. (BE)       =       0.00027
ELEV. OF BASIN (ELEV)    =    937.00000        DUST ATTENUATION COEF.  =       0.06000
ENDATA1                         0.00000                                        0.00000

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                         CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=      3.5000      O UPTAKE BY NO2 OXID(MG O/MG N)=       1.2000
O PROD  BY ALGAE (MG O/MG A)    =     1.6000      O UPTAKE BY ALGAE (MG O/MG A)   =      2.0000
N CONTENT OF ALGAE (MG N/MG A)  =     0.0850      P CONTENT OF ALGAE (MG P/MG A)  =      0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=      2.5000      ALGAE RESPIRATION RATE (1/DAY)  =      0.1000
N HALF SATURATION CONST  (MG/L)=      0.3000      P HALF SATURATION CONST  (MG/L)=       0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)      0.0088      NLIN SHADE(1/FT-(UGCHA/L)**2/3)=       0.0540
LIGHT FUNCTION OPTION (LFNOPT)  =     1.0000      LIGHT SAT'N COEF (BTU/FT2-MIN)  =      0.0300
DAILY AVERAGING OPTION (LAVOPT)=      2.0000      LIGHT AVERAGING FACTOR (AFACT)  =      0.9200
NUMBER OF DAYLIGHT HOURS (DLH)  =    10.0000      TOTAL DAILY SOLR RAD (BTU/FT-2)=     400.0000
ALGY GROWTH CALC OPTION(LGROPT)=      1.0000      ALGAL PREF FOR NH3-N (PREFN)    =      0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=      0.4500      NITRIFICATION INHIBITION COEF   =      0.6000
ENDATA1A                              0.0000                                             0.0000

 $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE     RATE CODE     THETA VALUE

THETA( 1)     BOD DECA        1.047     DFLT
THETA( 2)     BOD SETT        1.024     DFLT
THETA( 3)     OXY TRAN        1.024     DFLT
THETA( 4)     SOD RATE        1.060     DFLT
THETA( 5)     ORGN DEC        1.047     DFLT
THETA( 6)     ORGN SET        1.024     DFLT
THETA( 7)     NH3 DECA        1.083     DFLT
THETA( 8)     NH3 SRCE        1.074     DFLT
THETA( 9)     NO2 DECA        1.047     DFLT
THETA(10)     PORG DEC        1.047     DFLT
THETA(11)     PORG SET        1.024     DFLT
THETA(12)     DISP SRC        1.074     DFLT
THETA(13)     ALG GROW        1.047     DFLT
THETA(14)     ALG RESP        1.047     DFLT
THETA(15)     ALG SETT        1.024     DFLT
THETA(16)     COLI DEC        1.047     DFLT
THETA(17)     ANC DECA        1.000     DFLT
THETA(18)     ANC SETT        1.024     DFLT
THETA(19)     ANC SRCE        1.000     DFLT
ENDATA1B

 $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE          REACH ORDER AND IDENT                  R. MI/KM              R. MI/KM
STREAM REACH     1.0  RCH= HWY 151-PB          FROM        10.0      TO           9.4
STREAM REACH     2.0  RCH= PB-Lincoln          FROM         9.4      TO           8.4
STREAM REACH     3.0  RCH= Lincoln-151 By      FROM         8.4      TO           7.0
STREAM REACH     4.0  RCH= 151 By-HWY 69       FROM         7.0      TO           6.1
STREAM REACH     5.0  RCH= HWY 69-Sugar R      FROM         6.1      TO           5.4
STREAM REACH     6.0  RCH= Upstrm Sugar R      FROM         5.6      TO           5.4
STREAM REACH     7.0  RCH= Dnstrm Sugar R      FROM         5.4      TO           3.4
ENDATA2          0.0                                        0.0                   0.0

 $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE                 REACH  AVAIL HDWS TARGET     ORDER OF AVAIL SOURCES
ENDATA3                     0.        0.        0.0   0.   0.   0.   0.   0.   0.

 $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE          REACH ELEMENTS/REACH              COMPUTATIONAL FLAGS
FLAG FIELD           1.        6.           1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD           2.       10.           2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD           3.       14.           2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
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FLAG FIELD	4.	9.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CMANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	2.	945.00	0.13	0.10	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	3.	935.00	0.13	0.20	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	4.	925.00	0.13	0.05	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	5.	915.00	0.13	0.00	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	6.	910.00	0.13	0.05	40.00	40.00	29.10	15.40	1.00
TEMP/LCD	7.	910.00	0.13	0.05	40.00	40.00	29.10	15.40	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	OR EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	40.00	7.00	8.40	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	2.	40.00	7.00	8.40	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	3.	40.00	7.00	8.40	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	4.	40.00	7.00	8.40	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	5.	40.00	7.00	8.40	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	6.	40.00	7.00	8.40	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	7.	40.00	7.00	8.40	0.00	0.00	0.00	10.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	5.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

INCR INFLOW-2	1.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	2.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	3.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	4.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	5.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC=Sugar R Confluen	46.	49.	48.
ENDATA9	0.		0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	NSWTPOutfall	5.60	50.00	5.00	32.10	0.00	0.00	0.00
HEADWTR-1	2.	Sugar River	7.80	40.00	7.00	8.40	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	12.30	0.00	0.00	0.50	1.97	0.00	1.00	0.00	0.89
HEADWTR-2	2.	10.00	0.00	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
ENDATA11A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

	DAM	RCH	ELE	ADAM	BDAM	FDAM	HDAM
ENDATA12	0.	0.	0.	0.00	0.00	0.00	0.00

$$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

CARD TYPE	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI

ENDATA13 DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P

ENDATA13A DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS

TEMPERATURE ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	49.37	48.77	48.19	47.63	47.10	46.59														
2	46.14	45.73	45.33	44.95	44.59	44.23	43.89	43.56	43.25	42.94										
3	42.72	42.56	42.40	42.25	42.10	41.95	41.80	41.66	41.52	41.39	41.26	41.12	41.00	40.87						
4	40.70	40.42	40.15	39.90	39.65	39.42	39.20	38.99	38.79											
5	38.63	38.49	38.36	38.23	38.11	37.99	37.88													
6	39.74	39.49																		
7	38.72	38.60	38.49	38.38	38.27	38.17	38.07	37.97	37.87	37.78	37.69	37.61	37.52	37.44	37.36	37.29	37.21	37.14	37.07	37.01

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TEMPERATURE ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	49.35	48.74	48.15	47.58	47.05	46.53														
2	46.08	45.67	45.28	44.90	44.54	44.18	43.85	43.52	43.20	42.90										
3	42.68	42.52	42.36	42.21	42.06	41.91	41.77	41.63	41.49	41.35	41.22	41.09	40.97	40.84						
4	40.67	40.39	40.12	39.87	39.63	39.40	39.17	38.96	38.76											
5	38.60	38.46	38.32	38.19	38.07	37.95	37.83													
6	39.74	39.49																		
7	38.69	38.58	38.46	38.35	38.24	38.13	38.03	37.93	37.83	37.74	37.64	37.55	37.47	37.38	37.30	37.22	37.14	37.07	37.00	36.93

2 0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 9.2

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	0.00	9	0.00	17	0.00.
2	0.00	10	0.00	18	0.00
3	0.00	11	0.00	19	0.00
4	0.00	12	0.00	20	0.00
5	0.00	13	0.00	21	0.00
6	0.00	14	0.00	22	0.00
7	0.00	15	0.00	23	0.00
8	0.00	16	0.00	24	0.00

BIOCHEMICAL OXYGEN DEMAND (Ultimate) ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	31.97	31.84	31.71	31.59	31.47	31.35														
2	31.20	31.03	30.87	30.71	30.54	30.39	30.23	30.08	29.92	29.77										
3	29.65	29.56	29.46	29.37	29.28	29.19	29.10	29.01	28.92	28.83	28.74	28.66	28.57	28.48						
4	28.40	28.32	28.24	28.16	28.08	28.00	27.92	27.84	27.77											
5	27.69	27.62	27.55	27.47	27.40	27.33	27.25													
6	8.37	8.34																		
7	16.21	16.16	16.11	16.06	16.01	15.97	15.92	15.87	15.82	15.77	15.73	15.68	15.63	15.58	15.54	15.49	15.45	15.40	15.35	15.31

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	12.28	12.27	12.25	12.24	12.22	12.21														
2	12.19	12.17	12.14	12.12	12.10	12.08	12.06	12.04	12.02	12.00										
3	11.98	11.97	11.96	11.94	11.93	11.92	11.90	11.89	11.88	11.87	11.85	11.84	11.83	11.82						
4	11.80	11.79	11.78	11.77	11.76	11.74	11.73	11.72	11.71											
5	11.70	11.69	11.68	11.66	11.65	11.64	11.63													
6	9.99	9.97																		

7	10.66	10.65	10.63	10.62	10.61	10.60	10.59	10.58	10.56	10.55	10.54	10.53	10.52	10.51	10.49	10.48	10.47	10.46	10.45	10.44

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	2.70	2.70																		
7	1.57	1.58	1.58	1.58	1.58	1.58	1.58	1.59	1.59	1.59	1.59	1.59	1.59	1.60	1.60	1.60	1.60	1.60	1.60	1.61

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.89	0.89	0.89	0.89	0.89	0.89														
2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89										
3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89						
4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89											
5	0.89	0.89	0.89	0.89	0.89	0.89	0.89													
6	0.13	0.13																		
7	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.49														
2	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.48	0.48	0.48										
3	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47						
4	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47											
5	0.47	0.46	0.46	0.46	0.46	0.46	0.46													
6	0.62	0.62																		
7	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.96	1.96	1.95	1.95	1.94	1.93														
2	1.93	1.92	1.91	1.91	1.90	1.89	1.88	1.88	1.87	1.86										
3	1.86	1.96	1.85	1.85	1.84	1.84	1.84	1.83	1.83	1.83	1.82	1.82	1.81	1.81						
4	1.81	1.80	1.80	1.80	1.79	1.79	1.79	1.78	1.78											
5	1.78	1.78	1.77	1.77	1.77	1.76	1.76													
6	0.12	0.12																		
7	0.81	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.78	0.78

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.01	0.01	0.02	0.03	0.03	0.04														
2	0.05	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.10	0.11										
3	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.16						
4	0.17	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19											
5	0.19	0.20	0.20	0.20	0.21	0.21	0.21													
6	0.00	0.00																		
7	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	1.00	1.00	1.00	1.00	1.00														
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01										
3	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01						
4	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02											
5	1.02	1.02	1.02	1.02	1.02	1.02	1.02													
6	2.30	2.30																		
7	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.37	5.72	6.05	6.36	6.64	6.91														
2	7.05	6.99	6.94	6.90	6.86	6.82	6.79	6.77	6.75	6.73										
3	6.75	6.79	6.82	6.86	6.90	6.94	6.98	7.02	7.06	7.10	7.14	7.18	7.22	7.26						
4	7.47	7.84	8.17	8.48	8.77	9.03	9.27	9.50	9.71											
5	9.85	9.93	10.01	10.08	10.16	10.23	10.30													
6	7.12	7.23																		
7	8.58	8.63	8.69	8.74	8.79	8.85	8.90	8.95	9.00	9.05	9.10	9.15	9.20	9.24	9.29	9.34	9.38	9.43	9.47	9.51

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	66
ALGAE GROWTH RATE	2	66
ALGAE GROWTH RATE	3	66
ALGAE GROWTH RATE	4	66
ALGAE GROWTH RATE	5	66
ALGAE GROWTH RATE	6	0
NITRIFICATION INHIBITION	1	0
ALGAE GROWTH RATE	7	0
NITRIFICATION INHIBITION	2	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
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1. LIGHT AVERAGING OPTION. LAVOPT= 2

METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

SOURCE OF SOLAR VALUES: DATA TYPE 1A
DAILY NET SOLAR RADIATION: 400.000 BTU/FT-2 (108.548 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 9.2
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): N/A
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS. LGROPT= 1

MULTIPLICATIVE: FL*FN*FP

TEMPERATURE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	49.35	48.74	48.15	47.58	47.05	46.53														
2	46.08	45.67	45.28	44.90	44.54	44.18	43.85	43.52	43.20	42.90										
3	42.68	42.52	42.36	42.21	42.06	41.91	41.77	41.63	41.49	41.35	41.22	41.09	40.97	40.84						
4	40.67	40.39	40.12	39.87	39.63	39.40	39.17	38.96	38.76											
5	38.60	38.46	38.32	38.19	38.07	37.95	37.83													
6	39.74	39.49																		
7	38.69	38.58	38.46	38.35	38.24	38.13	38.03	37.93	37.83	37.74	37.64	37.55	37.47	37.38	37.30	37.22	37.14	37.07	37.00	36.93

DISSOLVED OXYGEN IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.37	5.72	6.05	6.36	6.64	6.91														
2	7.05	6.99	6.94	6.90	6.86	6.82	6.79	6.77	6.75	6.73										
3	6.75	6.79	6.83	6.86	6.90	6.94	6.98	7.02	7.06	7.10	7.14	7.18	7.22	7.26						
4	7.48	7.84	8.17	8.48	8.77	9.03	9.27	9.50	9.71											
5	9.85	9.93	10.01	10.08	10.16	10.23	10.29													
6	7.12	7.23																		
7	8.58	8.63	8.69	8.74	8.79	8.85	8.90	8.95	9.00	9.05	9.10	9.15	9.19	9.24	9.29	9.33	9.38	9.42	9.47	9.51

BIOCHEMICAL OXYGEN DEMAND (Ultimate) ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	31.97	31.84	31.71	31.59	31.47	31.35														
2	31.20	31.03	30.87	30.71	30.54	30.39	30.23	30.08	29.92	29.77										
3	29.65	29.56	29.46	29.37	29.28	29.19	29.10	29.01	28.92	28.83	28.74	28.66	28.57	28.48						
4	28.40	28.32	28.24	28.16	28.08	28.00	27.92	27.84	27.77											
5	27.69	27.62	27.55	27.47	27.40	27.33	27.25													
6	8.37	8.34																		
7	16.21	16.16	16.11	16.06	16.01	15.97	15.92	15.87	15.82	15.77	15.73	15.68	15.63	15.58	15.54	15.49	15.45	15.40	15.35	15.31

ORGANIC NITROGEN AS N IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.49														
2	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.48	0.48	0.48										
3	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47						
4	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47											
5	0.47	0.46	0.46	0.46	0.46	0.46	0.46													
6	0.62	0.62																		
7	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54

AMMONIA AS N IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.96	1.96	1.95	1.95	1.94	1.94														
2	1.93	1.92	1.91	1.91	1.90	1.89	1.89	1.88	1.87	1.87										
3	1.86	1.86	1.85	1.85	1.84	1.84	1.84	1.83	1.83	1.83	1.82	1.82	1.81	1.81						
4	1.81	1.80	1.80	1.80	1.79	1.79	1.79	1.78	1.78											
5	1.78	1.78	1.77	1.77	1.77	1.76	1.76													
6	0.12	0.12																		
7	0.81	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.78	0.78

NITRITE AS N IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.01	0.01	0.02	0.03	0.03	0.04														
2	0.05	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.10	0.11										
3	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.16						
4	0.17	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19											
5	0.19	0.20	0.20	0.20	0.21	0.21	0.21													
6	0.00	0.00																		
7	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

NITRATE AS N IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	1.00	1.00	1.00	1.00	1.00														
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01										
3	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01						
4	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02											
5	1.02	1.02	1.02	1.02	1.02	1.02	1.02													
6	2.30	2.30																		
7	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77

ORGANIC PHOSPHORUS AS P IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											

5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.89	0.89	0.89	0.89	0.89	0.89														
2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89										
3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89						
4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89											
5	0.89	0.89	0.89	0.89	0.89	0.89	0.89													
6	0.13	0.13																		
7	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

ALGAE AS CHL-A IN UG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	2.70	2.70																		
7	1.58	1.58	1.58	1.58	1.59	1.59	1.59	1.59	1.59	1.60	1.60	1.60	1.60	1.61	1.61	1.61	1.61	1.62	1.62	1.62

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	12.28	12.27	12.25	12.24	12.22	12.21														
2	12.19	12.17	12.14	12.12	12.10	12.08	12.06	12.04	12.02	12.00										
3	11.98	11.97	11.96	11.94	11.93	11.92	11.90	11.89	11.88	11.87	11.85	11.84	11.83	11.82						
4	11.80	11.79	11.78	11.77	11.76	11.74	11.73	11.72	11.71											
5	11.70	11.69	11.68	11.66	11.65	11.64	11.63													
6	9.99	9.97																		
7	10.66	10.65	10.63	10.62	10.61	10.60	10.59	10.58	10.56	10.55	10.54	10.53	10.52	10.51	10.49	10.48	10.47	10.46	10.45	10.44

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.49	0.49	0.48	0.47	0.47	0.46														
2	0.45	0.45	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42										
3	0.42	0.41	0.41	0.41	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0.40	0.40	0.40						
4	0.39	0.39	0.39	0.39	0.38	0.38	0.38	0.38	0.38											
5	0.37	0.37	0.37	0.37	0.37	0.37	0.37													
6	0.30	0.30																		
7	0.36	0.36	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.37	6.37	6.37	6.37	6.37	6.37														
2	6.37	6.37	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36										
3	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35						
4	6.35	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34											
5	6.34	6.34	6.34	6.34	6.34	6.34	6.34													
6	4.99	4.99																		
7	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02

STREAM QUALITY SIMULATION
QUAL-2E STREAM QUALITY ROUTING MODEL

Ver. 3.13 - September 1991

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
2	1	2	9.90	9.80	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
3	1	3	9.80	9.70	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
4	1	4	9.70	9.60	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
5	1	5	9.60	9.50	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
6	1	6	9.50	9.40	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
7	2	1	9.40	9.30	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
8	2	2	9.30	9.20	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
9	2	3	9.20	9.10	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
10	2	4	9.10	9.00	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
11	2	5	9.00	8.90	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
12	2	6	8.90	8.80	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
13	2	7	8.80	8.70	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
14	2	8	8.70	8.60	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
15	2	9	8.60	8.50	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
16	2	10	8.50	8.40	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
17	3	1	8.40	8.30	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
18	3	2	8.30	8.20	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
19	3	3	8.20	8.10	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
20	3	4	8.10	8.00	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
21	3	5	8.00	7.90	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
22	3	6	7.90	7.80	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
23	3	7	7.80	7.70	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
24	3	8	7.70	7.60	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
25	3	9	7.60	7.50	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
26	3	10	7.50	7.40	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
27	3	11	7.40	7.30	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
28	3	12	7.30	7.20	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
29	3	13	7.20	7.10	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
30	3	14	7.10	7.00	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
31	4	1	7.00	6.90	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
32	4	2	6.90	6.80	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
33	4	3	6.80	6.70	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
34	4	4	6.70	6.60	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
35	4	5	6.60	6.50	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
36	4	6	6.50	6.40	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
37	4	7	6.40	6.30	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
38	4	8	6.30	6.20	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
39	4	9	6.20	6.10	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
40	5	1	6.10	6.00	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
41	5	2	6.00	5.90	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
42	5	3	5.90	5.80	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
43	5	4	5.80	5.70	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
44	5	5	5.70	5.60	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
45	5	6	5.60	5.50	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
46	5	7	5.50	5.40	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
47	6	1	5.60	5.50	7.80	0.00	0.00	0.603	0.010	0.404	32.005	6.82	17.32	12.92	0.23
48	6	2	5.50	5.40	7.80	0.00	0.00	0.603	0.010	0.404	32.005	6.82	17.32	12.92	0.23
49	7	1	5.40	5.30	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
50	7	2	5.30	5.20	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
51	7	3	5.20	5.10	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
52	7	4	5.10	5.00	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
53	7	5	5.00	4.90	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
54	7	6	4.90	4.80	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
55	7	7	4.80	4.70	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
56	7	8	4.70	4.60	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
57	7	9	4.60	4.50	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
58	7	10	4.50	4.40	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
59	7	11	4.40	4.30	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
60	7	12	4.30	4.20	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
61	7	13	4.20	4.10	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
62	7	14	4.10	4.00	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
63	7	15	4.00	3.90	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
64	7	16	3.90	3.80	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
65	7	17	3.80	3.70	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
66	7	18	3.70	3.60	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
67	7	19	3.60	3.50	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
68	7	20	3.50	3.40	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	11.08	8	11.23	0.50	0.00	0.00	0.16	0.08	0.42	0.00	0.60	0.12	0.08	0.00	0.00	0.00	0.16	0.00
1	2	11.17	8	11.14	0.49	0.00	0.00	0.15	0.08	0.41	0.00	0.59	0.12	0.08	0.00	0.00	0.00	0.16	0.00
1	3	11.25	8	11.05	0.48	0.00	0.00	0.15	0.08	0.40	0.00	0.59	0.12	0.08	0.00	0.00	0.00	0.15	0.00
1	4	11.34	8	10.97	0.47	0.00	0.00	0.15	0.08	0.40	0.00	0.58	0.12	0.08	0.00	0.00	0.00	0.15	0.00
1	5	11.42	8	10.90	0.47	0.00	0.00	0.15	0.08	0.39	0.00	0.57	0.12	0.08	0.00	0.00	0.00	0.15	0.00
1	6	11.50	8	10.82	0.46	0.00	0.00	0.14	0.08	0.38	0.00	0.57	0.12	0.08	0.00	0.00	0.00	0.15	0.00
2	1	11.57	8	6.67	0.46	0.00	0.00	0.14	0.07	0.37	0.00	0.56	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	2	11.64	8	2.56	0.45	0.00	0.00	0.14	0.07	0.37	0.00	0.56	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	3	11.70	8	2.55	0.45	0.00	0.00	0.14	0.07	0.36	0.00	0.55	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	4	11.76	8	2.53	0.44	0.00	0.00	0.14	0.07	0.35	0.00	0.55	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	5	11.82	8	2.52	0.44	0.00	0.00	0.14	0.07	0.35	0.00	0.54	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	6	11.88	8	2.51	0.44	0.00	0.00	0.14	0.07	0.34	0.00	0.54	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	7	11.94	8	2.50	0.43	0.00	0.00	0.13	0.07	0.34	0.00	0.53	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	8	11.99	8	2.49	0.43	0.00	0.00	0.13	0.07	0.33	0.00	0.53	0.11	0.07	0.00	0.00	0.00	0.14	0.00
2	9	12.04	8	2.48	0.42	0.00	0.00	0.13	0.07	0.33	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
2	10	12.09	8	2.47	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
3	1	12.13	8	3.06	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	2	12.16	8	3.64	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	3	12.19	8	3.64	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	4	12.21	8	3.63	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	5	12.24	8	3.62	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	6	12.27	8	3.62	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	7	12.29	8	3.61	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	8	12.32	8	3.60	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	9	12.34	8	3.60	0.41	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	10	12.36	8	3.59	0.41	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	11	12.39	8	3.58	0.40	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	12	12.41	8	3.58	0.40	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	13	12.43	8	3.57	0.40	0.00	0.00	0.13	0.07	0.30	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	14	12.45	8	3.56	0.40	0.00	0.00	0.12	0.07	0.30	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	1	12.49	8	8.50	0.40	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	2	12.54	8	13.38	0.40	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	3	12.58	8	13.34	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	4	12.63	8	13.29	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	5	12.68	8	13.25	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	6	12.72	8	13.21	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	7	12.76	8	13.17	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	8	12.80	8	13.14	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	9	12.84	8	13.10	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
5	1	12.87	8	10.54	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
5	2	12.89	8	8.00	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
5	3	12.92	8	7.98	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
5	4	12.95	8	7.97	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	5	12.97	8	7.96	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	6	12.99	8	7.94	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	7	13.01	8	7.93	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
6	1	12.66	8	2.67	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
6	2	12.70	8	2.67	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	1	12.85	8	4.28	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	2	12.87	8	3.22	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	3	12.89	8	3.21	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	4	12.92	8	3.21	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	5	12.94	8	3.20	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	6	12.96	8	3.20	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	7	12.98	8	3.20	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	8	13.00	8	3.19	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	9	13.01	8	3.19	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	10	13.03	8	3.18	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	11	13.05	8	3.18	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	12	13.07	8	3.18	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	13	13.09	8	3.17	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	14	13.10	8	3.17	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	15	13.12	8	3.16	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	16	13.13	8	3.16	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	17	13.15	8	3.16	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	18	13.16	8	3.16	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	19	13.18	8	3.15	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	20	13.19	8	3.15	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota spen	CHLA UG/L
1	1	49.35	0.00	0.00	0.00	5.37	31.97	0.50	1.96	0.01	1.00	3.47	0.00	0.89	0.89	0.00	12.28	0.00
1	2	48.74	0.00	0.00	0.00	5.72	31.84	0.50	1.96	0.01	1.00	3.47	0.00	0.89	0.89	0.00	12.27	0.00
1	3	48.15	0.00	0.00	0.00	6.05	31.71	0.50	1.95	0.02	1.00	3.47	0.00	0.89	0.89	0.00	12.25	0.00
1	4	47.58	0.00	0.00	0.00	6.36	31.59	0.50	1.95	0.03	1.00	3.47	0.00	0.89	0.89	0.00	12.24	0.00
1	5	47.05	0.00	0.00	0.00	6.64	31.47	0.50	1.94	0.03	1.00	3.47	0.00	0.89	0.89	0.00	12.22	0.00
1	6	46.53	0.00	0.00	0.00	6.91	31.35	0.49	1.94	0.04	1.00	3.47	0.00	0.89	0.89	0.00	12.21	0.00
2	1	46.08	0.00	0.00	0.00	7.05	31.20	0.49	1.93	0.05	1.00	3.47	0.00	0.89	0.89	0.00	12.19	0.00
2	2	45.67	0.00	0.00	0.00	6.99	31.03	0.49	1.92	0.05	1.00	3.47	0.00	0.89	0.89	0.00	12.17	0.00
2	3	45.28	0.00	0.00	0.00	6.94	30.87	0.49	1.91	0.06	1.00	3.47	0.00	0.89	0.89	0.00	12.14	0.00
2	4	44.90	0.00	0.00	0.00	6.90	30.71	0.49	1.91	0.07	1.00	3.47	0.00	0.89	0.89	0.00	12.12	0.00
2	5	44.54	0.00	0.00	0.00	6.86	30.54	0.49	1.90	0.08	1.00	3.47	0.00	0.89	0.89	0.00	12.10	0.00
2	6	44.18	0.00	0.00	0.00	6.82	30.39	0.49	1.89	0.08	1.00	3.47	0.00	0.89	0.89	0.00	12.08	0.00
2	7	43.85	0.00	0.00	0.00	6.79	30.23	0.49	1.89	0.09	1.00	3.47	0.00	0.89	0.89	0.00	12.06	0.00
2	8	43.52	0.00	0.00	0.00	6.77	30.08	0.48	1.88	0.10	1.00	3.46	0.00	0.89	0.89	0.00	12.04	0.00
2	9	43.20	0.00	0.00	0.00	6.75	29.92	0.48	1.87	0.10	1.00	3.46	0.00	0.89	0.89	0.00	12.02	0.00
2	10	42.90	0.00	0.00	0.00	6.73	29.77	0.48	1.87	0.11	1.01	3.46	0.00	0.89	0.89	0.00	12.00	0.00
3	1	42.68	0.00	0.00	0.00	6.75	29.65	0.48	1.86	0.12	1.01	3.46	0.00	0.89	0.89	0.00	11.98	0.00
3	2	42.52	0.00	0.00	0.00	6.79	29.56	0.48	1.86	0.12	1.01	3.46	0.00	0.89	0.89	0.00	11.97	0.00
3	3	42.36	0.00	0.00	0.00	6.83	29.46	0.48	1.85	0.12	1.01	3.46	0.00	0.89	0.89	0.00	11.96	0.00
3	4	42.21	0.00	0.00	0.00	6.86	29.37	0.48	1.85	0.13	1.01	3.46	0.00	0.89	0.89	0.00	11.94	0.00
3	5	42.06	0.00	0.00	0.00	6.90	29.28	0.48	1.84	0.13	1.01	3.46	0.00	0.89	0.89	0.00	11.93	0.00
3	6	41.91	0.00	0.00	0.00	6.94	29.19	0.48	1.84	0.14	1.01	3.46	0.00	0.89	0.89	0.00	11.92	0.00
3	7	41.77	0.00	0.00	0.00	6.98	29.10	0.48	1.84	0.14	1.01	3.46	0.00	0.89	0.89	0.00	11.90	0.00
3	8	41.63	0.00	0.00	0.00	7.02	29.01	0.48	1.83	0.14	1.01	3.46	0.00	0.89	0.89	0.00	11.89	0.00
3	9	41.49	0.00	0.00	0.00	7.06	28.92	0.48	1.83	0.15	1.01	3.46	0.00	0.89	0.89	0.00	11.88	0.00
3	10	41.35	0.00	0.00	0.00	7.10	28.83	0.47	1.83	0.15	1.01	3.46	0.00	0.89	0.89	0.00	11.87	0.00
3	11	41.22	0.00	0.00	0.00	7.14	28.74	0.47	1.82	0.15	1.01	3.46	0.00	0.89	0.89	0.00	11.85	0.00
3	12	41.09	0.00	0.00	0.00	7.18	28.66	0.47	1.82	0.16	1.01	3.46	0.00	0.89	0.89	0.00	11.84	0.00
3	13	40.97	0.00	0.00	0.00	7.22	28.57	0.47	1.81	0.16	1.01	3.46	0.00	0.89	0.89	0.00	11.83	0.00
3	14	40.84	0.00	0.00	0.00	7.26	28.48	0.47	1.81	0.16	1.01	3.46	0.00	0.89	0.89	0.00	11.82	0.00
4	1	40.67	0.00	0.00	0.00	7.48	28.40	0.47	1.81	0.17	1.01	3.46	0.00	0.89	0.89	0.00	11.80	0.00
4	2	40.39	0.00	0.00	0.00	7.84	28.32	0.47	1.80	0.17	1.01	3.46	0.00	0.89	0.89	0.00	11.79	0.00
4	3	40.12	0.00	0.00	0.00	8.17	28.24	0.47	1.80	0.17	1.02	3.46	0.00	0.89	0.89	0.00	11.78	0.00
4	4	39.87	0.00	0.00	0.00	8.48	28.16	0.47	1.80	0.18	1.02	3.46	0.00	0.89	0.89	0.00	11.77	0.00
4	5	39.63	0.00	0.00	0.00	8.77	28.08	0.47	1.79	0.18	1.02	3.46	0.00	0.89	0.89	0.00	11.76	0.00
4	6	39.40	0.00	0.00	0.00	9.03	28.00	0.47	1.79	0.18	1.02	3.46	0.00	0.89	0.89	0.00	11.74	0.00
4	7	39.17	0.00	0.00	0.00	9.27	27.92	0.47	1.79	0.19	1.02	3.46	0.00	0.89	0.89	0.00	11.73	0.00
4	8	38.96	0.00	0.00	0.00	9.50	27.84	0.47	1.78	0.19	1.02	3.46	0.00	0.89	0.89	0.00	11.72	0.00
4	9	38.76	0.00	0.00	0.00	9.71	27.77	0.47	1.78	0.19	1.02	3.46	0.00	0.89	0.89	0.00	11.71	0.00
5	1	38.60	0.00	0.00	0.00	9.85	27.69	0.47	1.78	0.19	1.02	3.46	0.00	0.89	0.89	0.00	11.70	0.00
5	2	38.46	0.00	0.00	0.00	9.93	27.62	0.46	1.78	0.20	1.02	3.46	0.00	0.89	0.89	0.00	11.69	0.00
5	3	38.32	0.00	0.00	0.00	10.01	27.55	0.46	1.77	0.20	1.02	3.46	0.00	0.89	0.89	0.00	11.68	0.00
5	4	38.19	0.00	0.00	0.00	10.08	27.47	0.46	1.77	0.20	1.02	3.46	0.00	0.89	0.89	0.00	11.66	0.00
5	5	38.07	0.00	0.00	0.00	10.16	27.40	0.46	1.77	0.21	1.02	3.46	0.00	0.89	0.89	0.00	11.65	0.00
5	6	37.95	0.00	0.00	0.00	10.23	27.33	0.46	1.76	0.21	1.02	3.46	0.00	0.89	0.89	0.00	11.64	0.00
5	7	37.83	0.00	0.00	0.00	10.29	27.25	0.46	1.76	0.21	1.02	3.46	0.00	0.89	0.89	0.00	11.63	0.00
6	1	39.74	0.00	0.00	0.00	7.12	8.37	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	9.99	2.70
6	2	39.49	0.00	0.00	0.00	7.23	8.34	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	9.97	2.70
7	1	38.69	0.00	0.00	0.00	8.58	16.21	0.55	0.81	0.09	1.77	3.21	0.00	0.45	0.45	0.00	10.66	1.58
7	2	38.58	0.00	0.00	0.00	8.63	16.16	0.55	0.80	0.09	1.77	3.21	0.00	0.45	0.45	0.00	10.65	1.58
7	3	38.46	0.00	0.00	0.00	8.69	16.11	0.55	0.80	0.09	1.77	3.21	0.00	0.45	0.45	0.00	10.63	1.58
7	4	38.35	0.00	0.00	0.00	8.74	16.06	0.55	0.80	0.09	1.77	3.21	0.00	0.45	0.45	0.00	10.62	1.58
7	5	38.24	0.00	0.00	0.00	8.79	16.01	0.55	0.80	0.09	1.77	3.21	0.00	0.45	0.45	0.00	10.61	1.59
7	6	38.13	0.00	0.00	0.00	8.85	15.97	0.55	0.80	0.10	1.77	3.21	0.00	0.45	0.45	0.00	10.60	1.59
7	7	38.03	0.00	0.00	0.00	8.90	15.92	0.55	0.80	0.10	1.77	3.21	0.00	0.45	0.45	0.00	10.59	1.59
7	8	37.93	0.00	0.00	0.00	8.95	15.87	0.55	0.80	0.10	1.77	3.21	0.00	0.45	0.45	0.00	10.58	1.59
7	9	37.83	0.00	0.00	0.00	9.00	15.82	0.55	0.80	0.10	1.77	3.21	0.00	0.45	0.45	0.00	10.56	1.59
7	10	37.74	0.00	0.00	0.00	9.05	15.77	0.54	0.79	0.10	1.77	3.21	0.00	0.45	0.45	0.00	10.55	1.60
7	11	37.64	0.00	0.00	0.00	9.10	15.73	0.54	0.79	0.10	1.77	3.21	0.00	0.45	0.45	0.00	10.54	1.60
7	12	37.55	0.00	0.00	0.00	9.15	15.68	0.54	0.79	0.10	1.77	3.21	0.00	0.45	0.45	0.00	10.53	1.60
7	13	37.47	0.00	0.00	0.00	9.19	15.63	0.54	0.79	0.11	1.77	3.21	0.00	0.45	0.45	0.00	10.52	1.60
7	14	37.38	0.00	0.00	0.00	9.24	15.58	0.54	0.79	0.11	1.77	3.21	0.00	0.45	0.45	0.00	10.51	1.61
7	15	37.30	0.00	0.00	0.00	9.29	15.54	0.54	0.79	0.11	1.77	3.21	0.00	0.45	0.45	0.00	10.49	1.61
7	16	37.22	0.00	0.00	0.00	9.33	15.49	0.54	0.79	0.11	1.77	3.21	0.00	0.45	0.45	0.00	10.48	1.61
7	17	37.14	0.00	0.00	0.00	9.38	15.45	0.54	0.79	0.11	1.77	3.21	0.00	0.45	0.45	0.00	10.47	1.61
7	18	37.07	0.00	0.00	0.00	9.42	15.40	0.54	0.79	0.11	1.77	3.21	0.00	0.45	0.45	0.00	10.46	1.62
7	19	37.00	0.00	0.00	0.00	9.47	15.35	0.54	0.78	0.11	1.77	3.21	0.00	0.45	0.45	0.00	10.45	1.62
7	20	36.93	0.00	0.00	0.00	9.51	15.31	0.54	0.78	0.11	1.77	3.21	0.00	0.45	0.45	0.00	10.44	1.62

***** STEADY STATE SIMULATION *****

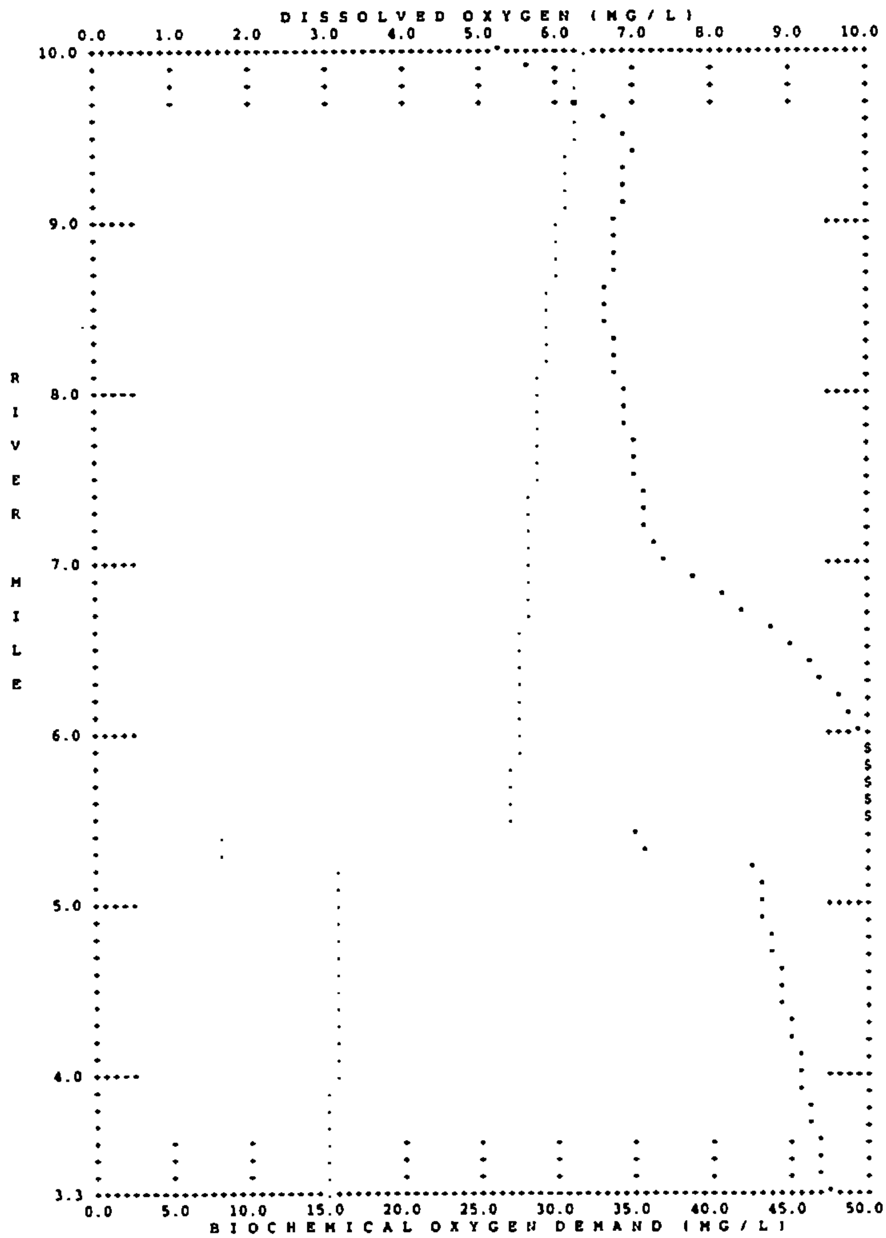
** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS: LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.00	0.49	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
2	1	2	0.00	0.49	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
3	1	3	0.00	0.48	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
4	1	4	0.00	0.47	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
5	1	5	0.00	0.47	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
6	1	6	0.00	0.46	0.06	0.08	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
7	2	1	0.00	0.45	0.06	0.07	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
8	2	2	0.00	0.45	0.06	0.07	6.37	0.00	0.90	0.95	0.01	0.37	0.91	0.96
9	2	3	0.00	0.45	0.06	0.07	6.36	0.00	0.90	0.95	0.01	0.37	0.91	0.96
10	2	4	0.00	0.44	0.06	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
11	2	5	0.00	0.44	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
12	2	6	0.00	0.43	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
13	2	7	0.00	0.43	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
14	2	8	0.00	0.43	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
15	2	9	0.00	0.42	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
16	2	10	0.00	0.42	0.05	0.07	6.36	0.00	0.90	0.94	0.01	0.37	0.91	0.96
17	3	1	0.00	0.42	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.91	0.96
18	3	2	0.00	0.41	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.91	0.96
19	3	3	0.00	0.41	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.91	0.96
20	3	4	0.00	0.41	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
21	3	5	0.00	0.41	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
22	3	6	0.00	0.41	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
23	3	7	0.00	0.41	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
24	3	8	0.00	0.40	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
25	3	9	0.00	0.40	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
26	3	10	0.00	0.40	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
27	3	11	0.00	0.40	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
28	3	12	0.00	0.40	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
29	3	13	0.00	0.40	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
30	3	14	0.00	0.40	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
31	4	1	0.00	0.39	0.05	0.07	6.35	0.00	0.90	0.94	0.01	0.37	0.90	0.96
32	4	2	0.00	0.39	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
33	4	3	0.00	0.39	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
34	4	4	0.00	0.39	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
35	4	5	0.00	0.38	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
36	4	6	0.00	0.38	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
37	4	7	0.00	0.38	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
38	4	8	0.00	0.38	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
39	4	9	0.00	0.38	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
40	5	1	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
41	5	2	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
42	5	3	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
43	5	4	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
44	5	5	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
45	5	6	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
46	5	7	0.00	0.37	0.05	0.07	6.34	0.00	0.90	0.94	0.01	0.37	0.90	0.96
47	6	1	2.70	0.30	0.05	0.07	4.99	0.02	0.90	0.32	0.14	0.37	0.89	0.76
48	6	2	2.70	0.30	0.05	0.07	4.99	0.02	0.90	0.32	0.14	0.37	0.89	0.77
49	7	1	1.58	0.36	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
50	7	2	1.58	0.36	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
51	7	3	1.58	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
52	7	4	1.58	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
53	7	5	1.59	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
54	7	6	1.59	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
55	7	7	1.59	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
56	7	8	1.59	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
57	7	9	1.59	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
58	7	10	1.60	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
59	7	11	1.60	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
60	7	12	1.60	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
61	7	13	1.60	0.35	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
62	7	14	1.61	0.34	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
63	7	15	1.61	0.34	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
64	7	16	1.61	0.34	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
65	7	17	1.61	0.34	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
66	7	18	1.62	0.34	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
67	7	19	1.62	0.34	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.90	0.92
68	7	20	1.62	0.34	0.05	0.07	6.02	0.01	0.90	0.80	0.10	0.37	0.89	0.92

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
1	1	1	49.35	11.08	5.37	5.70	0.00	0.96	604.43	64.04	-15.89	0.00	0.00	-2.89	0.00
2	1	2	48.74	11.17	5.72	5.44	0.00	0.97	0.00	60.64	-15.57	0.00	0.00	-2.82	-0.01
3	1	3	48.15	11.25	6.05	5.20	0.00	0.97	0.00	57.53	-15.28	0.00	0.00	-2.76	-0.01
4	1	4	47.58	11.34	6.36	4.98	0.00	0.98	0.00	54.69	-15.00	0.00	0.00	-2.69	-0.02
5	1	5	47.05	11.42	6.64	4.78	0.00	0.98	0.00	52.07	-14.74	0.00	0.00	-2.63	-0.02
6	1	6	46.53	11.50	6.91	4.59	0.00	0.98	0.00	49.67	-14.50	0.00	0.00	-2.57	-0.03
7	2	1	46.08	11.57	7.05	4.53	0.00	0.99	0.00	30.16	-14.26	0.00	0.00	-2.52	-0.03
8	2	2	45.67	11.64	6.99	4.65	0.00	0.98	0.00	11.89	-14.04	0.00	0.00	-2.46	-0.04
9	2	3	45.28	11.70	6.94	4.76	0.00	0.98	0.00	12.11	-13.82	0.00	0.00	-2.41	-0.04
10	2	4	44.90	11.76	6.90	4.86	0.00	0.98	0.00	12.32	-13.62	0.00	0.00	-2.36	-0.04
11	2	5	44.54	11.82	6.86	4.96	0.00	0.98	0.00	12.51	-13.42	0.00	0.00	-2.31	-0.05
12	2	6	44.18	11.88	6.82	5.06	0.00	0.98	0.00	12.68	-13.23	0.00	0.00	-2.27	-0.05
13	2	7	43.85	11.94	6.79	5.14	0.00	0.98	0.00	12.84	-13.05	0.00	0.00	-2.22	-0.06
14	2	8	43.52	11.99	6.77	5.22	0.00	0.98	0.00	12.99	-12.88	0.00	0.00	-2.18	-0.06
15	2	9	43.20	12.04	6.75	5.30	0.00	0.98	0.00	13.12	-12.71	0.00	0.00	-2.14	-0.07
16	2	10	42.90	12.09	6.73	5.37	0.00	0.98	0.00	13.24	-12.55	0.00	0.00	-2.11	-0.07
17	3	1	42.68	12.13	6.75	5.39	0.00	0.98	0.00	16.46	-12.43	0.00	0.00	-2.08	-0.07
18	3	2	42.52	12.16	6.79	5.37	0.00	0.98	0.00	19.58	-12.34	0.00	0.00	-2.06	-0.07
19	3	3	42.36	12.19	6.83	5.36	0.00	0.98	0.00	19.50	-12.25	0.00	0.00	-2.05	-0.08
20	3	4	42.21	12.21	6.86	5.35	0.00	0.98	0.00	19.42	-12.16	0.00	0.00	-2.03	-0.08
21	3	5	42.06	12.24	6.90	5.34	0.00	0.98	0.00	19.33	-12.08	0.00	0.00	-2.01	-0.08
22	3	6	41.91	12.27	6.94	5.32	0.00	0.98	0.00	19.24	-12.00	0.00	0.00	-2.00	-0.08
23	3	7	41.77	12.29	6.98	5.31	0.00	0.98	0.00	19.16	-11.91	0.00	0.00	-1.98	-0.08
24	3	8	41.63	12.32	7.02	5.29	0.00	0.99	0.00	19.07	-11.83	0.00	0.00	-1.96	-0.09
25	3	9	41.49	12.34	7.06	5.28	0.00	0.99	0.00	18.98	-11.76	0.00	0.00	-1.95	-0.09
26	3	10	41.35	12.36	7.10	5.26	0.00	0.99	0.00	18.89	-11.68	0.00	0.00	-1.93	-0.09
27	3	11	41.22	12.39	7.14	5.25	0.00	0.99	0.00	18.80	-11.61	0.00	0.00	-1.92	-0.09
28	3	12	41.09	12.41	7.18	5.23	0.00	0.99	0.00	18.71	-11.53	0.00	0.00	-1.90	-0.09
29	3	13	40.97	12.43	7.22	5.21	0.00	0.99	0.00	18.62	-11.46	0.00	0.00	-1.89	-0.10
30	3	14	40.84	12.45	7.26	5.20	0.00	0.99	0.00	18.53	-11.39	0.00	0.00	-1.88	-0.10
31	4	1	40.67	12.49	7.48	5.01	0.00	0.99	0.00	42.57	-11.31	0.00	0.00	-1.86	-0.10
32	4	2	40.39	12.54	7.84	4.70	0.00	0.99	0.00	62.88	-11.19	0.00	0.00	-1.84	-0.10
33	4	3	40.12	12.58	8.17	4.41	0.00	0.99	0.00	58.84	-11.09	0.00	0.00	-1.82	-0.10
34	4	4	39.87	12.63	8.48	4.15	0.00	0.99	0.00	55.16	-10.98	0.00	0.00	-1.80	-0.10
35	4	5	39.63	12.68	8.77	3.91	0.00	0.99	0.00	51.79	-10.88	0.00	0.00	-1.78	-0.10
36	4	6	39.40	12.72	9.03	3.69	0.00	1.00	0.00	48.72	-10.79	0.00	0.00	-1.76	-0.11
37	4	7	39.17	12.76	9.27	3.49	0.00	1.00	0.00	45.91	-10.70	0.00	0.00	-1.74	-0.11
38	4	8	38.96	12.80	9.50	3.30	0.00	1.00	0.00	43.34	-10.61	0.00	0.00	-1.72	-0.11
39	4	9	38.76	12.84	9.71	3.13	0.00	1.00	0.00	40.98	-10.53	0.00	0.00	-1.70	-0.11
40	5	1	38.60	12.87	9.85	3.02	0.00	1.00	0.00	31.83	-10.46	0.00	0.00	-1.69	-0.11
41	5	2	38.46	12.89	9.93	2.96	0.00	1.00	0.00	23.71	-10.39	0.00	0.00	-1.67	-0.11
42	5	3	38.32	12.92	10.01	2.91	0.00	1.00	0.00	23.25	-10.33	0.00	0.00	-1.66	-0.11
43	5	4	38.19	12.95	10.08	2.86	0.00	1.00	0.00	22.81	-10.27	0.00	0.00	-1.65	-0.11
44	5	5	38.07	12.97	10.16	2.81	0.00	1.00	0.00	22.38	-10.21	0.00	0.00	-1.64	-0.11
45	5	6	37.95	12.99	10.23	2.77	0.00	1.00	0.00	21.97	-10.15	0.00	0.00	-1.63	-0.12
46	5	7	37.83	13.01	10.29	2.72	0.00	1.00	0.00	21.58	-10.09	0.00	0.00	-1.61	-0.12
47	6	1	39.74	12.66	7.12	5.54	0.00	0.99	691.28	14.82	-3.25	0.00	0.02	-0.12	0.00
48	6	2	39.49	12.70	7.23	5.47	0.00	0.99	0.00	14.58	-3.22	0.00	0.02	-0.12	0.00
49	7	1	38.69	12.85	8.58	4.27	0.00	0.99	0.00	18.28	-6.14	0.00	0.01	-0.76	-0.05
50	7	2	38.58	12.87	8.63	4.24	0.00	0.99	0.00	13.65	-6.10	0.00	0.01	-0.76	-0.05
51	7	3	38.46	12.89	8.69	4.21	0.00	0.99	0.00	13.52	-6.06	0.00	0.01	-0.75	-0.05
52	7	4	38.35	12.92	8.74	4.18	0.00	0.99	0.00	13.40	-6.03	0.00	0.01	-0.75	-0.05
53	7	5	38.24	12.94	8.79	4.14	0.00	0.99	0.00	13.28	-5.99	0.00	0.01	-0.75	-0.05
54	7	6	38.13	12.96	8.85	4.11	0.00	1.00	0.00	13.15	-5.96	0.00	0.01	-0.74	-0.05
55	7	7	38.03	12.98	8.90	4.08	0.00	1.00	0.00	13.03	-5.92	0.00	0.01	-0.74	-0.05
56	7	8	37.93	13.00	8.95	4.05	0.00	1.00	0.00	12.92	-5.89	0.00	0.01	-0.73	-0.05
57	7	9	37.83	13.01	9.00	4.02	0.00	1.00	0.00	12.80	-5.86	0.00	0.01	-0.73	-0.06
58	7	10	37.74	13.03	9.05	3.98	0.00	1.00	0.00	12.68	-5.83	0.00	0.01	-0.72	-0.06
59	7	11	37.64	13.05	9.10	3.95	0.00	1.00	0.00	12.57	-5.79	0.00	0.01	-0.72	-0.06
60	7	12	37.55	13.07	9.15	3.92	0.00	1.00	0.00	12.45	-5.76	0.00	0.01	-0.72	-0.06
61	7	13	37.47	13.09	9.19	3.89	0.00	1.00	0.00	12.34	-5.73	0.00	0.01	-0.71	-0.06
62	7	14	37.38	13.10	9.24	3.86	0.00	1.00	0.00	12.23	-5.70	0.00	0.01	-0.71	-0.06
63	7	15	37.30	13.12	9.29	3.83	0.00	1.00	0.00	12.12	-5.68	0.00	0.01	-0.71	-0.06
64	7	16	37.22	13.13	9.33	3.80	0.00	1.00	0.00	12.01	-5.65	0.00	0.01	-0.70	-0.06
65	7	17	37.14	13.15	9.38	3.77	0.00	1.00	0.00	11.90	-5.62	0.00	0.01	-0.70	-0.06
66	7	18	37.07	13.16	9.42	3.74	0.00	1.00	0.00	11.80	-5.59	0.00	0.01	-0.70	-0.06
67	7	19	37.00	13.18	9.47	3.71	0.00	1.00	0.00	11.69	-5.57	0.00	0.01	-0.69	-0.06
68	7	20	36.93	13.19	9.51	3.68	0.00	1.00	0.00	11.59	-5.54	0.00	0.01	-0.69	-0.06



DISSOLVED OXYGEN • • • • •

BIOCHEMICAL OXYGEN DEMAND • . . . . .

* * * QUAL-2E STREAM QUALITY ROUTING MODEL * * *
Ver. 3.13 - September 1991

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-2E PROGRAM TITLES
TITLE01		BWAUU.IN - Winter, Average, Ultimate FLOW, BODU Simulation
TITLE02		NSWTP DISCHARGE TO BADGER MILL CREEK
TITLE03	NO	CONSERVATIVE MINERAL I IN
TITLE04	NO	CONSERVATIVE MINERAL II IN
TITLE05	NO	CONSERVATIVE MINERAL III IN
TITLE06	YES	TEMPERATURE
TITLE07	YES	BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)
TITLE08	YES	ALGAE AS CHL-A IN UG/L
TITLE09	YES	PHOSPHORUS CYCLE AS P IN MG/L
TITLE10		(ORGANIC-P, DISSOLVED-P)
TITLE11	YES	NITROGEN CYCLE AS N IN MG/L
TITLE12		(ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	NO	FECAL COLIFORMS IN NO./100 ML
TITLE15	YES	ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l
ENDTITLE		

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE		CARD TYPE	
LIST DATA INPUT	0.00000		0.00000
WRITE OPTIONAL SUMMARY	0.00000		0.00000
NO FLOW AUGMENTATION	0.00000		0.00000
STEADY STATE	0.00000		0.00000
TRAPEZOIDAL X-SECTIONS	0.00000		0.00000
PRINT LCD/SOLAR DATA	0.00000		0.00000
PLOT DO AND BOD	0.00000		0.00000
FIXED DNSTM COND (YES=1)=	0.00000	5D-ULT BOD CONV K COEF =	0.23000
INPUT METRIC (YES=1) =	0.00000	OUTPUT METRIC (YES=1) =	0.00000
NUMBER OF REACHES =	7.00000	NUMBER OF JUNCTIONS =	1.00000
NUM OF HEADWATERS =	2.00000	NUMBER OF POINT LOADS =	0.00000
TIME STEP (HOURS) =	1.00000	LNTH COMP ELEMENT (DX)=	0.10000
MAXIMUM ROUTE TIME (HRS)=	288.00000	TIME INC. FOR RPT2 (HRS)=	1.00000
LATITUDE OF BASIN (DEG) =	43.10000	LONGITUDE OF BASIN (DEG)=	89.30000
STANDARD MERIDIAN (DEG) =	75.00000	DAY OF YEAR START TIME =	15.00000
EVAP. COEFF. (AE) =	0.00068	EVAP. COEFF. (BE) =	0.00027
ELEV. OF BASIN (ELEV) =	937.00000	DUST ATTENUATION COEF. =	0.06000
ENDATA1	0.00000		0.00000

$$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE		CARD TYPE	
O UPTAKE BY NH3 OXID(MG O/MG N)=	3.5000	O UPTAKE BY NO2 OXID(MG O/MG N)=	1.2000
O PROD BY ALGAE (MG O/MG A) =	1.6000	O UPTAKE BY ALGAE (MG O/MG A) =	2.0000
N CONTENT OF ALGAE (MG N/MG A) =	0.0850	P CONTENT OF ALGAE (MG P/MG A) =	0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=	2.5000	ALGAE RESPIRATION RATE (1/DAY) =	0.1000
N HALF SATURATION CONST (MG/L)=	0.3000	P HALF SATURATION CONST (MG/L)=	0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)	0.0088	NLIN SHADE(1/FT-(UGCHA/L)**2/3)=	0.0540
LIGHT FUNCTION OPTION (LFNOPT) =	1.0000	LIGHT SAT'N COEF (BTU/FT2-MIN) =	0.0300
DAILY AVERAGING OPTION (LAVOPT)=	2.0000	LIGHT AVERAGING FACTOR (AFACT) =	0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =	10.0000	TOTAL DAILY SOLR RAD (BTU/FT-2)=	400.0000
ALGY GROWTH CALC OPTION(LGROPT)=	1.0000	ALGAL PREF FOR NH3-N (PREFN) =	0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=	0.4500	NITRIFICATION INHIBITION COEF =	0.6000
ENDATA1A	0.0000		0.0000

$$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE	RATE CODE	THETA VALUE	
THETA(1)	BOD DECA	1.047	DFLT
THETA(2)	BOD SETT	1.024	DFLT
THETA(3)	OXY TRAN	1.024	DFLT
THETA(4)	SOD RATE	1.060	DFLT
THETA(5)	ORGN DEC	1.047	DFLT
THETA(6)	ORGN SET	1.024	DFLT
THETA(7)	NH3 DECA	1.083	DFLT
THETA(8)	NH3 SRCE	1.074	DFLT
THETA(9)	NO2 DECA	1.047	DFLT
THETA(10)	PORG DEC	1.047	DFLT
THETA(11)	PORG SET	1.024	DFLT
THETA(12)	DISP SRC	1.074	DFLT
THETA(13)	ALG GROW	1.047	DFLT
THETA(14)	ALG RESP	1.047	DFLT
THETA(15)	ALG SETT	1.024	DFLT
THETA(16)	COLI DEC	1.047	DFLT
THETA(17)	ANC DECA	1.000	DFLT
THETA(18)	ANC SETT	1.024	DFLT
THETA(19)	ANC SRCE	1.000	DFLT
ENDATA1B			

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE		REACH ORDER AND IDENT		R. MI/KM		R. MI/KM
STREAM REACH	1.0	RCH= HWY 151-PB	FROM	10.0	TO	9.4
STREAM REACH	2.0	RCH= PB-Lincoln	FROM	9.4	TO	8.4
STREAM REACH	3.0	RCH= Lincoln-151 By	FROM	8.4	TO	7.0
STREAM REACH	4.0	RCH= 151 By-HWY 69	FROM	7.0	TO	6.1
STREAM REACH	5.0	RCH= HWY 69-Sugar R	FROM	6.1	TO	5.4
STREAM REACH	6.0	RCH= Upstrm Sugar R	FROM	5.6	TO	5.4
STREAM REACH	7.0	RCH= Dnstrm Sugar R	FROM	5.4	TO	3.4
ENDATA2	0.0			0.0		0.0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE	REACH	AVAIL HDWS	TARGET	ORDER OF AVAIL SOURCES					
ENDATA3	0.	0.	0.0	0.	0.	0.	0.	0.	0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE	REACH	ELEMENTS/REACH	COMPUTATIONAL FLAGS
FLAG FIELD	1.	6.	1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	2.	10.	2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	3.	14.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.

FLAG FIELD	4.	9.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CMANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	2.	945.00	0.13	0.10	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	3.	935.00	0.13	0.20	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	4.	925.00	0.13	0.05	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	5.	915.00	0.13	0.00	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	6.	910.00	0.13	0.05	35.00	35.00	29.10	15.40	1.00
TEMP/LCD	7.	910.00	0.13	0.05	35.00	35.00	29.10	15.40	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 TSIV COEF FOR OPT 8	OR OR	EXPQK2 SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000		0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	2.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	3.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	4.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	5.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	6.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	7.	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.390	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	2.	0.650	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	3.	0.910	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	4.	0.590	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	5.	0.460	43.40	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

INCR INFLOW-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC=Sugar R Confluen	46.	49.	48.
ENDATA9	0.		0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	NSWTPOutfall	5.60	56.10	6.00	15.30	0.00	0.00	0.00
HEADWTR-1	2.	Sugar River	18.00	43.40	7.00	4.00	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	8.30	0.00	0.00	0.50	0.73	0.00	1.00	0.00	0.89
HEADWTR-2	2.	5.00	0.00	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
ENDATA11A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

	DAM	RCH	ELE	ADAM	BDAM	FDAM	HDAM
ENDATA12	0.	0.	0.	0.00	0.00	0.00	0.00

$$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

CARD TYPE	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
ENDATA13	DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED							

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P
ENDATA13A	DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED						

STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS

TEMPERATURE — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	54.89	53.75	52.68	51.67	50.73	49.84														
2	49.07	48.37	47.71	47.09	46.50	45.93	45.40	44.90	44.42	43.96										
3	43.62	43.38	43.15	42.92	42.71	42.50	42.29	42.10	41.91	41.72	41.55	41.37	41.21	41.05						
4	40.82	40.45	40.10	39.77	39.46	39.16	38.88	38.61	38.35											
5	38.14	37.98	37.81	37.66	37.51	37.36	37.23													
6	43.10	42.80																		
7	40.85	40.69	40.52	40.36	40.20	40.04	39.89	39.73	39.58	39.43	39.29	39.14	39.00	38.86	38.73	38.59	38.46	38.33	38.20	38.07

1 40

TEMPERATURE — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	54.83	53.65	52.55	51.53	50.57	49.67														
2	48.89	48.19	47.54	46.91	46.33	45.77	45.24	44.74	44.27	43.82										
3	43.49	43.25	43.03	42.80	42.59	42.38	42.18	41.98	41.80	41.62	41.44	41.27	41.11	40.95						
4	40.73	40.36	40.02	39.69	39.38	39.08	38.80	38.53	38.27											
5	38.06	37.89	37.73	37.57	37.42	37.28	37.14													
6	43.10	42.80																		
7	40.83	40.66	40.49	40.33	40.17	40.01	39.86	39.71	39.55	39.41	39.26	39.12	38.97	38.83	38.70	38.56	38.43	38.29	38.16	38.04

2 0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 9.2

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	0.00	9	0.00	17	0.00
2	0.00	10	0.00	18	0.00
3	0.00	11	0.00	19	0.00
4	0.00	12	0.00	20	0.00
5	0.00	13	0.00	21	0.00
6	0.00	14	0.00	22	0.00
7	0.00	15	0.00	23	0.00
8	0.00	16	0.00	24	0.00

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	15.10	14.91	14.72	14.54	14.36	14.19														
2	14.02	13.83	13.65	13.48	13.31	13.15	12.99	12.84	12.69	12.54										
3	12.41	12.29	12.18	12.06	11.95	11.85	11.74	11.64	11.53	11.43	11.34	11.24	11.15	11.05						
4	10.96	10.88	10.79	10.71	10.62	10.54	10.47	10.39	10.31											
5	10.24	10.16	10.09	10.02	9.95	9.89	9.82													
6	3.99	3.98																		
7	5.86	5.84	5.83	5.81	5.80	5.78	5.77	5.76	5.74	5.73	5.71	5.70	5.69	5.67	5.66	5.65	5.63	5.62	5.61	5.59

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.25	8.20	8.16	8.11	8.07	8.02														
2	7.98	7.93	7.89	7.84	7.80	7.76	7.72	7.68	7.64	7.60										
3	7.57	7.53	7.50	7.47	7.44	7.41	7.38	7.35	7.32	7.30	7.27	7.24	7.21	7.19						
4	7.16	7.14	7.11	7.09	7.07	7.04	7.02	7.00	6.98											
5	6.95	6.93	6.91	6.89	6.87	6.85	6.83													
6	4.99	4.99																		

7	5.58	5.58	5.57	5.57	5.56	5.56	5.55	5.55	5.54	5.54	5.53	5.53	5.52	5.52	5.51	5.51	5.51	5.50	5.50	5.49

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.03	0.06	0.09	0.12	0.15	0.18														
2	0.20	0.23	0.26	0.28	0.31	0.33	0.36	0.38	0.41	0.43										
3	0.45	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.71						
4	0.73	0.75	0.77	0.78	0.80	0.81	0.83	0.85	0.86											
5	0.88	0.89	0.91	0.92	0.94	0.95	0.97													
6	2.70	2.71																		
7	2.14	2.15	2.15	2.15	2.15	2.16	2.16	2.16	2.16	2.17	2.17	2.17	2.17	2.17	2.18	2.18	2.18	2.18	2.19	2.19

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.87	0.86	0.86	0.85	0.84														
2	0.83	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77										
3	0.76	0.76	0.75	0.75	0.74	0.74	0.73	0.72	0.72	0.71	0.71	0.70	0.70	0.69						
4	0.69	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.65											
5	0.65	0.64	0.64	0.64	0.63	0.63	0.62													
6	0.13	0.13																		
7	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.50														
2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50										
3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.51	0.51	0.51	0.51	0.51						
4	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51											
5	0.51	0.51	0.51	0.51	0.51	0.51	0.51													
6	0.62	0.62																		
7	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.72	0.71	0.70	0.69	0.69	0.68														
2	0.67	0.66	0.65	0.65	0.64	0.63	0.63	0.62	0.61	0.61										
3	0.60	0.59	0.59	0.58	0.58	0.57	0.57	0.56	0.56	0.55	0.55	0.54	0.54	0.54						
4	0.53	0.53	0.52	0.52	0.52	0.51	0.51	0.51	0.50											
5	0.50	0.49	0.49	0.49	0.48	0.48	0.48													
6	0.12	0.12																		
7	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.01	0.01	0.01	0.01	0.02														
2	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04										
3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05						
4	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05											
5	0.05	0.05	0.05	0.05	0.05	0.05	0.05													
6	0.00	0.00																		
7	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.01	1.03	1.04	1.06	1.07	1.08														
2	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.21										
3	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.30	1.31	1.32	1.33	1.34						
4	1.35	1.36	1.36	1.37	1.38	1.39	1.40	1.40	1.41											
5	1.42	1.43	1.43	1.44	1.45	1.45	1.46													
6	2.30	2.30																		
7	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.33	6.63	6.92	7.19	7.44	7.68														
2	7.82	7.83	7.85	7.87	7.89	7.91	7.94	7.97	8.01	8.04										
3	8.09	8.15	8.20	8.25	8.30	8.35	8.40	8.45	8.50	8.55	8.60	8.65	8.69	8.74						
4	8.91	9.19	9.44	9.67	9.88	10.08	10.27	10.44	10.60											
5	10.71	10.77	10.83	10.89	10.95	11.01	11.06													
6	7.12	7.25																		
7	8.56	8.64	8.73	8.81	8.89	8.97	9.05	9.13	9.20	9.28	9.35	9.42	9.49	9.56	9.63	9.70	9.76	9.83	9.89	9.95

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	66
ALGAE GROWTH RATE	2	66
ALGAE GROWTH RATE	3	66
ALGAE GROWTH RATE	4	66
ALGAE GROWTH RATE	5	66
ALGAE GROWTH RATE	6	0
NITRIFICATION INHIBITION	1	0
ALGAE GROWTH RATE	7	0
NITRIFICATION INHIBITION	2	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:

1. LIGHT AVERAGING OPTION. LAVOPT= 2

METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

SOURCE OF SOLAR VALUES: DATA TYPE 1A
DAILY NET SOLAR RADIATION: 400.000 BTU/FT-2 (108.548 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 9.2
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): N/A
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS. LGROPT= 1

MULTIPLICATIVE: FL*FN*FP

TEMPERATURE — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	54.83	53.65	52.55	51.53	50.57	49.67														
2	48.89	48.19	47.54	46.91	46.33	45.77	45.24	44.74	44.27	43.82										
3	43.49	43.25	43.02	42.80	42.59	42.38	42.18	41.98	41.80	41.62	41.44	41.27	41.11	40.95						
4	40.73	40.36	40.02	39.69	39.38	39.08	38.80	38.53	38.27											
5	38.06	37.89	37.73	37.57	37.42	37.28	37.14													
6	43.10	42.80																		
7	40.83	40.66	40.49	40.33	40.17	40.01	39.86	39.71	39.55	39.41	39.26	39.12	38.97	38.83	38.70	38.56	38.43	38.29	38.16	38.04

DISSOLVED OXYGEN IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.33	6.63	6.92	7.19	7.44	7.68														
2	7.82	7.83	7.85	7.86	7.89	7.91	7.94	7.97	8.01	8.04										
3	8.09	8.14	8.20	8.25	8.30	8.35	8.40	8.45	8.50	8.55	8.60	8.64	8.69	8.74						
4	8.91	9.18	9.44	9.67	9.88	10.08	10.27	10.44	10.60											
5	10.71	10.77	10.83	10.89	10.95	11.01	11.06													
6	7.12	7.25																		
7	8.56	8.64	8.73	8.81	8.89	8.97	9.05	9.13	9.20	9.28	9.35	9.42	9.49	9.56	9.63	9.70	9.76	9.83	9.89	9.95

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	15.10	14.91	14.72	14.54	14.36	14.19														
2	14.02	13.83	13.65	13.48	13.31	13.15	12.99	12.84	12.69	12.54										
3	12.41	12.29	12.18	12.06	11.95	11.85	11.74	11.64	11.53	11.43	11.34	11.24	11.15	11.05						
4	10.96	10.88	10.79	10.71	10.62	10.54	10.47	10.39	10.31											
5	10.24	10.16	10.09	10.02	9.95	9.89	9.82													
6	3.99	3.98																		
7	5.86	5.84	5.83	5.81	5.80	5.78	5.77	5.76	5.74	5.73	5.71	5.70	5.69	5.67	5.66	5.65	5.63	5.62	5.61	5.59

ORGANIC NITROGEN AS N IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.50														
2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50										
3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.51	0.51	0.51	0.51	0.51						
4	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51											
5	0.51	0.51	0.51	0.51	0.51	0.51	0.51													
6	0.62	0.62																		
7	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57

AMMONIA AS N IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.72	0.71	0.70	0.69	0.69	0.68														
2	0.67	0.66	0.65	0.65	0.64	0.63	0.62	0.62	0.61	0.61										
3	0.60	0.59	0.59	0.58	0.58	0.57	0.57	0.56	0.56	0.55	0.55	0.54	0.54	0.54						
4	0.53	0.53	0.52	0.52	0.52	0.51	0.51	0.50	0.50											
5	0.50	0.49	0.49	0.49	0.48	0.48	0.48													
6	0.12	0.12																		
7	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

NITRITE AS N IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.01	0.01	0.01	0.01	0.02														
2	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04										
3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05						
4	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05											
5	0.05	0.05	0.05	0.05	0.05	0.05	0.05													
6	0.00	0.00																		
7	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.01	1.03	1.04	1.06	1.07	1.08														
2	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.21										
3	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.30	1.31	1.32	1.33	1.34						
4	1.35	1.36	1.36	1.37	1.38	1.39	1.40	1.40	1.41											
5	1.42	1.43	1.43	1.44	1.45	1.45	1.46													
6	2.30	2.30																		
7	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											

5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.87	0.86	0.86	0.85	0.84														
2	0.83	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77										
3	0.76	0.76	0.75	0.75	0.74	0.74	0.73	0.72	0.72	0.71	0.71	0.70	0.70	0.69						
4	0.69	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.65											
5	0.65	0.64	0.64	0.64	0.63	0.63	0.62													
6	0.13	0.13																		
7	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29

ALGAE AS CHL-A IN UG/L ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.03	0.06	0.09	0.12	0.15	0.18														
2	0.20	0.23	0.26	0.28	0.31	0.34	0.36	0.39	0.41	0.43										
3	0.46	0.48	0.50	0.52	0.54	0.56	0.59	0.61	0.63	0.65	0.66	0.68	0.70	0.72						
4	0.74	0.76	0.77	0.79	0.81	0.82	0.84	0.85	0.87											
5	0.89	0.90	0.92	0.93	0.95	0.96	0.98													
6	2.70	2.71																		
7	2.15	2.15	2.15	2.16	2.16	2.16	2.17	2.17	2.17	2.17	2.18	2.18	2.18	2.19	2.19	2.19	2.19	2.20	2.20	2.20

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.25	8.20	8.16	8.11	8.07	8.02														
2	7.98	7.93	7.89	7.84	7.80	7.76	7.72	7.68	7.64	7.60										
3	7.57	7.53	7.50	7.47	7.44	7.41	7.38	7.35	7.32	7.30	7.27	7.24	7.21	7.19						
4	7.16	7.14	7.11	7.09	7.07	7.04	7.02	7.00	6.98											
5	6.95	6.93	6.91	6.89	6.87	6.85	6.83													
6	4.99	4.99																		
7	5.58	5.58	5.57	5.57	5.56	5.56	5.55	5.55	5.54	5.54	5.53	5.53	5.52	5.52	5.51	5.51	5.51	5.50	5.50	5.49

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.53	0.52	0.50	0.49	0.48	0.47														
2	0.46	0.45	0.44	0.44	0.43	0.42	0.42	0.41	0.41	0.40										
3	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.38	0.38	0.38	0.38	0.38	0.38	0.37						
4	0.37	0.37	0.37	0.36	0.36	0.36	0.35	0.35	0.35											
5	0.35	0.35	0.34	0.34	0.34	0.34	0.34													
6	0.33	0.33																		
7	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33	0.33

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 9

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.98	5.98	5.98	5.98	5.98	5.98														
2	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98										
3	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.97	5.97	5.97	5.97	5.97						
4	5.98	5.98	5.98	5.97	5.97	5.97	5.97	5.97	5.97											
5	5.97	5.97	5.97	5.97	5.97	5.97	5.97													
6	4.98	4.98																		
7	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68	5.68

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	5.66	0.00	0.06	0.742	0.008	0.410	18.629	4.03	11.78	7.64	0.40
2	1	2	9.90	9.80	5.73	0.00	0.06	0.744	0.008	0.413	18.653	4.06	11.81	7.70	0.41
3	1	3	9.80	9.70	5.80	0.00	0.06	0.747	0.008	0.415	18.676	4.10	11.83	7.76	0.41
4	1	4	9.70	9.60	5.86	0.00	0.06	0.750	0.008	0.418	18.699	4.13	11.86	7.82	0.42
5	1	5	9.60	9.50	5.93	0.00	0.06	0.752	0.008	0.421	18.722	4.16	11.88	7.87	0.42
6	1	6	9.50	9.40	5.99	0.00	0.06	0.755	0.008	0.423	18.745	4.19	11.91	7.93	0.42
7	2	1	9.40	9.30	6.06	0.00	0.06	0.525	0.012	0.712	16.211	6.10	9.41	11.54	0.54
8	2	2	9.30	9.20	6.12	0.00	0.06	0.526	0.012	0.717	16.228	6.14	9.42	11.63	0.55
9	2	3	9.20	9.10	6.19	0.00	0.06	0.528	0.012	0.721	16.235	6.18	9.43	11.71	0.55
10	2	4	9.10	9.00	6.25	0.00	0.06	0.530	0.012	0.726	16.242	6.22	9.44	11.79	0.56
11	2	5	9.00	8.90	6.32	0.00	0.06	0.532	0.011	0.730	16.249	6.26	9.45	11.86	0.56
12	2	6	8.90	8.80	6.38	0.00	0.06	0.534	0.011	0.735	16.256	6.30	9.46	11.94	0.57
13	2	7	8.80	8.70	6.45	0.00	0.06	0.536	0.011	0.739	16.263	6.35	9.46	12.02	0.57
14	2	8	8.70	8.60	6.51	0.00	0.06	0.538	0.011	0.743	16.270	6.39	9.47	12.10	0.58
15	2	9	8.60	8.50	6.58	0.00	0.06	0.540	0.011	0.748	16.277	6.43	9.48	12.17	0.58
16	2	10	8.50	8.40	6.64	0.00	0.06	0.542	0.011	0.752	16.284	6.47	9.49	12.25	0.59
17	3	1	8.40	8.30	6.71	0.00	0.07	0.849	0.007	0.848	9.309	4.17	6.78	7.90	0.68
18	3	2	8.30	8.20	6.77	0.00	0.07	0.852	0.007	0.852	9.326	4.20	6.80	7.95	0.68
19	3	3	8.20	8.10	6.84	0.00	0.07	0.854	0.007	0.857	9.342	4.23	6.82	8.00	0.69
20	3	4	8.10	8.00	6.90	0.00	0.07	0.856	0.007	0.861	9.359	4.25	6.84	8.06	0.69
21	3	5	8.00	7.90	6.97	0.00	0.07	0.859	0.007	0.865	9.375	4.28	6.85	8.11	0.70
22	3	6	7.90	7.80	7.03	0.00	0.07	0.861	0.007	0.870	9.392	4.31	6.87	8.17	0.70
23	3	7	7.80	7.70	7.10	0.00	0.07	0.863	0.007	0.874	9.408	4.34	6.89	8.22	0.71
24	3	8	7.70	7.60	7.16	0.00	0.07	0.865	0.007	0.878	9.424	4.37	6.91	8.27	0.71
25	3	9	7.60	7.50	7.23	0.00	0.07	0.868	0.007	0.882	9.440	4.40	6.93	8.33	0.72
26	3	10	7.50	7.40	7.29	0.00	0.07	0.870	0.007	0.886	9.457	4.42	6.94	8.38	0.72
27	3	11	7.40	7.30	7.36	0.00	0.07	0.872	0.007	0.890	9.473	4.45	6.96	8.43	0.73
28	3	12	7.30	7.20	7.42	0.00	0.07	0.874	0.007	0.894	9.488	4.48	6.98	8.49	0.73
29	3	13	7.20	7.10	7.49	0.00	0.07	0.877	0.007	0.898	9.504	4.51	7.00	8.54	0.74
30	3	14	7.10	7.00	7.55	0.00	0.07	0.879	0.007	0.903	9.520	4.54	7.01	8.59	0.74
31	4	1	7.00	6.90	7.62	0.00	0.07	0.935	0.007	0.371	21.939	4.30	12.74	8.14	0.38
32	4	2	6.90	6.80	7.68	0.00	0.07	0.938	0.007	0.373	21.949	4.32	12.76	8.19	0.38
33	4	3	6.80	6.70	7.75	0.00	0.07	0.941	0.006	0.375	21.959	4.35	12.77	8.23	0.38
34	4	4	6.70	6.60	7.81	0.00	0.07	0.944	0.006	0.377	21.968	4.37	12.78	8.28	0.38
35	4	5	6.60	6.50	7.88	0.00	0.07	0.947	0.006	0.379	21.978	4.39	12.79	8.32	0.39
36	4	6	6.50	6.40	7.94	0.00	0.07	0.950	0.006	0.380	21.988	4.42	12.80	8.36	0.39
37	4	7	6.40	6.30	8.01	0.00	0.07	0.952	0.006	0.382	21.997	4.44	12.81	8.41	0.39
38	4	8	6.30	6.20	8.07	0.00	0.07	0.955	0.006	0.384	22.007	4.46	12.82	8.45	0.39
39	4	9	6.20	6.10	8.14	0.00	0.07	0.958	0.006	0.386	22.016	4.49	12.83	8.50	0.40
40	5	1	6.10	6.00	8.21	0.00	0.07	0.986	0.006	0.497	16.734	4.39	10.84	8.32	0.44
41	5	2	6.00	5.90	8.27	0.00	0.07	0.989	0.006	0.499	16.750	4.42	10.86	8.37	0.44
42	5	3	5.90	5.80	8.34	0.00	0.07	0.991	0.006	0.502	16.767	4.44	10.88	8.41	0.45
43	5	4	5.80	5.70	8.40	0.00	0.07	0.994	0.006	0.504	16.783	4.47	10.89	8.46	0.45
44	5	5	5.70	5.60	8.47	0.00	0.07	0.996	0.006	0.506	16.799	4.49	10.91	8.50	0.45
45	5	6	5.60	5.50	8.53	0.00	0.07	0.999	0.006	0.508	16.816	4.51	10.93	8.55	0.46
46	5	7	5.50	5.40	8.60	0.00	0.07	1.001	0.006	0.510	16.832	4.54	10.95	8.59	0.46
47	6	1	5.60	5.50	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
48	6	2	5.50	5.40	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
49	7	1	5.40	5.30	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
50	7	2	5.30	5.20	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
51	7	3	5.20	5.10	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
52	7	4	5.10	5.00	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
53	7	5	5.00	4.90	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
54	7	6	4.90	4.80	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
55	7	7	4.80	4.70	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
56	7	8	4.70	4.60	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
57	7	9	4.60	4.50	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
58	7	10	4.50	4.40	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
59	7	11	4.40	4.30	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
60	7	12	4.30	4.20	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
61	7	13	4.20	4.10	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
62	7	14	4.10	4.00	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
63	7	15	4.00	3.90	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
64	7	16	3.90	3.80	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
65	7	17	3.80	3.70	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
66	7	18	3.70	3.60	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
67	7	19	3.60	3.50	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
68	7	20	3.50	3.40	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	10.32	8	12.11	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
1	2	10.48	8	11.93	0.55	0.00	0.00	0.17	0.08	0.52	0.00	0.68	0.14	0.08	0.00	0.00	0.00	0.17	0.00
1	3	10.63	8	11.79	0.54	0.00	0.00	0.17	0.08	0.50	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
1	4	10.77	8	11.66	0.53	0.00	0.00	0.16	0.08	0.48	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
1	5	10.90	8	11.54	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
1	6	11.03	8	11.44	0.50	0.00	0.00	0.16	0.08	0.44	0.00	0.62	0.13	0.08	0.00	0.00	0.00	0.16	0.00
2	1	11.14	8	7.03	0.49	0.00	0.00	0.15	0.08	0.42	0.00	0.61	0.12	0.08	0.00	0.00	0.00	0.16	0.00
2	2	11.25	8	2.71	0.48	0.00	0.00	0.15	0.08	0.41	0.00	0.60	0.12	0.08	0.00	0.00	0.00	0.15	0.00
2	3	11.35	8	2.69	0.47	0.00	0.00	0.15	0.08	0.40	0.00	0.59	0.12	0.08	0.00	0.00	0.00	0.15	0.00
2	4	11.44	8	2.68	0.47	0.00	0.00	0.15	0.08	0.39	0.00	0.58	0.12	0.08	0.00	0.00	0.00	0.15	0.00
2	5	11.53	8	2.67	0.46	0.00	0.00	0.14	0.08	0.38	0.00	0.57	0.11	0.08	0.00	0.00	0.00	0.15	0.00
2	6	11.62	8	2.66	0.45	0.00	0.00	0.14	0.07	0.37	0.00	0.56	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	7	11.71	8	2.65	0.45	0.00	0.00	0.14	0.07	0.36	0.00	0.55	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	8	11.79	8	2.64	0.44	0.00	0.00	0.14	0.07	0.35	0.00	0.55	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	9	11.87	8	2.63	0.44	0.00	0.00	0.14	0.07	0.35	0.00	0.54	0.11	0.07	0.00	0.00	0.00	0.15	0.00
2	10	11.94	8	2.62	0.43	0.00	0.00	0.13	0.07	0.34	0.00	0.53	0.11	0.07	0.00	0.00	0.00	0.15	0.00
3	1	12.00	8	3.21	0.43	0.00	0.00	0.13	0.07	0.33	0.00	0.53	0.11	0.07	0.00	0.00	0.00	0.14	0.00
3	2	12.04	8	3.79	0.43	0.00	0.00	0.13	0.07	0.33	0.00	0.53	0.11	0.07	0.00	0.00	0.00	0.14	0.00
3	3	12.07	8	3.79	0.42	0.00	0.00	0.13	0.07	0.33	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
3	4	12.11	8	3.78	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
3	5	12.15	8	3.78	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.52	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	6	12.18	8	3.77	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.52	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	7	12.22	8	3.77	0.41	0.00	0.00	0.13	0.07	0.32	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	8	12.25	8	3.77	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	9	12.29	8	3.76	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	10	12.32	8	3.76	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.51	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	11	12.35	8	3.75	0.41	0.00	0.00	0.13	0.07	0.31	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	12	12.38	8	3.75	0.40	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	13	12.41	8	3.75	0.40	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
3	14	12.44	8	3.75	0.40	0.00	0.00	0.13	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	1	12.48	8	9.24	0.40	0.00	0.00	0.12	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	2	12.54	8	14.70	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	3	12.60	8	14.67	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	4	12.66	8	14.64	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	5	12.72	8	14.62	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	6	12.78	8	14.60	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
4	7	12.83	8	14.58	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
4	8	12.88	8	14.56	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
4	9	12.93	8	14.54	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
5	1	12.97	8	11.58	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	2	13.00	8	8.64	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	3	13.03	8	8.63	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	4	13.06	8	8.63	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	5	13.09	8	8.63	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	6	13.12	8	8.62	0.37	0.00	0.00	0.11	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00
5	7	13.15	8	8.62	0.36	0.00	0.00	0.11	0.07	0.25	0.00	0.45	0.09	0.07	0.00	0.00	0.00	0.13	0.00
6	1	12.06	8	3.80	0.42	0.00	0.00	0.13	0.07	0.33	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
6	2	12.11	8	3.79	0.42	0.00	0.00	0.13	0.07	0.32	0.00	0.52	0.11	0.07	0.00	0.00	0.00	0.14	0.00
7	1	12.46	8	5.30	0.40	0.00	0.00	0.12	0.07	0.30	0.00	0.50	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	2	12.49	8	4.22	0.40	0.00	0.00	0.12	0.07	0.30	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	3	12.52	8	4.21	0.40	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	4	12.55	8	4.20	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	5	12.58	8	4.20	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	6	12.60	8	4.19	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	7	12.63	8	4.18	0.39	0.00	0.00	0.12	0.07	0.29	0.00	0.49	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	8	12.66	8	4.17	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	9	12.69	8	4.16	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	10	12.72	8	4.15	0.39	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	11	12.74	8	4.14	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	12	12.77	8	4.14	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.48	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	13	12.80	8	4.13	0.38	0.00	0.00	0.12	0.07	0.28	0.00	0.47	0.10	0.07	0.00	0.00	0.00	0.14	0.00
7	14	12.82	8	4.12	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	15	12.85	8	4.11	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	16	12.88	8	4.11	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	17	12.90	8	4.10	0.38	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	18	12.93	8	4.09	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.14	0.00
7	19	12.95	8	4.09	0.37	0.00	0.00	0.12	0.07	0.27	0.00	0.47	0.09	0.07	0.00	0.00	0.00	0.13	0.00
7	20	12.98	8	4.08	0.37	0.00	0.00	0.12	0.07	0.26	0.00	0.46	0.09	0.07	0.00	0.00	0.00	0.13	0.00

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota open	CHLA UG/L
1	1	54.83	0.00	0.00	0.00	6.33	15.10	0.50	0.72	0.00	1.01	2.24	0.00	0.88	0.88	0.00	8.25	0.03
1	2	53.65	0.00	0.00	0.00	6.63	14.91	0.50	0.71	0.01	1.03	2.25	0.00	0.87	0.87	0.00	8.20	0.06
1	3	52.55	0.00	0.00	0.00	6.92	14.72	0.50	0.70	0.01	1.04	2.26	0.00	0.86	0.86	0.00	8.16	0.09
1	4	51.53	0.00	0.00	0.00	7.19	14.54	0.50	0.69	0.01	1.06	2.26	0.00	0.86	0.86	0.00	8.11	0.12
1	5	50.57	0.00	0.00	0.00	7.44	14.36	0.50	0.69	0.01	1.07	2.27	0.00	0.85	0.85	0.00	8.07	0.15
1	6	49.67	0.00	0.00	0.00	7.68	14.19	0.50	0.68	0.02	1.08	2.28	0.00	0.84	0.84	0.00	8.02	0.18
2	1	48.89	0.00	0.00	0.00	7.82	14.02	0.50	0.67	0.02	1.10	2.29	0.00	0.83	0.83	0.00	7.98	0.20
2	2	48.19	0.00	0.00	0.00	7.83	13.83	0.50	0.66	0.02	1.11	2.30	0.00	0.83	0.83	0.00	7.93	0.23
2	3	47.54	0.00	0.00	0.00	7.85	13.65	0.50	0.65	0.02	1.12	2.30	0.00	0.82	0.82	0.00	7.89	0.26
2	4	46.91	0.00	0.00	0.00	7.86	13.48	0.50	0.65	0.03	1.14	2.31	0.00	0.81	0.81	0.00	7.84	0.28
2	5	46.33	0.00	0.00	0.00	7.89	13.31	0.50	0.64	0.03	1.15	2.32	0.00	0.80	0.80	0.00	7.80	0.31
2	6	45.77	0.00	0.00	0.00	7.91	13.15	0.50	0.63	0.03	1.16	2.32	0.00	0.80	0.80	0.00	7.76	0.34
2	7	45.24	0.00	0.00	0.00	7.94	12.99	0.50	0.62	0.03	1.17	2.33	0.00	0.79	0.79	0.00	7.72	0.36
2	8	44.74	0.00	0.00	0.00	7.97	12.84	0.50	0.62	0.03	1.18	2.34	0.00	0.78	0.78	0.00	7.68	0.39
2	9	44.27	0.00	0.00	0.00	8.01	12.69	0.50	0.61	0.04	1.19	2.34	0.00	0.78	0.78	0.00	7.64	0.41
2	10	43.82	0.00	0.00	0.00	8.04	12.54	0.50	0.61	0.04	1.21	2.35	0.00	0.77	0.77	0.00	7.60	0.43
3	1	43.49	0.00	0.00	0.00	8.09	12.41	0.50	0.60	0.04	1.22	2.36	0.00	0.76	0.76	0.00	7.57	0.46
3	2	43.25	0.00	0.00	0.00	8.14	12.29	0.50	0.59	0.04	1.23	2.36	0.00	0.76	0.76	0.00	7.53	0.48
3	3	43.02	0.00	0.00	0.00	8.20	12.18	0.50	0.59	0.04	1.24	2.37	0.00	0.75	0.75	0.00	7.50	0.50
3	4	42.80	0.00	0.00	0.00	8.25	12.06	0.50	0.58	0.04	1.25	2.38	0.00	0.75	0.75	0.00	7.47	0.52
3	5	42.59	0.00	0.00	0.00	8.30	11.95	0.50	0.58	0.04	1.26	2.38	0.00	0.74	0.74	0.00	7.44	0.54
3	6	42.38	0.00	0.00	0.00	8.35	11.85	0.50	0.57	0.04	1.27	2.39	0.00	0.74	0.74	0.00	7.41	0.56
3	7	42.18	0.00	0.00	0.00	8.40	11.74	0.50	0.57	0.04	1.28	2.39	0.00	0.73	0.73	0.00	7.38	0.59
3	8	41.98	0.00	0.00	0.00	8.45	11.64	0.50	0.56	0.05	1.29	2.40	0.00	0.72	0.72	0.00	7.35	0.61
3	9	41.80	0.00	0.00	0.00	8.50	11.53	0.50	0.56	0.05	1.30	2.40	0.00	0.72	0.72	0.00	7.32	0.63
3	10	41.62	0.00	0.00	0.00	8.55	11.43	0.51	0.55	0.05	1.30	2.41	0.00	0.71	0.71	0.00	7.30	0.65 ✓
3	11	41.44	0.00	0.00	0.00	8.60	11.34	0.51	0.55	0.05	1.31	2.42	0.00	0.71	0.71	0.00	7.27	0.66
3	12	41.27	0.00	0.00	0.00	8.64	11.24	0.51	0.54	0.05	1.32	2.42	0.00	0.70	0.70	0.00	7.24	0.68
3	13	41.11	0.00	0.00	0.00	8.69	11.15	0.51	0.54	0.05	1.33	2.43	0.00	0.70	0.70	0.00	7.21	0.70
3	14	40.95	0.00	0.00	0.00	8.74	11.05	0.51	0.54	0.05	1.34	2.43	0.00	0.69	0.69	0.00	7.19	0.72
4	1	40.73	0.00	0.00	0.00	8.91	10.96	0.51	0.53	0.05	1.35	2.44	0.00	0.69	0.69	0.00	7.16	0.74
4	2	40.36	0.00	0.00	0.00	9.18	10.88	0.51	0.53	0.05	1.36	2.44	0.00	0.68	0.68	0.00	7.14	0.76
4	3	40.02	0.00	0.00	0.00	9.44	10.79	0.51	0.52	0.05	1.36	2.45	0.00	0.68	0.68	0.00	7.11	0.77
4	4	39.69	0.00	0.00	0.00	9.67	10.71	0.51	0.52	0.05	1.37	2.45	0.00	0.67	0.67	0.00	7.09	0.79
4	5	39.38	0.00	0.00	0.00	9.88	10.62	0.51	0.52	0.05	1.38	2.45	0.00	0.67	0.67	0.00	7.07	0.81
4	6	39.08	0.00	0.00	0.00	10.08	10.54	0.51	0.51	0.05	1.39	2.46	0.00	0.67	0.67	0.00	7.04	0.82
4	7	38.80	0.00	0.00	0.00	10.27	10.47	0.51	0.51	0.05	1.40	2.46	0.00	0.66	0.66	0.00	7.02	0.84
4	8	38.53	0.00	0.00	0.00	10.44	10.39	0.51	0.50	0.05	1.40	2.47	0.00	0.66	0.66	0.00	7.00	0.85
4	9	38.27	0.00	0.00	0.00	10.60	10.31	0.51	0.50	0.05	1.41	2.47	0.00	0.65	0.65	0.00	6.98	0.87
5	1	38.06	0.00	0.00	0.00	10.71	10.24	0.51	0.50	0.05	1.42	2.48	0.00	0.65	0.65	0.00	6.95	0.89
5	2	37.89	0.00	0.00	0.00	10.77	10.16	0.51	0.49	0.05	1.43	2.48	0.00	0.64	0.64	0.00	6.93	0.90
5	3	37.73	0.00	0.00	0.00	10.83	10.09	0.51	0.49	0.05	1.43	2.49	0.00	0.64	0.64	0.00	6.91	0.92
5	4	37.57	0.00	0.00	0.00	10.89	10.02	0.51	0.49	0.05	1.44	2.49	0.00	0.64	0.64	0.00	6.89	0.93
5	5	37.42	0.00	0.00	0.00	10.95	9.95	0.51	0.48	0.05	1.45	2.49	0.00	0.63	0.63	0.00	6.87	0.95
5	6	37.28	0.00	0.00	0.00	11.01	9.89	0.51	0.48	0.05	1.45	2.50	0.00	0.63	0.63	0.00	6.85	0.96
5	7	37.14	0.00	0.00	0.00	11.06	9.82	0.51	0.48	0.05	1.46	2.50	0.00	0.62	0.62	0.00	6.83	0.98 ✓
6	1	43.10	0.00	0.00	0.00	7.12	3.99	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.70
6	2	42.80	0.00	0.00	0.00	7.25	3.98	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.71
7	1	40.83	0.00	0.00	0.00	8.56	5.86	0.58	0.24	0.02	2.03	2.87	0.00	0.29	0.29	0.00	5.58	2.15
7	2	40.66	0.00	0.00	0.00	8.64	5.84	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.58	2.15
7	3	40.49	0.00	0.00	0.00	8.73	5.83	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.57	2.15
7	4	40.33	0.00	0.00	0.00	8.81	5.81	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.57	2.16
7	5	40.17	0.00	0.00	0.00	8.89	5.80	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.56	2.16
7	6	40.01	0.00	0.00	0.00	8.97	5.78	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.56	2.16
7	7	39.86	0.00	0.00	0.00	9.05	5.77	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.55	2.17
7	8	39.71	0.00	0.00	0.00	9.13	5.76	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.55	2.17
7	9	39.55	0.00	0.00	0.00	9.20	5.74	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.54	2.17
7	10	39.41	0.00	0.00	0.00	9.28	5.73	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.54	2.17
7	11	39.26	0.00	0.00	0.00	9.35	5.71	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.53	2.18
7	12	39.12	0.00	0.00	0.00	9.42	5.70	0.58	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.53	2.18
7	13	38.97	0.00	0.00	0.00	9.49	5.69	0.57	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.52	2.18
7	14	38.83	0.00	0.00	0.00	9.56	5.67	0.57	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.52	2.19
7	15	38.70	0.00	0.00	0.00	9.63	5.66	0.57	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.51	2.19
7	16	38.56	0.00	0.00	0.00	9.70	5.65	0.57	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.51	2.19
7	17	38.43	0.00	0.00	0.00	9.76	5.63	0.57	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.51	2.19
7	18	38.29	0.00	0.00	0.00	9.83	5.62	0.57	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.50	2.20
7	19	38.16	0.00	0.00	0.00	9.89	5.61	0.57	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.50	2.20
7	20	38.04	0.00	0.00	0.00	9.95	5.59	0.57	0.24	0.02	2.03	2.86	0.00	0.29	0.29	0.00	5.49	2.20

***** STEADY STATE SIMULATION *****

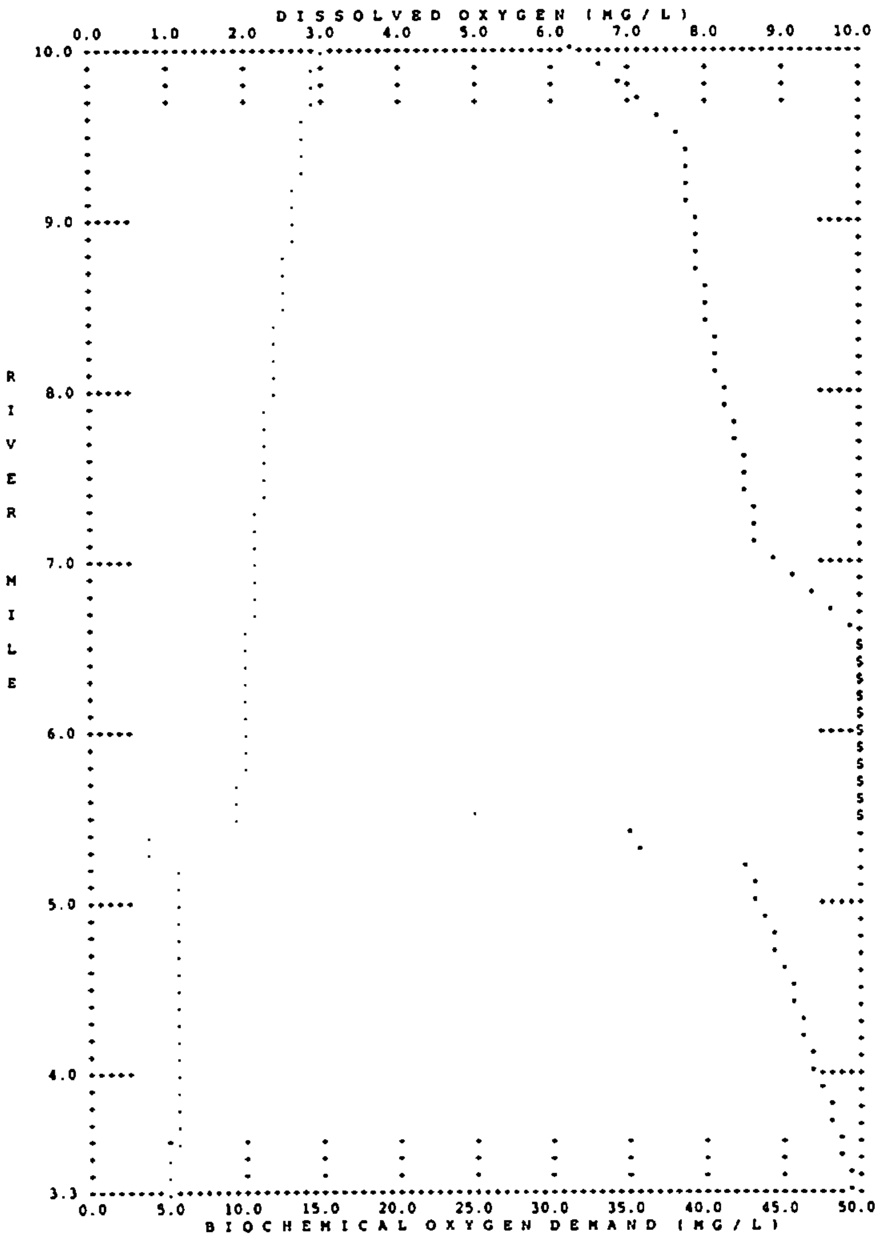
** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.03	0.53	0.07	0.08	5.98	0.00	0.90	0.86	0.02	0.37	0.85	0.96
2	1	2	0.06	0.52	0.07	0.08	5.98	0.00	0.90	0.86	0.02	0.37	0.85	0.96
3	1	3	0.09	0.50	0.07	0.08	5.98	0.00	0.90	0.86	0.02	0.37	0.85	0.96
4	1	4	0.12	0.49	0.07	0.08	5.98	0.00	0.90	0.86	0.02	0.37	0.85	0.96
5	1	5	0.15	0.48	0.06	0.08	5.98	0.00	0.90	0.85	0.03	0.37	0.85	0.95
6	1	6	0.18	0.47	0.06	0.08	5.98	0.00	0.90	0.85	0.03	0.37	0.85	0.95
7	2	1	0.20	0.46	0.06	0.08	5.98	0.00	0.90	0.85	0.03	0.37	0.85	0.95
8	2	2	0.23	0.45	0.06	0.08	5.98	0.00	0.90	0.84	0.03	0.37	0.86	0.95
9	2	3	0.26	0.44	0.06	0.08	5.98	0.00	0.90	0.84	0.03	0.37	0.86	0.95
10	2	4	0.28	0.44	0.06	0.08	5.98	0.00	0.90	0.84	0.04	0.37	0.86	0.95
11	2	5	0.31	0.43	0.06	0.08	5.98	0.00	0.90	0.83	0.04	0.37	0.86	0.95
12	2	6	0.34	0.42	0.06	0.07	5.98	0.00	0.90	0.83	0.04	0.37	0.86	0.95
13	2	7	0.36	0.42	0.06	0.07	5.98	0.00	0.90	0.83	0.04	0.37	0.86	0.95
14	2	8	0.39	0.41	0.06	0.07	5.98	0.00	0.90	0.82	0.04	0.37	0.86	0.95
15	2	9	0.41	0.41	0.05	0.07	5.98	0.00	0.90	0.82	0.04	0.37	0.86	0.95
16	2	10	0.43	0.40	0.05	0.07	5.98	0.00	0.90	0.82	0.04	0.37	0.86	0.95
17	3	1	0.46	0.40	0.05	0.07	5.98	0.00	0.90	0.82	0.05	0.37	0.86	0.95
18	3	2	0.48	0.40	0.05	0.07	5.98	0.01	0.90	0.81	0.05	0.37	0.86	0.95
19	3	3	0.50	0.39	0.05	0.07	5.98	0.01	0.90	0.81	0.05	0.37	0.86	0.95
20	3	4	0.52	0.39	0.05	0.07	5.98	0.01	0.90	0.81	0.05	0.37	0.86	0.95
21	3	5	0.54	0.39	0.05	0.07	5.98	0.01	0.90	0.81	0.05	0.37	0.86	0.95
22	3	6	0.56	0.39	0.05	0.07	5.98	0.01	0.90	0.80	0.05	0.37	0.86	0.95
23	3	7	0.59	0.39	0.05	0.07	5.98	0.01	0.90	0.80	0.05	0.37	0.86	0.95
24	3	8	0.61	0.38	0.05	0.07	5.98	0.01	0.90	0.80	0.05	0.37	0.86	0.95
25	3	9	0.63	0.38	0.05	0.07	5.98	0.01	0.90	0.80	0.05	0.37	0.86	0.95
26	3	10	0.65	0.38	0.05	0.07	5.97	0.01	0.90	0.79	0.06	0.37	0.86	0.95
27	3	11	0.66	0.38	0.05	0.07	5.97	0.01	0.90	0.79	0.06	0.37	0.86	0.95
28	3	12	0.68	0.38	0.05	0.07	5.97	0.01	0.90	0.79	0.06	0.37	0.86	0.95
29	3	13	0.70	0.38	0.05	0.07	5.97	0.01	0.90	0.79	0.06	0.37	0.86	0.95
30	3	14	0.72	0.37	0.05	0.07	5.97	0.01	0.90	0.78	0.06	0.37	0.86	0.95
31	4	1	0.74	0.37	0.05	0.07	5.98	0.01	0.90	0.78	0.06	0.37	0.86	0.95
32	4	2	0.76	0.37	0.05	0.07	5.98	0.01	0.90	0.78	0.06	0.37	0.86	0.94
33	4	3	0.77	0.37	0.05	0.07	5.98	0.01	0.90	0.78	0.06	0.37	0.86	0.94
34	4	4	0.79	0.36	0.05	0.07	5.97	0.01	0.90	0.77	0.06	0.37	0.86	0.94
35	4	5	0.81	0.36	0.05	0.07	5.97	0.01	0.90	0.77	0.06	0.37	0.86	0.94
36	4	6	0.82	0.36	0.05	0.07	5.97	0.01	0.90	0.77	0.06	0.37	0.86	0.94
37	4	7	0.84	0.35	0.05	0.07	5.97	0.01	0.90	0.77	0.07	0.37	0.86	0.94
38	4	8	0.85	0.35	0.05	0.07	5.97	0.01	0.90	0.76	0.07	0.37	0.86	0.94
39	4	9	0.87	0.35	0.05	0.07	5.97	0.01	0.90	0.76	0.07	0.37	0.86	0.94
40	5	1	0.89	0.35	0.05	0.07	5.97	0.01	0.90	0.76	0.07	0.37	0.86	0.94
41	5	2	0.90	0.35	0.05	0.07	5.97	0.01	0.90	0.76	0.07	0.37	0.86	0.94
42	5	3	0.92	0.34	0.05	0.07	5.97	0.01	0.90	0.76	0.07	0.37	0.87	0.94
43	5	4	0.93	0.34	0.05	0.07	5.97	0.01	0.90	0.75	0.07	0.37	0.87	0.94
44	5	5	0.95	0.34	0.05	0.07	5.97	0.01	0.90	0.75	0.07	0.37	0.87	0.94
45	5	6	0.96	0.34	0.05	0.07	5.97	0.01	0.90	0.75	0.07	0.37	0.87	0.94
46	5	7	0.98	0.34	0.05	0.07	5.97	0.01	0.90	0.75	0.07	0.37	0.87	0.94
47	6	1	2.70	0.33	0.05	0.07	4.98	0.02	0.90	0.32	0.14	0.37	0.89	0.76
48	6	2	2.71	0.33	0.05	0.07	4.98	0.02	0.90	0.32	0.14	0.37	0.89	0.76
49	7	1	2.15	0.35	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
50	7	2	2.15	0.35	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
51	7	3	2.15	0.35	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
52	7	4	2.16	0.35	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
53	7	5	2.16	0.35	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
54	7	6	2.16	0.35	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
55	7	7	2.17	0.35	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
56	7	8	2.17	0.34	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
57	7	9	2.17	0.34	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
58	7	10	2.17	0.34	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
59	7	11	2.18	0.34	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
60	7	12	2.18	0.34	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
61	7	13	2.18	0.34	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
62	7	14	2.19	0.34	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
63	7	15	2.19	0.34	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
64	7	16	2.19	0.33	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
65	7	17	2.19	0.33	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
66	7	18	2.20	0.33	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
67	7	19	2.20	0.33	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88
68	7	20	2.20	0.33	0.05	0.07	5.68	0.02	0.90	0.51	0.12	0.37	0.88	0.88

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY) F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	54.83	10.32	6.33	4.00	0.00	0.98	729.44	48.38	-8.63	0.00	0.00	-1.38	0.00
2	1	2	53.65	10.48	6.63	3.85	0.00	0.98	9.67	45.90	-8.27	0.00	0.00	-1.29	-0.01
3	1	3	52.55	10.63	6.92	3.71	0.00	0.98	9.60	43.72	-7.94	0.00	0.00	-1.22	-0.01
4	1	4	51.53	10.77	7.19	3.58	0.00	0.99	9.53	41.76	-7.64	0.00	0.00	-1.15	-0.01
5	1	5	50.57	10.90	7.44	3.46	0.00	0.99	9.46	39.97	-7.36	0.00	0.00	-1.10	-0.01
6	1	6	49.67	11.03	7.68	3.35	0.00	0.99	9.39	38.35	-7.11	0.00	0.00	-1.04	-0.01
7	2	1	48.89	11.14	7.82	3.32	0.00	0.99	6.45	23.37	-6.88	0.00	0.00	-1.00	-0.01
8	2	2	48.19	11.25	7.83	3.42	0.00	0.99	6.40	9.26	-6.67	0.00	0.00	-0.95	-0.02
9	2	3	47.54	11.35	7.85	3.50	0.00	0.99	6.36	9.43	-6.48	0.00	0.00	-0.92	-0.02
10	2	4	46.91	11.44	7.86	3.58	0.00	0.99	6.32	9.59	-6.29	0.00	0.00	-0.88	-0.02
11	2	5	46.33	11.53	7.89	3.65	0.00	0.99	6.28	9.73	-6.12	0.00	0.00	-0.85	-0.02
12	2	6	45.77	11.62	7.91	3.71	0.00	0.99	6.24	9.85	-5.96	0.00	0.00	-0.82	-0.02
13	2	7	45.24	11.71	7.94	3.76	0.00	0.99	6.20	9.96	-5.81	0.00	0.00	-0.79	-0.02
14	2	8	44.74	11.79	7.97	3.81	0.00	0.99	6.16	10.05	-5.67	0.00	0.00	-0.77	-0.02
15	2	9	44.27	11.87	8.01	3.86	0.00	0.99	6.12	10.14	-5.54	0.00	0.00	-0.74	-0.02
16	2	10	43.82	11.94	8.04	3.90	0.00	0.99	6.08	10.21	-5.41	0.00	0.00	-0.72	-0.02
17	3	1	43.49	12.00	8.09	3.90	0.00	0.99	9.43	12.52	-5.31	0.00	0.00	-0.70	-0.03
18	3	2	43.25	12.04	8.14	3.89	0.00	0.99	9.37	14.76	-5.23	0.00	0.01	-0.69	-0.03
19	3	3	43.02	12.07	8.20	3.88	0.00	0.99	9.30	14.69	-5.15	0.00	0.01	-0.68	-0.03
20	3	4	42.80	12.11	8.25	3.86	0.00	0.99	9.24	14.61	-5.07	0.00	0.01	-0.66	-0.03
21	3	5	42.59	12.15	8.30	3.85	0.00	0.99	9.18	14.54	-5.00	0.00	0.01	-0.65	-0.03
22	3	6	42.38	12.18	8.35	3.83	0.00	0.99	9.12	14.47	-4.93	0.00	0.01	-0.64	-0.03
23	3	7	42.18	12.22	8.40	3.82	0.00	0.99	9.06	14.39	-4.86	0.00	0.01	-0.63	-0.03
24	3	8	41.98	12.25	8.45	3.80	0.00	0.99	9.00	14.31	-4.79	0.00	0.01	-0.62	-0.03
25	3	9	41.80	12.29	8.50	3.79	0.00	0.99	8.94	14.24	-4.73	0.00	0.01	-0.61	-0.03
26	3	10	41.62	12.32	8.55	3.77	0.00	0.99	8.88	14.16	-4.66	0.00	0.01	-0.60	-0.03
27	3	11	41.44	12.35	8.60	3.75	0.00	0.99	8.83	14.08	-4.60	0.00	0.01	-0.59	-0.03
28	3	12	41.27	12.38	8.64	3.73	0.00	0.99	8.77	14.01	-4.54	0.00	0.01	-0.58	-0.03
29	3	13	41.11	12.41	8.69	3.71	0.00	0.99	8.72	13.93	-4.49	0.00	0.01	-0.57	-0.03
30	3	14	40.95	12.44	8.74	3.70	0.00	0.99	8.67	13.85	-4.43	0.00	0.01	-0.56	-0.03
31	4	1	40.73	12.48	8.91	3.56	0.00	1.00	9.22	32.94	-4.37	0.00	0.01	-0.55	-0.03
32	4	2	40.36	12.54	9.18	3.36	0.00	1.00	9.17	49.33	-4.30	0.00	0.01	-0.54	-0.03
33	4	3	40.02	12.60	9.44	3.17	0.00	1.00	9.12	46.46	-4.22	0.00	0.01	-0.53	-0.03
34	4	4	39.69	12.66	9.67	3.00	0.00	1.00	9.07	43.86	-4.16	0.00	0.01	-0.52	-0.03
35	4	5	39.38	12.72	9.88	2.84	0.00	1.00	9.03	41.49	-4.09	0.00	0.01	-0.51	-0.03
36	4	6	39.08	12.78	10.08	2.69	0.00	1.00	8.98	39.32	-4.03	0.00	0.01	-0.50	-0.03
37	4	7	38.80	12.83	10.27	2.56	0.00	1.00	8.93	37.35	-3.97	0.00	0.01	-0.49	-0.03
38	4	8	38.53	12.88	10.44	2.44	0.00	1.00	8.88	35.54	-3.92	0.00	0.01	-0.48	-0.03
39	4	9	38.27	12.93	10.60	2.33	0.00	1.00	8.84	33.89	-3.86	0.00	0.01	-0.47	-0.03
40	5	1	38.06	12.97	10.71	2.26	0.00	1.00	9.05	26.20	-3.81	0.00	0.01	-0.46	-0.03
41	5	2	37.89	13.00	10.77	2.23	0.00	1.00	9.00	19.27	-3.77	0.00	0.01	-0.45	-0.03
42	5	3	37.73	13.03	10.83	2.20	0.00	1.00	8.95	19.00	-3.73	0.00	0.01	-0.45	-0.03
43	5	4	37.57	13.06	10.89	2.17	0.00	1.00	8.90	18.74	-3.69	0.00	0.01	-0.44	-0.03
44	5	5	37.42	13.09	10.95	2.14	0.00	1.00	8.85	18.49	-3.65	0.00	0.01	-0.44	-0.03
45	5	6	37.28	13.12	11.01	2.12	0.00	1.00	8.81	18.25	-3.61	0.00	0.01	-0.43	-0.03
46	5	7	37.14	13.15	11.06	2.09	0.00	1.00	8.76	18.02	-3.57	0.00	0.01	-0.43	-0.03
47	6	1	43.10	12.06	7.12	4.94	0.00	0.99	959.81	18.76	-1.69	0.00	0.02	-0.14	0.00
48	6	2	42.80	12.11	7.25	4.87	0.00	0.99	0.00	18.42	-1.67	0.00	0.02	-0.14	0.00
49	7	1	40.83	12.46	8.56	3.90	0.00	0.99	0.00	20.67	-2.34	0.00	0.02	-0.25	-0.01
50	7	2	40.66	12.49	8.64	3.84	0.00	0.99	0.00	16.22	-2.32	0.00	0.02	-0.24	-0.01
51	7	3	40.49	12.52	8.73	3.79	0.00	0.99	0.00	15.96	-2.31	0.00	0.02	-0.24	-0.01
52	7	4	40.33	12.55	8.81	3.74	0.00	0.99	0.00	15.70	-2.29	0.00	0.02	-0.24	-0.01
53	7	5	40.17	12.58	8.89	3.68	0.00	1.00	0.00	15.45	-2.28	0.00	0.02	-0.24	-0.01
54	7	6	40.01	12.60	8.97	3.63	0.00	1.00	0.00	15.21	-2.26	0.00	0.02	-0.24	-0.01
55	7	7	39.86	12.63	9.05	3.58	0.00	1.00	0.00	14.97	-2.25	0.00	0.02	-0.24	-0.01
56	7	8	39.71	12.66	9.13	3.53	0.00	1.00	0.00	14.73	-2.24	0.00	0.02	-0.23	-0.01
57	7	9	39.55	12.69	9.20	3.49	0.00	1.00	0.00	14.51	-2.22	0.00	0.02	-0.23	-0.01
58	7	10	39.41	12.72	9.28	3.44	0.00	1.00	0.00	14.28	-2.21	0.00	0.02	-0.23	-0.01
59	7	11	39.26	12.74	9.35	3.39	0.00	1.00	0.00	14.07	-2.19	0.00	0.02	-0.23	-0.01
60	7	12	39.12	12.77	9.42	3.35	0.00	1.00	0.00	13.85	-2.18	0.00	0.02	-0.23	-0.01
61	7	13	38.97	12.80	9.49	3.30	0.00	1.00	0.00	13.65	-2.17	0.00	0.02	-0.23	-0.01
62	7	14	38.83	12.82	9.56	3.26	0.00	1.00	0.00	13.44	-2.16	0.00	0.02	-0.23	-0.01
63	7	15	38.70	12.85	9.63	3.22	0.00	1.00	0.00	13.25	-2.14	0.00	0.02	-0.23	-0.01
64	7	16	38.56	12.88	9.70	3.18	0.00	1.00	0.00	13.05	-2.13	0.00	0.02	-0.22	-0.01
65	7	17	38.43	12.90	9.76	3.14	0.00	1.00	0.00	12.86	-2.12	0.00	0.02	-0.22	-0.01
66	7	18	38.29	12.93	9.83	3.10	0.00	1.00	0.00	12.68	-2.11	0.00	0.02	-0.22	-0.01
67	7	19	38.16	12.95	9.89	3.06	0.00	1.00	0.00	12.50	-2.09	0.00	0.02	-0.22	-0.01
68	7	20	38.04	12.98	9.95	3.02	0.00	1.00	0.00	12.32	-2.08	0.00	0.02	-0.22	-0.01



DISSOLVED OXYGEN • • • • •

BIOCHEMICAL OXYGEN DEMAND • . . . .

Attachment C

Warm Weather Badger Mill Creek Simulations Using EPA QUAL2E Instream WQ Model

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                    * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                              Ver. 3.13 - September 1991

 $$$ (PROBLEM TITLES) $$$

CARD TYPE                          QUAL-2E PROGRAM TITLES
TITLE01                 BSCIU.IN - Summer, Critical, Interim FLOW BODU Simulation
TITLE02                 NSWTP DISCHARGE TO BADGER MILL CREEK
TITLE03    NO           CONSERVATIVE MINERAL I           IN
TITLE04    NO           CONSERVATIVE MINERAL II          IN
TITLE05    NO           CONSERVATIVE MINERAL III         IN
TITLE06   YES           TEMPERATURE
TITLE07   YES           BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)
TITLE08   YES           ALGAE AS CHL-A IN UG/L
TITLE09   YES           PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                   (ORGANIC-P, DISSOLVED-P)
TITLE11   YES           NITROGEN CYCLE AS N IN MG/L
TITLE12                   (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
TITLE13   YES           DISSOLVED OXYGEN IN MG/L
TITLE14    NO           FECAL COLIFORMS IN NO./100 ML
TITLE15   YES           ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS.mg/l
ENDTITLE

 $$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                   CARD TYPE
LIST DATA INPUT               0.00000                                      0.00000
WRITE OPTIONAL SUMMARY        0.00000                                      0.00000
NO FLOW AUGMENTATION          0.00000                                      0.00000
STEADY STATE                  0.00000                                      0.00000
TRAPEZOIDAL X-SECTIONS        0.00000                                      0.00000
PRINT LCD/SOLAR DATA          0.00000                                      0.00000
PLOT DO AND BOD               0.00000                                      0.00000
FIXED DNSTM COND (YES=1)=     0.00000       5D-ULT BOD CONV K COEF  =      0.80000
INPUT METRIC (YES=1)    =     0.00000       OUTPUT METRIC (YES=1)   =      0.00000
NUMBER OF REACHES       =     7.00000       NUMBER OF JUNCTIONS     =      1.00000
NUM OF HEADWATERS       =     2.00000       NUMBER OF POINT LOADS   =      0.00000
TIME STEP (HOURS)       =     1.00000       LNTH  COMP  ELEMENT (DX)=      0.10000
MAXIMUM ROUTE TIME (HRS)=   288.00000       TIME INC. FOR RPT2 (HRS)=      1.00000
LATITUDE OF BASIN (DEG) =    43.10000       LONGITUDE OF BASIN (DEG)=     89.30000
STANDARD MERIDIAN (DEG) =    75.00000       DAY OF YEAR START TIME  =    203.00000
EVAP. COEFF. (AE)       =     0.00068       EVAP. COEFF. (BE)       =      0.00027
ELEV. OF BASIN (ELEV)   =   937.00000       DUST ATTENUATION COEF.  =      0.06000
ENDATA1                       0.00000                                      0.00000

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                          CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=     3.5000        O UPTAKE BY NO2 OXID(MG O/MG N)=      1.2000
O PROD  BY ALGAE (MG O/MG A)   =     1.6000        O UPTAKE BY ALGAE (MG O/MG A)  =      2.0000
N CONTENT OF ALGAE (MG N/MG A) =     0.0850        P CONTENT OF ALGAE (MG P/MG A) =      0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=     2.5000        ALGAE RESPIRATION RATE (1/DAY) =      0.1000
N HALF SATURATION CONST  (MG/L)=     0.3000        P HALF SATURATION CONST  (MG/L)=      0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)     0.0088        NLIN SHADE(1/FT-(UGCHA/L)**2/3)=      0.0540
LIGHT FUNCTION OPTION (LFNOPT) =     1.0000        LIGHT SAT'N COEF (BTU/FT2-MIN) =      0.0300
DAILY AVERAGING OPTION (LAVOPT)=     1.0000        LIGHT AVERAGING FACTOR (AFACT) =      0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =    16.0000        TOTAL DAILY SOLR RAD (BTU/FT-2)=    400.0000
ALGY GROWTH CALC OPTION(LGROPT)=     1.0000        ALGAL PREF FOR NH3-N (PREFN)   =      0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=     0.4500        NITRIFICATION INHIBITION COEF  =      0.6000
ENDATA1A                             0.0000                                              0.0000

 $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE      RATE CODE      THETA VALUE

THETA( 1)       BOD DECA         1.047      DFLT
THETA( 2)       BOD SETT         1.024      DFLT
THETA( 3)       OXY TRAN         1.024      DFLT
THETA( 4)       SOD RATE         1.060      DFLT
THETA( 5)       ORGN DEC         1.047      DFLT
THETA( 6)       ORGN SET         1.024      DFLT
THETA( 7)       NH3 DECA         1.083      DFLT
THETA( 8)       NH3 SRCE         1.074      DFLT
THETA( 9)       NO2 DECA         1.047      DFLT
THETA(10)       PORG DEC         1.047      DFLT
THETA(11)       PORG SET         1.024      DFLT
THETA(12)       DISP SRC         1.074      DFLT
THETA(13)       ALG GROW         1.047      DFLT
THETA(14)       ALG RESP         1.047      DFLT
THETA(15)       ALG SETT         1.024      DFLT
THETA(16)       COLI DEC         1.047      DFLT
THETA(17)       ANC DECA         1.000      DFLT
THETA(18)       ANC SETT         1.024      DFLT
THETA(19)       ANC SRCE         1.000      DFLT
ENDATA1B

 $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE           REACH ORDER AND IDENT                  R. MI/KM                 R. MI/KM
STREAM REACH     1.0  RCH= HWY 151-PB          FROM        10.0      TO             9.4
STREAM REACH     2.0  RCH= PB-Lincoln          FROM         9.4      TO             8.4
STREAM REACH     3.0  RCH= Lincoln-151 By      FROM         8.4      TO             7.0
STREAM REACH     4.0  RCH= 151 By-HWY 69       FROM         7.0      TO             6.1
STREAM REACH     5.0  RCH= HWY 69-Sugar R      FROM         6.1      TO             5.4
STREAM REACH     6.0  RCH= Upstrm Sugar R      FROM         5.6      TO             5.4
STREAM REACH     7.0  RCH= Dnstrm Sugar R      FROM         5.4      TO             3.4
ENDATA2          0.0                                        0.0                     0.0

 $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE                      REACH  AVAIL HDWS TARGET     ORDER OF AVAIL SOURCES
ENDATA3                          0.        0.       0.0  0.   0.   0.   0.   0.   0.

 $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE        REACH ELEMENTS/REACH            COMPUTATIONAL FLAGS
FLAG FIELD         1.         6.         1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         2.        10.         2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         3.        14.         2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
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FLAG FIELD	4.	9.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CMANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	2.	945.00	0.13	0.10	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	3.	935.00	0.13	0.20	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	4.	925.00	0.13	0.05	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	5.	915.00	0.13	0.00	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	6.	910.00	0.13	0.05	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	7.	910.00	0.13	0.05	82.40	75.20	29.10	11.90	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	OR OR	EXPQK2 SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110		0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000		0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	2.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	3.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	4.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	5.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	6.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	7.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	5.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

```
INCR INFLOW-2          1.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2          2.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2          3.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2          4.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2          5.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2          6.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2          7.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
ENDATA8A               0.     0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE              JUNCTION ORDER AND IDENT       UPSTRM   JUNCTION   TRIB
STREAM JUNCTION        1.     JNC=Sugar R Confluen     46.       49.       48.
ENDATA9                0.                               0.        0.        0.

 $$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE     HDWTR   NAME                FLOW      TEMP      D.O.      BOD      CM-1      CM-2      CM-3
              ORDER
HEADWTR-1      1.  NSWTPOutfall           3.40     71.60      5.00      8.90     0.00      0.00      0.00
HEADWTR-1      2.  Sugar River            7.80     68.00      7.00      4.00     0.00      0.00      0.00
ENDATA10       0.                         0.00      0.00      0.00      0.00     0.00      0.00      0.00

 $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS,
                    COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE     HDWTR    ANC      COLI     CHL-A    ORG-N    NH3-N    NO2-N    NO3-N    ORG-P    DIS-P
              ORDER
HEADWTR-2      1.     10.80     0.00     0.00     0.50     1.38     0.00     1.00     0.00     0.89
HEADWTR-2      2.     10.00     0.00     2.70     0.62     0.12     0.00     2.30     0.00     0.13
ENDATA10A      0.      0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

              POINT
CARD TYPE     LOAD    NAME                EFF      FLOW     TEMP     D.O.     BOD      CM-1     CM-2     CM-3
              ORDER
ENDATA11       0.                         0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS,
                    COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

              POINT
CARD TYPE     LOAD     ANC      COLI     CHL-A    ORG-N    NH3-N    NO2-N    NO3-N    ORG-P    DIS-P
              ORDER
ENDATA11A      0.      0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

                       DAM   RCH   ELE    ADAM    BDAM    FDAM    HDAM

ENDATA12                0.    0.    0.    0.00    0.00    0.00    0.00

 $$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

     CARD TYPE                TEMP      D.O.      BOD      CM-1      CM-2      CM-3       ANC       COLI

ENDATA13                      DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

 $$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

     CARD TYPE                CHL-A     ORG-N     NH3-N     NO2-N     NH3-N     ORG-P     DIS-P

ENDATA13A                     DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED
```

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STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:
-------------------------------------------------------

                     NUMBER OF
       ITERATION   NONCONVERGENT
                     ELEMENTS

                TEMPERATURE                                            ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 71.76 71.91 72.05 72.18 72.29 72.40
  2 72.49 72.57 72.65 72.72 72.78 72.84 72.90 72.95 73.00 73.04
  3 73.08 73.10 73.13 73.15 73.17 73.19 73.21 73.23 73.25 73.27 73.28 73.30 73.31 73.33
  4 73.34 73.37 73.39 73.40 73.42 73.44 73.45 73.46 73.47
  5 73.48 73.49 73.49 73.50 73.51 73.51 73.51
  6 68.36 68.70
  7 70.30 70.45 70.59 70.73 70.86 70.99 71.11 71.22 71.33 71.44 71.54 71.63 71.72 71.81 71.89 71.97 72.04 72.11 72.18 72.25
            1          66

                TEMPERATURE                                            ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 71.75 71.88 72.01 72.12 72.22 72.32
  2 72.40 72.47 72.53 72.59 72.65 72.70 72.74 72.79 72.82 72.86
  3 72.89 72.91 72.93 72.95 72.97 72.98 73.00 73.02 73.03 73.04 73.06 73.07 73.08 73.10
  4 73.11 73.12 73.14 73.15 73.16 73.17 73.18 73.19 73.19
  5 73.20 73.20 73.21 73.21 73.21 73.22 73.22
  6 68.36 68.70
  7 70.21 70.36 70.51 70.65 70.78 70.91 71.02 71.14 71.24 71.35 71.44 71.53 71.62 71.70 71.78 71.86 71.93 72.00 72.06 72.12
            2           0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):
-------------------------------------------------------------------------------

     DAILY NET SOLAR RADIATION =       0.000 BTU/FT-2   (     0.000 LANGLEYS)
     NUMBER OF DAYLIGHT HOURS =  14.7

     HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

          1      0.00          9     0.00         17     0.00
          2      0.00         10     0.00         18     0.00
          3      0.00         11     0.00         19     0.00
          4      0.00         12     0.00         20     0.00
          5      0.00         13     0.00         21     0.00
          6      0.00         14     0.00         22     0.00
          7      0.00         15     0.00         23     0.00
          8      0.00         16     0.00         24     0.00

                BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)                   ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1  8.82  8.75  8.67  8.60  8.52  8.45
  2  8.36  8.25  8.15  8.04  7.94  7.84  7.74  7.64  7.54  7.44
  3  7.37  7.31  7.25  7.19  7.14  7.08  7.02  6.97  6.91  6.86  6.80  6.75  6.70  6.64
  4  6.59  6.54  6.48  6.43  6.38  6.33  6.28  6.23  6.18
  5  6.13  6.09  6.04  6.00  5.95  5.91  5.86
  6  3.97  3.94
  7  4.50  4.46  4.43  4.40  4.36  4.33  4.30  4.27  4.23  4.20  4.17  4.14  4.11  4.08  4.04  4.01  3.98  3.95  3.92  3.89

                ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l    ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 10.78 10.76 10.73 10.71 10.69 10.67
  2 10.64 10.61 10.58 10.54 10.51 10.48 10.45 10.41 10.38 10.35
  3 10.33 10.31 10.29 10.27 10.25 10.23 10.21 10.19 10.17 10.15 10.13 10.11 10.10 10.08
  4 10.06 10.04 10.02 10.00  9.98  9.96  9.95  9.93  9.91
  5  9.89  9.87  9.85  9.84  9.82  9.80  9.79
  6  9.98  9.96
```

7	9.89	9.88	9.86	9.84	9.82	9.80	9.79	9.77	9.75	9.73	9.72	9.70	9.68	9.66	9.64	9.63	9.61	9.59	9.57	9.56

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	2.69	2.68																		
7	1.86	1.86	1.85	1.85	1.84	1.84	1.83	1.83	1.82	1.82	1.81	1.81	1.80	1.80	1.79	1.79	1.78	1.78	1.77	1.77

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.89	0.89	0.89	0.89	0.89	0.89														
2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89										
3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89						
4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89											
5	0.89	0.89	0.89	0.89	0.89	0.89	0.89													
6	0.13	0.13																		
7	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.49	0.49	0.49	0.49														
2	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.46										
3	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.44	0.44	0.44						
4	0.44	0.44	0.44	0.43	0.43	0.43	0.43	0.43	0.43											
5	0.43	0.42	0.42	0.42	0.42	0.42	0.42													
6	0.62	0.62																		
7	0.55	0.55	0.55	0.55	0.55	0.55	0.54	0.54	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.53	0.52	0.52	0.52

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.37	1.35	1.34	1.32	1.31	1.30														
2	1.28	1.26	1.24	1.22	1.20	1.18	1.16	1.15	1.13	1.11										
3	1.10	1.09	1.08	1.07	1.05	1.04	1.03	1.02	1.01	1.01	1.00	0.99	0.98	0.97						
4	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.90	0.89											
5	0.88	0.87	0.86	0.85	0.85	0.84	0.83													
6	0.12	0.12																		
7	0.34	0.33	0.33	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.02	0.03	0.05	0.06	0.07	0.09														
2	0.11	0.13	0.14	0.16	0.18	0.20	0.22	0.23	0.25	0.26										
3	0.28	0.28	0.29	0.30	0.31	0.32	0.33	0.33	0.34	0.35	0.36	0.36	0.37	0.38						
4	0.38	0.39	0.40	0.40	0.41	0.41	0.42	0.43	0.43											
5	0.44	0.44	0.45	0.45	0.45	0.46	0.46													
6	0.00	0.00																		
7	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.18

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	1.00	1.00	1.00	1.00	1.00														
2	1.00	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.03	1.03										
3	1.04	1.04	1.04	1.05	1.05	1.05	1.05	1.06	1.06	1.06	1.07	1.07	1.08	1.08						
4	1.08	1.09	1.09	1.09	1.10	1.10	1.11	1.11	1.12											
5	1.12	1.12	1.13	1.13	1.14	1.14	1.15													
6	2.30	2.30																		
7	1.95	1.95	1.95	1.95	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.97	1.97	1.97	1.97	1.97	1.97	1.98	1.98	1.98

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.29	5.54	5.77	5.97	6.14	6.30														
2	6.35	6.26	6.18	6.10	6.03	5.96	5.90	5.84	5.78	5.73										
3	5.72	5.74	5.75	5.76	5.78	5.79	5.80	5.82	5.83	5.85	5.86	5.87	5.89	5.90						
4	6.04	6.27	6.47	6.64	6.80	6.93	7.04	7.14	7.23											
5	7.27	7.29	7.31	7.32	7.34	7.35	7.36													
6	7.03	7.06																		
7	7.18	7.19	7.20	7.21	7.22	7.23	7.23	7.24	7.25	7.25	7.26	7.27	7.27	7.28	7.28	7.29	7.29	7.30	7.30	7.31

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	0
NITRIFICATION INHIBITION	1	64
ALGAE GROWTH RATE	2	0
NITRIFICATION INHIBITION	2	34
ALGAE GROWTH RATE	3	0
NITRIFICATION INHIBITION	3	25
ALGAE GROWTH RATE	4	0
NITRIFICATION INHIBITION	4	0
ALGAE GROWTH RATE	5	0
NITRIFICATION INHIBITION	5	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:

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1. LIGHT AVERAGING OPTION.   LAVOPT= 1

   METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

   SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
   DAILY NET SOLAR RADIATION: 0.000 BTU/FT-2 (0.000 LANGLEYS)
   NUMBER OF DAYLIGHT HOURS: 14.7
   PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
   MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

   HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS.   LGROPT= 1

   MULTIPLICATIVE: FL*FN*FP

TEMPERATURE — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	71.75	71.88	72.01	72.12	72.22	72.32														
2	72.40	72.47	72.53	72.59	72.65	72.70	72.74	72.79	72.82	72.86										
3	72.89	72.91	72.93	72.95	72.97	72.98	73.00	73.02	73.03	73.04	73.06	73.07	73.08	73.10						
4	73.11	73.12	73.14	73.15	73.16	73.17	73.18	73.19	73.19											
5	73.20	73.20	73.21	73.21	73.21	73.22	73.22													
6	68.36	68.70																		
7	70.21	70.36	70.51	70.65	70.78	70.91	71.02	71.14	71.24	71.35	71.44	71.53	71.62	71.70	71.78	71.86	71.93	72.00	72.06	72.12

DISSOLVED OXYGEN IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.29	5.55	5.77	5.97	6.14	6.30														
2	6.35	6.26	6.18	6.10	6.03	5.97	5.90	5.84	5.79	5.74										
3	5.73	5.74	5.76	5.77	5.79	5.80	5.81	5.83	5.84	5.86	5.87	5.88	5.90	5.91						
4	6.05	6.28	6.48	6.65	6.80	6.93	7.04	7.14	7.23											
5	7.28	7.29	7.31	7.32	7.34	7.35	7.36													
6	7.03	7.06																		
7	7.18	7.19	7.20	7.21	7.22	7.23	7.23	7.24	7.25	7.25	7.26	7.27	7.27	7.28	7.28	7.29	7.29	7.30	7.30	7.30

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.82	8.75	8.67	8.60	8.52	8.45														
2	8.36	8.25	8.15	8.04	7.94	7.84	7.74	7.64	7.54	7.44										
3	7.37	7.31	7.25	7.19	7.14	7.08	7.02	6.97	6.91	6.86	6.80	6.75	6.70	6.64						
4	6.59	6.54	6.48	6.43	6.38	6.33	6.28	6.23	6.18											
5	6.13	6.09	6.04	6.00	5.95	5.91	5.86													
6	3.97	3.94																		
7	4.50	4.46	4.43	4.40	4.36	4.33	4.30	4.27	4.23	4.20	4.17	4.14	4.11	4.08	4.04	4.01	3.98	3.95	3.92	3.89

ORGANIC NITROGEN AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.49	0.49	0.49	0.49														
2	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.46										
3	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.44	0.44	0.44						
4	0.44	0.44	0.44	0.43	0.43	0.43	0.43	0.43	0.43											
5	0.43	0.42	0.42	0.42	0.42	0.42	0.42													
6	0.62	0.62																		
7	0.55	0.55	0.55	0.55	0.55	0.55	0.54	0.54	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.53	0.52	0.52	0.52

AMMONIA AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.37	1.35	1.34	1.32	1.31	1.30														
2	1.28	1.26	1.24	1.22	1.20	1.19	1.17	1.15	1.13	1.11										
3	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	0.99	0.98	0.97						
4	0.96	0.95	0.94	0.94	0.93	0.92	0.91	0.90	0.89											
5	0.88	0.88	0.87	0.86	0.85	0.84	0.84													
6	0.12	0.12																		
7	0.34	0.33	0.33	0.33	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30

NITRITE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.01	0.03	0.04	0.06	0.07	0.09														
2	0.10	0.12	0.14	0.16	0.18	0.20	0.21	0.23	0.25	0.26										
3	0.27	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.35	0.36	0.37	0.37						
4	0.38	0.39	0.39	0.40	0.41	0.41	0.42	0.42	0.43											
5	0.43	0.44	0.44	0.45	0.45	0.46	0.46													
6	0.00	0.00																		
7	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17

NITRATE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	1.00	1.00	1.00	1.00	1.00														
2	1.00	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.03	1.03										
3	1.04	1.04	1.04	1.04	1.05	1.05	1.05	1.06	1.06	1.06	1.07	1.07	1.07	1.08						
4	1.08	1.08	1.09	1.09	1.10	1.10	1.10	1.11	1.11											
5	1.12	1.12	1.13	1.13	1.13	1.14	1.14													
6	2.30	2.30																		
7	1.95	1.95	1.95	1.95	1.95	1.96	1.96	1.96	1.96	1.96	1.96	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.98	1.98

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						

4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.89	0.89	0.89	0.89	0.89	0.89														
2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89										
3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89						
4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89											
5	0.89	0.89	0.89	0.89	0.89	0.89	0.89													
6	0.13	0.13																		
7	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36

ALGAE AS CHL-A IN UG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	2.69	2.68																		
7	1.86	1.86	1.85	1.85	1.84	1.84	1.83	1.83	1.82	1.82	1.81	1.81	1.80	1.80	1.79	1.79	1.78	1.78	1.77	1.77

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	10.78	10.76	10.73	10.71	10.69	10.67														
2	10.54	10.61	10.58	10.54	10.51	10.48	10.45	10.41	10.38	10.35										
3	10.33	10.31	10.29	10.27	10.25	10.23	10.21	10.19	10.17	10.15	10.13	10.11	10.10	10.08						
4	10.06	10.04	10.02	10.00	9.98	9.96	9.95	9.93	9.91											
5	9.89	9.87	9.85	9.84	9.82	9.80	9.79													
6	9.98	9.96																		
7	9.89	9.88	9.86	9.84	9.82	9.80	9.79	9.77	9.75	9.73	9.72	9.70	9.68	9.66	9.64	9.63	9.61	9.59	9.57	9.56

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
2	1	2	9.90	9.80	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
3	1	3	9.80	9.70	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
4	1	4	9.70	9.60	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
5	1	5	9.60	9.50	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
6	1	6	9.50	9.40	3.40	0.00	0.00	0.626	0.010	0.307	17.715	2.87	10.81	5.43	0.27
7	2	1	9.40	9.30	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
8	2	2	9.30	9.20	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
9	2	3	9.20	9.10	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
10	2	4	9.10	9.00	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
11	2	5	9.00	8.90	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
12	2	6	8.90	8.80	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
13	2	7	8.80	8.70	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
14	2	8	8.70	8.60	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
15	2	9	8.60	8.50	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
16	2	10	8.50	8.40	3.40	0.00	0.00	0.424	0.014	0.505	15.860	4.23	8.98	8.01	0.33
17	3	1	8.40	8.30	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
18	3	2	8.30	8.20	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
19	3	3	8.20	8.10	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
20	3	4	8.10	8.00	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
21	3	5	8.00	7.90	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
22	3	6	7.90	7.80	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
23	3	7	7.80	7.70	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
24	3	8	7.70	7.60	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
25	3	9	7.60	7.50	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
26	3	10	7.50	7.40	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
27	3	11	7.40	7.30	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
28	3	12	7.30	7.20	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
29	3	13	7.20	7.10	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
30	3	14	7.10	7.00	3.40	0.00	0.00	0.695	0.009	0.590	8.300	2.58	5.68	4.89	0.41
31	4	1	7.00	6.90	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
32	4	2	6.90	6.80	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
33	4	3	6.80	6.70	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
34	4	4	6.70	6.60	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
35	4	5	6.60	6.50	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
36	4	6	6.50	6.40	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
37	4	7	6.40	6.30	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
38	4	8	6.30	6.20	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
39	4	9	6.20	6.10	3.40	0.00	0.00	0.696	0.009	0.230	21.205	2.58	11.92	4.89	0.19
40	5	1	6.10	6.00	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
41	5	2	6.00	5.90	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
42	5	3	5.90	5.80	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
43	5	4	5.80	5.70	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
44	5	5	5.70	5.60	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
45	5	6	5.60	5.50	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
46	5	7	5.50	5.40	3.40	0.00	0.00	0.738	0.008	0.302	15.264	2.43	9.28	4.61	0.22
47	6	1	5.60	5.50	7.80	0.00	0.00	0.603	0.010	0.404	32.005	6.82	17.32	12.92	0.23
48	6	2	5.50	5.40	7.80	0.00	0.00	0.603	0.010	0.404	32.005	6.82	17.32	12.92	0.23
49	7	1	5.40	5.30	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
50	7	2	5.30	5.20	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
51	7	3	5.20	5.10	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
52	7	4	5.10	5.00	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
53	7	5	5.00	4.90	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
54	7	6	4.90	4.80	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
55	7	7	4.80	4.70	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
56	7	8	4.70	4.60	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
57	7	9	4.60	4.50	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
58	7	10	4.50	4.40	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
59	7	11	4.40	4.30	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
60	7	12	4.30	4.20	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
61	7	13	4.20	4.10	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
62	7	14	4.10	4.00	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
63	7	15	4.00	3.90	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
64	7	16	3.90	3.80	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
65	7	17	3.80	3.70	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
66	7	18	3.70	3.60	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
67	7	19	3.60	3.50	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31
68	7	20	3.50	3.40	11.20	0.00	0.00	0.696	0.009	0.503	32.001	8.50	17.43	16.09	0.31

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	8.49	8	13.39	0.88	0.00	0.00	0.28	0.11	1.13	0.00	1.05	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	2	8.48	8	13.42	0.88	0.00	0.00	0.28	0.11	1.15	0.00	1.06	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	3	8.47	8	13.44	0.89	0.00	0.00	0.28	0.11	1.16	0.00	1.07	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	4	8.46	8	13.46	0.89	0.00	0.00	0.28	0.11	1.17	0.00	1.08	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	5	8.45	8	13.48	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	6	8.44	8	13.49	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	1	8.43	8	8.31	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	2	8.43	8	3.12	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	3	8.42	8	3.12	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.10	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	4	8.41	8	3.12	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.10	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	5	8.41	8	3.13	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
2	6	8.40	8	3.13	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
2	7	8.40	8	3.13	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
2	8	8.40	8	3.13	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
2	9	8.39	8	3.13	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
2	10	8.39	8	3.14	0.91	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	1	8.39	8	4.06	0.91	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	2	8.39	8	4.98	0.91	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	3	8.38	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	4	8.38	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	5	8.38	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	6	8.38	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	7	8.38	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	8	8.38	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	9	8.37	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	10	8.37	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	11	8.37	8	4.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	12	8.37	8	5.00	0.91	0.00	0.00	0.28	0.11	1.22	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	13	8.37	8	5.00	0.91	0.00	0.00	0.28	0.11	1.22	0.00	1.11	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	14	8.37	8	5.00	0.91	0.00	0.00	0.28	0.11	1.22	0.00	1.11	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	1	8.37	8	11.29	0.91	0.00	0.00	0.28	0.11	1.22	0.00	1.11	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	2	8.37	8	17.58	0.91	0.00	0.00	0.28	0.11	1.23	0.00	1.11	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	3	8.37	8	17.58	0.91	0.00	0.00	0.29	0.11	1.23	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	4	8.36	8	17.58	0.91	0.00	0.00	0.29	0.11	1.23	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	5	8.36	8	17.59	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	6	8.36	8	17.59	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	7	8.36	8	17.59	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	8	8.36	8	17.59	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	9	8.36	8	17.59	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	1	8.36	8	14.40	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	2	8.36	8	11.21	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	3	8.36	8	11.21	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	4	8.36	8	11.21	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	5	8.36	8	11.21	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	6	8.36	8	11.21	0.91	0.00	0.00	0.29	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	7	8.36	8	11.21	0.91	0.00	0.00	0.29	0.11	1.25	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
6	1	8.81	8	3.90	0.81	0.00	0.00	0.25	0.10	1.00	0.00	0.99	0.20	0.10	0.00	0.00	0.00	0.20	0.00
6	2	8.78	8	3.92	0.81	0.00	0.00	0.25	0.10	1.02	0.00	1.00	0.20	0.10	0.00	0.00	0.00	0.20	0.00
7	1	8.63	8	5.98	0.85	0.00	0.00	0.26	0.10	1.09	0.00	1.04	0.21	0.10	0.00	0.00	0.00	0.21	0.00
7	2	8.62	8	4.58	0.85	0.00	0.00	0.27	0.10	1.10	0.00	1.05	0.21	0.10	0.00	0.00	0.00	0.21	0.00
7	3	8.60	8	4.59	0.85	0.00	0.00	0.27	0.10	1.10	0.00	1.05	0.21	0.10	0.00	0.00	0.00	0.21	0.00
7	4	8.59	8	4.60	0.86	0.00	0.00	0.27	0.10	1.11	0.00	1.06	0.21	0.10	0.00	0.00	0.00	0.21	0.00
7	5	8.58	8	4.61	0.86	0.00	0.00	0.27	0.10	1.12	0.00	1.06	0.21	0.10	0.00	0.00	0.00	0.21	0.00
7	6	8.57	8	4.62	0.86	0.00	0.00	0.27	0.10	1.12	0.00	1.06	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	7	8.56	8	4.62	0.86	0.00	0.00	0.27	0.10	1.13	0.00	1.07	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	8	8.55	8	4.63	0.87	0.00	0.00	0.27	0.10	1.13	0.00	1.07	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	9	8.54	8	4.64	0.87	0.00	0.00	0.27	0.10	1.14	0.00	1.07	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	10	8.53	8	4.64	0.87	0.00	0.00	0.27	0.10	1.14	0.00	1.08	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	11	8.52	8	4.65	0.87	0.00	0.00	0.27	0.10	1.15	0.00	1.08	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	12	8.51	8	4.65	0.88	0.00	0.00	0.27	0.10	1.15	0.00	1.08	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	13	8.50	8	4.66	0.88	0.00	0.00	0.27	0.10	1.16	0.00	1.08	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	14	8.49	8	4.66	0.88	0.00	0.00	0.27	0.11	1.16	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	15	8.49	8	4.67	0.88	0.00	0.00	0.28	0.11	1.17	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	16	8.48	8	4.67	0.88	0.00	0.00	0.28	0.11	1.17	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	17	8.47	8	4.68	0.88	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	18	8.47	8	4.68	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	19	8.46	8	4.69	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.10	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	20	8.46	8	4.69	0.89	0.00	0.00	0.28	0.11	1.19	0.00	1.10	0.22	0.11	0.00	0.00	0.00	0.21	0.00

STREAM QUALITY SIMULATION
QUAL-2E STREAM QUALITY ROUTING MODEL

OUTPUT PAGE NUMBER 5
Ver. 3.13 - September 1991

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***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota spen	CHLA UG/L
1	1	71.75	0.00	0.00	0.00	5.29	8.82	0.50	1.37	0.01	1.00	2.88	0.00	0.89	0.89	0.00	10.78	0.00
1	2	71.88	0.00	0.00	0.00	5.55	8.75	0.50	1.35	0.03	1.00	2.88	0.00	0.89	0.89	0.00	10.76	0.00
1	3	72.01	0.00	0.00	0.00	5.77	8.67	0.49	1.34	0.04	1.00	2.88	0.00	0.89	0.89	0.00	10.73	0.00
1	4	72.12	0.00	0.00	0.00	5.97	8.60	0.49	1.32	0.06	1.00	2.88	0.00	0.89	0.89	0.00	10.71	0.00
1	5	72.22	0.00	0.00	0.00	6.14	8.52	0.49	1.31	0.07	1.00	2.88	0.00	0.89	0.89	0.00	10.69	0.00
1	6	72.32	0.00	0.00	0.00	6.30	8.45	0.49	1.30	0.09	1.00	2.88	0.00	0.89	0.89	0.00	10.67	0.00
2	1	72.40	0.00	0.00	0.00	6.35	8.36	0.49	1.28	0.10	1.00	2.88	0.00	0.89	0.89	0.00	10.64	0.00
2	2	72.47	0.00	0.00	0.00	6.26	8.25	0.48	1.26	0.12	1.01	2.88	0.00	0.89	0.89	0.00	10.61	0.00
2	3	72.53	0.00	0.00	0.00	6.18	8.15	0.48	1.24	0.14	1.01	2.87	0.00	0.89	0.89	0.00	10.58	0.00
2	4	72.59	0.00	0.00	0.00	6.10	8.04	0.48	1.22	0.16	1.01	2.87	0.00	0.89	0.89	0.00	10.54	0.00
2	5	72.65	0.00	0.00	0.00	6.03	7.94	0.48	1.20	0.18	1.01	2.87	0.00	0.89	0.89	0.00	10.51	0.00
2	6	72.70	0.00	0.00	0.00	5.97	7.84	0.47	1.19	0.20	1.02	2.87	0.00	0.89	0.89	0.00	10.48	0.00
2	7	72.74	0.00	0.00	0.00	5.90	7.74	0.47	1.17	0.21	1.02	2.87	0.00	0.89	0.89	0.00	10.45	0.00
2	8	72.79	0.00	0.00	0.00	5.84	7.64	0.47	1.15	0.23	1.02	2.87	0.00	0.89	0.89	0.00	10.41	0.00
2	9	72.82	0.00	0.00	0.00	5.79	7.54	0.47	1.13	0.25	1.03	2.87	0.00	0.89	0.89	0.00	10.38	0.00
2	10	72.86	0.00	0.00	0.00	5.74	7.44	0.46	1.11	0.26	1.03	2.87	0.00	0.89	0.89	0.00	10.35	0.00
3	1	72.89	0.00	0.00	0.00	5.73	7.37	0.46	1.10	0.27	1.04	2.87	0.00	0.89	0.89	0.00	10.33	0.00
3	2	72.91	0.00	0.00	0.00	5.74	7.31	0.46	1.09	0.28	1.04	2.87	0.00	0.89	0.89	0.00	10.31	0.00
3	3	72.93	0.00	0.00	0.00	5.76	7.25	0.46	1.08	0.29	1.04	2.87	0.00	0.89	0.89	0.00	10.29	0.00
3	4	72.95	0.00	0.00	0.00	5.77	7.19	0.46	1.07	0.30	1.04	2.87	0.00	0.89	0.89	0.00	10.27	0.00
3	5	72.97	0.00	0.00	0.00	5.79	7.14	0.45	1.06	0.31	1.05	2.87	0.00	0.89	0.89	0.00	10.25	0.00
3	6	72.98	0.00	0.00	0.00	5.80	7.08	0.45	1.05	0.31	1.05	2.87	0.00	0.89	0.89	0.00	10.23	0.00
3	7	73.00	0.00	0.00	0.00	5.81	7.02	0.45	1.04	0.32	1.05	2.87	0.00	0.89	0.89	0.00	10.21	0.00
3	8	73.02	0.00	0.00	0.00	5.83	6.97	0.45	1.03	0.33	1.06	2.87	0.00	0.89	0.89	0.00	10.19	0.00
3	9	73.03	0.00	0.00	0.00	5.84	6.91	0.45	1.02	0.34	1.06	2.87	0.00	0.89	0.89	0.00	10.17	0.00
3	10	73.04	0.00	0.00	0.00	5.86	6.86	0.45	1.01	0.35	1.06	2.87	0.00	0.89	0.89	0.00	10.15	0.00
~~3~~	~~11~~	~~73.06~~	~~0.00~~	~~0.00~~	~~0.00~~	~~5.87~~	~~6.80~~	~~0.45~~	~~1.00~~	~~0.35~~	~~1.07~~	~~2.86~~	~~0.00~~	~~0.89~~	~~0.89~~	~~0.00~~	~~10.13~~	~~0.00~~
3	12	73.07	0.00	0.00	0.00	5.88	6.75	0.44	0.99	0.36	1.07	2.86	0.00	0.89	0.89	0.00	10.11	0.00
3	13	73.08	0.00	0.00	0.00	5.90	6.70	0.44	0.98	0.37	1.07	2.86	0.00	0.89	0.89	0.00	10.10	0.00
3	14	73.10	0.00	0.00	0.00	5.91	6.64	0.44	0.97	0.37	1.08	2.86	0.00	0.89	0.89	0.00	10.08	0.00
4	1	73.11	0.00	0.00	0.00	6.05	6.59	0.44	0.96	0.38	1.08	2.86	0.00	0.89	0.89	0.00	10.06	0.00
4	2	73.12	0.00	0.00	0.00	6.28	6.54	0.44	0.95	0.39	1.08	2.86	0.00	0.89	0.89	0.00	10.04	0.00
4	3	73.14	0.00	0.00	0.00	6.48	6.48	0.44	0.94	0.39	1.09	2.86	0.00	0.89	0.89	0.00	10.02	0.00
4	4	73.15	0.00	0.00	0.00	6.65	6.43	0.43	0.94	0.40	1.09	2.86	0.00	0.89	0.89	0.00	10.00	0.00
4	5	73.16	0.00	0.00	0.00	6.80	6.38	0.43	0.93	0.41	1.10	2.86	0.00	0.89	0.89	0.00	9.98	0.00
4	6	73.17	0.00	0.00	0.00	6.93	6.33	0.43	0.92	0.41	1.10	2.86	0.00	0.89	0.89	0.00	9.96	0.00
4	7	73.18	0.00	0.00	0.00	7.04	6.28	0.43	0.91	0.42	1.10	2.86	0.00	0.89	0.89	0.00	9.95	0.00
4	8	73.19	0.00	0.00	0.00	7.14	6.23	0.43	0.90	0.42	1.11	2.86	0.00	0.89	0.89	0.00	9.93	0.00
4	9	73.19	0.00	0.00	0.00	7.23	6.18	0.43	0.89	0.43	1.11	2.86	0.00	0.89	0.89	0.00	9.91	0.00
5	1	73.20	0.00	0.00	0.00	7.28	6.13	0.43	0.88	0.43	1.12	2.86	0.00	0.89	0.89	0.00	9.89	0.00
5	2	73.20	0.00	0.00	0.00	7.29	6.09	0.42	0.88	0.44	1.12	2.86	0.00	0.89	0.89	0.00	9.87	0.00
5	3	73.21	0.00	0.00	0.00	7.31	6.04	0.42	0.87	0.44	1.13	2.86	0.00	0.89	0.89	0.00	9.85	0.00
5	4	73.21	0.00	0.00	0.00	7.32	6.00	0.42	0.86	0.45	1.13	2.86	0.00	0.89	0.89	0.00	9.84	0.00
5	5	73.21	0.00	0.00	0.00	7.34	5.95	0.42	0.85	0.45	1.13	2.86	0.00	0.89	0.89	0.00	9.82	0.00
5	6	73.22	0.00	0.00	0.00	7.35	5.91	0.42	0.84	0.46	1.14	2.86	0.00	0.89	0.89	0.00	9.80	0.00
5	7	73.22	0.00	0.00	0.00	7.36	5.86	0.42	0.84	0.46	1.14	2.86	0.00	0.89	0.89	0.00	9.79	0.00
6	1	68.36	0.00	0.00	0.00	7.03	3.97	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	9.98	2.69
6	2	68.70	0.00	0.00	0.00	7.06	3.94	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	9.96	2.68
7	1	70.21	0.00	0.00	0.00	7.18	4.50	0.55	0.34	0.14	1.95	2.98	0.00	0.36	0.36	0.00	9.89	1.86
7	2	70.36	0.00	0.00	0.00	7.19	4.46	0.55	0.33	0.14	1.95	2.98	0.00	0.36	0.36	0.00	9.88	1.86
7	3	70.51	0.00	0.00	0.00	7.20	4.43	0.55	0.33	0.15	1.95	2.98	0.00	0.36	0.36	0.00	9.86	1.85
7	4	70.65	0.00	0.00	0.00	7.21	4.40	0.55	0.33	0.15	1.95	2.98	0.00	0.36	0.36	0.00	9.84	1.85
7	5	70.78	0.00	0.00	0.00	7.22	4.36	0.55	0.33	0.15	1.95	2.98	0.00	0.36	0.36	0.00	9.82	1.84
7	6	70.91	0.00	0.00	0.00	7.23	4.33	0.55	0.33	0.15	1.96	2.98	0.00	0.36	0.36	0.00	9.80	1.8[illegible]
7	7	71.02	0.00	0.00	0.00	7.23	4.30	0.54	0.33	0.15	1.96	2.98	0.00	0.36	0.36	0.00	9.79	1.83
7	8	71.14	0.00	0.00	0.00	7.24	4.27	0.54	0.32	0.16	1.96	2.98	0.00	0.36	0.36	0.00	9.77	1.83
7	9	71.24	0.00	0.00	0.00	7.25	4.23	0.54	0.32	0.16	1.96	2.98	0.00	0.36	0.36	0.00	9.75	1.82
7	10	71.35	0.00	0.00	0.00	7.25	4.20	0.54	0.32	0.16	1.96	2.98	0.00	0.36	0.36	0.00	9.73	1.82
7	11	71.44	0.00	0.00	0.00	7.26	4.17	0.54	0.32	0.16	1.96	2.98	0.00	0.36	0.36	0.00	9.72	1.81
7	12	71.53	0.00	0.00	0.00	7.27	4.14	0.53	0.32	0.16	1.97	2.98	0.00	0.36	0.36	0.00	9.70	1.81
7	13	71.62	0.00	0.00	0.00	7.27	4.11	0.53	0.31	0.16	1.97	2.98	0.00	0.36	0.36	0.00	9.68	1.80
7	14	71.70	0.00	0.00	0.00	7.28	4.08	0.53	0.31	0.17	1.97	2.98	0.00	0.36	0.36	0.00	9.66	1.80
7	15	71.78	0.00	0.00	0.00	7.28	4.04	0.53	0.31	0.17	1.97	2.98	0.00	0.36	0.36	0.00	9.64	1.79
7	16	71.86	0.00	0.00	0.00	7.29	4.01	0.53	0.31	0.17	1.97	2.98	0.00	0.36	0.36	0.00	9.63	1.79
7	17	71.93	0.00	0.00	0.00	7.29	3.98	0.53	0.31	0.17	1.97	2.98	0.00	0.36	0.36	0.00	9.61	1.78
7	18	72.00	0.00	0.00	0.00	7.30	3.95	0.52	0.30	0.17	1.97	2.97	0.00	0.36	0.36	0.00	9.59	1.78
7	19	72.06	0.00	0.00	0.00	7.30	3.92	0.52	0.30	0.17	1.98	2.97	0.00	0.36	0.36	0.00	9.57	1.77
7	20	72.12	0.00	0.00	0.00	7.30	3.89	0.52	0.30	0.17	1.98	2.97	0.00	0.36	0.36	0.00	9.56	1.77

Existing Verona WI Bruce [S?]

BMC Immediately Upstream of Sugar River Confl.

***** STEADY STATE SIMULATION *****

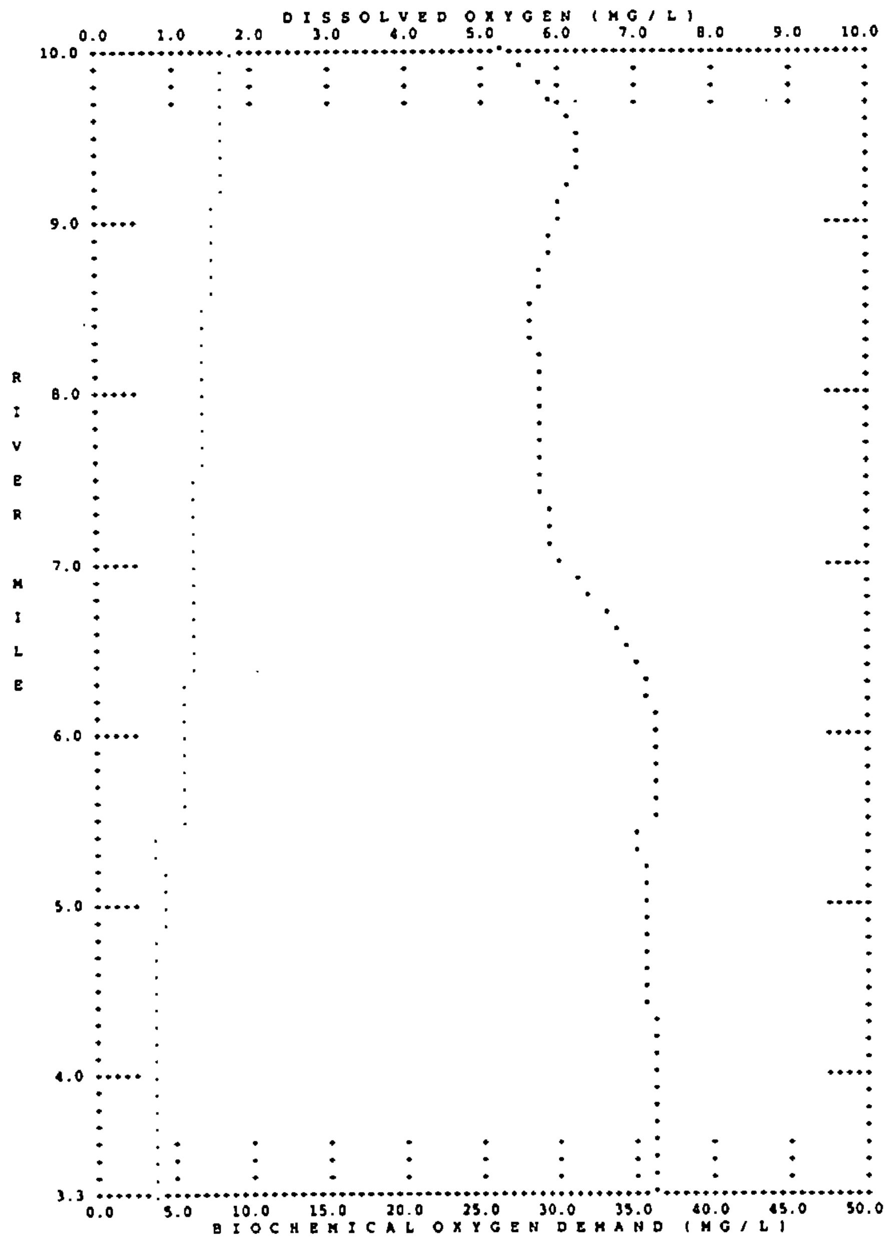
** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
2	1	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
3	1	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
4	1	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
5	1	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
6	1	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
7	2	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
8	2	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
9	2	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
10	2	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
11	2	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
12	2	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
13	2	7	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
14	2	8	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
15	2	9	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
16	2	10	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
17	3	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
18	3	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
19	3	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
20	3	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
21	3	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
22	3	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
23	3	7	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
24	3	8	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
25	3	9	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
26	3	10	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
27	3	11	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
28	3	12	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
29	3	13	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
30	3	14	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
31	4	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
32	4	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
33	4	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
34	4	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
35	4	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
36	4	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
37	4	7	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
38	4	8	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
39	4	9	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
40	5	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
41	5	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
42	5	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.87	0.01	0.00	0.87	0.96
43	5	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.87	0.01	0.00	0.87	0.96
44	5	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.87	0.01	0.00	0.87	0.96
45	5	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.87	0.01	0.00	0.87	0.96
46	5	7	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.87	0.01	0.00	0.87	0.96
47	6	1	2.69	0.00	0.10	0.10	0.00	-0.01	0.90	0.32	0.14	0.00	0.89	0.76
48	6	2	2.68	0.00	0.10	0.10	0.00	-0.01	0.90	0.32	0.14	0.00	0.89	0.76
49	7	1	1.86	0.00	0.11	0.10	0.00	-0.01	0.90	0.61	0.11	0.00	0.88	0.90
50	7	2	1.86	0.00	0.11	0.10	0.00	-0.01	0.90	0.61	0.11	0.00	0.88	0.90
51	7	3	1.85	0.00	0.11	0.10	0.00	-0.01	0.90	0.61	0.11	0.00	0.88	0.90
52	7	4	1.85	0.00	0.11	0.10	0.00	-0.01	0.90	0.60	0.11	0.00	0.88	0.90
53	7	5	1.84	0.00	0.11	0.10	0.00	-0.01	0.90	0.60	0.11	0.00	0.88	0.90
54	7	6	1.84	0.00	0.11	0.10	0.00	-0.01	0.90	0.60	0.11	0.00	0.88	0.90
55	7	7	1.83	0.00	0.11	0.10	0.00	-0.01	0.90	0.60	0.11	0.00	0.88	0.90
56	7	8	1.83	0.00	0.11	0.10	0.00	-0.01	0.90	0.60	0.11	0.00	0.88	0.90
57	7	9	1.82	0.00	0.11	0.10	0.00	-0.01	0.90	0.60	0.11	0.00	0.88	0.90
58	7	10	1.82	0.00	0.11	0.10	0.00	-0.01	0.90	0.59	0.11	0.00	0.88	0.90
59	7	11	1.81	0.00	0.11	0.10	0.00	-0.01	0.90	0.59	0.11	0.00	0.88	0.90
60	7	12	1.81	0.00	0.11	0.10	0.00	-0.01	0.90	0.59	0.11	0.00	0.88	0.90
61	7	13	1.80	0.00	0.11	0.10	0.00	-0.01	0.90	0.59	0.11	0.00	0.88	0.90
62	7	14	1.80	0.00	0.11	0.11	0.00	-0.01	0.90	0.59	0.11	0.00	0.88	0.90
63	7	15	1.79	0.00	0.11	0.11	0.00	-0.01	0.90	0.59	0.11	0.00	0.88	0.90
64	7	16	1.79	0.00	0.11	0.11	0.00	-0.01	0.90	0.58	0.11	0.00	0.88	0.90
65	7	17	1.78	0.00	0.11	0.11	0.00	-0.01	0.90	0.58	0.11	0.00	0.88	0.90
66	7	18	1.78	0.00	0.11	0.11	0.00	-0.01	0.90	0.58	0.10	0.00	0.88	0.90
67	7	19	1.77	0.00	0.11	0.11	0.00	-0.01	0.90	0.58	0.10	0.00	0.88	0.90
68	7	20	1.77	0.00	0.11	0.11	0.00	-0.01	0.90	0.58	0.10	0.00	0.88	0.90

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT (Components of dissolved oxygen mass balance (MG/L-DAY))	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	71.75	8.49	5.29	3.20	0.00	0.96	512.00	42.86	-7.77	0.00	0.00	-5.41	-0.02
2	1	2	71.88	8.48	5.55	2.93	0.00	0.96	0.00	39.35	-7.73	0.00	0.00	-5.42	-0.04
3	1	3	72.01	8.47	5.77	2.70	0.00	0.97	0.00	36.23	-7.69	0.00	0.00	-5.42	-0.06
4	1	4	72.12	8.46	5.97	2.49	0.00	0.97	0.00	33.48	-7.64	0.00	0.00	-5.41	-0.08
5	1	5	72.22	8.45	6.14	2.30	0.00	0.97	0.00	31.04	-7.60	0.00	0.00	-5.40	-0.10
6	1	6	72.32	8.44	6.30	2.14	0.00	0.98	0.00	28.87	-7.55	0.00	0.00	-5.37	-0.11
7	2	1	72.40	8.43	6.35	2.08	0.00	0.98	0.00	17.29	-7.48	0.00	0.00	-5.33	-0.14
8	2	2	72.47	8.43	6.26	2.16	0.00	0.98	0.00	6.74	-7.40	0.00	0.00	-5.25	-0.16
9	2	3	72.53	8.42	6.18	2.24	0.00	0.98	0.00	6.99	-7.32	0.00	0.00	-5.18	-0.19
10	2	4	72.59	8.41	6.10	2.31	0.00	0.97	0.00	7.21	-7.24	0.00	0.00	-5.11	-0.21
11	2	5	72.65	8.41	6.03	2.38	0.00	0.97	0.00	7.43	-7.15	0.00	0.00	-5.04	-0.24
12	2	6	72.70	8.40	5.97	2.44	0.00	0.97	0.00	7.63	-7.07	0.00	0.00	-4.97	-0.26
13	2	7	72.74	8.40	5.90	2.50	0.00	0.97	0.00	7.82	-6.99	0.00	0.00	-4.89	-0.28
14	2	8	72.79	8.40	5.84	2.55	0.00	0.97	0.00	7.99	-6.91	0.00	0.00	-4.82	-0.30
15	2	9	72.82	8.39	5.79	2.60	0.00	0.97	0.00	8.15	-6.82	0.00	0.00	-4.75	-0.32
16	2	10	72.86	8.39	5.74	2.65	0.00	0.97	0.00	8.30	-6.74	0.00	0.00	-4.68	-0.34
17	3	1	72.89	8.39	5.73	2.66	0.00	0.97	0.00	10.79	-6.68	0.00	0.00	-4.63	-0.36
18	3	2	72.91	8.39	5.74	2.64	0.00	0.97	0.00	13.16	-6.63	0.00	0.00	-4.59	-0.37
19	3	3	72.93	8.38	5.76	2.63	0.00	0.97	0.00	13.09	-6.58	0.00	0.00	-4.55	-0.38
20	3	4	72.95	8.38	5.77	2.61	0.00	0.97	0.00	13.02	-6.53	0.00	0.00	-4.52	-0.39
21	3	5	72.97	8.38	5.79	2.59	0.00	0.97	0.00	12.94	-6.48	0.00	0.00	-4.48	-0.40
22	3	6	72.98	8.38	5.80	2.58	0.00	0.97	0.00	12.87	-6.43	0.00	0.00	-4.44	-0.42
23	3	7	73.00	8.38	5.81	2.56	0.00	0.97	0.00	12.79	-6.38	0.00	0.00	-4.40	-0.43
24	3	8	73.02	8.38	5.83	2.55	0.00	0.97	0.00	12.72	-6.34	0.00	0.00	-4.36	-0.44
25	3	9	73.03	8.37	5.84	2.53	0.00	0.97	0.00	12.65	-6.29	0.00	0.00	-4.33	-0.45
26	3	10	73.04	8.37	5.86	2.52	0.00	0.97	0.00	12.57	-6.24	0.00	0.00	-4.29	-0.46
27	3	11	73.06	8.37	5.87	2.50	0.00	0.97	0.00	12.50	-6.19	0.00	0.00	-4.25	-0.47
28	3	12	73.07	8.37	5.88	2.49	0.00	0.97	0.00	12.43	-6.15	0.00	0.00	-4.22	-0.48
29	3	13	73.08	8.37	5.90	2.47	0.00	0.97	0.00	12.35	-6.10	0.00	0.00	-4.18	-0.49
30	3	14	73.10	8.37	5.91	2.46	0.00	0.97	0.00	12.28	-6.05	0.00	0.00	-4.14	-0.50
31	4	1	73.11	8.37	6.05	2.32	0.00	0.97	0.00	26.18	-6.01	0.00	0.00	-4.11	-0.51
32	4	2	73.12	8.37	6.28	2.09	0.00	0.98	0.00	36.71	-5.96	0.00	0.00	-4.09	-0.52
33	4	3	73.14	8.37	6.48	1.89	0.00	0.98	0.00	33.20	-5.91	0.00	0.00	-4.07	-0.53
34	4	4	73.15	8.36	6.65	1.71	0.00	0.98	0.00	30.14	-5.87	0.00	0.00	-4.04	-0.54
35	4	5	73.16	8.36	6.80	1.56	0.00	0.98	0.00	27.49	-5.82	0.00	0.00	-4.01	-0.55
36	4	6	73.17	8.36	6.93	1.43	0.00	0.98	0.00	25.18	-5.78	0.00	0.00	-3.98	-0.55
37	4	7	73.18	8.36	7.04	1.32	0.00	0.99	0.00	23.17	-5.74	0.00	0.00	-3.94	-0.56
38	4	8	73.19	8.36	7.14	1.22	0.00	0.99	0.00	21.42	-5.69	0.00	0.00	-3.91	-0.57
39	4	9	73.19	8.36	7.23	1.13	0.00	0.99	0.00	19.90	-5.65	0.00	0.00	-3.88	-0.58
40	5	1	73.20	8.36	7.28	1.08	0.00	0.99	0.00	15.60	-5.60	0.00	0.00	-3.84	-0.59
41	5	2	73.20	8.36	7.29	1.07	0.00	0.99	0.00	11.95	-5.56	0.00	0.00	-3.81	-0.59
42	5	3	73.21	8.36	7.31	1.05	0.00	0.99	0.00	11.77	-5.52	0.00	0.00	-3.78	-0.60
43	5	4	73.21	8.36	7.32	1.04	0.00	0.99	0.00	11.60	-5.48	0.00	0.00	-3.74	-0.61
44	5	5	73.21	8.36	7.34	1.02	0.00	0.99	0.00	11.45	-5.44	0.00	0.00	-3.71	-0.61
45	5	6	73.22	8.36	7.35	1.01	0.00	0.99	0.00	11.29	-5.40	0.00	0.00	-3.68	-0.62
46	5	7	73.22	8.36	7.36	1.00	0.00	0.99	0.00	11.15	-5.36	0.00	0.00	-3.64	-0.62
47	6	1	68.36	8.81	7.03	1.77	0.00	0.99	691.28	6.92	-3.20	0.00	-0.01	-0.42	0.00
48	6	2	68.70	8.78	7.06	1.71	0.00	0.99	0.00	6.70	-3.21	0.00	-0.01	-0.43	0.00
49	7	1	70.21	8.63	7.18	1.46	0.00	0.99	0.00	8.71	-3.81	0.00	-0.01	-1.28	-0.18
50	7	2	70.36	8.62	7.19	1.43	0.00	0.99	0.00	6.56	-3.79	0.00	-0.01	-1.28	-0.18
51	7	3	70.51	8.60	7.20	1.41	0.00	0.99	0.00	6.46	-3.78	0.00	-0.01	-1.28	-0.19
52	7	4	70.65	8.59	7.21	1.38	0.00	0.99	0.00	6.36	-3.76	0.00	-0.01	-1.29	-0.19
53	7	5	70.78	8.58	7.22	1.36	0.00	0.99	0.00	6.28	-3.75	0.00	-0.01	-1.29	-0.19
54	7	6	70.91	8.57	7.23	1.34	0.00	0.99	0.00	6.19	-3.73	0.00	-0.01	-1.29	-0.19
55	7	7	71.02	8.56	7.23	1.32	0.00	0.99	0.00	6.12	-3.72	0.00	-0.01	-1.28	-0.20
56	7	8	71.14	8.55	7.24	1.31	0.00	0.99	0.00	6.04	-3.70	0.00	-0.01	-1.28	-0.20
57	7	9	71.24	8.54	7.25	1.29	0.00	0.99	0.00	5.97	-3.68	0.00	-0.01	-1.28	-0.20
58	7	10	71.35	8.53	7.25	1.27	0.00	0.99	0.00	5.91	-3.66	0.00	-0.01	-1.28	-0.21
59	7	11	71.44	8.52	7.26	1.26	0.00	0.99	0.00	5.84	-3.64	0.00	-0.01	-1.28	-0.21
60	7	12	71.53	8.51	7.27	1.24	0.00	0.99	0.00	5.78	-3.62	0.00	-0.01	-1.28	-0.21
61	7	13	71.62	8.50	7.27	1.23	0.00	0.99	0.00	5.73	-3.60	0.00	-0.01	-1.27	-0.21
62	7	14	71.70	8.49	7.28	1.22	0.00	0.99	0.00	5.68	-3.58	0.00	-0.01	-1.27	-0.22
63	7	15	71.78	8.49	7.28	1.20	0.00	0.99	0.00	5.62	-3.56	0.00	-0.01	-1.27	-0.22
64	7	16	71.86	8.48	7.29	1.19	0.00	0.99	0.00	5.58	-3.54	0.00	-0.01	-1.26	-0.22
65	7	17	71.93	8.47	7.29	1.18	0.00	0.99	0.00	5.53	-3.52	0.00	-0.01	-1.26	-0.22
66	7	18	72.00	8.47	7.30	1.17	0.00	0.99	0.00	5.49	-3.50	0.00	-0.01	-1.25	-0.23
67	7	19	72.06	8.46	7.30	1.16	0.00	0.99	0.00	5.44	-3.48	0.00	-0.01	-1.25	-0.23
68	7	20	72.12	8.46	7.30	1.15	0.00	0.99	0.00	5.40	-3.46	0.00	-0.01	-1.25	-0.23



DISSOLVED OXYGEN ▪ • • • •

BIOCHEMICAL OXYGEN DEMAND • . . . .

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                         * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                  Ver. 3.13 - September 1991

 $$$ (PROBLEM TITLES) $$$

CARD TYPE                               QUAL-2E PROGRAM TITLES
TITLE01              BSAIU.IN - Summer, Average, INTERIM FLOW, BODU Simulation
TITLE02              NSWTP DISCHARGE TO BADGER MILL CREEK
TITLE03    NO        CONSERVATIVE MINERAL I         IN
TITLE04    NO        CONSERVATIVE MINERAL II        IN
TITLE05    NO        CONSERVATIVE MINERAL III       IN
TITLE06   YES        TEMPERATURE
TITLE07   YES        BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)
TITLE08   YES        ALGAE AS CHL-A IN UG/L
TITLE09   YES        PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                (ORGANIC-P, DISSOLVED-P)
TITLE11   YES        NITROGEN CYCLE AS N IN MG/L
TITLE12                (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
TITLE13   YES        DISSOLVED OXYGEN IN MG/L
TITLE14    NO        FECAL COLIFORMS IN NO./100 ML
TITLE15   YES        ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l
ENDTITLE

 $$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                    CARD TYPE
LIST DATA INPUT               0.00000                                         0.00000
WRITE OPTIONAL SUMMARY        0.00000                                         0.00000
NO FLOW AUGMENTATION          0.00000                                         0.00000
STEADY STATE                  0.00000                                         0.00000
TRAPEZOIDAL X-SECTIONS        0.00000                                         0.00000
PRINT LCD/SOLAR DATA          0.00000                                         0.00000
PLOT DO AND BOD               0.00000                                         0.00000
FIXED DNSTM COND (YES=1)=     0.00000        5D-ULT BOD CONV K COEF  =        0.23000
INPUT METRIC (YES=1)     =    0.00000        OUTPUT METRIC (YES=1)   =        0.00000
NUMBER OF REACHES        =    7.00000        NUMBER OF JUNCTIONS     =        1.00000
NUM OF HEADWATERS        =    2.00000        NUMBER OF POINT LOADS   =        0.00000
TIME STEP (HOURS)        =    1.00000        LNTH  COMP  ELEMENT (DX)=        0.10000
MAXIMUM ROUTE TIME (HRS)=   288.00000        TIME INC. FOR RPT2 (HRS)=        1.00000
LATITUDE OF BASIN (DEG) =    43.10000        LONGITUDE OF BASIN (DEG)=       89.30000
STANDARD MERIDIAN (DEG) =    75.00000        DAY OF YEAR START TIME  =      203.00000
EVAP. COEFF. (AE)       =     0.00068        EVAP. COEFF. (BE)       =        0.00027
ELEV. OF BASIN (ELEV)   =   937.00000        DUST ATTENUATION COEF.  =        0.06000
ENDATA1                       0.00000                                         0.00000

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                        CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.5000       O UPTAKE BY NO2 OXID(MG O/MG N)=       1.2000
O PROD  BY ALGAE (MG O/MG A)   =    1.6000       O UPTAKE BY ALGAE (MG O/MG A)  =       2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0850       P CONTENT OF ALGAE (MG P/MG A) =       0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000       ALGAE RESPIRATION RATE (1/DAY) =       0.1000
N HALF SATURATION CONST  (MG/L)=    0.3000       P HALF SATURATION CONST  (MG/L)=       0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0088       NLIN SHADE(1/FT-(UGCHA/L)**2/3)=       0.0540
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000       LIGHT SAT'N COEF (BTU/FT2-MIN) =       0.0300
DAILY AVERAGING OPTION (LAVOPT)=    1.0000       LIGHT AVERAGING FACTOR (AFACT) =       0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =   16.0000       TOTAL DAILY SOLR RAD (BTU/FT-2)=     400.0000
ALGY GROWTH CALC OPTION(LGROPT)=    1.0000       ALGAL PREF FOR NH3-N (PREFN)   =       0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500       NITRIFICATION INHIBITION COEF  =       0.6000
ENDATA1A                            0.0000                                              0.0000

 $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE      RATE CODE      THETA VALUE

THETA( 1)       BOD DECA         1.047      DFLT
THETA( 2)       BOD SETT         1.024      DFLT
THETA( 3)       OXY TRAN         1.024      DFLT
THETA( 4)       SOD RATE         1.060      DFLT
THETA( 5)       ORGN DEC         1.047      DFLT
THETA( 6)       ORGN SET         1.024      DFLT
THETA( 7)       NH3 DECA         1.083      DFLT
THETA( 8)       NH3 SRCE         1.074      DFLT
THETA( 9)       NO2 DECA         1.047      DFLT
THETA(10)       PORG DEC         1.047      DFLT
THETA(11)       PORG SET         1.024      DFLT
THETA(12)       DISP SRC         1.074      DFLT
THETA(13)       ALG GROW         1.047      DFLT
THETA(14)       ALG RESP         1.047      DFLT
THETA(15)       ALG SETT         1.024      DFLT
THETA(16)       COLI DEC         1.047      DFLT
THETA(17)       ANC DECA         1.000      DFLT
THETA(18)       ANC SETT         1.024      DFLT
THETA(19)       ANC SRCE         1.000      DFLT
ENDATA1B

 $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE          REACH ORDER AND IDENT                    R. MI/KM              R. MI/KM
STREAM REACH     1.0  RCH= HWY 151-PB          FROM          10.0     TO            9.4
STREAM REACH     2.0  RCH= PB-Lincoln          FROM           9.4     TO            8.4
STREAM REACH     3.0  RCH= Lincoln-151 By      FROM           8.4     TO            7.0
STREAM REACH     4.0  RCH= 151 By-HWY 69       FROM           7.0     TO            6.1
STREAM REACH     5.0  RCH= HWY 69-Sugar R      FROM           6.1     TO            5.4
STREAM REACH     6.0  RCH= Upstrm Sugar R      FROM           5.6     TO            5.4
STREAM REACH     7.0  RCH= Dnstrm Sugar R      FROM           5.4     TO            3.4
ENDATA2          0.0                                          0.0                   0.0

 $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE                     REACH   AVAIL HDWS TARGET    ORDER OF AVAIL SOURCES
ENDATA3                        0.        0.        0.0   0.   0.   0.   0.   0.   0.

 $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE        REACH ELEMENTS/REACH               COMPUTATIONAL FLAGS
FLAG FIELD         1.         6.          1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         2.        10.          2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         3.        14.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
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FLAG FIELD	4.	9.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	$$1	$$2	WIDTH	SLOPE	CHANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	2.	945.00	0.13	0.10	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	3.	935.00	0.13	0.20	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	4.	925.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	5.	915.00	0.13	0.00	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	6.	910.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	7.	910.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	2.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	3.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	4.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	5.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	6.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	7.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.390	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	2.	0.650	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	3.	0.910	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	4.	0.590	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	5.	0.460	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

INCR INFLOW-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC•Sugar R Confluen	46.	49.	48.
ENDATA9	0.		0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	NSWTPOutfall	3.40	65.90	6.00	5.13	0.00	0.00	0.00
HEADWTR-1	2.	Sugar River	18.00	63.30	7.00	4.00	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	6.10	0.00	0.00	0.50	0.25	0.00	1.00	0.00	0.89
HEADWTR-2	2.	5.00	0.00	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
ENDATA11A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

	DAM	RCH	ELE	ADAM	BDAM	FDAM	HDAM
ENDATA12	0.	0.	0.	0.00	0.00	0.00	0.00

$$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

CARD TYPE	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI

ENDATA13 DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P

ENDATA13A DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

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STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:
----------------------------------------------------------

                        NUMBER OF
         ITERATION    NONCONVERGENT
                         ELEMENTS

                  TEMPERATURE                                                 ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 64.27 62.82 61.52 60.37 59.34 58.42
  2 57.65 56.99 56.39 55.84 55.35 54.90 54.49 54.11 53.77 53.45
  3 53.27 53.19 53.10 53.03 52.95 52.88 52.82 52.75 52.69 52.64 52.58 52.53 52.48 52.43
  4 52.32 52.05 51.80 51.57 51.36 51.17 50.99 50.83 50.68
  5 50.58 50.51 50.45 50.39 50.34 50.29 50.25
  6 62.79 62.30
  7 58.90 58.62 58.34 58.07 57.81 57.55 57.30 57.06 56.82 56.58 56.35 56.13 55.91 55.69 55.48 55.28 55.07 54.88 54.68 54.50
              1            68

                  TEMPERATURE                                                 ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 64.26 62.79 61.47 60.29 59.22 58.25
  2 57.43 56.72 56.06 55.46 54.91 54.41 53.94 53.50 53.10 52.72
  3 52.49 52.38 52.28 52.17 52.07 51.98 51.89 51.81 51.72 51.64 51.57 51.50 51.43 51.36
  4 51.21 50.88 50.56 50.27 50.00 49.75 49.52 49.30 49.09
  5 48.95 48.85 48.75 48.67 48.58 48.50 48.43
  6 62.79 62.28
  7 58.40 58.12 57.83 57.56 57.28 57.02 56.75 56.50 56.24 56.00 55.75 55.51 55.28 55.05 54.82 54.60 54.38 54.16 53.95 53.74
              2            14

                  TEMPERATURE                                                 ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 64.26 62.79 61.47 60.29 59.22 58.25
  2 57.43 56.71 56.06 55.46 54.91 54.40 53.93 53.50 53.09 52.72
  3 52.49 52.38 52.27 52.17 52.07 51.98 51.89 51.80 51.72 51.64 51.57 51.49 51.42 51.36
  4 51.21 50.87 50.56 50.27 50.00 49.75 49.51 49.29 49.08
  5 48.94 48.83 48.74 48.65 48.56 48.48 48.40
  6 62.79 62.28
  7 58.40 58.11 57.83 57.55 57.28 57.01 56.75 56.49 56.24 55.99 55.75 55.51 55.27 55.04 54.81 54.59 54.37 54.16 53.95 53.74
              3             0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):
--------------------------------------------------------------------------------

     DAILY NET SOLAR RADIATION =        0.000 BTU/FT-2   (     0.000 LANGLEYS)
     NUMBER OF DAYLIGHT HOURS =  14.7

     HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

          1     0.00         9     0.00        17     0.00
          2     0.00        10     0.00        18     0.00
          3     0.00        11     0.00        19     0.00
          4     0.00        12     0.00        20     0.00
          5     0.00        13     0.00        21     0.00
          6     0.00        14     0.00        22     0.00
          7     0.00        15     0.00        23     0.00
          8     0.00        16     0.00        24     0.00

                  BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)                        ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1  5.07  5.02  4.97  4.92  4.88  4.83
  2  4.79  4.73  4.68  4.64  4.59  4.55  4.51  4.47  4.43  4.39
  3  4.36  4.34  4.31  4.29  4.27  4.25  4.23  4.21  4.19  4.17  4.15  4.13  4.11  4.09
  4  4.08  4.06  4.04  4.03  4.01  4.00  3.99  3.97  3.96
  5  3.94  3.93  3.92  3.91  3.90  3.88  3.87
  6  3.98  3.96
  7  3.93  3.91  3.89  3.88  3.86  3.85  3.83  3.82  3.80  3.79  3.78  3.76  3.75  3.73  3.72  3.71  3.69  3.68  3.67  3.65

                  ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l  ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1  6.07  6.04  6.01  5.98  5.95  5.93
  2  5.90  5.87  5.84  5.82  5.79  5.77  5.74  5.72  5.69  5.67
  3  5.65  5.64  5.62  5.60  5.59  5.57  5.56  5.55  5.53  5.52  5.50  5.49  5.48  5.47
  4  5.45  5.44  5.43  5.42  5.41  5.40  5.39  5.38  5.37
  5  5.36  5.35  5.34  5.33  5.32  5.31  5.30
  6  4.99  4.99
```

7	5.07	5.06	5.05	5.05	5.04	5.04	5.03	5.03	5.02	5.01	5.01	5.00	5.00	4.99	4.99	4.98	4.98	4.97	4.97	4.96

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.05	0.10	0.15	0.19	0.23	0.27														
2	0.31	0.35	0.39	0.43	0.46	0.49	0.53	0.56	0.59	0.62										
3	0.65	0.67	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.87	0.89	0.92	0.94	0.96						
4	0.98	0.99	1.01	1.03	1.05	1.06	1.08	1.09	1.11											
5	1.12	1.14	1.15	1.17	1.18	1.20	1.21													
6	2.70	2.69																		
7	2.30	2.30	2.29	2.29	2.29	2.29	2.28	2.28	2.28	2.28	2.27	2.27	2.27	2.27	2.26	2.26	2.26	2.26	2.25	2.25

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.86	0.85	0.84	0.82	0.81														
2	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71										
3	0.70	0.70	0.69	0.68	0.67	0.66	0.66	0.65	0.64	0.64	0.63	0.63	0.62	0.61						
4	0.61	0.60	0.60	0.59	0.59	0.58	0.57	0.57	0.57											
5	0.56	0.56	0.55	0.55	0.54	0.54	0.53													
6	0.13	0.13																		
7	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.50														
2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50										
3	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51						
4	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51											
5	0.52	0.52	0.52	0.52	0.52	0.52	0.52													
6	0.62	0.62																		
7	0.59	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.25	0.24	0.24	0.24	0.24	0.23														
2	0.23	0.23	0.23	0.22	0.22	0.22	0.22	0.22	0.21	0.21										
3	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20						
4	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19											
5	0.19	0.19	0.19	0.18	0.18	0.18	0.18													
6	0.12	0.12																		
7	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.01	0.01	0.01	0.01														
2	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02										
3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03						
4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03											
5	0.03	0.03	0.03	0.03	0.03	0.03	0.03													
6	0.00	0.00																		
7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.02	1.05	1.07	1.09	1.11	1.13														
2	1.15	1.17	1.19	1.21	1.23	1.24	1.26	1.28	1.29	1.31										
3	1.32	1.33	1.35	1.36	1.37	1.39	1.40	1.41	1.42	1.43	1.45	1.46	1.47	1.48						
4	1.49	1.50	1.51	1.52	1.52	1.53	1.54	1.55	1.56											
5	1.57	1.58	1.58	1.59	1.60	1.61	1.61													
6	2.30	2.30																		
7	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.32	6.61	6.88	7.12	7.35	7.56														
2	7.70	7.73	7.76	7.79	7.82	7.86	7.90	7.93	7.97	8.01										
3	8.05	8.10	8.14	8.18	8.23	8.27	8.30	8.34	8.38	8.42	8.45	8.48	8.52	8.55						
4	8.67	8.85	9.02	9.18	9.32	9.45	9.57	9.68	9.78											
5	9.64	9.88	9.91	9.94	9.97	10.00	10.03													
6	7.06	7.12																		
7	7.93	7.98	8.02	8.07	8.11	8.16	8.20	8.25	8.29	8.34	8.38	8.42	8.46	8.51	8.55	8.59	8.63	8.67	8.71	8.75

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	0
NITRIFICATION INHIBITION	1	67
ALGAE GROWTH RATE	2	0
NITRIFICATION INHIBITION	2	63
ALGAE GROWTH RATE	3	0
NITRIFICATION INHIBITION	3	12
ALGAE GROWTH RATE	4	0
NITRIFICATION INHIBITION	4	0
ALGAE GROWTH RATE	5	0
NITRIFICATION INHIBITION	5	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:

1. LIGHT AVERAGING OPTION. LAVOPT= 1

METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
DAILY NET SOLAR RADIATION: 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 14.7
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS. LGROPT= 1

MULTIPLICATIVE: FL*FN*FP

TEMPERATURE — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.26	62.79	61.47	60.29	59.22	58.25														
2	57.43	56.71	56.06	55.46	54.91	54.40	53.93	53.50	53.09	52.72										
3	52.49	52.38	52.27	52.17	52.07	51.98	51.89	51.80	51.72	51.64	51.57	51.49	51.42	51.36						
4	51.21	50.87	50.56	50.27	50.00	49.75	49.51	49.29	49.08											
5	48.94	48.83	48.74	48.65	48.56	48.48	48.40													
6	62.79	62.28																		
7	58.40	58.11	57.83	57.55	57.28	57.01	56.75	56.49	56.24	55.99	55.75	55.51	55.27	55.04	54.81	54.59	54.37	54.16	53.95	53.74

DISSOLVED OXYGEN IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.32	6.61	6.88	7.12	7.35	7.56														
2	7.70	7.73	7.76	7.79	7.82	7.86	7.89	7.93	7.97	8.01										
3	8.05	8.10	8.14	8.18	8.23	8.27	8.30	8.34	8.38	8.41	8.45	8.48	8.52	8.55						
4	8.67	8.85	9.02	9.18	9.32	9.45	9.57	9.68	9.78											
5	9.84	9.88	9.91	9.94	9.97	10.00	10.03													
6	7.06	7.12																		
7	7.93	7.98	8.02	8.07	8.11	8.16	8.20	8.25	8.29	8.34	8.38	8.42	8.46	8.51	8.55	8.59	8.63	8.67	8.71	8.75

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.07	5.02	4.97	4.92	4.88	4.83														
2	4.79	4.73	4.68	4.64	4.59	4.55	4.51	4.47	4.43	4.39										
3	4.36	4.34	4.31	4.29	4.27	4.25	4.23	4.21	4.19	4.17	4.15	4.13	4.11	4.09						
4	4.08	4.06	4.04	4.03	4.01	4.00	3.99	3.97	3.96											
5	3.94	3.93	3.92	3.91	3.90	3.88	3.87													
6	3.98	3.96																		
7	3.93	3.91	3.89	3.88	3.86	3.85	3.83	3.82	3.80	3.79	3.78	3.76	3.75	3.73	3.72	3.71	3.69	3.68	3.67	3.65

ORGANIC NITROGEN AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.50														
2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50										
3	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51						
4	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51											
5	0.52	0.52	0.52	0.52	0.52	0.52	0.52													
6	0.62	0.62																		
7	0.59	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57

AMMONIA AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.25	0.24	0.24	0.24	0.24	0.23														
2	0.23	0.23	0.23	0.22	0.22	0.22	0.22	0.22	0.21	0.21										
3	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20						
4	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19											
5	0.19	0.19	0.19	0.18	0.18	0.18	0.18													
6	0.12	0.12																		
7	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14

NITRITE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.01	0.01	0.01	0.01														
2	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02										
3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03						
4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03											
5	0.03	0.03	0.03	0.03	0.03	0.03	0.03													
6	0.00	0.00																		
7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.02	1.05	1.07	1.09	1.11	1.13														
2	1.15	1.17	1.19	1.21	1.23	1.24	1.26	1.28	1.29	1.31										
3	1.32	1.33	1.35	1.36	1.37	1.39	1.40	1.41	1.42	1.43	1.45	1.46	1.47	1.48						
4	1.49	1.50	1.51	1.52	1.52	1.53	1.54	1.55	1.56											
5	1.57	1.58	1.58	1.59	1.60	1.61	1.61													
6	2.30	2.30																		
7	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						

4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.86	0.85	0.84	0.82	0.81														
2	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71										
3	0.70	0.70	0.69	0.68	0.67	0.66	0.66	0.65	0.64	0.64	0.63	0.63	0.62	0.61						
4	0.61	0.60	0.60	0.59	0.59	0.58	0.57	0.57	0.57											
5	0.56	0.56	0.55	0.55	0.54	0.54	0.53													
6	0.13	0.13																		
7	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

ALGAE AS CHL-A IN UG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.05	0.10	0.15	0.19	0.23	0.27														
2	0.31	0.35	0.39	0.43	0.46	0.49	0.53	0.56	0.59	0.62										
3	0.65	0.67	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.87	0.89	0.92	0.94	0.96						
4	0.98	0.99	1.01	1.03	1.05	1.06	1.08	1.09	1.11											
5	1.12	1.14	1.15	1.17	1.18	1.20	1.21													
6	2.70	2.69																		
7	2.30	2.30	2.29	2.29	2.29	2.29	2.28	2.28	2.28	2.28	2.27	2.27	2.27	2.27	2.26	2.26	2.26	2.26	2.25	2.25

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS.mg/l ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.07	6.04	6.01	5.98	5.95	5.93														
2	5.90	5.87	5.84	5.82	5.79	5.77	5.74	5.72	5.69	5.67										
3	5.65	5.64	5.62	5.60	5.59	5.57	5.56	5.55	5.53	5.52	5.50	5.49	5.48	5.47						
4	5.45	5.44	5.43	5.42	5.41	5.40	5.39	5.38	5.37											
5	5.36	5.35	5.34	5.33	5.32	5.31	5.30													
6	4.39	4.99																		
7	5.07	5.06	5.05	5.05	5.04	5.04	5.03	5.03	5.02	5.01	5.01	5.00	5.00	4.99	4.99	4.98	4.98	4.97	4.97	4.96

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	3.47	0.00	0.06	0.630	0.010	0.310	17.744	2.90	10.84	5.50	0.27
2	1	2	9.90	9.80	3.53	0.00	0.06	0.634	0.010	0.313	17.774	2.94	10.87	5.57	0.28
3	1	3	9.80	9.70	3.60	0.00	0.06	0.638	0.010	0.317	17.803	2.98	10.90	5.64	0.28
4	1	4	9.70	9.60	3.66	0.00	0.06	0.642	0.010	0.320	17.832	3.01	10.93	5.70	0.28
5	1	5	9.60	9.50	3.73	0.00	0.06	0.645	0.009	0.323	17.860	3.05	10.97	5.77	0.29
6	1	6	9.50	9.40	3.79	0.00	0.06	0.649	0.009	0.326	17.889	3.08	11.00	5.84	0.29
7	2	1	9.40	9.30	3.86	0.00	0.06	0.445	0.014	0.545	15.926	4.58	9.06	8.67	0.37
8	2	2	9.30	9.20	3.92	0.00	0.06	0.447	0.014	0.550	15.935	4.63	9.07	8.76	0.37
9	2	3	9.20	9.10	3.99	0.00	0.06	0.450	0.014	0.555	15.944	4.68	9.08	8.86	0.38
10	2	4	9.10	9.00	4.05	0.00	0.06	0.453	0.013	0.561	15.953	4.72	9.09	8.95	0.38
11	2	5	9.00	8.90	4.12	0.00	0.06	0.455	0.013	0.566	15.963	4.77	9.10	9.04	0.39
12	2	6	8.90	8.80	4.18	0.00	0.06	0.458	0.013	0.571	15.972	4.82	9.11	9.13	0.40
13	2	7	8.80	8.70	4.25	0.00	0.06	0.461	0.013	0.577	15.980	4.87	9.12	9.22	0.40
14	2	8	8.70	8.60	4.31	0.00	0.06	0.463	0.013	0.582	15.989	4.91	9.14	9.30	0.41
15	2	9	8.60	8.50	4.38	0.00	0.06	0.466	0.013	0.587	15.998	4.96	9.15	9.39	0.41
16	2	10	8.50	8.40	4.44	0.00	0.06	0.468	0.013	0.592	16.007	5.01	9.16	9.48	0.42
17	3	1	8.40	8.30	4.51	0.00	0.07	0.756	0.008	0.687	8.678	3.15	6.09	5.96	0.51
18	3	2	8.30	8.20	4.57	0.00	0.07	0.759	0.008	0.692	8.699	3.18	6.12	6.02	0.51
19	3	3	8.20	8.10	4.64	0.00	0.07	0.762	0.008	0.697	8.719	3.21	6.14	6.08	0.52
20	3	4	8.10	8.00	4.70	0.00	0.07	0.766	0.008	0.702	8.739	3.24	6.16	6.14	0.52
21	3	5	8.00	7.90	4.77	0.00	0.07	0.769	0.008	0.708	8.760	3.27	6.18	6.20	0.53
22	3	6	7.90	7.80	4.83	0.00	0.07	0.772	0.008	0.713	8.780	3.30	6.20	6.26	0.53
23	3	7	7.80	7.70	4.90	0.00	0.07	0.775	0.008	0.718	8.800	3.34	6.23	6.32	0.54
24	3	8	7.70	7.60	4.96	0.00	0.07	0.778	0.008	0.723	8.820	3.37	6.25	6.38	0.54
25	3	9	7.60	7.50	5.03	0.00	0.07	0.781	0.008	0.728	8.839	3.40	6.27	6.43	0.55
26	3	10	7.50	7.40	5.09	0.00	0.07	0.784	0.008	0.733	8.859	3.43	6.29	6.49	0.55
27	3	11	7.40	7.30	5.16	0.00	0.07	0.787	0.008	0.738	8.878	3.46	6.31	6.55	0.56
28	3	12	7.30	7.20	5.22	0.00	0.07	0.790	0.008	0.743	8.897	3.49	6.33	6.61	0.57
29	3	13	7.20	7.10	5.29	0.00	0.07	0.793	0.008	0.748	8.917	3.52	6.35	6.67	0.57
30	3	14	7.10	7.00	5.35	0.00	0.07	0.795	0.008	0.753	8.936	3.55	6.37	6.73	0.58
31	4	1	7.00	6.90	5.42	0.00	0.07	0.827	0.007	0.304	21.586	3.46	12.35	6.55	0.28
32	4	2	6.90	6.80	5.48	0.00	0.07	0.830	0.007	0.306	21.597	3.49	12.36	6.60	0.28
33	4	3	6.80	6.70	5.55	0.00	0.07	0.834	0.007	0.308	21.609	3.51	12.37	6.65	0.29
34	4	4	6.70	6.60	5.61	0.00	0.07	0.837	0.007	0.310	21.620	3.54	12.38	6.70	0.29
35	4	5	6.60	6.50	5.68	0.00	0.07	0.841	0.007	0.312	21.631	3.56	12.40	6.75	0.29
36	4	6	6.50	6.40	5.74	0.00	0.07	0.845	0.007	0.314	21.642	3.59	12.41	6.80	0.30
37	4	7	6.40	6.30	5.81	0.00	0.07	0.848	0.007	0.316	21.653	3.62	12.42	6.85	0.30
38	4	8	6.30	6.20	5.87	0.00	0.07	0.851	0.007	0.318	21.664	3.64	12.43	6.90	0.30
39	4	9	6.20	6.10	5.94	0.00	0.07	0.855	0.007	0.321	21.675	3.67	12.45	6.95	0.30
40	5	1	6.10	6.00	6.01	0.00	0.07	0.892	0.007	0.417	16.130	3.55	10.20	6.73	0.35
41	5	2	6.00	5.90	6.07	0.00	0.07	0.895	0.007	0.420	16.150	3.58	10.22	6.78	0.35
42	5	3	5.90	5.80	6.14	0.00	0.07	0.898	0.007	0.423	16.169	3.61	10.24	6.83	0.35
43	5	4	5.80	5.70	6.20	0.00	0.07	0.901	0.007	0.425	16.188	3.63	10.26	6.88	0.35
44	5	5	5.70	5.60	6.27	0.00	0.07	0.905	0.007	0.428	16.207	3.66	10.28	6.93	0.36
45	5	6	5.60	5.50	6.33	0.00	0.07	0.908	0.007	0.430	16.226	3.68	10.30	6.98	0.36
46	5	7	5.50	5.40	6.40	0.00	0.07	0.911	0.007	0.433	16.245	3.71	10.32	7.03	0.36
47	6	1	5.60	5.50	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
48	6	2	5.50	5.40	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
49	7	1	5.40	5.30	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
50	7	2	5.30	5.20	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
51	7	3	5.20	5.10	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
52	7	4	5.10	5.00	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
53	7	5	5.00	4.90	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
54	7	6	4.90	4.80	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
55	7	7	4.80	4.70	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
56	7	8	4.70	4.60	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
57	7	9	4.60	4.50	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
58	7	10	4.50	4.40	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
59	7	11	4.40	4.30	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
60	7	12	4.30	4.20	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
61	7	13	4.20	4.10	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
62	7	14	4.10	4.00	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
63	7	15	4.00	3.90	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
64	7	16	3.90	3.80	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
65	7	17	3.80	3.70	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
66	7	18	3.70	3.60	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
67	7	19	3.60	3.50	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63
68	7	20	3.50	3.40	24.40	0.00	0.00	0.943	0.006	0.808	32.002	13.66	17.75	25.87	0.63

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	9.22	8	12.19	0.73	0.00	0.00	0.23	0.10	0.83	0.00	0.89	0.18	0.10	0.00	0.00	0.00	0.19	0.00
1	2	9.38	8	11.99	0.70	0.00	0.00	0.22	0.09	0.78	0.00	0.86	0.18	0.09	0.00	0.00	0.00	0.19	0.00
1	3	9.53	8	11.83	0.68	0.00	0.00	0.21	0.09	0.74	0.00	0.83	0.17	0.09	0.00	0.00	0.00	0.18	0.00
1	4	9.66	8	11.70	0.66	0.00	0.00	0.21	0.09	0.70	0.00	0.81	0.16	0.09	0.00	0.00	0.00	0.18	0.00
1	5	9.78	8	11.59	0.64	0.00	0.00	0.20	0.09	0.67	0.00	0.79	0.16	0.09	0.00	0.00	0.00	0.18	0.00
1	6	9.90	8	11.49	0.62	0.00	0.00	0.19	0.09	0.64	0.00	0.77	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	1	10.00	8	7.03	0.61	0.00	0.00	0.19	0.09	0.62	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	2	10.09	8	2.64	0.60	0.00	0.00	0.19	0.09	0.60	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	3	10.17	8	2.64	0.59	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	4	10.24	8	2.63	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.15	0.08	0.00	0.00	0.00	0.17	0.00
2	5	10.31	8	2.62	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
2	6	10.38	8	2.62	0.57	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
2	7	10.44	8	2.61	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
2	8	10.50	8	2.61	0.55	0.00	0.00	0.17	0.08	0.52	0.00	0.68	0.14	0.08	0.00	0.00	0.00	0.17	0.00
2	9	10.55	8	2.61	0.55	0.00	0.00	0.17	0.08	0.51	0.00	0.68	0.14	0.08	0.00	0.00	0.00	0.16	0.00
2	10	10.60	8	2.61	0.54	0.00	0.00	0.17	0.08	0.50	0.00	0.67	0.14	0.08	0.00	0.00	0.00	0.16	0.00
3	1	10.63	8	3.31	0.54	0.00	0.00	0.17	0.08	0.50	0.00	0.67	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	2	10.65	8	4.00	0.54	0.00	0.00	0.17	0.08	0.50	0.00	0.67	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	3	10.66	8	4.01	0.54	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	4	10.68	8	4.01	0.53	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	5	10.69	8	4.02	0.53	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	6	10.70	8	4.02	0.53	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	7	10.72	8	4.03	0.53	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	8	10.73	8	4.03	0.53	0.00	0.00	0.17	0.08	0.48	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	9	10.74	8	4.04	0.53	0.00	0.00	0.16	0.08	0.48	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	10	10.75	8	4.04	0.53	0.00	0.00	0.16	0.08	0.48	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	11	10.76	8	4.04	0.53	0.00	0.00	0.16	0.08	0.48	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	12	10.77	8	4.05	0.52	0.00	0.00	0.16	0.08	0.48	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	13	10.78	8	4.05	0.52	0.00	0.00	0.16	0.08	0.48	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
3	14	10.79	8	4.06	0.52	0.00	0.00	0.16	0.08	0.48	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	1	10.81	8	9.67	0.52	0.00	0.00	0.16	0.08	0.47	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	2	10.86	8	15.24	0.52	0.00	0.00	0.16	0.08	0.47	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	3	10.90	8	15.23	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	4	10.94	8	15.23	0.51	0.00	0.00	0.16	0.08	0.45	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	5	10.98	8	15.23	0.51	0.00	0.00	0.16	0.08	0.45	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	6	11.02	8	15.23	0.50	0.00	0.00	0.16	0.08	0.44	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	7	11.05	8	15.24	0.50	0.00	0.00	0.16	0.08	0.44	0.00	0.62	0.12	0.08	0.00	0.00	0.00	0.16	0.00
4	8	11.09	8	15.25	0.50	0.00	0.00	0.16	0.08	0.43	0.00	0.62	0.12	0.08	0.00	0.00	0.00	0.16	0.00
4	9	11.12	8	15.26	0.49	0.00	0.00	0.15	0.08	0.43	0.00	0.62	0.12	0.08	0.00	0.00	0.00	0.16	0.00
5	1	11.14	8	12.29	0.49	0.00	0.00	0.15	0.08	0.43	0.00	0.61	0.12	0.08	0.00	0.00	0.00	0.16	0.00
5	2	11.15	8	9.33	0.49	0.00	0.00	0.15	0.08	0.43	0.00	0.61	0.12	0.08	0.00	0.00	0.00	0.16	0.00
5	3	11.17	8	9.34	0.49	0.00	0.00	0.15	0.08	0.42	0.00	0.61	0.12	0.08	0.00	0.00	0.00	0.16	0.00
5	4	11.18	8	9.35	0.49	0.00	0.00	0.15	0.08	0.42	0.00	0.61	0.12	0.08	0.00	0.00	0.00	0.15	0.00
5	5	11.19	8	9.36	0.49	0.00	0.00	0.15	0.08	0.42	0.00	0.61	0.12	0.08	0.00	0.00	0.00	0.15	0.00
5	6	11.21	8	9.37	0.49	0.00	0.00	0.15	0.08	0.42	0.00	0.61	0.12	0.08	0.00	0.00	0.00	0.15	0.00
5	7	11.22	8	9.39	0.49	0.00	0.00	0.15	0.08	0.42	0.00	0.60	0.12	0.08	0.00	0.00	0.00	0.15	0.00
6	1	9.38	8	4.93	0.70	0.00	0.00	0.22	0.09	0.78	0.00	0.86	0.18	0.09	0.00	0.00	0.00	0.19	0.00
6	2	9.44	8	4.89	0.69	0.00	0.00	0.22	0.09	0.77	0.00	0.85	0.17	0.09	0.00	0.00	0.00	0.19	0.00
7	1	9.88	8	6.43	0.63	0.00	0.00	0.20	0.09	0.65	0.00	0.78	0.16	0.09	0.00	0.00	0.00	0.18	0.00
7	2	9.92	8	5.16	0.62	0.00	0.00	0.19	0.09	0.64	0.00	0.77	0.16	0.09	0.00	0.00	0.00	0.18	0.00
7	3	9.95	8	5.14	0.62	0.00	0.00	0.19	0.09	0.63	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	4	9.98	8	5.12	0.61	0.00	0.00	0.19	0.09	0.62	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	5	10.02	8	5.10	0.61	0.00	0.00	0.19	0.09	0.62	0.00	0.75	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	6	10.05	8	5.08	0.60	0.00	0.00	0.19	0.09	0.61	0.00	0.75	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	7	10.08	8	5.07	0.60	0.00	0.00	0.19	0.09	0.60	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	8	10.11	8	5.05	0.60	0.00	0.00	0.19	0.09	0.60	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	9	10.14	8	5.03	0.59	0.00	0.00	0.19	0.09	0.59	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	10	10.18	8	5.01	0.59	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	11	10.21	8	5.00	0.59	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	12	10.24	8	4.98	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.15	0.08	0.00	0.00	0.00	0.17	0.00
7	13	10.27	8	4.97	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	14	10.30	8	4.95	0.57	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	15	10.33	8	4.94	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	16	10.35	8	4.92	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	17	10.38	8	4.91	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	18	10.41	8	4.89	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	19	10.44	8	4.88	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	20	10.47	8	4.87	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota spen	CHLA UG/L
1	1	64.26	0.00	0.00	0.00	6.32	5.07	0.50	0.25	0.00	1.02	1.77	0.00	0.88	0.88	0.00	6.07	0.05
1	2	62.79	0.00	0.00	0.00	6.61	5.02	0.50	0.24	0.00	1.05	1.80	0.00	0.86	0.86	0.00	6.04	0.10
1	3	61.47	0.00	0.00	0.00	6.88	4.97	0.50	0.24	0.01	1.07	1.82	0.00	0.85	0.85	0.00	6.01	0.15
1	4	60.29	0.00	0.00	0.00	7.12	4.92	0.50	0.24	0.01	1.09	1.84	0.00	0.84	0.84	0.00	5.98	0.19
1	5	59.22	0.00	0.00	0.00	7.35	4.88	0.50	0.24	0.01	1.11	1.86	0.00	0.82	0.82	0.00	5.95	0.23
1	6	58.25	0.00	0.00	0.00	7.56	4.83	0.50	0.23	0.01	1.13	1.88	0.00	0.81	0.81	0.00	5.93	0.27
2	1	57.43	0.00	0.00	0.00	7.70	4.79	0.50	0.23	0.01	1.15	1.90	0.00	0.80	0.80	0.00	5.90	0.31
2	2	56.71	0.00	0.00	0.00	7.73	4.73	0.50	0.23	0.01	1.17	1.92	0.00	0.79	0.79	0.00	5.87	0.35
2	3	56.06	0.00	0.00	0.00	7.76	4.68	0.50	0.23	0.01	1.19	1.94	0.00	0.78	0.78	0.00	5.84	0.39
2	4	55.46	0.00	0.00	0.00	7.79	4.64	0.50	0.22	0.01	1.21	1.95	0.00	0.77	0.77	0.00	5.82	0.43
2	5	54.91	0.00	0.00	0.00	7.82	4.59	0.50	0.22	0.02	1.23	1.97	0.00	0.76	0.76	0.00	5.79	0.46
2	6	54.40	0.00	0.00	0.00	7.86	4.55	0.50	0.22	0.02	1.24	1.99	0.00	0.75	0.75	0.00	5.77	0.49
2	7	53.93	0.00	0.00	0.00	7.89	4.51	0.50	0.22	0.02	1.26	2.00	0.00	0.74	0.74	0.00	5.74	0.53
2	8	53.50	0.00	0.00	0.00	7.93	4.47	0.50	0.22	0.02	1.28	2.02	0.00	0.73	0.73	0.00	5.72	0.56
2	9	53.09	0.00	0.00	0.00	7.97	4.43	0.50	0.21	0.02	1.29	2.03	0.00	0.72	0.72	0.00	5.69	0.59
2	10	52.72	0.00	0.00	0.00	8.01	4.39	0.50	0.21	0.02	1.31	2.04	0.00	0.71	0.71	0.00	5.67	0.62
3	1	52.49	0.00	0.00	0.00	8.05	4.36	0.51	0.21	0.02	1.32	2.06	0.00	0.70	0.70	0.00	5.65	0.65
3	2	52.38	0.00	0.00	0.00	8.10	4.34	0.51	0.21	0.02	1.33	2.07	0.00	0.70	0.70	0.00	5.64	0.67
3	3	52.27	0.00	0.00	0.00	8.14	4.31	0.51	0.21	0.02	1.35	2.09	0.00	0.69	0.69	0.00	5.62	0.70
3	4	52.17	0.00	0.00	0.00	8.18	4.29	0.51	0.21	0.02	1.36	2.10	0.00	0.68	0.68	0.00	5.60	0.73
3	5	52.07	0.00	0.00	0.00	8.23	4.27	0.51	0.21	0.02	1.37	2.11	0.00	0.67	0.67	0.00	5.59	0.75
3	6	51.98	0.00	0.00	0.00	8.27	4.25	0.51	0.20	0.02	1.39	2.12	0.00	0.66	0.66	0.00	5.57	0.78
3	7	51.89	0.00	0.00	0.00	8.30	4.23	0.51	0.20	0.02	1.40	2.14	0.00	0.66	0.66	0.00	5.56	0.80
3	8	51.80	0.00	0.00	0.00	8.34	4.21	0.51	0.20	0.02	1.41	2.15	0.00	0.65	0.65	0.00	5.55	0.83
3	9	51.72	0.00	0.00	0.00	8.38	4.19	0.51	0.20	0.02	1.42	2.16	0.00	0.64	0.64	0.00	5.53	0.85
3	10	51.64	0.00	0.00	0.00	8.41	4.17	0.51	0.20	0.03	1.43	2.17	0.00	0.64	0.64	0.00	5.52	0.87
3	11	51.57	0.00	0.00	0.00	8.45	4.15	0.51	0.20	0.03	1.45	2.18	0.00	0.63	0.63	0.00	5.50	0.89
3	12	51.49	0.00	0.00	0.00	8.48	4.13	0.51	0.20	0.03	1.46	2.19	0.00	0.63	0.63	0.00	5.49	0.92
3	13	51.42	0.00	0.00	0.00	8.52	4.11	0.51	0.20	0.03	1.47	2.20	0.00	0.62	0.62	0.00	5.48	0.94
3	14	51.36	0.00	0.00	0.00	8.55	4.09	0.51	0.20	0.03	1.48	2.21	0.00	0.61	0.61	0.00	5.47	0.96
4	1	51.21	0.00	0.00	0.00	8.67	4.08	0.51	0.19	0.03	1.49	2.22	0.00	0.61	0.61	0.00	5.45	0.98
4	2	50.87	0.00	0.00	0.00	8.85	4.06	0.51	0.19	0.03	1.50	2.23	0.00	0.60	0.60	0.00	5.44	0.99
4	3	50.56	0.00	0.00	0.00	9.02	4.04	0.51	0.19	0.03	1.51	2.24	0.00	0.60	0.60	0.00	5.43	1.01
4	4	50.27	0.00	0.00	0.00	9.18	4.03	0.51	0.19	0.03	1.52	2.25	0.00	0.59	0.59	0.00	5.42	1.03
4	5	50.00	0.00	0.00	0.00	9.32	4.01	0.51	0.19	0.03	1.52	2.26	0.00	0.59	0.59	0.00	5.41	1.05
4	6	49.75	0.00	0.00	0.00	9.45	4.00	0.51	0.19	0.03	1.53	2.27	0.00	0.58	0.58	0.00	5.40	1.06
4	7	49.51	0.00	0.00	0.00	9.57	3.99	0.51	0.19	0.03	1.54	2.27	0.00	0.57	0.57	0.00	5.39	1.08
4	8	49.29	0.00	0.00	0.00	9.68	3.97	0.51	0.19	0.03	1.55	2.28	0.00	0.57	0.57	0.00	5.38	1.09
4	9	49.08	0.00	0.00	0.00	9.78	3.96	0.51	0.19	0.03	1.56	2.29	0.00	0.57	0.57	0.00	5.37	1.11
5	1	48.94	0.00	0.00	0.00	9.84	3.94	0.52	0.19	0.03	1.57	2.30	0.00	0.56	0.56	0.00	5.36	1.12
5	2	48.83	0.00	0.00	0.00	9.88	3.93	0.52	0.19	0.03	1.58	2.31	0.00	0.56	0.56	0.00	5.35	1.14
5	3	48.74	0.00	0.00	0.00	9.91	3.92	0.52	0.19	0.03	1.58	2.31	0.00	0.55	0.55	0.00	5.34	1.15
5	4	48.65	0.00	0.00	0.00	9.94	3.91	0.52	0.18	0.03	1.59	2.32	0.00	0.55	0.55	0.00	5.33	1.17
5	5	48.56	0.00	0.00	0.00	9.97	3.90	0.52	0.18	0.03	1.60	2.33	0.00	0.54	0.54	0.00	5.32	1.18
5	6	48.48	0.00	0.00	0.00	10.00	3.88	0.52	0.18	0.03	1.61	2.33	0.00	0.54	0.54	0.00	5.31	1.20
5	7	48.40	0.00	0.00	0.00	10.03	3.87	0.52	0.18	0.03	1.61	2.34	0.00	0.53	0.53	0.00	5.30	1.21
6	1	62.79	0.00	0.00	0.00	7.06	3.98	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.70
6	2	62.28	0.00	0.00	0.00	7.12	3.96	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.69
7	1	58.40	0.00	0.00	0.00	7.93	3.93	0.59	0.14	0.01	2.12	2.86	0.00	0.24	0.24	0.00	5.07	2.30
7	2	58.11	0.00	0.00	0.00	7.98	3.91	0.59	0.14	0.01	2.12	2.86	0.00	0.24	0.24	0.00	5.06	2.30
7	3	57.83	0.00	0.00	0.00	8.02	3.89	0.59	0.14	0.01	2.12	2.86	0.00	0.24	0.24	0.00	5.05	2.29
7	4	57.55	0.00	0.00	0.00	8.07	3.88	0.59	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.05	2.29
7	5	57.28	0.00	0.00	0.00	8.11	3.86	0.59	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.04	2.29
7	6	57.01	0.00	0.00	0.00	8.16	3.85	0.58	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.04	2.29
7	7	56.75	0.00	0.00	0.00	8.20	3.83	0.58	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.03	2.28
7	8	56.49	0.00	0.00	0.00	8.25	3.82	0.58	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.03	2.28
7	9	56.24	0.00	0.00	0.00	8.29	3.80	0.58	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.02	2.28
7	10	55.99	0.00	0.00	0.00	8.34	3.79	0.58	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.01	2.28
7	11	55.75	0.00	0.00	0.00	8.38	3.78	0.58	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.01	2.27
7	12	55.51	0.00	0.00	0.00	8.42	3.76	0.58	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.00	2.27
7	13	55.27	0.00	0.00	0.00	8.46	3.75	0.58	0.14	0.01	2.12	2.85	0.00	0.24	0.24	0.00	5.00	2.27
7	14	55.04	0.00	0.00	0.00	8.51	3.73	0.58	0.14	0.02	2.12	2.85	0.00	0.24	0.24	0.00	4.99	2.27
7	15	54.81	0.00	0.00	0.00	8.55	3.72	0.58	0.14	0.02	2.12	2.85	0.00	0.24	0.24	0.00	4.99	2.26
7	16	54.59	0.00	0.00	0.00	8.59	3.71	0.57	0.14	0.02	2.12	2.85	0.00	0.24	0.24	0.00	4.98	2.26
7	17	54.37	0.00	0.00	0.00	8.63	3.69	0.57	0.14	0.02	2.12	2.85	0.00	0.24	0.24	0.00	4.98	2.26
7	18	54.16	0.00	0.00	0.00	8.67	3.68	0.57	0.14	0.02	2.12	2.85	0.00	0.24	0.24	0.00	4.97	2.26
7	19	53.95	0.00	0.00	0.00	8.71	3.67	0.57	0.14	0.02	2.12	2.85	0.00	0.24	0.24	0.00	4.97	2.25
7	20	53.74	0.00	0.00	0.00	8.75	3.65	0.57	0.14	0.02	2.12	2.85	0.00	0.24	0.24	0.00	4.96	2.25

***** STEADY STATE SIMULATION *****

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.05	0.00	0.09	0.10	0.00	0.00	0.90	0.68	0.02	0.00	0.81	0.96
2	1	2	0.10	0.00	0.09	0.09	0.00	0.00	0.90	0.68	0.02	0.00	0.81	0.96
3	1	3	0.15	0.00	0.08	0.09	0.00	0.00	0.90	0.67	0.03	0.00	0.81	0.95
4	1	4	0.19	0.00	0.08	0.09	0.00	0.00	0.90	0.66	0.03	0.00	0.82	0.95
5	1	5	0.23	0.00	0.08	0.09	0.00	0.00	0.90	0.66	0.03	0.00	0.82	0.95
6	1	6	0.27	0.00	0.08	0.09	0.00	0.00	0.90	0.65	0.04	0.00	0.82	0.95
7	2	1	0.31	0.00	0.08	0.09	0.00	0.00	0.90	0.64	0.04	0.00	0.82	0.95
8	2	2	0.35	0.00	0.07	0.09	0.00	0.00	0.90	0.64	0.04	0.00	0.82	0.95
9	2	3	0.39	0.00	0.07	0.09	0.00	0.00	0.90	0.63	0.04	0.00	0.83	0.95
10	2	4	0.43	0.00	0.07	0.08	0.00	0.00	0.90	0.62	0.04	0.00	0.83	0.95
11	2	5	0.46	0.00	0.07	0.08	0.00	0.00	0.90	0.62	0.05	0.00	0.83	0.95
12	2	6	0.49	0.00	0.07	0.08	0.00	0.00	0.90	0.61	0.05	0.00	0.83	0.95
13	2	7	0.53	0.00	0.07	0.08	0.00	0.00	0.90	0.61	0.05	0.00	0.83	0.95
14	2	8	0.56	0.00	0.07	0.08	0.00	0.00	0.90	0.60	0.05	0.00	0.83	0.95
15	2	9	0.59	0.00	0.07	0.08	0.00	0.00	0.90	0.60	0.05	0.00	0.83	0.95
16	2	10	0.62	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.05	0.00	0.84	0.95
17	3	1	0.65	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.06	0.00	0.84	0.95
18	3	2	0.67	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.06	0.00	0.84	0.95
19	3	3	0.70	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.95
20	3	4	0.73	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.94
21	3	5	0.75	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
22	3	6	0.78	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
23	3	7	0.80	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
24	3	8	0.83	0.00	0.07	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
25	3	9	0.85	0.00	0.07	0.08	0.00	0.00	0.90	0.56	0.07	0.00	0.84	0.94
26	3	10	0.87	0.00	0.07	0.08	0.00	0.00	0.90	0.56	0.07	0.00	0.84	0.94
27	3	11	0.89	0.00	0.07	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
28	3	12	0.92	0.00	0.07	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
29	3	13	0.94	0.00	0.07	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
30	3	14	0.96	0.00	0.07	0.08	0.00	0.00	0.90	0.54	0.07	0.00	0.85	0.94
31	4	1	0.98	0.00	0.07	0.08	0.00	0.00	0.90	0.54	0.07	0.00	0.85	0.94
32	4	2	0.99	0.00	0.06	0.08	0.00	0.00	0.90	0.54	0.07	0.00	0.85	0.94
33	4	3	1.01	0.00	0.06	0.08	0.00	0.00	0.90	0.53	0.07	0.00	0.85	0.94
34	4	4	1.03	0.00	0.06	0.08	0.00	0.00	0.90	0.53	0.07	0.00	0.85	0.94
35	4	5	1.05	0.00	0.06	0.08	0.00	0.00	0.90	0.53	0.07	0.00	0.85	0.94
36	4	6	1.06	0.00	0.06	0.08	0.00	0.00	0.90	0.53	0.08	0.00	0.85	0.94
37	4	7	1.08	0.00	0.06	0.08	0.00	0.00	0.90	0.52	0.08	0.00	0.85	0.93
38	4	8	1.09	0.00	0.06	0.08	0.00	0.00	0.90	0.52	0.08	0.00	0.85	0.93
39	4	9	1.11	0.00	0.06	0.08	0.00	0.00	0.90	0.52	0.08	0.00	0.85	0.93

***** STEADY STATE SIMULATION *****

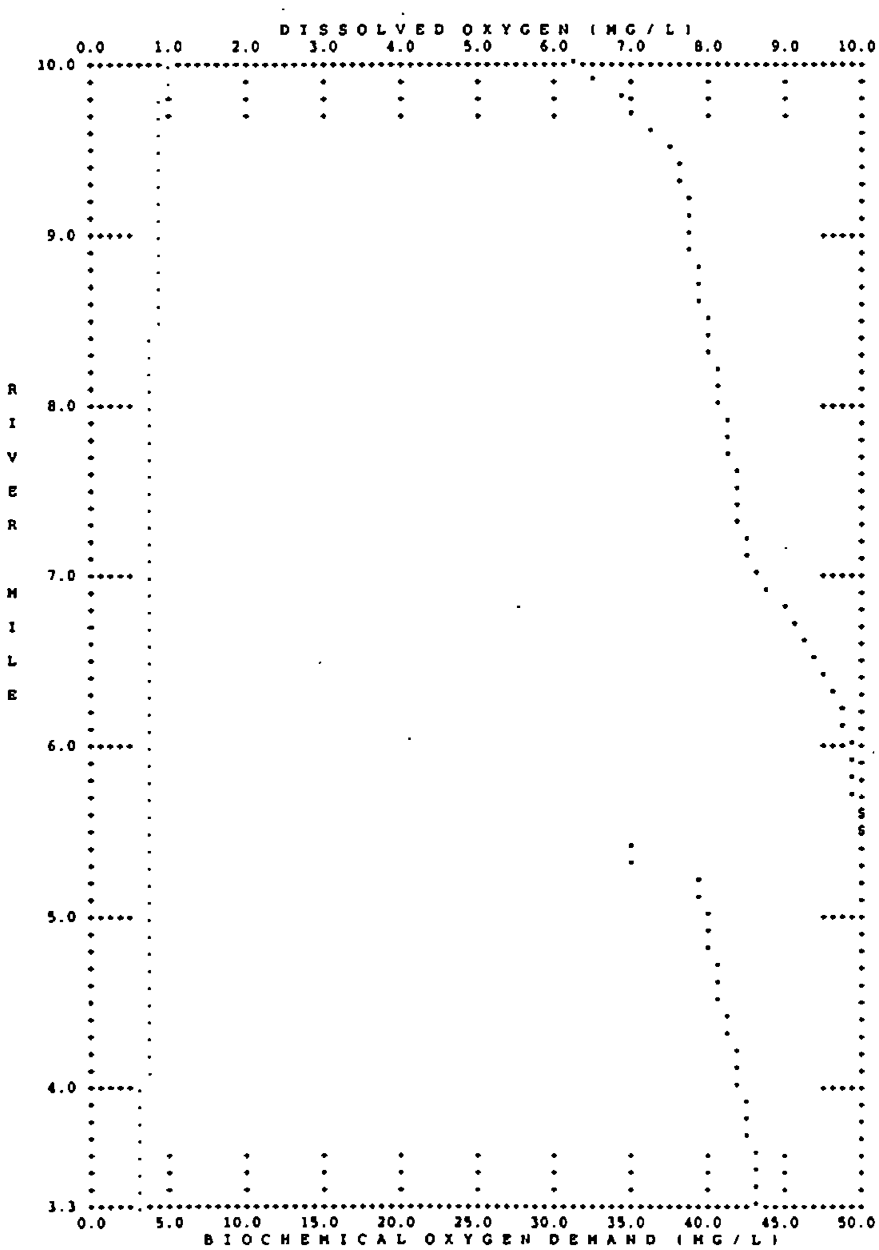
** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
40	5	1	1.12	0.00	0.06	0.08	0.00	0.00	0.90	0.52	0.08	0.00	0.85	0.93
41	5	2	1.14	0.00	0.06	0.08	0.00	0.00	0.90	0.52	0.08	0.00	0.85	0.93
42	5	3	1.15	0.00	0.06	0.08	0.00	0.00	0.90	0.51	0.08	0.00	0.86	0.93
43	5	4	1.17	0.00	0.06	0.08	0.00	0.00	0.90	0.51	0.08	0.00	0.86	0.93
44	5	5	1.18	0.00	0.06	0.08	0.00	0.00	0.90	0.51	0.08	0.00	0.86	0.93
45	5	6	1.20	0.00	0.06	0.08	0.00	0.00	0.90	0.51	0.08	0.00	0.86	0.93
46	5	7	1.21	0.00	0.06	0.08	0.00	0.00	0.90	0.50	0.08	0.00	0.86	0.93
47	6	1	2.70	0.00	0.09	0.09	0.00	-0.01	0.90	0.33	0.14	0.00	0.89	0.76
48	6	2	2.69	0.00	0.09	0.09	0.00	-0.01	0.90	0.33	0.14	0.00	0.89	0.76
49	7	1	2.30	0.00	0.08	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
50	7	2	2.30	0.00	0.08	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
51	7	3	2.29	0.00	0.08	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
52	7	4	2.29	0.00	0.08	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
53	7	5	2.29	0.00	0.08	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
54	7	6	2.29	0.00	0.08	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
55	7	7	2.28	0.00	0.08	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
56	7	8	2.28	0.00	0.07	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
57	7	9	2.28	0.00	0.07	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
58	7	10	2.28	0.00	0.07	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
59	7	11	2.27	0.00	0.07	0.09	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
60	7	12	2.27	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
61	7	13	2.27	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
62	7	14	2.27	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
63	7	15	2.26	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
64	7	16	2.26	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
65	7	17	2.26	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
66	7	18	2.26	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
67	7	19	2.25	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86
68	7	20	2.25	0.00	0.07	0.08	0.00	-0.01	0.90	0.37	0.12	0.00	0.88	0.86

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
1	1	1	64.26	9.22	6.32	2.91	0.00	0.98	620.28	35.42	-3.69	0.00	0.00	-0.71	0.00
2	1	2	62.79	9.38	6.61	2.77	0.00	0.98	13.37	33.22	-3.52	0.00	0.00	-0.66	0.00
3	1	3	61.47	9.53	6.88	2.65	0.00	0.98	13.21	31.35	-3.37	0.00	0.00	-0.62	-0.01
4	1	4	60.29	9.66	7.12	2.54	0.00	0.99	13.05	29.68	-3.23	0.00	0.00	-0.58	-0.01
5	1	5	59.22	9.78	7.35	2.43	0.00	0.99	12.90	28.19	-3.12	0.00	0.00	-0.55	-0.01
6	1	6	58.25	9.90	7.56	2.34	0.00	0.99	12.75	26.83	-3.01	0.00	0.00	-0.52	-0.01
7	2	1	57.43	10.00	7.70	2.30	0.00	0.99	8.59	16.15	-2.92	0.00	0.00	-0.50	-0.01
8	2	2	56.71	10.09	7.73	2.36	0.00	0.99	8.50	6.23	-2.84	0.00	0.00	-0.48	-0.01
9	2	3	56.06	10.17	7.76	2.41	0.00	0.99	8.41	6.35	-2.76	0.00	0.00	-0.46	-0.01
10	2	4	55.46	10.24	7.79	2.45	0.00	0.99	8.32	6.44	-2.69	0.00	0.00	-0.44	-0.01
11	2	5	54.91	10.31	7.82	2.49	0.00	0.99	8.24	6.53	-2.63	0.00	0.00	-0.43	-0.01
12	2	6	54.40	10.38	7.86	2.52	0.00	0.99	8.16	6.60	-2.57	0.00	0.00	-0.42	-0.01
13	2	7	53.93	10.44	7.89	2.55	0.00	0.99	8.08	6.66	-2.52	0.00	0.00	-0.40	-0.02
14	2	8	53.50	10.50	7.93	2.57	0.00	0.99	8.00	6.70	-2.47	0.00	0.00	-0.39	-0.02
15	2	9	53.09	10.55	7.97	2.58	0.00	0.99	7.93	6.74	-2.42	0.00	0.00	-0.38	-0.02
16	2	10	52.72	10.60	8.01	2.60	0.00	0.99	7.85	6.77	-2.38	0.00	0.00	-0.37	-0.02
17	3	1	52.49	10.63	8.05	2.58	0.00	0.99	12.50	8.53	-2.35	0.00	0.00	-0.37	-0.02
18	3	2	52.38	10.65	8.10	2.55	0.00	0.99	12.37	10.21	-2.33	0.00	0.00	-0.36	-0.02
19	3	3	52.27	10.66	8.14	2.52	0.00	0.99	12.25	10.11	-2.31	0.00	0.00	-0.36	-0.02
20	3	4	52.17	10.68	8.18	2.49	0.00	0.99	12.13	10.00	-2.29	0.00	0.00	-0.36	-0.02
21	3	5	52.07	10.69	8.23	2.47	0.00	0.99	12.01	9.90	-2.27	0.00	0.00	-0.35	-0.02
22	3	6	51.98	10.70	8.27	2.44	0.00	0.99	11.90	9.80	-2.26	0.00	0.00	-0.35	-0.02
23	3	7	51.89	10.72	8.30	2.41	0.00	0.99	11.79	9.71	-2.24	0.00	0.00	-0.35	-0.02
24	3	8	51.80	10.73	8.34	2.39	0.00	0.99	11.68	9.61	-2.23	0.00	0.00	-0.34	-0.02
25	3	9	51.72	10.74	8.38	2.36	0.00	0.99	11.57	9.52	-2.21	0.00	0.00	-0.34	-0.02
26	3	10	51.64	10.75	8.41	2.34	0.00	0.99	11.47	9.43	-2.20	0.00	0.00	-0.34	-0.02
27	3	11	51.57	10.76	8.45	2.31	0.00	0.99	11.36	9.35	-2.18	0.00	0.00	-0.33	-0.02
28	3	12	51.49	10.77	8.48	2.29	0.00	0.99	11.26	9.26	-2.17	0.00	0.00	-0.33	-0.02
29	3	13	51.42	10.78	8.52	2.26	0.00	0.99	11.17	9.18	-2.15	0.00	0.00	-0.33	-0.02
30	3	14	51.36	10.79	8.55	2.24	0.00	0.99	11.07	9.10	-2.14	0.00	0.00	-0.32	-0.02
31	4	1	51.21	10.81	8.67	2.14	0.00	0.99	11.46	20.72	-2.12	0.00	0.00	-0.32	-0.02
32	4	2	50.87	10.86	8.85	2.00	0.00	1.00	11.37	30.55	-2.10	0.00	0.00	-0.32	-0.02
33	4	3	50.56	10.90	9.02	1.88	0.00	1.00	11.29	28.63	-2.07	0.00	0.00	-0.31	-0.02
34	4	4	50.27	10.94	9.18	1.77	0.00	1.00	11.20	26.90	-2.05	0.00	0.00	-0.30	-0.02
35	4	5	50.00	10.98	9.32	1.66	0.00	1.00	11.12	25.34	-2.03	0.00	0.00	-0.30	-0.02
36	4	6	49.75	11.02	9.45	1.57	0.00	1.00	11.04	23.93	-2.01	0.00	0.00	-0.29	-0.02
37	4	7	49.51	11.05	9.57	1.49	0.00	1.00	10.96	22.66	-1.99	0.00	0.00	-0.29	-0.02
38	4	8	49.29	11.09	9.68	1.41	0.00	1.00	10.88	21.50	-1.97	0.00	0.00	-0.29	-0.02
39	4	9	49.08	11.12	9.78	1.34	0.00	1.00	10.81	20.46	-1.95	0.00	0.00	-0.28	-0.02
40	5	1	48.94	11.14	9.84	1.30	0.00	1.00	11.18	15.95	-1.94	0.00	0.00	-0.28	-0.02
41	5	2	48.83	11.15	9.88	1.28	0.00	1.00	11.10	11.91	-1.93	0.00	0.00	-0.28	-0.02
42	5	3	48.74	11.17	9.91	1.26	0.00	1.00	11.02	11.75	-1.92	0.00	0.00	-0.28	-0.02
43	5	4	48.65	11.18	9.94	1.24	0.00	1.00	10.94	11.58	-1.91	0.00	0.00	-0.27	-0.02
44	5	5	48.56	11.19	9.97	1.22	0.00	1.00	10.86	11.43	-1.90	0.00	0.00	-0.27	-0.02
45	5	6	48.48	11.21	10.00	1.20	0.00	1.00	10.79	11.27	-1.89	0.00	0.00	-0.27	-0.02
46	5	7	48.40	11.22	10.03	1.19	0.00	1.00	10.71	11.13	-1.88	0.00	0.00	-0.27	-0.02
47	6	1	62.79	9.38	7.06	2.32	0.00	0.99	959.81	11.43	-2.79	0.00	-0.01	-0.33	0.00
48	6	2	62.28	9.44	7.12	2.31	0.00	0.99	0.00	11.33	-2.74	0.00	-0.01	-0.32	0.00
49	7	1	58.40	9.88	7.93	1.95	0.00	0.99	0.00	12.55	-2.46	0.00	-0.01	-0.31	-0.01
50	7	2	58.11	9.92	7.98	1.94	0.00	0.99	0.00	10.00	-2.43	0.00	-0.01	-0.31	-0.01
51	7	3	57.83	9.95	8.02	1.93	0.00	0.99	0.00	9.90	-2.40	0.00	-0.01	-0.30	-0.01
52	7	4	57.55	9.98	8.07	1.91	0.00	0.99	0.00	9.80	-2.38	0.00	-0.01	-0.30	-0.01
53	7	5	57.28	10.02	8.11	1.90	0.00	0.99	0.00	9.70	-2.35	0.00	-0.01	-0.30	-0.01
54	7	6	57.01	10.05	8.16	1.89	0.00	0.99	0.00	9.60	-2.33	0.00	-0.01	-0.29	-0.01
55	7	7	56.75	10.08	8.20	1.88	0.00	0.99	0.00	9.51	-2.30	0.00	-0.01	-0.29	-0.01
56	7	8	56.49	10.11	8.25	1.86	0.00	0.99	0.00	9.41	-2.28	0.00	-0.01	-0.29	-0.01
57	7	9	56.24	10.14	8.29	1.85	0.00	0.99	0.00	9.32	-2.25	0.00	-0.01	-0.29	-0.01
58	7	10	55.99	10.18	8.34	1.84	0.00	0.99	0.00	9.23	-2.23	0.00	-0.01	-0.28	-0.01
59	7	11	55.75	10.21	8.38	1.83	0.00	0.99	0.00	9.14	-2.21	0.00	-0.01	-0.28	-0.01
60	7	12	55.51	10.24	8.42	1.82	0.00	0.99	0.00	9.05	-2.19	0.00	-0.01	-0.28	-0.01
61	7	13	55.27	10.27	8.46	1.80	0.00	0.99	0.00	8.96	-2.17	0.00	-0.01	-0.28	-0.01
62	7	14	55.04	10.30	8.51	1.79	0.00	0.99	0.00	8.87	-2.15	0.00	-0.01	-0.27	-0.01
63	7	15	54.81	10.33	8.55	1.78	0.00	0.99	0.00	8.79	-2.13	0.00	-0.01	-0.27	-0.01
64	7	16	54.59	10.35	8.59	1.77	0.00	0.99	0.00	8.70	-2.11	0.00	-0.01	-0.27	-0.01
65	7	17	54.37	10.38	8.63	1.76	0.00	0.99	0.00	8.62	-2.09	0.00	-0.01	-0.27	-0.01
66	7	18	54.16	10.41	8.67	1.74	0.00	0.99	0.00	8.53	-2.07	0.00	-0.01	-0.26	-0.01
67	7	19	53.95	10.44	8.71	1.73	0.00	0.99	0.00	8.45	-2.05	0.00	-0.01	-0.26	-0.01
68	7	20	53.74	10.47	8.75	1.72	0.00	0.99	0.00	8.37	-2.03	0.00	-0.01	-0.26	-0.01



DISSOLVED OXYGEN • • • • •

BIOCHEMICAL OXYGEN DEMAND • . . . .

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                    * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                              Ver. 3.13 - September 1991

$$$ (PROBLEM TITLES) $$$

CARD TYPE                         QUAL-2E PROGRAM TITLES
TITLE01            BSCUU.IN - Summer, Critical, Ultimate FLOW, BODU Simulation
TITLE02            NSWTP DISCHARGE TO BADGER MILL CREEK
TITLE03   NO       CONSERVATIVE MINERAL I          IN
TITLE04   NO       CONSERVATIVE MINERAL II         IN
TITLE05   NO       CONSERVATIVE MINERAL III        IN
TITLE06   YES      TEMPERATURE
TITLE07   YES      BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)
TITLE08   YES      ALGAE AS CHL-A IN UG/L
TITLE09   YES      PHOSPHORUS CYCLE AS P IN MG/L
TITLE10              (ORGANIC-P, DISSOLVED-P)
TITLE11   YES      NITROGEN CYCLE AS N IN MG/L
TITLE12              (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
TITLE13   YES      DISSOLVED OXYGEN IN MG/L
TITLE14   NO       FECAL COLIFORMS IN NO./100 ML
TITLE15   YES      ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l
ENDTITLE

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                         CARD TYPE
LIST DATA INPUT                0.00000                                          0.00000
WRITE OPTIONAL SUMMARY         0.00000                                          0.00000
NO FLOW AUGMENTATION           0.00000                                          0.00000
STEADY STATE                   0.00000                                          0.00000
TRAPEZOIDAL X-SECTIONS         0.00000                                          0.00000
PRINT LCD/SOLAR DATA           0.00000                                          0.00000
PLOT DO AND BOD                0.00000                                          0.00000
FIXED DNSTM COND (YES=1)=      0.00000     5D-ULT BOD CONV K COEF    =          0.23000
INPUT METRIC (YES=1)     =     0.00000     OUTPUT METRIC (YES=1)     =          0.00000
NUMBER OF REACHES        =     7.00000     NUMBER OF JUNCTIONS       =          1.00000
NUM OF HEADWATERS        =     2.00000     NUMBER OF POINT LOADS     =          0.00000
TIME STEP (HOURS)        =     1.00000     LNTH  COMP  ELEMENT (DX)=            0.10000
MAXIMUM ROUTE TIME (HRS)=    288.00000     TIME INC. FOR RPT2 (HRS)=            1.00000
LATITUDE OF BASIN (DEG) =     43.10000     LONGITUDE OF BASIN (DEG)=           89.30000
STANDARD MERIDIAN (DEG) =     75.00000     DAY OF YEAR START TIME   =         203.00000
EVAP. COEFF. (AE)        =     0.00068     EVAP. COEFF. (BE)         =          0.00027
ELEV. OF BASIN (ELEV)    =   937.00000     DUST ATTENUATION COEF.    =          0.06000
ENDATA1                        0.00000                                          0.00000

$$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                            CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=      3.5000        O UPTAKE BY NO2 OXID(MG O/MG N)=      1.2000
O PROD  BY ALGAE (MG O/MG A)    =     1.6000        O UPTAKE BY ALGAE (MG O/MG A)   =     2.0000
N CONTENT OF ALGAE (MG N/MG A)  =     0.0850        P CONTENT OF ALGAE (MG P/MG A)  =     0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=      2.5000        ALGAE RESPIRATION RATE (1/DAY)  =     0.1000
N HALF SATURATION CONST  (MG/L)=      0.3000        P HALF SATURATION CONST  (MG/L)=      0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)      0.0088        NLIN SHADE(1/FT-(UGCHA/L)**2/3)=      0.0540
LIGHT FUNCTION OPTION (LFNOPT)  =     1.0000        LIGHT SAT'N COEF (BTU/FT2-MIN)  =     0.0300
DAILY AVERAGING OPTION (LAVOPT)=      1.0000        LIGHT AVERAGING FACTOR (AFACT)  =     0.9200
NUMBER OF DAYLIGHT HOURS (DLH)  =    16.0000        TOTAL DAILY SOLR RAD (BTU/FT-2)=    400.0000
ALGY GROWTH CALC OPTION(LGROPT)=      1.0000        ALGAL PREF FOR NH3-N (PREFN)    =     0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=      0.4500        NITRIFICATION INHIBITION COEF   =     0.6000
ENDATA1A                              0.0000                                              0.0000

$$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE       RATE CODE       THETA VALUE

THETA( 1)       BOD DECA          1.047      DFLT
THETA( 2)       BOD SETT          1.024      DFLT
THETA( 3)       OXY TRAN          1.024      DFLT
THETA( 4)       SOD RATE          1.060      DFLT
THETA( 5)       ORGN DEC          1.047      DFLT
THETA( 6)       ORGN SET          1.024      DFLT
THETA( 7)       NH3 DECA          1.083      DFLT
THETA( 8)       NH3 SRCE          1.074      DFLT
THETA( 9)       NO2 DECA          1.047      DFLT
THETA(10)       PORG DEC          1.047      DFLT
THETA(11)       PORG SET          1.024      DFLT
THETA(12)       DISP SRC          1.074      DFLT
THETA(13)       ALG GROW          1.047      DFLT
THETA(14)       ALG RESP          1.047      DFLT
THETA(15)       ALG SETT          1.024      DFLT
THETA(16)       COLI DEC          1.047      DFLT
THETA(17)       ANC DECA          1.000      DFLT
THETA(18)       ANC SETT          1.024      DFLT
THETA(19)       ANC SRCE          1.000      DFLT
ENDATA1B

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE            REACH ORDER AND IDENT                     R. MI/KM            R. MI/KM
STREAM REACH     1.0  RCH= HWY 151-PB          FROM        10.0      TO          9.4
STREAM REACH     2.0  RCH= PB-Lincoln          FROM         9.4      TO          8.4
STREAM REACH     3.0  RCH= Lincoln-151 By      FROM         8.4      TO          7.0
STREAM REACH     4.0  RCH= 151 By-HWY 69       FROM         7.0      TO          6.1
STREAM REACH     5.0  RCH= HWY 69-Sugar R      FROM         6.1      TO          5.4
STREAM REACH     6.0  RCH= Upstrm Sugar R      FROM         5.6      TO          5.4
STREAM REACH     7.0  RCH= Dnstrm Sugar R      FROM         5.4      TO          3.4
ENDATA2          0.0                                        0.0                  0.0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE                  REACH   AVAIL HDWS TARGET     ORDER OF AVAIL SOURCES
ENDATA3                      0.        0.       0.0   0.   0.   0.   0.   0.   0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE          REACH ELEMENTS/REACH              COMPUTATIONAL FLAGS
FLAG FIELD           1.        6.          1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD           2.       10.          2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD           3.       14.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
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FLAG FIELD	4.	9.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CHANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	2.	945.00	0.13	0.10	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	3.	935.00	0.13	0.20	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	4.	925.00	0.13	0.05	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	5.	915.00	0.13	0.00	82.40	75.20	29.10	11.90	1.00
TEMP/LCD	6.	910.00	0.13	0.05	82.40	75.20	29.10	11.90	1:00
TEMP/LCD	7.	910.00	0.13	0.05	82.40	75.20	29.10	11.90	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	OR EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	2.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	3.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	4.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	5.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	6.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
INITIAL COND-1	7.	68.00	7.00	4.00	0.00	0.00	0.00	10.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	5.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

```
INCR INFLOW-2        1.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2        2.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2        3.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2        4.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2        5.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2        6.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2        7.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
ENDATA8A             0.     0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE            JUNCTION ORDER AND IDENT      UPSTRM   JUNCTION   TRIB
STREAM JUNCTION      1.    JNC=Sugar R Confluen     46.      49.        48.
ENDATA9              0.                              0.       0.         0.

 $$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE     HDWTR    NAME              FLOW     TEMP     D.O.     BOD      CM-1     CM-2     CM-3
              ORDER
HEADWTR-1       1.   NSWTPOutfall        5.60    71.60     5.00     8.90     0.00     0.00     0.00
HEADWTR-1       2.   Sugar River         7.80    68.00     7.00     4.00     0.00     0.00     0.00
ENDATA10        0.                       0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS,
                   COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE     HDWTR    ANC      COLI     CHL-A    ORG-N    NH3-N    NO2-N    NO3-N    ORG-P    DIS-P
              ORDER
HEADWTR-2       1.    10.80     0.00     0.00     0.50     1.38     0.00     1.00     0.00     0.89
HEADWTR-2       2.    10.00     0.00     2.70     0.62     0.12     0.00     2.30     0.00     0.13
ENDATA10A       0.     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

              POINT
CARD TYPE     LOAD     NAME              EFF      FLOW     TEMP     D.O.     BOD      CM-1     CM-2     CM-3
              ORDER
ENDATA11        0.                       0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS,
                    COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

              POINT
CARD TYPE     LOAD     ANC      COLI     CHL-A    ORG-N    NH3-N    NO2-N    NO3-N    ORG-P    DIS-P
              ORDER
ENDATA11A       0.     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00

 $$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

                     DAM   RCH   ELE    ADAM     BDAM     FDAM     HDAM

ENDATA12               0.    0.    0.    0.00     0.00     0.00     0.00

 $$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

    CARD TYPE              TEMP     D.O.     BOD      CM-1     CM-2     CM-3     ANC      COLI

ENDATA13                   DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

 $$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

    CARD TYPE              CHL-A    ORG-N    NH3-N    NO2-N    NH3-N    ORG-P    DIS-P

ENDATA13A                  DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED
```

```
STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:
-----------------------------------------------------------

                         NUMBER OF
         ITERATION    NONCONVERGENT
                         ELEMENTS

                  TEMPERATURE                                                   ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 71.71 71.81 71.90 71.99 72.08 72.16
  2 72.23 72.30 72.36 72.42 72.47 72.52 72.57 72.62 72.67 72.71
  3 72.75 72.77 72.80 72.82 72.84 72.87 72.89 72.91 72.93 72.95 72.97 72.99 73.01 73.03
  4 73.05 73.08 73.11 73.14 73.17 73.19 73.22 73.24 73.26
  5 73.28 73.29 73.30 73.31 73.33 73.34 73.35
  6 68.36 68.70
  7 70.74 70.85 70.96 71.06 71.16 71.25 71.34 71.43 71.51 71.59 71.67 71.75 71.82 71.89 71.95 72.02 72.08 72.14 72.19 72.25
             1             66

                  TEMPERATURE                                                   ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 71.70 71.79 71.88 71.96 72.04 72.11
  2 72.17 72.23 72.28 72.33 72.38 72.43 72.47 72.51 72.55 72.59
  3 72.62 72.64 72.66 72.68 72.70 72.72 72.74 72.76 72.77 72.79 72.81 72.82 72.84 72.85
  4 72.87 72.90 72.92 72.94 72.96 72.98 73.00 73.02 73.03
  5 73.05 73.06 73.07 73.08 73.09 73.09 73.10
  6 68.36 68.70
  7 70.64 70.75 70.86 70.96 71.06 71.15 71.24 71.33 71.41 71.49 71.56 71.63 71.70 71.77 71.83 71.89 71.95 72.01 72.06 72.11
             2              0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):
--------------------------------------------------------------------------------

     DAILY NET SOLAR RADIATION =        0.000 BTU/FT-2   (      0.000 LANGLEYS)
     NUMBER OF DAYLIGHT HOURS =  14.7

     HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

           1     0.00         9     0.00        17     0.00
           2     0.00        10     0.00        18     0.00
           3     0.00        11     0.00        19     0.00
           4     0.00        12     0.00        20     0.00
           5     0.00        13     0.00        21     0.00
           6     0.00        14     0.00        22     0.00
           7     0.00        15     0.00        23     0.00
           8     0.00        16     0.00        24     0.00

                  BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)                          ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1  8.84  8.77  8.71  8.64  8.58  8.52
  2  8.44  8.35  8.27  8.18  8.09  8.01  7.92  7.84  7.75  7.67
  3  7.60  7.55  7.50  7.45  7.40  7.35  7.30  7.25  7.20  7.15  7.10  7.05  7.01  6.96
  4  6.91  6.87  6.82  6.78  6.73  6.69  6.64  6.60  6.55
  5  6.51  6.47  6.43  6.39  6.35  6.31  6.27
  6  3.97  3.94
  7  4.89  4.85  4.82  4.79  4.75  4.72  4.68  4.65  4.62  4.59  4.55  4.52  4.49  4.46  4.42  4.39  4.36  4.33  4.30  4.27

                  ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l   ITERATION  1
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

  1 10.78 10.76 10.74 10.73 10.71 10.69
  2 10.66 10.64 10.61 10.58 10.56 10.53 10.50 10.48 10.45 10.42
  3 10.40 10.39 10.37 10.35 10.34 10.32 10.30 10.29 10.27 10.25 10.24 10.22 10.20 10.19
  4 10.17 10.15 10.14 10.12 10.11 10.09 10.08 10.06 10.04
  5 10.03 10.01 10.00  9.98  9.97  9.95  9.94
  6  9.98  9.96
```

7	9.94	9.92	9.91	9.89	9.87	9.86	9.84	9.82	9.80	9.79	9.77	9.75	9.74	9.72	9.70	9.69	9.67	9.65	9.64	9.62

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	2.69	2.68																		
7	1.56	1.55	1.55	1.55	1.54	1.54	1.54	1.53	1.53	1.52	1.52	1.52	1.51	1.51	1.51	1.50	1.50	1.49	1.49	1.49

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.89	0.89	0.89	0.89	0.89	0.89														
2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89										
3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89						
4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89											
5	0.89	0.89	0.89	0.89	0.89	0.89	0.89													
6	0.13	0.13																		
7	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.49	0.49	0.49														
2	0.49	0.49	0.48	0.48	0.48	0.48	0.48	0.47	0.47	0.47										
3	0.47	0.47	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45						
4	0.45	0.45	0.45	0.44	0.44	0.44	0.44	0.44	0.44											
5	0.44	0.44	0.43	0.43	0.43	0.43	0.43													
6	0.62	0.62																		
7	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52	0.51	0.51	0.51	0.51	0.51	0.51

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.37	1.36	1.34	1.33	1.32	1.31														
2	1.29	1.28	1.26	1.25	1.23	1.21	1.20	1.18	1.17	1.15										
3	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.08	1.07	1.06	1.05	1.04	1.03	1.02						
4	1.02	1.01	1.00	0.99	0.98	0.98	0.97	0.96	0.95											
5	0.95	0.94	0.93	0.92	0.92	0.91	0.90													
6	0.12	0.12																		
7	0.45	0.44	0.44	0.44	0.43	0.43	0.43	0.43	0.42	0.42	0.42	0.41	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0.39

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.01	0.03	0.04	0.05	0.06	0.08														
2	0.09	0.11	0.12	0.14	0.15	0.17	0.18	0.20	0.21	0.23										
3	0.24	0.25	0.25	0.26	0.27	0.28	0.29	0.29	0.30	0.31	0.31	0.32	0.33	0.33						
4	0.34	0.35	0.35	0.36	0.37	0.37	0.38	0.38	0.39											
5	0.39	0.40	0.40	0.41	0.41	0.42	0.42													
6	0.00	0.00																		
7	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.20	0.20	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.21	0.22	0.22	0.22

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	1.00	1.00	1.00	1.00	1.00														
2	1.00	1.00	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02										
3	1.03	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.05	1.05	1.05	1.06	1.06						
4	1.06	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08											
5	1.09	1.09	1.09	1.10	1.10	1.10	1.11													
6	2.30	2.30																		
7	1.80	1.80	1.81	1.81	1.81	1.81	1.81	1.81	1.82	1.82	1.82	1.82	1.82	1.82	1.83	1.83	1.83	1.83	1.83	1.84

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.29	5.55	5.78	5.98	6.16	6.32														
2	6.38	6.32	6.26	6.21	6.16	6.11	6.06	6.02	5.98	5.94										
3	5.94	5.95	5.96	5.97	5.98	5.99	6.00	6.01	6.02	6.03	6.05	6.06	6.07	6.08						
4	6.21	6.42	6.61	6.77	6.91	7.04	7.14	7.24	7.32											
5	7.36	7.38	7.39	7.40	7.42	7.43	7.44													
6	7.03	7.06																		
7	7.24	7.24	7.24	7.25	7.25	7.25	7.26	7.26	7.26	7.26	7.26	7.27	7.27	7.27	7.27	7.27	7.27	7.28	7.28	7.28

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	0
NITRIFICATION INHIBITION	1	64
ALGAE GROWTH RATE	2	0
NITRIFICATION INHIBITION	2	36
ALGAE GROWTH RATE	3	0
NITRIFICATION INHIBITION	3	20
ALGAE GROWTH RATE	4	0
NITRIFICATION INHIBITION	4	0
ALGAE GROWTH RATE	5	0
NITRIFICATION INHIBITION	5	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
----

1. LIGHT AVERAGING OPTION.   LAVOPT= 1

METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
DAILY NET SOLAR RADIATION: 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 14.7
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS.   LGROPT= 1

MULTIPLICATIVE: FL*FN*FP

TEMPERATURE — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	71.70	71.79	71.88	71.96	72.04	72.11														
2	72.17	72.23	72.28	72.33	72.38	72.43	72.47	72.51	72.55	72.59										
3	72.62	72.64	72.66	72.68	72.70	72.72	72.74	72.76	72.77	72.79	72.81	72.82	72.84	72.85						
4	72.87	72.90	72.92	72.94	72.96	72.98	73.00	73.02	73.03											
5	73.05	73.06	73.07	73.08	73.09	73.09	73.10													
6	68.36	68.70																		
7	70.64	70.75	70.86	70.96	71.06	71.15	71.24	71.33	71.41	71.49	71.56	71.63	71.70	71.77	71.83	71.89	71.95	72.01	72.06	72.11

DISSOLVED OXYGEN IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.29	5.55	5.78	5.98	6.16	6.32														
2	6.39	6.32	6.27	6.21	6.16	6.11	6.07	6.03	5.99	5.95										
3	5.94	5.95	5.97	5.98	5.99	6.00	6.01	6.02	6.03	6.04	6.05	6.06	6.08	6.09						
4	6.21	6.43	6.61	6.78	6.92	7.04	7.15	7.24	7.32											
5	7.36	7.38	7.39	7.40	7.42	7.43	7.44													
6	7.03	7.06																		
7	7.24	7.24	7.24	7.25	7.25	7.25	7.25	7.26	7.26	7.26	7.26	7.26	7.27	7.27	7.27	7.27	7.27	7.27	7.28	7.28

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.84	8.77	8.71	8.64	8.58	8.52														
2	8.44	8.35	8.27	8.18	8.09	8.01	7.92	7.84	7.75	7.67										
3	7.60	7.55	7.50	7.45	7.40	7.35	7.30	7.25	7.20	7.15	7.10	7.05	7.01	6.96						
4	6.91	6.87	6.82	6.78	6.73	6.69	6.64	6.60	6.55											
5	6.51	6.47	6.43	6.39	6.35	6.31	6.27													
6	3.97	3.94																		
7	4.89	4.85	4.82	4.79	4.75	4.72	4.68	4.65	4.62	4.59	4.55	4.52	4.49	4.46	4.42	4.39	4.36	4.33	4.30	4.27

ORGANIC NITROGEN AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.49	0.49	0.49														
2	0.49	0.49	0.48	0.48	0.48	0.48	0.48	0.47	0.47	0.47										
3	0.47	0.47	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45						
4	0.45	0.45	0.45	0.44	0.44	0.44	0.44	0.44	0.44											
5	0.44	0.44	0.43	0.43	0.43	0.43	0.43													
6	0.62	0.62																		
7	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52	0.51	0.51	0.51	0.51	0.51	0.51

AMMONIA AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.37	1.36	1.35	1.33	1.32	1.31														
2	1.30	1.28	1.26	1.25	1.23	1.22	1.20	1.18	1.17	1.15										
3	1.14	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03						
4	1.02	1.01	1.00	1.00	0.99	0.98	0.97	0.96	0.96											
5	0.95	0.94	0.93	0.93	0.92	0.91	0.91													
6	0.12	0.12																		
7	0.45	0.44	0.44	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0.39

NITRITE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.01	0.03	0.04	0.05	0.06	0.07														
2	0.09	0.11	0.12	0.14	0.15	0.17	0.18	0.20	0.21	0.22										
3	0.24	0.24	0.25	0.26	0.27	0.28	0.28	0.29	0.30	0.30	0.31	0.32	0.33	0.33						
4	0.34	0.34	0.35	0.36	0.36	0.37	0.37	0.38	0.39											
5	0.39	0.40	0.40	0.41	0.41	0.41	0.42													
6	0.00	0.00																		
7	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.20	0.20	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.21	0.22	0.22	0.22

NITRATE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	1.00	1.00	1.00	1.00	1.00														
2	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.02	1.02	1.02										
3	1.03	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.05	1.05	1.05	1.05	1.06						
4	1.06	1.06	1.07	1.07	1.07	1.07	1.08	1.08	1.08											
5	1.09	1.09	1.09	1.10	1.10	1.10	1.11													
6	2.30	2.30																		
7	1.80	1.80	1.81	1.81	1.81	1.81	1.81	1.81	1.82	1.82	1.82	1.82	1.82	1.82	1.83	1.83	1.83	1.83	1.83	1.84

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											

5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.89	0.89	0.89	0.89	0.89	0.89														
2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89										
3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89						
4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89											
5	0.89	0.89	0.89	0.89	0.89	0.89	0.89													
6	0.13	0.13																		
7	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45

ALGAE AS CHL-A IN UG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	2.69	2.68																		
7	1.56	1.55	1.55	1.55	1.54	1.54	1.54	1.53	1.53	1.52	1.52	1.52	1.51	1.51	1.51	1.50	1.50	1.49	1.49	1.49

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	10.78	10.76	10.74	10.73	10.71	10.69														
2	10.66	10.64	10.61	10.58	10.56	10.53	10.50	10.48	10.45	10.42										
3	10.40	10.39	10.37	10.35	10.34	10.32	10.30	10.29	10.27	10.25	10.24	10.22	10.20	10.19						
4	10.17	10.15	10.14	10.12	10.11	10.09	10.08	10.06	10.04											
5	10.03	10.01	10.00	9.98	9.97	9.95	9.94													
6	9.98	9.96																		
7	9.94	9.92	9.91	9.89	9.87	9.86	9.84	9.82	9.80	9.79	9.77	9.75	9.74	9.72	9.70	9.69	9.67	9.65	9.64	9.62

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STREAM QUALITY SIMULATION
QUAL-2E STREAM QUALITY ROUTING MODEL

OUTPUT PAGE NUMBER 1
Ver. 3.13 - September 1991

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
2	1	2	9.90	9.80	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
3	1	3	9.80	9.70	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
4	1	4	9.70	9.60	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
5	1	5	9.60	9.50	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
6	1	6	9.50	9.40	5.60	0.00	0.00	0.739	0.008	0.407	18.606	4.00	11.76	7.58	0.40
7	2	1	9.40	9.30	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
8	2	2	9.30	9.20	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
9	2	3	9.20	9.10	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
10	2	4	9.10	9.00	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
11	2	5	9.00	8.90	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
12	2	6	8.90	8.80	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
13	2	7	8.80	8.70	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
14	2	8	8.70	8.60	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
15	2	9	8.60	8.50	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
16	2	10	8.50	8.40	5.60	0.00	0.00	0.510	0.012	0.680	16.156	5.80	9.34	10.98	0.51
17	3	1	8.40	8.30	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
18	3	2	8.30	8.20	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
19	3	3	8.20	8.10	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
20	3	4	8.10	8.00	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
21	3	5	8.00	7.90	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
22	3	6	7.90	7.80	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
23	3	7	7.80	7.70	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
24	3	8	7.70	7.60	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
25	3	9	7.60	7.50	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
26	3	10	7.50	7.40	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
27	3	11	7.40	7.30	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
28	3	12	7.30	7.20	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
29	3	13	7.20	7.10	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
30	3	14	7.10	7.00	5.60	0.00	0.00	0.806	0.008	0.771	9.008	3.67	6.45	6.95	0.60
31	4	1	7.00	6.90	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
32	4	2	6.90	6.80	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
33	4	3	6.80	6.70	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
34	4	4	6.70	6.60	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
35	4	5	6.60	6.50	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
36	4	6	6.50	6.40	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
37	4	7	6.40	6.30	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
38	4	8	6.30	6.20	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
39	4	9	6.20	6.10	5.60	0.00	0.00	0.837	0.007	0.310	21.618	3.53	12.38	6.69	0.29
40	5	1	6.10	6.00	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
41	5	2	6.00	5.90	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
42	5	3	5.90	5.80	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
43	5	4	5.80	5.70	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
44	5	5	5.70	5.60	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
45	5	6	5.60	5.50	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
46	5	7	5.50	5.40	5.60	0.00	0.00	0.872	0.007	0.401	16.009	3.39	10.07	6.42	0.33
47	6	1	5.60	5.50	7.80	0.00	0.00	0.603	0.010	0.404	32.005	6.82	17.32	12.92	0.23
48	6	2	5.50	5.40	7.80	0.00	0.00	0.603	0.010	0.404	32.005	6.82	17.32	12.92	0.23
49	7	1	5.40	5.30	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
50	7	2	5.30	5.20	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
51	7	3	5.20	5.10	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
52	7	4	5.10	5.00	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
53	7	5	5.00	4.90	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
54	7	6	4.90	4.80	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
55	7	7	4.80	4.70	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
56	7	8	4.70	4.60	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
57	7	9	4.60	4.50	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
58	7	10	4.50	4.40	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
59	7	11	4.40	4.30	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
60	7	12	4.30	4.20	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
61	7	13	4.20	4.10	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
62	7	14	4.10	4.00	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
63	7	15	4.00	3.90	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
64	7	16	3.90	3.80	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
65	7	17	3.80	3.70	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
66	7	18	3.70	3.60	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
67	7	19	3.60	3.50	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37
68	7	20	3.50	3.40	13.40	0.00	0.00	0.747	0.008	0.561	32.000	9.48	17.49	17.95	0.37

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	8.49	8	15.08	0.88	0.00	0.00	0.27	0.10	1.13	0.00	1.05	0.22	0.10	0.00	0.00	0.00	0.21	0.00
1	2	8.49	8	15.10	0.88	0.00	0.00	0.28	0.11	1.14	0.00	1.06	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	3	8.48	8	15.12	0.88	0.00	0.00	0.28	0.11	1.15	0.00	1.07	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	4	8.47	8	15.13	0.89	0.00	0.00	0.28	0.11	1.16	0.00	1.08	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	5	8.46	8	15.15	0.89	0.00	0.00	0.28	0.11	1.17	0.00	1.08	0.22	0.11	0.00	0.00	0.00	0.21	0.00
1	6	8.46	8	15.16	0.89	0.00	0.00	0.28	0.11	1.17	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	1	8.45	8	9.40	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	2	8.45	8	3.63	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	3	8.44	8	3.63	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	4	8.44	8	3.64	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	5	8.43	8	3.64	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	6	8.43	8	3.64	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	7	8.42	8	3.64	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	8	8.42	8	3.65	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	9	8.42	8	3.65	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
2	10	8.41	8	3.65	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
3	1	8.41	8	4.54	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	2	8.41	8	5.42	0.90	0.00	0.00	0.28	0.11	1.19	0.00	1.09	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	3	8.41	8	5.42	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.09	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	4	8.41	8	5.42	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	5	8.40	8	5.43	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	6	8.40	8	5.43	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	7	8.40	8	5.43	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	8	8.40	8	5.43	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	9	8.40	8	5.43	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	10	8.40	8	5.43	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	11	8.39	8	5.43	0.90	0.00	0.00	0.28	0.11	1.20	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	12	8.39	8	5.43	0.90	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	13	8.39	8	5.44	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
3	14	8.39	8	5.44	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.10	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	1	8.39	8	12.99	0.91	0.00	0.00	0.28	0.11	1.21	0.00	1.11	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	2	8.39	8	20.55	0.91	0.00	0.00	0.28	0.11	1.22	0.00	1.11	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	3	8.38	8	20.55	0.91	0.00	0.00	0.28	0.11	1.22	0.00	1.11	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	4	8.38	8	20.56	0.91	0.00	0.00	0.28	0.11	1.22	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	5	8.38	8	20.57	0.91	0.00	0.00	0.28	0.11	1.23	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	6	8.38	8	20.57	0.91	0.00	0.00	0.28	0.11	1.23	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	7	8.38	8	20.58	0.91	0.00	0.00	0.28	0.11	1.23	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	8	8.38	8	20.58	0.91	0.00	0.00	0.28	0.11	1.23	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
4	9	8.37	8	20.59	0.91	0.00	0.00	0.28	0.11	1.23	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	1	8.37	8	16.60	0.91	0.00	0.00	0.28	0.11	1.24	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	2	8.37	8	12.62	0.91	0.00	0.00	0.28	0.11	1.24	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	3	8.37	8	12.62	0.91	0.00	0.00	0.28	0.11	1.24	0.00	1.12	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	4	8.37	8	12.62	0.91	0.00	0.00	0.28	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	5	8.37	8	12.63	0.91	0.00	0.00	0.28	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	6	8.37	8	12.63	0.91	0.00	0.00	0.28	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
5	7	8.37	8	12.63	0.91	0.00	0.00	0.28	0.11	1.24	0.00	1.13	0.23	0.11	0.00	0.00	0.00	0.21	0.00
6	1	8.81	8	3.90	0.81	0.00	0.00	0.25	0.10	1.00	0.00	0.99	0.20	0.10	0.00	0.00	0.00	0.20	0.00
6	2	8.77	8	3.92	0.81	0.00	0.00	0.25	0.10	1.02	0.00	1.00	0.20	0.10	0.00	0.00	0.00	0.20	0.00
7	1	8.59	8	6.52	0.86	0.00	0.00	0.27	0.10	1.11	0.00	1.06	0.21	0.10	0.00	0.00	0.00	0.21	0.00
7	2	8.58	8	4.92	0.86	0.00	0.00	0.27	0.10	1.11	0.00	1.06	0.21	0.10	0.00	0.00	0.00	0.21	0.00
7	3	8.57	8	4.93	0.86	0.00	0.00	0.27	0.10	1.12	0.00	1.06	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	4	8.56	8	4.93	0.86	0.00	0.00	0.27	0.10	1.13	0.00	1.06	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	5	8.55	8	4.94	0.86	0.00	0.00	0.27	0.10	1.13	0.00	1.07	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	6	8.54	8	4.95	0.87	0.00	0.00	0.27	0.10	1.14	0.00	1.07	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	7	8.54	8	4.95	0.87	0.00	0.00	0.27	0.10	1.14	0.00	1.07	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	8	8.53	8	4.96	0.87	0.00	0.00	0.27	0.10	1.14	0.00	1.07	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	9	8.52	8	4.96	0.87	0.00	0.00	0.27	0.10	1.15	0.00	1.08	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	10	8.51	8	4.97	0.87	0.00	0.00	0.27	0.10	1.15	0.00	1.08	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	11	8.51	8	4.97	0.88	0.00	0.00	0.27	0.10	1.16	0.00	1.08	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	12	8.50	8	4.98	0.88	0.00	0.00	0.27	0.10	1.16	0.00	1.08	0.22	0.10	0.00	0.00	0.00	0.21	0.00
7	13	8.49	8	4.98	0.88	0.00	0.00	0.27	0.11	1.16	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	14	8.49	8	4.99	0.88	0.00	0.00	0.28	0.11	1.17	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	15	8.48	8	4.99	0.88	0.00	0.00	0.28	0.11	1.17	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	16	8.48	8	4.99	0.88	0.00	0.00	0.28	0.11	1.17	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	17	8.47	8	5.00	0.88	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	18	8.47	8	5.00	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.09	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	19	8.46	8	5.00	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.10	0.22	0.11	0.00	0.00	0.00	0.21	0.00
7	20	8.46	8	5.01	0.89	0.00	0.00	0.28	0.11	1.18	0.00	1.10	0.22	0.11	0.00	0.00	0.00	0.21	0.00

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota spen	CHLA UG/L
1	1	71.70	0.00	0.00	0.00	5.29	8.84	0.50	1.37	0.01	1.00	2.88	0.00	0.89	0.89	0.00	10.78	0.00
1	2	71.79	0.00	0.00	0.00	5.55	8.77	0.50	1.36	0.03	1.00	2.88	0.00	0.89	0.89	0.00	10.76	0.00
1	3	71.88	0.00	0.00	0.00	5.78	8.71	0.50	1.35	0.04	1.00	2.88	0.00	0.89	0.89	0.00	10.74	0.00
1	4	71.96	0.00	0.00	0.00	5.98	8.64	0.49	1.33	0.05	1.00	2.88	0.00	0.89	0.89	0.00	10.73	0.00
1	5	72.04	0.00	0.00	0.00	6.16	8.58	0.49	1.32	0.06	1.00	2.88	0.00	0.89	0.89	0.00	10.71	0.00
1	6	72.11	0.00	0.00	0.00	6.32	8.52	0.49	1.31	0.07	1.00	2.88	0.00	0.89	0.89	0.00	10.69	0.00
2	1	72.17	0.00	0.00	0.00	6.39	8.44	0.49	1.30	0.09	1.00	2.88	0.00	0.89	0.89	0.00	10.66	0.00
2	2	72.23	0.00	0.00	0.00	6.32	8.35	0.49	1.28	0.11	1.00	2.88	0.00	0.89	0.89	0.00	10.64	0.00
2	3	72.28	0.00	0.00	0.00	6.27	8.27	0.48	1.26	0.12	1.01	2.88	0.00	0.89	0.89	0.00	10.61	0.00
2	4	72.33	0.00	0.00	0.00	6.21	8.18	0.48	1.25	0.14	1.01	2.88	0.00	0.89	0.89	0.00	10.58	0.00
2	5	72.38	0.00	0.00	0.00	6.16	8.09	0.48	1.23	0.15	1.01	2.87	0.00	0.89	0.89	0.00	10.56	0.00
2	6	72.43	0.00	0.00	0.00	6.11	8.01	0.48	1.22	0.17	1.01	2.87	0.00	0.89	0.89	0.00	10.53	0.00
2	7	72.47	0.00	0.00	0.00	6.07	7.92	0.48	1.20	0.18	1.01	2.87	0.00	0.89	0.89	0.00	10.50	0.00
2	8	72.51	0.00	0.00	0.00	6.03	7.84	0.47	1.18	0.20	1.02	2.87	0.00	0.89	0.89	0.00	10.48	0.00
2	9	72.55	0.00	0.00	0.00	5.99	7.75	0.47	1.17	0.21	1.02	2.87	0.00	0.89	0.89	0.00	10.45	0.00
2	10	72.59	0.00	0.00	0.00	5.95	7.67	0.47	1.15	0.22	1.02	2.87	0.00	0.89	0.89	0.00	10.42	0.00
3	1	72.62	0.00	0.00	0.00	5.94	7.60	0.47	1.14	0.24	1.03	2.87	0.00	0.89	0.89	0.00	10.40	0.00
3	2	72.64	0.00	0.00	0.00	5.95	7.55	0.47	1.13	0.24	1.03	2.87	0.00	0.89	0.89	0.00	10.39	0.00
3	3	72.66	0.00	0.00	0.00	5.97	7.50	0.46	1.12	0.25	1.03	2.87	0.00	0.89	0.89	0.00	10.37	0.00
3	4	72.68	0.00	0.00	0.00	5.98	7.45	0.46	1.12	0.26	1.03	2.87	0.00	0.89	0.89	0.00	10.35	0.00
3	5	72.70	0.00	0.00	0.00	5.99	7.40	0.46	1.11	0.27	1.03	2.87	0.00	0.89	0.89	0.00	10.34	0.00
3	6	72.72	0.00	0.00	0.00	6.00	7.35	0.46	1.10	0.28	1.04	2.87	0.00	0.89	0.89	0.00	10.32	0.00
3	7	72.74	0.00	0.00	0.00	6.01	7.30	0.46	1.09	0.28	1.04	2.87	0.00	0.89	0.89	0.00	10.30	0.00
3	8	72.76	0.00	0.00	0.00	6.02	7.25	0.46	1.08	0.29	1.04	2.87	0.00	0.89	0.89	0.00	10.29	0.00
3	9	72.77	0.00	0.00	0.00	6.03	7.20	0.46	1.07	0.30	1.04	2.87	0.00	0.89	0.89	0.00	10.27	0.00
3	10	72.79	0.00	0.00	0.00	6.04	7.15	0.45	1.06	0.30	1.05	2.87	0.00	0.89	0.89	0.00	10.25	0.00
3	11	72.81	0.00	0.00	0.00	6.05	7.10	0.45	1.05	0.31	1.05	2.87	0.00	0.89	0.89	0.00	10.24	0.00
3	12	72.82	0.00	0.00	0.00	6.06	7.05	0.45	1.04	0.32	1.05	2.87	0.00	0.89	0.89	0.00	10.22	0.00
3	13	72.84	0.00	0.00	0.00	6.08	7.01	0.45	1.04	0.33	1.05	2.87	0.00	0.89	0.89	0.00	10.20	0.00
3	14	72.85	0.00	0.00	0.00	6.09	6.96	0.45	1.03	0.33	1.06	2.87	0.00	0.89	0.89	0.00	10.19	0.00
4	1	72.87	0.00	0.00	0.00	6.21	6.91	0.45	1.02	0.34	1.06	2.87	0.00	0.89	0.89	0.00	10.17	0.00
4	2	72.90	0.00	0.00	0.00	6.43	6.87	0.45	1.01	0.34	1.06	2.87	0.00	0.89	0.89	0.00	10.15	0.00
4	3	72.92	0.00	0.00	0.00	6.61	6.82	0.45	1.00	0.35	1.07	2.87	0.00	0.89	0.89	0.00	10.14	0.00
4	4	72.94	0.00	0.00	0.00	6.78	6.78	0.44	1.00	0.36	1.07	2.86	0.00	0.89	0.89	0.00	10.12	0.00
4	5	72.96	0.00	0.00	0.00	6.92	6.73	0.44	0.99	0.36	1.07	2.86	0.00	0.89	0.89	0.00	10.11	0.00
4	6	72.98	0.00	0.00	0.00	7.04	6.69	0.44	0.98	0.37	1.07	2.86	0.00	0.89	0.89	0.00	10.09	0.00
4	7	73.00	0.00	0.00	0.00	7.15	6.64	0.44	0.97	0.37	1.08	2.86	0.00	0.89	0.89	0.00	10.08	0.00
4	8	73.02	0.00	0.00	0.00	7.24	6.60	0.44	0.96	0.38	1.08	2.86	0.00	0.89	0.89	0.00	10.06	0.00
4	9	73.03	0.00	0.00	0.00	7.32	6.55	0.44	0.96	0.39	1.08	2.86	0.00	0.89	0.89	0.00	10.04	0.00
5	1	73.05	0.00	0.00	0.00	7.36	6.51	0.44	0.95	0.39	1.09	2.86	0.00	0.89	0.89	0.00	10.03	0.00
5	2	73.06	0.00	0.00	0.00	7.38	6.47	0.44	0.94	0.40	1.09	2.86	0.00	0.89	0.89	0.00	10.01	0.00
5	3	73.07	0.00	0.00	0.00	7.39	6.43	0.43	0.93	0.40	1.09	2.86	0.00	0.89	0.89	0.00	10.00	0.00
5	4	73.08	0.00	0.00	0.00	7.40	6.39	0.43	0.93	0.41	1.10	2.86	0.00	0.89	0.89	0.00	9.98	0.00
5	5	73.09	0.00	0.00	0.00	7.42	6.35	0.43	0.92	0.41	1.10	2.86	0.00	0.89	0.89	0.00	9.97	0.00
5	6	73.09	0.00	0.00	0.00	7.43	6.31	0.43	0.91	0.41	1.10	2.86	0.00	0.89	0.89	0.00	9.95	0.00
5	7	73.10	0.00	0.00	0.00	7.44	6.27	0.43	0.91	0.42	1.11	2.86	0.00	0.89	0.89	0.00	9.94	0.00
6	1	68.36	0.00	0.00	0.00	7.03	3.97	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	9.98	2.69
6	2	68.70	0.00	0.00	0.00	7.06	3.94	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	9.96	2.68
7	1	70.64	0.00	0.00	0.00	7.24	4.89	0.54	0.45	0.18	1.80	2.96	0.00	0.45	0.45	0.00	9.94	1.56
7	2	70.75	0.00	0.00	0.00	7.24	4.85	0.54	0.44	0.18	1.80	2.96	0.00	0.45	0.45	0.00	9.92	1.55
7	3	70.86	0.00	0.00	0.00	7.24	4.82	0.53	0.44	0.18	1.81	2.96	0.00	0.45	0.45	0.00	9.91	1.55
7	4	70.96	0.00	0.00	0.00	7.25	4.79	0.53	0.44	0.19	1.81	2.96	0.00	0.45	0.45	0.00	9.89	1.55
7	5	71.06	0.00	0.00	0.00	7.25	4.75	0.53	0.44	0.19	1.81	2.96	0.00	0.45	0.45	0.00	9.87	1.54
7	6	71.15	0.00	0.00	0.00	7.25	4.72	0.53	0.43	0.19	1.81	2.96	0.00	0.45	0.45	0.00	9.86	1.54
7	7	71.24	0.00	0.00	0.00	7.25	4.68	0.53	0.43	0.19	1.81	2.96	0.00	0.45	0.45	0.00	9.84	1.54
7	8	71.33	0.00	0.00	0.00	7.26	4.65	0.53	0.43	0.20	1.81	2.96	0.00	0.45	0.45	0.00	9.82	1.53
7	9	71.41	0.00	0.00	0.00	7.26	4.62	0.52	0.42	0.20	1.82	2.96	0.00	0.45	0.45	0.00	9.80	1.53
7	10	71.49	0.00	0.00	0.00	7.26	4.59	0.52	0.42	0.20	1.82	2.96	0.00	0.45	0.45	0.00	9.79	1.52
7	11	71.56	0.00	0.00	0.00	7.26	4.55	0.52	0.42	0.20	1.82	2.96	0.00	0.45	0.45	0.00	9.77	1.52
7	12	71.63	0.00	0.00	0.00	7.26	4.52	0.52	0.42	0.20	1.82	2.96	0.00	0.45	0.45	0.00	9.75	1.52
7	13	71.70	0.00	0.00	0.00	7.27	4.49	0.52	0.41	0.21	1.82	2.96	0.00	0.45	0.45	0.00	9.74	1.51
7	14	71.77	0.00	0.00	0.00	7.27	4.46	0.52	0.41	0.21	1.82	2.96	0.00	0.45	0.45	0.00	9.72	1.51
7	15	71.83	0.00	0.00	0.00	7.27	4.42	0.51	0.41	0.21	1.83	2.96	0.00	0.45	0.45	0.00	9.70	1.51
7	16	71.89	0.00	0.00	0.00	7.27	4.39	0.51	0.40	0.21	1.83	2.96	0.00	0.45	0.45	0.00	9.69	1.50
7	17	71.95	0.00	0.00	0.00	7.27	4.36	0.51	0.40	0.21	1.83	2.96	0.00	0.45	0.45	0.00	9.67	1.50
7	18	72.01	0.00	0.00	0.00	7.27	4.33	0.51	0.40	0.22	1.83	2.96	0.00	0.45	0.45	0.00	9.65	1.49
7	19	72.06	0.00	0.00	0.00	7.28	4.30	0.51	0.40	0.22	1.83	2.96	0.00	0.45	0.45	0.00	9.64	1.49
7	20	72.11	0.00	0.00	0.00	7.28	4.27	0.51	0.39	0.22	1.84	2.96	0.00	0.45	0.45	0.00	9.62	1.49

***** STEADY STATE SIMULATION *****

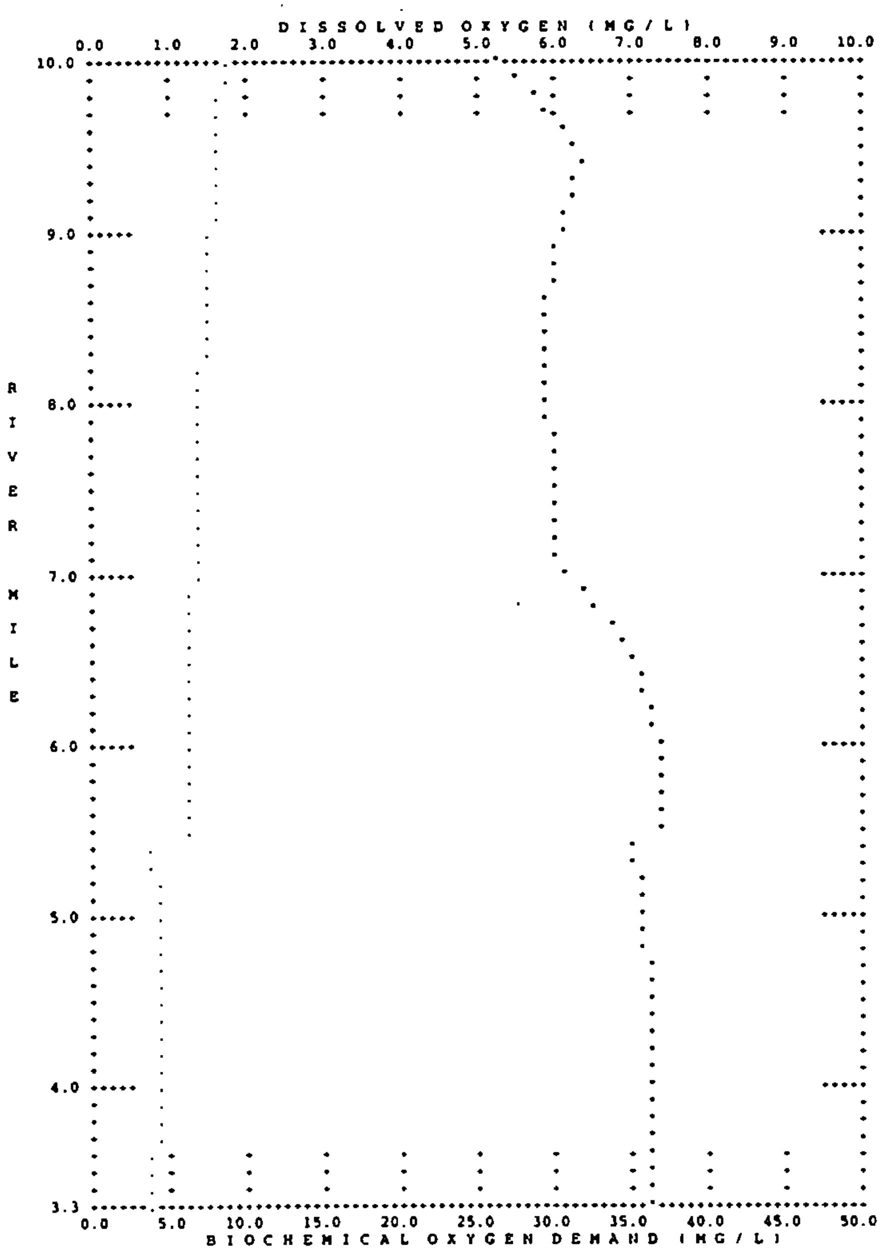
** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS: LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.00	0.00	0.11	0.10	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
2	1	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
3	1	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
4	1	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
5	1	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
6	1	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.89	0.96
7	2	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
8	2	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
9	2	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
10	2	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
11	2	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
12	2	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.92	0.01	0.00	0.88	0.96
13	2	7	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
14	2	8	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
15	2	9	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
16	2	10	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
17	3	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
18	3	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
19	3	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
20	3	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
21	3	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
22	3	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.91	0.01	0.00	0.88	0.96
23	3	7	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
24	3	8	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
25	3	9	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
26	3	10	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
27	3	11	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.88	0.96
28	3	12	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
29	3	13	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
30	3	14	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
31	4	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
32	4	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.90	0.01	0.00	0.87	0.96
33	4	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
34	4	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
35	4	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
36	4	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
37	4	7	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
38	4	8	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
39	4	9	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
40	5	1	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
41	5	2	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.89	0.01	0.00	0.87	0.96
42	5	3	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
43	5	4	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
44	5	5	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
45	5	6	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
46	5	7	0.00	0.00	0.11	0.11	0.00	0.00	0.90	0.88	0.01	0.00	0.87	0.96
47	6	1	2.69	0.00	0.10	0.10	0.00	-0.01	0.90	0.32	0.14	0.00	0.89	0.76
48	6	2	2.68	0.00	0.10	0.10	0.00	-0.01	0.90	0.32	0.14	0.00	0.89	0.77
49	7	1	1.56	0.00	0.11	0.10	0.00	-0.01	0.90	0.69	0.10	0.00	0.88	0.92
50	7	2	1.55	0.00	0.11	0.10	0.00	-0.01	0.90	0.69	0.10	0.00	0.88	0.92
51	7	3	1.55	0.00	0.11	0.10	0.00	-0.01	0.90	0.69	0.10	0.00	0.88	0.92
52	7	4	1.55	0.00	0.11	0.10	0.00	-0.01	0.90	0.69	0.10	0.00	0.88	0.92
53	7	5	1.54	0.00	0.11	0.10	0.00	-0.01	0.90	0.68	0.10	0.00	0.88	0.92
54	7	6	1.54	0.00	0.11	0.10	0.00	-0.01	0.90	0.68	0.10	0.00	0.88	0.92
55	7	7	1.54	0.00	0.11	0.10	0.00	-0.01	0.90	0.68	0.10	0.00	0.88	0.92
56	7	8	1.53	0.00	0.11	0.10	0.00	-0.01	0.90	0.68	0.10	0.00	0.88	0.92
57	7	9	1.53	0.00	0.11	0.10	0.00	-0.01	0.90	0.68	0.10	0.00	0.88	0.92
58	7	10	1.52	0.00	0.11	0.10	0.00	-0.01	0.90	0.68	0.09	0.00	0.88	0.92
59	7	11	1.52	0.00	0.11	0.10	0.00	-0.01	0.90	0.67	0.09	0.00	0.88	0.92
60	7	12	1.52	0.00	0.11	0.10	0.00	-0.01	0.90	0.67	0.09	0.00	0.88	0.92
61	7	13	1.51	0.00	0.11	0.11	0.00	-0.01	0.90	0.67	0.09	0.00	0.88	0.92
62	7	14	1.51	0.00	0.11	0.11	0.00	-0.01	0.90	0.67	0.09	0.00	0.88	0.92
63	7	15	1.51	0.00	0.11	0.11	0.00	-0.01	0.90	0.67	0.09	0.00	0.88	0.92
64	7	16	1.50	0.00	0.11	0.11	0.00	-0.01	0.90	0.67	0.09	0.00	0.88	0.92
65	7	17	1.50	0.00	0.11	0.11	0.00	-0.01	0.90	0.66	0.09	0.00	0.88	0.92
66	7	18	1.49	0.00	0.11	0.11	0.00	-0.01	0.90	0.66	0.09	0.00	0.88	0.92
67	7	19	1.49	0.00	0.11	0.11	0.00	-0.01	0.90	0.66	0.09	0.00	0.88	0.92
68	7	20	1.49	0.00	0.11	0.11	0.00	-0.01	0.90	0.66	0.09	0.00	0.88	0.92

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY) F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	71.70	8.49	5.29	3.20	0.00	0.96	604.43	48.32	-7.77	0.00	0.00	-5.41	-0.02
2	1	2	71.79	8.49	5.55	2.94	0.00	0.96	0.00	44.36	-7.73	0.00	0.00	-5.42	-0.03
3	1	3	71.88	8.48	5.78	2.70	0.00	0.97	0.00	40.83	-7.69	0.00	0.00	-5.42	-0.05
4	1	4	71.96	8.47	5.98	2.49	0.00	0.97	0.00	37.69	-7.65	0.00	0.00	-5.41	-0.06
5	1	5	72.04	8.46	6.16	2.30	0.00	0.98	0.00	34.89	-7.61	0.00	0.00	-5.40	-0.08
6	1	6	72.11	8.46	6.32	2.14	0.00	0.98	0.00	32.40	-7.57	0.00	0.00	-5.38	-0.10
7	2	1	72.17	8.45	6.39	2.07	0.00	0.98	0.00	19.42	-7.51	0.00	0.00	-5.34	-0.12
8	2	2	72.23	8.45	6.32	2.12	0.00	0.98	0.00	7.71	-7.44	0.00	0.00	-5.28	-0.14
9	2	3	72.28	8.44	6.27	2.18	0.00	0.98	0.00	7.91	-7.38	0.00	0.00	-5.22	-0.16
10	2	4	72.33	8.44	6.21	2.23	0.00	0.98	0.00	8.09	-7.31	0.00	0.00	-5.16	-0.18
11	2	5	72.38	8.43	6.16	2.27	0.00	0.98	0.00	8.27	-7.24	0.00	0.00	-5.10	-0.20
12	2	6	72.43	8.43	6.11	2.32	0.00	0.97	0.00	8.43	-7.17	0.00	0.00	-5.05	-0.22
13	2	7	72.47	8.42	6.07	2.36	0.00	0.97	0.00	8.59	-7.10	0.00	0.00	-4.99	-0.24
14	2	8	72.51	8.42	6.03	2.40	0.00	0.97	0.00	8.73	-7.03	0.00	0.00	-4.93	-0.26
15	2	9	72.55	8.42	5.99	2.43	0.00	0.97	0.00	8.87	-6.97	0.00	0.00	-4.87	-0.28
16	2	10	72.59	8.41	5.95	2.46	0.00	0.97	0.00	8.99	-6.90	0.00	0.00	-4.81	-0.29
17	3	1	72.62	8.41	5.94	2.47	0.00	0.97	0.00	11.19	-6.84	0.00	0.00	-4.77	-0.31
18	3	2	72.64	8.41	5.95	2.46	0.00	0.97	0.00	13.31	-6.80	0.00	0.00	-4.74	-0.32
19	3	3	72.66	8.41	5.97	2.44	0.00	0.97	0.00	13.24	-6.76	0.00	0.00	-4.70	-0.33
20	3	4	72.68	8.41	5.98	2.43	0.00	0.97	0.00	13.18	-6.72	0.00	0.00	-4.67	-0.34
21	3	5	72.70	8.40	5.99	2.42	0.00	0.97	0.00	13.11	-6.67	0.00	0.00	-4.64	-0.35
22	3	6	72.72	8.40	6.00	2.40	0.00	0.97	0.00	13.05	-6.63	0.00	0.00	-4.60	-0.36
23	3	7	72.74	8.40	6.01	2.39	0.00	0.97	0.00	12.98	-6.59	0.00	0.00	-4.57	-0.37
24	3	8	72.76	8.40	6.02	2.38	0.00	0.97	0.00	12.92	-6.55	0.00	0.00	-4.54	-0.38
25	3	9	72.77	8.40	6.03	2.37	0.00	0.97	0.00	12.85	-6.51	0.00	0.00	-4.51	-0.39
26	3	10	72.79	8.40	6.04	2.35	0.00	0.97	0.00	12.79	-6.46	0.00	0.00	-4.47	-0.40
27	3	11	72.81	8.39	6.05	2.34	0.00	0.97	0.00	12.72	-6.42	0.00	0.00	-4.44	-0.41
28	3	12	72.82	8.39	6.06	2.33	0.00	0.97	0.00	12.66	-6.38	0.00	0.00	-4.41	-0.42
29	3	13	72.84	8.39	6.08	2.32	0.00	0.97	0.00	12.59	-6.34	0.00	0.00	-4.38	-0.43
30	3	14	72.85	8.39	6.09	2.30	0.00	0.97	0.00	12.53	-6.30	0.00	0.00	-4.35	-0.44
31	4	1	72.87	8.39	6.21	2.17	0.00	0.98	0.00	28.25	-6.26	0.00	0.00	-4.32	-0.45
32	4	2	72.90	8.39	6.43	1.96	0.00	0.98	0.00	40.25	-6.22	0.00	0.00	-4.31	-0.46
33	4	3	72.92	8.38	6.61	1.77	0.00	0.98	0.00	36.39	-6.19	0.00	0.00	-4.29	-0.47
34	4	4	72.94	8.38	6.78	1.61	0.00	0.98	0.00	33.04	-6.15	0.00	0.00	-4.26	-0.48
35	4	5	72.96	8.38	6.92	1.46	0.00	0.98	0.00	30.11	-6.11	0.00	0.00	-4.24	-0.49
36	4	6	72.98	8.38	7.04	1.34	0.00	0.99	0.00	27.56	-6.07	0.00	0.00	-4.21	-0.49
37	4	7	73.00	8.38	7.15	1.23	0.00	0.99	0.00	25.34	-6.04	0.00	0.00	-4.19	-0.50
38	4	8	73.02	8.38	7.24	1.14	0.00	0.99	0.00	23.40	-6.00	0.00	0.00	-4.16	-0.51
39	4	9	73.03	8.37	7.32	1.05	0.00	0.99	0.00	21.71	-5.96	0.00	0.00	-4.13	-0.52
40	5	1	73.05	8.37	7.36	1.01	0.00	0.99	0.00	16.76	-5.93	0.00	0.00	-4.10	-0.53
41	5	2	73.06	8.37	7.38	0.99	0.00	0.99	0.00	12.55	-5.89	0.00	0.00	-4.07	-0.53
42	5	3	73.07	8.37	7.39	0.98	0.00	0.99	0.00	12.37	-5.85	0.00	0.00	-4.05	-0.54
43	5	4	73.08	8.37	7.40	0.97	0.00	0.99	0.00	12.20	-5.82	0.00	0.00	-4.02	-0.55
44	5	5	73.09	8.37	7.42	0.95	0.00	0.99	0.00	12.04	-5.78	0.00	0.00	-3.99	-0.55
45	5	6	73.09	8.37	7.43	0.94	0.00	0.99	0.00	11.88	-5.75	0.00	0.00	-3.96	-0.56
46	5	7	73.10	8.37	7.44	0.93	0.00	0.99	0.00	11.74	-5.71	0.00	0.00	-3.93	-0.57
47	6	1	68.36	8.81	7.03	1.77	0.00	0.99	691.28	6.92	-3.20	0.00	-0.01	-0.42	0.00
48	6	2	68.70	8.77	7.06	1.71	0.00	0.99	0.00	6.70	-3.21	0.00	-0.01	-0.43	0.00
49	7	1	70.64	8.59	7.24	1.36	0.00	0.99	0.00	8.84	-4.18	0.00	-0.01	-1.74	-0.23
50	7	2	70.75	8.58	7.24	1.34	0.00	0.99	0.00	6.60	-4.16	0.00	-0.01	-1.73	-0.23
51	7	3	70.86	8.57	7.24	1.33	0.00	0.99	0.00	6.54	-4.15	0.00	-0.01	-1.73	-0.23
52	7	4	70.96	8.56	7.25	1.32	0.00	0.99	0.00	6.49	-4.13	0.00	-0.01	-1.73	-0.24
53	7	5	71.06	8.55	7.25	1.30	0.00	0.99	0.00	6.44	-4.11	0.00	-0.01	-1.72	-0.24
54	7	6	71.15	8.54	7.25	1.29	0.00	0.99	0.00	6.39	-4.09	0.00	-0.01	-1.72	-0.24
55	7	7	71.24	8.54	7.25	1.28	0.00	0.99	0.00	6.35	-4.07	0.00	-0.01	-1.71	-0.25
56	7	8	71.33	8.53	7.26	1.27	0.00	0.99	0.00	6.30	-4.05	0.00	-0.01	-1.71	-0.25
57	7	9	71.41	8.52	7.26	1.26	0.00	0.99	0.00	6.26	-4.03	0.00	-0.01	-1.70	-0.25
58	7	10	71.49	8.51	7.26	1.25	0.00	0.99	0.00	6.22	-4.01	0.00	-0.01	-1.70	-0.26
59	7	11	71.56	8.51	7.26	1.24	0.00	0.99	0.00	6.18	-3.99	0.00	-0.01	-1.69	-0.26
60	7	12	71.63	8.50	7.26	1.24	0.00	0.99	0.00	6.15	-3.97	0.00	-0.01	-1.69	-0.26
61	7	13	71.70	8.49	7.27	1.23	0.00	0.99	0.00	6.11	-3.95	0.00	-0.01	-1.68	-0.27
62	7	14	71.77	8.49	7.27	1.22	0.00	0.99	0.00	6.08	-3.93	0.00	-0.01	-1.68	-0.27
63	7	15	71.83	8.48	7.27	1.21	0.00	0.99	0.00	6.05	-3.90	0.00	-0.01	-1.67	-0.27
64	7	16	71.89	8.48	7.27	1.21	0.00	0.99	0.00	6.02	-3.88	0.00	-0.01	-1.66	-0.28
65	7	17	71.95	8.47	7.27	1.20	0.00	0.99	0.00	5.99	-3.86	0.00	-0.01	-1.66	-0.28
66	7	18	72.01	8.47	7.27	1.19	0.00	0.99	0.00	5.96	-3.84	0.00	-0.01	-1.65	-0.28
67	7	19	72.06	8.46	7.28	1.19	0.00	0.99	0.00	5.93	-3.81	0.00	-0.01	-1.64	-0.29
68	7	20	72.11	8.46	7.28	1.18	0.00	0.99	0.00	5.91	-3.79	0.00	-0.01	-1.63	-0.29



DISSOLVED OXYGEN ▪ • • • •

BIOCHEMICAL OXYGEN DEMAND ▪ . . . .

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                         * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                  Ver. 3.13 - September 1991

  $$$ (PROBLEM TITLES) $$$

 CARD TYPE                             QUAL-2E PROGRAM TITLES
 TITLE01                   BSAUU.IN - Summer, Average, Ultimate FLOW, BODU Simulation
 TITLE02                   NSWTP DISCHARGE TO BADGER MILL CREEK
 TITLE03    NO             CONSERVATIVE MINERAL I          IN
 TITLE04    NO             CONSERVATIVE MINERAL II         IN
 TITLE05    NO             CONSERVATIVE MINERAL III        IN
 TITLE06   YES             TEMPERATURE
 TITLE07   YES             BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)
 TITLE08   YES             ALGAE AS CHL-A IN UG/L
 TITLE09   YES             PHOSPHORUS CYCLE AS P IN MG/L
 TITLE10                     (ORGANIC-P, DISSOLVED-P)
 TITLE11   YES             NITROGEN CYCLE AS N IN MG/L
 TITLE12                     (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
 TITLE13   YES             DISSOLVED OXYGEN IN MG/L
 TITLE14    NO             FECAL COLIFORMS IN NO./100 ML
 TITLE15   YES             ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l
 ENDTITLE

  $$$ DATA TYPE 1 (CONTROL DATA) $$$

 CARD TYPE                                          CARD TYPE
 LIST DATA INPUT              0.00000                                              0.00000
 WRITE OPTIONAL SUMMARY       0.00000                                              0.00000
 NO FLOW AUGMENTATION         0.00000                                              0.00000
 STEADY STATE                 0.00000                                              0.00000
 TRAPEZOIDAL X-SECTIONS       0.00000                                              0.00000
 PRINT LCD/SOLAR DATA         0.00000                                              0.00000
 PLOT DO AND BOD              0.00000                                              0.00000
 FIXED DNSTM COND (YES=1)=    0.00000               5D-ULT BOD CONV K COEF   =     0.23000
 INPUT METRIC (YES=1)     =   0.00000               OUTPUT METRIC (YES=1)    =     0.00000
 NUMBER OF REACHES        =   7.00000               NUMBER OF JUNCTIONS      =     1.00000
 NUM OF HEADWATERS        =   2.00000               NUMBER OF POINT LOADS    =     0.00000
 TIME STEP (HOURS)        =   1.00000               LNTH  COMP  ELEMENT (DX)=      0.10000
 MAXIMUM ROUTE TIME (HRS)= 288.00000                TIME INC. FOR RPT2 (HRS)=      1.00000
 LATITUDE OF BASIN (DEG) =   43.10000               LONGITUDE OF BASIN (DEG)=     89.30000
 STANDARD MERIDIAN (DEG) =   75.00000               DAY OF YEAR START TIME   =   203.00000
 EVAP. COEFF. (AE)        =   0.00068               EVAP. COEFF. (BE)        =     0.00027
 ELEV. OF BASIN (ELEV)    = 937.00000               DUST ATTENUATION COEF.   =     0.06000
 ENDATA1                      0.00000                                              0.00000

  $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

 CARD TYPE                                            CARD TYPE
 O UPTAKE BY NH3 OXID(MG O/MG N)=    3.5000          O UPTAKE BY NO2 OXID(MG O/MG N)=      1.2000
 O PROD  BY ALGAE (MG O/MG A)    =   1.6000          O UPTAKE BY ALGAE (MG O/MG A)  =      2.0000
 N CONTENT OF ALGAE (MG N/MG A) =    0.0850          P CONTENT OF ALGAE (MG P/MG A) =      0.0120
 ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000          ALGAE RESPIRATION RATE (1/DAY) =      0.1000
 N HALF SATURATION CONST  (MG/L)=    0.3000          P HALF SATURATION CONST  (MG/L)=      0.0400
 LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0088          NLIN SHADE(1/FT-(UGCHA/L)**2/3)=      0.0540
 LIGHT FUNCTION OPTION (LFNOPT) =    1.0000          LIGHT SAT'N COEF (BTU/FT2-MIN) =      0.0300
 DAILY AVERAGING OPTION (LAVOPT)=    1.0000          LIGHT AVERAGING FACTOR (AFACT) =      0.9200
 NUMBER OF DAYLIGHT HOURS (DLH) =   16.0000          TOTAL DAILY SOLR RAD (BTU/FT-2)=    400.0000
 ALGY GROWTH CALC OPTION(LGROPT)=    1.0000          ALGAL PREF FOR NH3-N (PREFN)   =      0.9000
 ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500          NITRIFICATION INHIBITION COEF  =      0.6000
 ENDATA1A                            0.0000                                                0.0000

  $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

 CARD TYPE       RATE CODE       THETA VALUE

 THETA( 1)        BOD DECA          1.047       DFLT
 THETA( 2)        BOD SETT          1.024       DFLT
 THETA( 3)        OXY TRAN          1.024       DFLT
 THETA( 4)        SOD RATE          1.060       DFLT
 THETA( 5)        ORGN DEC          1.047       DFLT
 THETA( 6)        ORGN SET          1.024       DFLT
 THETA( 7)        NH3 DECA          1.083       DFLT
 THETA( 8)        NH3 SRCE          1.074       DFLT
 THETA( 9)        NO2 DECA          1.047       DFLT
 THETA(10)        PORG DEC          1.047       DFLT
 THETA(11)        PORG SET          1.024       DFLT
 THETA(12)        DISP SRC          1.074       DFLT
 THETA(13)        ALG GROW          1.047       DFLT
 THETA(14)        ALG RESP          1.047       DFLT
 THETA(15)        ALG SETT          1.024       DFLT
 THETA(16)        COLI DEC          1.047       DFLT
 THETA(17)        ANC DECA          1.000       DFLT
 THETA(18)        ANC SETT          1.024       DFLT
 THETA(19)        ANC SRCE          1.000       DFLT
 ENDATA1B

  $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

 CARD TYPE          REACH ORDER AND IDENT                   R. MI/KM             R. MI/KM
 STREAM REACH    1.0  RCH= HWY 151-PB          FROM          10.0     TO            9.4
 STREAM REACH    2.0  RCH= PB-Lincoln          FROM           9.4     TO            8.4
 STREAM REACH    3.0  RCH= Lincoln-151 By      FROM           8.4     TO            7.0
 STREAM REACH    4.0  RCH= 151 By-HWY 69       FROM           7.0     TO            6.1
 STREAM REACH    5.0  RCH= HWY 69-Sugar R      FROM           6.1     TO            5.4
 STREAM REACH    6.0  RCH= Upstrm Sugar R      FROM           5.6     TO            5.4
 STREAM REACH    7.0  RCH= Dnstrm Sugar R      FROM           5.4     TO            3.4
 ENDATA2         0.0                                          0.0                   0.0

  $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

 CARD TYPE                   REACH   AVAIL HDWS TARGET     ORDER OF AVAIL SOURCES
 ENDATA3                       0.         0.       0.0  0.    0.    0.    0.    0.    0.

  $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

 CARD TYPE       REACH ELEMENTS/REACH                 COMPUTATIONAL FLAGS
 FLAG FIELD        1.         6.            1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
 FLAG FIELD        2.        10.            2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
 FLAG FIELD        3.        14.            2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
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FLAG FIELD	4.	9.	.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CHANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	2.	945.00	0.13	0.10	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	3.	935.00	0.13	0.20	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	4.	925.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	5.	915.00	0.13	0.00	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	6.	910.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	7.	910.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF FOR OPT 8	OR EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	2.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	3.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	4.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	5.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	6.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	7.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.390	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	2.	0.650	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	3.	0.910	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	4.	0.590	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	5.	0.460	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.0C	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

INCR INFLOW-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC=Sugar R Confluen	46.	49.	48.
ENDATA9	0.		0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	NSWTPOutfall	5.60	65.90	6.00	5.13	0.00	0.00	0.00
HEADWTR-1	2.	Sugar River	18.00	63.30	7.00	4.00	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	6.10	0.00	0.00	0.50	0.25	0.00	1.00	0.00	0.89
HEADWTR-2	2.	5.00	0.00	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
ENDATA11A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

	DAM	RCH	ELE	ADAM	BDAM	FDAM	HDAM
ENDATA12	0.	0.	0.	0.00	0.00	0.00	0.00

$$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

CARD TYPE TEMP D.O. BOD CM-1 CM-2 CM-3 ANC COLI

ENDATA13 DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE CHL-A ORG-N NH3-N NO2-N NH3-N ORG-P DIS-P

ENDATA13A DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
1	68
2	3
3	0

TEMPERATURE ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.82	63.82	62.89	62.03	61.23	60.49														
2	59.85	59.29	58.77	58.28	57.81	57.38	56.97	56.59	56.22	55.88										
3	55.65	55.51	55.37	55.23	55.10	54.98	54.85	54.74	54.63	54.52	54.42	54.31	54.22	54.12						
4	53.97	53.68	53.41	53.15	52.91	52.68	52.47	52.27	52.08											
5	51.94	51.83	51.72	51.62	51.53	51.44	51.36													
6	62.79	62.30																		
7	58.55	58.30	58.05	57.81	57.57	57.34	57.12	56.89	56.68	56.46	56.26	56.05	55.85	55.65	55.46	55.27	55.09	54.91	54.73	54.55

1 68

TEMPERATURE ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.82	63.81	62.87	62.00	61.18	60.41														
2	59.76	59.18	58.63	58.11	57.62	57.15	56.71	56.29	55.90	55.52										
3	55.27	55.10	54.94	54.79	54.64	54.50	54.36	54.23	54.10	53.97	53.85	53.73	53.61	53.50						
4	53.32	52.98	52.66	52.35	52.06	51.78	51.52	51.27	51.03											
5	50.85	50.70	50.57	50.43	50.31	50.19	50.07													
6	62.79	62.28																		
7	58.12	57.86	57.60	57.35	57.10	56.86	56.62	56.39	56.16	55.93	55.71	55.49	55.27	55.06	54.85	54.65	54.45	54.25	54.05	53.86

2 3

TEMPERATURE ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.82	63.81	62.87	62.00	61.18	60.41														
2	59.76	59.18	58.63	58.11	57.62	57.15	56.71	56.29	55.90	55.52										
3	55.26	55.10	54.94	54.79	54.64	54.50	54.36	54.22	54.09	53.97	53.85	53.73	53.61	53.50						
4	53.32	52.98	52.66	52.35	52.06	51.78	51.52	51.27	51.03											
5	50.85	50.70	50.57	50.43	50.31	50.18	50.07													
6	62.79	62.28																		
7	58.11	57.86	57.60	57.35	57.10	56.86	56.62	56.39	56.16	55.93	55.71	55.49	55.27	55.06	54.85	54.65	54.45	54.25	54.05	53.86

3 0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 14.7

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	0.00	9	0.00	17	0.00
2	0.00	10	0.00	18	0.00
3	0.00	11	0.00	19	0.00
4	0.00	12	0.00	20	0.00
5	0.00	13	0.00	21	0.00
6	0.00	14	0.00	22	0.00
7	0.00	15	0.00	23	0.00
8	0.00	16	0.00	24	0.00

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.09	5.04	5.00	4.97	4.93	4.89														
2	4.85	4.81	4.76	4.72	4.68	4.64	4.60	4.57	4.53	4.50										
3	4.47	4.45	4.42	4.40	4.38	4.36	4.34	4.32	4.30	4.28	4.26	4.24	4.22	4.21						
4	4.19	4.17	4.16	4.14	4.13	4.11	4.10	4.08	4.07											
5	4.05	4.04	4.03	4.01	4.00	3.99	3.98													
6	3.98	3.96																		
7	3.95	3.94	3.92	3.91	3.89	3.88	3.87	3.85	3.84	3.82	3.81	3.80	3.78	3.77	3.75	3.74	3.73	3.71	3.70	3.69

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.08	6.06	6.04	6.01	5.99	5.98														
2	5.95	5.93	5.91	5.89	5.87	5.85	5.83	5.81	5.79	5.77										
3	5.75	5.74	5.73	5.71	5.70	5.69	5.67	5.66	5.65	5.63	5.62	5.61	5.60	5.59						
4	5.58	5.57	5.55	5.54	5.53	5.52	5.51	5.50	5.49											
5	5.48	5.48	5.47	5.46	5.45	5.44	5.43													
6	4.99	4.99																		

7	5.13	5.12	5.12	5.11	5.10	5.10	5.09	5.09	5.08	5.08	5.07	5.07	5.06	5.06	5.05	5.04	5.04	5.03	5.03	5.02

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION: CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.03	0.06	0.09	0.12	0.15	0.17														
2	0.20	0.23	0.25	0.28	0.30	0.33	0.35	0.37	0.39	0.41										
3	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.59	0.61	0.63	0.65	0.66	0.68						
4	0.70	0.71	0.73	0.74	0.76	0.77	0.79	0.80	0.82											
5	0.83	0.84	0.86	0.87	0.88	0.90	0.91													
6	2.70	2.69																		
7	2.11	2.11	2.11	2.11	2.10	2.10	2.10	2.10	2.09	2.09	2.09	2.09	2.08	2.08	2.08	2.08	2.08	2.07	2.07	2.07

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.87	0.86	0.86	0.85	0.84														
2	0.83	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77										
3	0.76	0.76	0.75	0.75	0.74	0.74	0.73	0.72	0.72	0.71	0.71	0.70	0.70	0.69						
4	0.69	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.65											
5	0.65	0.64	0.64	0.64	0.63	0.63	0.62													
6	0.13	0.13																		
7	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.50														
2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50										
3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50						
4	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50											
5	0.50	0.50	0.50	0.50	0.50	0.50	0.50													
6	0.62	0.62																		
7	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.56

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.25	0.25	0.24	0.24	0.24	0.24														
2	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.22	0.22										
3	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21						
4	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20											
5	0.20	0.20	0.20	0.20	0.20	0.20	0.19													
6	0.12	0.12																		
7	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.01	0.01	0.01														
2	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02										
3	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03						
4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03											
5	0.03	0.03	0.03	0.03	0.03	0.03	0.03													
6	0.00	0.00																		
7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.01	1.03	1.04	1.06	1.07	1.08														
2	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.21										
3	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.29	1.30	1.31	1.32	1.33	1.34						
4	1.35	1.36	1.36	1.37	1.38	1.39	1.39	1.40	1.41											
5	1.42	1.42	1.43	1.44	1.44	1.45	1.46													
6	2.30	2.30																		
7	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.30	6.57	6.82	7.06	7.27	7.47														
2	7.59	7.62	7.66	7.69	7.72	7.76	7.79	7.83	7.87	7.90										
3	7.95	7.99	8.03	8.07	8.11	8.15	8.19	8.22	8.26	8.30	8.33	8.36	8.40	8.43						
4	8.54	8.72	8.88	9.03	9.17	9.29	9.41	9.51	9.61											
5	9.68	9.72	9.75	9.79	9.82	9.85	9.88													
6	7.06	7.12																		
7	8.06	8.10	8.14	8.19	8.23	8.27	8.31	8.36	8.40	8.44	8.48	8.52	8.56	8.59	8.63	8.67	8.71	8.75	8.78	8.82

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	0
NITRIFICATION INHIBITION	1	66
ALGAE GROWTH RATE	2	0
NITRIFICATION INHIBITION	2	63
ALGAE GROWTH RATE	3	0
NITRIFICATION INHIBITION	3	11
ALGAE GROWTH RATE	4	0
NITRIFICATION INHIBITION	4	0
ALGAE GROWTH RATE	5	0
NITRIFICATION INHIBITION	5	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
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1. LIGHT AVERAGING OPTION. LAVOPT= 1

METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
DAILY NET SOLAR RADIATION: 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 14.7
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS. LGROPT= 1

MULTIPLICATIVE: FL*FN*FP

TEMPERATURE — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.82	63.81	62.87	62.00	61.18	60.41														
2	59.76	59.18	58.63	58.11	57.62	57.15	56.71	56.29	55.90	55.52										
3	55.26	55.10	54.94	54.79	54.64	54.50	54.36	54.22	54.09	53.97	53.85	53.73	53.61	53.50						
4	53.32	52.98	52.66	52.35	52.06	51.78	51.52	51.27	51.03											
5	50.85	50.70	50.57	50.43	50.31	50.18	50.07													
6	62.79	62.28																		
7	58.11	57.86	57.60	57.35	57.10	56.86	56.62	56.39	56.16	55.93	55.71	55.49	55.27	55.06	54.85	54.65	54.45	54.25	54.05	53.86

DISSOLVED OXYGEN IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.30	6.57	6.82	7.06	7.27	7.47														
2	7.59	7.62	7.66	7.69	7.72	7.76	7.79	7.83	7.87	7.90										
3	7.95	7.99	8.03	8.07	8.11	8.15	8.19	8.22	8.26	8.30	8.33	8.36	8.40	8.43						
4	8.54	8.72	8.88	9.03	9.17	9.29	9.41	9.51	9.61											
5	9.68	9.72	9.75	9.79	9.82	9.85	9.88													
6	7.06	7.12																		
7	8.06	8.10	8.14	8.19	8.23	8.27	8.31	8.35	8.40	8.44	8.48	8.52	8.56	8.59	8.63	8.67	8.71	8.75	8.78	8.82

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.09	5.04	5.00	4.97	4.93	4.89														
2	4.85	4.81	4.76	4.72	4.68	4.64	4.60	4.57	4.53	4.50										
3	4.47	4.45	4.42	4.40	4.38	4.36	4.34	4.32	4.30	4.28	4.26	4.24	4.22	4.21						
4	4.19	4.17	4.16	4.14	4.13	4.11	4.10	4.08	4.07											
5	4.05	4.04	4.03	4.01	4.00	3.99	3.98													
6	3.98	3.96																		
7	3.95	3.94	3.92	3.91	3.89	3.88	3.87	3.85	3.84	3.82	3.81	3.80	3.78	3.77	3.75	3.74	3.73	3.71	3.70	3.69

ORGANIC NITROGEN AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.50														
2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50										
3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50						
4	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50											
5	0.50	0.50	0.50	0.50	0.50	0.50	0.50													
6	0.62	0.62																		
7	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.56

AMMONIA AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.25	0.25	0.24	0.24	0.24	0.24														
2	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.22	0.22										
3	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21						
4	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20											
5	0.20	0.20	0.20	0.20	0.20	0.20	0.19													
6	0.12	0.12																		
7	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

NITRITE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.01	0.01	0.01														
2	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02										
3	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03						
4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03											
5	0.03	0.03	0.03	0.03	0.03	0.03	0.03													
6	0.00	0.00																		
7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.01	1.03	1.04	1.06	1.07	1.08														
2	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.21										
3	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.29	1.30	1.31	1.32	1.33	1.34						
4	1.35	1.36	1.36	1.37	1.38	1.39	1.39	1.40	1.41											
5	1.42	1.42	1.43	1.44	1.44	1.45	1.46													
6	2.30	2.30																		
7	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						

4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.87	0.86	0.86	0.85	0.84														
2	0.83	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77										
3	0.76	0.76	0.75	0.75	0.74	0.74	0.73	0.72	0.72	0.71	0.71	0.70	0.70	0.69						
4	0.69	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.65											
5	0.65	0.64	0.64	0.64	0.63	0.63	0.62													
6	0.13	0.13																		
7	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29

ALGAE AS CHL-A IN UG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.03	0.06	0.09	0.12	0.15	0.17														
2	0.20	0.23	0.25	0.28	0.30	0.33	0.35	0.37	0.39	0.41										
3	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.59	0.61	0.63	0.65	0.66	0.68						
4	0.70	0.71	0.73	0.74	0.76	0.77	0.79	0.80	0.82											
5	0.83	0.84	0.86	0.87	0.88	0.90	0.91													
6	2.70	2.69																		
7	2.11	2.11	2.11	2.11	2.10	2.10	2.10	2.10	2.09	2.09	2.09	2.09	2.08	2.08	2.08	2.08	2.08	2.07	2.07	2.07

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS.mg/l ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.08	6.06	6.04	6.01	5.99	5.98														
2	5.95	5.93	5.91	5.89	5.87	5.85	5.83	5.81	5.79	5.77										
3	5.75	5.74	5.73	5.71	5.70	5.69	5.67	5.66	5.65	5.63	5.62	5.61	5.60	5.59						
4	5.58	5.57	5.55	5.54	5.53	5.52	5.51	5.50	5.49											
5	5.48	5.48	5.47	5.46	5.45	5.44	5.43													
6	4.99	4.99																		
7	5.13	5.12	5.12	5.11	5.10	5.10	5.09	5.09	5.08	5.08	5.07	5.07	5.06	5.06	5.05	5.04	5.04	5.03	5.03	5.02

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	5.66	0.00	0.06	0.742	0.008	0.410	18.629	4.03	11.78	7.64	0.40
2	1	2	9.90	9.80	5.73	0.00	0.06	0.744	0.008	0.413	18.653	4.06	11.81	7.70	0.41
3	1	3	9.80	9.70	5.80	0.00	0.06	0.747	0.008	0.415	18.676	4.10	11.83	7.76	0.41
4	1	4	9.70	9.60	5.86	0.00	0.06	0.750	0.008	0.418	18.699	4.13	11.86	7.82	0.42
5	1	5	9.60	9.50	5.93	0.00	0.06	0.752	0.008	0.421	18.722	4.16	11.88	7.87	0.42
6	1	6	9.50	9.40	5.99	0.00	0.06	0.755	0.008	0.423	18.745	4.19	11.91	7.93	0.42
7	2	1	9.40	9.30	6.06	0.00	0.06	0.525	0.012	0.712	16.211	6.10	9.41	11.54	0.54
8	2	2	9.30	9.20	6.12	0.00	0.06	0.526	0.012	0.717	16.228	6.14	9.42	11.63	0.55
9	2	3	9.20	9.10	6.19	0.00	0.06	0.528	0.012	0.721	16.235	6.18	9.43	11.71	0.55
10	2	4	9.10	9.00	6.25	0.00	0.06	0.530	0.012	0.726	16.242	6.22	9.44	11.79	0.56
11	2	5	9.00	8.90	6.32	0.00	0.06	0.532	0.011	0.730	16.249	6.26	9.45	11.86	0.56
12	2	6	8.90	8.80	6.38	0.00	0.06	0.534	0.011	0.735	16.256	6.30	9.46	11.94	0.57
13	2	7	8.80	8.70	6.45	0.00	0.06	0.536	0.011	0.739	16.263	6.35	9.46	12.02	0.57
14	2	8	8.70	8.60	6.51	0.00	0.06	0.538	0.011	0.743	16.270	6.39	9.47	12.10	0.58
15	2	9	8.60	8.50	6.58	0.00	0.06	0.540	0.011	0.748	16.277	6.43	9.48	12.17	0.58
16	2	10	8.50	8.40	6.64	0.00	0.06	0.542	0.011	0.752	16.284	6.47	9.49	12.25	0.59
17	3	1	8.40	8.30	6.71	0.00	0.07	0.849	0.007	0.848	9.309	4.17	6.78	7.90	0.68
18	3	2	8.30	8.20	6.77	0.00	0.07	0.852	0.007	0.852	9.326	4.20	6.80	7.95	0.68
19	3	3	8.20	8.10	6.84	0.00	0.07	0.854	0.007	0.857	9.342	4.23	6.82	8.00	0.69
20	3	4	8.10	8.00	6.90	0.00	0.07	0.856	0.007	0.861	9.359	4.25	6.84	8.06	0.69
21	3	5	8.00	7.90	6.97	0.00	0.07	0.859	0.007	0.865	9.375	4.28	6.85	8.11	0.70
22	3	6	7.90	7.80	7.03	0.00	0.07	0.861	0.007	0.870	9.392	4.31	6.87	8.17	0.70
23	3	7	7.80	7.70	7.10	0.00	0.07	0.863	0.007	0.874	9.408	4.34	6.89	8.22	0.71
24	3	8	7.70	7.60	7.16	0.00	0.07	0.865	0.007	0.878	9.424	4.37	6.91	8.27	0.71
25	3	9	7.60	7.50	7.23	0.00	0.07	0.868	0.007	0.882	9.440	4.40	6.93	8.33	0.72
26	3	10	7.50	7.40	7.29	0.00	0.07	0.870	0.007	0.886	9.457	4.42	6.94	8.38	0.72
27	3	11	7.40	7.30	7.36	0.00	0.07	0.872	0.007	0.890	9.473	4.45	6.96	8.43	0.73
28	3	12	7.30	7.20	7.42	0.00	0.07	0.874	0.007	0.894	9.488	4.48	6.98	8.49	0.73
29	3	13	7.20	7.10	7.49	0.00	0.07	0.877	0.007	0.898	9.504	4.51	7.00	8.54	0.74
30	3	14	7.10	7.00	7.55	0.00	0.07	0.879	0.007	0.903	9.520	4.54	7.01	8.59	0.74
31	4	1	7.00	6.90	7.62	0.00	0.07	0.935	0.007	0.371	21.939	4.30	12.74	8.14	0.38
32	4	2	6.90	6.80	7.68	0.00	0.07	0.938	0.007	0.373	21.949	4.32	12.76	8.19	0.38
33	4	3	6.80	6.70	7.75	0.00	0.07	0.941	0.006	0.375	21.959	4.35	12.77	8.23	0.38
34	4	4	6.70	6.60	7.81	0.00	0.07	0.944	0.006	0.377	21.968	4.37	12.78	8.28	0.38
35	4	5	6.60	6.50	7.88	0.00	0.07	0.947	0.006	0.379	21.978	4.39	12.79	8.32	0.39
36	4	6	6.50	6.40	7.94	0.00	0.07	0.950	0.006	0.380	21.988	4.42	12.80	8.36	0.39
37	4	7	6.40	6.30	8.01	0.00	0.07	0.952	0.006	0.382	21.997	4.44	12.81	8.41	0.39
38	4	8	6.30	6.20	8.07	0.00	0.07	0.955	0.006	0.384	22.007	4.46	12.82	8.45	0.39
39	4	9	6.20	6.10	8.14	0.00	0.07	0.958	0.006	0.386	22.016	4.49	12.83	8.50	0.40
40	5	1	6.10	6.00	8.21	0.00	0.07	0.986	0.006	0.497	16.734	4.39	10.84	8.32	0.44
41	5	2	6.00	5.90	8.27	0.00	0.07	0.989	0.006	0.499	16.750	4.42	10.86	8.37	0.44
42	5	3	5.90	5.80	8.34	0.00	0.07	0.991	0.006	0.502	16.767	4.44	10.88	8.41	0.45
43	5	4	5.80	5.70	8.40	0.00	0.07	0.994	0.006	0.504	16.783	4.47	10.89	8.46	0.45
44	5	5	5.70	5.60	8.47	0.00	0.07	0.996	0.006	0.506	16.799	4.49	10.91	8.50	0.45
45	5	6	5.60	5.50	8.53	0.00	0.07	0.999	0.006	0.508	16.816	4.51	10.93	8.55	0.46
46	5	7	5.50	5.40	8.60	0.00	0.07	1.001	0.006	0.510	16.832	4.54	10.95	8.59	0.46
47	6	1	5.60	5.50	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
48	6	2	5.50	5.40	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
49	7	1	5.40	5.30	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
50	7	2	5.30	5.20	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
51	7	3	5.20	5.10	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
52	7	4	5.10	5.00	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
53	7	5	5.00	4.90	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
54	7	6	4.90	4.80	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
55	7	7	4.80	4.70	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
56	7	8	4.70	4.60	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
57	7	9	4.60	4.50	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
58	7	10	4.50	4.40	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
59	7	11	4.40	4.30	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
60	7	12	4.30	4.20	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
61	7	13	4.20	4.10	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
62	7	14	4.10	4.00	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
63	7	15	4.00	3.90	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
64	7	16	3.90	3.80	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
65	7	17	3.80	3.70	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
66	7	18	3.70	3.60	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
67	7	19	3.60	3.50	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
68	7	20	3.50	3.40	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	9.16	8	13.81	0.74	0.00	0.00	0.23	0.10	0.85	0.00	0.90	0.18	0.10	0.00	0.00	0.00	0.19	0.00
1	2	9.27	8	13.64	0.72	0.00	0.00	0.22	0.09	0.81	0.00	0.88	0.18	0.09	0.00	0.00	0.00	0.19	0.00
1	3	9.37	8	13.51	0.70	0.00	0.00	0.22	0.09	0.78	0.00	0.86	0.18	0.09	0.00	0.00	0.00	0.19	0.00
1	4	9.47	8	13.39	0.69	0.00	0.00	0.21	0.09	0.76	0.00	0.85	0.17	0.09	0.00	0.00	0.00	0.18	0.00
1	5	9.56	8	13.28	0.67	0.00	0.00	0.21	0.09	0.73	0.00	0.83	0.17	0.09	0.00	0.00	0.00	0.18	0.00
1	6	9.65	8	13.18	0.66	0.00	0.00	0.21	0.09	0.71	0.00	0.81	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	1	9.72	8	8.12	0.65	0.00	0.00	0.20	0.09	0.69	0.00	0.80	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	2	9.79	8	3.13	0.64	0.00	0.00	0.20	0.09	0.67	0.00	0.79	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	3	9.85	8	3.12	0.63	0.00	0.00	0.20	0.09	0.65	0.00	0.78	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	4	9.92	8	3.10	0.62	0.00	0.00	0.19	0.09	0.64	0.00	0.77	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	5	9.98	8	3.09	0.61	0.00	0.00	0.19	0.09	0.62	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	6	10.03	8	3.09	0.61	0.00	0.00	0.19	0.09	0.61	0.00	0.75	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	7	10.09	8	3.08	0.60	0.00	0.00	0.19	0.09	0.60	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	8	10.14	8	3.07	0.59	0.00	0.00	0.19	0.09	0.59	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	9	10.19	8	3.06	0.59	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	10	10.23	8	3.06	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.15	0.08	0.00	0.00	0.00	0.17	0.00
3	1	10.27	8	3.75	0.58	0.00	0.00	0.18	0.08	0.56	0.00	0.72	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	2	10.29	8	4.43	0.58	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	3	10.31	8	4.43	0.57	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	4	10.33	8	4.43	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	5	10.35	8	4.43	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	6	10.37	8	4.43	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	7	10.38	8	4.43	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	8	10.40	8	4.42	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	9	10.42	8	4.42	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	10	10.44	8	4.42	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	11	10.45	8	4.42	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	12	10.47	8	4.42	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	13	10.48	8	4.42	0.55	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	14	10.50	8	4.42	0.55	0.00	0.00	0.17	0.08	0.52	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
4	1	10.52	8	10.91	0.55	0.00	0.00	0.17	0.08	0.52	0.00	0.68	0.14	0.08	0.00	0.00	0.00	0.16	0.00
4	2	10.57	8	17.36	0.55	0.00	0.00	0.17	0.08	0.51	0.00	0.68	0.14	0.08	0.00	0.00	0.00	0.16	0.00
4	3	10.61	8	17.33	0.54	0.00	0.00	0.17	0.08	0.50	0.00	0.67	0.14	0.08	0.00	0.00	0.00	0.16	0.00
4	4	10.65	8	17.30	0.54	0.00	0.00	0.17	0.08	0.50	0.00	0.67	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	5	10.69	8	17.28	0.53	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	6	10.73	8	17.26	0.53	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	7	10.77	8	17.24	0.53	0.00	0.00	0.16	0.08	0.48	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	8	10.80	8	17.22	0.52	0.00	0.00	0.16	0.08	0.47	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	9	10.84	8	17.21	0.52	0.00	0.00	0.16	0.08	0.47	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	1	10.86	8	13.71	0.52	0.00	0.00	0.16	0.08	0.47	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	2	10.88	8	10.23	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	3	10.90	8	10.22	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	4	10.92	8	10.22	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	5	10.94	8	10.22	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	6	10.96	8	10.22	0.51	0.00	0.00	0.16	0.08	0.45	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	7	10.97	8	10.23	0.51	0.00	0.00	0.16	0.08	0.45	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
6	1	9.38	8	4.93	0.70	0.00	0.00	0.22	0.09	0.78	0.00	0.86	0.18	0.09	0.00	0.00	0.00	0.19	0.00
6	2	9.44	8	4.89	0.69	0.00	0.00	0.22	0.09	0.77	0.00	0.85	0.17	0.09	0.00	0.00	0.00	0.19	0.00
7	1	9.91	8	6.66	0.62	0.00	0.00	0.19	0.09	0.64	0.00	0.77	0.16	0.09	0.00	0.00	0.00	0.18	0.00
7	2	9.95	8	5.30	0.62	0.00	0.00	0.19	0.09	0.63	0.00	0.77	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	3	9.98	8	5.28	0.61	0.00	0.00	0.19	0.09	0.63	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	4	10.01	8	5.26	0.61	0.00	0.00	0.19	0.09	0.62	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	5	10.04	8	5.24	0.61	0.00	0.00	0.19	0.09	0.61	0.00	0.75	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	6	10.07	8	5.23	0.60	0.00	0.00	0.19	0.09	0.61	0.00	0.75	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	7	10.10	8	5.21	0.60	0.00	0.00	0.19	0.09	0.60	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	8	10.13	8	5.20	0.59	0.00	0.00	0.19	0.09	0.59	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	9	10.15	8	5.18	0.59	0.00	0.00	0.18	0.09	0.59	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	10	10.18	8	5.16	0.59	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	11	10.21	8	5.15	0.58	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	12	10.24	8	5.13	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.15	0.08	0.00	0.00	0.00	0.17	0.00
7	13	10.27	8	5.12	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	14	10.29	8	5.11	0.57	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	15	10.32	8	5.09	0.57	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	16	10.35	8	5.08	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	17	10.37	8	5.06	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	18	10.40	8	5.05	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	19	10.43	8	5.04	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	20	10.45	8	5.02	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota spen	CHLA UG/L
1	1	64.82	0.00	0.00	0.00	6.30	5.09	0.50	0.25	0.00	1.01	1.76	0.00	0.88	0.88	0.00	6.08	0.03
1	2	63.81	0.00	0.00	0.00	6.57	5.04	0.50	0.25	0.00	1.03	1.78	0.00	0.87	0.87	0.00	6.06	0.06
1	3	62.87	0.00	0.00	0.00	6.82	5.00	0.50	0.24	0.00	1.04	1.79	0.00	0.86	0.86	0.00	6.04	0.09
1	4	62.00	0.00	0.00	0.00	7.06	4.97	0.50	0.24	0.01	1.06	1.81	0.00	0.86	0.86	0.00	6.01	0.12
1	5	61.18	0.00	0.00	0.00	7.27	4.93	0.50	0.24	0.01	1.07	1.82	0.00	0.85	0.85	0.00	5.99	0.15
1	6	60.41	0.00	0.00	0.00	7.47	4.89	0.50	0.24	0.01	1.08	1.83	0.00	0.84	0.84	0.00	5.98	0.17
2	1	59.76	0.00	0.00	0.00	7.59	4.85	0.50	0.24	0.01	1.10	1.84	0.00	0.83	0.83	0.00	5.95	0.20
2	2	59.18	0.00	0.00	0.00	7.62	4.81	0.50	0.23	0.01	1.11	1.86	0.00	0.83	0.83	0.00	5.93	0.23
2	3	58.63	0.00	0.00	0.00	7.66	4.76	0.50	0.23	0.01	1.12	1.87	0.00	0.82	0.82	0.00	5.91	0.25
2	4	58.11	0.00	0.00	0.00	7.69	4.72	0.50	0.23	0.01	1.14	1.88	0.00	0.81	0.81	0.00	5.89	0.28
2	5	57.62	0.00	0.00	0.00	7.72	4.68	0.50	0.23	0.02	1.15	1.89	0.00	0.80	0.80	0.00	5.87	0.30
2	6	57.15	0.00	0.00	0.00	7.76	4.64	0.50	0.23	0.02	1.16	1.90	0.00	0.80	0.80	0.00	5.85	0.33
2	7	56.71	0.00	0.00	0.00	7.79	4.60	0.50	0.23	0.02	1.17	1.91	0.00	0.79	0.79	0.00	5.83	0.35
2	8	56.29	0.00	0.00	0.00	7.83	4.57	0.50	0.22	0.02	1.18	1.92	0.00	0.78	0.78	0.00	5.81	0.37
2	9	55.90	0.00	0.00	0.00	7.87	4.53	0.50	0.22	0.02	1.19	1.94	0.00	0.78	0.78	0.00	5.79	0.39
2	10	55.52	0.00	0.00	0.00	7.90	4.50	0.50	0.22	0.02	1.21	1.95	0.00	0.77	0.77	0.00	5.77	0.41
3	1	55.26	0.00	0.00	0.00	7.95	4.47	0.50	0.22	0.02	1.22	1.96	0.00	0.76	0.76	0.00	5.75	0.44
3	2	55.10	0.00	0.00	0.00	7.99	4.45	0.50	0.22	0.02	1.23	1.97	0.00	0.76	0.76	0.00	5.74	0.46
3	3	54.94	0.00	0.00	0.00	8.03	4.42	0.50	0.22	0.02	1.24	1.98	0.00	0.75	0.75	0.00	5.73	0.48
3	4	54.79	0.00	0.00	0.00	8.07	4.40	0.50	0.22	0.02	1.25	1.99	0.00	0.75	0.75	0.00	5.71	0.50
3	5	54.64	0.00	0.00	0.00	8.11	4.38	0.50	0.22	0.02	1.26	1.99	0.00	0.74	0.74	0.00	5.70	0.52
3	6	54.50	0.00	0.00	0.00	8.15	4.36	0.50	0.21	0.03	1.27	2.00	0.00	0.74	0.74	0.00	5.69	0.54
3	7	54.36	0.00	0.00	0.00	8.19	4.34	0.50	0.21	0.03	1.28	2.01	0.00	0.73	0.73	0.00	5.67	0.56
3	8	54.22	0.00	0.00	0.00	8.22	4.32	0.50	0.21	0.03	1.29	2.02	0.00	0.72	0.72	0.00	5.66	0.58
3	9	54.09	0.00	0.00	0.00	8.26	4.30	0.50	0.21	0.03	1.29	2.03	0.00	0.72	0.72	0.00	5.65	0.59
3	10	53.97	0.00	0.00	0.00	8.30	4.28	0.50	0.21	0.03	1.30	2.04	0.00	0.71	0.71	0.00	5.63	0.61
3	11	53.85	0.00	0.00	0.00	8.33	4.26	0.50	0.21	0.03	1.31	2.05	0.00	0.71	0.71	0.00	5.62	0.63
3	12	53.73	0.00	0.00	0.00	8.36	4.24	0.50	0.21	0.03	1.32	2.06	0.00	0.70	0.70	0.00	5.61	0.65
3	13	53.61	0.00	0.00	0.00	8.40	4.22	0.50	0.21	0.03	1.33	2.07	0.00	0.70	0.70	0.00	5.60	0.66
3	14	53.50	0.00	0.00	0.00	8.43	4.21	0.50	0.21	0.03	1.34	2.07	0.00	0.69	0.69	0.00	5.59	0.68
4	1	53.32	0.00	0.00	0.00	8.54	4.19	0.50	0.21	0.03	1.35	2.08	0.00	0.69	0.69	0.00	5.58	0.70
4	2	52.98	0.00	0.00	0.00	8.72	4.17	0.50	0.20	0.03	1.36	2.09	0.00	0.68	0.68	0.00	5.57	0.71
4	3	52.66	0.00	0.00	0.00	8.88	4.16	0.50	0.20	0.03	1.36	2.10	0.00	0.68	0.68	0.00	5.55	0.73
4	4	52.35	0.00	0.00	0.00	9.03	4.14	0.50	0.20	0.03	1.37	2.10	0.00	0.67	0.67	0.00	5.54	0.74
4	5	52.06	0.00	0.00	0.00	9.17	4.13	0.50	0.20	0.03	1.38	2.11	0.00	0.67	0.67	0.00	5.53	0.76
4	6	51.78	0.00	0.00	0.00	9.29	4.11	0.50	0.20	0.03	1.39	2.12	0.00	0.67	0.67	0.00	5.52	0.77
4	7	51.52	0.00	0.00	0.00	9.41	4.10	0.50	0.20	0.03	1.39	2.13	0.00	0.66	0.66	0.00	5.51	0.79
4	8	51.27	0.00	0.00	0.00	9.51	4.08	0.50	0.20	0.03	1.40	2.13	0.00	0.66	0.66	0.00	5.50	0.80
4	9	51.03	0.00	0.00	0.00	9.61	4.07	0.50	0.20	0.03	1.41	2.14	0.00	0.65	0.65	0.00	5.49	0.82
5	1	50.85	0.00	0.00	0.00	9.68	4.05	0.50	0.20	0.03	1.42	2.15	0.00	0.65	0.65	0.00	5.48	0.83
5	2	50.70	0.00	0.00	0.00	9.72	4.04	0.50	0.20	0.03	1.42	2.15	0.00	0.64	0.64	0.00	5.48	0.84
5	3	50.57	0.00	0.00	0.00	9.75	4.03	0.50	0.20	0.03	1.43	2.16	0.00	0.64	0.64	0.00	5.47	0.86
5	4	50.43	0.00	0.00	0.00	9.79	4.01	0.50	0.20	0.03	1.44	2.17	0.00	0.64	0.64	0.00	5.46	0.87
5	5	50.31	0.00	0.00	0.00	9.82	4.00	0.50	0.20	0.03	1.44	2.17	0.00	0.63	0.63	0.00	5.45	0.88
5	6	50.18	0.00	0.00	0.00	9.85	3.99	0.50	0.20	0.03	1.45	2.18	0.00	0.63	0.63	0.00	5.44	0.90
5	7	50.07	0.00	0.00	0.00	9.88	3.98	0.50	0.19	0.03	1.46	2.19	0.00	0.62	0.62	0.00	5.43	0.91
6	1	62.79	0.00	0.00	0.00	7.06	3.98	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.70
6	2	62.28	0.00	0.00	0.00	7.12	3.96	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.69
7	1	58.11	0.00	0.00	0.00	8.06	3.95	0.58	0.14	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.13	2.11
7	2	57.86	0.00	0.00	0.00	8.10	3.94	0.58	0.14	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.12	2.11
7	3	57.60	0.00	0.00	0.00	8.14	3.92	0.58	0.14	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.12	2.11
7	4	57.35	0.00	0.00	0.00	8.19	3.91	0.58	0.15	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.11	2.11
7	5	57.10	0.00	0.00	0.00	8.23	3.89	0.58	0.15	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.10	2.10
7	6	56.86	0.00	0.00	0.00	8.27	3.88	0.57	0.15	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.10	2.10
7	7	56.62	0.00	0.00	0.00	8.31	3.87	0.57	0.15	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.09	2.10
7	8	56.39	0.00	0.00	0.00	8.35	3.85	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.09	2.10
7	9	56.16	0.00	0.00	0.00	8.40	3.84	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.08	2.09
7	10	55.93	0.00	0.00	0.00	8.44	3.82	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.08	2.09
7	11	55.71	0.00	0.00	0.00	8.48	3.81	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.07	2.09
7	12	55.49	0.00	0.00	0.00	8.52	3.80	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.07	2.09
7	13	55.27	0.00	0.00	0.00	8.56	3.78	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.06	2.08
7	14	55.06	0.00	0.00	0.00	8.59	3.77	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.06	2.08
7	15	54.85	0.00	0.00	0.00	8.63	3.75	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.05	2.08
7	16	54.65	0.00	0.00	0.00	8.67	3.74	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.04	2.08
7	17	54.45	0.00	0.00	0.00	8.71	3.73	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.04	2.08
7	18	54.25	0.00	0.00	0.00	8.75	3.71	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.03	2.07
7	19	54.05	0.00	0.00	0.00	8.78	3.70	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.03	2.07
7	20	53.86	0.00	0.00	0.00	8.82	3.69	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.02	2.07

***** STEADY STATE SIMULATION *****

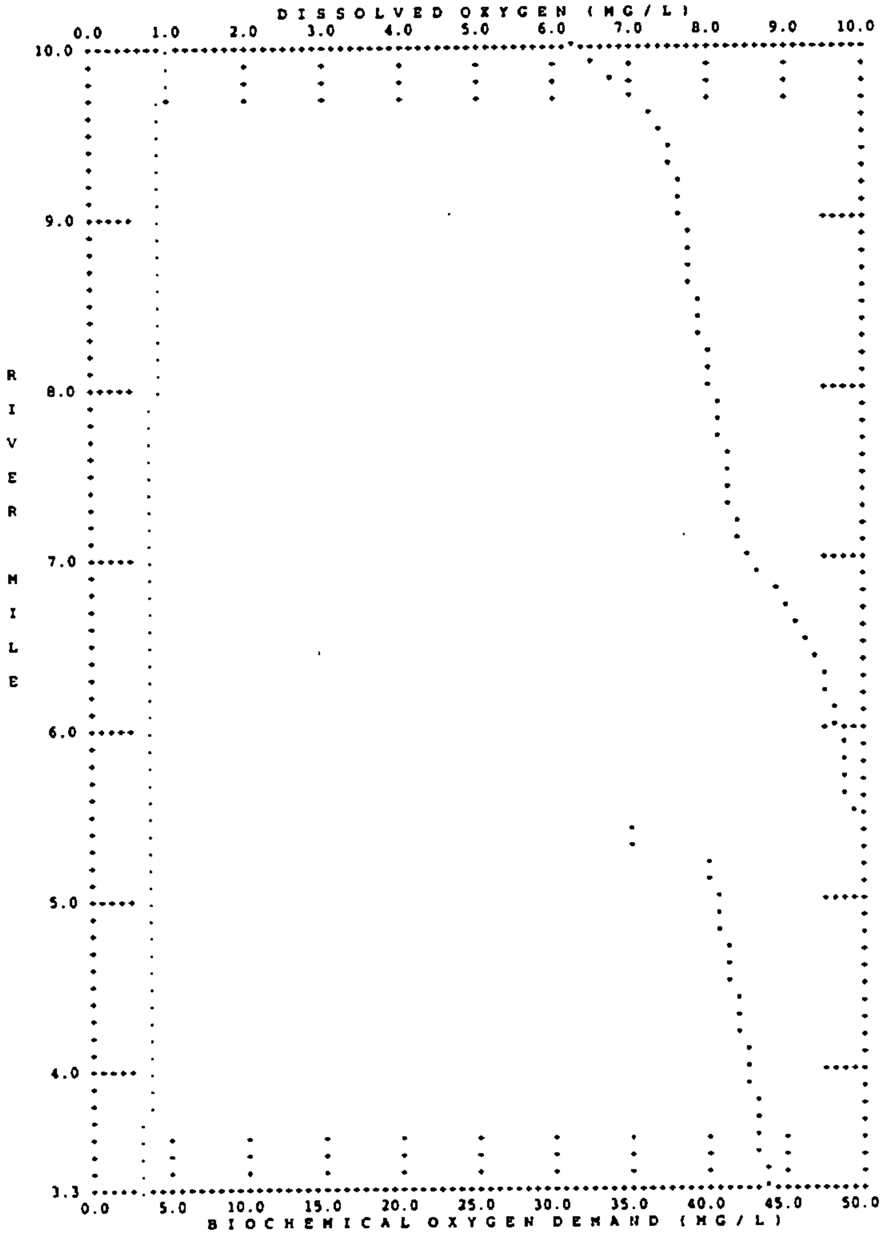
** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.03	0.00	0.09	0.10	0.00	0.00	0.90	0.69	0.02	0.00	0.81	0.96
2	1	2	0.06	0.00	0.09	0.09	0.00	0.00	0.90	0.68	0.02	0.00	0.81	0.96
3	1	3	0.09	0.00	0.09	0.09	0.00	0.00	0.90	0.68	0.02	0.00	0.81	0.96
4	1	4	0.12	0.00	0.09	0.09	0.00	0.00	0.90	0.67	0.02	0.00	0.81	0.96
5	1	5	0.15	0.00	0.08	0.09	0.00	0.00	0.90	0.67	0.03	0.00	0.81	0.95
6	1	6	0.17	0.00	0.08	0.09	0.00	0.00	0.90	0.66	0.03	0.00	0.82	0.95
7	2	1	0.20	0.00	0.08	0.09	0.00	0.00	0.90	0.66	0.03	0.00	0.82	0.95
8	2	2	0.23	0.00	0.08	0.09	0.00	0.00	0.90	0.65	0.03	0.00	0.82	0.95
9	2	3	0.25	0.00	0.08	0.09	0.00	0.00	0.90	0.65	0.03	0.00	0.82	0.95
10	2	4	0.28	0.00	0.08	0.09	0.00	0.00	0.90	0.65	0.04	0.00	0.82	0.95
11	2	5	0.30	0.00	0.08	0.09	0.00	0.00	0.90	0.64	0.04	0.00	0.82	0.95
12	2	6	0.33	0.00	0.08	0.09	0.00	0.00	0.90	0.64	0.04	0.00	0.82	0.95
13	2	7	0.35	0.00	0.07	0.09	0.00	0.00	0.90	0.63	0.04	0.00	0.82	0.95
14	2	8	0.37	0.00	0.07	0.09	0.00	0.00	0.90	0.63	0.04	0.00	0.82	0.95
15	2	9	0.39	0.00	0.07	0.09	0.00	0.00	0.90	0.63	0.04	0.00	0.83	0.95
16	2	10	0.41	0.00	0.07	0.08	0.00	0.00	0.90	0.62	0.04	0.00	0.83	0.95
17	3	1	0.44	0.00	0.07	0.08	0.00	0.00	0.90	0.62	0.04	0.00	0.83	0.95
18	3	2	0.46	0.00	0.07	0.08	0.00	0.00	0.90	0.62	0.05	0.00	0.83	0.95
19	3	3	0.48	0.00	0.07	0.08	0.00	0.00	0.90	0.61	0.05	0.00	0.83	0.95
20	3	4	0.50	0.00	0.07	0.08	0.00	0.00	0.90	0.61	0.05	0.00	0.83	0.95
21	3	5	0.52	0.00	0.07	0.08	0.00	0.00	0.90	0.61	0.05	0.00	0.83	0.95
22	3	6	0.54	0.00	0.07	0.08	0.00	0.00	0.90	0.60	0.05	0.00	0.83	0.95
23	3	7	0.56	0.00	0.07	0.08	0.00	0.00	0.90	0.60	0.05	0.00	0.83	0.95
24	3	8	0.58	0.00	0.07	0.08	0.00	0.00	0.90	0.60	0.05	0.00	0.83	0.95
25	3	9	0.59	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.05	0.00	0.83	0.95
26	3	10	0.61	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.05	0.00	0.83	0.95
27	3	11	0.63	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.06	0.00	0.84	0.95
28	3	12	0.65	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.06	0.00	0.84	0.95
29	3	13	0.66	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.95
30	3	14	0.68	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.95
31	4	1	0.70	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.95
32	4	2	0.71	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.94
33	4	3	0.73	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
34	4	4	0.74	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
35	4	5	0.76	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
36	4	6	0.77	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
37	4	7	0.79	0.00	0.07	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
38	4	8	0.80	0.00	0.07	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
39	4	9	0.82	0.00	0.06	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
40	5	1	0.83	0.00	0.06	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
41	5	2	0.84	0.00	0.06	0.08	0.00	0.00	0.90	0.56	0.07	0.00	0.84	0.94
42	5	3	0.86	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.84	0.94
43	5	4	0.87	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.84	0.94
44	5	5	0.88	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
45	5	6	0.90	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
46	5	7	0.91	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
47	6	1	2.70	0.00	0.09	0.09	0.00	-0.01	0.90	0.32	0.14	0.00	0.89	0.76
48	6	2	2.69	0.00	0.09	0.09	0.00	-0.01	0.90	0.32	0.14	0.00	0.89	0.76
49	7	1	2.11	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
50	7	2	2.11	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
51	7	3	2.11	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
52	7	4	2.11	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
53	7	5	2.10	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
54	7	6	2.10	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
55	7	7	2.10	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
56	7	8	2.10	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
57	7	9	2.09	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
58	7	10	2.09	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
59	7	11	2.09	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
60	7	12	2.09	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
61	7	13	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
62	7	14	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
63	7	15	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
64	7	16	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
65	7	17	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
66	7	18	2.07	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
67	7	19	2.07	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
68	7	20	2.07	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
1	1	1	64.82	9.16	6.30	2.87	0.00	0.98	729.44	39.56	-3.75	0.00	0.00	-0.74	0.00
2	1	2	63.81	9.27	6.57	2.70	0.00	0.98	9.67	36.81	-3.63	0.00	0.00	-0.70	0.00
3	1	3	62.87	9.37	6.82	2.55	0.00	0.98	9.60	34.42	-3.51	0.00	0.00	-0.67	0.00
4	1	4	62.00	9.47	7.06	2.41	0.00	0.99	9.53	32.30	-3.41	0.00	0.00	-0.64	-0.01
5	1	5	61.18	9.56	7.27	2.29	0.00	0.99	9.46	30.40	-3.31	0.00	0.00	-0.61	-0.01
6	1	6	60.41	9.65	7.47	2.18	0.00	0.99	9.39	28.71	-3.22	0.00	0.00	-0.59	-0.01
7	2	1	59.76	9.72	7.59	2.13	0.00	0.99	6.45	17.26	-3.14	0.00	0.00	-0.57	-0.01
8	2	2	59.18	9.79	7.62	2.16	0.00	0.99	6.40	6.78	-3.07	0.00	0.00	-0.55	-0.01
9	2	3	58.63	9.85	7.66	2.20	0.00	0.99	6.36	6.85	-3.00	0.00	0.00	-0.53	-0.01
10	2	4	58.11	9.92	7.69	2.23	0.00	0.99	6.32	6.91	-2.93	0.00	0.00	-0.52	-0.01
11	2	5	57.62	9.98	7.72	2.25	0.00	0.99	6.28	6.97	-2.87	0.00	0.00	-0.50	-0.01
12	2	6	57.15	10.03	7.76	2.27	0.00	0.99	6.24	7.02	-2.82	0.00	0.00	-0.49	-0.02
13	2	7	56.71	10.09	7.79	2.29	0.00	0.99	6.20	7.06	-2.76	0.00	0.00	-0.47	-0.02
14	2	8	56.29	10.14	7.83	2.31	0.00	0.99	6.16	7.09	-2.71	0.00	0.00	-0.46	-0.02
15	2	9	55.90	10.19	7.87	2.32	0.00	0.99	6.12	7.11	-2.66	0.00	0.00	-0.45	-0.02
16	2	10	55.52	10.23	7.90	2.33	0.00	0.99	6.08	7.13	-2.62	0.00	0.00	-0.44	-0.02
17	3	1	55.26	10.27	7.95	2.32	0.00	0.99	9.43	8.70	-2.58	0.00	0.00	-0.43	-0.02
18	3	2	55.10	10.29	7.99	2.30	0.00	0.99	9.37	10.20	-2.56	0.00	0.00	-0.43	-0.02
19	3	3	54.94	10.31	8.03	2.28	0.00	0.99	9.30	10.10	-2.54	0.00	0.00	-0.42	-0.02
20	3	4	54.79	10.33	8.07	2.26	0.00	0.99	9.24	10.01	-2.51	0.00	0.00	-0.42	-0.02
21	3	5	54.64	10.35	8.11	2.24	0.00	0.99	9.18	9.91	-2.49	0.00	0.00	-0.41	-0.02
22	3	6	54.50	10.37	8.15	2.22	0.00	0.99	9.12	9.82	-2.47	0.00	0.00	-0.41	-0.02
23	3	7	54.36	10.38	8.19	2.20	0.00	0.99	9.06	9.73	-2.45	0.00	0.00	-0.40	-0.02
24	3	8	54.22	10.40	8.22	2.18	0.00	0.99	9.00	9.64	-2.43	0.00	0.00	-0.40	-0.02
25	3	9	54.09	10.42	8.26	2.16	0.00	0.99	8.94	9.55	-2.41	0.00	0.00	-0.40	-0.02
26	3	10	53.97	10.44	8.30	2.14	0.00	0.99	8.88	9.47	-2.39	0.00	0.00	-0.39	-0.02
27	3	11	53.85	10.45	8.33	2.12	0.00	0.99	8.83	9.39	-2.37	0.00	0.00	-0.39	-0.02
28	3	12	53.73	10.47	8.36	2.10	0.00	0.99	8.77	9.30	-2.36	0.00	0.00	-0.38	-0.02
29	3	13	53.61	10.48	8.40	2.09	0.00	0.99	8.72	9.22	-2.34	0.00	0.00	-0.38	-0.02
30	3	14	53.50	10.50	8.43	2.07	0.00	0.99	8.67	9.14	-2.32	0.00	0.00	-0.38	-0.02
31	4	1	53.32	10.52	8.54	1.98	0.00	0.99	9.22	21.59	-2.30	0.00	0.00	-0.37	-0.02
32	4	2	52.98	10.57	8.72	1.85	0.00	0.99	9.17	32.04	-2.27	0.00	0.00	-0.37	-0.02
33	4	3	52.66	10.61	8.88	1.73	0.00	1.00	9.12	29.93	-2.25	0.00	0.00	-0.36	-0.02
34	4	4	52.35	10.65	9.03	1.62	0.00	1.00	9.07	28.04	-2.22	0.00	0.00	-0.35	-0.02
35	4	5	52.06	10.69	9.17	1.52	0.00	1.00	9.03	26.34	-2.20	0.00	0.00	-0.35	-0.02
36	4	6	51.78	10.73	9.29	1.44	0.00	1.00	8.98	24.81	-2.17	0.00	0.00	-0.34	-0.02
37	4	7	51.52	10.77	9.41	1.36	0.00	1.00	8.93	23.43	-2.15	0.00	0.00	-0.34	-0.02
38	4	8	51.27	10.80	9.51	1.29	0.00	1.00	8.88	22.18	-2.13	0.00	0.00	-0.33	-0.02
39	4	9	51.03	10.84	9.61	1.22	0.00	1.00	8.84	21.05	-2.11	0.00	0.00	-0.33	-0.02
40	5	1	50.85	10.86	9.68	1.18	0.00	1.00	9.05	16.23	-2.09	0.00	0.00	-0.32	-0.02
41	5	2	50.70	10.88	9.72	1.17	0.00	1.00	9.00	11.93	-2.08	0.00	0.00	-0.32	-0.02
42	5	3	50.57	10.90	9.75	1.15	0.00	1.00	8.95	11.76	-2.06	0.00	0.00	-0.32	-0.02
43	5	4	50.43	10.92	9.79	1.13	0.00	1.00	8.90	11.59	-2.05	0.00	0.00	-0.31	-0.02
44	5	5	50.31	10.94	9.82	1.12	0.00	1.00	8.85	11.43	-2.04	0.00	0.00	-0.31	-0.02
45	5	6	50.18	10.96	9.85	1.10	0.00	1.00	8.81	11.28	-2.02	0.00	0.00	-0.31	-0.02
46	5	7	50.07	10.97	9.88	1.09	0.00	1.00	8.76	11.14	-2.01	0.00	0.00	-0.31	-0.02
47	6	1	62.79	9.38	7.06	2.32	0.00	0.99	959.81	11.43	-2.79	0.00	-0.01	-0.33	0.00
48	6	2	62.28	9.44	7.12	2.31	0.00	0.99	0.00	11.33	-2.74	0.00	-0.01	-0.32	0.00
49	7	1	58.11	9.91	8.06	1.86	0.00	0.99	0.00	12.37	-2.46	0.00	-0.01	-0.32	-0.01
50	7	2	57.86	9.95	8.10	1.85	0.00	0.99	0.00	9.77	-2.43	0.00	-0.01	-0.32	-0.01
51	7	3	57.60	9.98	8.14	1.83	0.00	0.99	0.00	9.67	-2.41	0.00	-0.01	-0.32	-0.01
52	7	4	57.35	10.01	8.19	1.82	0.00	0.99	0.00	9.58	-2.38	0.00	-0.01	-0.31	-0.01
53	7	5	57.10	10.04	8.23	1.81	0.00	0.99	0.00	9.48	-2.36	0.00	-0.01	-0.31	-0.01
54	7	6	56.86	10.07	8.27	1.80	0.00	0.99	0.00	9.39	-2.34	0.00	-0.01	-0.31	-0.01
55	7	7	56.62	10.10	8.31	1.78	0.00	0.99	0.00	9.29	-2.31	0.00	-0.01	-0.31	-0.01
56	7	8	56.39	10.13	8.35	1.77	0.00	0.99	0.00	9.20	-2.29	0.00	-0.01	-0.30	-0.01
57	7	9	56.16	10.15	8.40	1.76	0.00	0.99	0.00	9.11	-2.27	0.00	-0.01	-0.30	-0.01
58	7	10	55.93	10.18	8.44	1.75	0.00	0.99	0.00	9.02	-2.25	0.00	-0.01	-0.30	-0.01
59	7	11	55.71	10.21	8.48	1.74	0.00	0.99	0.00	8.93	-2.23	0.00	-0.01	-0.29	-0.01
60	7	12	55.49	10.24	8.52	1.72	0.00	0.99	0.00	8.85	-2.21	0.00	-0.01	-0.29	-0.01
61	7	13	55.27	10.27	8.56	1.71	0.00	0.99	0.00	8.76	-2.19	0.00	-0.01	-0.29	-0.01
62	7	14	55.06	10.29	8.59	1.70	0.00	0.99	0.00	8.68	-2.17	0.00	-0.01	-0.29	-0.02
63	7	15	54.85	10.32	8.63	1.69	0.00	0.99	0.00	8.59	-2.15	0.00	-0.01	-0.28	-0.02
64	7	16	54.65	10.35	8.67	1.68	0.00	0.99	0.00	8.51	-2.13	0.00	-0.01	-0.28	-0.02
65	7	17	54.45	10.37	8.71	1.67	0.00	0.99	0.00	8.43	-2.11	0.00	-0.01	-0.28	-0.02
66	7	18	54.25	10.40	8.75	1.65	0.00	0.99	0.00	8.35	-2.09	0.00	-0.01	-0.28	-0.02
67	7	19	54.05	10.43	8.78	1.64	0.00	0.99	0.00	8.27	-2.07	0.00	-0.01	-0.28	-0.02
68	7	20	53.86	10.45	8.82	1.63	0.00	0.99	0.00	8.20	-2.06	0.00	-0.01	-0.27	-0.02



DISSOLVED OXYGEN * * * * *

BIOCHEMICAL OXYGEN DEMAND * . . . .

Appendix C

MONTGOMERY WATSON

State Historical Society of Wisconsin

Division of Historic Preservation

816 State Street • Madison, Wisconsin 53706-1488
(608) 264-6500 • FAX (608) 264-6404

July 6, 1995

Mr. Paul A. Nelson
Montgomery Watson
Waterford Park
505 U.S. Highway 169, Suite #555
Minneapolis, Minnesota 55441

IN REPLY PLEASE REFER TO SHSW: #95-0946/DA
RE: Sugar River Basin Effluent Return Project
ID: #4248

Dear Mr. Nelson

We have reviewed the above-referenced information which accompanied your submitted dated June 29, 1995 as required for compliance with Section 106 of the National Historic Preservation Act and 36 CFR Part 800: Protection of Historic Properties, the regulations of the Advisory Council on Historic Preservation governing the Section 106 review process.

There is a very high density of archeodlogical sites (many of which contain Native American burials) in the project area. Therefore, we recommend that all areas of proposed ground disturbing activity be surveyed by a qualified archeologist to locate and evaluate the significance of any archeological sites that may be present. When the survey has been completed, please provide <u>two</u> copies of the archeologist's report for our review and comment. Please ensure that the archeologists's report is accompanied by our project identification number (SHSW: #95-0946/DA).

The project as described in your correspondence will not affect any <u>structures</u> that are listed in, or known to be eligible for inclusion in, the National Register of Historic Places. We remind that 36 CFR 800.4 includes the requirement that you seek information, as appropriate to the undertaking, from parties likely to have knowledge of or concerns with historic properties in the project area - such as Indian tribes, local governments, and public and private organizations.

If there are any questions concerning this matter, please contact me at (608) 264-6507.

Sincerely,

Sherman J. Banker
Compliance Archeologist

SJB:lks

MADISON METROPOLITAN SEWERAGE DISTRICT

1610 Moorland Road
Madison, WI 53713-3398
Telephone (608) 222-1201
Fax (608) 222-2703

James L. Nemke
Chief Engineer & Director

September 19, 1995

State Historical Society of Wisconsin
816 State Street
Madison, WI 53706-1488

Gentlemen:

Please find enclosed two copies of An Archaeological Survey of the Proposed Effluent Force Main from the Madison Metropolitan Sewerage District Plant to the City of Verona, Wisconsin dated September, 1995. This report was prepared by Phil Salkin in response to a District request to review archaeological impact of a potential force main route.

The District is anticipating that a force main along the route chosen might be constructed beginning in 1996 through 1997. If you have any additional questions relative to the report, you can contact Mr. Salkin directly.

Sincerely,

James L. Nemke
Chief Engineer and Director

:dms
Enclosures as stated
cc: Phil Salkin
Paul Nelson

SEP 22 1995

metrogro

Archaeological Consulting and Services

102 East Park Lane • Verona, Wisconsin 53593
(608) 845-5585 • (608) 845-9849

Archaeological Consulting and Services

Cultural Resource Management

September 12th, 1995

Mr. Jim Nemke
MMSD
1610 Moorland Rd.
Madison, Wisconsin 53713-3398

RE: Archaeological Survey
Sugar River Basin Effluent Return Project
SHSW 95-0946/DA

Dear Mr. Nemke:

Enclosed please find five copies of the report on the archaeological survey of the proposed effluent force main corridor from the MMSD plant to the city of Verona. As noted in the report, archaeological materials were recovered from only one location in the corridor and another site was found in the vicinity. No significant finds were made and no additional archaeological work is recommended. Two copies of this report and a copy of the state bibliographic form should be submitted to the Wisconsin Historic Preservation Division for their review.

Also enclosed is an invoice. As we did not find very much, the cost of the survey is somewhat below the $7000 minimum fee that we proposed. Please do not hesitate to inquire for additional information or services we may provide. Thank you.

Sincerely,

Philip H. Salkin
Senior Partner

Bibliography of Archeological Reports
Information for Data Entry

SHSW #: 95-0946 County: Dane Acreage: 430

Author/s: Philip H. Salkin

Title of Report: An Archaeological Survey of the Proposed Effluent Force Main from the Madison Metropolitan Sewerage District Plant to the City of Verona, Wisconsin

Date of Report (month and year): September, 1995

Series/Number: ACS 970

Place of Publication: Archaeological Consulting and Services

Quad Map/s (7.5' Series): Verona, Oregon, Madison West and Madison East, Wis. Quads

Legal description of survey area: portions of Sec. 12-14, T6N, R8E, Sec. 1-7, T6N, R9E and Sec. 31, T7N, R10E

Site Information (if applicable):

State Codification Number/s: MMSD Survey Site #1 - site form submitted

For Office Use Only:

Project Name: ______________________

____

Lead Agency: ______________________

Archaeological
Consulting and
Services

REPORTS OF INVESTIGATIONS

AN ARCHAEOLOGICAL SURVEY OF THE PROPOSED EFFLUENT FORCE MAIN FROM THE MADISON METROPOLITAN SEWERAGE DISTRICT PLANT TO THE CITY OF VERONA, WISCONSIN

SEPTEMBER, 1995

REPORT NUMBER

970

PREPARED BY

PHILIP H. SALKIN

ARCHAEOLOGICAL CONSULTING AND SERVICES
102 E. PARK LANE
VERONA, WISCONSIN

PROJECT SUMMARY

Title: An Archaeological Survey of the Proposed Effluent Force Main from the Madison Metropolitan Sewerage District Plant to the City of Verona, Wisconsin

I.D.: ACS 970
95-0946/DA
MMSD P.O. B35404

Principal Investigator: Philip H. Salkin
Archaeological Consulting and Services
102 E. Park Lane
Verona, Wisconsin 53593

Project Personnel: Carl Hendrickson
Ted Waddington
Paula Salkin
Heath Fife

Contractor: Madison Metropolitan Sewerage District
1610 Moorland Road
Madison, Wisconsin 53713-3398

Methods: Literature and Records Search
Pedestrian Survey
Excavation of 313 Shovel Test Units and Various Shovel Probes

Results of the Survey:
Much of the project corridor can be described as highly disturbed or low and marshy. The only Native American site encountered consisted of three pieces of debitage found on the surface of an agricultural field in a line about 210 meters long. Euro-American artifacts were limited to surface finds of recent age or which were not temporally diagnostic.

Recommendations:
No additional archaeological work is recommended for the project corridor as no sites were encountered which might be considered as eligible for the National Register of Historic Places.

Dates of Field Work: August, 1995
Date of Report : September 8th, 1995

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                         * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                 Ver. 3.13 - September 1991

$$$ (PROBLEM TITLES) $$$

CARD TYPE                             QUAL-2E PROGRAM TITLES
TITLE01             BSAUU.IN - Summer, Average, Ultimate FLOW, BODU Simulation
TITLE02             NSWTP DISCHARGE TO BADGER MILL CREEK
TITLE03    NO       CONSERVATIVE MINERAL I        IN
TITLE04    NO       CONSERVATIVE MINERAL II       IN
TITLE05    NO       CONSERVATIVE MINERAL III      IN
TITLE06   YES       TEMPERATURE
TITLE07   YES       BIOCHEMICAL OXYGEN DEMAND (ULTIMATE)
TITLE08   YES       ALGAE AS CHL-A IN UG/L
TITLE09   YES       PHOSPHORUS CYCLE AS P IN MG/L
TITLE10               (ORGANIC-P, DISSOLVED-P)
TITLE11   YES       NITROGEN CYCLE AS N IN MG/L
TITLE12               (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRATE-N)
TITLE13   YES       DISSOLVED OXYGEN IN MG/L
TITLE14    NO       FECAL COLIFORMS IN NO./100 ML
TITLE15   YES       ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l
ENDTITLE

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                    CARD TYPE
LIST DATA INPUT                0.00000                                      0.00000
WRITE OPTIONAL SUMMARY         0.00000                                      0.00000
NO FLOW AUGMENTATION           0.00000                                      0.00000
STEADY STATE                   0.00000                                      0.00000
TRAPEZOIDAL X-SECTIONS         0.00000                                      0.00000
PRINT LCD/SOLAR DATA           0.00000                                      0.00000
PLOT DO AND BOD                0.00000                                      0.00000
FIXED DNSTM COND (YES=1)=      0.00000       5D-ULT BOD CONV K COEF  =      0.23000
INPUT METRIC (YES=1)     =     0.00000       OUTPUT METRIC (YES=1)   =      0.00000
NUMBER OF REACHES        =     7.00000       NUMBER OF JUNCTIONS     =      1.00000
NUM OF HEADWATERS        =     2.00000       NUMBER OF POINT LOADS   =      0.00000
TIME STEP (HOURS)        =     1.00000       LNTH  COMP  ELEMENT (DX)=      0.10000
MAXIMUM ROUTE TIME (HRS)=    288.00000       TIME INC. FOR RPT2 (HRS)=      1.00000
LATITUDE OF BASIN (DEG) =     43.10000       LONGITUDE OF BASIN (DEG)=     89.30000
STANDARD MERIDIAN (DEG) =     75.00000       DAY OF YEAR START TIME  =    203.00000
EVAP. COEFF. (AE)        =     0.00068       EVAP. COEFF. (BE)       =      0.00027
ELEV. OF BASIN (ELEV)    =   937.00000       DUST ATTENUATION COEF.  =      0.06000
ENDATA1                        0.00000                                      0.00000

$$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                          CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.5000         O UPTAKE BY NO2 OXID(MG O/MG N)=     1.2000
O PROD  BY ALGAE (MG O/MG A)   =    1.6000         O UPTAKE BY ALGAE (MG O/MG A)  =     2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0850         P CONTENT OF ALGAE (MG P/MG A) =     0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000         ALGAE RESPIRATION RATE (1/DAY) =     0.1000
N HALF SATURATION CONST  (MG/L)=    0.3000         P HALF SATURATION CONST  (MG/L)=     0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)    0.0088         NLIN SHADE(1/FT-(UGCHA/L)**2/3)=     0.0540
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000         LIGHT SAT'N COEF (BTU/FT2-MIN) =     0.0300
DAILY AVERAGING OPTION (LAVOPT)=    1.0000         LIGHT AVERAGING FACTOR (AFACT) =     0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =   16.0000         TOTAL DAILY SOLR RAD (BTU/FT-2)=   400.0000
ALGY GROWTH CALC OPTION(LGROPT)=    1.0000         ALGAL PREF FOR NH3-N (PREFN)   =     0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.4500         NITRIFICATION INHIBITION COEF  =     0.6000
ENDATA1A                            0.0000                                              0.0000

$$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE      RATE CODE      THETA VALUE

THETA( 1)      BOD DECA         1.047     DFLT
THETA( 2)      BOD SETT         1.024     DFLT
THETA( 3)      OXY TRAN         1.024     DFLT
THETA( 4)      SOD RATE         1.060     DFLT
THETA( 5)      ORGN DEC         1.047     DFLT
THETA( 6)      ORGN SET         1.024     DFLT
THETA( 7)      NH3 DECA         1.083     DFLT
THETA( 8)      NH3 SRCE         1.074     DFLT
THETA( 9)      NO2 DECA         1.047     DFLT
THETA(10)      PORG DEC         1.047     DFLT
THETA(11)      PORG SET         1.024     DFLT
THETA(12)      DISP SRC         1.074     DFLT
THETA(13)      ALG GROW         1.047     DFLT
THETA(14)      ALG RESP         1.047     DFLT
THETA(15)      ALG SETT         1.024     DFLT
THETA(16)      COLI DEC         1.047     DFLT
THETA(17)      ANC DECA         1.000     DFLT
THETA(18)      ANC SETT         1.024     DFLT
THETA(19)      ANC SRCE         1.000     DFLT
ENDATA1B

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE          REACH ORDER AND IDENT                   R. MI/KM              R. MI/KM
STREAM REACH     1.0  RCH= HWY 151-PB          FROM        10.0     TO             9.4
STREAM REACH     2.0  RCH= PB-Lincoln          FROM         9.4     TO             8.4
STREAM REACH     3.0  RCH= Lincoln-151 By      FROM         8.4     TO             7.0
STREAM REACH     4.0  RCH= 151 By-HWY 69       FROM         7.0     TO             6.1
STREAM REACH     5.0  RCH= HWY 69-Sugar R      FROM         6.1     TO             5.4
STREAM REACH     6.0  RCH= Upstrm Sugar R      FROM         5.6     TO             5.4
STREAM REACH     7.0  RCH= Dnstrm Sugar R      FROM         5.4     TO             3.4
ENDATA2          0.0                                        0.0                    0.0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE                     REACH   AVAIL HDWS  TARGET    ORDER OF AVAIL SOURCES
ENDATA3                        0.        0.        0.0   0.   0.   0.   0.   0.   0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE        REACH ELEMENTS/REACH                 COMPUTATIONAL FLAGS
FLAG FIELD        1.        6.          1.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        2.       10.          2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD        3.       14.          2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
```

FLAG FIELD	4.	9.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	7.	2.2.2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	2.	1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	20.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	SS1	SS2	WIDTH	SLOPE	CHANN
HYDRAULICS	1.	6.00	4.500	13.200	15.000	0.003	0.050
HYDRAULICS	2.	6.00	2.000	1.400	15.000	0.001	0.060
HYDRAULICS	3.	6.00	2.900	4.900	6.000	0.001	0.040
HYDRAULICS	4.	6.00	0.450	10.000	20.000	0.003	0.040
HYDRAULICS	5.	6.00	9.400	5.600	13.000	0.002	0.035
HYDRAULICS	6.	6.00	0.000	0.000	32.000	0.001	0.035
HYDRAULICS	7.	6.00	0.000	0.000	32.000	0.001	0.035
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	950.00	0.13	0.10	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	2.	945.00	0.13	0.10	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	3.	935.00	0.13	0.20	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	4.	925.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	5.	915.00	0.13	0.00	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	6.	910.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
TEMP/LCD	7.	910.00	0.13	0.05	54.50	44.60	29.10	11.90	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF OR FOR OPT 8	EXPQK2 SLOPE FOR OPT 8
REACT COEF	1.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	2.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	3.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	4.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	5.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	6.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
REACT COEF	7.	0.80	0.00	0.000	8.	0.00	0.110	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	2.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	3.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	4.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	5.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	6.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
N AND P COEF	7.	0.25	0.10	1.00	0.00	1.00	0.20	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	2.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	3.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	4.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	5.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	6.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ALG/OTHER COEF	7.	50.00	0.10	0.01	1.20	0.00	0.20	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	2.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	3.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	4.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	5.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	6.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INITIAL COND-1	7.	68.00	7.00	4.00	0.00	0.00	0.00	5.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	6.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INITIAL COND-2	7.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.390	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	2.	0.650	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	3.	0.910	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	4.	0.590	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	5.	0.460	63.30	7.00	4.00	0.00	0.00	0.00	5.00	0.00
INCR INFLOW-1	6.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	7.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P

INCR INFLOW-2	1.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	2.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	3.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	4.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	5.	2.70	0.62	0.12	0.00	2.30	0.00	0.13
INCR INFLOW-2	6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-2	7.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC=Sugar R Confluen	46.	49.	48.
ENDATA9	0.		0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	NSWTPOutfall	5.60	65.90	6.00	5.13	0.00	0.00	0.00
HEADWTR-1	2.	Sugar River	18.00	63.30	7.00	4.00	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	6.10	0.00	0.00	0.50	0.25	0.00	1.00	0.00	0.89
HEADWTR-2	2.	5.00	0.00	2.70	0.62	0.12	0.00	2.30	0.00	0.13
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
ENDATA11A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

	DAM	RCH	ELE	ADAM	BDAM	FDAM	HDAM
ENDATA12	0.	0.	0.	0.00	0.00	0.00	0.00

$$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

CARD TYPE	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI

ENDATA13 DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P

ENDATA13A DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED

STEADY STATE TEMPERATURE SIMULATION; CONVERGENCE SUMMARY:

ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
1	68
2	3
3	0

TEMPERATURE ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.82	63.82	62.89	62.03	61.23	60.49														
2	59.85	59.29	58.77	58.28	57.81	57.38	56.97	56.59	56.22	55.88										
3	55.65	55.51	55.37	55.23	55.10	54.98	54.85	54.74	54.63	54.52	54.42	54.31	54.22	54.12						
4	53.97	53.68	53.41	53.15	52.91	52.68	52.47	52.27	52.08											
5	51.94	51.83	51.72	51.62	51.53	51.44	51.36													
6	62.79	62.30																		
7	58.55	58.30	58.05	57.81	57.57	57.34	57.12	56.89	56.68	56.46	56.26	56.05	55.85	55.65	55.46	55.27	55.09	54.91	54.73	54.55

1 68

TEMPERATURE ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.82	63.81	62.87	62.00	61.18	60.41														
2	59.76	59.18	58.63	58.11	57.62	57.15	56.71	56.29	55.90	55.52										
3	55.27	55.10	54.94	54.79	54.64	54.50	54.36	54.23	54.10	53.97	53.85	53.73	53.61	53.50						
4	53.32	52.98	52.66	52.35	52.06	51.78	51.52	51.27	51.03											
5	50.85	50.70	50.57	50.43	50.31	50.19	50.07													
6	62.79	62.28																		
7	58.12	57.86	57.60	57.35	57.10	56.86	56.62	56.39	56.16	55.93	55.71	55.49	55.27	55.06	54.85	54.65	54.45	54.25	54.05	53.86

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TEMPERATURE ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.82	63.81	62.87	62.00	61.18	60.41														
2	59.76	59.18	58.63	58.11	57.62	57.15	56.71	56.29	55.90	55.52										
3	55.26	55.10	54.94	54.79	54.64	54.50	54.36	54.22	54.09	53.97	53.85	53.73	53.61	53.50						
4	53.32	52.98	52.66	52.35	52.06	51.78	51.52	51.27	51.03											
5	50.85	50.70	50.57	50.43	50.31	50.18	50.07													
6	62.79	62.28																		
7	58.11	57.86	57.60	57.35	57.10	56.86	56.62	56.39	56.16	55.93	55.71	55.49	55.27	55.06	54.85	54.65	54.45	54.25	54.05	53.86

3 0

SUMMARY OF VALUES FOR STEADY STATE TEMPERATURE CALCULATIONS (SUBROUTINE HEATER):

DAILY NET SOLAR RADIATION = 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS = 14.7

HOURLY VALUES OF SOLAR RADIATION (BTU/FT-2)

1	0.00	9	0.00	17	0.00
2	0.00	10	0.00	18	0.00
3	0.00	11	0.00	19	0.00
4	0.00	12	0.00	20	0.00
5	0.00	13	0.00	21	0.00
6	0.00	14	0.00	22	0.00
7	0.00	15	0.00	23	0.00
8	0.00	16	0.00	24	0.00

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.09	5.04	5.00	4.97	4.93	4.89														
2	4.85	4.81	4.76	4.72	4.68	4.64	4.60	4.57	4.53	4.50										
3	4.47	4.45	4.42	4.40	4.38	4.36	4.34	4.32	4.30	4.28	4.26	4.24	4.22	4.21						
4	4.19	4.17	4.16	4.14	4.13	4.11	4.10	4.08	4.07											
5	4.05	4.04	4.03	4.01	4.00	3.99	3.98													
6	3.98	3.96																		
7	3.95	3.94	3.92	3.91	3.89	3.88	3.87	3.85	3.84	3.82	3.81	3.80	3.78	3.77	3.75	3.74	3.73	3.71	3.70	3.69

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.08	6.06	6.04	6.01	5.99	5.98														
2	5.95	5.93	5.91	5.89	5.87	5.85	5.83	5.81	5.79	5.77										
3	5.75	5.74	5.73	5.71	5.70	5.69	5.67	5.66	5.65	5.63	5.62	5.61	5.60	5.59						
4	5.58	5.57	5.55	5.54	5.53	5.52	5.51	5.50	5.49											
5	5.48	5.48	5.47	5.46	5.45	5.44	5.43													
6	4.99	4.99																		

7	5.13	5.12	5.12	5.11	5.10	5.10	5.09	5.09	5.08	5.08	5.07	5.07	5.06	5.06	5.05	5.04	5.04	5.03	5.03	5.02

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

ALGAE AS CHL-A IN UG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.03	0.06	0.09	0.12	0.15	0.17														
2	0.20	0.23	0.25	0.28	0.30	0.33	0.35	0.37	0.39	0.41										
3	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.59	0.61	0.63	0.65	0.66	0.68						
4	0.70	0.71	0.73	0.74	0.76	0.77	0.79	0.80	0.82											
5	0.83	0.84	0.86	0.87	0.88	0.90	0.91													
6	2.70	2.69																		
7	2.11	2.11	2.11	2.11	2.10	2.10	2.10	2.10	2.09	2.09	2.09	2.09	2.08	2.08	2.08	2.08	2.08	2.07	2.07	2.07

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.87	0.86	0.86	0.85	0.84														
2	0.83	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77										
3	0.76	0.76	0.75	0.75	0.74	0.74	0.73	0.72	0.72	0.71	0.71	0.70	0.70	0.69						
4	0.69	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.65											
5	0.65	0.64	0.64	0.64	0.63	0.63	0.62													
6	0.13	0.13																		
7	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29

ORGANIC NITROGEN AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.50														
2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50										
3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50						
4	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50											
5	0.50	0.50	0.50	0.50	0.50	0.50	0.50													
6	0.62	0.62																		
7	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.56

AMMONIA AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.25	0.25	0.24	0.24	0.24	0.24														
2	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.22	0.22										
3	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21						
4	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20											
5	0.20	0.20	0.20	0.20	0.20	0.20	0.19													
6	0.12	0.12																		
7	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

NITRITE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.01	0.01	0.01														
2	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02										
3	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03						
4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03											
5	0.03	0.03	0.03	0.03	0.03	0.03	0.03													
6	0.00	0.00																		
7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.01	1.03	1.04	1.06	1.07	1.08														
2	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.21										
3	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.29	1.30	1.31	1.32	1.33	1.34						
4	1.35	1.36	1.36	1.37	1.38	1.39	1.39	1.40	1.41											
5	1.42	1.42	1.43	1.44	1.44	1.45	1.46													
6	2.30	2.30																		
7	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03

DISSOLVED OXYGEN IN MG/L — ITERATION 1

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.30	6.57	6.82	7.06	7.27	7.47														
2	7.59	7.62	7.66	7.69	7.72	7.76	7.79	7.83	7.87	7.90										
3	7.95	7.99	8.03	8.07	8.11	8.15	8.19	8.22	8.26	8.30	8.33	8.36	8.40	8.43						
4	8.54	8.72	8.88	9.03	9.17	9.29	9.41	9.51	9.61											
5	9.68	9.72	9.75	9.79	9.82	9.85	9.88													
6	7.06	7.12																		
7	8.06	8.10	8.14	8.19	8.23	8.27	8.31	8.36	8.40	8.44	8.48	8.52	8.56	8.59	8.63	8.67	8.71	8.75	8.78	8.82

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	0
NITRIFICATION INHIBITION	1	66
ALGAE GROWTH RATE	2	0
NITRIFICATION INHIBITION	2	63
ALGAE GROWTH RATE	3	0
NITRIFICATION INHIBITION	3	11
ALGAE GROWTH RATE	4	0
NITRIFICATION INHIBITION	4	0
ALGAE GROWTH RATE	5	0
NITRIFICATION INHIBITION	5	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:
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1. LIGHT AVERAGING OPTION. LAVOPT= 1

METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

SOURCE OF SOLAR VALUES: SUBROUTINE HEATER (SS TEMP)
DAILY NET SOLAR RADIATION: 0.000 BTU/FT-2 (0.000 LANGLEYS)
NUMBER OF DAYLIGHT HOURS: 14.7
PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): 0.45
MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.920

2. LIGHT FUNCTION OPTION: LFNOPT= 1

HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.008 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS. LGROPT= 1

MULTIPLICATIVE: FL*FN*FP

TEMPERATURE — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	64.82	63.81	62.87	62.00	61.18	60.41														
2	59.76	59.18	58.63	58.11	57.62	57.15	56.71	56.29	55.90	55.52										
3	55.26	55.10	54.94	54.79	54.64	54.50	54.36	54.22	54.09	53.97	53.85	53.73	53.61	53.50						
4	53.32	52.98	52.66	52.35	52.06	51.78	51.52	51.27	51.03											
5	50.85	50.70	50.57	50.43	50.31	50.18	50.07													
6	62.79	62.28																		
7	58.11	57.86	57.60	57.35	57.10	56.86	56.62	56.39	56.16	55.93	55.71	55.49	55.27	55.06	54.85	54.65	54.45	54.25	54.05	53.86

DISSOLVED OXYGEN IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.30	6.57	6.82	7.06	7.27	7.47														
2	7.59	7.62	7.66	7.69	7.72	7.76	7.79	7.83	7.87	7.90										
3	7.95	7.99	8.03	8.07	8.11	8.15	8.19	8.22	8.26	8.30	8.33	8.36	8.40	8.43						
4	8.54	8.72	8.88	9.03	9.17	9.29	9.41	9.51	9.61											
5	9.68	9.72	9.75	9.79	9.82	9.85	9.88													
6	7.06	7.12																		
7	8.06	8.10	8.14	8.19	8.23	8.27	8.31	8.35	8.40	8.44	8.48	8.52	8.56	8.59	8.63	8.67	8.71	8.75	8.78	8.82

BIOCHEMICAL OXYGEN DEMAND (ULTIMATE) — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5.09	5.04	5.00	4.97	4.93	4.89														
2	4.85	4.81	4.76	4.72	4.68	4.64	4.60	4.57	4.53	4.50										
3	4.47	4.45	4.42	4.40	4.38	4.36	4.34	4.32	4.30	4.28	4.26	4.24	4.22	4.21						
4	4.19	4.17	4.16	4.14	4.13	4.11	4.10	4.08	4.07											
5	4.05	4.04	4.03	4.01	4.00	3.99	3.98													
6	3.98	3.96																		
7	3.95	3.94	3.92	3.91	3.89	3.88	3.87	3.85	3.84	3.82	3.81	3.80	3.78	3.77	3.75	3.74	3.73	3.71	3.70	3.69

ORGANIC NITROGEN AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.50	0.50	0.50	0.50	0.50	0.50														
2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50										
3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50						
4	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50											
5	0.50	0.50	0.50	0.50	0.50	0.50	0.50													
6	0.62	0.62																		
7	0.58	0.58	0.58	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.56

AMMONIA AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.25	0.25	0.24	0.24	0.24	0.24														
2	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.22	0.22										
3	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21						
4	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20											
5	0.20	0.20	0.20	0.20	0.20	0.20	0.19													
6	0.12	0.12																		
7	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

NITRITE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.01	0.01	0.01														
2	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02										
3	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03						
4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03											
5	0.03	0.03	0.03	0.03	0.03	0.03	0.03													
6	0.00	0.00																		
7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

NITRATE AS N IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.01	1.03	1.04	1.06	1.07	1.08														
2	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.21										
3	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.29	1.30	1.31	1.32	1.33	1.34						
4	1.35	1.36	1.36	1.37	1.38	1.39	1.39	1.40	1.41											
5	1.42	1.42	1.43	1.44	1.44	1.45	1.46													
6	2.30	2.30																		
7	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03

ORGANIC PHOSPHORUS AS P IN MG/L — ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.88	0.87	0.86	0.86	0.85	0.84														
2	0.83	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77										
3	0.76	0.76	0.75	0.75	0.74	0.74	0.73	0.72	0.72	0.71	0.71	0.70	0.70	0.69						
4	0.69	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.65											
5	0.65	0.64	0.64	0.64	0.63	0.63	0.62													
6	0.13	0.13																		
7	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29

ALGAE AS CHL-A IN UG/L ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.03	0.06	0.09	0.12	0.15	0.17														
2	0.20	0.23	0.25	0.28	0.30	0.33	0.35	0.37	0.39	0.41										
3	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.59	0.61	0.63	0.65	0.66	0.68						
4	0.70	0.71	0.73	0.74	0.76	0.77	0.79	0.80	0.82											
5	0.83	0.84	0.86	0.87	0.88	0.90	0.91													
6	2.70	2.69																		
7	2.11	2.11	2.11	2.11	2.10	2.10	2.10	2.10	2.09	2.09	2.09	2.09	2.08	2.08	2.08	2.08	2.08	2.07	2.07	2.07

ARBITRARY NON-CONSERVATIVE Total Suspended Solids (TSS,mg/l ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6.08	6.06	6.04	6.01	5.99	5.98														
2	5.95	5.93	5.91	5.89	5.87	5.85	5.83	5.81	5.79	5.77										
3	5.75	5.74	5.73	5.71	5.70	5.69	5.67	5.66	5.65	5.63	5.62	5.61	5.60	5.59						
4	5.58	5.57	5.55	5.54	5.53	5.52	5.51	5.50	5.49											
5	5.48	5.48	5.47	5.46	5.45	5.44	5.43													
6	4.99	4.99																		
7	5.13	5.12	5.12	5.11	5.10	5.10	5.09	5.09	5.08	5.08	5.07	5.07	5.06	5.06	5.05	5.04	5.04	5.03	5.03	5.02

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 10

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00														
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00													
6	0.00	0.00																		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC MILE	END LOC MILE	FLOW CFS	POINT SRCE CFS	INCR FLOW CFS	VEL FPS	TRVL TIME DAY	DEPTH FT	WIDTH FT	VOLUME K-FT-3	BOTTOM AREA K-FT-2	X-SECT AREA FT-2	DSPRSN COEF FT-2/S
1	1	1	10.00	9.90	5.66	0.00	0.06	0.742	0.008	0.410	18.629	4.03	11.78	7.64	0.40
2	1	2	9.90	9.80	5.73	0.00	0.06	0.744	0.008	0.413	18.653	4.06	11.81	7.70	0.41
3	1	3	9.80	9.70	5.80	0.00	0.06	0.747	0.008	0.415	18.676	4.10	11.83	7.76	0.41
4	1	4	9.70	9.60	5.86	0.00	0.06	0.750	0.008	0.418	18.699	4.13	11.86	7.82	0.42
5	1	5	9.60	9.50	5.93	0.00	0.06	0.752	0.008	0.421	18.722	4.16	11.88	7.87	0.42
6	1	6	9.50	9.40	5.99	0.00	0.06	0.755	0.008	0.423	18.745	4.19	11.91	7.93	0.42
7	2	1	9.40	9.30	6.06	0.00	0.06	0.525	0.012	0.712	16.211	6.10	9.41	11.54	0.54
8	2	2	9.30	9.20	6.12	0.00	0.06	0.526	0.012	0.717	16.228	6.14	9.42	11.63	0.55
9	2	3	9.20	9.10	6.19	0.00	0.06	0.528	0.012	0.721	16.235	6.18	9.43	11.71	0.55
10	2	4	9.10	9.00	6.25	0.00	0.06	0.530	0.012	0.726	16.242	6.22	9.44	11.79	0.56
11	2	5	9.00	8.90	6.32	0.00	0.06	0.532	0.011	0.730	16.249	6.26	9.45	11.86	0.56
12	2	6	8.90	8.80	6.38	0.00	0.06	0.534	0.011	0.735	16.256	6.30	9.46	11.94	0.57
13	2	7	8.80	8.70	6.45	0.00	0.06	0.536	0.011	0.739	16.263	6.35	9.46	12.02	0.57
14	2	8	8.70	8.60	6.51	0.00	0.06	0.538	0.011	0.743	16.270	6.39	9.47	12.10	0.58
15	2	9	8.60	8.50	6.58	0.00	0.06	0.540	0.011	0.748	16.277	6.43	9.48	12.17	0.58
16	2	10	8.50	8.40	6.64	0.00	0.06	0.542	0.011	0.752	16.284	6.47	9.49	12.25	0.59
17	3	1	8.40	8.30	6.71	0.00	0.07	0.849	0.007	0.848	9.309	4.17	6.78	7.90	0.68
18	3	2	8.30	8.20	6.77	0.00	0.07	0.852	0.007	0.852	9.326	4.20	6.80	7.95	0.68
19	3	3	8.20	8.10	6.84	0.00	0.07	0.854	0.007	0.857	9.342	4.23	6.82	8.00	0.69
20	3	4	8.10	8.00	6.90	0.00	0.07	0.856	0.007	0.861	9.359	4.25	6.84	8.06	0.69
21	3	5	8.00	7.90	6.97	0.00	0.07	0.859	0.007	0.865	9.375	4.28	6.85	8.11	0.70
22	3	6	7.90	7.80	7.03	0.00	0.07	0.861	0.007	0.870	9.392	4.31	6.87	8.17	0.70
23	3	7	7.80	7.70	7.10	0.00	0.07	0.863	0.007	0.874	9.408	4.34	6.89	8.22	0.71
24	3	8	7.70	7.60	7.16	0.00	0.07	0.865	0.007	0.878	9.424	4.37	6.91	8.27	0.71
25	3	9	7.60	7.50	7.23	0.00	0.07	0.868	0.007	0.882	9.440	4.40	6.93	8.33	0.72
26	3	10	7.50	7.40	7.29	0.00	0.07	0.870	0.007	0.886	9.457	4.42	6.94	8.38	0.72
27	3	11	7.40	7.30	7.36	0.00	0.07	0.872	0.007	0.890	9.473	4.45	6.96	8.43	0.73
28	3	12	7.30	7.20	7.42	0.00	0.07	0.874	0.007	0.894	9.488	4.48	6.98	8.49	0.73
29	3	13	7.20	7.10	7.49	0.00	0.07	0.877	0.007	0.898	9.504	4.51	7.00	8.54	0.74
30	3	14	7.10	7.00	7.55	0.00	0.07	0.879	0.007	0.903	9.520	4.54	7.01	8.59	0.74
31	4	1	7.00	6.90	7.62	0.00	0.07	0.935	0.007	0.371	21.939	4.30	12.74	8.14	0.38
32	4	2	6.90	6.80	7.68	0.00	0.07	0.938	0.007	0.373	21.949	4.32	12.76	8.19	0.38
33	4	3	6.80	6.70	7.75	0.00	0.07	0.941	0.006	0.375	21.959	4.35	12.77	8.23	0.38
34	4	4	6.70	6.60	7.81	0.00	0.07	0.944	0.006	0.377	21.968	4.37	12.78	8.28	0.38
35	4	5	6.60	6.50	7.88	0.00	0.07	0.947	0.006	0.379	21.978	4.39	12.79	8.32	0.39
36	4	6	6.50	6.40	7.94	0.00	0.07	0.950	0.006	0.380	21.988	4.42	12.80	8.36	0.39
37	4	7	6.40	6.30	8.01	0.00	0.07	0.952	0.006	0.382	21.997	4.44	12.81	8.41	0.39
38	4	8	6.30	6.20	8.07	0.00	0.07	0.955	0.006	0.384	22.007	4.46	12.82	8.45	0.39
39	4	9	6.20	6.10	8.14	0.00	0.07	0.958	0.006	0.386	22.016	4.49	12.83	8.50	0.40
40	5	1	6.10	6.00	8.21	0.00	0.07	0.986	0.006	0.497	16.734	4.39	10.84	8.32	0.44
41	5	2	6.00	5.90	8.27	0.00	0.07	0.989	0.006	0.499	16.750	4.42	10.86	8.37	0.44
42	5	3	5.90	5.80	8.34	0.00	0.07	0.991	0.006	0.502	16.767	4.44	10.88	8.41	0.45
43	5	4	5.80	5.70	8.40	0.00	0.07	0.994	0.006	0.504	16.783	4.47	10.89	8.46	0.45
44	5	5	5.70	5.60	8.47	0.00	0.07	0.996	0.006	0.506	16.799	4.49	10.91	8.50	0.45
45	5	6	5.60	5.50	8.53	0.00	0.07	0.999	0.006	0.508	16.816	4.51	10.93	8.55	0.46
46	5	7	5.50	5.40	8.60	0.00	0.07	1.001	0.006	0.510	16.832	4.54	10.95	8.59	0.46
47	6	1	5.60	5.50	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
48	6	2	5.50	5.40	18.00	0.00	0.00	0.838	0.007	0.671	32.000	11.34	17.60	21.48	0.48
49	7	1	5.40	5.30	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
50	7	2	5.30	5.20	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
51	7	3	5.20	5.10	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
52	7	4	5.10	5.00	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
53	7	5	5.00	4.90	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
54	7	6	4.90	4.80	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
55	7	7	4.80	4.70	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
56	7	8	4.70	4.60	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
57	7	9	4.60	4.50	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
58	7	10	4.50	4.40	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
59	7	11	4.40	4.30	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
60	7	12	4.30	4.20	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
61	7	13	4.20	4.10	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
62	7	14	4.10	4.00	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
63	7	15	4.00	3.90	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
64	7	16	3.90	3.80	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
65	7	17	3.80	3.70	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
66	7	18	3.70	3.60	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
67	7	19	3.60	3.50	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68
68	7	20	3.50	3.40	26.60	0.00	0.00	0.975	0.006	0.852	32.001	14.40	17.80	27.27	0.68

STREAM QUALITY SIMULATION
QUAL-2E STREAM QUALITY ROUTING MODEL

Ver. 3.13 - September 1991

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/F2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/F2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/F2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/F2D
1	1	9.16	8	13.81	0.74	0.00	0.00	0.23	0.10	0.85	0.00	0.90	0.18	0.10	0.00	0.00	0.00	0.19	0.00
1	2	9.27	8	13.64	0.72	0.00	0.00	0.22	0.09	0.81	0.00	0.88	0.18	0.09	0.00	0.00	0.00	0.19	0.00
1	3	9.37	8	13.51	0.70	0.00	0.00	0.22	0.09	0.78	0.00	0.86	0.18	0.09	0.00	0.00	0.00	0.19	0.00
1	4	9.47	8	13.39	0.69	0.00	0.00	0.21	0.09	0.76	0.00	0.85	0.17	0.09	0.00	0.00	0.00	0.18	0.00
1	5	9.56	8	13.28	0.67	0.00	0.00	0.21	0.09	0.73	0.00	0.83	0.17	0.09	0.00	0.00	0.00	0.18	0.00
1	6	9.65	8	13.18	0.66	0.00	0.00	0.21	0.09	0.71	0.00	0.81	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	1	9.72	8	8.12	0.65	0.00	0.00	0.20	0.09	0.69	0.00	0.80	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	2	9.79	8	3.13	0.64	0.00	0.00	0.20	0.09	0.67	0.00	0.79	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	3	9.85	8	3.12	0.63	0.00	0.00	0.20	0.09	0.65	0.00	0.78	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	4	9.92	8	3.10	0.62	0.00	0.00	0.19	0.09	0.64	0.00	0.77	0.16	0.09	0.00	0.00	0.00	0.18	0.00
2	5	9.98	8	3.09	0.61	0.00	0.00	0.19	0.09	0.62	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	6	10.03	8	3.09	0.61	0.00	0.00	0.19	0.09	0.61	0.00	0.75	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	7	10.09	8	3.08	0.60	0.00	0.00	0.19	0.09	0.60	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	8	10.14	8	3.07	0.59	0.00	0.00	0.19	0.09	0.59	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	9	10.19	8	3.06	0.59	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
2	10	10.23	8	3.06	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.15	0.08	0.00	0.00	0.00	0.17	0.00
3	1	10.27	8	3.75	0.58	0.00	0.00	0.18	0.08	0.56	0.00	0.72	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	2	10.29	8	4.43	0.58	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	3	10.31	8	4.43	0.57	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	4	10.33	8	4.43	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	5	10.35	8	4.43	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	6	10.37	8	4.43	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	7	10.38	8	4.43	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	8	10.40	8	4.42	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	9	10.42	8	4.42	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	10	10.44	8	4.42	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	11	10.45	8	4.42	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	12	10.47	8	4.42	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	13	10.48	8	4.42	0.55	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
3	14	10.50	8	4.42	0.55	0.00	0.00	0.17	0.08	0.52	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00
4	1	10.52	8	10.91	0.55	0.00	0.00	0.17	0.08	0.52	0.00	0.68	0.14	0.08	0.00	0.00	0.00	0.16	0.00
4	2	10.57	8	17.36	0.55	0.00	0.00	0.17	0.08	0.51	0.00	0.68	0.14	0.08	0.00	0.00	0.00	0.16	0.00
4	3	10.61	8	17.33	0.54	0.00	0.00	0.17	0.08	0.50	0.00	0.67	0.14	0.08	0.00	0.00	0.00	0.16	0.00
4	4	10.65	8	17.30	0.54	0.00	0.00	0.17	0.08	0.50	0.00	0.67	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	5	10.69	8	17.28	0.53	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	6	10.73	8	17.26	0.53	0.00	0.00	0.17	0.08	0.49	0.00	0.66	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	7	10.77	8	17.24	0.53	0.00	0.00	0.16	0.08	0.48	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	8	10.80	8	17.22	0.52	0.00	0.00	0.16	0.08	0.47	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
4	9	10.84	8	17.21	0.52	0.00	0.00	0.16	0.08	0.47	0.00	0.65	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	1	10.86	8	13.71	0.52	0.00	0.00	0.16	0.08	0.47	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	2	10.88	8	10.23	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	3	10.90	8	10.22	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	4	10.92	8	10.22	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.64	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	5	10.94	8	10.22	0.51	0.00	0.00	0.16	0.08	0.46	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	6	10.96	8	10.22	0.51	0.00	0.00	0.16	0.08	0.45	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
5	7	10.97	8	10.23	0.51	0.00	0.00	0.16	0.08	0.45	0.00	0.63	0.13	0.08	0.00	0.00	0.00	0.16	0.00
6	1	9.38	8	4.93	0.70	0.00	0.00	0.22	0.09	0.78	0.00	0.86	0.18	0.09	0.00	0.00	0.00	0.19	0.00
6	2	9.44	8	4.89	0.69	0.00	0.00	0.22	0.09	0.77	0.00	0.85	0.17	0.09	0.00	0.00	0.00	0.19	0.00
7	1	9.91	8	6.66	0.62	0.00	0.00	0.19	0.09	0.64	0.00	0.77	0.16	0.09	0.00	0.00	0.00	0.18	0.00
7	2	9.95	8	5.30	0.62	0.00	0.00	0.19	0.09	0.63	0.00	0.77	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	3	9.98	8	5.28	0.61	0.00	0.00	0.19	0.09	0.63	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	4	10.01	8	5.26	0.61	0.00	0.00	0.19	0.09	0.62	0.00	0.76	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	5	10.04	8	5.24	0.61	0.00	0.00	0.19	0.09	0.61	0.00	0.75	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	6	10.07	8	5.23	0.60	0.00	0.00	0.19	0.09	0.61	0.00	0.75	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	7	10.10	8	5.21	0.60	0.00	0.00	0.19	0.09	0.60	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	8	10.13	8	5.20	0.59	0.00	0.00	0.19	0.09	0.59	0.00	0.74	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	9	10.15	8	5.18	0.59	0.00	0.00	0.18	0.09	0.59	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	10	10.18	8	5.16	0.59	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	11	10.21	8	5.15	0.58	0.00	0.00	0.18	0.09	0.58	0.00	0.73	0.15	0.09	0.00	0.00	0.00	0.17	0.00
7	12	10.24	8	5.13	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.15	0.08	0.00	0.00	0.00	0.17	0.00
7	13	10.27	8	5.12	0.58	0.00	0.00	0.18	0.08	0.57	0.00	0.72	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	14	10.29	8	5.11	0.57	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	15	10.32	8	5.09	0.57	0.00	0.00	0.18	0.08	0.56	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	16	10.35	8	5.08	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.71	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	17	10.37	8	5.06	0.57	0.00	0.00	0.18	0.08	0.55	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	18	10.40	8	5.05	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	19	10.43	8	5.04	0.56	0.00	0.00	0.18	0.08	0.54	0.00	0.70	0.14	0.08	0.00	0.00	0.00	0.17	0.00
7	20	10.45	8	5.02	0.56	0.00	0.00	0.17	0.08	0.53	0.00	0.69	0.14	0.08	0.00	0.00	0.00	0.17	0.00

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-F	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC Tota spen	CHLA UG/L
1	1	64.82	0.00	0.00	0.00	6.30	5.09	0.50	0.25	0.00	1.01	1.76	0.00	0.88	0.88	0.00	6.08	0.03
1	2	63.81	0.00	0.00	0.00	6.57	5.04	0.50	0.25	0.00	1.03	1.78	0.00	0.87	0.87	0.00	6.06	0.06
1	3	62.87	0.00	0.00	0.00	6.82	5.00	0.50	0.24	0.00	1.04	1.79	0.00	0.86	0.86	0.00	6.04	0.09
1	4	62.00	0.00	0.00	0.00	7.06	4.97	0.50	0.24	0.01	1.06	1.81	0.00	0.86	0.86	0.00	6.01	0.12
1	5	61.18	0.00	0.00	0.00	7.27	4.93	0.50	0.24	0.01	1.07	1.82	0.00	0.85	0.85	0.00	5.99	0.15
1	6	60.41	0.00	0.00	0.00	7.47	4.89	0.50	0.24	0.01	1.08	1.83	0.00	0.84	0.84	0.00	5.98	0.17
2	1	59.76	0.00	0.00	0.00	7.59	4.85	0.50	0.24	0.01	1.10	1.84	0.00	0.83	0.83	0.00	5.95	0.20
2	2	59.18	0.00	0.00	0.00	7.62	4.81	0.50	0.23	0.01	1.11	1.86	0.00	0.83	0.83	0.00	5.93	0.23
2	3	58.63	0.00	0.00	0.00	7.66	4.76	0.50	0.23	0.01	1.12	1.87	0.00	0.82	0.82	0.00	5.91	0.25
2	4	58.11	0.00	0.00	0.00	7.69	4.72	0.50	0.23	0.01	1.14	1.88	0.00	0.81	0.81	0.00	5.89	0.28
2	5	57.62	0.00	0.00	0.00	7.72	4.68	0.50	0.23	0.02	1.15	1.89	0.00	0.80	0.80	0.00	5.87	0.30
2	6	57.15	0.00	0.00	0.00	7.76	4.64	0.50	0.23	0.02	1.16	1.90	0.00	0.80	0.80	0.00	5.85	0.33
2	7	56.71	0.00	0.00	0.00	7.79	4.60	0.50	0.23	0.02	1.17	1.91	0.00	0.79	0.79	0.00	5.83	0.35
2	8	56.29	0.00	0.00	0.00	7.83	4.57	0.50	0.22	0.02	1.18	1.92	0.00	0.78	0.78	0.00	5.81	0.37
2	9	55.90	0.00	0.00	0.00	7.87	4.53	0.50	0.22	0.02	1.19	1.94	0.00	0.78	0.78	0.00	5.79	0.39
2	10	55.52	0.00	0.00	0.00	7.90	4.50	0.50	0.22	0.02	1.21	1.95	0.00	0.77	0.77	0.00	5.77	0.41
3	1	55.26	0.00	0.00	0.00	7.95	4.47	0.50	0.22	0.02	1.22	1.96	0.00	0.76	0.76	0.00	5.75	0.44
3	2	55.10	0.00	0.00	0.00	7.99	4.45	0.50	0.22	0.02	1.23	1.97	0.00	0.76	0.76	0.00	5.74	0.46
3	3	54.94	0.00	0.00	0.00	8.03	4.42	0.50	0.22	0.02	1.24	1.98	0.00	0.75	0.75	0.00	5.73	0.48
3	4	54.79	0.00	0.00	0.00	8.07	4.40	0.50	0.22	0.02	1.25	1.99	0.00	0.75	0.75	0.00	5.71	0.50
3	5	54.64	0.00	0.00	0.00	8.11	4.38	0.50	0.22	0.02	1.26	1.99	0.00	0.74	0.74	0.00	5.70	0.52
3	6	54.50	0.00	0.00	0.00	8.15	4.36	0.50	0.21	0.03	1.27	2.00	0.00	0.74	0.74	0.00	5.69	0.54
3	7	54.36	0.00	0.00	0.00	8.19	4.34	0.50	0.21	0.03	1.28	2.01	0.00	0.73	0.73	0.00	5.67	0.56
3	8	54.22	0.00	0.00	0.00	8.22	4.32	0.50	0.21	0.03	1.29	2.02	0.00	0.72	0.72	0.00	5.66	0.58
3	9	54.09	0.00	0.00	0.00	8.26	4.30	0.50	0.21	0.03	1.29	2.03	0.00	0.72	0.72	0.00	5.65	0.59
3	10	53.97	0.00	0.00	0.00	8.30	4.28	0.50	0.21	0.03	1.30	2.04	0.00	0.71	0.71	0.00	5.63	0.61
3	11	53.85	0.00	0.00	0.00	8.33	4.26	0.50	0.21	0.03	1.31	2.05	0.00	0.71	0.71	0.00	5.62	0.63
3	12	53.73	0.00	0.00	0.00	8.36	4.24	0.50	0.21	0.03	1.32	2.06	0.00	0.70	0.70	0.00	5.61	0.65
3	13	53.61	0.00	0.00	0.00	8.40	4.22	0.50	0.21	0.03	1.33	2.07	0.00	0.70	0.70	0.00	5.60	0.66
3	14	53.50	0.00	0.00	0.00	8.43	4.21	0.50	0.21	0.03	1.34	2.07	0.00	0.69	0.69	0.00	5.59	0.68
4	1	53.32	0.00	0.00	0.00	8.54	4.19	0.50	0.21	0.03	1.35	2.08	0.00	0.69	0.69	0.00	5.58	0.70
4	2	52.98	0.00	0.00	0.00	8.72	4.17	0.50	0.20	0.03	1.36	2.09	0.00	0.68	0.68	0.00	5.57	0.71
4	3	52.66	0.00	0.00	0.00	8.88	4.16	0.50	0.20	0.03	1.36	2.10	0.00	0.68	0.68	0.00	5.55	0.73
4	4	52.35	0.00	0.00	0.00	9.03	4.14	0.50	0.20	0.03	1.37	2.10	0.00	0.67	0.67	0.00	5.54	0.74
4	5	52.06	0.00	0.00	0.00	9.17	4.13	0.50	0.20	0.03	1.38	2.11	0.00	0.67	0.67	0.00	5.53	0.76
4	6	51.78	0.00	0.00	0.00	9.29	4.11	0.50	0.20	0.03	1.39	2.12	0.00	0.67	0.67	0.00	5.52	0.77
4	7	51.52	0.00	0.00	0.00	9.41	4.10	0.50	0.20	0.03	1.39	2.13	0.00	0.66	0.66	0.00	5.51	0.79
4	8	51.27	0.00	0.00	0.00	9.51	4.08	0.50	0.20	0.03	1.40	2.13	0.00	0.66	0.66	0.00	5.50	0.80
4	9	51.03	0.00	0.00	0.00	9.61	4.07	0.50	0.20	0.03	1.41	2.14	0.00	0.65	0.65	0.00	5.49	0.82
5	1	50.85	0.00	0.00	0.00	9.68	4.05	0.50	0.20	0.03	1.42	2.15	0.00	0.65	0.65	0.00	5.48	0.83
5	2	50.70	0.00	0.00	0.00	9.72	4.04	0.50	0.20	0.03	1.42	2.15	0.00	0.64	0.64	0.00	5.48	0.84
5	3	50.57	0.00	0.00	0.00	9.75	4.03	0.50	0.20	0.03	1.43	2.16	0.00	0.64	0.64	0.00	5.47	0.86
5	4	50.43	0.00	0.00	0.00	9.79	4.01	0.50	0.20	0.03	1.44	2.17	0.00	0.64	0.64	0.00	5.46	0.87
5	5	50.31	0.00	0.00	0.00	9.82	4.00	0.50	0.20	0.03	1.44	2.17	0.00	0.63	0.63	0.00	5.45	0.88
5	6	50.18	0.00	0.00	0.00	9.85	3.99	0.50	0.20	0.03	1.45	2.18	0.00	0.63	0.63	0.00	5.44	0.90
5	7	50.07	0.00	0.00	0.00	9.88	3.98	0.50	0.19	0.03	1.46	2.19	0.00	0.62	0.62	0.00	5.43	0.91
6	1	62.79	0.00	0.00	0.00	7.06	3.98	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.70
6	2	62.28	0.00	0.00	0.00	7.12	3.96	0.62	0.12	0.00	2.30	3.04	0.00	0.13	0.13	0.00	4.99	2.69
7	1	58.11	0.00	0.00	0.00	8.06	3.95	0.58	0.14	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.13	2.11
7	2	57.86	0.00	0.00	0.00	8.10	3.94	0.58	0.14	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.12	2.11
7	3	57.60	0.00	0.00	0.00	8.14	3.92	0.58	0.14	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.12	2.11
7	4	57.35	0.00	0.00	0.00	8.19	3.91	0.58	0.15	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.11	2.11
7	5	57.10	0.00	0.00	0.00	8.23	3.89	0.58	0.15	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.10	2.10
7	6	56.86	0.00	0.00	0.00	8.27	3.88	0.57	0.15	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.10	2.10
7	7	56.62	0.00	0.00	0.00	8.31	3.87	0.57	0.15	0.01	2.03	2.76	0.00	0.29	0.29	0.00	5.09	2.10
7	8	56.39	0.00	0.00	0.00	8.35	3.85	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.09	2.10
7	9	56.16	0.00	0.00	0.00	8.40	3.84	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.08	2.09
7	10	55.93	0.00	0.00	0.00	8.44	3.82	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.08	2.09
7	11	55.71	0.00	0.00	0.00	8.48	3.81	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.07	2.09
7	12	55.49	0.00	0.00	0.00	8.52	3.80	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.07	2.09
7	13	55.27	0.00	0.00	0.00	8.56	3.78	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.06	2.08
7	14	55.06	0.00	0.00	0.00	8.59	3.77	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.06	2.08
7	15	54.85	0.00	0.00	0.00	8.63	3.75	0.57	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.05	2.08
7	16	54.65	0.00	0.00	0.00	8.67	3.74	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.04	2.08
7	17	54.45	0.00	0.00	0.00	8.71	3.73	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.04	2.08
7	18	54.25	0.00	0.00	0.00	8.75	3.71	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.03	2.07
7	19	54.05	0.00	0.00	0.00	8.78	3.70	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.03	2.07
7	20	53.86	0.00	0.00	0.00	8.82	3.69	0.56	0.15	0.02	2.03	2.76	0.00	0.29	0.29	0.00	5.02	2.07

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT FT/DA	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/FT	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
1	1	1	0.03	0.00	0.09	0.10	0.00	0.00	0.90	0.69	0.02	0.00	0.81	0.96
2	1	2	0.06	0.00	0.09	0.09	0.00	0.00	0.90	0.68	0.02	0.00	0.81	0.96
3	1	3	0.09	0.00	0.09	0.09	0.00	0.00	0.90	0.68	0.02	0.00	0.81	0.96
4	1	4	0.12	0.00	0.09	0.09	0.00	0.00	0.90	0.67	0.02	0.00	0.81	0.96
5	1	5	0.15	0.00	0.08	0.09	0.00	0.00	0.90	0.67	0.03	0.00	0.81	0.95
6	1	6	0.17	0.00	0.08	0.09	0.00	0.00	0.90	0.66	0.03	0.00	0.82	0.95
7	2	1	0.20	0.00	0.08	0.09	0.00	0.00	0.90	0.66	0.03	0.00	0.82	0.95
8	2	2	0.23	0.00	0.08	0.09	0.00	0.00	0.90	0.65	0.03	0.00	0.82	0.95
9	2	3	0.25	0.00	0.08	0.09	0.00	0.00	0.90	0.65	0.03	0.00	0.82	0.95
10	2	4	0.28	0.00	0.08	0.09	0.00	0.00	0.90	0.65	0.04	0.00	0.82	0.95
11	2	5	0.30	0.00	0.08	0.09	0.00	0.00	0.90	0.64	0.04	0.00	0.82	0.95
12	2	6	0.33	0.00	0.08	0.09	0.00	0.00	0.90	0.64	0.04	0.00	0.82	0.95
13	2	7	0.35	0.00	0.07	0.09	0.00	0.00	0.90	0.63	0.04	0.00	0.82	0.95
14	2	8	0.37	0.00	0.07	0.09	0.00	0.00	0.90	0.63	0.04	0.00	0.82	0.95
15	2	9	0.39	0.00	0.07	0.09	0.00	0.00	0.90	0.63	0.04	0.00	0.83	0.95
16	2	10	0.41	0.00	0.07	0.08	0.00	0.00	0.90	0.62	0.04	0.00	0.83	0.95
17	3	1	0.44	0.00	0.07	0.08	0.00	0.00	0.90	0.62	0.04	0.00	0.83	0.95
18	3	2	0.46	0.00	0.07	0.08	0.00	0.00	0.90	0.62	0.05	0.00	0.83	0.95
19	3	3	0.48	0.00	0.07	0.08	0.00	0.00	0.90	0.61	0.05	0.00	0.83	0.95
20	3	4	0.50	0.00	0.07	0.08	0.00	0.00	0.90	0.61	0.05	0.00	0.83	0.95
21	3	5	0.52	0.00	0.07	0.08	0.00	0.00	0.90	0.61	0.05	0.00	0.83	0.95
22	3	6	0.54	0.00	0.07	0.08	0.00	0.00	0.90	0.60	0.05	0.00	0.83	0.95
23	3	7	0.56	0.00	0.07	0.08	0.00	0.00	0.90	0.60	0.05	0.00	0.83	0.95
24	3	8	0.58	0.00	0.07	0.08	0.00	0.00	0.90	0.60	0.05	0.00	0.83	0.95
25	3	9	0.59	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.05	0.00	0.83	0.95
26	3	10	0.61	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.05	0.00	0.83	0.95
27	3	11	0.63	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.06	0.00	0.84	0.95
28	3	12	0.65	0.00	0.07	0.08	0.00	0.00	0.90	0.59	0.06	0.00	0.84	0.95
29	3	13	0.66	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.95
30	3	14	0.68	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.95
31	4	1	0.70	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.95
32	4	2	0.71	0.00	0.07	0.08	0.00	0.00	0.90	0.58	0.06	0.00	0.84	0.94
33	4	3	0.73	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
34	4	4	0.74	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
35	4	5	0.76	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
36	4	6	0.77	0.00	0.07	0.08	0.00	0.00	0.90	0.57	0.06	0.00	0.84	0.94
37	4	7	0.79	0.00	0.07	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
38	4	8	0.80	0.00	0.07	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
39	4	9	0.82	0.00	0.06	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
40	5	1	0.83	0.00	0.06	0.08	0.00	0.00	0.90	0.56	0.06	0.00	0.84	0.94
41	5	2	0.84	0.00	0.06	0.08	0.00	0.00	0.90	0.56	0.07	0.00	0.84	0.94
42	5	3	0.86	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.84	0.94
43	5	4	0.87	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.84	0.94
44	5	5	0.88	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
45	5	6	0.90	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
46	5	7	0.91	0.00	0.06	0.08	0.00	0.00	0.90	0.55	0.07	0.00	0.85	0.94
47	6	1	2.70	0.00	0.09	0.09	0.00	-0.01	0.90	0.32	0.14	0.00	0.89	0.76
48	6	2	2.69	0.00	0.09	0.09	0.00	-0.01	0.90	0.32	0.14	0.00	0.89	0.76
49	7	1	2.11	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
50	7	2	2.11	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
51	7	3	2.11	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
52	7	4	2.11	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
53	7	5	2.10	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
54	7	6	2.10	0.00	0.08	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
55	7	7	2.10	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
56	7	8	2.10	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
57	7	9	2.09	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
58	7	10	2.09	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
59	7	11	2.09	0.00	0.07	0.09	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
60	7	12	2.09	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
61	7	13	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
62	7	14	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
63	7	15	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
64	7	16	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
65	7	17	2.08	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
66	7	18	2.07	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
67	7	19	2.07	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88
68	7	20	2.07	0.00	0.07	0.08	0.00	-0.01	0.90	0.39	0.12	0.00	0.88	0.88

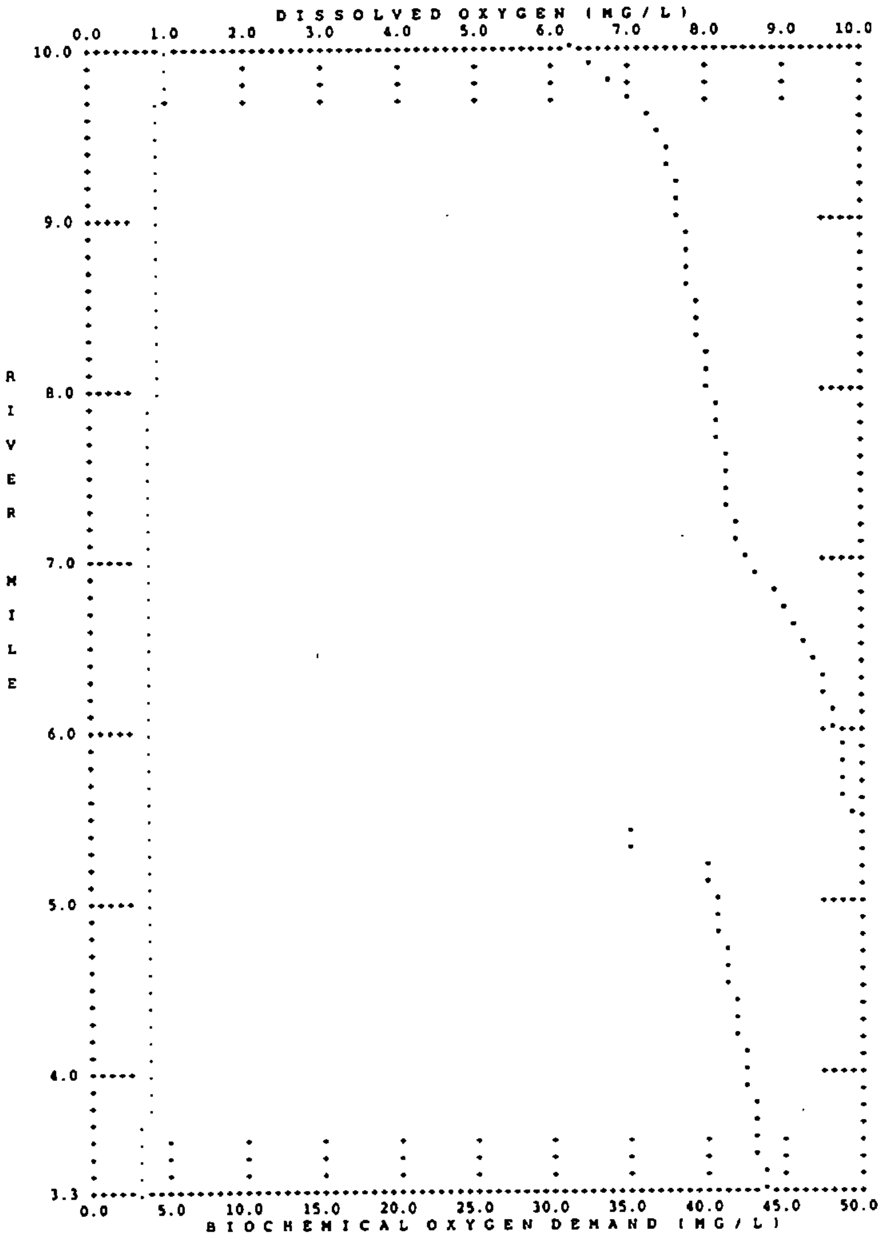
686

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)

ELE ORD	RCH NUM	ELE NUM	TEMP DEG-F	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	64.82	9.16	6.30	2.87	0.00	0.98	729.44	39.56	-3.75	0.00	0.00	-0.74	0.00
2	1	2	63.81	9.27	6.57	2.70	0.00	0.98	9.67	36.81	-3.63	0.00	0.00	-0.70	0.00
3	1	3	62.87	9.37	6.82	2.55	0.00	0.98	9.60	34.42	-3.51	0.00	0.00	-0.67	0.00
4	1	4	62.00	9.47	7.06	2.41	0.00	0.99	9.53	32.30	-3.41	0.00	0.00	-0.64	-0.01
5	1	5	61.18	9.56	7.27	2.29	0.00	0.99	9.46	30.40	-3.31	0.00	0.00	-0.61	-0.01
6	1	6	60.41	9.65	7.47	2.18	0.00	0.99	9.39	28.71	-3.22	0.00	0.00	-0.59	-0.01
7	2	1	59.76	9.72	7.59	2.13	0.00	0.99	6.45	17.26	-3.14	0.00	0.00	-0.57	-0.01
8	2	2	59.18	9.79	7.62	2.16	0.00	0.99	6.40	6.78	-3.07	0.00	0.00	-0.55	-0.01
9	2	3	58.63	9.85	7.66	2.20	0.00	0.99	6.36	6.85	-3.00	0.00	0.00	-0.53	-0.01
10	2	4	58.11	9.92	7.69	2.23	0.00	0.99	6.32	6.91	-2.93	0.00	0.00	-0.52	-0.01
11	2	5	57.62	9.98	7.72	2.25	0.00	0.99	6.28	6.97	-2.87	0.00	0.00	-0.50	-0.01
12	2	6	57.15	10.03	7.76	2.27	0.00	0.99	6.24	7.02	-2.82	0.00	0.00	-0.49	-0.02
13	2	7	56.71	10.09	7.79	2.29	0.00	0.99	6.20	7.06	-2.76	0.00	0.00	-0.47	-0.02
14	2	8	56.29	10.14	7.83	2.31	0.00	0.99	6.16	7.09	-2.71	0.00	0.00	-0.46	-0.02
15	2	9	55.90	10.19	7.87	2.32	0.00	0.99	6.12	7.11	-2.66	0.00	0.00	-0.45	-0.02
16	2	10	55.52	10.23	7.90	2.33	0.00	0.99	6.08	7.13	-2.62	0.00	0.00	-0.44	-0.02
17	3	1	55.26	10.27	7.95	2.32	0.00	0.99	9.43	8.70	-2.58	0.00	0.00	-0.43	-0.02
18	3	2	55.10	10.29	7.99	2.30	0.00	0.99	9.37	10.20	-2.56	0.00	0.00	-0.43	-0.02
19	3	3	54.94	10.31	8.03	2.28	0.00	0.99	9.30	10.10	-2.54	0.00	0.00	-0.42	-0.02
20	3	4	54.79	10.33	8.07	2.26	0.00	0.99	9.24	10.01	-2.51	0.00	0.00	-0.42	-0.02
21	3	5	54.64	10.35	8.11	2.24	0.00	0.99	9.18	9.91	-2.49	0.00	0.00	-0.41	-0.02
22	3	6	54.50	10.37	8.15	2.22	0.00	0.99	9.12	9.82	-2.47	0.00	0.00	-0.41	-0.02
23	3	7	54.36	10.38	8.19	2.20	0.00	0.99	9.06	9.73	-2.45	0.00	0.00	-0.40	-0.02
24	3	8	54.22	10.40	8.22	2.18	0.00	0.99	9.00	9.64	-2.43	0.00	0.00	-0.40	-0.02
25	3	9	54.09	10.42	8.26	2.16	0.00	0.99	8.94	9.55	-2.41	0.00	0.00	-0.40	-0.02
26	3	10	53.97	10.44	8.30	2.14	0.00	0.99	8.88	9.47	-2.39	0.00	0.00	-0.39	-0.02
27	3	11	53.85	10.45	8.33	2.12	0.00	0.99	8.83	9.39	-2.37	0.00	0.00	-0.39	-0.02
28	3	12	53.73	10.47	8.36	2.10	0.00	0.99	8.77	9.30	-2.36	0.00	0.00	-0.38	-0.02
29	3	13	53.61	10.48	8.40	2.09	0.00	0.99	8.72	9.22	-2.34	0.00	0.00	-0.38	-0.02
30	3	14	53.50	10.50	8.43	2.07	0.00	0.99	8.67	9.14	-2.32	0.00	0.00	-0.38	-0.02
31	4	1	53.32	10.52	8.54	1.98	0.00	0.99	9.22	21.59	-2.30	0.00	0.00	-0.37	-0.02
32	4	2	52.98	10.57	8.72	1.85	0.00	0.99	9.17	32.04	-2.27	0.00	0.00	-0.37	-0.02
33	4	3	52.66	10.61	8.88	1.73	0.00	1.00	9.12	29.93	-2.25	0.00	0.00	-0.36	-0.02
34	4	4	52.35	10.65	9.03	1.62	0.00	1.00	9.07	28.04	-2.22	0.00	0.00	-0.35	-0.02
35	4	5	52.06	10.69	9.17	1.52	0.00	1.00	9.03	26.34	-2.20	0.00	0.00	-0.35	-0.02
36	4	6	51.78	10.73	9.29	1.44	0.00	1.00	8.98	24.81	-2.17	0.00	0.00	-0.34	-0.02
37	4	7	51.52	10.77	9.41	1.36	0.00	1.00	8.93	23.43	-2.15	0.00	0.00	-0.34	-0.02
38	4	8	51.27	10.80	9.51	1.29	0.00	1.00	8.88	22.18	-2.13	0.00	0.00	-0.33	-0.02
39	4	9	51.03	10.84	9.61	1.22	0.00	1.00	8.84	21.05	-2.11	0.00	0.00	-0.33	-0.02
40	5	1	50.85	10.86	9.68	1.18	0.00	1.00	9.05	16.23	-2.09	0.00	0.00	-0.32	-0.02
41	5	2	50.70	10.88	9.72	1.17	0.00	1.00	9.00	11.93	-2.08	0.00	0.00	-0.32	-0.02
42	5	3	50.57	10.90	9.75	1.15	0.00	1.00	8.95	11.76	-2.06	0.00	0.00	-0.32	-0.02
43	5	4	50.43	10.92	9.79	1.13	0.00	1.00	8.90	11.59	-2.05	0.00	0.00	-0.31	-0.02
44	5	5	50.31	10.94	9.82	1.12	0.00	1.00	8.85	11.43	-2.04	0.00	0.00	-0.31	-0.02
45	5	6	50.18	10.96	9.85	1.10	0.00	1.00	8.81	11.28	-2.02	0.00	0.00	-0.31	-0.02
46	5	7	50.07	10.97	9.88	1.09	0.00	1.00	8.76	11.14	-2.01	0.00	0.00	-0.31	-0.02
47	6	1	62.79	9.38	7.06	2.32	0.00	0.99	959.81	11.43	-2.79	0.00	-0.01	-0.33	0.00
48	6	2	62.28	9.44	7.12	2.31	0.00	0.99	0.00	11.33	-2.74	0.00	-0.01	-0.32	0.00
49	7	1	58.11	9.91	8.06	1.86	0.00	0.99	0.00	12.37	-2.46	0.00	-0.01	-0.32	-0.01
50	7	2	57.86	9.95	8.10	1.85	0.00	0.99	0.00	9.77	-2.43	0.00	-0.01	-0.32	-0.01
51	7	3	57.60	9.98	8.14	1.83	0.00	0.99	0.00	9.67	-2.41	0.00	-0.01	-0.32	-0.01
52	7	4	57.35	10.01	8.19	1.82	0.00	0.99	0.00	9.58	-2.38	0.00	-0.01	-0.31	-0.01
53	7	5	57.10	10.04	8.23	1.81	0.00	0.99	0.00	9.48	-2.36	0.00	-0.01	-0.31	-0.01
54	7	6	56.86	10.07	8.27	1.80	0.00	0.99	0.00	9.39	-2.34	0.00	-0.01	-0.31	-0.01
55	7	7	56.62	10.10	8.31	1.78	0.00	0.99	0.00	9.29	-2.31	0.00	-0.01	-0.31	-0.01
56	7	8	56.39	10.13	8.35	1.77	0.00	0.99	0.00	9.20	-2.29	0.00	-0.01	-0.30	-0.01
57	7	9	56.16	10.15	8.40	1.76	0.00	0.99	0.00	9.11	-2.27	0.00	-0.01	-0.30	-0.01
58	7	10	55.93	10.18	8.44	1.75	0.00	0.99	0.00	9.02	-2.25	0.00	-0.01	-0.30	-0.01
59	7	11	55.71	10.21	8.48	1.74	0.00	0.99	0.00	8.93	-2.23	0.00	-0.01	-0.29	-0.01
60	7	12	55.49	10.24	8.52	1.72	0.00	0.99	0.00	8.85	-2.21	0.00	-0.01	-0.29	-0.01
61	7	13	55.27	10.27	8.56	1.71	0.00	0.99	0.00	8.76	-2.19	0.00	-0.01	-0.29	-0.01
62	7	14	55.06	10.29	8.59	1.70	0.00	0.99	0.00	8.68	-2.17	0.00	-0.01	-0.29	-0.02
63	7	15	54.85	10.32	8.63	1.69	0.00	0.99	0.00	8.59	-2.15	0.00	-0.01	-0.28	-0.02
64	7	16	54.65	10.35	8.67	1.68	0.00	0.99	0.00	8.51	-2.13	0.00	-0.01	-0.28	-0.02
65	7	17	54.45	10.37	8.71	1.67	0.00	0.99	0.00	8.43	-2.11	0.00	-0.01	-0.28	-0.02
66	7	18	54.25	10.40	8.75	1.65	0.00	0.99	0.00	8.35	-2.09	0.00	-0.01	-0.28	-0.02
67	7	19	54.05	10.43	8.78	1.64	0.00	0.99	0.00	8.27	-2.07	0.00	-0.01	-0.28	-0.02
68	7	20	53.86	10.45	8.82	1.63	0.00	0.99	0.00	8.20	-2.06	0.00	-0.01	-0.27	-0.02



DISSOLVED OXYGEN * * * * *

BIOCHEMICAL OXYGEN DEMAND . . . . .

Appendix C

State Historical Society of Wisconsin

Division of Historic Preservation

816 State Street • Madison, Wisconsin 53706-1488
(608) 264-6500 • FAX (608) 264-6404

July 6, 1995

Mr. Paul A. Nelson
Montgomery Watson
Waterford Park
505 U.S. Highway 169, Suite #555
Minneapolis, Minnesota 55441

IN REPLY PLEASE REFER TO SHSW: #95-0946/DA
RE: Sugar River Basin Effluent Return Project
ID: #4248

Dear Mr. Nelson

We have reviewed the above-referenced information which accompanied your submitted dated June 29, 1995 as required for compliance with Section 106 of the National Historic Preservation Act and 36 CFR Part 800: Protection of Historic Properties, the regulations of the Advisory Council on Historic Preservation governing the Section 106 review process.

There is a very high density of archeodlogical sites (many of which contain Native American burials) in the project area. Therefore, we recommend that all areas of proposed ground disturbing activity be surveyed by a qualified archeologist to locate and evaluate the significance of any archeological sites that may be present. When the survey has been completed, please provide <u>two</u> copies of the archeologist's report for our review and comment. Please ensure that the archeologists's report is accompanied by our project identification number (SHSW: #95-0946/DA).

The project as described in your correspondence will not affect any <u>structures</u> that are listed in, or known to be eligible for inclusion in, the National Register of Historic Places. We remind that 36 CFR 800.4 includes the requirement that you seek information, as appropriate to the undertaking, from parties likely to have knowledge of or concerns with historic properties in the project area - such as Indian tribes, local governments, and public and private organizations.

If there are any questions concerning this matter, please contact me at (608) 264-6507.

Sincerely,

Sherman Banker

Sherman J. Banker
Compliance Archeologist

SJB:lks

MADISON METROPOLITAN SEWERAGE DISTRICT

1610 Moorland Road
Madison, WI 53713-3398
Telephone (608) 222-1201
Fax (608) 222-2703

James L. Nemke
Chief Engineer & Director

September 19, 1995

State Historical Society of Wisconsin
816 State Street
Madison, WI 53706-1488

Gentlemen:

Please find enclosed two copies of An Archaeological Survey of the Proposed Effluent Force Main from the Madison Metropolitan Sewerage District Plant to the City of Verona, Wisconsin dated September, 1995. This report was prepared by Phil Salkin in response to a District request to review archaeological impact of a potential force main route.

The District is anticipating that a force main along the route chosen might be constructed beginning in 1996 through 1997. If you have any additional questions relative to the report, you can contact Mr. Salkin directly.

Sincerely,

James L. Nemke
Chief Engineer and Director

:dms
Enclosures as stated
cc: Phil Salkin
Paul Nelson

SEP 22 1995

metrogro

Archaeological Consulting and Services

102 East Park Lane • Verona, Wisconsin 53593
(608) 845-5585 • (608) 845-9849

Archaeological Consulting and Services

Cultural Resource Management

RECEIVED

SEP 1? 1995

September 12th, 1995

Mr. Jim Nemke
MMSD
1610 Moorland Rd.
Madison, Wisconsin 53713-3398

RE: Archaeological Survey
Sugar River Basin Effluent Return Project
SHSW 95-0946/DA

Dear Mr. Nemke:

Enclosed please find five copies of the report on the archaeological survey of the proposed effluent force main corridor from the MMSD plant to the city of Verona. As noted in the report, archaeological materials were recovered from only one location in the corridor and another site was found in the vicinity. No significant finds were made and no additional archaeological work is recommended. Two copies of this report and a copy of the state bibliographic form should be submitted to the Wisconsin Historic Preservation Division for their review.

Also enclosed is an invoice. As we did not find very much, the cost of the survey is somewhat below the $7000 minimum fee that we proposed. Please do not hesitate to inquire for additional information or services we may provide. Thank you.

Sincerely,

Philip H. Salkin
Senior Partner

Bibliography of Archeological Reports
Information for Data Entry

SHSW #: 95-0946 County: Dane Acreage: 430

Author/s: Philip H. Salkin

Title of Report: An Archaeological Survey of the Proposed Effluent Force Main from the Madison Metropolitan Sewerage District Plant to the City of Verona, Wisconsin

Date of Report (month and year): September, 1995

Series/Number: ACS 970

Place of Publication: Archaeological Consulting and Services

Quad Map/s (7.5' Series): Verona, Oregon, Madison West and Madison East, Wis. Quads

Legal description of survey area: portions of Sec. 12-14, T6N, R8E, Sec. 1-7, T6N, R9E and Sec. 31, T7N, R10E

Site Information (if applicable):

State Codification Number/s: MMSD Survey Site #1 - site form submitted

For Office Use Only:

Project Name: ______________________

Lead Agency: ______________________

THE STATE HISTORICAL SOCIETY OF WISCONSIN
816 State Street • Madison, Wisconsin 53706-1488

HP-05-07 (6-10-92)

REPORTS OF INVESTIGATIONS

AN ARCHAEOLOGICAL SURVEY OF THE PROPOSED EFFLUENT FORCE MAIN FROM THE MADISON METROPOLITAN SEWERAGE DISTRICT PLANT TO THE CITY OF VERONA, WISCONSIN

SEPTEMBER, 1995

REPORT NUMBER

970

PREPARED BY

PHILIP H. SALKIN

ARCHAEOLOGICAL CONSULTING AND SERVICES
102 E. PARK LANE
VERONA, WISCONSIN

PROJECT SUMMARY

Title: An Archaeological Survey of the Proposed Effluent Force Main from the Madison Metropolitan Sewerage District Plant to the City of Verona, Wisconsin

I.D.: ACS 970
95-0946/DA
MMSD P.O. B35404

Principal Investigator: Philip H. Salkin
Archaeological Consulting and Services
102 E. Park Lane
Verona, Wisconsin 53593

Project Personnel: Carl Hendrickson
Ted Waddington
Paula Salkin
Heath Fife

Contractor: Madison Metropolitan Sewerage District
1610 Moorland Road
Madison, Wisconsin 53713-3398

Methods: Literature and Records Search
Pedestrian Survey
Excavation of 313 Shovel Test Units and Various Shovel Probes

Results of the Survey:
Much of the project corridor can be described as highly disturbed or low and marshy. The only Native American site encountered consisted of three pieces of debitage found on the surface of an agricultural field in a line about 210 meters long. Euro-American artifacts were limited to surface finds of recent age or which were not temporally diagnostic.

Recommendations:
No additional archaeological work is recommended for the project corridor as no sites were encountered which might be considered as eligible for the National Register of Historic Places.

Dates of Field Work: August, 1995
Date of Report : September 8th, 1995

Abstract

In August, 1995, the author conducted an archaeological survey of the proposed effluent force main corridor which will link the Nine Springs Wastewater Treatment Plant of the Madison Metropolitan Sewerage District and the city of Verona facilities. In the course of the survey, the project corridor, much of which is either highly disturbed or low and marshy, was subjected to pedestrian survey and the excavation of 313 shovel test units and various shovel probes.

The survey resulted in the discovery of three pieces of debitage scattered on the surface of an agricultural field in a line about 210 meters long. Another small, disturbed site was discovered about 60 meters south of the project corridor. No other Native American sites were encountered. Euro-American materials consisted of surface finds of recent age, or which were not temporally diagnostic. No additional archaeological work is recommended for this project as no sites were encountered which might be eligible for inclusion on the National Register of Historic Places.

Table of Contents

Figures

Introduction

In August, 1995, the author conducted an archaeological survey of the proposed effluent force main corridor which will link the Nine Springs Wastewater Treatment Plant of the Madison Metropolitan Sewerage District (MMSD) facility and the city of Verona facilities. The purpose of the survey was to determine if any archaeological resources might be impacted by the proposed construction.

The project corridor is approximately 17.4km (10.8 miles) in length, with a width of 30.4 meters (except when it passes through a municipal golf course and will only be 15.2 meters wide). It begins, on the west in the SE1/4, NW1/4, SW1/4, Sec. 14 and extends across the N1/2, Sec. 14, the NW1/4, Sec. 13 and the southeastern corner of Sec. 12, T6N, R8E. It continues into through portions of Sections 1-7 of T6N, R9E. The eastern end of the project runs through the W1/2, Sec. 31, T7N, R10E.

The survey was conducted by the author with the assistance of Carl Hendrickson, Ted Waddington, Heath Fife and Paula Salkin of Archaeological Consulting and Services. It was conducted for the Madison Metropolitan Sewerage District of Madison, Wisconsin and the firm of Montgomery Watson of Minneapolis, Minnesota.

The Area

The project area is located in south-central Dane County in the south-central portion of Wisconsin (Figs. 1-2). This part of the state lies in the Eastern Ridges and Lowlands Province, a region distinguished by its level to rolling topography. The area is dominated by cuestas; ridges with steep escarpments on one side and long, gentle slopes on the other (Martin 1965: 212). The western end of the project corridor is in the Verona area which is on the eastern edge of the Western Uplands Province, which includes most of western and southwestern Wisconsin. This area is a thoroughly dissected upland with elevations largely between 250 and 390 meters m.s.l. (ibid: 42) and includes the Driftless Zone.

The project corridor is primarily underlain by dolomites, sandstones and shales of the Prairie du Chien Group and sandstones, limestones, shales and conglomerates of the St. Peter Formation (Wisconsin Geological and Natural History Survey 1981). The western portion of the project corridor is overlain by outwash deposits and end moraines. To the east are end and ground moraines (Wisconsin Geological and Natural History Survey 1976).

Prior to the intensive utilization of this portion of Dane County by Euro-American settlers, the area was covered by oak-savannahs. These included upland stands of bur, white and black oak with a mesic prairie understory and lowland stands of swamp white oak with a wet, mesic prairie understory (Curtis 1959: 326). There

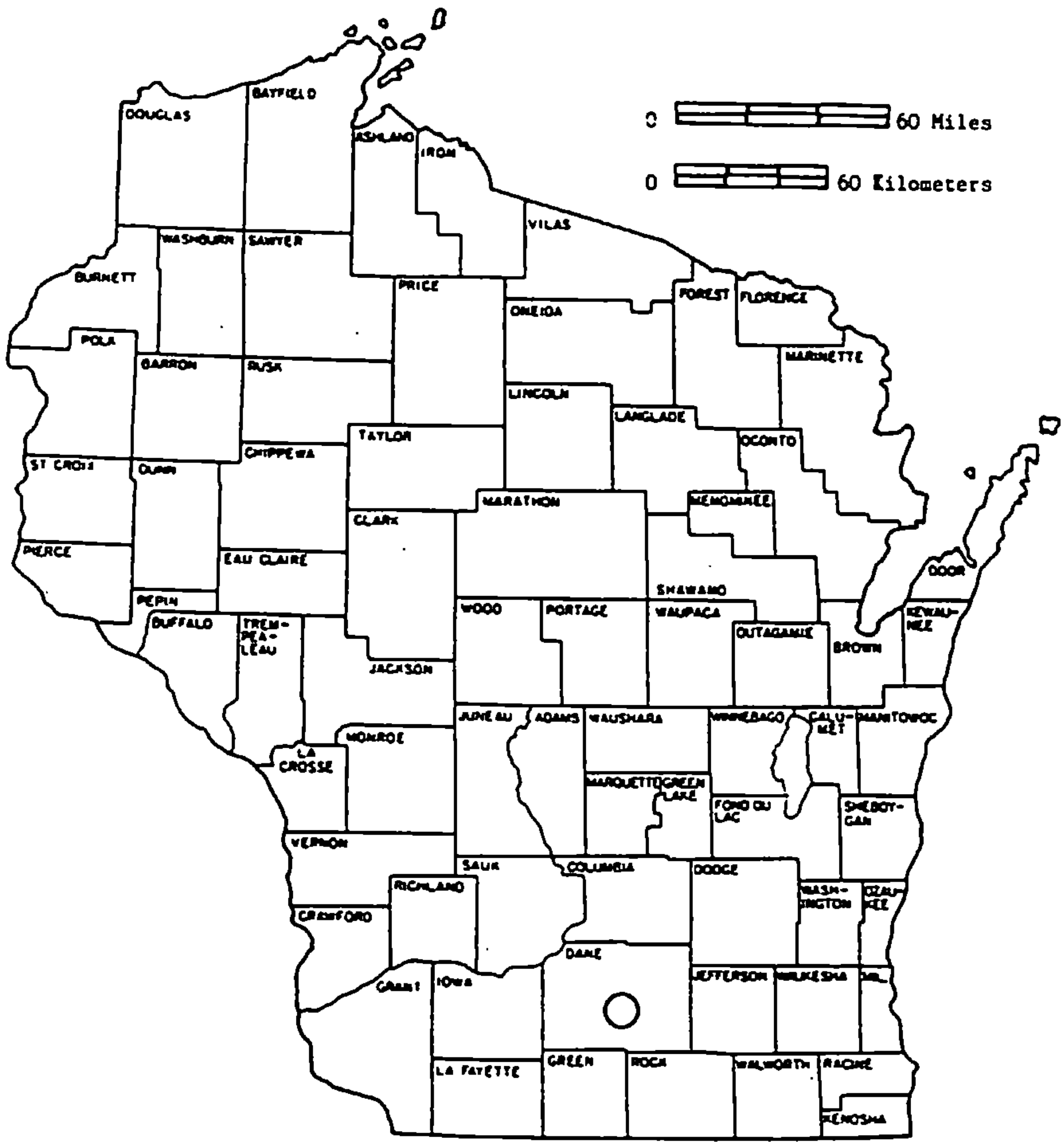


Fig. 1 - The Location of the Project Corridor in Dane County,
Wisconsin

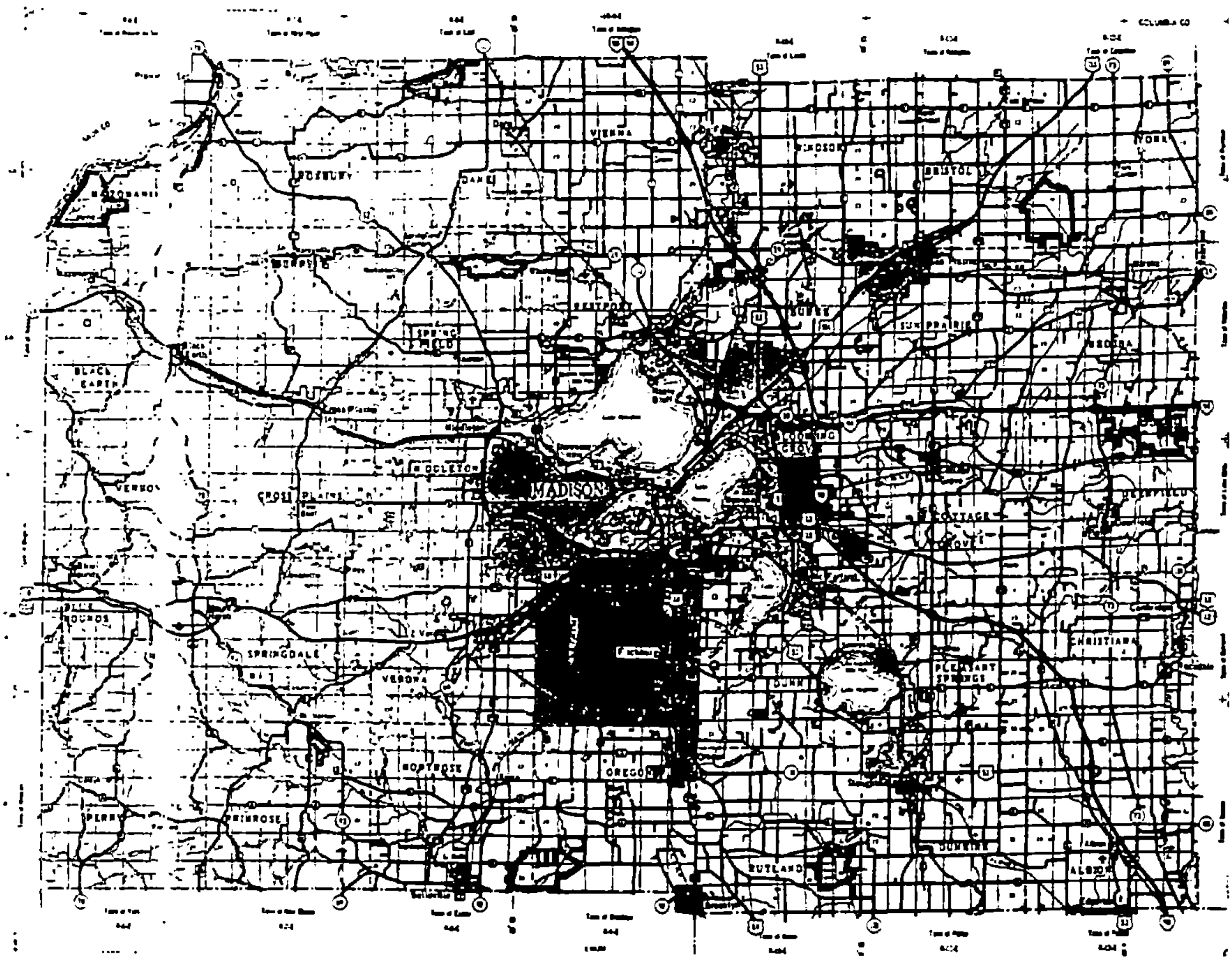


Fig. 2 - The Location of the Project Corridor in Dane County (WisDOT Map)

were also some areas of prairies, dominated by non-arboreal species of grasses (such as bluestem), forbs and some woody plants (ibid: 262). Finley (1976) also shows the project area as formerly lying under stands of white, black and bur oak or prairie. However, he also shows the presence of marshes and other wetlands.

The Project Corridor

Beginning on the west, the project will run along one side of the old Chicago and Northwestern railroad corridor (now a bike path). This area is generally low and not well-drained, or bordered by quarries (Fig. 3). Just east of the Central Wisconsin tracks, the project corridor runs south and around Dunn's Marsh (Fig. 4). This is also a relatively level area, with elevations at or below 289.5 meters m.s.l. The vegetation cover consists of mixed hardwoods with a water-tolerant understory of brome grasses and weeds on higher elevations.

East of the Seminole Highway, the corridor returns to the old railroad corridor before heading through a rolling area with elevations of around 283-290 meters m.s.l. This area is either highly disturbed, or in an agricultural field. Before reaching C.T.H. 'D', the corridor runs through a small, municipal golf course, built largely on fill brought into a low valley (Fig. 5).

East of C.T.H. 'D', the project corridor runs east and south through a portion of the Nine Springs Marsh (Fig. 5). This area is almost all low and poorly drained. Elevations are below 262 meters m.s.l. The vegetation cover consists of water-tolerant species, often reed canary grass. Portions of the area have been filled.

In the southwestern corner of Sec. 2, T6N, R10E, the project area turns northwest towards MCCoy Rd (Fig. 5). This area is generally low and not well-drained, but lies slightly above the marshes

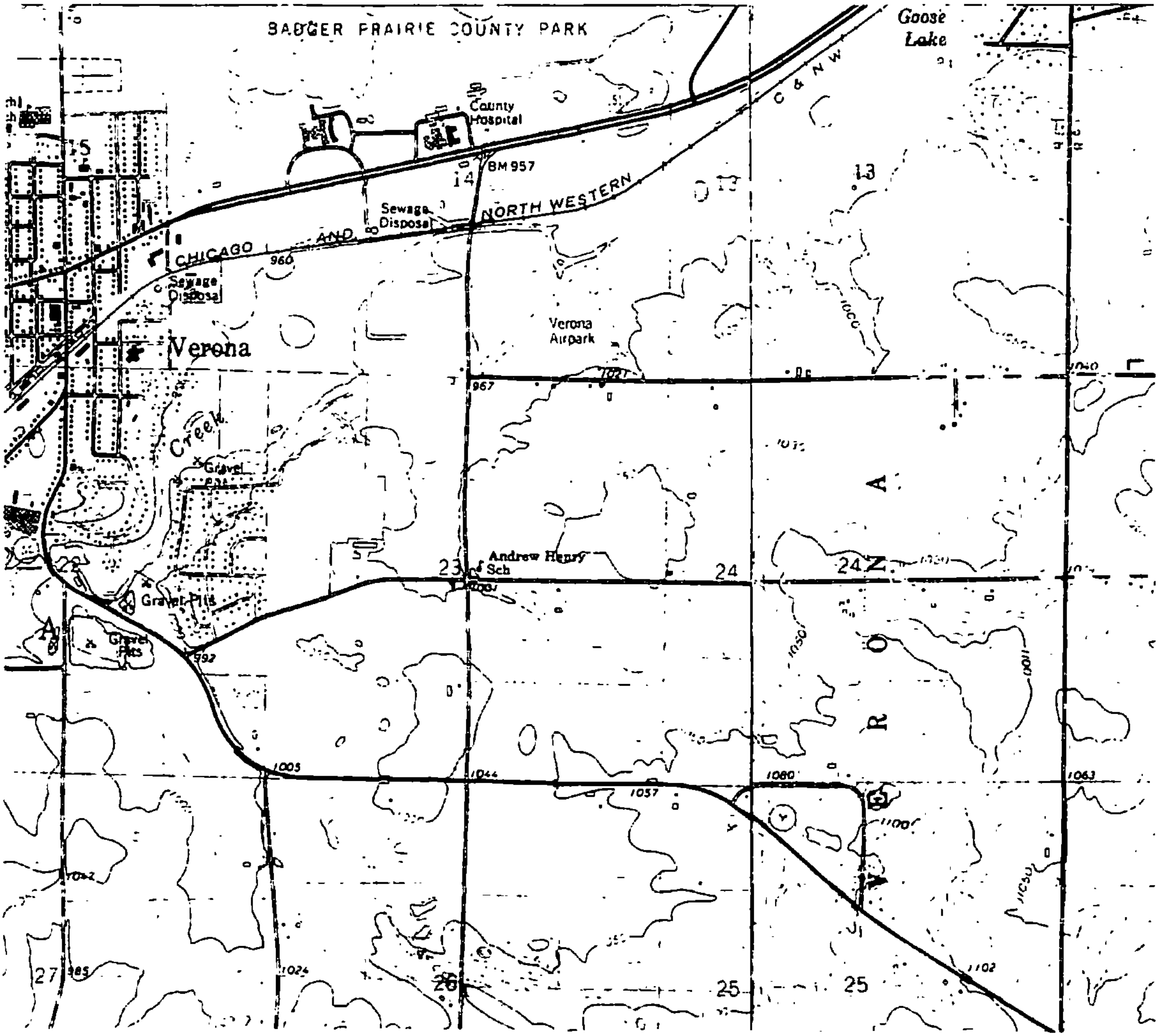


Fig. 3 - The Project Corridor
Verona and Oregon, Wis. Quads 1982
1:24,000

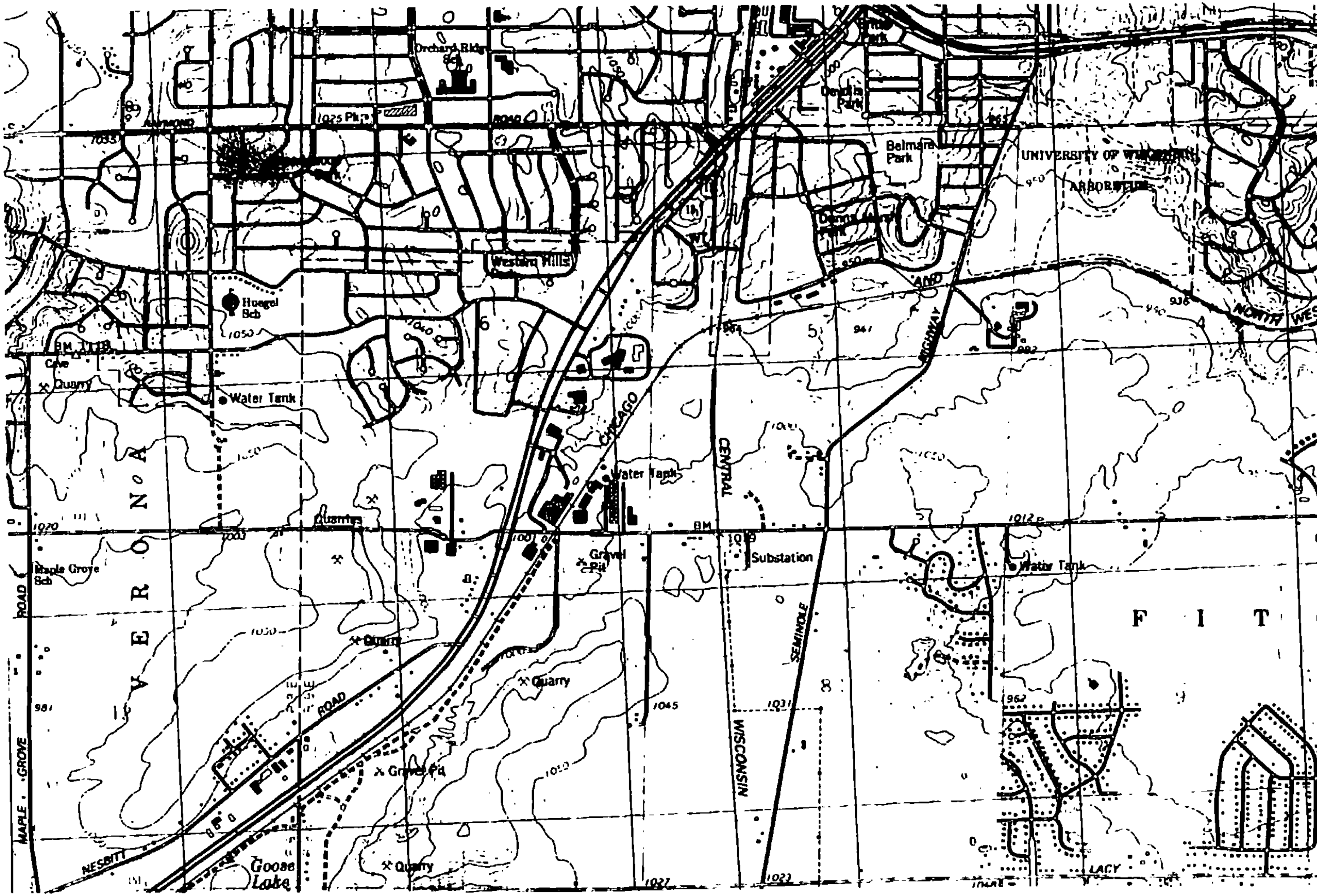


Fig. 4 - The Project Corridor
Madison West, Wis. Quad 1983 1:24,000

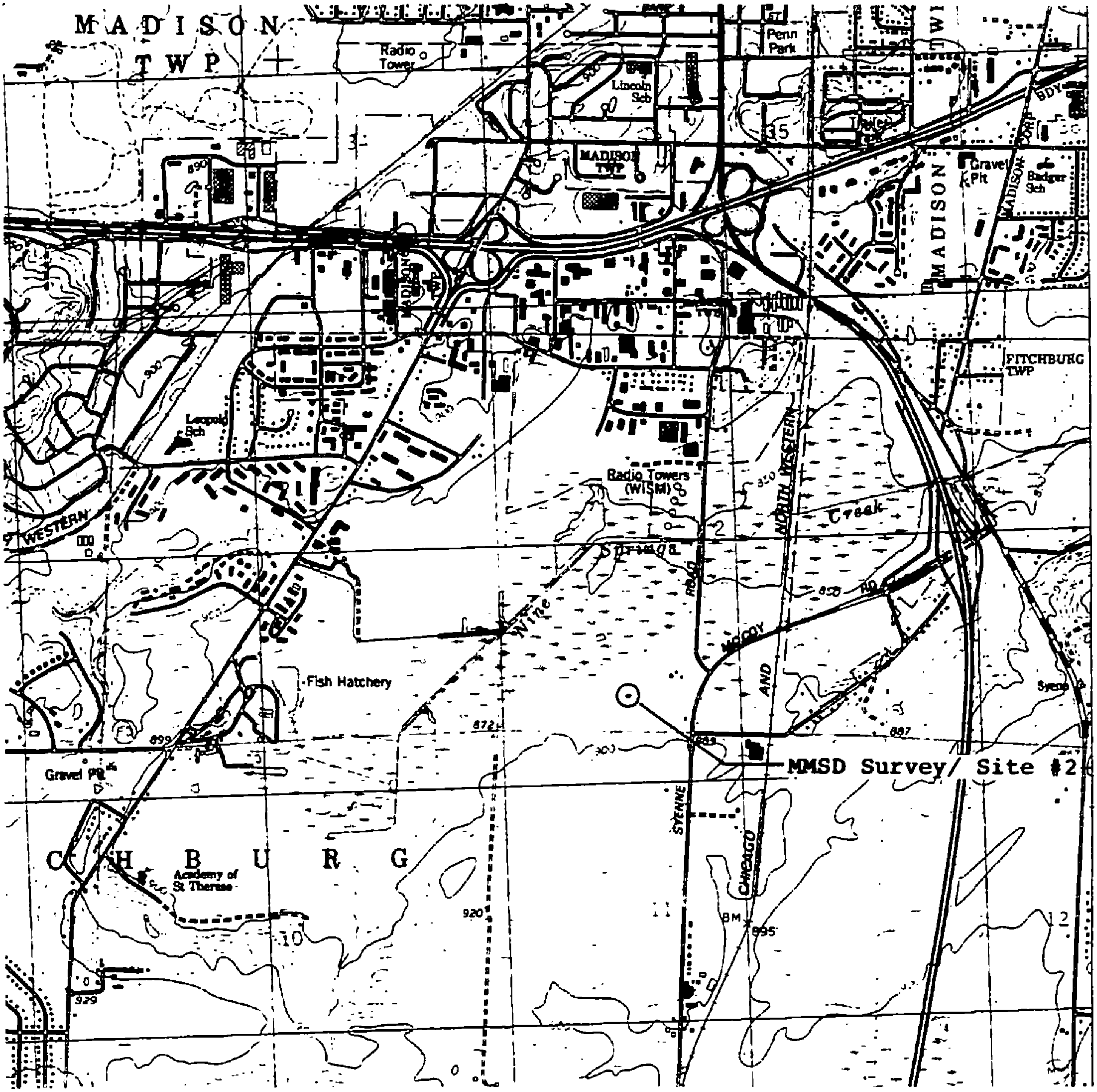


Fig. 5 - The Project Corridor
Madison West, Wis. Quad 1983
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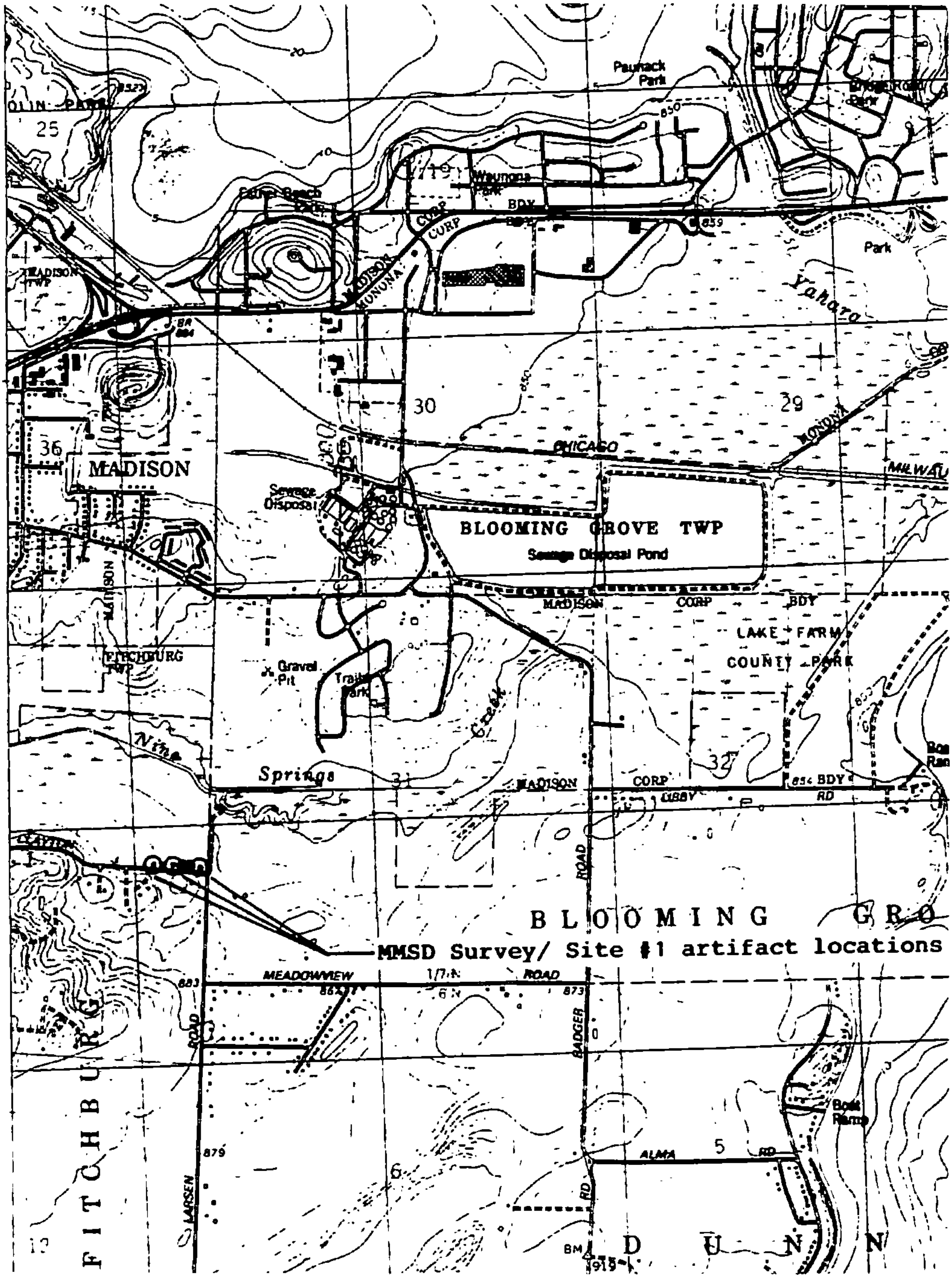


<u>Fig. 6</u> - The Project Corridor
Madison East, Wis. Quad 1983
1:24,000

to the north. At MCCoy Road, the project corridor will run along the north side of the road in a disturbed area.

East of U.S.H. 14, the corridor runs along the north side of Clayton Rd. (Figs. 5-6). This area has a rolling topography with elevations of 265-268 meters m.s.l. Most of this area lies in agricultural fields or former agricultural fields. Due to the better drained conditions and proximity to the marshes to the north, this area was felt to have a relatively high agricultural potential.

The eastern portion of the project corridor runs north from the end of Clayton Rd. to the border of the MMSD property on Raywood Rd. (Fig. 6). The corridor runs downhill towards the Nine Springs Creek and then uphill again to the north. Elevations are generally around 259-265 meters m.s.l. A portion of the area consists of wetlands or drained wetlands. Higher portions lay in agricultural fields.

West of U.S.H. 14, the following are the dominant soil types found in the general area;

Houghton muck - very poorly drained soil found on low benchlands and bottoms - formed under a cover of sedge grasses (Glocker and Patzer 1978: 37-38)

Orion silt loam - somewhat poorly drained soil found on low bottoms of stream valleys - formed in moderately thick, recent silty alluvium and deep, dark-colored older silty alluvium under a cover of mixed hardwoods (ibid: 48-49)

Radford silt loam, 0-3% slopes - somewhat poorly drained soil found on low bottoms near streams - formed in recent, silty alluvium overlying a buried, poorly drained silty soil under a cover of prairie grasses (ibid: 56-57)

Sable silty clay loam, 0-3% slopes - poorly drained soil found on low benches in stream valleys - formed in silty material under a cover of sedges (Glocker and Patzer 1978: 59-60)

Virgil silt loam, 1-4% slopes - somewhat poorly drained soils found on lower side slopes - formed in deep loess and glacial till or sand and gravel outwash under a cover of mixed hardwoods with a grassy understory (ibid: 69).

These soils reflect the generally low and poorly drained contions in much of the project corridor. As seen in the 1890 U.S.G.S. map (Fig. 7), the area was once considerably wetter, before extensive drainage projects, many conducted in the 1920' and 1930's. However, a few smaller areas have better drained soils such as the Boyer sandy loam, 2-6% slopes, McHenry silt loam, 2-6% slopes and Plano silt loam, gravelly substratum, 2-6% slopes types.

East of U.S.H. 14, the portion of the project corridor along Clayton Rd. has some better drained soils of the St. Charles, McHenry and Virgil soils (Glocker and Patzer 1978). However, in the vicinity of Nine Springs Creek and to the north, much of the area has poorly drained soils of the Palms muck and Orion silt loam types (ibid).

Most of the project corridor is in some proximity to water resources. On the west, this includes Badger Mill Creek, Dunn's Marsh and several intermittent streams. In the central and eastern portions of the corridor, this includes the Nine Springs Creek (much of which is now channelized) and its attendant marshes. The eastern terminus of the project area is about 2.6km west of Lake Waubesa and 1.6km south of Lake Monona.

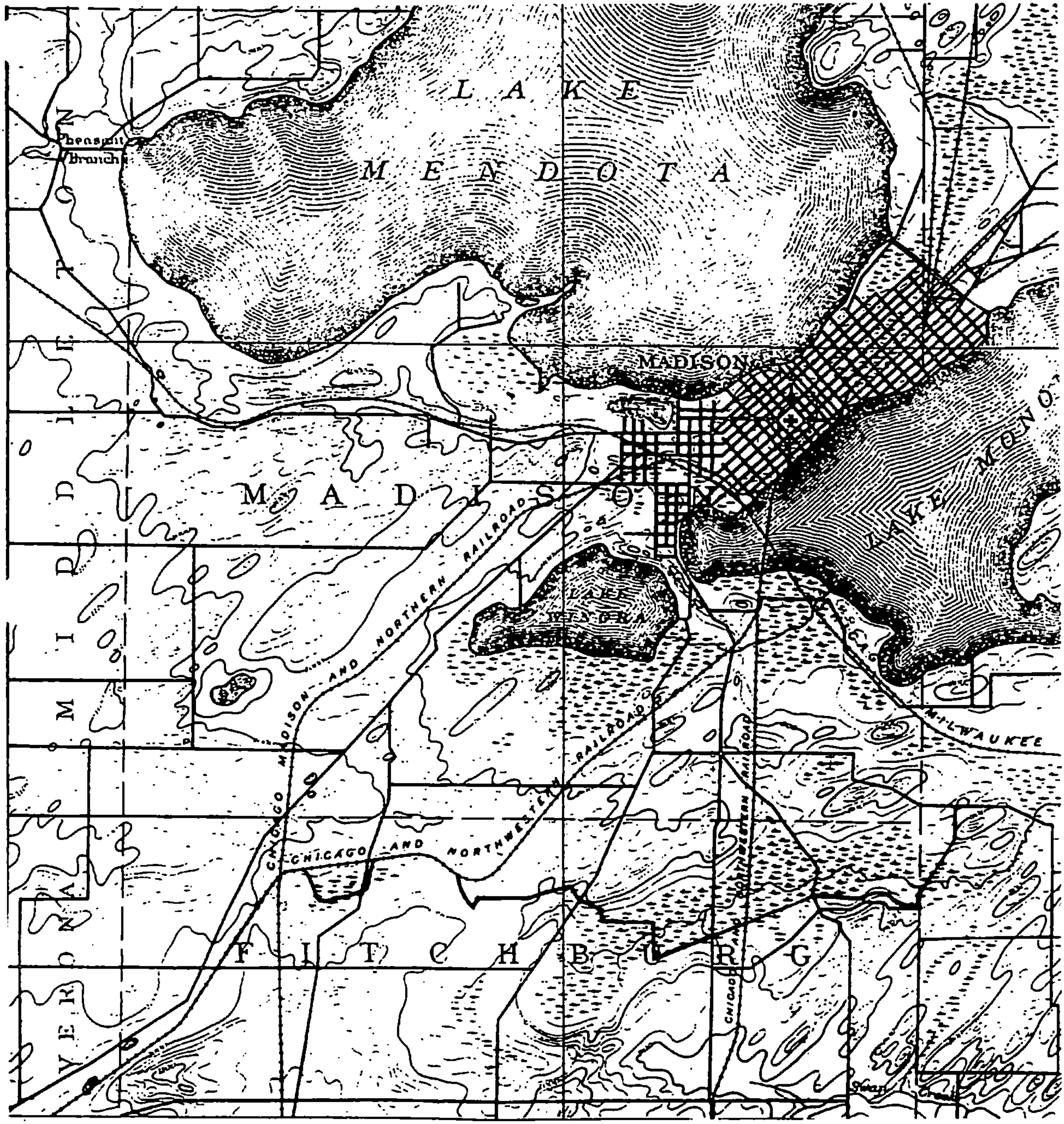


Fig. 7 - The General Project Area as Mapped in 1887
Madison, Wis. Quad 1890
1:62,500

Previously Reported Sites in the General Project Area

Prior to the initiation of the field work, a literature and records search was conducted on the previously reported sites in the general project area. The following data sources were utilized:

Site files and archives of the Wisconsin Historic Preservation Division

Site files and archives of the Anthropology Section of the State Historical Society of Wisconsin

Site files and archives of the Burial Sites Preservation Office

Site files and archives of Archaeological Consulting and Services (especially Salkin 1976, 1979, 1983b)

National Register of Historic Places

Charles E. Brown Atlas

Charles E. Brown Manuscripts

Wisconsin Archeologist

"A Literature and Records Search on the Prehistoric Cultural Resources of Dane County, Wisconsin" (Salkin 1983).

The literature and records search indicated that presence of over 1030 previously reported archaeological sites in Dane County. Many of sites have been reported in the vicinity of Lake Monona, Lake Waubesa and Nine Springs Creek. Portions of this area have been intensively surveyed for various projects including the present South Beltline Highway and the Dane County E-Way (Salkin 1976, 1979). The sites closest to the project corridor are as follows:

47Da397 - Uphoff Mound - Sec. 6 - reported as a linear mound associated with an occupation site - about 1.6km southeast of the project corridor

47Da398 - Uphoff Ridge Group - Sec. 6, T6N, R10E - group of four linear and one effigy mound - reported as extant in 1979 - about 1.6km southeast of the project corridor

47Da865 - Libby Site #8-9 - Native American occupation with Late Paleo-Indian and Early Woodland Stage occupations - approx. 1.6km east of the project corridor

47Da38 - Sec. 29, T7N, R10E - reported as three circular earthworks - about 1.6km northeast of the project corridor

47Da862 - Libby Site #5 - Sec. 31, T7N, R10E - Native American occupation - about 1.4km east of the project corridor

47Da827 - Site C - Sec. 30, T7N, R10E - Native American occupation with Early Paleo-Indian and Early Woodland Stage occupations - about 1.1km northeast of the project corridor

Lake Farms Archaeological District - Sec. 29, 31-32 T7N, R10E - several dozen Native American sites - the western boundary of the district is about 1.0km east of the project corridor

47Da1002 - Kearny-Icke Site - Sec. 1, T6N, R10E - Native American occupation - approx. 825 meters north of the project corridor

47Da111 - Sec. 1, T6N, R9E - mound group with linear, conical and effigy mounds - no additional data provided - approx. 760 meters north of the project corridor

47Da159 - Sec. 36, T7N, R9E - mound group - little additional data provided - approx. 760 meters north of the project corridor

47Da415 - Sec. 1, T6N, R9E - Native American occupation - approx. 670 meters north of the project corridor

47Da41 - Sec. 31, T7N, R10E - Native American occupation with Early Archaic(?) and Early Woodland Stage components - approx. 610 meters east of the project corridor

47Da40 - Bryant Mound Group - Sec. 31, T7N, R10E - mound group reported as destroyed - about 600 meters east of the project corridor

47Da42 - Gilman Mound - Sec. 31, T7N, R10E - reported as a single mound - little additional information - about 600 meters east of the project corridor

47Da462 - Site D - Sec. 31, T7N, R10E - Native American site is a possible Early Woodland occupation - approx. 460 meters southeast of the project corridor

47Da112 - Sec. 2, T6N, R9E - mound group - little other data provided - approx. 450 meters north of the project corridor

47Da467 - Site H - Sec. 1, T6N, R9E - two pieces of debitage - approx. 400 meters north of the project corridor

47Da828 - Nine Springs STP Site - Sec. 30, T7N, R10E - Native American occupation with an Archaic Tradition occupation - approx. 300 meters northeast of the project corridor

47Da907 - VE-10 Site - Sec. 14, T6N, R8E - Native American occupation - 300 meters south of the project corridor

47Da905 - VE-8 Site - Sec. 14, T6N, R8E - Native American occupation - approx. 250 meters south of the project corridor

47Da909 - Nigh Site - Sec. 14, T6N, R8E - approx. 250 meters north of the project corridor

47Da906 - VE-9 Site - Sec. 14, T6N, R8E - Native American occupation - approx. 215 meters south of the project corridor

47Da406 - Goose Lake Site - Sec. 13, T6N, R8E - Native American occupation site with a Woodland Tradition occupation - approx. 215 meters southeast of the project corridor

47Da904 - VE-7 Site - Sec. 14, T6N, R8E - Native American occupation - approx. 180 meters south of the project corridor

47Da921 - VE-24 Site - Sec. 13, T6N, R8E - Native American occupation with a Late Archaic occupation

47Da923 - VE-26 Site - Sec. 14, T6N, R8E - Euro-American occupation - approx. 120 meters north of the project corridor

47Da910 - Warren Hause Site - Sec. 13, T6N, R8E - Euro-American occupation - approx. 90 meters north of the project corridor

47Da908 - VE-11 Site - Sec. 14, T6N, R8E - Native American occupation - close to the project corridor, but to the south

47Da911-919 - complex of eight Native American sites - Sec. 13, T6N, R8E - from adjacent (but outside) of the project corridor to about 300 meters to the southeast

47Da354 - Tigar Site - Sec. 13, T6N, R8E - mound group - little additional information provided - just north, but out of the project corridor.

Thus, it is obvious that numerous archaeological sites have been reported within 1.6km of the project corridor. Most of the sites were located in the vicinity of Lake Waubesa, Lake Monona and the associated marshes. These included the sites of the Lake Farms Archaeological District and the sites discovered as a result of the E-Way Archaeological Survey (Salkin 1979, Salkin and Emerson 1976). However, another cluster of sites was discovered near the western end of the project in Sections 13-14, T6N, R8E. These sites were discovered (and some tested and/or mitigated) as a result of the studies associated with the Verona 18/151 Bypass (Benchley, et al. 1991, Paulus and Benchley 1995a, Paulus and Benchley 1995b, Porubcan and Benchley 1995). It may be noted, however, that no previously reported sites could be definitely identified as in the project corridor. A small portion of the west end of the project corridor was included in a survey conducted by the author in 1984 (Salkin 1984). A review of various maps and plats suggested that the project should not impact any historic structures or likely locations for historic foundation remains.

Methods

A large portion of the project corridor lay within old railroad corridors or other highly disturbed areas. These areas were subjected to pedestrian survey. This was sometimes augmented by shovel probing to determine the extent of disturbance when this was not already apparent.

Another large portion of the project corridor lay in wetlands or areas which were previously wetlands. Examination of the original Government Land Office and old U.S.G.S. maps (Fig. 7) indicated that these were more extensive than at present. These areas were also subjected to pedestrian survey, especially to search for small, better drained rises which might be site locations.

A third portion of the project subjected to pedestrian survey included a series of agricultural and former agricultural fields. These fields had good conditions for pedestrian survey and were walked at five meter intervals.

The project included a number of areas which lay in pasture, under grass in a public golf course, or in woodlots. These areas could not be assessed using pedestrian survey methods. Therefore, they were shovel tested at 15 meter intervals. The units were about 40x40cm in size and were excavated into the underlying B Horizon. Soils were screened through 1/4" mesh screen and the units immediately backfilled. Often, the excavation of these units was augmented by shovel probes which were not expanded into shovel test units due to the presence of disturbed or very poorly drained conditions.

Finally, when archaeological materials were located within the project corridor, the site areas, all in agricultural fields, were intensively walked in 2-3 meter intervals. The site locations were flagged. On another day, the general site areas were rewalked at one meter intervals, and the sites were mapped.

Results of the Survey

In the course of the survey, the entire project corridor was subjected to pedestrian survey, even if the areas could be readily determined to be highly disturbed or low and wet. In addition, a total of 313 shovel test units and numerous shovel probes were also excavated. Figures 8-9, shows the areas which were shovel tested or shovel probed.

Native American artifacts were located in one location in the project corridor. They consisted of the recovery of three pieces of chert debitage. They were recovered from the surface of cornfields on the north side of Clayton Rd. in the N1/2, NE1/4, SE1/4, Sec. 1, T6N, R8E (Fig. 6). The easternmost flake was about 120 meters from the next flake to the west, which was, in turn, located about 90 meters from the third flake.

Little may be said regarding this site, which might be more properly considered to be three isolates, as there were only three flakes scattered in a line about 210 meters long. They were found on the northern edge of a small rise, much of the was destroyed by the construction of the existing road. To the south, the site and road are bordered by steep uphill slopes. To the north is a much more gentle slope down to the floodplains of Nine Springs Creek. No culturally or temporally diagnostic artifacts were recovered.

The only other site encountered in this survey was a cluster of four secondary chert flakes found in the NE1/4, SW1/4, SE1/4,

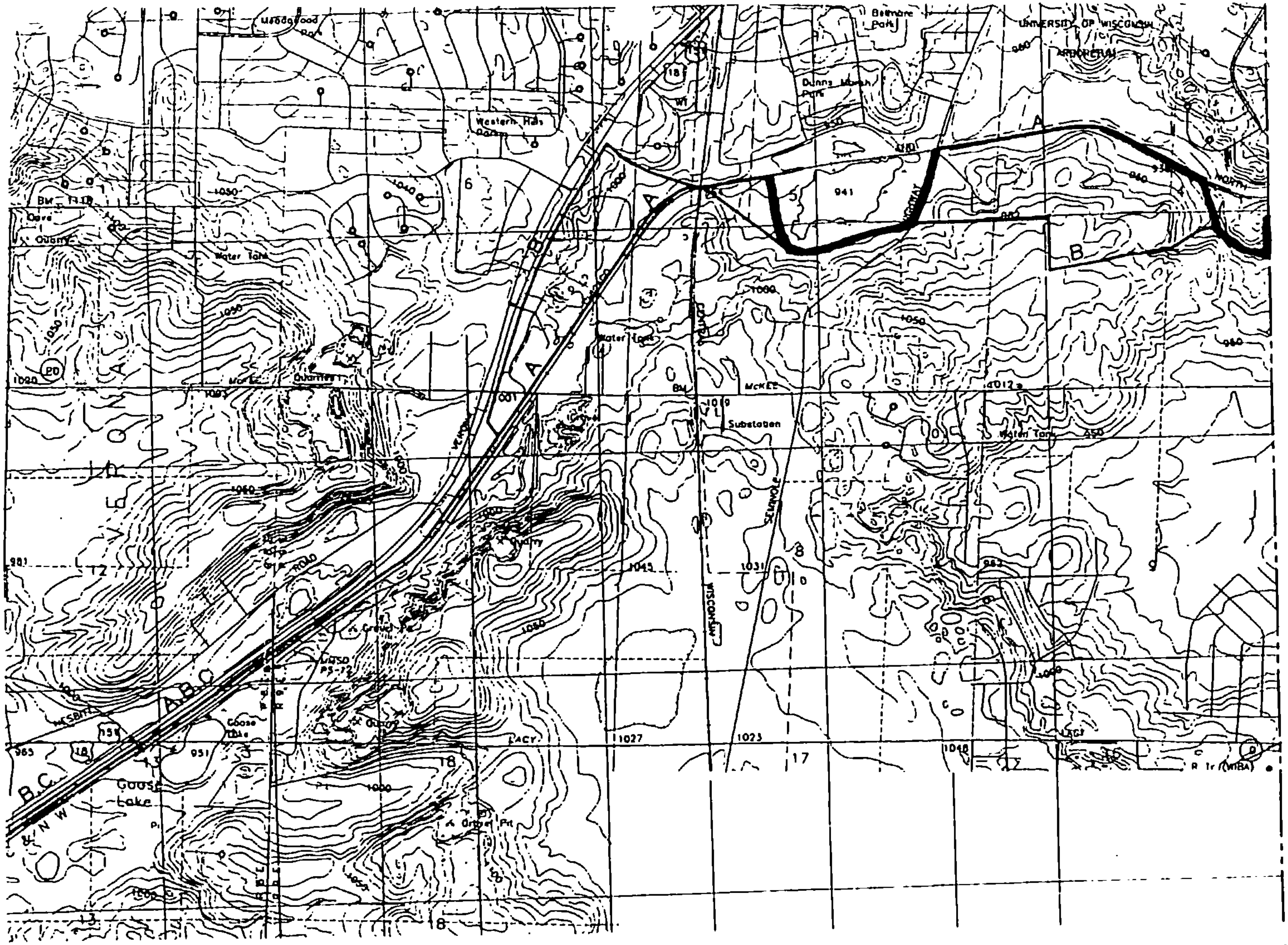
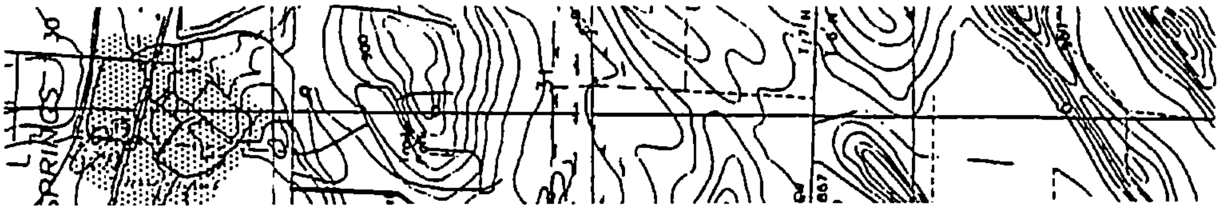


Fig. 8 - Shovel Tested or Probed Areas in the Western Portion of the Project corridor



Summation and Recommendations

In August, 1995, the author conducted an archaeological survey of the corridor for the proposed effluent force main linking the MMSD Nine Springs facility and the city of Verona wastewater treatment facilities. In the course of the survey, the project corridor was subjected to pedestrian survey and the excavation of 313 shovel test units and numerous shovel probes. Much of the project corridor can be described as highly disturbed or low and marshy.

One Native American site was discovered during the survey: a total of three chert flakes scattered along 210 meters of the project corridor in Sec. 1, T6N, R9E. Despite additional intensive survey, no other artifacts were found in this location. Another small Native American site was found in Sec. 2, T6N, R9E, but this disturbed location was determined to be outside of the project corridor. Euro-American artifacts were limited to surface finds of recent age or items which were not temporally diagnostic.

No additional archaeological work is recommended for the project corridor as no sites were encountered which might be eligible for inclusion on the National Register of Historic Places. It is possible that deeply buried archaeological resources may be present in the project corridor. If such materials are encountered in the course of construction, immediate consultation may be obtained by contacting the Compliance Section of the Wisconsin Division of Historic Preservation at 608-264-6507. If burials or potential human remains of any kind are encountered, the Burial Sites Preservation Office should be contacted at 608-264-6503.

Curation

All materials associated with this project will be curated at the facilities of Archaeological Consulting and Services in Verona, Wisconsin.

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1976 Geological Deposits of Wisconsin. Wisconsin Geological and Natural History Survey, Map 10. Madison.

1981 Bedrock Geology of Wisconsin. Wisconsin Geological and Natural History Survey. Madison.

Maps and Plats

1833 - Governmental Land Office Survey Map of T6N, R8E and T6N, R9E - Dubuque

1861 - Map of Dane County, Wisconsin - A. Ligowsky - Madison

1873 - Atlas of Dane County, Wisconsin - Harrison and Warner - Madison

1890 - Plat Book of Dane County, Wisconsin - C.M. Foote and Co. - Minneapolis

1890 - U.S.G.S. Plat Map of the Madison Area

1899 - New Atlas of Dane County, Wisconsin - Leonard W. Gray and Co. - Madison

1904 - Atlas of Dane County, Wisconsin - Democrat Printing Co. - Madison

1906 - U.S.G.S. Plat Map of the Madison Area

1911 - Standard Historical Atlas of Dane County, Wisconsin - Cantwell Printing Co. - Madison

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1926 - New Atlas of Dane County, Wisconsin - Dane County Atlas Co. - Madison

1931 - Atlas and Plat Book of Dane County, Wisconsin - The Thrift Press - Rockford

1940 - Dane County Plat Book - W.W. Hixson and Co. - Rockford

1947 - Ownership Plat Book of Dane County, Wisconsin - Marathon Map Service - Milwaukee

Additional Sources

Site files and archives of the Wisconsin Historic Preservation Division

Site files and archives of the Anthropology Section of the State Historical Society of Wisconsin

Site files and archives of the Burial Sites Preservation Office

Site files and archives of Archaeological Consulting and Services

National Register of Historic Places

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Wisconsin Archeologist

Appendix D

MONTGOMERY WATSON

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

WISCONSIN
DEPT. OF NATURAL RESOURCES

George E. Meyer
Secretary

101 South Webster Street
Box 7921
Madison, Wisconsin 53707
TELEPHONE 608-266-2621
TELEFAX 608-267-3579
TDD 608-267-6897

August 9, 1995

IN REPLY REFER TO: 1650

Mr. Paul Nelson
Montgomery Watson
505 USH 169, Suite 555
Minneapolis, MN 55441

SUBJECT: Endangered Resources Information Review (Log Number 95-214)

Dear Mr. Nelson:

The Bureau of Endangered Resources has reviewed the project area described in your letter and Information Request Form of June 30, 1995 for the Sugar River Effluent Discharge Study in which an effluent transmission line from Nine Springs Wastewater Treatment Plant to Badger Mill Creek is proposed. The project proposes alternative routes, discharge sites and constructed wetlands sites shown on maps included with your request.

Our Natural Heritage Inventory (NHI) data files contain the following rare species and natural communities information for the project site located in Section 12-14 of T6N R8E, Sections 1-8, 10, and 11 of T6N R9E and Sections 30 and 31 of T7N R10E, Dane County. In addition to the actual project site, I am providing endangered resource information for an area within one mile of the project's location (within five miles for aquatic species.) I provide this information both so impacts to nearby endangered resources can be assessed and to assist in determining which rare species may occur in the project's impact area if appropriate habitat exists. If the described habitat types occur in the project's impact area, then species that are represented by older records or that occur nearby may be present there. A description is provided for the natural areas, and the species information provided includes the location, date of the most recent observation, and other information useful in planning protection measures. Endangered resources occurring within or near the project site include:

Gentiana alba (yellowish gentian), a plant listed as Threatened in Wisconsin, occurs in Section 7 of T6N R9E. The observation date for this occurrence record is 1989. In Wisconsin this species has been observed in wet, sandy railroad prairie; thin soil on open and wooded ridges and bluff-tops; wooded ravines in clay soils and damp roadsides on edges of woods. Blooming occurs from mid-August through early October.

Platanthera leucophaea (prairie white-fringed orchid), a plant listed as Threatened at the Federal level and Endangered in Wisconsin, occurs in Section 4 of T6N R9E. The observation date for this occurrence record is 1981. This species prefers wet prairies; wet meadows; bogs; and other open, grassy places. Blooming occurs during June and July.

Lower Mud Lake (Dunn) natural area occurs in parts of the E1/2 SW1/4 of Section 10, the S1/2 of Section 11, the NW1/4 of Section 15, and the NE1/4 of Section 16 in T6N R10E, Dane County. This large wetland complex (approximately 400 acres) lies east and southwest of Lower Mud Lake, a widening of the Yahara River. The shallow marsh and sedge meadow are interspersed with deeper marsh and shrub carr. A good compliment of submerged aquatics are found in the lake and the area is used extensively by migrating waterfowl.

Nine Springs Meadows natural area occurs in Sections 2, 3 and 10 of T6N R9E, Dane County. This approximately 130-acre site contains occurrences of scrub carr, southern sedge meadow and a slow, hard, warm water stream.

Agastache nepetoides (giant yellow hyssop), a plant listed as Threatened in Wisconsin, occurs in Section 19 of T7N R10E. The observation date for this occurrence record is 1991. This species prefers oak woodlands and woodland edges and rich thickets. Blooming occurs from July through September.

Colias cesonia (dog-face butterfly), a State Special Concern butterfly, occurs in Section 4 of T6N R9E. The observation date for this record is 1991. This species prefers open dry areas, such as hot, dry scrub groves, short grass prairie hills, and open woodlands. It migrates north from south and breeds most summers in the midwest. Host plants include herbs of the pea family.

In addition to the above information, our data files also contain an historical record (generally, records that are 25 years old or older) of a rare species known to occur within the vicinity of the project site. Unfortunately, the Bureau does not have more current survey information documenting the continued existence of this species in this area. I am including this older records as an indication of which species may still occur in the project area if appropriate habitat exists:

Nothocalais cuspidata (prairie dandelion), a State Special Concern plant, has been known to occur in T6N R9E. The species prefers dry and dry sand prairies. Blooming occurs from April through May.

Special Concern (Watch) species are species about which some problem of abundance or distribution is suspected but not yet proved. The main purpose of this category is to focus attention on certain species before they become endangered or threatened.

Comprehensive endangered resource surveys have not been completed for the project area. As a result, our data files may be incomplete. The lack of additional known occurrences does not preclude the possibility that other endangered resources may be present.

The specific location of endangered resources is sensitive information that has been provided to you for the analysis and review of this project. Exact locations should not be released or reproduced in any publicly disseminated documents.

This letter is for informational purposes and only addresses endangered resource issues. This letter does not constitute Department of Natural Resources authorization of the proposed project and does not exempt the project from securing necessary permits and approvals from the Department.

Please contact Becky Isenring at (608) 264-8968 if you have any questions about this information.

Sincerely,

Charles M. Pils

Charles M. Pils
Director, Bureau of Endangered Resources

cc: Bob Roden - EA/6
Harold Meier - SD
Carl Batha - SD

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Appendix E

MONTGOMERY WATSON

BADGER MILL CREEK IFIM CALIBRATION REPORT

INTRODUCTION

This study evaluated instream effects of the proposed water diversion from the Dane County sewage treatment system into Badger Mill Creek, Verona, Wisconsin. The proposed diversions into Badger Mill Creek were 2.2 mgd (3.4 cfs) and 3.6 mgd (5.5 cfs).

Caldwell & Associates, Olympia, WA was responsible for the instream flow study of Badger Mill Creek. This report documents the modeling process, and discusses development of fish habitat preference criteria. Appendix A, archived on diskette, contains model input and output information. Photos of the instream flow study sites at the calibration flows are on file with Caldwell & Associates.

OVERVIEW OF THE INSTREAM FLOW INCREMENTAL METHOD

The Instream Flow Incremental Method quantifies available physical habitat for fish species of interest at various levels of stream flow (Bovee 1982). This method can be used for very site-specific analyses of potential projects, or for planning and reconnaissance-level assessment, as was done here. Major components of the IFIM methodology include: (1) study site and transect selection; (2) field collection of hydraulic data; (3) development of habitat suitability criteria; (4) hydraulic simulation to identify the spatial distribution of combinations of depths and velocities with different discharges, and (5) habitat simulation, using habitat suitability criteria, to estimate an index of change in habitat relative to change in discharge. The product of the habitat simulation is a habitat index value, Weighted Usable Volume (WUV), for a range of simulated stream discharges.

A major assumption of this method is that other habitat variables such as lack of escape cover, poor quality or limited spawning areas, water temperature or other water quality parameters are not limiting the production of fish. This may not be entirely true in Badger Mill Creek where it is likely that a combination of low flows, lack of of habitat and water quality limit fish production (Dane Co., 1993).

ANALYSIS METHODS

The study reach in Badger Mill Creek was from the confluence of Badger Mill Creek with the Sugar River upstream 4.8 miles to PB Road. At the time of this study, several potential diversion points were under consideration, all between PB Road and the Lincoln St. pedestrian bridge.

Data Collection

On April 3 - 4, 1995, two inventory teams of two people each walked approximately 25,240 feet of Badger Mill Creek from its confluence with the Sugar River upstream to Highway 151. Approximately 5300 feet of private property between Highway 69 and the City of Verona Sewage Treatment Plant was not inventoried because access was not granted. The habitat information from this inventory was used to identify the number and location of cross-sections (transects) for habitat modeling.

The location and habitat type represented by each of the 13 selected transects is contained in Table 1. The transects were located throughout the study reach to describe potential changes from the proposed discharges. The table also notes the flow measured at each transect during the inventory in April 1995.

Field data were collected at one calibration flow using standard techniques (Trihey and Wegner 1981). Water surface elevations (WSELs) and channel cross-sections were measured with an autolevel and stadia rod using standard leveling techniques. Water depths and velocities were measured with Swoffer™ and Marsh-McBirney™ flow meters. Channel characteristics such as substrate size and amount of instream sediments, and riparian characteristics such as amount of shading and type of streamside vegetation were noted.

Inflow Estimation

Stage-discharge measurements collected between February and April, 1995 and measured flows during the week of April 3, 1995 were used to estimate inflows between transects, and between mapping points such as bridges and road crossings. It was assumed that the late-winter flows in Badger Mill Creek reflected baseflow levels during other seasons. We assumed that conditions observed at that time were representative of both summer and winter baseflow conditions; and that the gradual increases in flow in Badger Mill Creek in a downstream direction would also be present during other seasons.

Target Fish Species

Two predictive habitat models for two target fish species groups were developed for this study. Dane County (1993) characterizes Badger Mill Creek as supporting a forage fish assemblage, and as having the potential to support trout in the lower reaches. Transects 1 - 6 were selected to represent both forage fish and trout habitat, and were used in both habitat models. Additionally, transects 7 - 13 were used in predicting forage fish habitat in the upper reaches of Badger Mill Creek where the existence of trout populations was considered less probable.

HYDRAULIC AND HABITAT MODELING

Analysis of physical stream measurements and habitat preference criteria use a group of computer programs developed by the US Fish and Wildlife Service, called the Physical Habitat Simulation System (PHABSIM). There are two types of programs in the PHABSIM library: hydraulic models and habitat models (Milhous and others 1989).

The hydraulic simulation model predicts depth of flow and mean water column velocities across the stream transect as a function of discharge. Stage-discharge relationships were developed for each transect to predict velocity/discharge relationships across each cross-section. For Badger Mill Creek, most stage-discharge relationships were estimated using Mannings' equation (the MANSQ program), and calibrated where possible to available measured flow information at sites nearby (such as bridges and culvert crossings). The range of flows modeled was based on the proposed additional flow augmentations and the limits of extrapolation imposed by having one flow measurement at low flow.

Table 1. Location, habitat type and measured baseflow for 13 transects in Badger Mill Creek. River Mile (RM) 0.0 is the confluence of Badger Mill Creek with the Sugar River.

Reach	Transect	Location (R.M.)	Habitat type	Measured flow (cfs)[1]
Mouth to Highway 69	1	0.05	Corner Pool	6.6
	2	0.05	Glide	6.4
	3	0.05	Riffle	7.0
Highway 69 to Main St.	4	0.82	Riffle	7.0
	5	0.86	Main Channel Pool	6.0
	6	0.87	Glide	6.4
Verona STP to Main St.	7	2.2	Glide	8.5[2]
	8	2.2	Glide	10.0[2]
Main St. to PB Road	9	3.2	Glide	2.6
	10	3.2	Glide	2.6
	11	3.3	Glide	2.0
	12	3.4	Glide	2.1
	13	4.1	Glide	0.34[3]

1. Measured flows are considered the same if they are within 10% of each other. Thus, transects 1-3, and 4-6 were measured at a similar flow.

2. Flows were measured after a rain event. An estimated baseflow of 4.1 cfs, apportioned from lineal distance, was used in estimating accretion flow for these transects.

3. This transect is upstream of the pond outlet near the Military Ridge Trail. The flow downstream of the pond outlet (i.e., the pond and the stream combined) was 1.4 cfs.

Regression equations were used to model flows between and beyond the measured discharges. The resulting simulated hydraulic data is then input to the HABTAT program. The HABTAT program integrates the simulated hydraulic information with habitat suitability criteria to estimate the available for the target species over a range of flows. The quantity of estimated habitat is expressed as an index, Weighted Useable Volume (WUV), as cubic feet of habitat per 1,000 linear ft. of stream.

The habitat model requires estimates of fish habitat preferences for water velocity and depth. These can be developed from site-specific fish observations, from observations from nearby regions, or from the literature. For brown trout, literature-based preference criteria (Bovee 1978, Raleigh and others 1986) were modified using professional judgement and recently-collected information from a similar size stream in Pend Orielle County, Washington (Blum, 1995).

Literature-based preference criteria were developed for forage fish using literature criteria for white sucker (Twomey and Nelson 1984) and information on the swimming speed of other small fishes (Bell 1991).

The predicted habitat index for forage fish in all of Badger Mill Creek is represented by the aggregate of the estimated habitat at all 13 cross sections. While the habitat values presented are indexed to flows at county road 69, flows at each transect were adjusted to match the inflow measured in the field.

Table 2. Habitat preference criteria used for PHABSIM modeling, Badger Mill Creek. Preferences range from 0.0 (not preferred) to 1.0 (preferred).

Forage fish (white sucker, darters)			
Velocity (fps)	Preference	Depth (ft)	Preference
0.0	0.10	0.0	0.0
0.3	1.0	0.2	0.4
1.0	1.0	0.3	0.6
2.5	1.0	0.4	1.0
3.0	0.5	5.0	1.0
4.0	0.0	> 5.0	1.0
All available substrate in Badger Mill Creek was assumed to be suitable,			
Brown trout juveniles and adults, summer habitat			
Velocity (fps)	Preference	Depth (ft)	Preference
0.0	0.2	0.0	0.0
0.1	0.63	0.4	0.0
0.25	0.73	1.5	1.0
0.4	1.0	> 1.5	1.0
0.6	1.0		
1.3	0.44		
4.0	0.0		

> 4.0	0.0		

HABITAT MODELING RESULTS

Forage Fish Habitat

The modeling results are indexed to flows at Road 69. When interpreting results, it should be remembered that base flows near county road 69 were in the 6 cfs range. Lower flows are shown here to illustrate the relationship of flow and predicted habitat.

The estimated available habitat for forage fish increases with both discharge scenarios (Figure 1). Increases in potential habitat range from 33 to 71 percent with a 2.2 mgd and from 50 to 100 percent with a 3.6 mgd.

A benefit of flow augmentation to forage fish would be a longer reach of stream with baseflows in the preferred range. The Wisconsin Department of Natural Resources (WDNR) stream classifications define a desired baseflow for supporting forage fish as greater than 5 cfs (Ball 1982). The measured baseflow in upper Badger Mill Creek near PB Road was 0.3 cfs (1.4 cfs downstream of the pond), and 2.5 cfs upstream of the Lincoln St. pedestrian bridge. With either proposed discharge, a greater portion of the reaches of Badger Mill Creek upstream of Main St. would approach or exceed the five cfs threshold than at present. The amount of increase depends on the chosen discharge and the location of the discharge point.

Brown Trout Habitat

All six of the cross-sections used for estimating brown trout habitat were near Highway 69. The potential habitat for brown trout in the lower reaches of Badger Mill Creek increases with both discharge scenarios (Figure 2). The increase in habitat ranges from 58 percent with 2.2 mgd and 105 percent with 3.6 mgd. This analysis did not address whether stream temperatures are suitable for brown trout in Badger Mill Creek, or whether additional habitat benefits to brown trout could be realized from the addition of instream cover structures or increased riparian shading.

Predicted Water Velocities

The increase in stream velocities with the addition of 2.2 or 3.6 mgd was analyzed to identify possible changes in bank erosion or channel degradation. The average measured velocity at baseflow was compared with calculated velocities at the baseflow plus 2.2 and 3.6 mgd and the highest modeled flow at four transects (Table 2). These transects were chosen to be typical of the entire stream reach downstream of PB Road. No water velocities greater than 2.0 fps were predicted at any of the flows modeled. It is not likely that bank erosion would increase with these small velocity increases, although it is possible that some of the high sediment load present in places along the stream reach may be removed with slightly higher water velocities.

Appendix F

MONTGOMERY WATSON

SITE EVALUATION MATRIX
MADISON METROPOLITAN SEWERAGE DISTRICT
POTENTIAL WETLAND CONSTRUCTION/ENHANCEMENT SITES

DRAFT 3/95
FACILITY SITE NUMBER:____
NAME:____________

INITIAL SCREENING

	YES	NO
At least 10 Acres available	______	______
Within 1/4 mile of Badger Mill Creek	______	______
"Bowl" shape with<1000' of 10' berm required	______	______
No history of significant public opposition to change in use	______	______
Regulatory conditions not prohibitory	______	______
No significant flood damage impact on structures	______	______
No history of containing hazardous materials	______	______
No known P/other pollutant contribution potential from soils	______	______

NOTE: Any NO above eliminates the site from further consideration

FEASIBILITY SCREENING

FEASIBILITY SCREENING	Value Range Low	Value Range High	Weight Factor	Assigned Value	Weighted Value	Max Value
A) Infiltration/percolation potential	1	5	2			10
B) P/pollutant removal potential of the soils	1	5	3			15
C) Soil potential for wetland use	1	5	1			5
D) Size	1	5	3			15
E) Shape (3-D)	1	5	2			10
F) Lateral groundwater movement to Badger Mill Creek	1	5	3			15
G) Access Potential	1	5	1			5
H) Land Aquisition Potential	1	5	2			10
I) Close to public use areas	0	5	1			5
J) Wildlife Potential	0	5	1			5
) Safe Edge Shape	0	5	1			5
OTAL POINTS:						100

A) Infiltration/percolation should generally be in the mid range-specifically ________ ________ ________ ________ and ________ in descending preference.

B) Acceptable soils (surface and up to 30' depth) include in descending preference.

C) In descending order of preference these soils include ________ ________ ________ ________ and ________.

D) 10 to 15 acres - 1
15 to 20 acres - 2
20 to 25 acres - 3
25 to 30 acres - 4
> 30 acres - 5

E) Ideal would involve - length to width ratio = >2
- maximum water depth = 6'
- average water depth = 18"
- > 1/3 surface area < 6" deep

F) Definite shallow flow path to Badger Mill Creek with < 10 day travel time =5

G) Main access road now exists - 5
> 2 miles of access road required - 1

H) Available public land - 5
Eager seller - 4
Tough potential seller - 1

I) Within one mile - 5
Over five miles - 1

J) Subjective - Consider adjacent/nearby wildlife area needs for complementary habitat.

K) Highest rating for sites where a perimiter depth of < 6" can be easily provided for 10' into wetland around entire edge.

Appendix G

CORRESPONDENCE / MEMORANDUM STATE OF WISCONSIN

DATE: June 5, 1995

TO: Gerry Novotny - WW/2

FROM: Duane Schuettpelz - WR/2

SUBJECT: Effluent Limitations for facility planning purposes at the annexation of Verona by the Madison Metropolitan Sewerage District (MMSD) - ADDENDUM

This memo addresses additional limitations and some changes to the previous memo to you from me dated May 23, 1995. Please add effluent dissolved oxygen limit of 7 mg/L daily minimum, to all alternatives except the discharge to Badger Mill Creek with the current classification as a Limited Forage Fish Community (Intermediate).

Also, based on the recent Department guidance regarding BOD and TSS limits below 10 mg/L for effluent-dominated streams, please change all of the alternatives where a 10 mg/L weekly average limit was recommended for TSS, in my May 23, 1995 memo to you. Those 10 mg/L TSS limits should be expressed as monthly averages instead of weekly.

If you have any questions please contact Nasrin Mohajerani at (608) 267 - 2303).

PREPARED BY:

N. Mohajerani

Nasrin Mohajerani
Water Resources Engineer

APPROVED FOR SIGNATURE BY:

Robert G. Masnado

Robert G. Masnado
Water Quality Effluent
Limits Unit Supervisor

James W. Schmidt

James W. Schmidt
Water Resources Engineer

CC: Roger Schlesser - SD
Steve Fix - SD

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To PAUL NELSON	From GERRY NOVOTNY
Co. MONT. WATSON	Co.
Dept. 612 593-9975	Phone # (608) 267-7625
Fax # 612 593 9000	Fax #

TOTAL P.01

WISCONSIN
DEPT. OF NATURAL RESOURCES
George E. Meyer
Secretary

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

101 South Webster Street
Box 7921
Madison, Wisconsin 53707
TELEPHONE 608-266-2621
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TDD 608-267-6897

June 1, 1995

James Nemke
Chief Engineer & Director
Madison Metropolitan Sewerage District
1620 Moorland Road
Madison, WI 53713-3398

MADISON METROPOLITAN SEWERAGE DISTRICT
RECEIVED
JUN 5 1995

Dear Mr. Nemke:

Attached please find a copy of the effluent limits memo prepared by our Bureau of Water Resources Management for the proposed discharge to Badger Mill Creek. I've also enclosed a copy of the Environmental Assessment which was prepared on the Facilities Plan Update. A press release was was issued with a comment period that will end on Friday June 9, 1995. The Department recieved the amendment to the Dane County Regional Planning Commission water quality plan and the approval of that amendment should be complete next week. Unless there are significant public comments on the Environmental Assessment we could except that the plan could be approved the week of June 12th. Approval of the plans and specifications should follow shortly after the facilities plan approval.

As we discussed that at the last advisory committee meeting I attended, I propose have the Department approve all the recommendations of the Facilities Plan Update accept for the recommendations for excess effluent discharge to Nine-Springs Creek. I have been delayed in pulling together the Department's comments on that recommendation but I will be sending you a letter with out comments in the near future.

The approval will of course not cover any final recommendations for the sludge lagoon rehabilitation or the proposed return of flows to the Sugar River basin as these are the subject of additional planning.

Thank you for your patience with our progress on your plan. I sincerely appreciate the efforts you are making to work cooperatively with the Department. As always, if you have any questions about the status of the plan

Sincerely,

Gerald Novotny, P.E.
Municipal Wastewater Section
Bureau of Wastewater Management

cc: Bob Weber - SD
Nasrin Mohajerani - WR/2
George Osipoff - Madison Area
Bob Masnado - WR/2
Steve Fix - SD

CORRESPONDENCE / MEMORANDUM STATE OF WISCONSIN

DATE: May 23, 1995

TO: Gerry Novotny - WW/2

FROM: Duane Schuettpelz - WR/2
Prepared by Nasrin Mohajerani - WR/2

SUBJECT: Effluent Limitations for facility planning purposes (annexation of Verona by the Madison Metropolitan Sewerage District (MMSD).

This is in response to your request for a review of the effluent limitations for conventional pollutants for the City of MMSD/Verona WPDES permit using chapters NR 102, 104, 210 and, since an increased discharge is proposed, NR 207 of the Wisconsin Administrative Code. Those pollutants include BOD5, total suspended solids (TSS), ammonia nitrogen, phosphorus and pH.

This discharge would be indirectly to the Sugar River via Badger Mill Creek (BMC) while a final discharge location has not yet been determined. The proposed alternative effluent return flows would be 2.2, 2.9 or 3.6 mgd.

Badger Mill Creek is currently classified as a limited forage fish community (intermediate) in NR 104. However, NR 104 is to be updated within the next two years and Badger Mill Creek is to be removed from NR 104 since it is proposed to be reclassified to a warm water forage fish community. Approximately 3.5 miles downstream, BMC flows into the Sugar River which is classified as warm water community and as an exceptional resource water. However, NR 102 is also to be updated within the next two years and the Sugar River is proposed to be reclassified to a cold water community. Therefore, effluent limitations have been calculated to protect the Sugar River and BMC for current classifications and proposed reclassifications.

A receiving water flow of 0.18 cfs was used in establishing effluent limitations were obtained from the U.S. Geological Survey.

Based on the three proposed alternative discharge flows of 2.2, 2.9 and 3.6 mgd, the following effluent limitations are provided for redirected flows from Verona to MMSD.

REOMMENDED EFFLUENT LIMITATIONS (FLOW 2.2 MGD)		
TO PROTECT Sugar River CURRENT CLASSIFICATION (WARM WATER)		
PARAMETER	SUMMER WEEKLY AVG. (MG/L)	WINTER WEEKLY AVG. (MG/L)
BOD5	5.8	10.9
TSS	10	10.9
AMMONIA	0.7	3.8

RECOMMENDED EFFLUENT LIMITATIONS (FLOW 2.9 MGD)		
TO PROTECT **SUGAR RIVER** CURRENT CLASSIFICATION **(WARM WATER)**		
PARAMETER	SUMMER WEEKLY AVG. (MG/L)	WINTER WEEKLY AVG. (MG/L)
BOD5	5.7	10.8
TSS	10	10.8
AMMONIA	0.7	3.7

RECOMMENDED EFFLUENT LIMITATIONS (FLOW 3.6 MGD)		
TO PROTECT **SUGAR RIVER** CURRENT CLASSIFICATION **(WARM WATER)**		
PARAMETER	SUMMER WEEKLY AVG. (MG/L)	WINTER WEEKLY AVG. (MG/L)
BOD5	5.6	10.7
TSS	10	10.7
AMMONIA	0.7	3.7

RECOMMENDED EFFLUENT LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)		
TO PROTECT **SUGAR RIVER** FUTURE CLASSIFICATION **(COLD WATER)**		
PARAMETER	SUMMER WEEKLY AVG. (MG/L)	WINTER WEEKLY AVG. (MG/L)
BOD5	5	10
TSS	10	10
AMMONIA	0.7	1.5

RECOMMENDED EFFLUENT LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)					
TO PROTECT **BADGER MILL CREEK** CURRENT CLASSIFICATION (LIMITED FORAGE FISH COMMUNITIES) **(INTERMEDIATE)**					
PARAMETER	MONTHLY AVG. (MG/L)	DAILY MAX. (MG/L)	WEEKLY AVG. SUM.	WEEKLY AVG. WINT.	OTHER (MG/L)
BOD5	15	30			
TSS	20	30			
AMMONIA			3	6	
DISSOLVED OXYGEN					4 (MIN)

RECOMMENDED EFFLUENT LIMITATIONS (FLOW 2.2 MGD)		
TO PROTECT **BADGER MILL CREEK** FUTURE CLASSIFICATION (**WARM WATER**)		
PARAMETER	SUMMER WEEKLY AVG. (MG/L)	WINTER WEEKLY AVE. (MG/L)
BOD5	6.3	10.9
TSS	10	10.9
AMMONIA	4.1	18.7

RECOMMENDED EFFLUENT LIMITATIONS (FLOW 2.9 MGD)		
TO PROTECT **BADGER MILL CREEK** FUTURE CLASSIFICATION (**WARM WATER**)		
PARAMETER	SUMMER (MG/L)	WINTER (MG/L)
BOD5	6.2	10.8
TSS	10	10.8
AMMONIA	4.0	18.5

RECOMMENDED EFFLUENT LIMITATIONS (FLOW 3.6 MGD)		
TO PROTECT **BADGER MILL CREEK** FUTURE CLASSIFICATION (**WARM WATER**)		
PARAMETER	SUMMER (MG/L)	WINTER (MG/L)
BOD5	6.1	10.7
TSS	10	10.7
AMMONIA	4.0	18.3

RECOMMENDED EFFLUENT LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)	
SUGAR RIVER AND **BADGER MILL CREEK**	
PARAMETER	
pH (s.u.) (Daily Range)	6.0 - 9.0
CHLORINE (Total Res.)	37 (µg/L) Daily Maximum 7.0 (µg/L) Weekly Average
PHOSPHORUS (Total)	1.5 (MG/L) Monthly Average

These recommendations are discussed in the attached report.

Mass limits are not recommended at this time, pending the selection of one of the alternative design flows. Annual mass limitations will be adequate for BOD5, TSS, ammonia, chlorine and phosphorus, so the mass limitations should be calculated using the lowest concentration limits for each parameter and the appropriate design flow.

Note: If the calculated summer BOD5 limitations based on water quality are less than 5 mg/L, a weekly average limit of 5 mg/L is recommended. Also the lowest TSS limit recommended is 10 mg/L. This adjustment is consistent with current Department policy on BOD5 and TSS limits for municipal dischargers.

Finally, it should be pointed out that this memo and the attached report do not address the Department's review of MMSD/Verona's priority pollutant scan using chapters NR 102, 105 and 106 as well as any recommendation pertaining to whole effluent toxicity monitoring. That review will be addressed under separate cover in the near future. However, that review will not affect the limits recommended above.

If you have any further questions or comments regarding the above recommendations or the forthcoming priority pollutant review, please contact either Nasrin Mohajerani at (608) 267-2303, Robert Masnado at (608) 267-7662, or myself at (608) 266-0156.

PREPARED BY:

N. Mohajerani

Nasrin Mohajerani
Water Resources Engineer

APPROVED FOR SIGNATURE BY:

Robert G. Masnado

Robert G. Masnado
Water Quality Effluent
Limits Unit Supervisor

James W. Schmidt

James W. Schmidt
Water Resources Engineer

CC: Roger Schlesser - SD
Steve Fix - SD

Water Quality-Based Effluent Limitations
For Conventional Pollutants at

MMSD/Verona

WPDES Permit No. WI - 0022454

Prepared By:

N. Mohajerani

Nasrin Mohajerani, E. E.

May 23, 1995

Date

Approved By:

James Schmidt for RM

Robert Masnado
Water Quality Effluent Limits Unit
Program Supervisor

Water Quality-Based Effluent Limitations
For
Annexation of Verona by the Madison Metropolitan Sewerage District
Outfall 001

This report discusses the determination of water quality-based effluent limitations for conventional pollutants for the proposed Nine Springs WWTP (NSWWTP)discharge to (BMC).

General Information:

Madison Metropolitan Sewerage District annexed the City of Verona urban service in 1993. Currently the City of Verona treats wastewater from the Verona urban service area and discharges the treated effluent to the Sugar River.

The facilities plan update evaluated a number of alternatives for the Verona urban service area including: upgrading the Verona plant; abandoning the Verona plant and pumping all wastewater to NSWWTP; continued operation of the Verona plant at a flow rate such that the plant will continue to meet effluent limits and pump the "excess" flow to NSWWTP; construct a new regional treatment plant at Verona to serve the Sugar River Watershed.

The facilities plan update recommends construction of a pumping station and force main to convey wastewater from Verona to NSWWTP as the first phase of final plan recommendation. Initially, a portion of the wastewater would be pumped to NSWWTP while the Verona plant is maintained in operation. However, concerns about continued diversion of water out of the Sugar River watershed, the potential to enhance the condition of BMC and regulatory requirements for a future discharge to the Sugar River lead MMSD to initiate an additional planning effort to investigate the environmental impacts, costs, and potential benefits of returning treated effluent from the NSWWTP to the Sugar River basin via BMC. This planning effort is underway and is scheduled to be completed by August of 1995.

The recommended construction of a pumping station and force main connection to NSWWTP will preserve all the alternatives evaluated except the expansion of the existing Verona plant. It is desirable to proceed with the construction of these facilities to ensure that the Verona plant continues to stay in compliance with its discharge permit.

The selected alternative is; continued operation of the Verona plant at a flow rate such that the plant will continue to meet effluent limits and pump the "excess" flow to NSWWTP. This alternative would result in discharge of wastewater to the BMC via one outfall 001. The outfall location has not yet been determined. BMC is classified as a limited forage fish community (intermediate) according to chapters NR 102 and 104 and has a seven-day, ten-year low flow (7Q10) of (0 - 0.18) cfs (see attached map). Approximately 3.5 miles downstream, BMC flows into the Sugar River which is classified as warm water community and as an exceptional resource water.

Several limits are provided based on current and future classifications for Sugar River and BMC. Two sets of limitations are recommended. One is based on the current classification of the Sugar River and the second set of limitations is based on the proposed classification. In both situations, limitations based on the Sugar River will protect Badger Mill Creek as well. The recommended effluent limitations must be protective of downstream uses, pursuant to s. NR 104. 02(5).

Discussion Of Recommended Permit Limitations

Based on the stream classification, the following DNR (NR 105 and 102) water-quality criteria are applicable for the purposes of this review:

Substance	Water Quality Criteria For Warm Water
Dissolved Oxygen	5 mg/L
Ammonia Nitrogen (un-ionized)	0.04 mg/L chronic
pH (daily range)	6.0 - 9.0 s.u.
Total Residual Chlorine	18.4 ug/L acute, 7.06 ug/L chronic

Substance	Water Quality Criteria For Cold Water
Dissolved Oxygen	6 mg/L
Ammonia Nitrogen (un-ionized)	0.016 mg/L chronic
pH (daily range)	6.0 - 9.0 s.u.
Total Residual Chlorine	18.4 ug/L acute, 7.06 ug/L chronic

BOD5:

In establishing BOD5 limitations based on water quality standards the following formula was used.

$$BOD5 = \frac{(2.4)\ (DO)\ (Qe + Q7,10)\ (0.967)^{(T-24)}}{Qe}$$

where:

- DO = The decrease in DO (mg/L) (1 mg/L in cold water, 2 mg/L in warm water)
- Qe = The effluent design flow (2.2, 2.9 and 3.6 mgd) (converted to cfs)
- Q7,10 = The receiving water Q7,10 = 0.18 cfs (BMC)
- T = The receiving water temperature
  BMC : summer 17.5°C winter 1.14°C
  Sugar River : summer 20°C winter 1°C

Weekly average limitations are calculated based on an allowance that 26 pounds of BOD be discharged per cfs of flow (after mixing) in order to produce an edge-of mixing-zone decrease of 2 mg/L DO at a temperature of 24 degrees C (75 degrees F). Corrections to the formula are necessary at different temperatures and/or to account for different DO decreases. A decrease from an assumed background concentration of 7 mg/L DO to the 5 mg/L warm water standard equals the 2 mg/L decrease mentioned earlier.

Note:
If the calculated summer BOD5 limitations are less than 5 mg/L, a weekly average limit of 5 mg/L is recommended along with a mass limitation based on the 5 mg/L limit. The lowest permitted winter limitation is 10 mg/L. These adjustment are consistent with current Department policy on BOD5 limitations.

RECOMMENDED BOD5 LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)				
SUGAR RIVER CLASSIFICATION (WARM WATER)				
FLOW (MGD)	SUMMER WEEKLY AVG.(MG/L)	SUMMER MASS MAY - OCT. (LBS)	WINTER WEEKLY AVG.(MG/L)	WINTER MASS NOV.- APRIL (LBS)
2.2	5.8	19,400	10.9	36,500
2.9	5.7	25,100	10.8	47,600
3.6	5.6	30,700	10.7	58,600

RECOMMENDED BOD5 LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)			
SUGAR RIVER FUTURE CLASSIFICATION (COLD WATER)			
FLOW (MGD)	SUMMER WEEKLY AVG.(MG/L)	WINTER WEEKLY AVG.(MG/L)	ANNUAL MASS (LBS/Y)
2.2	5	10	50,200
2.9	5	10	66,200
3.6	5	10	82,200

TSS:

The suspended solids limitations are primarily given to maintain, or improve water clarity, and are not water-quality based. Normally suspended solids limitations are thus established the same as the BOD5 limitations to prevent objectionable deposits on shores or beds of receiving waters.

Note:
If the calculated BOD5 limitations are less than 10 mg/L, a weekly average limit of 10 mg/L is recommended for TSS along with a mass limitation based on the 10 mg/L limit. This adjustment is consistent with current Department policy on BOD5 and TSS limitations.

RECOMMENDED TSS LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)				
SUGAR RIVER CURRENT CLASSIFICATION (WARM WATER)				
FLOW (MGD)	SUMMER WEEKLY AVG.(MG/L)	SUMMER MASS MAY-OCT.(LBS)	WINTER WEEKLY AVG.(MG/L)	WINTER MASS NOV.-APRIL (LBS)
2.2	10	33,500	10.9	36,500
2.9	10	44,100	10.8	47,600
3.6	10	54,800	10.7	58,600

RECOMMENDED TSS LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)		
SUGAR RIVER FUTURE CLASSIFICATION (COLD WATER)		
FLOW (MGD)	SUMMER & WINTER WEEKLY AVG.(MG/L)	ANNUAL MASS (LBS/Y)
2.2	10	67,000
2.9	10	88,200
3.6	10	109,600

AMMONIA NITROGEN:

The existing procedure for calculating effluent limitations for ammonia is based on the application of an in-stream un-ionized ammonia nitrogen (NH_3-N) criterion of 0.016/0.04 mg/L after mixing in the receiving water taking into account background pH levels and background river temperatures, each of which influence the criterion. The general calculation procedure and information is summarized below:

In establishing ammonia nitrogen limitations where daily variables are used, the daily percent of un-ionized ammonia has to be determined.

To determine the percent of total ammonia the following equations are used:

$$\% \text{ NH3-N} = \frac{1}{1 + 10^{(pka-pH)}}$$

Where: $pka = 0.09018 + \frac{2729.92}{T}$

T = Temperature (C) + 273.2
Receiving water temperature:
BMC : summer 17.5°C winter 1.14°C
Sugar River : summer 20°C winter 1°C

$\%NH_3$-N = Percent of the total NH_3-N in the un-ionized form

The total NH_3-N concentration is then equal to the appropriate un-ionized NH_3-N criterion divided by the $\%NH_3$-N.

In establishing ammonia effluent limitations the daily percent of unionized ammonia has to be calculated and a background pH has to be determined. The receiving water temperature is also used. Establishing these appropriate background concentrations is a critical step. Once the total allowable ammonia is determined, then a mass balance is used to determine the appropriate effluent limitation.

With this determined and the receiving water temperature measured, the formulas used to determine the fraction of the total NH_3-N are applied resulting in total allowable NH_3-N values for use in the equations.

To determine the chronic effluent limitation on any given day, a mass balance of the receiving water input parameters and effluent parameters is calculated. The mass balance calculation includes input parameters such as allowable dilution, background concentrations, and total allowable ammonia to determine the final effluent limitation. The mass balance equation is as follows:

$$NH3 - N_{(effluent)} = \frac{Q_{(mix)} * NH3\text{-}N_{(total\ allowable\ ammonia)} - Q_{(receiving\ water)} * NH3\text{-}N_{(receiving\ water)}}{Q_{(effluent)}}$$

where:

$NH3\text{-}N_{(effluent)}$ = Final limitation

$NH3\text{-}N_{(receiving\ water)}$ = Background concentration
BMC : summer 0.15 mg/L , winter 0.1 mg/L
Sugar River : summer 0.12 mg/L , winter 0.12 mg/L

$NH3\text{-}N_{(total\ allowable\ ammonia)}$ = Total allowable NH3-N

$Q_{(mix)} = Q_{(receiving\ water)} + Q_{(effluent)}$

$Q_{(receiving\ water)}$ = Allowable dilution, BMC's Q7,10 = 0.18 cfs

$Q_{(effluent)}$ = Effluent flow, three alternative flows : 2.2, 2.9 and 3.6 mgd

Using available information and the above procedures, recommended ammonia nitrogen limitations are as follows:

RECOMMENDED AMMONIA LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)						
SUGAR RIVER CURRENT (WARM WATER) AND FUTURE (COLD WATER)						
FLOW (MGD)	SUMMER (WARM)&(COLD) WEEKLY AVERAGE		WINTER (WARM) WEEKLY AVERAGE		WINTER (COLD) WEEKLY AVERAGE	
	MG/L	LBS/D	MG/L	LBS/D	MG/L	LBS/D
2.2	0.7	13	3.8	70	1.5	27
2.9	0.7	17	3.7	90	1.5	36
3.6	0.7	21	3.7	111	1.5	45

If the calculated ammonia nitrogen limitations are less than 0.7 mg/L, a weekly average limit of 0.7 mg/L is recommended for ammonia along with a mass limitation based on the 0.7 mg/L limit. The lowest permitted winter ammonia limitation is 1.4 mg/L. This adjustment is consistent with current Department policy on ammonia limitations.

These recommendations should be compared to any technology or Best Professional Judgement - based limitations prior to drafting a WPDES permit.

pH:

The pH requirement for MMSD/VERONA is required under S. NR 102.04(4)4(c) where the effluent pH cannot change the ambient pH range by 0.5 units or be outside the range of 6.0 - 9.0 s.u.

Chlorine:

Disinfection of discharges to fish and aquatic life waters is required from May 1 to September 30 annually to protect recreational uses pursuant to s.NR 210.06 (1)(a). If chlorine is used for disinfection, effluent limitations are recommended based on the water quality criteria in Ch. NR 105 and the implementation procedures in ch. NR 106. Acute and chronic toxicity criteria are available in NR 105 for cold water sportfish communities, those criteria are 18.4 and 7.06 ug/L, respectively.

Using ch. NR 106, daily maximum limitations for residual chlorine are equal to twice the acute toxicity criteria, while weekly average limitations are calculated using the following formula:

$$\text{Limitation} = \frac{(WQC)\ (Qs + (1-f)Qe) - (QsCs)}{Qe}$$

Where:

Limitation = Water quality based effluent limitation (in ug/L)

WQC = The applicable water quality criterion (7.06 ug/L)

Qs = Receiving water flow (Q7,10 = 0.18 cfs)

Qe = Effluent flow (2.2 MGD, 2.9 MGD and 3.6 MGD)

f = Fraction of the effluent flow that is withdrawn from the receiving water(zero)

Cs = Background concentration of the substance (in ug/L) as specified in s. NR 106.06 (3)(e). Since chlorine is not a naturally occurring or a persistent substance in the environment, the background concentration is assumed to be zero.

Effluent limits for chlorine are evaluated for three different alternatives at MMSD/Verona. Those limitations are summarized in following table:

RECOMMENDED CHLORINE LIMITATIONS (FLOW 2.2, 2.9 AND 3.6 MGD)			
SUGAR RIVER CURRENT (WARM WATER) AND FUTURE (COLD WATER)			
FLOW (MGD)	DAILY MAXIMUM (μg/L)	WEEKLY AVERAGE (μg/L)	MASS (lbs/d)
2.2	37	7.4	0.14
2.9	37	7.3	0.18
3.6	37	7.3	0.22

RECOMMENDATION: The calculated weekly average limits for residual chlorine are lower than those daily maximum limitations of 37 ug/L. Therefore weekly average limitations along with a mass limit is recommended for inclusion in MMSD/Verona's WPDES permit.

Phosphorus:

Chapter NR 217 of the Wisconsin Administrative Code has been promulgated to address point sources of phosphorus to surface waters. The code limits municipal dischargers of more than 150 pounds of phosphorus per month to 1 mg/L total phosphorus limitation. Based on the memo of June 29, 1994 from Duane Schuettpelz to MMSD regarding biological phosphorus removal and the phosphorus limit, the Department (Bureaus of Water Resources Management and Wastewater Management) has approved the alternative total phosphorus limitation of 1.5 mg/L for facilities planning for MMSD. Therefore the same limitation would be recommended for the annexation of Verona by MMSD.

RECOMMENDED PHOSPHORUS LIMITATIONS		
SUGAR RIVER CURRENT AND FUTURE CLASSIFICATIONS		
FLOW (MGD)	MONTHLY AVERAGE (MG/L)	MASS (LBS/DAY)
2.2	1.5	27.5
2.9	1.5	36.3
3.6	1.5	45

Since there is an increased discharge a review in consideration of the antidegradation provisions of NR 207 is necessary.

NR 207 Antidegradation Determination:

Procedures for implementing the antidegradation policy are contained in Ch. NR 207 Wisc. Adm. Code. These procedures are applicable to proposed new or increased discharges to outstanding resource waters, exceptional resource waters, Great Lakes waters, fish and aquatic life waters, and waters receiving variances in ch. NR 104.

The existing WPDES permit for Verona, based on a 0.625 mgd design flow, contains water quality-based or categorical effluent limitations for BOD and total suspended solids (30 mg/L monthly average and 45 mg/L weekly average on each), pH (6.0 to 9.0 s.u. daily range) and total residual chlorine (0.1 mg/L daily maximum).

Although there is an increase in discharge, the recommended effluent limitations for protection of Sugar River for both, warm water and cold water are much lower than those in the existing permit, thus there is no increase in concentration limits. Also, since the WPDES permit which expired on March 31, 1993 contained no mass limits, there is no way to determine if the new discharge will result in an increase in mass loadings. Based on this information, mass limits are recommended to be used for future implementation of NR 207.

Appendix H

MONTGOMERY WATSON

AppliedTechnologies

PREDESIGN MEMORANDUM

TO: Madison Metropolitan Sewerage District

FROM: Steve Verish / ATI
Bill Ericson / ATI

CC: Paul Nelson / Montgomery Watson

DATE: July 17, 1995
Revised: November 30, 1995

SUBJECT: Effluent Return Force Main and Pumping Configuration
Screening of Alternative Routes

BACKGROUND

The Madison Metropolitan Sewerage District (MMSD) recently annexed the Verona Urban Service Area and took over operation of the Verona Wastewater Treatment Plant. In MMSD's Facilities Plan Update (1994), several options for treating Verona's wastewater were evaluated. The selected alternative was to abandon the Verona plant and construct a new pump station and force main to convey the wastewater to the Nine Springs Wastewater Treatment Plant (NSWWTP). Included with this option were several alternatives for effluent discharge. These options were developed because of concerns about transferring water from the Sugar River watershed (which includes the City of Verona and a portion the City of Madison) to the Yahara River watershed. The option chosen for further study was to divert treated effluent from the NSWWTP to Badger Mill Creek just north of the Military Ridge Trail, southwest of Goose Lake. The purpose of this memorandum is to provide a screening of alternative force main routes with respect to hydraulics and construction cost. The proposed effluent return flows would be as follows:

Year	Flow (mgd)
1997	2.2
2006	2.9
2016	3.6

PRELIMINARY SCREENING OF FORCE MAIN OPTIONS

A preliminary screening of force main options was presented in ATI memorandum dated 4 April 1995. The memorandum evaluated the effluent transmission system proposed in the Facility Plan Update and concluded that use of the existing effluent transmission system to divert to Badger Mill Creek would require the addition of booster pumping. The memorandum evaluated three alternative force main configurations, each with an alternate route. The selected alternative included a direct tap of MMSD's 54-inch effluent force main, a booster pump station adjacent to MMSD's Pump Station No. 11, an 18-inch force main for 33,000 feet, and a 30-inch gravity sewer for the remaining 12,000 feet to the discharge location. Three separate pipeline routes were developed for the selected alternative.

Subsequent review of the preliminary screening effort determined that the selected alternative included undesirable features. These disadvantages are as follows:

- The booster pump station would be subjected to variable suction head conditions (depending on the residual head in the existing 54-inch effluent transmission line), making flow control to Badger Mill Creek more difficult and complex.
- An independent pumping system would provide better flexibility to accommodate the addition of future treatment units for aeration or filtration.
- A direct tap of the existing 54-inch effluent force main would require an expensive, risky construction operation on piping that has been in service 37 years. The risk was deemed to be highly undesirable because of the critical need to maintain effluent transmission from the NSWWTP to Badfish Creek.

Because of these disadvantages, the selected alternative was modified to include installation of independent effluent pumps at the NSWWTP and force main from the NSWWTP to the various routes to the Badger Mill Creek.

FORCE MAIN ROUTE ALTERNATIVES

Review of the route alternatives in the preliminary screening analysis indicated that the proposed 10-mile force main would traverse several "sensitive" areas requiring careful review and planning. Selection of a force main route will require integration with Dane County's plans for developing recreational parks and trails as well as private residential development in Fitchburg. Meetings with Dane County and the City of Fitchburg were held to discuss route alternatives and selection. Field inspections of route alternatives were done to verify current land uses and construction conditions. These efforts resulted in the selection of final route alternatives to be considered.

For the purposes of this Predesign Memorandum, the force main from the NSWWTP to Badger Mill Creek will be divided into nine segments labelled FM-1 through FM-9. The proposed alignments are depicted on Figures 1 and 2, and the ground profiles for the alignments are shown on Figures 3 and 4. The segments are summarized as follows:

FM-1 NSWWTP to MMSD PS-11

Proposed route is parallel to the existing alignment for PS-11 force main on MMSD property.

FM-2 MMSD PS-11 to USH 14

Proposed routes are in two alternatives:

FM-2A - Follows existing easement for Nine Springs Valley Interceptor (NSVI) in MMSD and Dane County property parallel to Nine Springs Creek. This route is mainly in wetlands.

FM-2B - Follows proposed Capital City Bike Trail along Clayton Rd. in MMSD and Dane County property, as well as existing road right of way (ROW).

FM-3 USH 14 to Syenne Road

Proposed routes are in two alternatives:

FM-3A - Follows existing easement for NSVI along Nine Springs Creek, mainly in Dane County property. This route is in wetlands.

FM-3B - Follows proposed Capital City Bike Trail along McCoy Rd., mainly in existing road ROW.

FM-4 Syenne Road to Longford Terrace (Highlands of Seminole Subdivision)

Proposed routes are in three alternatives:

FM-4A - Follows existing easement for NSVI up to Highlands of Seminole Subdivision, then in the road ROW for proposed Longford Terrace. This route includes wetlands in Dane County property, approximately 4,000 feet of private easement acquisition, 3,000 feet in a City of Fitchburg golf course, and 1,400 feet in proposed road ROW in Highlands of Seminole Subdivision.

FM-4B - Follows proposed Capital City Bike Trail southwest to Fish Hatchery Rd., McKee Rd., up to Longford Terrace. This route includes Dane County property, 3,400 feet of easement in Wisconsin DNR (WDNR) property, and about 4,200 feet of private easements. The route also includes about 2,000 feet of difficult construction in a heavily wooded ravine adjacent to Yarmouth Greenway Drive.

FM-4C - Follows proposed Capital City Bike Trail (same as 4B) to western edge of Dane County Property in Section 2, then north through wetlands on Dane County property to the same alignment as 4A for the remainder of the segment.

FM-5 Longford Terrace (Highlands of Seminole Subdivision) to Seminole Highway

Proposed routes are in two alternatives:

FM-5A - Follows existing easement for NSVI to Seminole Highway, then south to the highway crossing location in the highway ROW. This route includes 1,400 feet in public outlot in Highlands of Seminole, 4,200 feet of easement in Chicago & Northwestern (C&N) railroad ROW.

FM-5B - Follows proposed Capital City Bike Trail westward to Seminole Highway within public outlot and existing ROW.

FM-6 Seminole Highway to Central Wisconsin RR

Proposed route follows proposed Capital City Bike Trail south around Dunn's Marsh in City of Fitchburg, Dane County, and City of Madison properties.

FM-7 Central Wisconsin RR to Military Ridge Bike Trail

Proposed routes are in two alternatives:

FM-7A - Follows existing easement for NSVI along C&NW Railroad ROW to the head of the Military Ridge Bike Trail south of McKee Rd. This route includes about 5,100 feet of easement in C&NW Railroad ROW.

FM-7B - Follows proposed Capital City Bike Trail westward to Verona Road and connection with the Military Ridge Bike Trail. This route includes about 800 feet of private easements, 900 feet in City of Fitchburg property, and 4,500 feet in highway ROW.

FM-8 Military Ridge Bike Trail Head to Fitchrona Rd.

Proposed route follows existing Military Ridge Bike Trail in abandoned railroad ROW and includes about 4,300 feet of easement in WDNR Bike Trail.

FM-9 Fitchrona Rd. to discharge sites.

Proposed routes are in three alternatives:

FM-9A - Follows existing Military Ridge Bike Trail in abandoned railroad ROW to discharge site A, immediately SW of Goose Lake.

FM-9B - Follows existing Military Ridge Bike Trail in abandoned RR ROW to discharge site B, near Badger Mill Creek highway crossing.

FM-9C - Follows existing Military Ridge Bike Trail in abandoned RR ROW to discharge site C, on County Property south of the Bike Trail and west of CTH PB.

ALTERNATIVE ANALYSIS

The alternative analysis evaluates the force main alignment options in terms of construction cost, operational costs, and basic feasibility of construction. The cost estimates are based on a nominal 6-foot bury for the 20-inch diameter force main. A 20 inch pipe size was chosen for representative purposes based on velocity at a 3.6 mgd flow rate and to allow for future capacity. A detailed economic evaluation of pipe sizing for the selected route is included later in this memo. Each alignment will result in a different point of highest elevation and static head requirement which will affect the annual operating cost. Each alignment also results in a different length of pipeline which will have a great effect on the installed cost and a much lesser effect on the operational cost. The preferred alignment will then be the one with the lowest present worth cost. However, there are other non-monetary factors which are not considered in this memorandum that could have an effect on the final alignment selected for the force main.

Force Main Construction Cost Analysis

The analysis of construction cost for each of the force main route segments is summarized on Table 1. The design criteria employed in the analysis are listed on Table 1. Construction costs include pipe material, installation, surface restoration, jack and bore crossings, easement acquisitions, and trench dewatering in wetlands. Construction costs for individual segments are used to develop overall costs for the entire route.

Force Main Operational Cost Analysis

The analysis of operational costs includes a hydraulic analysis of each force main segment. The hydraulic analyses, based on the ground profiles in Figures 3 and 4, are summarized on Table 2. The hydraulic characteristics of each of the segments were combined together in three main route alternatives:

- <u>Alternative 1</u> - Nine Springs Valley Interceptor Route: Generally follows the NSVI route from the NSWWTP to MMSD PS-12

- Alternative 2 - Capital City Trail Route: Generally follows proposed Capital City Bike Trail from MMSD PS-11 to MMSD PS-12

- Alternative 3 - Combination Route: Follows NSVI route in pipeline segments FM-1, FM-7, and FM-8, and follows proposed Capital City Bike Trail for pipeline segments FM-2, FM-3, FM-5, and FM-6. This alternative includes route"C" in FM-4.

Table 3 summarizes the operational costs for each of the three alternatives for three effluent return flow rates identified the Facilities Plan Update.

Force Main Present Worth Analysis

Table 4 summarizes the total present worth costs for the three pipeline alternatives. Construction costs for the three alternatives range from $4.3 million to $4.7, while present worth costs range from $4.6 million to $5.0 million. The present worth analysis shows that none of the three alternatives would have a distinct cost advantage.

SELECTED ALTERNATIVE

The selected alternative for effluent transmission from the NSWWTP to Badger Mill Creek is described in the following narrative.

Force Main Alignment

The Combination Route as described in Alternative 3 above was selected as the optimal route based on the criteria set forth above. The final alignment is then as follows:

FM-1	FM-2	FM-3	FM-4	FM-5	FM-6	FM-7	FM-8	FM-9
N/A	B	B	C	A	N/A	A	N/A	B

Note that in line segment FM-5, the selected alternative will follow the "A" route adjacent to the railroad instead of the Capital City Bike Trail. This is the preferred route identified in discussions with Dane County Parks. This route adds about 1000 feet to the original Combination Route, and it avoids the high peak at elevation 1020 feet in Route B in this segment.

Hydraulics and Economics

Table 5 summarizes the estimated construction cost, hydraulics and annual operating costs, and present worth costs for pipe sizes 16 through 24 inches for the chosen alignment as described above. The analysis does not include the effects of electrical demand charge or escalation in power costs. Given the relatively low cost of electric power, the life cycle cost analysis favors smaller pipe with its resulting higher operating costs over the larger pipe sizes.

Although it does not offer the lowest present worth cost, the 20 inch pipe was selected on the basis that its present worth cost was only 13% higher than the 16 inch size which offered the lowest present worth cost. This added cost is offset by the significant reductions in velocity and total head at a flow rate of 3.6 mgd. The lower velocity will most likely extend the useful life of the pipe and provide for future capacity at a later date if it is needed. The 20 inch pipe will keep the discharge pressure below 100 psi. The lower total head should also have a positive effect on the pipe and pump system under transient and surge conditions.

Pump Configuration Options

Discussions with MMSD indicated that, assuming effluent filtration will not be required, the most cost effective location for the new effluent pumps would be in the existing Effluent Building at the NSWWTP. If filtration would be required, the new effluent pumps would best be located in the new filtration facility (as discussed in the effluent filtration tech memo).

There are three options for pump configurations in the Effluent Building. One of the options uses horizontal split case pumps mounted on their sides such that the shafts are vertical and the motor is on top. Its advantages are that the pumps are located in the existing pump room with access to the overhead crane. Disadvantages include the fact that the split case pumps take up a lot of floor space. Turning them on end is the only way to fit two pumps (one standby) into the existing space. The space available for discharge pipe fittings is more limiting than the other two options in this arrangement which will limit the choices of point of exit of the force main from the building.

A second option would use multi-stage vertical turbine pumps. The pumps would be located in the existing effluent wet well with the motors mounted on the mechanical mezzanine. The pump discharge would be below the mezzanine in the wet well and penetrate the wall between the wet well and pump room. Its advantages include the flexibility of discharge piping arrangements and the close proximity of the motors to the electrical gear and probable location of the variable speed drives. The disadvantages are related to construction and maintenance. Setting the pumps and working on the discharge piping in an enclosed and live wet well would be very difficult. Vortexing and adverse effects on existing inlet piping could also be a problem with this configuration. Additionally, there would be no crane access to the motors or pumps making maintenance extremely difficult.

The third option would be to use "canned" or "potted" multi-stage vertical turbine pumps located in the pump room. The basic arrangement is a standard vertical turbine pump set in a steel tube which would be hard piped to the wet well. Its advantages include the ease of construction and minimal amount of floor space required for the pumps. The discharge piping could most likely be configured such that the exit point of the force main from the building would encounter the least number of interferences from existing piping and utilities. Additionally, no work would have to be done in the wet well during construction. The overhead crane would be available for pump and motor maintenance. Disadvantages include a possible loss in efficiency (1-2%) vs. the split case pump and slightly more difficult maintenance due to the multi stage arrangement.

All three options would use a variable frequency drive or control valve arrangement to provide the variable flow requirements. The pumps will be sized to handle 3.6 mgd at full capacity. A flow meter would provide a control signal to the variable frequency drive or controller for the valve.

Since the cost of the pumps is essentially equal for all options, the third option of canned turbine pumps appears to offer the most installation flexibility with the least construction and maintenance disadvantages. Further investigation of the above three options will be done in the design phase. Table 6 outlines the estimated construction cost of the effluent pump installation. The items in the estimate include both material and installation. The cost for the flow control equipment is for either control valves or variable frequency drives. The most cost effective method of flow control will be investigated in the design phase.

Costs for Selected Alternative

Table 7 outlines the cost of the selected alternative for the effluent return system. It contains costs for the Combination Route effluent force main and effluent pumps installed in the existing Effluent Building at the NSWWTP.

SEGMENT	Length (Ft) A	B	C	Pur Easement at $10/ft A	C	Pipeline Cost for 20" DI*** A	B	C	Total Pipeline Cost A	B	C
FM-1	5,747					$316,085	$0	$0	$358,085	$0	$0
FM-2	5,333	6,283				$293,315	$345,565	$0	$596,645	$595,565	$0
FM-3	3,399	3,513		100		$186,945	$193,215	$0	$271,968	$244,248	$0
FM-4	10,682	15,304	11,477	3,700	$1,495	$587,510	$841,720	$631,235	$752,438	$1,019,613	$772,730
FM-5	6,905	5,845		4,241		$379,775	$321,475	$0	$523,587	$321,475	$0
FM-6	3,580			120		$196,900	$0	$0	$298,140	$0	$0
FM-7	5,548	7,000		5,091		$305,140	$385,000	$0	$357,733	$394,607	$0
FM-8	3,928			4,340		$216,040	$0	$0	$260,875	$0	$0
FM-9a*	2,458			2,378		$135,190	$0	$0	$159,756		
FM-9b*	4,964			4,884		$273,020	$0	$0	$323,475		
FM-9c*	10,864			10,824		$597,520	$0	$0	$709,338		

* Lengths for segments of FM-9 are independent of each other

** Easement cost based on the following:
- $20,000 per acre purchase price
- 50' permanent easement
- 100' construction easement
- Permanent easement 25% of purchase price
- Temporary easement 10% of purchase price

*** Based on 6' depth of bury, 20" Dia. DI pipe, and $30/ft material, $1

TABLE 2
FORCE MAIN ALTERNATIVES
HYDRAULIC ANALYSIS

Low water EL at suction	850
Discharge EL Site A	970
Discharge EL Site B	960
Discharge EL Site C	950
Electrical Power Cost ($/KWH)	0.042
Hazen-Williams "C" factor	120
Flow Rate 1 (MGD)	2.2
Flow Rate 2 (MGD)	2.9
Flow Rate 3 (MGD)	3.6
Pipe Diameter (Nominal, Inches	20

	Highest Elevation (Ft)			Static Head (Ft)*			Dynamic Head (Ft)** at 2.2 MGD			Dynamic Head (Ft)** at 2.9 MGD			Dynamic Head (Ft)** at 3.6 MGD		
Force Main Segment	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
FM-1	890			40			3			4			6		
FM-2	860	880		10	30		2	3		4	5		6	7	
FM-3	860	870		10	20		2	2		3	3		4	4	
FM-4	920	940	940	70	90	90	5	7	5	8	12	9	12	17	13
FM-5	950	1020		100	170		3	3		5	4		8	7	
FM-6	950	950		100	100		2			3			4		
FM-7	1001	1032		151	182		3	3		4	5		6	8	
FM-8	990	990		140	140		2			3			4		
FM-9a	972	972	972	122	122	122	1			2			3		
FM-9b	972	972	972	122	122	122	2			4			6		
FM-9c	972	972	972	122	122	122	5			8			12		

* Assumes segment high point is system high point.
** Major losses only

TABLE 3
FORCE MAIN ALTERNATIVES
OPERATIONAL COSTS

Low water EL at suction	850
Discharge EL Site A	970
Discharge EL Site B	960
Discharge EL Site C	950
Electrical Power Cost ($/KWH)	0.042
Hazen-Williams "C" factor	120
Flow Rate 1 (MGD)	2.2
Flow Rate 2 (MGD)	2.9
Flow Rate 3 (MGD)	3.6
Pipe Diameter (Nominal, Inches)	20

FORCE MAIN ROUTE	Length (ft)	Forced Length (ft)	Static Head (ft)*	Dynamic Head (Ft)** at flow (MGD)			Total Head (Ft)** at flow (MGD)			Annual Pumping Cost*** at flow (MGD)		
				2.2	2.9	3.6	2.2	2.9	3.6	2.2	2.9	3.6
NSVI Route	50,086	50,086	151	23	38	56	174	189	207	$22,790	$32,653	$44,518
Capitol City Trail Route	56,164	56,164	182	25	42	63	207	224	245	$27,220	$38,808	$52,643
Combination Route (B,C,B,A)	50,885	50,885	170	23	38	57	193	208	227	$25,332	$36,044	$48,792

* To highest pumped point in system
** Based on forced length of pipe
*** Assumes 85% efficient pump and 95% efficient motor

Note: All options assume discharge point "B"

TABLE 4
FORCE MAIN ALTERNATIVES
COST SUMMARY

FORCE MAIN ROUTE	Construction Cost*	Total Project Cost**	Annual Pumping Cost at flow (MGD)			Present Worth Cost**
			2.2	2.9	3.6	
NSVI Route	$4,500,000	$4,900,000	$23,000	$33,000	$45,000	$5,200,000
Capitol City Trail Route	$4,600,000	$5,000,000	$27,000	$39,000	$53,000	$5,300,000
Combination Route (B,C,B,A)	$4,200,000	$4,600,000	$25,000	$36,000	$49,000	$4,900,000

*Includes construction contingecies at 20%
**Includes engineering & administration at 10%

**Assumes: Interest rate at 8.25%
Flow schedule per report
20 year study period; 1997-2016
20" CLDI pipe size

Note: All options assume discharge point "B"

Table 5
Effluent Return Force Main
Hydraulic and Economic Analysis
Combination Route

Input Variables

Low water EL at pump suction	850	Hazen-Williams "C" factor	120
Discharge EL at Aerator	960	Electrical Power Cost ($/KWH)	0.042
EL of highest point in Force Main	1001	Pipe Diameter 1 (in, nominal)	16
EL allowance for disch. aerator	10	Pipe Diameter 2 (in, nominal)	18
Force Main Length (ft)	51,945	Pipe Diameter 3 (in, nominal)	20
Flow rate 1 (MGD)	2.2	Pipe Diameter 4 (in, nominal)	24
Flow rate 2 (MGD)	2.9	Interest Rate (%)	8.25
Flow rate 3 (MGD)	3.6	Planning period (years)	20
Qty Air/Vacuum valve vaults req'd	11	Cost per Air/Vacuum valve vault ($)	5,500

Pipe Budget Costs ($/lin ft @ 6' bury; CLDI)

Pipe Size	Material	Labor	Restoration	Adder for wetland installation
16	$18.70	$11	$6	$11
18	$22.85	$12	$6	$12
20	$26.69	$13	$6	$13
24	$35.60	$14	$6	$17

Construction Considerations

Wetland Crossing Length (ft)	12,882
Roadway Crossing Length (ft)	1,284
Roadway Crossing Cost ($/lin ft)	$500
River Crossing Length (ft)	250
River Crossing Cost ($/lin ft)	$500
Easement Cost ($/lin ft)	$10.33

Estimated Force Main Construction Cost

Pipe Size	
16	$3,334,258
18	$3,614,657
20	$3,878,952
24	$4,471,228

Calculated Total Pump Head
(ft w.c.)

Static Head (ft) 151

		Flow Rate (MGD)		
Pipe Size	I.D. (in)	2.2	2.9	3.6
16	16.8	217	260	314
18	18.88	188	213	243
20	20.94	173	188	207
24	25.06	160	167	174

Calculated Force Main Velocities
(ft/sec)

		Flow Rate (MGD)		
Pipe Size	I.D. (in)	2.2	2.9	3.6
16	16.8	2.2	2.9	3.6
18	18.88	1.8	2.3	2.9
20	20.94	1.4	1.9	2.3
24	25.06	1.0	1.3	1.6

Calculated Annual Pumping Costs*

		Flow Rate (MGD)		
Pipe Size	I.D. (in)	2.2	2.9	3.6
16	16.8	$30,522	$48,358	$72,426
18	18.88	$26,519	$39,561	$56,135
20	20.94	$24,447	$35,007	$47,701
24	25.06	$22,604	$30,957	$40,201

*Based on 80% efficient pump and 94% efficient motor

Calculated Pumping Dynamic Head
(ft w.c.)

		Flow Rate (MGD)		
Pipe Size	I.D. (in)	2.2	2.9	3.6
16	16.8	66	109	163
18	18.88	37	62	92
20	20.94	22	37	56
24	25.06	9	16	23

Calculated Present Worth Cost**
20 year study of 50 year life

Pipe Size	
16	$3,681,998
18	$3,909,419
20	**$4,146,291**
24	$4,714,173

**Salvage Value not deducted

TABLE 6
ESTIMATED CONSTRUCTION COST
EFFLUENT PUMP INSTALLATION

Item	Qty	U.O.M	Cost (ea)	Total Cost
Pumps	2	ea	$30,000	$60,000
Piping & Valves	1	lot	$25,000	$25,000
Equipment Pad	1	lot	$10,000	$10,000
Electrical Equipment	1	lot	$25,000	$25,000
Flow Controls*	1	lot	$55,000	$55,000
Total				**$175,000**

* Control Valves or VFD's

TABLE 7
EFFLUENT RETURN SYSTEM COST SUMMARY

Construction Cost*	Total Project Cost**	Annual Pumping Cost @ Flow (mgd)			Present Worth Cost
		2.2	2.9	3.6	
$4,700,000	$5,100,000	$25,000	$36,000	$49,000	**$5,400,000**

* Construction Cost includes 20% contingency
** Total Project Cost includes 10% engineering & administration

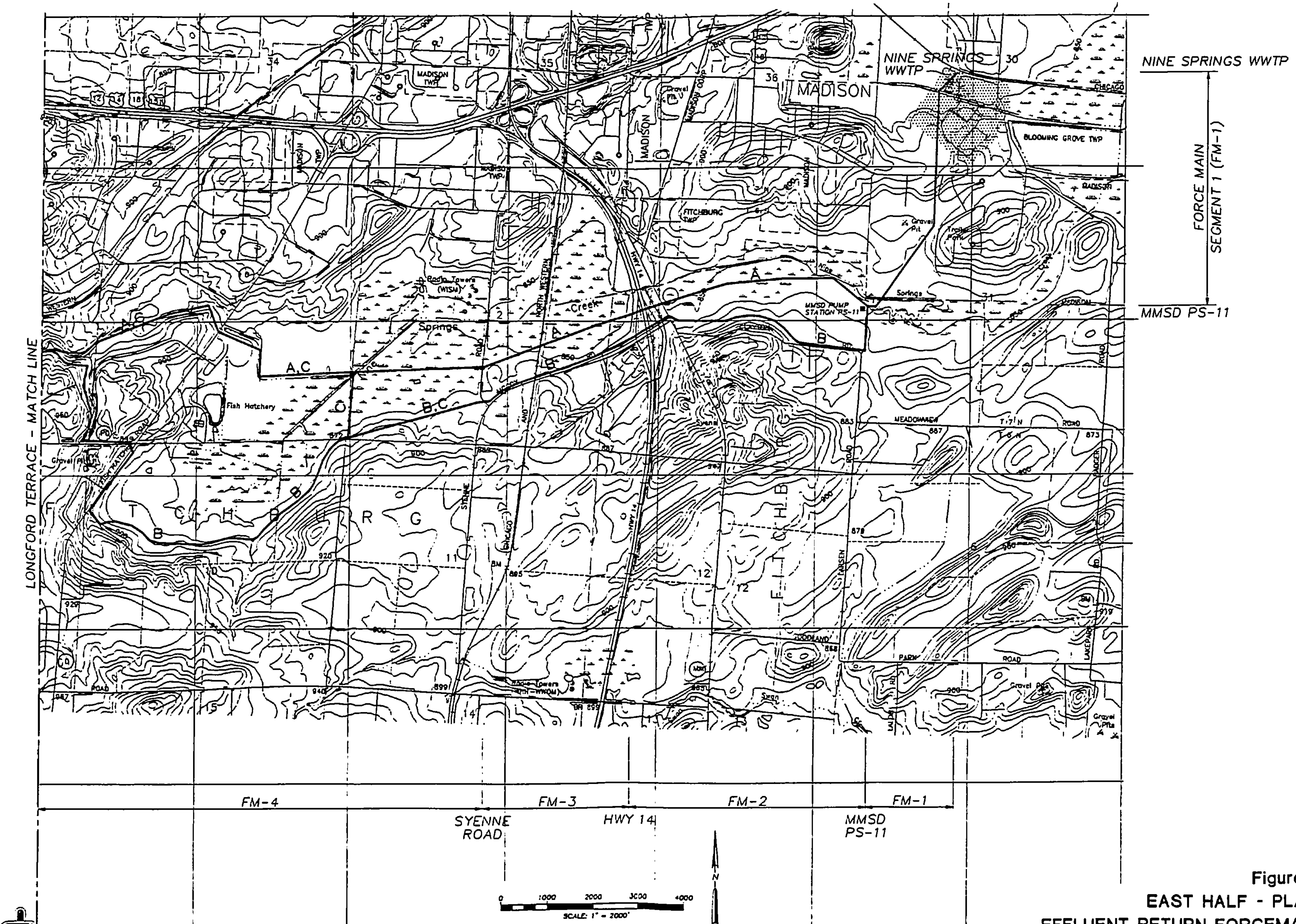


Figure 1

EAST HALF - PLAN

EFFLUENT RETURN FORCEMAIN

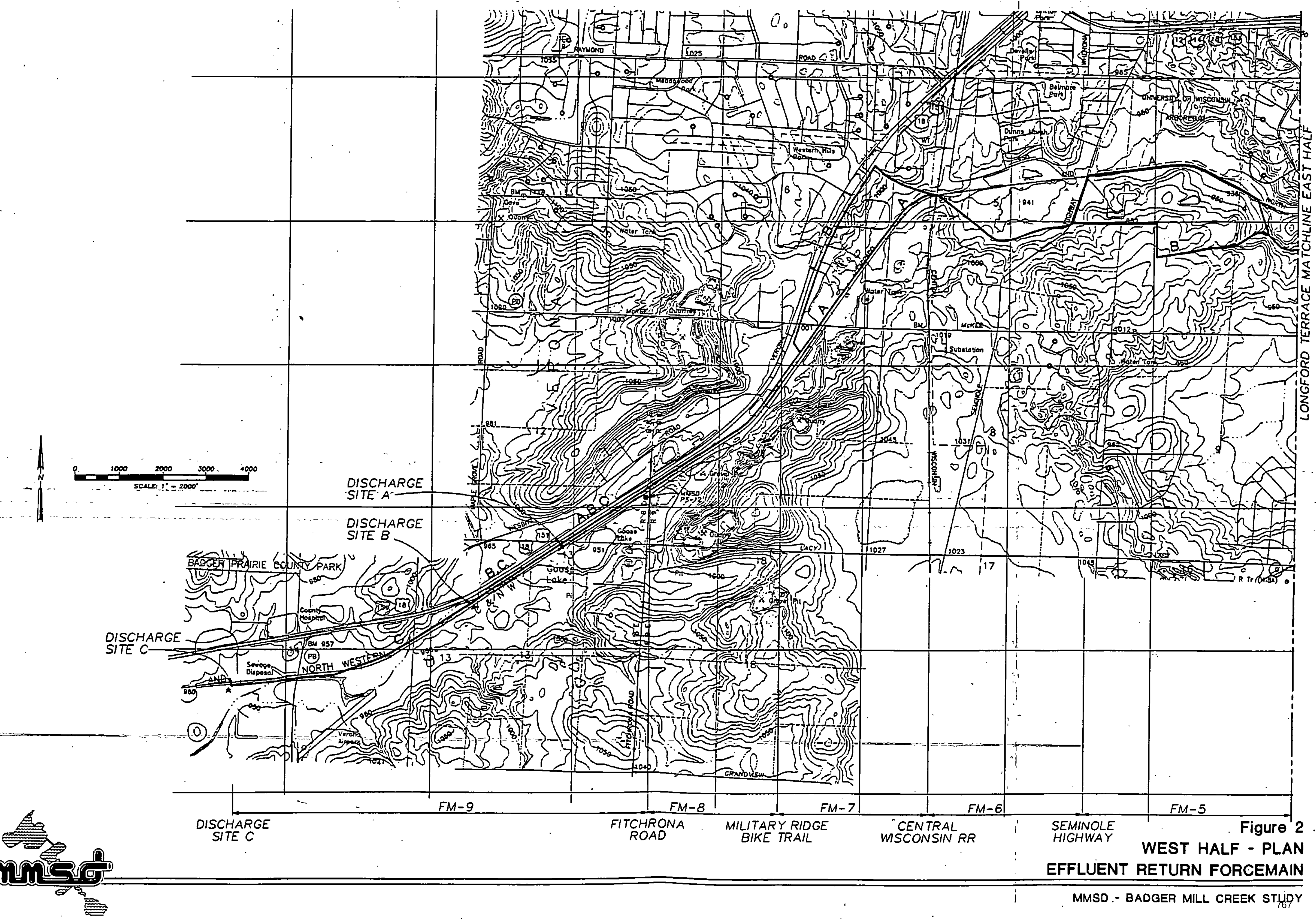


Figure 2
WEST HALF - PLAN
EFFLUENT RETURN FORCEMAIN

MMSD - BADGER MILL CREEK STUDY

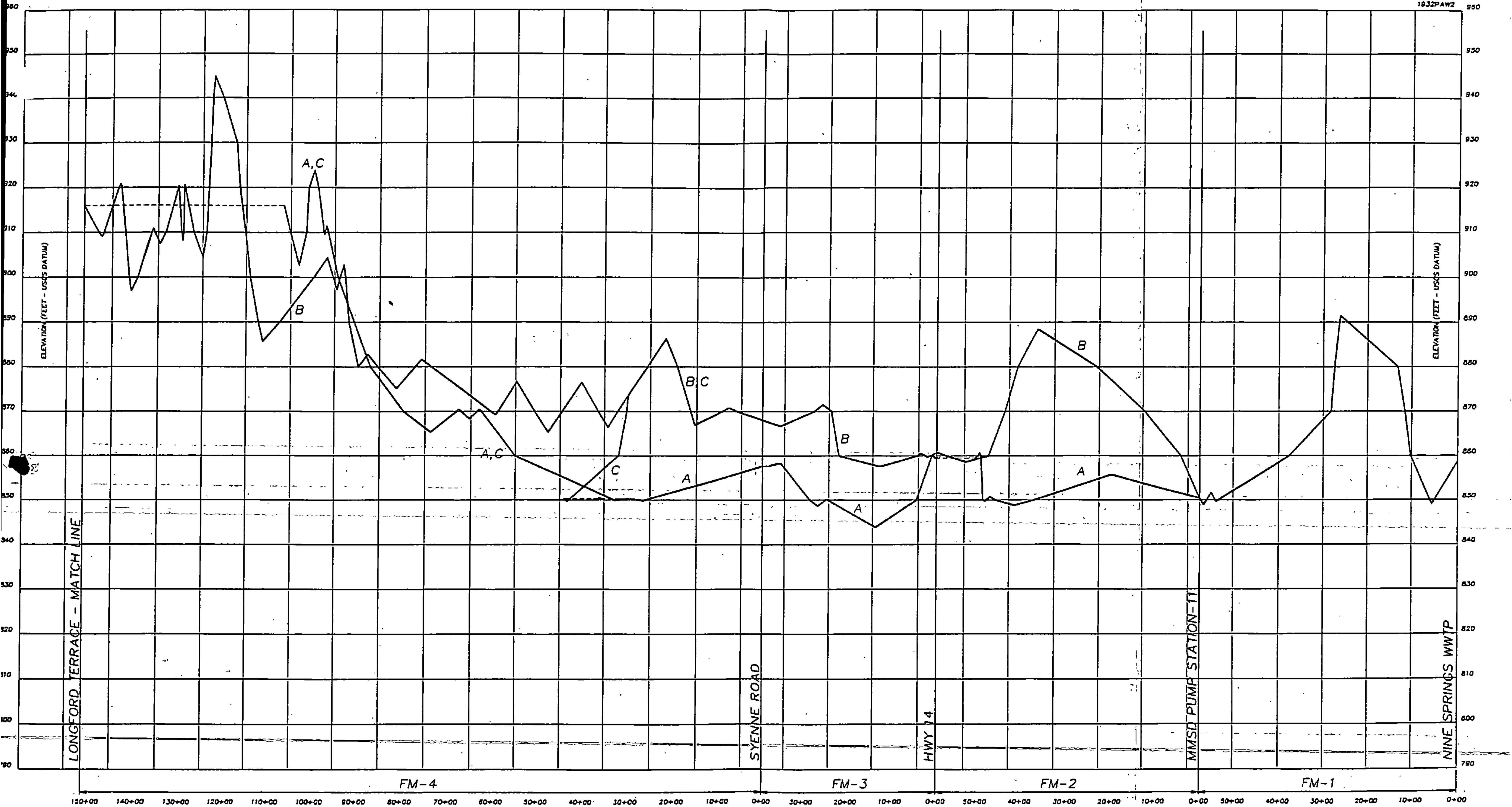


Figure 3
EAST HALF - GROUND PROFILE
EFFLUENT RETURN FORCEMAIN

MMSD - BADGER MILL CREEK STUDY

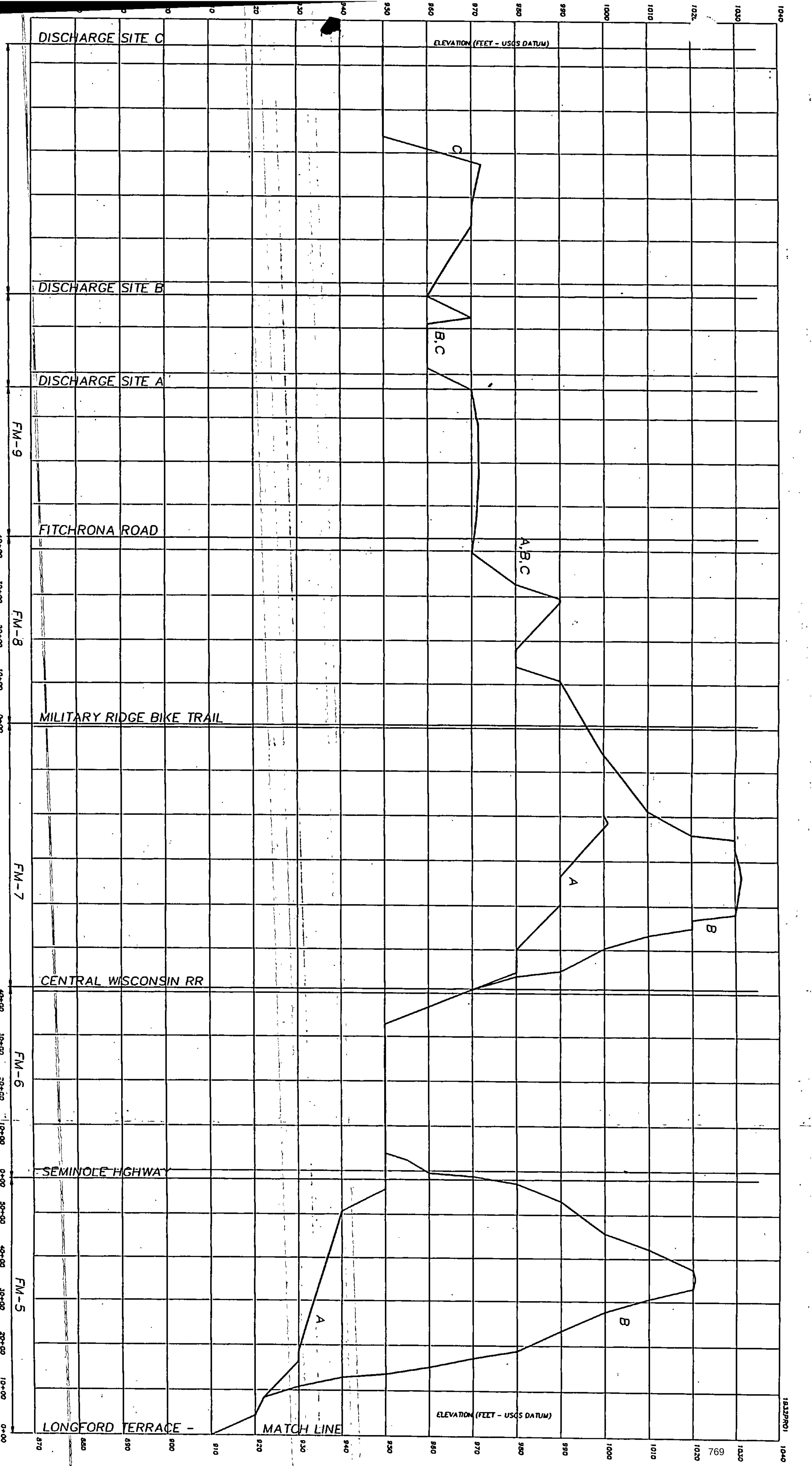


Figure 4
WEST HALF - GROUND PROFILE
EFFLUENT RETURN FORCEMAIN
MMSD NINE SPRINGS WWTP

Applied Technologies

PREDESIGN MEMORANDUM

To: Madison Metropolitan Sewerage District

From: Steve Verish / ATI
Bill Ericson / ATI

CC: Paul Nelson / Montgomery Watson

Date: August 23, 1995
November 30, 1995 (Revised)

Subject: Effluent Return Force Main
Effluent Filtration

BACKGROUND

Return of highly treated effluent from the Nine Springs Wastewater Treatment Plant (NSWWTP) to the Badger Mill Creek may require compliance with stringent discharge standards. Under certain future scenarios, effluent filtration may be needed to meet the discharge limits. The purpose of this memorandum is to evaluate several different filter configurations and two different filter sites with respect to hydraulics and construction cost.

FILTER SITE ALTERNATIVES

Due to concerns relating to the operation and maintenance of the proposed filters, the preferred location for the filter equipment would be at the NSWWTP. Two sites would be considered for filtering disinfected effluent. The first site is northeast of the Effluent Pump Station, between the Effluent Building and Storage Building No. 1. This site has been chosen to facilitate gravity flow to the filters and avoid the existing effluent force main and electrical duct banks on the west side of the effluent building. The second site is at the south end of the plant, directly south of the west digester complex, adjacent to the water storage tank currently owned by the Madison water utility. This site is under consideration due to the fact that the Madison water utility plans to abandon the water storage tank and turn it over to MMSD. It is possible that the tank could be used as a wet well for the filter and thus save construction cost. Locating the filter at this site would involve tapping the existing 54" effluent force main to feed the filters. Additionally, this location would save approximately 1700 feet of buried force main to Badger Mill Creek as compared to site 1. The fundamental difference between the two proposed sites is that site 1 is gravity fed via the junction box at the Effluent Building. The filter at site 2 is pressure fed via the existing 54" effluent force main. Figure 1 shows the proposed filter locations and the yard piping associated with each location.

Regardless of the chosen filter technology, the backwash from the filter system would be captured in a surge tank and returned at a controlled rate to the plant for treatment. At site 1 the backwash will be pumped to the wet well of MMSD Pump Station #3. The backwash from the filter located at site 2 will be pumped to the grit chamber effluent channel.

FILTER TECHNOLOGY AND SIZING ALTERNATIVES

Three basic filter arrangements will be suitable for this project from a cost and operations standpoint. All three filter arrangements considered would be gravity type filters operating at atmospheric pressure. Due to operations and maintenance concerns, pressure filters will not be considered for this project. The three types of filters under consideration are as follows:

1. Standard multi cell gravity filter with steel tank design.

2. Standard multi cell gravity filter with concrete tank design.

3. Continuous backwash upflow type gravity filter.

All of the filters under consideration are packaged systems complete with automatic controls. Some of the packaged systems would require cast in place concrete work. The filters would be located in a building which would also house the filtered effluent pumps, chlorination equipment (chlorine for sand·bed cleaning), air compressors, and backwash tanks and pumps as required.

The standard type filters under consideration are 4 cell gravity type filters with gravel/sand/anthracite media, an underdrain system, and an air scour system.

Given that the flow rate varies from 2.2 MGD to 3.6 MGD over the study period, it would be most cost effective to size the standard filters for the 3.6 MGD flow rate initially rather than add capacity in the future. At the design loading rates, sizing for the 3.6 MGD flow rate initially amounts to adding 65 square feet per cell. By inspection, it will be much more cost effective to size the steel or concrete filter cells for the ultimate flow initially rather than attempt to modify the influent channels and tank structures at a later date. The cost estimates are based on a filter loading rate of 5 gpm/ft^2 at 3.6 MGD with one filter cell out of service. At the initial flow rate of 2.2 MGD, this design would provide for filter loading of 3 gpm/ft^2 with one cell out of service.

With the loading rates and media as outlined above, the standard filters would provide a minimum 75% removal rate of BOD/TSS from 20mg/l to 5 mg/l.

The standard filters are available in either influent flow splitting configuration or a declining rate configuration. In the influent flow splitting arrangement, each in service cell has an equal flow rate and variable head depending on the degree of solids accumulation in each cell. The declining rate configuration provides each in service cell equal head, with the flow rate through each cell varying with the degree of solids accumulation. In a typical installation, the declining rate configuration yields a savings in overall head which may have a positive impact on plant hydraulics and construction cost due to less excavation and shallower structures. Since site 2 is pressure fed with excess head available, the declining rate configuration would have no advantage with regard to head savings. In the gravity flow arrangement at site 1, the declining rate configuration would likely allow for less excavation and a less expensive building. Since the filter technology has not been chosen, the cost estimates do not make an allowance for the possible declining rate advantage.

In either configuration, pipe galleries are eliminated by the use of a factory assembled central control/piping manifold. It is possible to eliminate backwash pumps and backwash supply reservoirs by configuring the filter system to use the in service cells to provide backwash water to the cell being backwashed. However, this arrangement would interrupt the supply of filtered effluent to the filtered effluent pumps during backwash cycles unless a clear well of adequate size is provided. Since clear well and backwash reservoir construction cost would be essentially the same, this arrangement yields no significant cost savings other than the backwash pumps. The cost estimates assume that backwash pumps and reservoirs would be required.

The continuous backwash type filter requires no backwash reservoir and no backwash pumps since there is a continuous discharge of backwash to waste. It may be possible to save some construction cost by avoiding the backwash reservoir and pumps. Chlorination of this type of filter may be more difficult since by its design it is not taken off line for backwashing. The continuous backwash design uses a two cell arrangement with 4 modules per cell so that the loading rates are 3.8 and 7.6 gpm/ft^2 with both cells and one cell in service, respectively. This arrangement would be sufficient up to 2.9 MGD flow rates. One additional cell of 4 modules would have to be added to accommodate the 3.6 MGD flow condition. As with the standard type filters, it would likely be most cost effective to install the CIP concrete during the initial construction. Since this type of filter has separate modules, it is possible to install the filter modules and media when flow conditions dictate. Other cell arrangements are possible and would be investigated during design if deemed necessary.

Table 1 shows the budget cost of the three different filter arrangements. The price for the filter reflects the filter equipment itself and associated peripheral equipment required to operate the filter. It does not include concrete work or pumps, which are delineated separately. Although the prices presented are budgetary, they show that there is not a significant cost difference favoring one particular type of filtration equipment. Deletion of the backwash reservoir may

TABLE 1
BUDGET PRICES
FILTER EQUIPMENT

ITEM	QTY	UOM	COST (ea)	COST (total)
Standard Filter	1	lot	$301,000	$301,000
Concrete	225	cu yd	$430	$96,750
Backwash Pumps	2	ea	$5,000	$10,000
Backwash Reservoir	75	cu yd	$430	$32,250
SUB TOTAL - STANDARD FILTER/CONCRETE TANK				$440,000
Standard Filter	1	lot	$385,000	$385,000
Backwash Pumps	2	ea	$5,000	$10,000
Backwash Reservoir	75	cu yd	$430	$32,250
SUB TOTAL - STANDARD FILTER/STEEL TANK				$427,250
Continuous Backwash Filter	1	lot	$350,000	$350,000
Concrete	225	cu yd	$430	$96,750
SUB TOTAL - CONTINUOUS BACKWASH FILTER				$446,750

TABLE 2
FILTER BUILDING SPACE ALLOCATION

ROOM/EQUIPMENT	AREA (sq. ft)
Filter	1000
Effluent Pumps	500
Filtered Effluent Reservoir	650
Spent Backwash Wet Well	350
Chemical Room	125
Compressor Room	125
Electrical Room	125
Sub Total	2875
Allowance for Aisles @ 25%	719
Total	**3594**

allow a physically smaller filter building, however, this has not been considered in the building cost estimate since innovative design may allow the reservoir to be incorporated into the filter building design at a low square foot cost.

FILTER BUILDING SIZE & CONSTRUCTION

Table 2 shows a preliminary space allocation for a typical filter building. The preliminary design assumes all of the equipment would be located on the same level. The amount of "floor" area required by the three different filter technologies does not vary significantly. This memorandum assumes that the filter building size would be the same regardless of the filter configuration chosen. Due to the presumed soil conditions at site 1, the design assumes that the filter building located at site 1 would have to be built on pilings. For the purposes of predesign, it is assumed that a backwash reservoir would be required.

FILTER BUILDING CONSTRUCTION COST

In addition to filter type, the site where the filter building is located and the means by which influent is fed to it will have an effect on the total cost. This is mainly due to the fact that the force main lengths are different for the two different sites. To evaluate the effect of site selection on the cost, the cost estimates outline the costs for the spent backwash force mains to get to their required destinations and the effluent force main to get to the south limits of the NSWWTP. Since there is not a significant difference in cost between the three different filter types, the building construction cost estimate allows $450,000 for the filter and its peripheral equipment.

Table 3 outlines the construction cost for a fully functional 3.6 MGD filter building at site 1. In this case, influent would be fed to the filter by tapping a new 24-inch pipe into the junction box at the east side of existing effluent building. The tap would be made in the location that ties into the existing 60-inch connecting tunnel between the effluent pump wet well and the effluent reservoirs. Disinfected effluent will be diverted to the new filtration building at a controlled rate through a splitter box with adjustable weirs in the new building. The filter building would be bypassed by closing gates on the influent splitter box. The building would include a filtered effluent wetwell and effluent pumps. The estimated present worth cost for construction at this site is $1.4 million.

Table 4 outlines the construction cost for a fully functional 3.6 MGD filter building at site 2. In this case, influent would be fed to the filter by tapping the existing 54" main plant effluent force main. The new tap would be a 20-inch diameter connection. A nearby air release manhole on the existing 54-inch was investigated as a potential connection site, but it would not be large enough. Flow to the filter building would be regulated through a control valve and flow meter. The

TABLE 3
FILTER BUILDING CONSTRUCTION COST ESTIMATE
SITE 1

ITEM	QTY	UOM	COST (ea)	COST (total)
Filter Building	3600	sq ft	$170	$612,000
Excavation	2600	cu yd	$10	$26,000
Piling (20')	132	ea	$520	$68,640
SUB TOTAL - BUILDING				$706,640
Influent Pipe Connection	1	lot	$5,000	$5,000
Influent Splitter Box	1	lot	$10,000	$10,000
Influent Piping (24")	150	lf	$75	$11,250
Effluent Force Main (20")	2100	lf	$55	$115,500
Backwash Force Main (6")	1200	lf	$30	$36,000
SUB TOTAL - PIPING & FORCE MAIN				$177,750
Filters, Concrete, Blowers	1	ea	$450,000	$450,000
Spent Backwash Pumps	2	ea	$5,000	$10,000
Filter Effluent Pumps	2	ea	$25,000	$50,000
Chlorine Feed System	1	lot	$5,000	$5,000
SUB TOTAL - EQUIPMENT				$515,000
SUB TOTAL				$1,399,390
Engineering & Administration @ 10%				$139,939
Construction Contingency @ 20%				$279,878
SUB TOTAL				$1,819,207
Annual Labor	208	hours	$21	$4,430
Annual Maintenance @ 1% Equipment Cost				$5,150
Labor 20 yr Present Worth Cost @ 8.25%				$42,709
Maintenance 20 yr Present Worth Cost @ 8.25%				$49,646
Salvage Value, 20 yr, Bldg, Piping, Valves				($442,195)
TOTAL PRESENT WORTH COST				**$1,469,367**

TABLE 4
FILTER BUILDING CONSTRUCTION COST ESTIMATE
SITE 2

ITEM	QTY	UOM	COST (ea)	COST (total)
Filter Building	3600	sq ft	$170	$612,000
Excavation	2600	cu yd	$10	$26,000
SUB TOTAL - BUILDING				$638,000
Force Main Connection	1	lot	$85,000	$85,000
Control Valve	1	ea	$5,000	$5,000
Influent Force Main (20")	400	lf	$55	$22,000
Effluent Force Main (20")	400	lf	$55	$22,000
Backwash Force Main (6")	550	lf	$30	$16,500
SUB TOTAL - PIPING & FORCE MAIN				$150,500
Filters, Concrete, Blowers	1	ea	$450,000	$450,000
Spent Backwash Pumps	2	ea	$5,000	$10,000
Filter Effluent Pumps	2	ea	$25,000	$50,000
Chlorine Feed System	1	lot	$5,000	$5,000
SUB TOTAL - EQUIPMENT				$515,000
SUB TOTAL				$1,303,500
Engineering & Administration @ 10%				$130,350
Construction Contingency @ 20%				$260,700
SUB TOTAL				$1,694,550
Annual Labor	208	hours	$21	$4,430
Annual Maintenance @ 1% Equipment Cost				$5,150
Labor 20 yr Present Worth Cost @ 8.25%				$42,709
Maintenance 20 yr Present Worth Cost @ 8.25%				$49,646
Salvage Value, 20 yr, Bldg, Piping, Valves				($394,250)
TOTAL PRESENT WORTH COST				**$1,392,655**

estimate includes the cost for constructing a concrete valve vault at the tap site and tapping the 54" force main. A valve at the tap would be used to isolate and bypass the filtration facility. The estimated present worth cost for construction at this site is $1.4 million. Since the filter at site 2 is fed from a force main, there is excess head available upstream of the filter. Although it is not reflected in the cost estimate, it is probable that the structure could be built primarily above ground and thus save excavation and construction cost relative to the filter at site 1. The cost includes a filtered effluent wetwell and effluent pumps. There is the future potential for utilizing the existing water reservoir at this site for a filtered effluent wetwell.

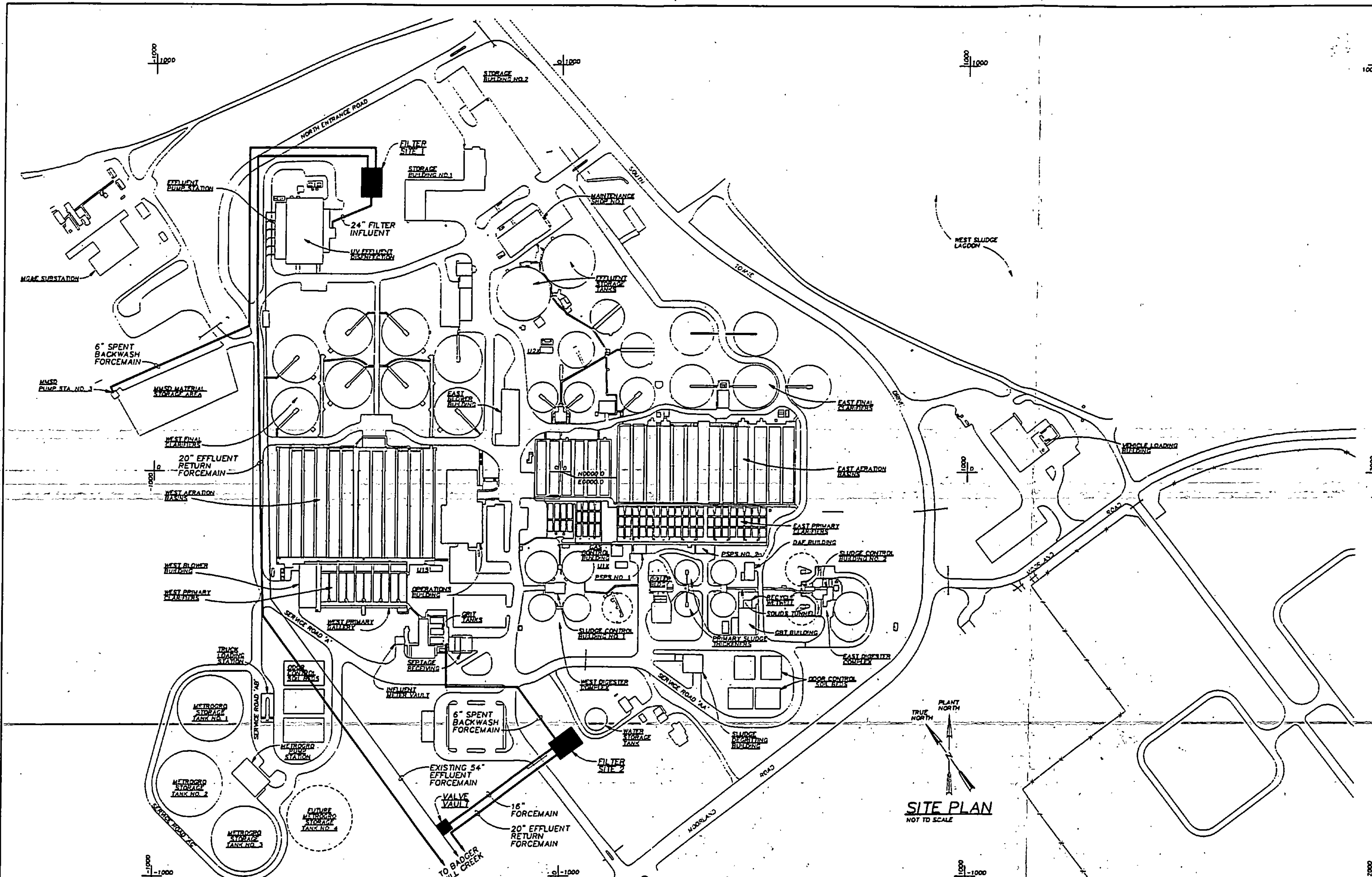
NON MONETARY FACTORS

Drawbacks of locating the filter at site 1 include using the physical space which may become important in the future. Additionally, there may be existing utility obstructions complicating force main installation along the west side of the Effluent Building.

To build the filter at site 2, the 54" effluent force main must be tapped. Although that is physically possible, there is risk associated with disturbing the main plant effluent pipeline. Benefits of locating the filter at site 2 include the fact that it would be possible to incorporate a W3 (treated effluent) service water system into the design to serve the south end of the NSWWTP. The MMSD currently purchases city water in lieu of using W3 since effluent is not available at the south end of the plant. Additionally, the water storage tank adjacent to site 2 may be turned over to the MMSD by the water utility. In that event, the existing storage tank could be incorporated into the design of a filter / W3 system to offset construction costs.

CONCLUSIONS

There is not a significant difference in cost between the filter technologies under consideration or the site at which the filter building is constructed. Economics will have little effect on which type of filter to use and at which site it is located. Non monetary factors will determine where to build the filter building. Further investigation into existing installations of the various filter technologies may assist in choosing the most appropriate technology. Site 2 has the advantages of greater site flexibility and potential as a source for a W3 system. Site 2 would probably be favored over site 1 for a filter facility for the effluent return to Badger Mill Creek.



DESIGNED BY	S.J.V.
DRAWN BY	D.A.K.
CHECKED BY	W.A.E.
APPROVED BY	

VERIFY SCALES
LENGTH OF BAR IS 1" ON ORIGINAL DRAWING
IF BAR IS NOT 1" ON THIS DRAWING, ADJUST SCALE(S) ACCORDINGLY

NO.	DATE	REVISION	BY	APVD

Applied Technologies

MADISON METROPOLITAN SEWERAGE DISTRICT
BADGER MILL CREEK STUDY
MADISON, WISCONSIN

NINE SPRINGS WWTP
OVERALL SITE SCHEMATIC
EFFLUENT FILTRATION MODIFICATIONS

PROJECT NO. 1932
DATE 8-23-95
DRAWING NO. FIGURE 1

Appendix I

MONTGOMERY WATSON

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SUGAR RIVER EFFLUENT RETURN

PUBLIC HEARING

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TRANSCRIPT OF PROCEEDINGS

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Date: Thursday, September 28, 1995

Time: 7:05 o'clock p.m.

Reported by LINDA KUHLMAN

TRANSCRIPT OF PROCEEDINGS, held in the above-entitled mater at the Verona City Hall, 111 Lincoln Street, in the City of Verona, County of Dane, and State of Wisconsin, on the 28th day of September, commencing at 7:05 p.m.

A P P E A R A N C E S

JAMES L. NEMKE, MMSD
PAUL NELSON, MONTGOMERY-WATSON
ALAN JOHNSON, AQUATIC RESOURCE CONSULTANTS

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MR. NEMKE: Why don't we start the meeting. I don't want to penalize those of you who got here on time for those who might show up a little bit later.

I'm the chief engineer and director of the Madison Metropolitan Sewerage District. This is a public hearing on the issue of returning effluent from the Nine Springs Plant at Sugar River Basin. So while we want to keep this very informal, there are a few formalities.

Since this is a public hearing we have

Linda doing the recording for us. Linda will take notes and transcribe the questions and the comments from everybody tonight. To make her job easier, when you do make a comment, please identify who you are and whether you represent a specific organization, and if have a name like Jon, J-o-n, Schellpfeffer, S-c-h-e-l-l-p-f-e-f-f-e-r, you might want to spell it for Linda because she's good, but she can't read minds.

We also have a sign-up sheet. If you have not signed up, please do so. Linda will have access to this and can check and cross-reference the sign-up sheet with whoever makes comments or asks the questions.

I would like to indicate before we get into the presentation that we did advertise this several times on September 14th and September 16th, and I'm going to give Linda these to put in our record. We did send out a notice of the public hearing to approximately 200 to 300 people including all the media who expressed an interest, that we knew might have an interest or was a member of a special interest group like Trout Unlimited, Sierra Club and so on. I'm going to include the published hearing notice and also the mailing list that we used.

We're going to try to break this up to about a 30, 40-minute formal presentation. We're going to ask that you not interrupt that because we might just go on forever if we allow questions, and hold those questions and comments and after this 30, 40-minute presentation we'll have adequate time to answer all your questions and accept all your comments for the record.

I think it's important before I go any further to introduce Ed Schten, who's the president of our commission. We did a presentation this morning in front of the entire commission, so the commission is very interested in this whole issue, but they have already heard this once. Ed is representing the commission and eventually will take all your comments back on behalf of the Madison Metropolitan Sewerage District.

I think it's important that we cover a little bit of history for those who may not have tracked this for the last five years and also to compile a complete record. I'm going to do that in the next five to 10 minutes.

Back about five years ago the city developed a facilities plan to decide how they were going to handle the existing city and expanding city population.

They completed a facilities plan in 1992, and that facilities plan looked at a number of options -- build a regional plant in the City of Verona that would also handle wastewater generated on the west side of Madison.

The west side of Madison, for those who don't know, is actually in the Sugar River Basin and Verona also is in the Sugar River Basin. Most of Madison and our plant is Yahara River Basin. That Verona facilities plan looked at reducing the existing plant and just serving Verona, a region around Verona and on the west side of Madison that currently are in the Sugar River Basin.

And they looked at abandoning their plant and pumping to Nine Springs for treatment. The recommendation of that plan was to abandon their existing plant, annex to the Madison Metropolitan Sewerage Distrit and pump their wastewater from Verona to our plant.

It was the job of our commissioners to have an annexation hearing to decide whether in fact they could abandon their plant and pump that wastewater to our plant at Nine Springs.

The commission had some significant concerns relative to transferring the water over to the Yahara. When we treat it at Nine Springs, we pump down to the Bad Fish Creek and into the Yahara. There was a lot of discussion. There was a public hearing, and the outcome of that annexation process was an order by the commission indicating they would annex Verona, but they would only do so if the issue of the inner basin transfer the -- in fact, the order is that an alternative should be pursued that maintains the water balance between the Sugar River Basin and Yahara.

At that time we were also doing a facilities planning process that was looking at improvement of the plant. Let's take another look at how we handle Verona now that they are a part of the district. We also examined a number of alternatives. We relooked at building a regional plant in the Sugar River Basin.

I'm going to put up a slide that is actually a slide that was our end of the -- our facilities planning process. It was completed in 1994. And these are the alternatives we again looked at.

Keep the treatment plant at a cost of

$8.2 million to operate the Verona wastewater treatment plant and to divert a portion of the wastewater from the newly expanded Verona area to Nine Springs. This option would have retained the Verona plant but would have downsized the plant to provide better treatment at the plant. It included construction of a pump station and force main to divert the existing wastewater over to Madison.

The second alternative was to abandon the Verona plant and pump it all to our plant in Nine Springs with no effluent return. The other one was to abandon the Verona plant and pump all the wastewater to our plant at Nine Springs but then return all of that effluent, not only the effluent generated there but all the effluent generated back to the Sugar River Basin.

The commission basically said this option that would not return water to the Sugar River Basin would not be an acceptable option based on the overwhelming public opinion at the meeting and hearing that people wanted to see that water stay in the Sugar River Basin.

And also they didn't favor upgrading the existing Verona plant when the costs were just as high as running it to Madison and returning the effluent. So really the commission said, let's focus on two alternatives, building the pump station to convey wastewater from here to Nine Springs and either maintaining the existing plant and upgrading it or abandoning the plant, treating it all at Nine Springs and returning it. And they primarily favored this alternative, and that would be abandoning the Verona plant, pumping it all over to Madison.

But because there was not heavy consideration until the tremendous public input considering the effluent coming back, we had not examined the impact of bringing that effluent back in great detail.

In order to confirm that this was a viable alternative it was necessary to do some additional studies to determine what we can do in environmentally sound ways. That was about the fall of '94.

At that time Montgomery-Watson was asked to look at the issue of can we bring effluent back to the area in an environmentally sound way, what are the impacts both on the trout in the Badger Mill Creek and the Sugar River and can we really do this in a sensible way.

And that's what the meeting tonight is all about, to present to you the outcome of that additional study on bringing that effluent back to Verona, and with that I'm going to introduce Paul Nelson and Alan Johnson who are going to tell you what we discovered.

One more thing I'd like to mention, we have 15 people, to save time I won't mention who they represent, anybody that in some way had a significant interest or impact and served with this project as the advisory committee. They were very helpful in keeping us on track and helping direct the study. I'm going to also give this list of names to Linda, and she can put it as part of the record so we give credit to those people who did participate in this.

MR. NELSON: We are going to take you through the results of the study. We're going to talk about existing conditions, because that frames how you define impact. Then we'll talk about the evaluation of returning the effluent and what the impacts are and then a little bit about alternatives and future direction, which is a lot of what the advisory committee was looking at, more on future directions.

To put this in perspective, Jim had talked about where the different watersheds are. Verona is over here. You can see the hatched area there is the service area for Verona. (Indicating)

The watershed divides where the Yahara and Sugar River runs. Both Verona and this area are within Madison. This area is already -- wastewater from here is already pumped or sent to the Nine Springs treatment plant and there is a corridor going back, and then the impacts to Badger Mill Creek which runs through here and then connects with the Sugar River which runs through here. (Indicating)

So we took Badger Mill Creek and the Sugar River as the project scope. As Jim said, this was different than your typical facilities plan. We think it was a little more. One, we were looking at the impact of returning effluent, not so much coming up with new alternatives. These were already looked at. We were really looking at the impact of returning effluent and what other additional actions are needed to improve and protect some of the resources over here. It was more a large scale planning effort.

Basically I want to start out with what we found. Put the bottom line first. First of all, the existing effluent from the Nine Springs wastewater treatment plant is protective of aquatic life. In the Badger Mill Creek and Sugar River we have the quality of that effluent that won't negatively affect aquatic life.

Second, returning effluent increases potential fish habitat. In terms of some of that, that's now bringing more water, a little more area for fish, more habitat basically, but potential meaning to try a lot of other things that are missing from Badger Mill in terms of the fishery.

And then the future impacts of the wastewater diversion on flows in Badger Mill Creek is still uncertain. This comes about because the idea of diverting water that originates in this basin over to Yahara may affect ground water flows back to the stream and affect base flows.

I'll get into each of these a little more later. We think that's uncertain. That may be in a hydrogeologic study by the Dane County Planning Commission.

Basically, that's the introduction. What I want to do now is get a little bit into the existing effluent quality in Nine Springs, because effluent quality from Nine Springs would be the future quality effluent if it's returned, the best picture of what's going to happen in the future with effluent.

Nine Springs wastewater treatment is currently very good quality, 95 percent removal of most effluents at the plant. They do bioassay testing of organisms, invertebrates, insects and some fish. They put in the testing on a regular basis in some sample type of situations, and they've never had a failure of these organisms with their effluent. It will never be cleaner water than it is now. And future quality will improve with the addition of enhanced biological phosphorus removal.

That sets the stage for the Nine Springs effluent and its current conditions. Alan is the fisheries expert on this project, and he will tell us a little bit of what we did in the stream corridor and then the impacts of returning effluent on fisheries.

MR. JOHNSON: I'm going to talk a little bit about what we did regarding the fisheries evaluation of returning the effluent to Badger Mill Creek. During a cold blustery week in last April we came and we walked all accessible portions of the stream that were open to us. That's approximately four and a half miles. That was from basically the bypass or Highway 151 all the way down to the mouth.

We measured as we walked along. We took measurements on the physical attributes, width of the stream, the depth, overhead cover, the substrate, just the type of structures we could find in the stream to give us an idea of what the existing quality of the fishery habitat was.

At that time we also established 13 transect cross-sections across the stream we could use in the habitat modeling to see if we could protect added additional effluent into the stream.

What we found from our little adventure is that if we break the stream down by its physical characteristics, we found four different reaches of stream in Badger Mill Creek, and that in those four different reaches the potential exists for forage fish and for trout.

This is little bit of a no brainer in that the forage fish and trout to a certain extent it was more of looking at what can we do to enhance the habitat that was there if that opportunity was available to us.

In evaluating the information that we got from our stream log, what we found is that there are a number of factors that I feel are limiting the fish production potential in Badger Mill Creek. One is a lack of cover, and by a lack of cover it means a structural element of the channel itself.

If you look at it, half or more of it is channelized, a very fine formed channel, basically rectangle in shape. It limits the amounts of the refuge cover to basically go out into the Sugar River. There's excess sediment, in some places there is a foot to a foot and a half of sediment that covers the substrate out there.

The base flows out there and given the existing channel morphology over large portions of the water, you do have a spread over an area, so what that does is makes the water very shallow over most of it, about half of it.

There is some indication that there may be warm water out there over a large period of the year. The checks on measurement, we don't have a complete record, we have some records that indicate especially for the trout the water temperature is at lethal levels or certainly in distress levels.

Water quality is mostly related to how much sediment is being transported during form flows.

What we came up with in that analysis is what can we do to make things better if we were given a chance to do so.

The three options we discussed were, number one, leave the stream as it is. If we didn't do anything to it, what would happen, and basically probably not much more than what's been going on.

We did look at augmenting the flows, which is the purpose of this study. Is the water volume limiting the amounts of fish habitat? If we add some additional flows to that, would that create additional habitat, or could we augment the flows and modify the habitat that exists in Badger Mill.

The first question on augmenting the flows from the modeling work that we did, what we can say is that if they add effluent back to the channel, they would have gains in habitat of 30 to 100 percent, depending on which area of the stream you're looking at. And you can see there's a bit more habitat back in the lower reaches than the upper reaches.

Looking at the existing channel out there, the channel in the upper reaches is actually buoyed more than the lower reaches, 17 feet, and it compares to about 13 feet in the lower reaches of the stream. More water, less area, more depth and we have more volume. In the upper reaches of the stream we have a much wider stream and lower volume, subsequently we have less habitat. This in effect is the easy one. If we put more water in, we simply get more volume.

That's not the only factor that's limiting the fish production in Badger Mill. As we mentioned, there are several other factors that are going on. So that if we want to up the level of production, and especially if you're interested in getting something like trout back in here again or any number of things that would make a viable resource for fishing or other activities, one of the first things is to control the sediment input.

Simply if you want any kind of spawning or a level of food production, then we're going to have to control how much sediment is covering everything that's out there. We need some kind of cover so that for refuge purposes during high flows these fish have some place to go. There is no place for them to go otherwise.

In some of the upper channel areas we can re-establish channel morphology, and by that I mean inside of the channel we're going to have to put a meander pattern back in there again. Right now we have the conveyance but because it's so wide it's not transporting the sediment. There's not enough power in the water to move the sediment that's showing up.

Finally, in some areas we're going to have to add vegetation back to the streamside corridor, and there's no controversy in what vegetation and what areas, but if we're going to control water temperature to something like along the sides again, we can help bring the water temperature back down.

And just some examples here of the typical kinds of things that could be done to help establish the appropriate channel morphology, the one theory we can't simply go back out there and reconstruct. We have sewer lines on both sides of the stream, and so we can't go back and simply remeander it.

We have to work inside the existing channel, and the kinds of simple things such as rock berms, woody debris and brush bundles and mats, the upstream facing logs that help to construct the channel at lower floors and bring the meander pattern back in there.

The deeper pools bring in the outsides of the bends right now. If you look at the profiles out there, most of the pools are very, very shallow and they're very far apart. We need to put these kinds of activities in the upper portions of the stream inside the existing channel and establish some sort of meander pattern in there.

On other portions of the stream, especially in some of the lower portions of the stream, the stream still has its meander pattern there. In some areas, not all areas, the outside of the bends are eroding and there's not a lot of the structure in the bank.

In some of these areas, we can establish some kind of woody debris back along and put the structure back in the bends of the deeper pools rather than moving laterally. Those are the kinds of things that can be done.

Lastly, we will need a lot of discussion about where we can do this and exactly where we go. But this can give you the idea of the kinds of things we can start to look at.

With that, I'll turn it back over to Paul who will talk some about water quantity issues of this portion of the study.

MR. NELSON: One of the issues or questions was by diverting water would that affect ground water and then base flow in the streams at some point in the future. As I said when we started, the conclusion here is still uncertain, but does -- and for a number of reasons a potential does exist.

We took a look at the municipal wells for Verona and they do pull water from aquifers and in this case through the final materials, but there are aquifers.

And the other thing that we think makes it a potential for base flow impacts is that the shallow ground water area draining to Badger Mill Creek is relatively small. I'll show you a figure of that.

This is the Badger Mill Creek watershed, the dark line around the outside here is a surface watershed. This is the Beltline Highway in here. Here is Verona down here. Sugar River is way down here. The shaded area is the urban service area, the Verona and Madison area. (Indicating)

The red line I've highlighted here is the shallow ground water divide. The ground water goes in different directions. It goes up around like this. This area over here drains to the Sugar River Basin. This area up here drains to Black Earth Creek and this area the Sugar River. (Indicating)

Bottom line is the surface watershed is about 32 square miles, the ground water watershed, whatever you want to call this, is about 19 square miles. So that may explain some of the reasons why there are some lower base flows than you would expect. You would expect the base flows are the normal day-to-day base, not the stream flows. That may explain it, because it's logging water to other watersheds.

So basically the diversion impacts, we know right now that the Verona wastewater treatment plant discharges one cubic foot per second of water to the Sugar River. That would definitely be a loss if that's pumped over to Nine Springs and not returned. That represents that one cfs, five to six percent of the normal everyday base flow in the Sugar River during flow conditions. It's about 13 percent, that ground water.

Whether it affects ground water and that type of flow that reaches the creek, the direct discharge loss of Verona outfall is five percent and 13 percent of the normal and low flows in the Sugar River.

Badger Mill Creek, there's potential because of the ground water issue. By the hydrogeologic study hopefully they'll have modeled this as one of their management scenarios for water quality impacts.

And we did modeling of returning effluent and the impact of that on the creeks, and we feel that that shows that the Nine Springs effluent is protective of aquatic life of the Sugar River and Badger Mill Creek whether for warm water fish or cold water fish.

And we feel the best place for it is at Reach 5. There's a plan in the map, if you want to look at it afterwards, that shows the river reaches, but Reach 5 is the area east of PB Road before the upstream area, so this outfall would be PB Road and Highway 151.

One thing we would need to construct is an outfall area or keep the oxygen up in the effluent as it's discharged. We looked at other types of impacts. Phil Salkin looked at the archeological resources in the beginning of the transmission line corridors and didn't find anything that would be eligible for the National Registry, so we had no archeological impacts.

We looked at natural and endangered resources. We don't feel there are any threatened or endangered plants along the pipeline corridor. There is, however, the Nine Springs Meadows Natural Area that we do have to go through with a couple of the alternative routes off the transmission.

We have three alternative routes that we looked at. Again, there's a map that shows those routes in the back of the room. Route A, 12,000 foot of line; Route C, 4,000 foot of line. Route B avoids the wetland but is borderline on whether it's really constructible. So from this right now the preferred route is Route C.

Flooding and erosion. We looked at with the effluent coming into the creek, would the extra effluent create flooding impacts. The answer there is no based on modeling. Though we do have to have some operational protocol during peak times to bring down the discharge a little bit.

There's erosion. We looked at that in terms of the velocities that would be predicted with and without effluent. The increases that are predicted are too small, they are negligible to cause any erosion. We feel the storm flows would have much more significant impact. We're talking effluentwise of about 3.4 cubic feet per second of water. A hundred year storm is 200. It's a small amount.

We looked at recreational resources a little bit. We think there are a number of positive or potential impacts in terms of flow augmentation and the fish potential might increase in recreational upper layer areas of this public land.

The Military Ridge Trail and Capital State Trail and the Nine Springs E-Way, we think there's potential there for positive impacts in terms of having the transmission line coming through and essentially clearing and constructing future trails.

So this would give early clean out, construction, grading of areas that would be future trails. So that that was the basic impact that we looked at. We didn't come up with anything negative except for temporary construction going through those wetlands.

We then tried to formulate some alternatives, although we knew already that the commission had decided they wanted to maintain their flexibility and keep a discharge over here.

And under these we knew we had to have some necessary improvements to return the effluent, that being a transmission line. We have to have a pump station and that outfall aerator.

We also -- as I said, the advisory committee and the commission asked us to take a look at more than just the effluent in terms of what makes or would improve this resource. We've identified as we've been out at the watershed some water quality and stream corridor strategies.

Stream corridor strategies being some of the things that Alan has already talked about, and we came up with really three alternatives. First being no additional action, understanding that there is already some action going on in terms of the construction of the line going to Nine Springs. Two, return effluent, and then return effluent with water quality and stream corridor improvements.

As we went through this process and discussed things with the advisory group, we wanted to keep the understanding that there are these additional added value things that would make the resources better, but there are different groups and different agencies that are suited to do these things. Simply, added value improvements are not necessarily the jurisdiction of the sewer district. So we kept those separate.

Alternative one being, again, this is looking at no action alternative. It's done for the purposes of simply not returning effluent. We would have existing conditions continue in Badger Mill Creek; the Sugar River would have decreased wastewater loads, because that wastewater would no longer be there; immediate reduction of that one cfs to the Sugar River; potential for future flow reductions because of the base flow issue; restricts the flexibility in terms of the future management of the wastewater, if we give you that discharge point sometime in the future.

And the last one is that in order to maintain the district's desire for having flexibility for discharging effluent over here, they'd either have to put in a new plant or upgrade the existing plant in order to maintain a discharge point.

Second alternative, returning effluent, we feel first of all that it protects aquatic life. The effluent into Nine Springs is protective of aquatic life. The potential is to increase fisheries in Badger Mill, decrease wastewater loads to the Sugar River. We would have that flow back in the Sugar River. We actually enhance the flow in the Sugar River, and minimize future reductions due to decreases in base flow; enhance recreational opportunities and maintains future operations flexibility.

The third alternative that we looked at was basically taking that second one with these added value strategies for water quality and stream corridors. We basically suggested some strategies depending on who has storm water and agricultural improvements. Those are not in the normal operational functions for MMSD.

The commission this morning did express that they may be willing to go beyond the normal in terms of some demonstrations in the stream corridor if there is some opportunity for partnershipping going on with some other groups.

The water quality strategies that we looked at, we looked at whether we could build a wetland or use wetlands to provide a little bit further polishing of the wastewater effluent, and what we found there was quite interesting. The effluent from the Nine Springs wastewater treatment plant is better than what a wetland would discharge.

It takes a little bit of thinking, but it's because the plant and the residual materials in the wetland have a higher concentration of some of these nutrients. To increase the loading of some of those nutrients to Badger Mill then we discussed with the advisory group some areas for additional ponds, marshes, for storm water management, different ways for erosion control, impervious surface control, temporary pavement and concrete, that's where a lot of the nutrients originally are, and wetland restoration, identify any sites for the wetlands, and not using effluent, just restoring them as wetlands themselves.

And also agricultural, a lot of the -- a little bit more testing for livestock exclusion. All the farmers down at the end put in a lot of fencing and excluded livestock.

The best way for implementation was this priority watershed planning. It's our understanding the watershed -- may start a watershed planning process in '97, this being the

Sugar River, with implementation starting in 1999.

Those types of things are more done on a community type of time that the priority watershed type of program permits. We looked at water quality -- it should be stream corridor improvement. The stream corridor improvement, we looked at channel improvements, narrowing it down. The one that Alan showed on narrowing the channel down there, we think it might be appropriate.

The commission may be willing to go a little bit further or do some demonstrations of that that would lead into greater implementation through other programs such as the riparian improvement, planting for shade along the corridor. It needs a little bit more discussion by the group. That really is a prairie stream. They have concerns naturally that this be a prairie stream, and so that's something that needs to be discussed a little bit further in terms of which streams finally are going to be targeted toward management.

A likely implementation way is the priority watershed program and woody debris that may be appropriate for some demonstrations leading on to future expansion through other programs.

So actually in terms of impacts, the

negative impacts of returning effluent are limited. We really didn't find anything. There are numerous positive impacts in terms of potential -- a potential for fisheries, the diversion issue is still a little bit uncertain in terms of the base flows. We know it will preserve that one cfs in the reduction. Then there is the recreational benefit and synergy. And raising the stakes for the other management grounds in the area and particularly leading into the priority watershed project.

The other thing that everybody asks is how much does it cost. Jim is going to respond to that.

MR. NEMKE: I just wanted to say also that Paul said cfs a number of times in returning this. In terms of the volume, it would double what you normally see there every day.

If you can accept the fact that the commission's determined to balance the water flows in these basins, it is a more important thing to do in the long term than what is that all going to cost.

In alternative one, which is not returning effluent but in fact building a plant here, it would cost about 7.2 to 8.2 million dollars. That was evaluated in the previous facilities plan and that was rejected because we have the difficulty of running two plants.

Giving you that first opinion, that we're going to maintain the old building or a plant here or get the water back here, that decision has already been made. Part of that 7.2 is money the commission has already committed to the pump station and the force main. And 2.7, the remaining amount is the amount it would take to build a new plant or upgrade the existing plant. We are concerned that we're saying what we really run one plant. So that's to not bring the effluent back.

Alternative two, which would be that 7.7, that includes the 2.7 that we've already committed in the pump station and force main to take the wastewater and five million to bring the clean water back to the Sugar River Basin.

And alternative three includes the added in-stream enhancements, that would be the demonstration project. We have a cooperative working arrangement with all the other people that are involved in improving these streams.

What does that mean to the residential?

Our current charges today, the average charges within the district are about $130 per year per household. Of that our charges are about $95. The local charges, the average is like $130. That would increase those about $3.

Going on to the Nine Springs map, so in 1998 it would be $158, and with that if we return the effluent here, the average annual would be about $161 per year.

Now, with that I believe we're done. We have a copy of all the slides here, so if you can't read them or if you'd like to take a copy of these, please feel free to do that when you leave tonight. We'll open it up to comments and questions.

I would remind you we have a very talented reporter, but please identify yourself and if you have an affiliation or if you're just speaking as a citizen, please mention that. I'll try to direct the questions to the appropriate person.

MR. EXO: John Exo, the Dane County Lakes and Watershed Division. The question I have -- I have a lot of questions, but I'll just ask one right now, which is assuming a worst case scenario in terms of impervious necessary impacts on base flow to Badger Mill, is it possible to increase the return flow given this size piping you're assuming, or is that a maximum return flow given that pipe diameter that you're assuming here?

MR. NEMKE: The amount of flow that can be returned is determined by the current Department of Natural Resources regulations. The current permit for the Verona plant allows so much mass of discharge of effluents, BOD, ammonia and so on, they're currently .62 million gallons per day, that is one cfs.

We can bring back as much flow as we want as long as the effluent load doesn't exceed the mass that you have in the existing permit. So for instance, if we want to bring back four mgd's, we have to make that effluent four times as clean as the current discharge for Verona.

So you run into a practical limitation as to flow simply because we're restricted by ultimate mass. That's because the outstanding resource water has a regulation that says you cannot ever increase the nutrient flow in this way.

The commission was very determined because that same rule says if you eliminate that discharge, you can never bring a discharge back in here. So if you institutionalize the diverting the wastewater to Madison, maintain the existing plant or building a new plant or bringing it back, you could never again back in the future bring back water back to the basin, and in fact may not be ruling -- our commission said what about 30 years, 40 years with all the massive growth on the west side of Madison, largely expanding Verona, is that really what we want to institutionalize for our kids and grandkids.

I went a lot off, but I think that's important background for how the rules govern what we can or can't return.

MR. FRANKE: Dennis Franke, a member of Trout Unlimited, a smallmouth bass alliance. A question regarding basically temperature, and was any study done of any potential negative impact by the construction of the bypass because it's immediately adjacent at least surface vicinity in the form of the springs immediately above and below PB, and, number 2, what temperature will the effluent come back at and, of course, will that be compatible?

MR. NEMKE: I'll let you handle that question.

MR. JOHNSON: In reviewing the ESI for the bypass, I don't recall them having an analysis on the temperature. The second question in terms of the effluent, the effluent temperature varies monthly from Nine Springs. In summer the highest it ever gets is 21, 22 degrees.

MR. FRANKE: Per height slope?

MR. JOHNSON: That's ascent grade, 68 to 70.

MR. FRANKE: What was the range?

MR. JOHNSON: I'd have to say about 50 to about 70. It's in the range that brown trout, which is what the target is here, can tolerate.

In addition, what I want to add is the force main that's coming from Nine Springs is going to be made of ductal iron, which would be the best thing because it will lose temperature to the ground and moderate some of that temperature.

I might also add that although there's limited temperature, the extremes of the temperature that are measured now are beyond the band that the effluent would fall in. Meaning, there's been warmer temperature than that and significant warmer and colder.

MR. NEMKE: I would just point out as an example of the effectiveness, we routinely do fish monitoring surveys on the Bad Fish Creek, an area where we have 100 percent effluent. We have brown trout living at 100. It is too warm for that, but they are very healthy and they live very well in the temperature currently discharged.

MR. FRANKE: One of those nonclassified trout streams?

MR. NEMKE: Yes. We collect these specimens every year. They keep getting bigger.

Other questions?

MR. HAMPTON: Kris Hampton, Town of Cottage Grove. Will your return of the effluent to the Badger Mill basin be in place at the time that you start pumping from Verona to Nine Springs?

MR. NEMKE: No. The pumping from Verona to Nine Springs will be able to occur in 1996. This project would not be completed until the end of 1997.

What that means from a practical sense, we could not pump all of the wastewater from Verona with the current pump. A portion of the -- we need to keep the Verona plant running until the DNR makes a determination that in fact return of the effluent is appropriate. We would petition the DNR to allow us to abandon the Verona plant with the understanding that as soon as possible we could start returning effluent.

MR. HAMPTON: Then with the additional water that would go to Bad Fish, have you looked at any potential flooding problems with that additional flow?

MR. NEMKE: We didn't look specifically at the increments. All we have done is a model on the Bad Fish looking at the impact of our 50 million gallons per day flow on the flood flows in Bad Fish, and flood flows were about 50 percent of the total flows on the Bad Fish.

But the action of the water is the flood flows are much greater than the base flows that we provide, which stays quite steady at 40 to 50 million gallons per day. The impact would be negligible of that additional .3 mgd's that we would probably send to Madison before we started returning effluent.

MR. HAMPTON: It would be two years time period then before anything would probably come back to the Badger Mill?

MR. NEMKE: Probably a year after the

existing pump station we're building now would be completed, but probably two years from today before we could actually have something implemented.

MR. RHINER: Julian Rhiner. I'm a farmer down there at the end of Badger Mill where it runs into the Sugar River. Would they eventually do away with the tube that goes out into the Sugar River now?

MR. NEMKE: Some interesting -- Paul --

MR. RHINER: Maybe they don't know.

MR. NEMKE: Obviously it would not be used for effluent transmittal. I don't think it would be taken out. Paul had an interesting comment today about possibly being able to that to divert some of the storm flow to prevent some of the erosion during high peak flows within that capacity.

MR. RHINER: It would help.

MR. NEMKE: That might be an alternative use for that.

MR. RHINER: If it is not used for effluent, how will it be able to go east of Verona? Would you run it into a pond or Badger Mill Creek or spread it out into the particular --

MR. NELSON: In terms of discharge point, a discharge goes to a start of like a waterfall, a cascade, and discharges directly into the stream.

MR. NEMKE: We looked at rearranging the marshes or creating a wetland. That turned out to not be a good idea. They thought initially it sounds good on the surface but the quality of the water coming out of the marsh or out of the wetland would be poorer than the actual effluent.

MR. RHINER: So they would run it from Nine Springs, bring it over and run it right into Badger Mill east of Verona?

MR. NEMKE: Correct.

MR. RHINER: Okay.

MR. NEMKE: Yes.

MR. SCHTEN: All these folks are wondering about the effluent variety and the characteristics, why don't you talk about how we do disinfection and what it's like in terms of potential disease and things like that.

MR. NEMKE: The process uses ultraviolet radiation to kill the bacteria and viruses. Most plants use chlorine. We have had some concern all along that chlorine could produce certain chlorinated expounds that can be harmful unless you dechlorinate.

We went to some time ago ultraviolet disinfection. It's been very effective. We're upgrading this entire system so we can meet all the water quality standards for not only fish and aquatic life but certainly for human recreational use.

Other questions or comments?

MR. HAMPTON: You talked about when you're returning effluent during a good storm you may reduce that return and then force that back into Bad Fish.

MR. NEMKE: That's right.

MR. HAMPTON: Why would you do that, I guess?

MR. NEMKE: Because there are certain flood rules that say you cannot increase the elevation by more than one-hundredth of a foot, .01 foot, otherwise you're in violation of -- Paul, help me out.

MR. NELSON: Badger Mill Creek is part of the management agency flood insurance program, so they have requirements.

MR. RHINER: When you got a good

flood, what's coming out of that tube is completely different.

MR. NEMKE: What I was --

MR. RHINER: I got the Badger Mill that drains way up to Madison. You ought to see the water in that tube you're going to bring.

MR. HAMPTON: That's why I wondered if it floods, what's it going to take to divert it?

MR. NEMKE: It would take more than a one-hundredth of a foot. If we made any more, it would be in violation of this federal rule on flood production. But that gentleman is right, you would not even see this flow. But we did model it all to show that, because that's a requirement of this flood insurance.

Other questions or comments?

MR. WERNER: Gary Werner with the Dane County Chapter Ice Age Park & Trail. I'm wondering, you talked about doing some demonstration projects in the stream to alter the stream back to some of its meander qualities or do other stream quality improvements, but you didn't say specifically where you would do that.

The stream that would be between Highway PB and Highway M, which is the stretch basically that goes through Badger Prairie County Park, a portion of that is the Ice Age Trail along the back. I wonder if any of that area would be some of the area that you'd do some of the projects to improve stream quality and habitat quality?

MR. NELSON: Well, I think first of all as we said, we walked 25,000 feet of the creek. It looked like there was only very little altered in some way, so there's lots of opportunity wherever you looked.

We've been talking about where it would be best to do demonstrations. We have talked extensively about that area, the advantages of the upper areas. It is public, and there's opportunities to work in there that way.

Disadvantages, and Alan can correct me here if I'm wrong, is in this upper area the habitat increase from the flow augmentation, which is the back two groups, is not as great as the potential in the lower area.

So biologically from an advantage standpoint and stuff, this area is not -- from a biological standpoint, doing some things down lower may have a better fisheries return.

MR. WERNER: That's regarding

habitat, but what about the possibility of narrowing the stream channel in the head water flows at PB and therefore making that a substrate?

MR. NEMKE: If you narrow that stream, then the habitat potential here would jump up more than it does down here. There is the advantage of more visibility in the upper end. For the demonstration projects it might be good to have it where people can actually --

MR. JOHNSON: Mostly for potential spawning, successful spawning of the trout in the head water. The main discharge of the springs is --

MR. SCHTEN: The people would get a chance to help us decide if we went there. We wouldn't do this unilaterally.

MR. NEMKE: We will keep either the existing committee in place or have a supplemental committee that would work with us to decide answers to these questions -- where we do it, what we do, who participates.

MR. NELSON: Guidance on whether visibility or ease for demonstration is important for biological return, those type of questions by a committee or so forth, and one of the things you said about the sediment, one of the things we were looking at is that a lot of the sediment coming from point barriers as they are formed instead of sitting there waiting for a huge storm to flow.

MR. JOHNSON: We've had quite a bit of discussion about trying to decide where would the best spot be to do a small demonstration. We are talking about approximately 1,500 feet possibly, somewhere in that range, as a demonstration to do in one chunk or a couple of chunks, so we do some spots that are more visible to educational placards or whatever, so people have access to it.

We would do them in the area that gets the most biological return. We've considered all of those, and I'd say at this point we had no decision but lots of options.

MR. WERNER: Anything is better than nothing.

MR. JOHNSON: It's kind of good news-bad news scenario. The bad news is pretty much most of the stream has been trashed. The good news is in terms of doing something, you can do anything you want to do with all the different groups in what would be looked at to do and access and easements and all sorts of things.

MR. NEMKE: There's a question.

MR. PEDERSEN: Ross Pedersen, Southern Wisconsin Chapter Trout Unlimited. In regard to the fishery, was there any choking done or any testing done of any existing population? We understand there is some group trout in work sets along with the colder water.

MR. NELSON: Wrong.

MR. NEMKE: There are none in our choking. We did find, I think, some brown trout found in the lower end of this gentleman's farm.

MR. PEDERSEN: Coming up on the Sugar River. Next, to continue the question, if you do the enhancements to the stream, where you can clear out the silt and tighten the stream banks, your other comment was there's no spawning in the Bad Fish.

We could make a fish habitat, but we'd still be dealing with planted fish, right? We couldn't have a reproducing fish population in the effluent flow?

MR. JOHNSON: I think the reality is if you put the small amounts of effluent as much as what's being put into the stream in terms of temperature of the effluent or even the general water quality of it, it's going to adjust in the short distance.

When it gets downstream too far, in terms of the effluent affecting the quality, I don't think that's going to be a major problem. I think the natural water temperature may limit it more than the effluent is going to limit it. That lack of vegetation on it is more likely to affect it.

There's questions about the exact areas that are wooded would provide some temporary relief for that. Some of the areas that are groups provide some.

MR. PEDERSEN: It's fairly shaded through from Lincoln Street down to --

MR. JOHNSON: Yeah.

MR. NEMKE: Ed?

MR. BRICK: Ed Brick, B-r-i-c-k, from Fitchburg. I'm just wondering if the significant springs -- or the springs along Badger Mill might be a significant difference between Badger Mill and Bad Fish?

MR. RHINER: That's just one continual spring. The bottom -- that water is coming up all along that sewer line down there.

That was laying in water -- or water was about level with the creek. That's feeding all from the bottom of the creek, and that's why the water is good effluent probably.

MR. JOHNSON: One of the things we are looking at is that. Because I did most of my inventory work in April, the temperature differs throughout the summer at different points where we could ask that question. All that I've been able to do about that is the information spot checks.

So I think one of the things before we start is to install some monitoring at different points along the creek to have a better idea of what the summer temperature is. That would be a relatively inexpensive project with the electronic devices available.

MR. NEMKE: I didn't want to totally discount the possibility. I just didn't want to leave the impression that that is the answer relative to spawning, because there are so many, including the storm water runoff and the siltation loads and everything else, that I think we'd be in dangerous territory if we said that is all.

MR. JOHNSON: I think we've been discussing from a fisheries standpoint. If we look at all the different aspects of the effluent, I think at worst it's probably a neutral impact, and I think what it does give you is the potential for opening lots of doors to doing various things that could improve the fishery, and so I think the effluent by itself is not going to magically turn Badger Mill into a blue ribbon trout stream. It certainly will make things --

MR. NEMKE: I might also add, it shows a commitment at least on the part of the district to begin the process to making improvements to follow-up on.

We're going to go forward with this, and if you folks all agree this is a good idea, make a very sizable investment of five million to get effluent back to this water shed. We want to protect that investment, so we're going to do everything we can to work cooperatively with Verona and any others.

We'll work with the City of Madison to try to encourage them to also do some things that are going to -- we're going to make and hopefully help improve Badger Mill Creek. It's going to happen, but it's going to take a lot of cooperation to get it done. But we're taking the first step, I guess.

MR. WERNER: Jim, Gary Werner again. You made the comment if DNR allows the transfer back, then you'll proceed to do it. I was under the impression that that decision had been made to allow this?

MR. NEMKE: It has not been made. That portion of the original facility money that suggested that's what we want to do, has not been approved subject to this study being completed, and number two, there are some issues that the department is wrestling with.

This is not the low cost alternative, the amount of dollars being spent. Simply because the low cost is to just build that pump station and force main and to pump it over there and leave it there. And so the DNR is going to have to evaluate is this in fact the best solution for the region even though the costs may be greater than just pumping it over there and leaving it.

They did support initially the facilities plan you ought to do just that, abandon this plant, pump it all out of this watershed and over to -- down to the Bad Fish Creek. We had some significant discussions with the DNR.

And there are DNR people here that are I think listening to these comments and hopefully are persuaded by the significant positive comments during this hearing. Actually this is probably the only project I've been involved in my 20 some years where 100 percent of the comments were in favor of maintaining the water balance and actually bringing effluent back here.

So I would hope that that type of public reaction would be persuasive to the department, even though this is not the bottom line low cost solution.

MR. BRICK: Low cost is kind of more a reflection that we hope won't do as much in terms of the environmental impact really considered by the commission, and I hope the DNR agrees there are the other costs.

MR. NEMKE: The traditional way that decision was made didn't consider the environmental costs as much as just the plain dollar costs.

MR. WIESSNER: Jerry Wiessner, Friends of the Sugar River out of Belleville. I want to say that I really am very, very impressed to hear all of these studies and everything. I think you folks are to be highly commended for the great job you've done in evaluating all of these things.

We in Belleville are very vocal about the flowage that is potentially possible by diverting the stuff over to Bad Fish Creek. We want it back, and well, I just want to reiterate that and say once more what we have said many times in earlier meetings, don't take our water away from us.

MR. NEMKE: We did get that message loud and clear. The supplemental study did figure it out.

MR. SCHTEN: Why don't you explain a little bit about what's happening with the DNR and what's approved and what's sitting in front of whom and what is happening.

MR. NEMKE: We submitted our facilities plan in the fall of '94 -- and I'm getting old. And we had a number of significant issues in that facilities plan. One of which was how do we deal with Verona.

There were also some other controversial issues. What do we do when we leave and can we discharge excess flow to the Sugar River system were the two controversial ones. The DNR did not approve it. They approved the building of this pump station and force main, because that was going to have to be done regardless of which alternative was selected.

If you pump it over here, you will need a pump station and force main. If you pump it over there, you still need the pump. They said, "We will approve your going forward with that. We will reserve the decision on the return until this study is done," until they have a chance to look at their policies.

Is that helpful?

MR. SCHTEN: Do we have any expectation of the --

MR. NEMKE: We were waiting for the public to comment after this third hearing and we will include all these comments and this transcript, and we hope to have the final draft of this facilities plan amendment done sometime in November.

We would like to submit it to the department shortly thereafter. We could ask the department to possibly be quick in their decision-making process. If they could make a decision, say, within 90 days and whether there is support, we could actually do the zoning of the line this winter and have it wrote by June 30 and they can start construction in the '96 season.

And that becomes somewhat dependent -- Jim Mueller from the Dane County Parks Department and the DNR people that are managing the Military Ridge Trail have also applied for funds from the federal government to make improvements to those bike trails and walking trails.

Our force main would parallel that line over a great distance, and we could save quite a bit of public money by the things we could do when we put in our force main. Plus if they went ahead and we hadn't started and they staked out a brand new trail, that wouldn't make a lot of sense.

They plan to begin construction of parts of that trail in '96, and I know the Military Ridge people have plans in to do the section from PB up to the weigh station in '96.

If we go through the bike trail, we will basically -- if they spend that money on other projects in the state, it would be a shame not to dovetail those projects to save the public some money. That's why we would like to see something going as early as '96. That would ensure we could get it done by '97.

If in fact we get approval from the process in six months to a year, we'd definitely be in construction in the '97 season, with conclusion in maybe early '98.

MR. RINGGENBERG: I'm Ed Ringgenberg from the City of Verona. You talked like if you got approval to do this, you would already shut the plant down here in Verona and pump everything over there and then you'd have no outflow to --

MR. NEMKE: That would be --

MR. RINGGENBERG: -- the Sugar River at all for awhile.

MR. NEMKE: That would be a decision we would have to discuss. The longer we have to run the Verona plant, the more improvements we have to make in the plant, and obviously if we want it eventually to -- we want to put as little investment as we need to do.

So we would run that plant only as long as we could while still maintaining the right to put effluent back into the stream. The DNR would obviously -- we do need to get, like Ed said, we asked them that specifically. "Can we abandon the plant if we returned effluent?" They said you could do it if there was definite plans to do that, and we could consider a two-year period to do effluent return so that you wouldn't lose your right to come back into that stream, if the construction project was definite.

Now, that was a memo we got some two, three years ago when that was our current position, but our preference would be to in fact eliminate this plant as soon as possible. We have an operator there. We have maintenance problems. And we would like to spend our resources in doing these other projects.

MR. RHINER: Would it dry up if there's no flow there?

MR. NEMKE: You wouldn't lose anything in Badger Mill. You would lose the one cfs that currently goes into the Sugar River for awhile, but you would gain flow once we got that return line.

Returning that one cfs, the return of the flow on the west side of Madison that comes out to the Sugar River, we'd be going from .6 mgd to 2.2 million gallons initially and ultimately flow .6 million.

And John, you asked that question if the force main could probably return much more than that if in fact sometime 20 years from now the DNR regulations would change to allow more flow, but from the current regulations the mass is limiting. You could not return more than that flow of .6 million gallons.

Great questions, great comments. We appreciate them.

MR. RHINER: How much more -- okay. Say you get everything operating in a couple of years. How much more water will be coming back than what is going on now?

MR. NEMKE: Right now --

MR. RHINER: You said it's one cubic foot a second.

MR. NEMKE: Right now the plant is discharging about one cubic foot per second or million gallons.

MR. RHINER: Use the point.

MR. NEMKE: .6 million gallons per day.

MR. RHINER: For the limit.

MR. NEMKE: Which is three times as much as currently is discharged by the existing plant.

MR. RHINER: That's what I want to know.

MR. RINGGENBERG: That .6 million gallons a day that is what you're basically --

MR. NEMKE: We would be bringing back 2,200,000 gallons. That's how much is generated within the Sugar River Basin.

MR. SCHTEN: Would it flow more pounds of phosphorous or smaller flow down into --

MR. NEMKE: It would actually contain less.

MR. SCHTEN: It could not contain more?

MR. NEMKE: It could not contain more than your existing effluent quantity. It could contain less. We do have some specs that would be at that and maybe greater. That's an area DNR also has to address.

Maybe I should follow-up on that a little bit. DNR has some ability to allow us to do this. If we impose those very stringent effluent limits on the district and say you have to meet those the day you go on line, we would have difficulty doing that 100 percent of the time.

So we asked a consultant to do modeling work which is a more case specific study of the creek, the modeling shows that the DNR's limits are more stringent than they need to be to protect the type of -- the DNR says you need to have fish and aquatic life, as we can show in the model, 100 percent of the time as from the DNR standards as currently calculated.

What we are going to ask DNR to do is accept our modeling results, which allows us to bring the effluent over as is and then allows us to monitor the stream to see, are we actually getting in the stream what we predicted we would have to to meet the DNR limits of more than that five million.

Filtration, which is another one hundred million, now we start getting to the point where it becomes more questionable about whether that additional investment is something worth making, particularly since our modeling shows we think we can meet all the water quality with the existing effluent quality.

A lot of the decisions that have to be made by the department we're suggesting -- we will be suggesting in this report from the commission, you know, approval of this approach, that we take a sequential approach to the problem, that we bring our effluent or we do modeling and see what you have, then we do more, but don't until you find out if you really have to spend that million and a half dollars.

MR. EXO: You said that in the whole scheme of things next to do --

MR. HAMPTON: Each of those effluent limits or those specs, if you will, or exceeds of those limits or an ambient or point or whatever, are probably insignificant to the levels that are introduced during storm events from nonpoint sources, so it's really a shell game.

MR. NEMKE: That's not the way the DNR rules operate, you're absolutely correct.

MR. EXO: It's not faulting the process or the agency. It needs to be said.

MR. NEMKE: That's correct, John, but DNR in this instance will have to deal with a lot of different policies or different approaches than they have really dealt with before.

And it's leading to evaluating problems on a watershed basis which the department reorganization is leaning toward and really that's how you probably should be making decisions, spend your money in a watershed to get the most bang for the buck.

Maybe spend, for instance, if in fact you needed to shave those peaks, you could take that million and a half or take 200,000 and cut out 10 times as much additional effluent in an agricultural setting or farm water setting, something additional at our plant.

Yet the current rules don't account for a mechanism to do that. We're hoping this opens the door to that kind of thinking, and I am not so sure the district would be opposed to working with the City of Verona, the City of Madison and whoever, to do other things that might help the stream and might help protect the Badger Mill as opposed to dumping an extra million and a half dollars in a treatment plant to shave off two steps of the time or first --

MR. SCHTEN: It's statutory to deal with storm water.

MR. EXO: Can you elaborate on that process? It's not been used, it's very clear, in that Chapter 60. Continuing along those lines, Jim, you know, isn't there precedent for DNR accepting -- and in fact in the case of Bad Fish Creek I was thinking they'd require actually modeling as a better basis for the oversimplified kind of equation that they use to come up with preliminary effluent limits in this case, and so this is -- I'm not seeing why this should be so difficult to get DNR to accept this as actually better evidence to base effluent limits on that simplified 26,013 pounds or --

MR. NEMKE: That's correct. We did meet with DNR approximately a month ago and we did talk about that modeling. We did ask them what information they needed to be included. They said continuing to do the modeling was a better mechanism.

Montgomery-Watson has provided all that data, all the modeling work that was done and the parameters that were relative to that modeling. We're hoping that in fact they accept that modeling as they did for the Bad Fish Creek. That's worked out quite well.

Generally the procedure that DNR uses is a simplified procedure. They just don't have the resources or the time to model all these individual cases. So because it's a simplified conservative procedure we think the modeling is obviously more accurate and more representative of what you would see.

We're quite confident in that modeling, but again we have to convince the department that that's an appropriate mechanism or tool to use.

Anything else?

MR. WERNER: As I'm hearing this, you would also like comments rather than just questions. As a resident of Madison and Dane County, certainly, and as not being an expert in any of this water quality material, I think that both of the concepts, as you've said, of keeping the water in the basin and the way you're talking about doing it is a commendable thing to do.

I certainly would be willing to pay that extra little increment that you're saying it's going to cost to do it. As a person who uses the services of the Madison Metropolitan Sewerage District, I think it is a -- hopefully is a precedent-setting type of project and not only here, but the kind of thinking involved will continue to be applied to other water quality and water basin issues in Dane County.

MR. NEMKE: Thank you for the positive comments. We hope so. We hope it's a direction that can be followed in other places in the county and other places in the state and nationally.

I think there's some movement toward trying to make decisions a little more holistically and look at applying monies a little differently.

I would like to ask this question just to see if my 100 percent is still intact. Is there anyone here tonight that really opposes our returning effluent to the basin and spending that money to do it?

(No response)

MR. NEMKE: We're still at 100 percent. We have made great progress since the time when people didn't want anything to do with our effluent. We have made tremendous improvements in the treatment capability.

One last chance for comments or questions.

(No response)

MR. NEMKE: We appreciate your coming out on such a wonderful evening to listen to this kind of dry stuff. We will be proceeding as we said.

Please take a copy of this with you, and if you want to submit any written comments, we'd be delighted to have them included in the record before we complete this facilities planning update and send it on to DNR.

Thank you very much for coming out.

(8:35 p.m.)

- -

SUGAR RIVER EFFLUENT RETURN

PUBLIC HEARING

- -

C E R T I F I C A T E

I, LINDA KUHLMAN, hereby certify that as the duly-appointed shorthand reporter, I took in shorthand the proceedings had in the above-entitled matter on the 28th day of September, 1995, commencing at 7:05 p.m., and that the attached is a true and correct transcription of the proceedings so taken.

Dated at Madison, Wisconsin this 10th day of November, 1995.

Notary Public, State of Wisconsin

MADISON METROPOLITAN SEWERAGE DISTRICT

1610 Moorland Road, Madison, Wisconsin 53713 (608-222-1201)

DATE: 9-29-95

TO: Linda
Professional Reporters
One East Main
Madison, WI 53713

RE:

	For your use		Approved as noted
X	For your information		Revise & resubmit
	Per your request		Rejected
	For your review and/or comments		

Enclosed please find:

Remarks: Linda - Attached is the attendance list for the Sugar River effluent return public hearing.

Sincerely yours,

Jim Nemke

TITLE:

FILE:

CC:

PUBLIC HEARING

SUGAR RIVER EFFLUENT DISCHARGE STUDY

The Madison Metropolitan Sewerage District and its consultants, Montgomery-Watson, have been investigating the advantages and disadvantages of returning treated effluent to Badger Mill Creek in the upper Sugar River drainage basin. The results of that study are now available and a Public Hearing to discuss those results will be held at the Verona City Hall, 111 Lincoln Street, on Thursday, September 28, 1995 at 7:00 p.m. The draft report will recommend construction of a pipeline from the Nine Springs Wastewater Treatment Plant to an area just east of Highway PB and south of the Military Ridge Bike Trail, with direct discharge of effluent to Badger Mill Creek. Effluent aeration and improvements to certain segments of Badger Mill Creek are also anticipated. The total cost of the project is estimated to be between $5 and $7 million. The following agenda items will be covered:

- Introduction
- Discussion of Existing Conditions
- Evaluation of Returning Effluent
- Review of Alternatives
- Future Directions
- Conclusions and Questions

Any questions prior to the hearing can be addressed to Jim Nemke, Madison Metropolitan Sewerage District, 1610 Moorland Road, Madison, Wisconsin 53713, or telephone (608) 222-1201, Ext. 253

SUGAR RIVER EFFLUENT RETURN
PUBLIC HEARING
SEPTEMBER 28, 1995
7:00 PM

NAME	ADDRESS	REPRESENTING
Jim Nemke	1610 Moorland Road Madison, Wi 53713	Madison Metropolitan Sewerage
ALAN JOHNSON	1606 NOB HILL AVE N SEATTLE, WA. 98109	AQUATIC RESOURCE CONSULTANTS
PAUL NELSON	555 Waterford PK Minneapolis, MN	MONTGOMERY ~~WATSON~~
Harold J [illegible]	Madison	
Ross A Pedersen	2269 Dahk Cir. Verona, WI 53593	So. Wisconsin Trout Unlimited
BILL LANE		DANE COUNTY RPC
Ed Brick	1664 BORCHERT RD OREGON, WI 53575	NEW BADGER ENTERPRISES
EDWARD SCHTEN	MMSD	MMSD
GARY WERNER	2302 LAKELAND AVE. MADISON, WI 53704	DANE COUNTY CHAPTER ICE AGE PARK & TRAIL FDN
JERRY WIESSNER	7127 NORTH SHORE 53508 BELLEVILLE, IL 53508	FRIENDS OF THE SUGAR RIVER
Arthur Cresson	317 Thompson Verona Wi 53593	City of Verona
Jon Schellpfeffer	MMSD	MMSD
Paul Nehm	MMSD	MMSD
Dave Taylor	MMSD	MMSD
Ron RIEDER	111 LINCOLN ST. VERONA Wi.	City of Verona
ED. RINGGENBERG	305 MELODY LA.	CITY OF VERONA.
JIM MUELLER	4318 ROBERTSON RD. MADISON, WI 53714 ~~Dane Co. Parks~~	DANE CO. PARKS
KRIS HAMPTON	3310 CTY N COTTAGE GROVE, WI 53527	TOWN OF COTTAGE GROVE

SUGAR RIVER EFFLUENT RETURN
PUBLIC HEARING
SEPTEMBER 28, 1995
7:00 PM

NAME	ADDRESS	REPRESENTING
George Osipoff	2801 Coho St, Madison	W-DNR
Steve Fix	3911 Fish Hatchery Rd. Fitchburg	W-DNR
Julian Rhiner	304 Barberry St. Verona	Farm owner on Badger Mill Creek.
Craig Rhiner	2266 RIVERSIDE RD. VERONA	Farm Owner on Badger Mill Creek
Michael Root	111 Lincoln St	City of Verona
DENNIS FRANKE	4765 C.T.H. KP CROSS PLAINS	SMALLMOUTH BASS ALLIANCE SW. TROUT UNLIMITED
John Exo	4430 Sentinel Pass Madison	Self

SUGAR RIVER CLEAN-UP

In all of the discussions, both verbal and written, about the river and Lake Belle View clean-up, dredging, whatever, no one has ever said to me, anything about (in my personal opinion) the biggest single problem we face.

It is, very simply, cattle. The erosion of the stream banks and manure run-off have been and continue to be the greatest pollution factors.

If you want proof, I refer you to the West branch, Mt. Vernon and Deer Creeks, accessible at the PB bridge. There you can easily see how the 1940s fencing by the Dane County Conservation League and other groups has made the difference. There are trout and other game fish in the water which is clear and comparatively clean. You can see sand, not muck, mud and sludge on the bottom.

Thus, as I personally have advocated for many years, let us solve the problems in the river up stream before we spend too much more money, time and energy in the lake and below it. If you are a farmer or cattleman and want some help solving our problem, please call me at 424-3818.

Jerry Wiessner

MADISON METROPOLITAN SEWERAGE DISTRICT

1610 Moorland Road
Madison, WI 53713-3398
Telephone (608) 222-1201
Fax (608) 222-2703

James L. Nemke
Chief Engineer & Director

MEMORANDUM

TO: Interested Public

FROM: Madison Metropolitan Sewerage District

DATE: September 11, 1995

SUBJECT: **Facilities Planning Update**
Return of Treated Effluent to Badger Mill Creek

Please find attached the advertisement for a Public Hearing where alternatives for returning treated effluent to the Badger Mill Creek area will be discussed. Your input would be helpful in the decision making process and we urge your attendance.

:dms

STATE OF WISCONSIN }ss.

Dane County

PUBLIC HEARING

SUGAR RIVER EFFLUENT DISCHARGE STUDY

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PUB. WSJ: September 14 and 16, 1995

(Seal)

Teresa L. Mason, being duly sworn, doth depose and say the he (she) is an authorized representative of The Wisconsin State Journal a newspaper, published at Madison, the seat of government of said State, and that an advertisement of which the annexed is a true copy, taken from said paper, was published therein on

September 14, 1995
September 16, 1995

(Signed) Teresa L. Mason

Principal Clerk (Title)

Subscribed and sworn to before me this 20th day of September, 1995

[signature]
Notary Public, Dane County, Wisconsin

My Commission expires 6-22, 1997

Updated: 03-03-95

SUGAR RIVER/VERONA FACILITIES PLANNING

Citizen's Advisory Committee

?aMr. Ken Potter
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Department of Civil & Environmental Engineering
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1415 Johnson Drive
Madison, WI 53706?bMr. Potter?!

?aMr. Jim Mueller
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4318 Robertson Road
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?aMr. Bill Lane
Dane County Regional Planning
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217 South Hamilton St.
Madison, WI 53703?bMr. Lane?!

?aMr. Robert Belle, President
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Belleville, WI 53508?bMr. Belle?!

?aWisconsin Wetlands Association
222 South Hamilton, Suite 1
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?aMr. Russ Hefty
City of Madison Parks Department
215 Martin Luther King Blvd.
Madison, WI 53709?bMr. Hefty?!

?aMr. Jerry Novotny
Wisconsin Department of Natural Resources
101 South Webster Street
Post Office Box 7921
Madison, WI 53707?bMr. Novotny?!

?aMr. Ron Rieder
City of Verona
116 Paoli Street
Verona, WI 53593?bMr. Rieder?!

?aMr. George Osipoff
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?aMr. Jon Felly
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?aMr. Topf Wells
Southern Wisconsin Chapter
Trout Unliminted
4914 Marathon
Madison, WI 53705?bMr. Wells?!

?aMs. Caryl Terrell
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?aMr. Jim March
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?aMr. Jim Knowles
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148 Wisconsin Avenue, Suite 214
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?aMr. Kevin Connors
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57 Fairgrounds Drive
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?aMr. Edmund M. Brick
New Badger Enterprises
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Oregon, WI 53575?bMr. Brick?!

?aMr. Philip H. Salkin
127 North Main Street
Verona, WI 53593?bMr. Salkin?!

?aMr. Stuart Shapiro
Belleville Recorder
Belleville, WI 53508?bMr. Shapiro?!

?aMr. Greg Fries
City of Madison Engineering Department
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Mr. Tom Hovel
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Mr. Eugene Gehl
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Mr. Scott McCormick
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Mr. James Mohrbacher
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Fitchburg, WI 53711

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D.C. Parks Commissioner
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Four Lakes Group SC
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Mr. Dan Holloway
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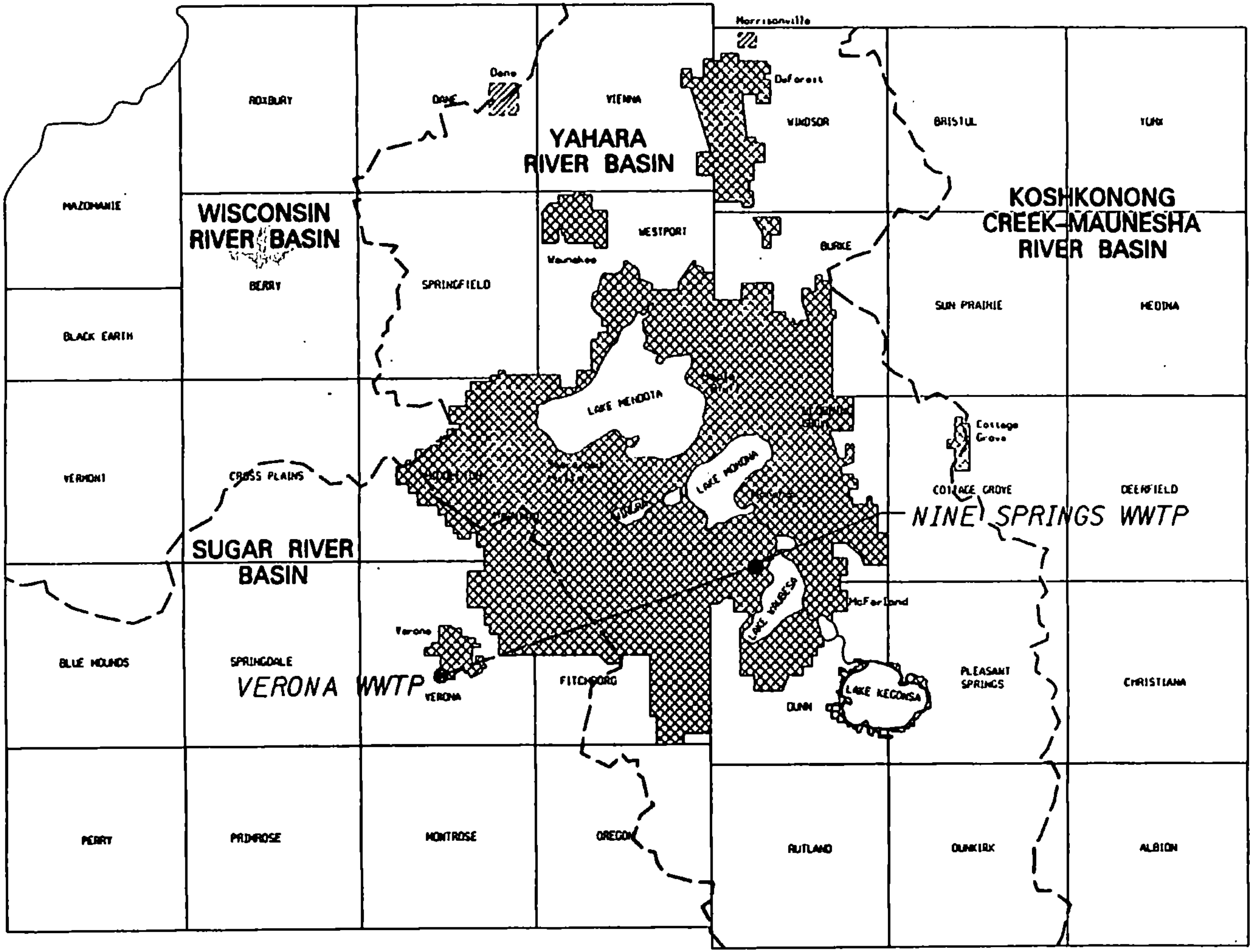
Outline

- **INTRODUCTION**
- **EXISTING CONDITIONS**
  - Effluent Quality
  - Stream Corridor
- **RETURN EFFLUENT EVALUATION**
  - Fisheries
  - Water Quantity
  - Water Quality
  - Archaeological Resources
  - Natural and Endangered Resources
  - Flooding and Erosion
  - Recreation Resources
- **ALTERNATIVES**
  - Definition
  - Evaluation
  - Screening and Selection
- **FUTURE DIRECTIONS**



LEGEND (cross-hatch) REPRESENTS EXISTING MMSD BOUNDARY
(diagonal hatch) REPRESENTS POSSIBLE FUTURE MMSD BOUNDARY INCORPORATION
— — — EFFLUENT RETURN LINE CORRIDOR

SOURCE: DANE COUNTY REGIONAL PLANNING COMMISSION

Figure 1-1
Service Area
Nine Springs WWTP

Project Scope

- More than the typical facilities plan
- Impacts of returning effluent
- What additional actions are needed to improve and protect the resource?

What We've Found

- The existing quality of NSWWTP effluent will protect aquatic life
- Returning effluent increases potential fish habitat
- Future impacts of wastewater diversion on flow in Badger Mill Creek are uncertain

Nine Springs WWTP Effluent

- Currently very good quality
  - 95% (+) removal of BOD, TSS, and TKN
- No past bioassay failures
- Future quality will improve with addition of Enhanced Biological Phosphorus Removal

What We Completed

- Walked all accessible portions (approximately 4.5 miles)
- What we measured
- Habitat modeling

What We Found

- ◆Four reaches
- ◆Potential exists for:
  - Forage fish
  - Trout

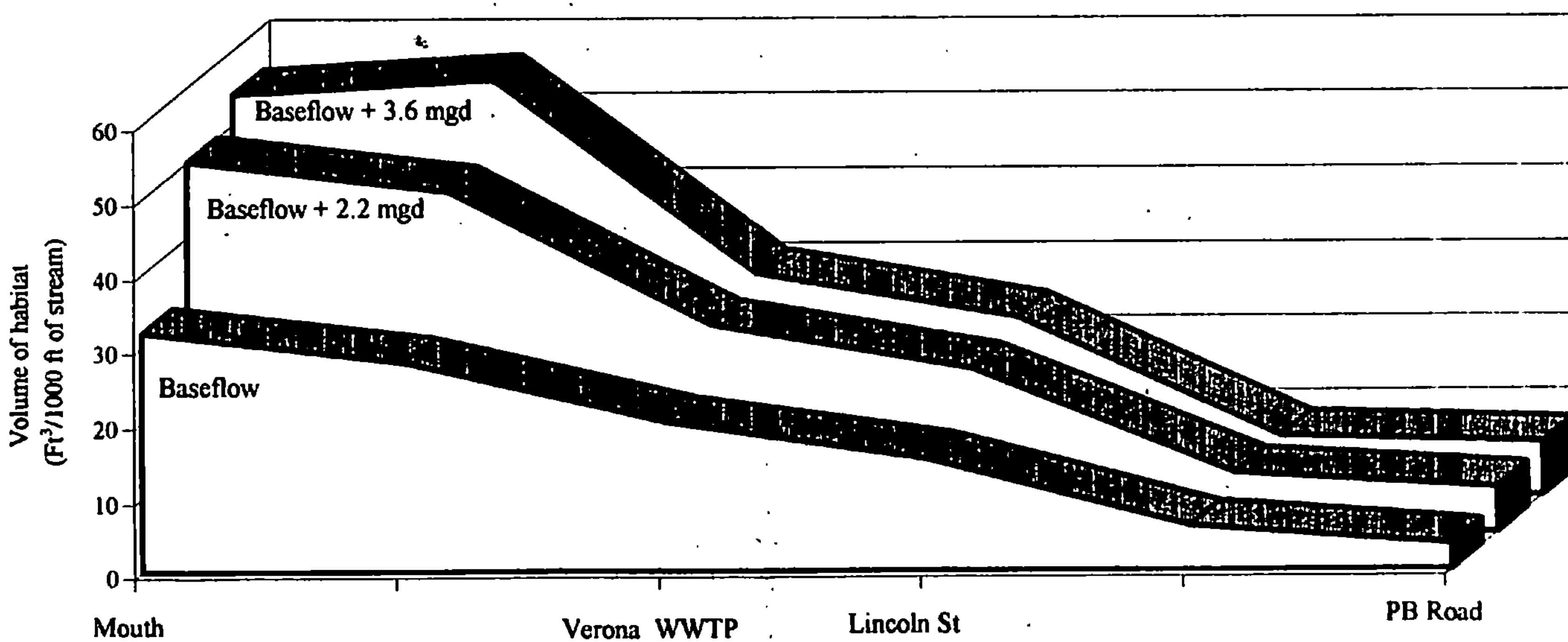
Factors Limiting Fisheries Resource in Badger Mill Creek

- Lack of cover
- Excess sediment
- Flows/channel morphology
- Water temperature
- Water quality

What Are Our Options?

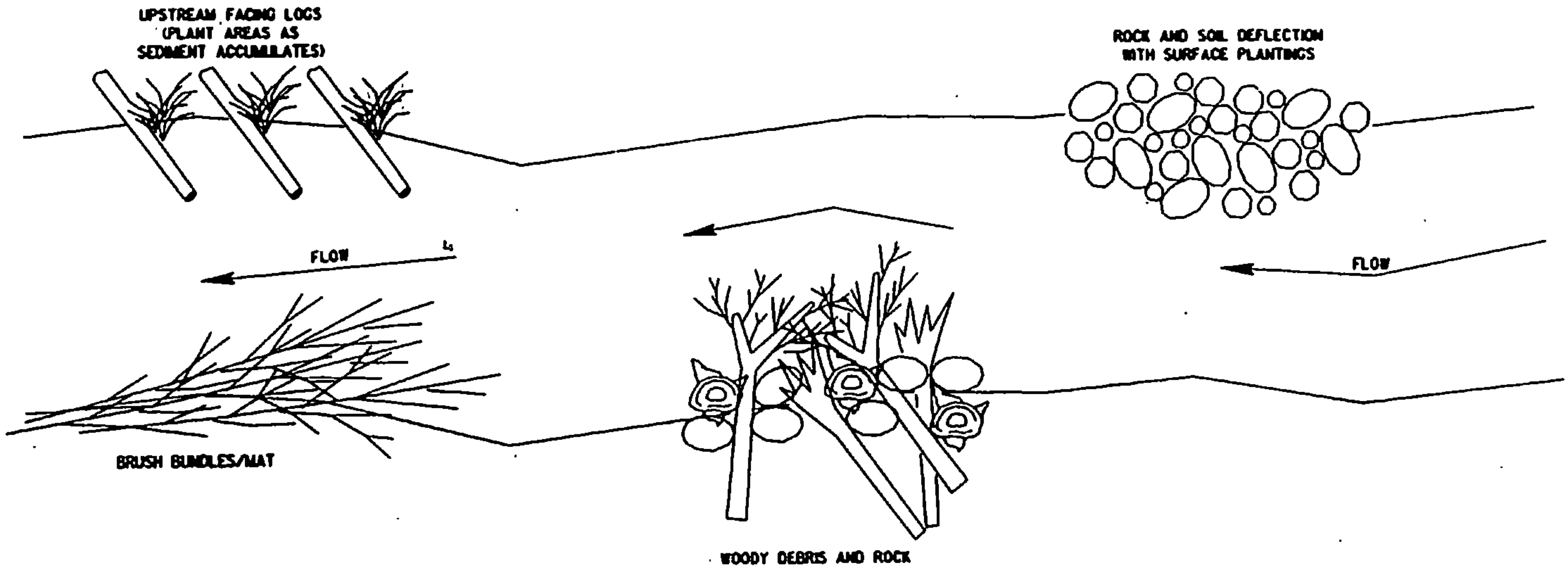
- Leave stream as is
- Augment flows
- Augment flows and modify habitat

Effect of flow augmentation on the volume of habitat in different reaches of Badger Mill Creek



Options for Habitat Modification

- Control sediment inputs
- Add cover
- Re-establish channel morphology
- Add vegetation to streamside corridor

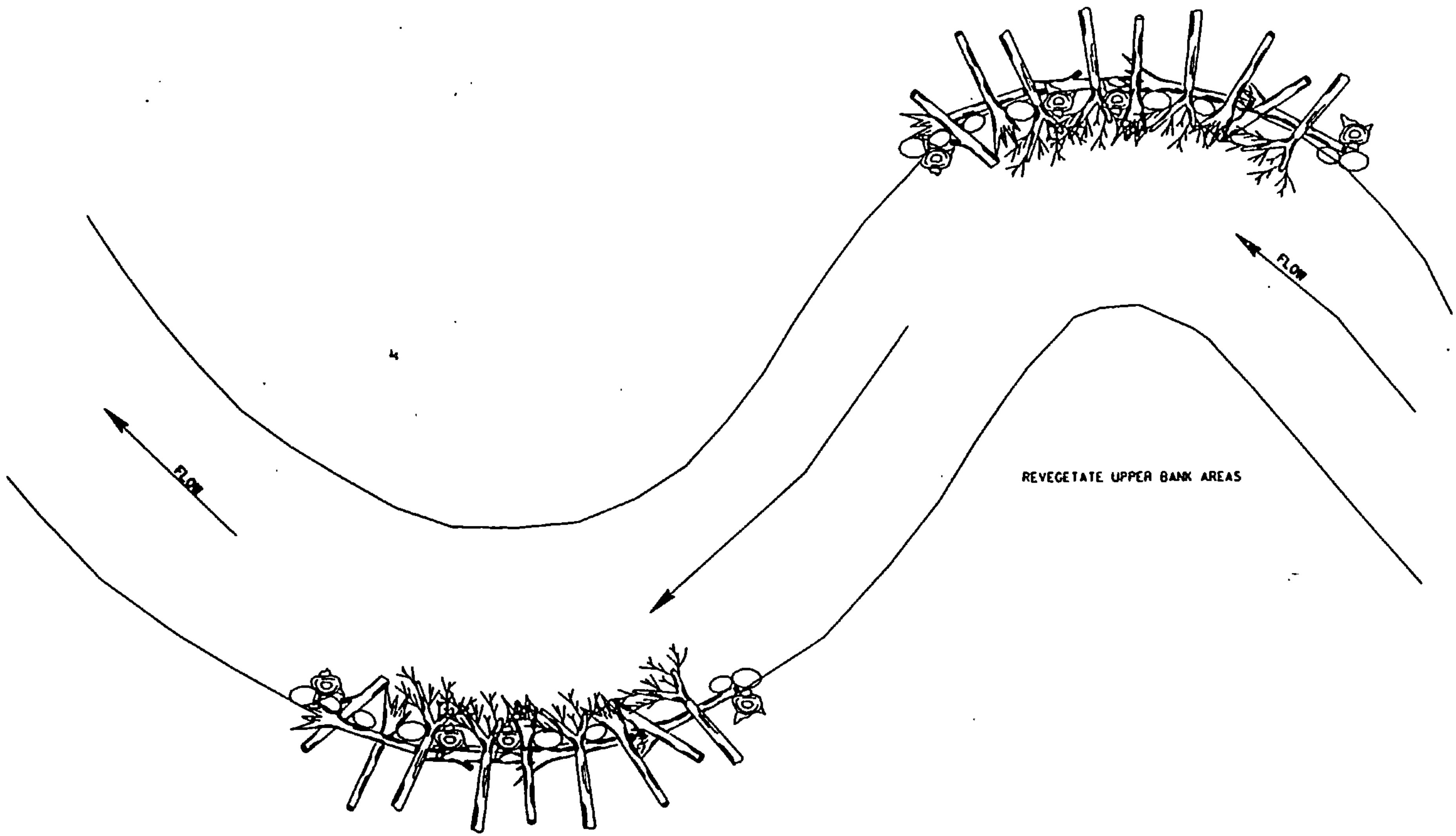


not to scale

MONTGOMERY WATSON
Minneapolis, Minn

TYPICAL STRUCTURES FOR FISH HABITAT
IN THE MIDDLE AND UPPER REACHES
OF BADGER MILL CREEK

Figure
5-6



not to scale

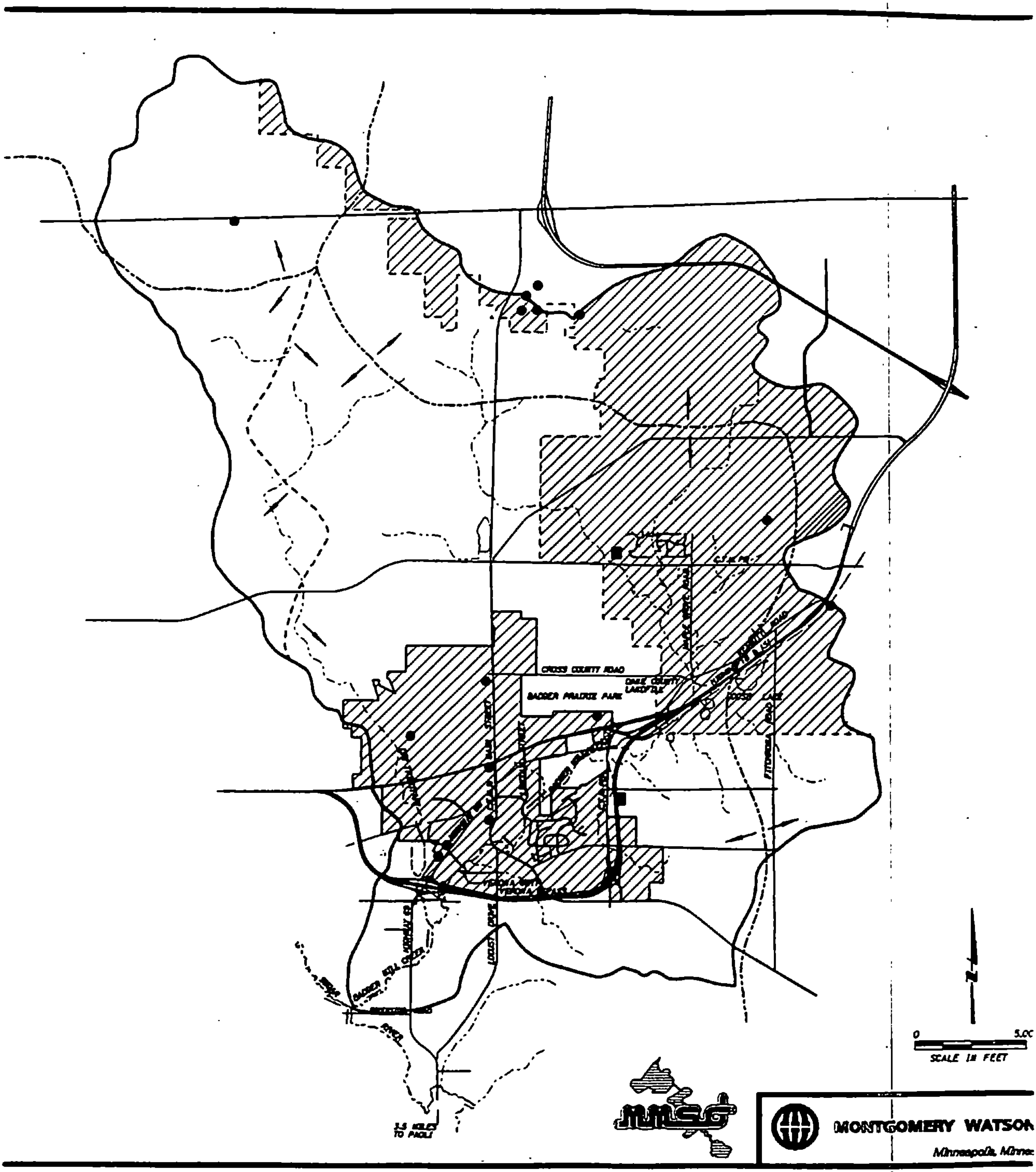
MONTGOMERY WATSON
Minneapolis, Minnesota

EXAMPLE PLACEMENT OF ROCK AND WOODY DEBRIS FOR HABITAT AND BANK STABILIZATION IN THE LOWER REACHES OF BADGER MILL CREEK

Figure 5-7

Potential Baseflow Reductions

- Municipal wells retrieve water from aquifers connected with shallow groundwater
- Shallow groundwater area draining to Badger Mill Creek is relatively small


CROSS COUNTY ROAD
BADGER PRAIRIE PARK
0
SCALE IN FEET
MONTGOMERY WATSON
3.5 MILES TO PAOLI

Diversion Impacts

	Impact
◆**Sugar River**	**5-6% (+) of baseflow, 13% (+) of low flow**
◆**Badger Mill Creek**	**Possible reduction in baseflow**

Modeling Demonstrated that Existing NSWWTP Effluent is Protective of Aquatic Life

- Sugar River and Badger Mill Creek
- Warmwater and coldwater fisheries
- Discharge in Reach 5, outfall aerator

Archaeological Resources

- No resources eligible for the National Registry of Historic Places

Natural and Endangered Resources

- ◆ No threatened or endangered plants
- ◆ Nine Springs Meadows Natural Area
  - Route A 12,000 LF
  - Route B --
  - Route C 4,000 LF

Alternatives Definition

Necessary Improvements	⟷	**Added Value Improvements**

◆Transmission System

- Pump station
- Transmission line

◆Outfall Aerator

◆Strategies

- Water quality
- Stream corridor

Alternatives

Alternative 1: No Additional Action

Alternative 2: Return Effluent

Alternative 3: Return Effluent with Water Quality and Stream Corridor Improvement

Alternative 1: No Action Alternative

- Existing conditions continue in Badger Mill Creek
- Sugar River has decreased wastewater loads
- Immediate reduction of 0.62 mgd(1cfs) flow in Sugar River
- Potential for future flow reductions in both the Sugar River and Badger Mill Creek
- Restricts future flexibility of wastewater management in the Sugar River Basin
- Plant Replacement or Regional Facility Required in the future

Alternative 2: Return Effluent

- Protects aquatic life
- Increases fishery potential of Badger Mill Creek
- Reduces wastewater loads to the Sugar River
- Maintains and enhances existing Sugar River baseflows
- Minimizes future reductions in baseflow
- Enhances recreational opportunities
- Maintains future operations flexibility

Alternative 3: Return Effluent with Water Quality and Stream Corridor Improvement

- Same as Alternative 2
- With added value strategies for water quality and stream corridor
- Suggests strategies for stormwater and agricultural runoff improvement
- Demonstrates stream corridor improvement techniques

Water Quality Strategies

Strategy	**Implementation**
◆**Polishing Wetland**	Not feasible
◆**Stormwater Management**	
• Ponds/marshes	PWP
• Erosion control	PWP
• Impervious surface control	PWP
• Wetland Restoration	PWP
◆**Agriculture**	
• Livestock exclusion	PWP

Water Quality Strategies

Strategy	**Implementation**
◆**Channel Improvements**	Demonstrations ⟶ PWP
◆**Riparian Improvements**	PWP
◆**Woody Debris**	Demonstrations ⟶ PWP

Summary

- ◆Negative impacts of returning effluent are limited
- ◆Numerous positive impacts
  - Fisheries
  - Diversions
  - Recreation
  - Synergy
- ◆Priority watershed program

Alternatives Evaluation

	Incremental Cost	Incremental Service Charge
Alternative 1	$7.2 to $8.2	$3
Alternative 2	$7.7 million	$3
Alternative 3	$7.8 million	$3

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Jon W. Schellpfeffer
Chief Engineer & Director

Protecting Public Health and the Environment

MEMORANDUM

To: Commissioners

From: Jon Schellpfeffer

Subject: **Effluent Discharge Locations and Impacts on Stream Base Flows, Inter-Basin Transfers, and Conservation of Groundwater through Reuse**

Date: August 21, 2006

This is the second in a series of papers on issues to be addressed in the District's upcoming Master Plan. This paper discusses policy issues related to determining the locations for discharging effluent from treatment plants and analyzing the impacts the discharge locations can have on stream base flows, inter-basin water transfers, and conservation of groundwater through effluent reuse. Commission policy will determine the approach the District uses and the scope of the effort in preparing the Master Plan.

Background

Since the first treatment plant was constructed in Madison in the late 1800's, the effluent discharge location has proven to be controversial. The most significant event in this regard was the 1949 law (Wisconsin State Statute 281.47) that prohibits discharges to the Madison lakes, unless an advanced form of treatment is used that will eliminate nuisances to the same degree as diversion of effluent from the lakes. The District constructed the necessary facilities to divert effluent from the lakes and has followed this practice since 1959. The impact of this diversion on the base flow in the Yahara River has been the subject of several studies since then, and current modeling suggests that over 43 million gallons per day will be diverted from the Yahara River watershed by 2030 if the current discharge practices continue. This will result in a 53 percent reduction in the base flow at the outlet from Lake Waubesa in a normal year, and will result in "no flow" conditions for weeks or more at a time during years with significantly lower than normal precipitation.

Since completion of the District's first advanced secondary treatment plant addition twenty years ago, the improved quality of the Nine Springs effluent has led to a vision of someday returning the effluent to the lakes to restore the natural water balance in the Yahara River basin. Jim Nemke's 1997 memorandum, "Effluent as a Resource," a copy of which is attached, included recommendations that the District follows today concerning approaches to beneficially reusing the effluent. The District's efforts in this area have begun to change the perception of the effluent from being a waste to a resource that can be reused to benefit the environment. The positive impacts on the aesthetics and the fisheries in Badfish Creek and Badger Mill Creek have been major factors in this regard. However, regulators, UW limnologists, and others remain skeptical concerning the environmental impacts of the discharge of effluent to impoundments such as the Madison lakes, and more work is required in this area if the District's vision is to be realized.

Impact of Effluent Diversion on Stream Base Flows

The Dane County groundwater model was used to predict the 2030 reduction in base flows of streams in the Yahara watershed if current effluent discharge practices continue. These practices include the return of up to 3.6 million gallons per day (mgd) to Badger Mill Creek and the diversion of the remainder of the Nine Springs effluent to Badfish Creek. The results of this model are shown in Table 1.

Table 1 – Impact of Effluent Diversion on Stream Base Flows

Lake Drainage Basin **Stream**	**Base Flow Reduction (mgd)**	**Base Flow Reduction (%)**
Lake Mendota		
Pheasant Branch Creek	1.19	85
Six Mile Creek	1.03	23
Token Creek at Hwy 51	1.80	15
Yahara River at Windsor Golf Course	2.06	27
Lake Monona		
Wingra (Murphy) Creek	1.88	59
East Branch of Starkweather Creek	1.31	96
West Branch of Starkweather Creek	2.88	82
Lake Waubesa		
Nine Springs Creek	1.27	27
Lake Bottoms Discharge Above the Lake Waubesa Outlet	30.19	66
Yahara River at Lake Waubesa Outlet	43.59	53
Lake Kegonsa		
Door Creek	1.38	44

In addition to the reduction in flow in the Yahara River at the outlet from Lake Waubesa, the most-impacted streams are Pheasant Branch Creek in Middleton, and the three streams in Madison that discharge to Lake Monona; Wingra (Murphy) Creek, and the east and west branches of Starkweather Creek. The other significant impact is on the amount of groundwater discharged directly into Lakes Mendota, Monona, and Waubesa.

Impact of Water Use and Effluent Diversions on Inter-Basin Water Transfers

The Dane County groundwater model was also used to predict the impact on overall base flows in the various watersheds in central Dane County in 2030 if current effluent diversion practices continue. The results are shown in Figure 1.

2030 Base Flow Impacts Due to MMSD Operation

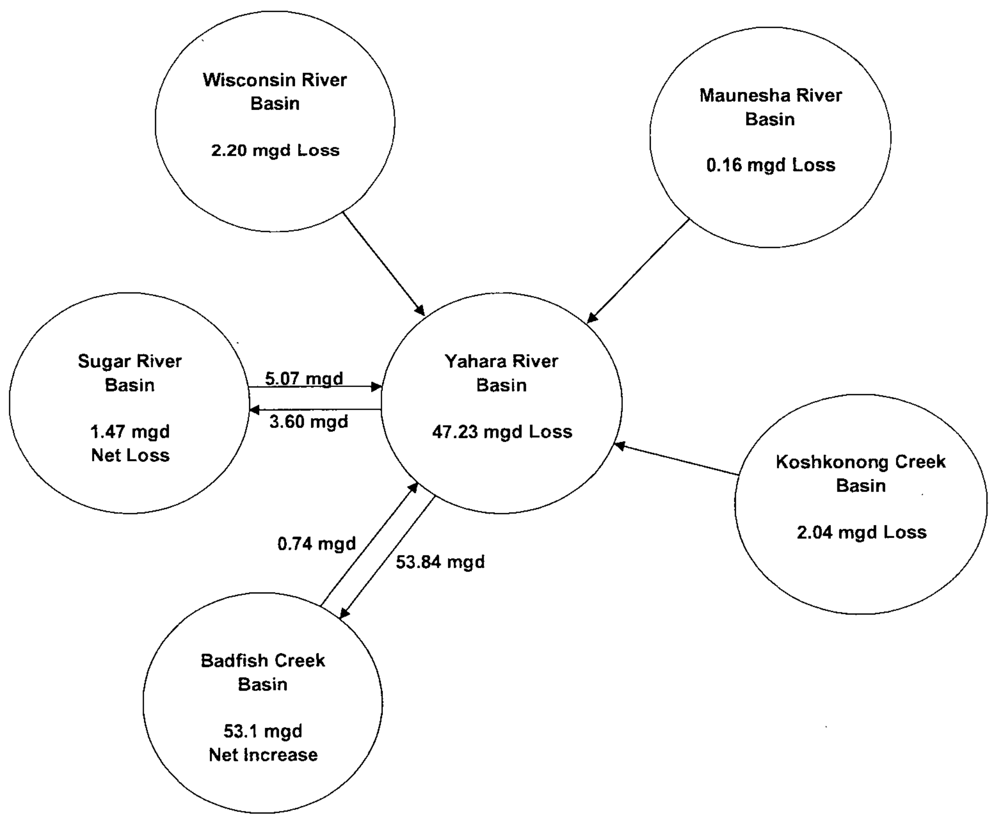


Figure 1 - Impact of Water Use and Effluent Diversion on River Basin Base Flows

The 3.60 mgd return to the Sugar River basin reflects the volume cap currently in the District's WPDES permit for effluent return to Badger Mill Creek.

The Dane County groundwater model was also used to show the impact of all water use in Dane County and the District's effluent diversions on stream base flows in these same watersheds. The results are shown in Figure 2.

2030 Base Flow Impacts in Central Dane County

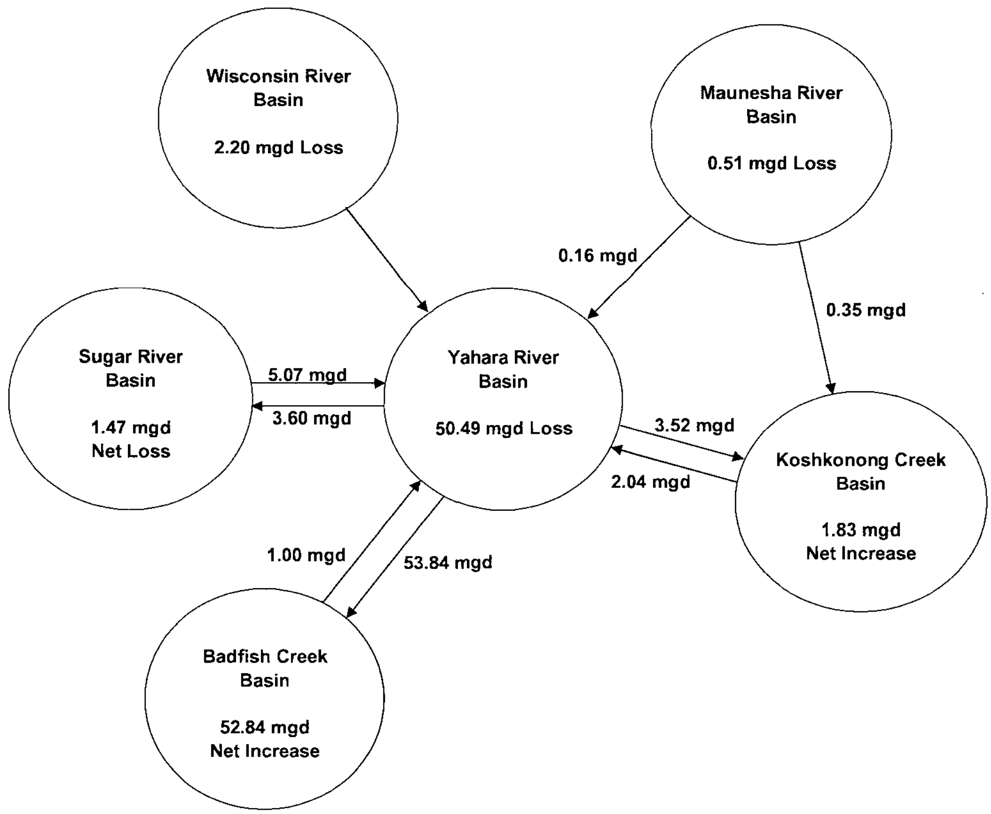


Figure 2 - Impact of All Dane County Water Use and Effluent Diversion on River Basin Base Flows

The diversion of water from the Yahara River basin and the Maunesha River basin to the Koshkonong Creek basin is due to Sun Prairie's water use. The additional base flow from the Badfish Creek basin to the Yahara River basin is due to Stoughton's water use. The overall reduction in the Yahara River base flow and the impact on the Madison lakes is somewhat greater when all water use is accounted for. The impact on base flows in Koshkonong Creek is also more accurately depicted in this case.

Policy Issues

The District recognizes the water quantity impacts of its current effluent discharge practices; however, the District has no statutory authority or regulatory requirement to address these impacts. The Wisconsin Department of Natural Resources is the agency with the responsibility to manage the waters of the state, including water quantity issues. The decision to address the impacts of groundwater pumping and effluent diversion will require a broad consensus within the community along with a regulatory effort from the DNR. With this in mind, how should the District address water quantity issues in the Master Plan? Using the District's effluent to address water quantity issues in Dane

County will involve significantly greater costs than continued/expanded discharge of effluent to Badfish Creek and Badger Mill Creek. Should the District identify and evaluate opportunities to address water quantity issues in future planning efforts?

Discussion

The District's primary goal is to provide high quality wastewater services at a cost that is below the median for similar organizations. It is likely that any future option involving the use of effluent to address reductions in stream base flows, inter-basin water transfers, or to preserve groundwater resources through the reuse of effluent will be more costly than the current treatment and effluent discharge configuration. Nevertheless, the District has implemented options to maintain flexibility to address the water quantity impacts resulting from the current effluent diversion practices and to limit capital expenditures related to increased effluent diversion capacity. The District also continues to work to promote effluent as a resource that can be used to provide environmental benefits. Are these efforts in conflict with the goal of maintaining reasonable costs, or do they reflect the goal of providing high quality services?

The 2004 update to the Dane County Water Quality Plan recommends that, as part of a facilities planning process, the District should consider the use of satellite treatment plants that would discharge their effluent to nearby streams as a means of addressing base-flow reductions. Although effluent may be a reasonable source of water to address this sort of water quantity issue, stormwater might be a more cost-effective and more acceptable choice. The District cannot make this determination alone. The WDNR, the Dane County Lakes and Watershed Commission, various municipal stormwater utilities, and several other entities should be involved in any such decision-making process. How should the District address this issue in the Master Plan? The entire Master Plan could be delayed until another group has studied this issue and a community consensus has been achieved, or the District could proceed with the Master Plan and evaluate various alternatives related to water quantity issues with the knowledge that implementing any of the alternatives would require greater community input.

Recommendations

The District is best served by continuing to act in a proactive manner and should proceed with the Master Plan, including evaluations of various alternatives for returning effluent to the watershed upstream of the Madison lakes, to streams tributary to the lakes, and directly to the lakes. The plan should also recommend which, if any, of the alternatives should be pursued and include those that make the cut in a ranked hierarchy that would reflect cost, acceptability, constructability, operability, effectiveness, and other issues of importance to the District and the community. The plan should also include an implementation schedule that would reflect both tasks and milestones that are controllable and in the purview of the District and those that are controlled by others.

The District should actively seek input from the DNR, the Dane County Lakes and Watershed Commission, and the new regional planning commission when evaluating alternative discharge locations and practices. The District should also involve the Dane County Land Conservation Department and the affected stormwater utilities when the alternatives could affect their areas of responsibility.

The District should form a technical advisory committee to aid in the development and screening of alternatives. The advisory committee should include representatives from the DNR, the Dane County Lakes and Watershed Commission, the new regional planning commission staff, the Dane County Land Conservation Department, the City of Madison Stormwater and Sewer Utilities, the UW Limnology Department, and the UW Civil and Environmental Engineering Department.

The District should develop a public education and information program to communicate with the public during the planning process. This program would include public information meetings and a project website. This effort should also attempt to gain comprehensive coverage from the local newspapers and TV and radio stations.

MADISON METROPOLITAN SEWERAGE DISTRICT

1610 Moorland Road
Madison, WI 53713-3398
Telephone (608) 222-1201
Fax (608) 222-2703

James L. Nemke
Chief Engineer & Director

To: Commissioners

From: Jim Nemke

Subject: Effluent as a Resource

Date: November 7, 1997

The fifth and last area chosen for general review and discussion is Effluent as a Resource. How effluent is viewed by the District, the District's customers and the general public may dictate future actions and initiatives by the District.

History

Significant controversy has surrounded the issue of effluent discharge from the time the first treatment plant was built in the City of Madison in the late 1800s. Until recently, effluent had been considered a "waste product" that had an adverse impact on whatever receiving body of water was selected as the discharge location. Selecting a location for discharge has always generated heated debate and legal challenges.

The single action that most impacted the District's operation was the law passed in the late 1940's that prohibited the discharge of any primary or secondary effluent into a watercourse that would enter the Madison lakes. This law required the District to evaluate, and select, an alternate discharge location. It eventually required all communities within the Lake Mendota drainage basin to connect to the District's system. The basic provisions of that law are contained in Section 144.05 of the Wisconsin Statutes, part of which has been attached to this memo.

When the law was passed, there was no advanced treatment technology as referred to in 144.05(c). Since advanced treatment technology which would meet the requirements of 144.05(c) did not exist, the statute was an outright prohibition against discharge in the upper Yahara system. It is interesting to note that the statute did contemplate improved technology that might allow the reintroduction of highly treated effluent if it could be shown that such discharge would not lead to nuisance conditions or other objectionable or damaging results.

While the District has generally employed the latest technology at Nine Springs, it was clear that even good secondary effluent could lead to nuisance conditions in the receiving stream. A big step was taken with the completion of the Seventh Addition, when additional capacity and nitrogen conversion were added. The lower suspended solids and ammonia nitrogen in the effluent resulted in significantly improved conditions in Badfish Creek. Fish and macroinvertibrate studies have confirmed that habitat, and not water quality, is the major constraint to further improvements to Badfish Creek.

Completion of the 9th Addition has again improved treatment, with effluent phosphorus levels in the 0.2 to 1.0 mg/l range and BOD5 levels less than 5.0 mg/l. While additional technologies are available to further polish the effluent, those technologies are very expensive and would result in limited improvements in effluent quality.

The export of effluent from the upper Yahara basin in the late 1950s reduced the pollutant loading to the Madison lakes. Because water quality was the main focus of the diversion, little attention was paid to any water quantity issues. The relationships between well water pumping, treatment and diversion and flow in the Yahara river system were not clearly understood or defined. Cline (1965) had suggested that the groundwater resource in the Madison area had a direct relationship to the Madison lakes and the Yahara River system.

During the 1970s, the District's consultants had done some crude modeling that suggested that as water was withdrawn from wells in the Madison area and diverted through the District's treatment system, less water would be available in the Yahara River system. Projections indicated that by the year 2000, very low flow conditions could exist in the Yahara River during extremely dry years. Little attention was paid to that prediction since the Madison area has always seemed to be "water rich".

During the mid -90s, the Dane County Regional Planning Commission, the Wisconsin Geological and Natural History Survey, and the U.S. Geological Survey cooperated in completing the Dane County Regional Hydrologic Study. The purposes of the study were to improve the understanding of the groundwater system and its relationship to surface water, update Cline's comprehensive groundwater resource assessment and provide a groundwater flow model that would be useful in water resource management decision making. That study confirmed the relationships between groundwater withdrawal, wastewater diversion and flow in the Yahara River system. It can be broadly generalized that every gallon of water treated and diverted from Nine Springs will result in one less gallon of water going through the Yahara River and lakes system.

Subsequent evaluations have shown that, by carefully managing the dams, it would be possible to maintain a minimum flow of 36 cubic feet per second in the Yahara River under weather conditions previously experienced without lowering the lake levels below acceptable limits. This would require detailed computations to guide the operation of the dams during the year. Even though this management technique may be the immediate solution to low flows in the Yahara River system, agencies like the District need to be concerned about the long term impacts of diversion. Beyond the impact on the Yahara River/lakes system, well water pumping and effluent diversion adversely affect base flow in urban streams and wetlands. Some of those impacts are more clearly seen in Badger Mill Creek, Pheasant Branch Creek, Starkweather Creek, Cherokee Marsh and the Nine Springs Marsh.

The District made a major commitment to the water balance issue with the decision to return treated effluent to the upper Sugar River watershed. Along with the practical impacts the returned water will have on Badger Mill Creek and the Sugar River, the discussions surrounding the decision making process greatly expanded the public's understanding of, and concern for, water quantity issues. It is hoped that a future benefit will be their developing a realization that the current treatment levels produce an excellent water resource.

The installation of the effluent return pipeline has opened other opportunities for effluent reuse. A tee and valve have been installed at the Fitchburg golf course which would allow effluent diversion to the holding pond or a water distribution system should such use be determined beneficial and technically feasible. A tee, valve and hydrant will be installed west of Syene road to allow the University of Wisconsin easy access to treated effluent for planned wetland restoration research. Discussions have already occurred with the Dane County Parks Department regarding the feasibility of a pipeline tap along Parks Department property south of Verona Road. Should there be advantages to better controlling water levels in the adjoining wetlands, effluent will be considered for that purpose.

Discussion

Growth in the Madison area will continue, with increased requirements for well water use. These water withdrawals will have a continuing effect on groundwater and surface water flow in Dane County. The predicted impacts are well defined in the documents recently generated as part of the Regional Hydrologic Study and will not be repeated here.

It appears that the concerns for low flow in the Yahara River system can be adequately addressed over the next 20 years by a more rigorous approach to controlling the Madison lake levels. Other management strategies, such as water conservation, can lessen the anticipated impacts. Beyond the 20 year horizon, there is an increasing likelihood that flow augmentation using highly treated effluent will become necessary somewhere within the watershed. Since it has taken 20 years for the Madison community to begin focusing on water quantity issues, it is not unreasonable to suggest that it will take another 20 years to cultivate a wide acceptance of using effluent as a resource.

Because of legitimate concerns for water quality issues associated with effluent return to the Madison lakes system, regardless of the treatment levels, such return will probably be a "last resort" alternative. However, effluent return may become the only reasonable long term solution.

Continuing development and water withdrawal will have more subtle, but equally serious, impacts on the remaining wetlands in the Madison area. Innovative ways of using stormwater and/or effluent may provide some opportunities for protection or re-establishment of those resources.

From the facilities perspective, the District is approaching the peak pumping capacity of the effluent forcemain. The limiting capacity of 75 million gallons per day will currently be exceeded during a major storm event. A review of rainfall events, and corresponding wastewater flows, would lead to the expectation of an overflow event every several years. As years pass, those events will become more frequent unless additional effluent pumping capacity is added to Nine Springs.

With the completion of the 9th Addition, the quality of the treated effluent that will periodically overflow to Nine Springs Creek and Lake Waubesa will be excellent. The District suggested during the most recent facilities planning process that it would not be cost effective, or necessarily good public policy, to invest $7 - $9 million dollars to build a second force main. The argument was made that the pollutant load from the occasional overflows would be small and could be mitigated by investing dollars for non-point controls within the watershed.

The District requested that the DNR take a position that would allow periodic discharge to Nine Springs Creek, with the understanding that the District would invest funds elsewhere to more than offset the anticipated additional loading to Lake Waubesa. The DNR has not responded to that recommendation in the facilities plan. There seemed to be those in the Department who favored the effluent trading concept and those who support additional export of effluent from the upper basin, regardless of the cost. Since the District has clearly defined the current, and anticipated situation, relative to effluent handling capacity, the ball is in DNR's court. Since the movement is toward acceptance of effluent trading and more innovative ways of meeting environmental objectives at lower costs, there seems to be little reason to push DNR on the issue at this time.

Recommendations

The District should anticipate that the time will come, even though it may be 20 years away, when there will be a need to reintroduce effluent into the upper reaches of the Yahara watershed. To facilitate the acceptance of effluent as a resource by the public and regulatory agencies, the District should promote opportunities to highlight the effluent quality and potential uses. It is not unreasonable to anticipate that it might take 20 years to overcome the public's view of effluent as a waste product instead of a resource.

Some of the near term things the District should be doing to promote effluent as a resource include the following:

- Promote the effluent return to Badger Mill Creek as a significant effluent reuse project which should be the cornerstone for other restoration and environmental enhancements in the upper Sugar River basin. We should insure that the discharge location becomes a positive focal point for the District's effluent. This can be done by appropriate signing, landscaping and maintenance. If the DNR or Dane County Parks Department decide to add enhancements at the site, such as an observation deck or picnic area serving the Military Ridge Trail, the District should consider participating in those efforts.

- The District should provide active support for additional initiatives in the upper Sugar River watershed by continuing to participate on the advisory committee and in projects that will improve Badger Mill Creek and the Sugar River. The better Badger Mill Creek looks in the future, the better will be the public's perception of our effluent. Conversely, once the effluent discharge begins to Badger Mill Creek, we should anticipate that the District may be blamed for any flow or quality problems, regardless of where they originate.

- The District should continue to work with Professors Ken Potter and Dave Armstrong on the proposed research on wetland restoration within the Dane County E-way. While the amount of effluent that might be reused on a full scale for such activities would be fairly small, the research could promote the concept of beneficial reuse and help identify approaches and constraints that could be helpful in maintaining healthy wetlands using effluent or stormwater.

- The District should be receptive to other proposals or projects that might promote effluent reuse.

- The District should continue to support additional technical studies by the Dane County Regional Planning Commission, the Wisconsin Geologic and Natural History Survey and the U.S. Geological Survey which will further define the future impacts of groundwater withdrawal and effluent reuse or export.

- The District should vigorously oppose any initiatives that would require the construction of an additional effluent forcemain that would institutionalize export of significantly greater effluent volumes.

- The District should oppose legislation or administrative rules that would have the impact of reducing the flexibility to reuse effluent if environmentally beneficial to do so.

- The District should use public forums to highlight the Badger Mill Creek Effluent Return Project and other initiatives that might promote beneficial effluent use.

WISCONSIN STATUTES 144.05

Sewage drains; sewage discharge into certain lakes.

(1)

(a) When any city, village, town or owner has constructed or constructs a sewage system complying with s.144.04, the outflow or effluent from such system may be discharged into any stream or drain constructed pursuant to law, but no such outflow of untreated sewage or effluent from a primary or secondary treatment plant from a city, village, town, town sanitary district or metropolitan sewage district in a county having a population of 240,000 or more, according to the latest U.S. bureau of census figures available including any special census of municipalities within the county, any part of which is located within a drainage basin which drains into a lake of more than 2 square miles and less than 16 square miles in area, shall be discharged directly into, or through any stream, or through any drain, into such a lake located within 18 miles of the system or plant of such city, village, town, town sanitary district or metropolitan sewage district. All necessary construction of plant, system or drains for full compliance with this subsection in the discharge of untreated sewage or sewage effluent from all existing primary or secondary plants shall be completed by September 1, 1970, and the plans for any new system or plant shall include provisions for compliance with this subsection. The department may at any time order and require any owner of an existing plant to prepare and file with it, within a prescribed time, preliminary or final plans or both, for proposed construction to comply with this subsection.

(b) Any municipality, which on April 30, 1972, has an operating sewerage collection and treatment system and has an application for attachment to a metropolitan sewerage district pending in the county court, in such a county, any part of which is located within such a drainage basin and which is located within 10 miles of a metropolitan sewerage district on September 1, 1967, shall be added to the metropolitan sewerage district upon application of the governing body of the municipality as provided in s. 66.205 (1), 1969 stats., if such petitioning municipality pays its fair share of the cost of attachment as determined by mutual agreement or a court of competent jurisdiction.

(c) In lieu of the construction in compliance with the foregoing provision for diversion from such lakes, any owner of an existing plant, on or before September 1, 1967, or any owner of a new system or plant prior to construction of such new system or plant, may file with the department such plans for advanced treatment of effluent from primary or secondary treatment as in the judgment of the department will accomplish substantially the same results in eliminating nuisance conditions on such lake as would be accomplished by diversion of secondary sewage effluent from said lake (without at the same time creating other objectionable or damaging results), and such owner shall be exempt from the foregoing provisions of this subsection for diversion from such lakes upon approval of such plans and installation of advanced treatment facilities and procedures in compliance therewith, but nothing shall impair the authority of the department to require at any time preliminary or final plans, or both, for diversion construction.

From: Kathy Lake
To: Amanda Wegner
Subject: FW: ASSISTANCE REQUESTED: Madison Met Final Compliance Alternatives Report for Badger Mill Creek Phosphorus Compliance
Date: Monday, April 24, 2023 9:03:36 AM
Attachments: image001.png
image002.png
image003.png
image004.png
image005.png
image006.png
image007.png
image008.png

From: Claucherty, Matthew L - DNR <Matthew.Claucherty@wisconsin.gov>
Sent: Tuesday, March 21, 2023 11:55 AM
To: Martin Griffin <marting@madsewer.org>; Brechlin, Ashley J - DNR <ashley.brechlin@wisconsin.gov>; Bauman, Thomas S - DNR <Thomas.Bauman@wisconsin.gov>
Cc: Spencer, Sean R - DNR <Sean.Spencer@wisconsin.gov>; Kathy Lake <kathyl@madsewer.org>
Subject: RE: ASSISTANCE REQUESTED: Madison Met Final Compliance Alternatives Report for Badger Mill Creek Phosphorus Compliance

Martye-
I can answer your questions regarding trading and adaptive management for Badger Mill Creek.

1. Undertaking adaptive management for Badger Mill Creek (either Badger Mill only or in combination with the Upper Sugar) would require specific phosphorus reductions from the Badger Mill Creek HUC 12. The extent of reductions would be defined in the adaptive management plan. The amount of reductions proposed would need to be sufficient for Badger Mill Creek to meet the phosphorus water quality criterion just above its confluence with the Upper Sugar River.

2. For water quality trading, the point of compliance is where the stream receives the discharge. Reductions above that would be considered an "upstream trade" and reductions put in place below that point would be considered a "downstream trade"

a. The water quality trading guidance document defines how delivery is evaluated (for upstream trades) and a downstream factor (for downstream trades).

Delivery factor: Based on the SPARROW model, there would be a very small delivery factor. The discharge's SPARROW catchment is 0.85 for a delivery fraction and there are a couple of upstream basins with 0.79 delivery fractions. The delivery factor would add less than 0.1 to the trade ratio in this case. More on the calculation here.

Downstream factor: As part of the downstream trading policy which allows credits to be obtained anywhere downstream in the HUC 12 watershed, a downstream factor is used. The percentage of in-stream phosphorus contributed by the point source (at the point of discharge) is what determines the downstream factor. Using the numbers from DNR's PRESTO analysis, I am seeing 844 nonpoint and 3060 point. That puts outfall 005 at 78% point source, so just barely into the 0.8 category. We could look at more up-to-date numbers if those are available. As of now, it looks like anything downstream of the outfall would have 0.8 added to the trade ratio.

Table 2. Downstream Trading Factor

Credit User's Load as a Percentage of Total In-Stream Load	Downstream Trading Factor
<25%	0.1
<50%	0.2
<75%	0.4
≥75%	0.8

Let us know if you have any more questions. Thanks!
-Matt

We are committed to service excellence.
Visit our survey at http://dnr.wi.gov/customersurvey to evaluate how I did.

Matt Claucherty
Phone: (608) 400–5596
Matthew.Claucherty@wisconsin.gov

From: Martin Griffin <marting@madsewer.org>
Sent: Friday, March 17, 2023 3:53 PM
To: Brechlin, Ashley J - DNR <ashley.brechlin@wisconsin.gov>; Bauman, Thomas S - DNR <Thomas.Bauman@wisconsin.gov>
Cc: Claucherty, Matthew L - DNR <Matthew.Claucherty@wisconsin.gov>; Spencer, Sean R - DNR <Sean.Spencer@wisconsin.gov>; Kathy Lake <kathyl@madsewer.org>
Subject: ASSISTANCE REQUESTED: Madison Met Final Compliance Alternatives Report for Badger Mill Creek Phosphorus Compliance
Importance: High

Hi Ashely,
We are preparing the final compliance alternatives report per our permit and we have a couple questions for you and your team around the watershed options for compliance that we are evaluating as part of the final options being considered. We feel that obtaining answers to these questions from you is necessary to help us make sure our assessments are as complete as possible. Considering the deadline for the final report we would appreciate any answers you can give us as quickly as you can.
The three questions are as follows:

1. If MMSD were to undertake an adaptive management project for TP compliance for outfall 005 that would include both the Upper Sugar River Watershed above the confluence with Badger Mill Creek as well as Badger Mill Creek, would specific pound reductions be required in the Badger Mill Creek HUC 12. If so, to what extent?
2. IF MMSD were to undertake a water quality trading program for the Badger Mill Creek HUC 12 for TP compliance for outfall 005, would the point of compliance be the downstream end of the HUC 12?
    a. Specifically, would there be any downstream or delivery factors needed when determining water quality trades from our effluent return location to the lower end of the Badger Mill Creek HUC 12?

Thanks in advance for your answers to these questions and please feel free to reach out directly if you need any additional clarifying information.

Thanks
~M

Martye Griffin
Director of Ecosystem Services
Madison Metropolitan Sewerage District
1610 Moorland Road • Madison, WI 53713-3398
P: 608-709-1813 • General: 608-222-1201
Email: MartinG@madsewer.org • madsewer.org

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF:
WP-16J

June 17, 2022

Wade Strickland, Chief
Permits Section
Water Quality Bureau
Wisconsin Department of Natural Resources
101 South Webster Street
Post Office Box 7921
Madison, Wisconsin 63707-7921

Re: Geographic Extent of Water Quality Trading for Badger Mill Creek, Dane County, Wis.

Dear Mr. Strickland:

The U.S. Environmental Protection Agency has reviewed your May 24, 2022, letter (submitted electronically) regarding the geographic extent of water quality trading for Badger Mill Creek, Dane County, Wisconsin. Your inquiry is in response to issues raised by the Madison Metropolitan Sewerage District (MMSD), which is currently evaluating compliance options for its discharge to Badger Mill Creek. You wrote that MMSD is proposing a water quality trading program to offset discharges from its facility with nonpoint source partners from the Upper Sugar River Watershed, which is adjacent to the Badger Mill Creek Watershed.

As the issue is described in your letter, we concur with the Wisconsin Department of Natural Resources that MMSD's proposed approach does not conform to EPA water quality trading guidance, as set forth in EPA's 2003 Water Quality Trading Policy and 2009 Water Quality Trading Toolkit for Permit Writers. The Policy and Toolkit provide that water quality trading may not cause or contribute to localized water quality impairment, or "hot spots", and must comply with the CWA, EPA's implementing regulations, and EPA-approved water quality standards.

Regarding the geographic extent of trading, the Policy and Toolkit provide that water quality trading programs should occur between sources within the same watershed. More specifically, trading should occur only within a hydrological unit that is appropriately defined to ensure that trades will achieve and maintain water quality standards within that unit as well as within downstream and contiguous waters. Further, the appropriate trading area should be based on hydrologic conditions, fate and transport of pollutants, ecological parameters, the location of dischargers, and distance between trading partners, etc. Given WDNR's experience on using the HUC 12 as the maximum geographic extent, we believe that trading within this area is appropriate when it achieves the above goals of EPA water quality trading policy and guidance.

Sincerely,

STEPHEN JANN

Digitally signed by STEPHEN JANN
Date: 2022.06.17 12:04:39 -05'00'

Stephen M. Jann
Manager, Permits Branch
Water Division

cc: Phillip Spranger, WDNR, phillip.spranger@wisconsin.gov

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
3911 Fish Hatchery Road
Fitchburg WI 53711-5397

Tony Evers, Governor
Preston D. Cole, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

WISCONSIN DEPT. OF NATURAL RESOURCES

December 2, 2022

D. Michael Mucha
1610 Moorland Road
Madison WI 53713

Subject: Phosphorus Preliminary Compliance Alternatives Plan – DNR Response
Madison Metropolitan Sewerage District
WPDES Permit No: WI-0024597-09-1

Dear Mr. Mucha:

Thank you for submitting the Preliminary Compliance Alternatives Plan (PCAP) for the Madison Metropolitan Sewerage District that was required as part of the "Water Quality Based Effluent Limits (WQBELs) for Total Phosphorus (Outfall 005)" compliance schedule (Section 6.4 of the WPDES permit). The PCAP was received on April 13, 2022. The Department has reviewed your submittal and determined that a new alternative must be selected in the Final Compliance Alternatives Plan, due May 31, 2023.

The selected option in the PCAP is to pursue Water Quality Trading in the Sugar River Watershed (HUC 070900040202). However, the point of compliance for Outfall 005 is within the Badger Mill Creek Watershed (HUC 070900040201). Water Quality Trading credits generated further downstream or in different watersheds are not able to be used by MMSD because those credits do not aid in meeting water quality standards within MMSD's receiving water and would not be consistent with s. 283.31(3)(d)1. Wis. Stats. Therefore, trading in the Sugar River Watershed is not an available compliance option. I have also attached a letter from the Environmental Protection Agency (EPA) dated June 17, 2022, that states the proposed compliance option does not conform to the EPA water quality trading policy and guidance. EPA policy and guidance provide that water quality trading may not cause or contribute to localized water quality impairment and must comply with the Clean Water Act, EPA's implementing regulations, and EPA approved water quality standards.

Since WQT in the Sugar River Watershed is not a viable compliance alternative, MMSD will need to evaluate a different compliance alternative to comply with the WQBELs for Phosphorus. The next compliance schedule action required by May 31, 2023 is a Final Facilities Plan or a Compliance Alternatives Plan. This report should contain all the relevant and supplemental information for how MMSD will comply with the future phosphorus limits for Badger Mill Creek and select a viable compliance option. Potential other compliance options include water quality trading within the Badger Mill Creek HUC12, adaptive management within the Badger Mill HUC 12, adaptive management within the combined Badger Mill and Upper Sugar River HUC 12s, tertiary treatment of the Badger Mill Creek discharge or discontinuing diversion in Badger Mill Creek.

Please see department comments below if Discontinuing Diversion to Badger Mill Creek will be the selected phosphorus compliance alternative:

- MMSD will need to provide more documentation about stream flow in Badger Mill Creek and Badfish Creek if discontinuing the diversion to Badger Mill Creek is the selected compliance option. This documentation will need to demonstrate that the addition of the Badger Mill Creek discharge to the Badfish Creek will not result in a lowering of water quality in either Badger Mill Creek or Badfish Creek.

- MMSD currently has water quality standard variances for chloride and mercury at both the Badger Mill Creek and Badfish Creek Outfalls. In order to justify the renewal of these variances for the Bad Fish Creek following discontinuation of the Badger Mill Creek discharge, MMSD may need to complete extensive in stream monitoring reflective of current conditions and preform a mass balance analysis that shows the statistical significance of the increased flow and pollutant loading. MMSD should reach out to the Statewide Variance Coordinator, Laura Dietrich (Laura.Dietrich@wisconsin.gov), to discuss further.
- An evaluation showing that MMSD's waste load allocations contained in the EPA approved "Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin" are sufficient to offset the increased mass loads of total phosphorus (TP) and total suspended solids (TSS) associated with returning MMSD's Badger Mill Creek discharge to Badfish Creek. If there is not sufficient waste load allocation to cover the increased mass load of TP or TSS attributed to the Badger Mill Creek discharge, the difference between MMSD's mass discharge and MMSD's Badfish Creek current waste load allocations for TP and TSS must off-set. This off-set can be made using alternative compliance options such as water quality trading.
- An update to the Yahara WINS Adaptive Management Plan demonstrating that compliance with water quality standards can still be achieved with the inclusion of the Badger Mill Creek. MMSD should reach out to the Phosphorus Implementation Coordinator, Matt Claucherty (Matthew.Claucherty@wisconsin.gov), to discuss further.

If you have any questions or comments on this letter or moving forward, please contact me at (608) 438-9930 or at Ashley.brechlin@wisconsin.gov.

Thank you,

Ashley Brechlin
Wastewater Engineer
Wisconsin Department of Natural Resources

CC (email copy):	Martye Griffin	Director of Ecosystem Services, MMSD
	Thomas Bauman	South Central Wastewater Supervisor, DNR
	Matt Claucherty	Statewide Phosphorus Implementation Coordinator, DNR
	Laura Dietrich	Statewide Variance Coordinator, DNR

Attachments:
EPA Letter dated June 17, 2022

Madison Metropolitan Sewerage District
1610 Moorland Road • Madison, WI 53713-3398 • P: (608) 222-1201 • F: (608) 222-2703

Preliminary Compliance Alternatives Assessment
Phosphorus Compliance Badger Mill Creek, Outfall 005
Madison Metropolitan Sewerage District
June 7, 2022

Table of Contents

Overview:

Badger Mill Creek is an effluent-dominated stream downstream of the Madison Metropolitan Sewerage District's (District) effluent location for Outfall 005 which the District is permitted to discharge up to 3.6 million gallons per day (MGD). The applicable phosphorus water quality criterion for Badger Mill Creek is 0.075 mg/l. Current operations at Nine Springs Wastewater Treatment Plant (NSWWTP) achieve biological phosphorus removal using a modified University of Cape Town activated sludge process. Total phosphorus (TP) enters the plant typically between 5 – 6 mg/L and is reduced to a concentration below 0.30 mg/L, on average, prior to discharge to Badfish Creek (BFC) and Badger Mill Creek (BMC.) Current processes are able to remove 95% of influent phosphorus, but an activated sludge process alone is unable to achieve the final effluent limitation of 0.075 mg/L. In the Yahara watershed, where the majority of the District's effluent is returned (Badfish Creek, Outfall 001), the District is leading the Yahara WINS adaptive management project. This project aims to achieve phosphorus compliance for all participating point source permittees, including the District.

The District has evaluated six basic compliance options as well as logical combinations of these approaches to achieve phosphorus compliance in BMC. These include treatment, discontinuation of flow to outfall 005, watershed alternatives including water quality trading and adaptive management as well as a site-specific criterion and/or variance. The district has narrowed these down to three remaining compliance strategies. Since the district has two discharge locations, one option is for the district to discontinue effluent discharge to Badger Mill Creek, thus eliminating the need for phosphorus compliance at the discharge point. Engaging in a water quality trading program or an adaptive management plan also remain as possible compliance options.

There are challenges and opportunities with each of these strategies. In addition, it is important to remember that the effluent that is discharged to BMC makes up an average of approximately 8% of the total District effluent (> 92% of the District's flow goes to outfall 001, Badfish Creek). The option that includes discontinuing flow to outfall 005 could reduce or eliminate discharge to Outfall 005. Undertaking this option reduces operating costs and energy requirements, provides a valuable pipeline corridor and associated easements for the district and could be straight-forward to implement. However, considering this approach may also require resource assessments and will involve significant stakeholder engagement. Due to the District's discharge location in the upper reach of a rapidly urbanizing watershed, the water quality trading option would be very challenging if the area available for trading were limited. There is more interest and longevity of trades available if the point of standards application is downstream of the confluence of Badger Mill Creek and the Sugar River, including the HUC 12 - 070900040202) (Exhibit B). While adaptive management remains a possibility, the standard challenges associated with adaptive management are compounded in this case by multiple stakeholders and lack of an established Total Maximum Daily Load (TMDL) for phosphorus in the watershed.

Assessment of Possible Compliance Options:

During this process, we have evaluated and assessed six compliance options. We have undertaken pilot testing of treatment technologies, discussed trading and adaptive management possibilities with municipalities and landowners, worked with the Wisconsin Department of Natural Resources (DNR) to assess a site-specific criterion and variance possibilities and impacts, discussed flow implications with USGS and began to engage a variety of stakeholders. A general overview of each of the six options assessed is included below:

Treatment:

As described in the Operational Evaluation and Optimization Plan submitted by the District in March 2021 (included as exhibit 28), no operational improvements to the current treatment process would result in a significant enough reduction in effluent TP to meet the new limit. Therefore, a tertiary treatment system would need to be constructed for the approximately 3.6 MGD discharged to BMC.

A literature review of viable tertiary treatment alternatives for TP removal was conducted, as well as research into systems pursued by other treatment facilities in Wisconsin facing similar TP requirements. The information gathered identified five types of treatment technologies capable of removing phosphorus to the low levels required. These are ballasted settling, algae photobioreactors, membrane filtration, cloth media filtration, and sand filtration.

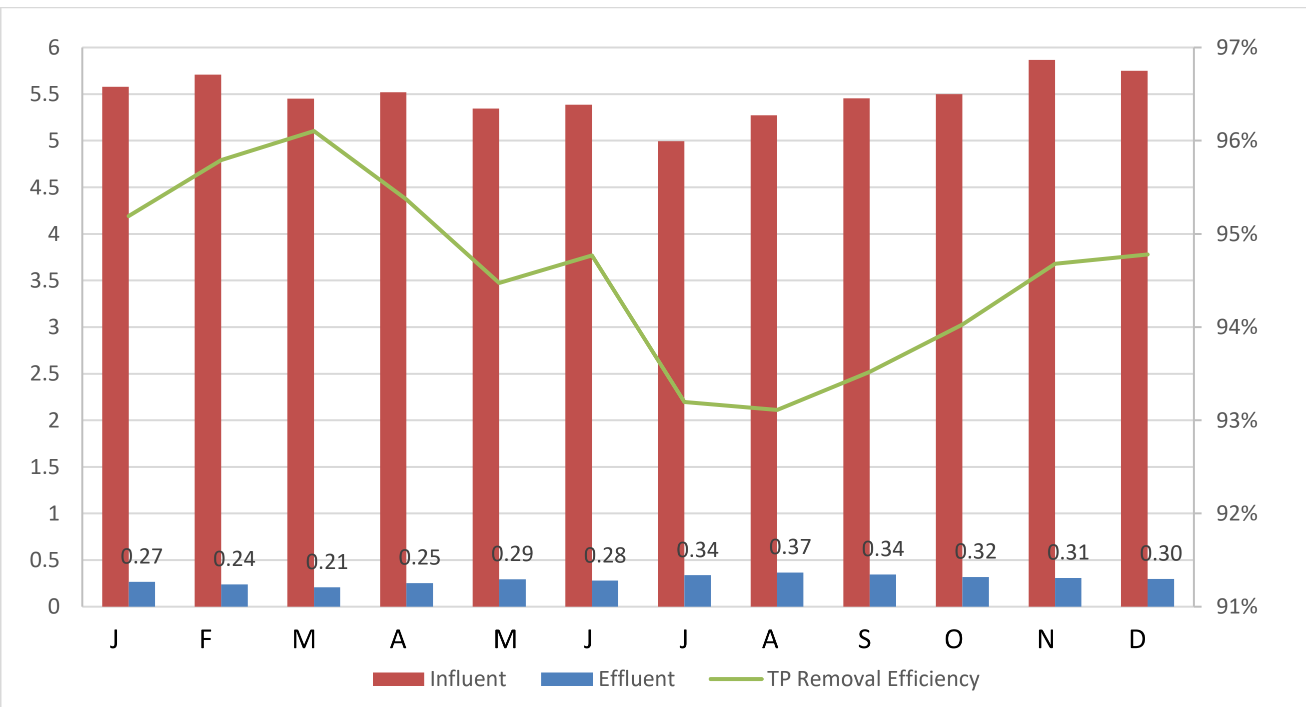


Figure 1. Average Monthly Total Phosphorus Reduction 2017 - 2021

Identification of Treatment Alternatives

At least one representative technology for each of the five viable tertiary treatment alternatives was selected for further investigation and potential piloting. These were:

- Ballasted settling – CoMag from Evoqua Water Technologies and Actiflo from Veolia Water Technologies
- Membrane filtration – ZeeWeed 1500 Ultrafiltration from Suez Water Technologies
- Cloth media filtration – AquaDisk from Aqua-Aerobic Systems
- Algae photobioreactors – CLEARAS Water Recovery
- Sand filtration – BluePro from Nexom

Generally, all treatment options offer similar advantages and disadvantages compared to other compliance methods. The District could achieve phosphorus discharge to BMC which meets the water quality standard through tertiary treatment. This, however, requires the installation of expensive, energy-intensive treatment systems.

To discern the benefits and drawbacks of each individual treatment technology, an initial screening and ranking of the six aforementioned systems was conducted (Figure 2). This ranking also helped to prioritize which systems to pilot and further investigate. The systems were evaluated on the following criteria:

- System complexity and staffing needs
- TP removal efficiency
- Cost (Capital and O&M)
- Chemical requirements
- Footprint
- Energy demand
- Long-term goals (e.g., will it assist with other pollutants aside from TP? Does it offer resource recovery or effluent reuse opportunities?)
- Community impacts (e.g., will it provide a higher level of treatment aside from TP?)
- Risk/Number of installations (e.g., is this a demonstrated technology?)

These considerations were weighted on the basis of perceived importance as it relates to consideration of tertiary treatment as a means to achieve phosphorus compliance. Therefore, ability to remove phosphorus was given the most weight, while considerations involving treatment beyond TP were given less weight. O&M demands fell somewhere in the middle.

Considerations	% Weight	Actiflo Ballast Settling	BluePro Sand Filter	Clearas Algae ABNR	AquaDisk Cloth Filters	CoMag Ballast Settling	Zeeweed UF Membranes
Staffing/System Complexity	11%	2	3	2	4	2	3
P Removal Effeciency	17%	3	4	5	1	4	3
Capital Cost	11%	2	3	2	4	2	1
O&M Costs	11%	2	3	3	4	2	2
Chemical Usage	7%	2	3	4	3	2	3
Footprint	7%	3	4	1	4	3	4
Energy	14%	3	3	2	4	3	1
Long-term Goals	7%	3	3	4	2	3	4
Community Impacts	4%	3	3	4	2	2	4
# of Installations/Risk	11%	3	4	1	4	3	3
	100%						
	Weighted Score:	2.6	3.4	2.8	3.2	2.7	2.6
	Rank:	**6**	**1**	**3**	**2**	**4**	**5**

Scoring	Scale
5	Excellent
4	Good
3	Average
2	Fair
1	Poor

Figure 2. Initial Screening of Treatment Technologies

Evaluation of Treatment Alternatives

The top four technologies from the initial screening were carried forward to piloting (BluePro, AquaDisk, Clearas, and CoMag), which took place between October 2018 – September 2019. The objectives of piloting were as follows:

1. Demonstrate TP removal efficiency
2. Determine chemical needs
3. Monitor removal efficiencies of currently regulated parameters: BOD, TSS, metals (Cd, Cr, Cu, Pb, Ni, Zn, and Hg), NH_3, and chloride
4. Analyze other effluent parameters of interest. Ancillary treatment benefits, such as total nitrogen (TN) removal, would factor into the decision-making process.
5. Estimate basic design parameters
6. Develop an understanding of staffing and maintenance needs.

Each pilot was operated for approximately ten days. Pilots were temporarily installed following final clarification on the west plant of NSWWTP. Effluent from one final clarifier was pumped through the pilot before being discharged to the effluent trough of a second final clarifier. Influent and effluent samples were collected twice daily and analyzed in-house by the District's lab staff. The vendors and operators of the pilots were encouraged to conduct their own sampling and analysis to inform operational changes and compare data with the District's findings. These results, however, were to be used solely for the vendor's benefit, and do not appear in the performance data presented in this report.

Performance Data

Figures 3 and 4 summarize the treatment results. It should be noted that during the AquaDisk pilot, the type of cloth media was changed from a 5-micron microfiber to a 2-micron ultrafiber in order to improve treatment. Overall, each technology trialed was able to meet the 0.075 mg/L target as anticipated.

Other effluent parameters of interest (TN, chloride, and mercury) were not significantly removed by the pilots. In the case of chloride, effluent numbers actually increased for most of the pilots. This is likely due to the addition of coagulant chemicals. Results indicate a modest benefit in mercury removal. However, influent mercury concentrations were already below the level of detection for approximately half of the samples. No negative impact was found on the District's other regulated parameters (BOD, TSS, NH_3, metals) for any of the systems.

Detailed discussion of pilot results can be found for each treatment system in the next section.

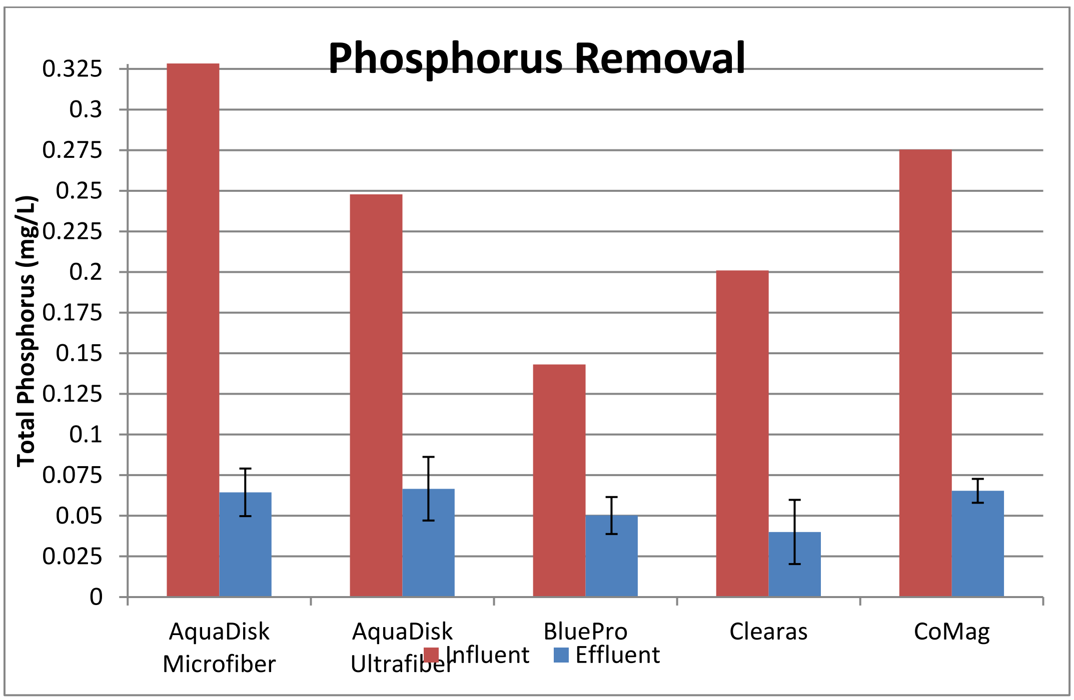


Figure 3. TP Removal

	Total N	Chloride	Mercury
AquaDisk Microfiber	8.0%	-4.6%	38.2%
AquaDisk Ultrafiber	4.6%	-5.2%	35.6%
BluePro	1.1%	-4.1%	9.3%
Clearas	5.9%	5.3%	20.1%
CoMag	N/A	N/A	14.4%

Figure 4. Removal Efficiencies of Other Pollutants of Interest

Results

Once piloting was complete, an analysis containing both qualitative and quantitative considerations was conducted for each of the treatment technologies.

1. AquaDisk

Description: Ferric chloride and polymer are dosed to the incoming flow and mixed in a flocculation tank. As flocs of solids begin to form, the wastewater enters the filter tank, where it flows by gravity into the cloth media disks. Solids are filtered, leaving a mat on the surface of the cloth disks, as treated effluent exits the filter tank. A routine backwashing sequence rotates the disks, while a vacuum-pressured nozzle removes the solids build-up from the surface of the cloth disk.

Advantages: Cloth media filtration is a simple, well-established method for tertiary polishing of treated wastewater. Capital costs are low compared to other systems and can be installed in a compact footprint.

Disadvantages: Neither the 5-micron microfiber or 2-micron ultrafiber were able to reliably meet the 0.075 mg/L TP target. While each cloth media averaged below the limit for the duration of the pilot, effluent samples regularly exceeded 0.075 mg/L. This system also demands more coagulant and polymer than others.

Conclusion: Due to the inability to reliably achieve the desired effluent results, this technology was not pursued once the pilot ended.

2. BluePro

Description: The system is described as “reactive filtration”, consisting of either a single or dual stage upflow sand filter. Wastewater enters the bottom of the vessel, traveling upwards through the sand as ferric chloride (or other coagulants) are injected into the incoming stream. The sand media is coated in the coagulant, which aids in the reaction and filtration of particulates. An airlift pump sends the captured solids to a washbox, where the sand media is recovered and recycled into the filter vessel.

Advantages: The pilot was able to achieve the desired level of treatment with a single stage filter. No polymer was needed. The only chemical required was ferric chloride, which was used at concentrations lower than other technologies piloted. Sand filtration has long been used in water filtration and is a relatively simple process.

Disadvantages: While simplicity of the system is a benefit from and O&M perspective, the sand filter does not offer many ancillary benefits beyond TP removal. A second stage could be added if the DIstrict were to receive more stringent effluent limits in the future, but opportunities for resource recovery, effluent reuse, or removal of contaminants of emerging concern (CECs) are limited. As with any technology reliant on chemicals, the threat of fluctuations in chemical costs is also a concern.

Conclusion: BluePro met many of the District’s requirements and was selected as one of the technologies to investigate further if treatment was selected as the compliance option to pursue.

3. Clearas

Description: This system is unique in that it was the only biological systems trialed. Carbon dioxide is added to the incoming wastewater as a carbon source needed for the removal of phosphorus. Wastewater is then mixed with a stream of microalgae, similar to how a conventional biological nutrient removal system uses activated sludge. Instead of aeration tanks, however, the wastewater/algae blend travels through clear glass tubes fitted with LED lights, which serve as the photobioreactors. Following biological treatment, algae is separated and recovered from the effluent using an ultrafiltration membrane. A portion of the recovered algae is returned, while the remaining is wasted from the system. The wasted fraction can be dried and used in a number of commercial applications.

Advantages: The Clearas photobioreactors achieved the lowest effluent TP concentrations of the technologies piloted by the District. In addition to a high level of treatment, this system provides a resource recovery opportunity. Recovered algae has the potential to be a high-value, renewable product in the bioplastic, biofuel, or animal agriculture industries. Biological systems are also well-suited for steady, consistent loadings as seen in the BMC outfall.

Disadvantages: To date, there are few full-scale installations, all of which are located at small, rural treatment plants. This would be the largest application by a significant margin. The footprint required is approximately an acre. This would also be the most expensive treatment option. Some of the capital and O&M costs would be offset by the sale of the dried algae product. However, to make the installation more economical, the District's current treatment would need to be reduced, allowing more TP to enter the Clearas system. A higher influent TP concentration would yield more algae product but degrade current treatment performance. Another drawback is handling of the algae product. An energy-intensive process is required to dry the material, and once made, the District would need to rely on an outside entity to market and sell the product.

Conclusion: Clearas carries a large amount of risk at this time. Likewise, disadvantages such as expense and energy demand make it a less attractive option if the scope of this research is solely TP removal. However, the potential benefits and high level of treatment warrant further investigation into this technology if treatment is selected as the compliance option to pursue

4. <u>CoMag</u>

Description: CoMag is a ballasted settling system that uses magnetite to achieve TP removal. Flocculation and mixing tanks are used to dose polymer and coagulant, resulting in floc formation of solids. Also introduced in this step are the magnetite particles. Once the magnetite is incorporated in the floc, the solids quickly settle out in the following clarification step. A magnet is used to recover the magnetite from the solids, which in turn can be recycled to the flocculation tanks.

Advantages: The pilot successfully removed TP to the desired concentrations. The rapid clarification process associated with ballasted settling is beneficial when space is limited and tankage is nearing capacity or there is a large peaking factor.

Disadvantages: The system is more complex than others piloted and requires the addition of polymer, a coagulant, and magnetite. Additional tankage would need to be constructed for the mixing/flocculation tanks and clarifiers, making this a more expensive option. There are also concerns with fluctuations in chemical costs and magnetite being a more niche product.

Conclusion: While CoMag is an effective way to remove TP from effluent, it is better suited for a different application. The BMC outfall is a consistent flow, with very little fluctuations in loading. This excludes the advantages typically associated with a ballasted settling process. Likewise, it would be difficult to incorporate into the existing treatment scheme, requiring new tankage to be constructed.

Discussion

Of the four treatment technologies piloted, Clearas algae photobioreactor and BluePro sand filter were identified as two viable options if treatment is selected as the phosphorus compliance alternative. Investigation into these technologies included basic design requirements, O&M and consumables, and preliminary capital cost estimates.
Both systems could potentially be located in the area north of the west plant final clarifiers and east of the effluent building (Figure 5). Clearas would fill most of the available area, while BluePro is considerably more compact with room to expand if tertiary treatment for the BFC outfall is required in the future.

Figure 5. Possible Location for TP Treatment at NSWWTP (Top), Clearas footprint (Left), BluePro footprint (Right)

Currently, all effluent undergoes the same treatment regardless of whether it is discharged to BMC or BFC. This means a common effluent well can be used to pump to either outfall. If tertiary treatment is selected as the compliance alternative, the portion of effluent pumped to BMC (approximately 8% of daily flows) would need to be separated. This would require heavy construction within the effluent building to partition UV and effluent wells between each outfall. Engineering and costs for this project are not included the following analysis.

Clearas would require the installation of a 140’ x 202’ greenhouse to contain the glass tube photobioreactors, lighting, membrane filters, algae dewatering system, cleaning system, and other appurtenances. Additional piping, chemical storage, and construction costs would bring the preliminary capital cost estimate up to $15.1 million. Costs for consumables are estimated to be $110,000 for electricity and $60,000 for chemicals annually. Assuming a production of 0.32 tons per day of algal biomass, an annual revenue of $174,500 is projected.

Treatment of BMC phosphorus with BluePro would require the installation of twelve prefabricated filter cones and airlift systems with a total filtration area of 768 ft^2. Filter cones would be housed in reinforced concrete cells. Chemical storage, piping, electrical, and construction costs bring the preliminary capital cost estimate up to $7.2 million. Costs for consumables are estimated to be $6,500 for electricity and $29,000 for chemicals annually.

Recommendations

While treatment could be a viable option with respect to phosphorus compliance for this discharge location, doing so brings many draw backs. It is an expensive alternative and negatively impacts the District’s goals of reducing energy consumption and the carbon footprint associated with manufacturing and transportation of chemicals. In addition, these treatment technologies would not be providing significant ancillary benefits to the receiving water such as nitrogen or chloride removal. Based on piloting results and preliminary design and cost estimates, the BluePro sand filter or equivalent treatment system would be the best suited to meet the District’s phosphorus compliance goals (should tertiary treatment be selected). Clearas may also be considered, though there is significantly more risk and cost involved with this option. The costs and energy impacts presented in this section only relate to treatment for 8% of the District’s effluent. Based on these findings, the District is not intending to pursue treatment as a preferred compliance option for BMC at this time.

Discontinuing Flow to Outfall 005:

The District currently pumps up to 3.6 MGD of effluent to Badger Mill Creek, which is approximately 8% of the District's effluent. The District began returning effluent to Badger Mill Creek after the City of Verona discontinued operation of their wastewater treatment plant near Bruce Street which discharged effluent to Badger Mill Creek. In 1998, when this diversion began, the District's effluent made up a significant portion of non-flood flows in Badger Mill Creek. In recent years, stream hydrology and the tributary land use have changed. Over the past thirteen years, the district's effluent has remained relatively constant but the flow in the stream has increased, as shown in Figure 6.

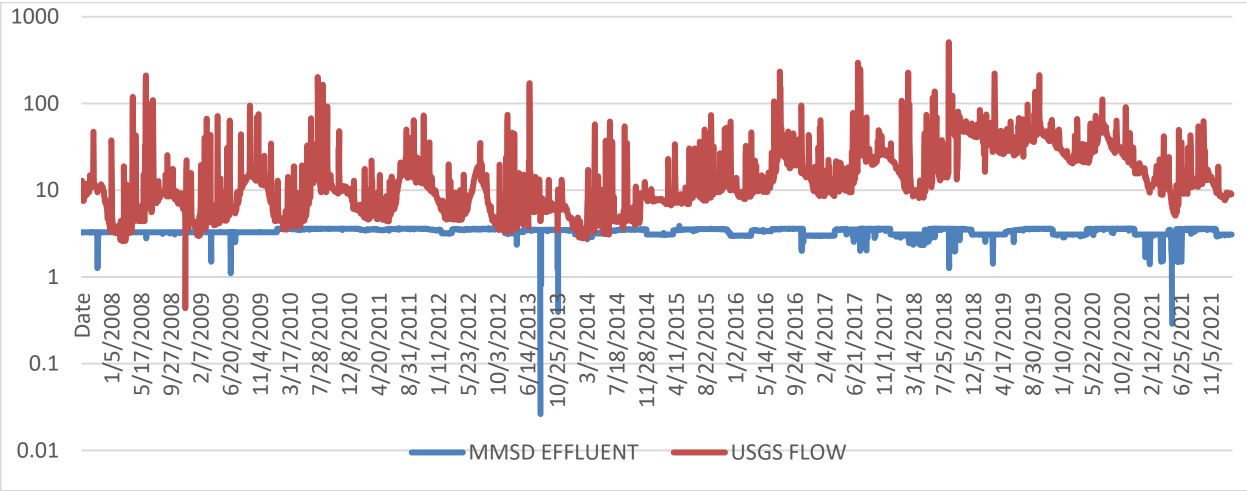


*Figure 6 - **USGS Flow Data for Bruce Street Gage on Badger Mill Creek (MGD) and District Effluent (MGD) – Log based scale***

The DNR stocks trout in Badger Mill Creek and local partners including Trout Unlimited and Dane County recently made habitat improvements to the stream. Upstream of the District's effluent return (aerator), flow coming from north of STH 151 and east from the Goose Lake Area and adjacent wetlands add to the flow in Badger Mill Creek. Immediately downstream of the District's aerator, natural springs add to the baseflow in Badger Mill Creek. Further hydrologic changes are proposed for the watershed, including changing flow routing to alleviate flooding in the Fitchrona Road/Goose Lake area which will change the hydrology and are predicted to increase flood flows to Badger Mill Creek. These are more fully described in the reports and presentations found on the project City of Fitchburg/Town of Verona project website: Fitchrona Road Stormwater Study | Fitchburg, WI - Official Website (fitchburgwi.gov).

The following graphics are from the AE2S Report included with the website above for the project and indicate the flow increases proposed by the recommended Alternative:

City of Fitchburg
Town of Verona
Goose Lake/Fitchrona Road Flood Study
Page 3 of 27

Figure 2 Preferred Alternative Impacts on 100-year Storm

Indicates the location of MMSD effluent return to Outfall 005, Badger Mill Creek – for comparison, MMSD's effluent maximum of 3.6 MGD is equal to 5.6 cfs (cubic feet per second)

One phosphorus compliance option is for the District to reduce or discontinue the effluent volume that is pumped to Badger Mill Creek. If this discharge location was discontinued, the district's entire effluent would flow to Badfish Creek (Outfall 001). We recognize that certain permit changes would be required if the current discharge to BMC were diverted to Outfall 001. However, based upon our initial review, these changes would not preclude this as a possible compliance option. The District's variances for mercury and chloride and associated pollutant minimization/source reduction plans are based on overall district operations and are not specific to outfall location. With respect to phosphorus limitations, the Rock River TMDL included the District's entire design flow (50 MGD) at a phosphorus concentration of 1.0 mg/l for baseline. Currently, the district average flows remain around 40 MGD and the phosphorus concentration remains under 0.3 mg/l, which illustrates that this baseline would be inclusive of the District's entire discharge.

Case study:

There was a recent event that provided a trial for this compliance alternative. Because of construction of the District's Nine Springs Valley Interceptor, a portion of the effluent return line needed to be reconstructed. Construction sequencing for this project required a three-week shut down period for the BMC effluent return line. Incidentally, 2021 was a significantly dry year which provides further insights.

Following discussions and coordination with a DNR biologist, the District started to reduce flows on May 11, 2021 and the return effluent was fully discontinued on May 18, 2021 and pumping did not begin again until June 4, 2021. In retrospect, we are able to assess possible impacts because of the USGS monitoring station at Bruce Street which provides continuous data on parameters such as flow, temperature, conductivity and dissolved oxygen. In addition, the district monitored the stream with photographs to document current conditions.

During our coordination before this shutdown, DNR expressed specific concerns which we worked to overcome. Specifically, DNR was worried about stranding species, so requested that we slowly reduce the flow to allow species a chance to relocate. We accommodated this request. DNR expressed concern with draw down in the fall or winter because of a risk to spawning or egg development for trout. Therefore, we completed this work at the end of May and beginning of June. Below are a series of observations from May and June 2021.

Temperature: One of the District's concerns is temperature as the District maintains alternative effluent limitations for Badger Mill Creek for cooler months. The USGS monitoring station at Bruce Street records temperature of the stream. Figure 7 includes data for May of 2021. In general, the temperatures remain in a standard range. When the District is not discharging, the impact of the significant air temperature drop May 26-27, 2021 is shown to impact temperature in the stream (Figure 8).

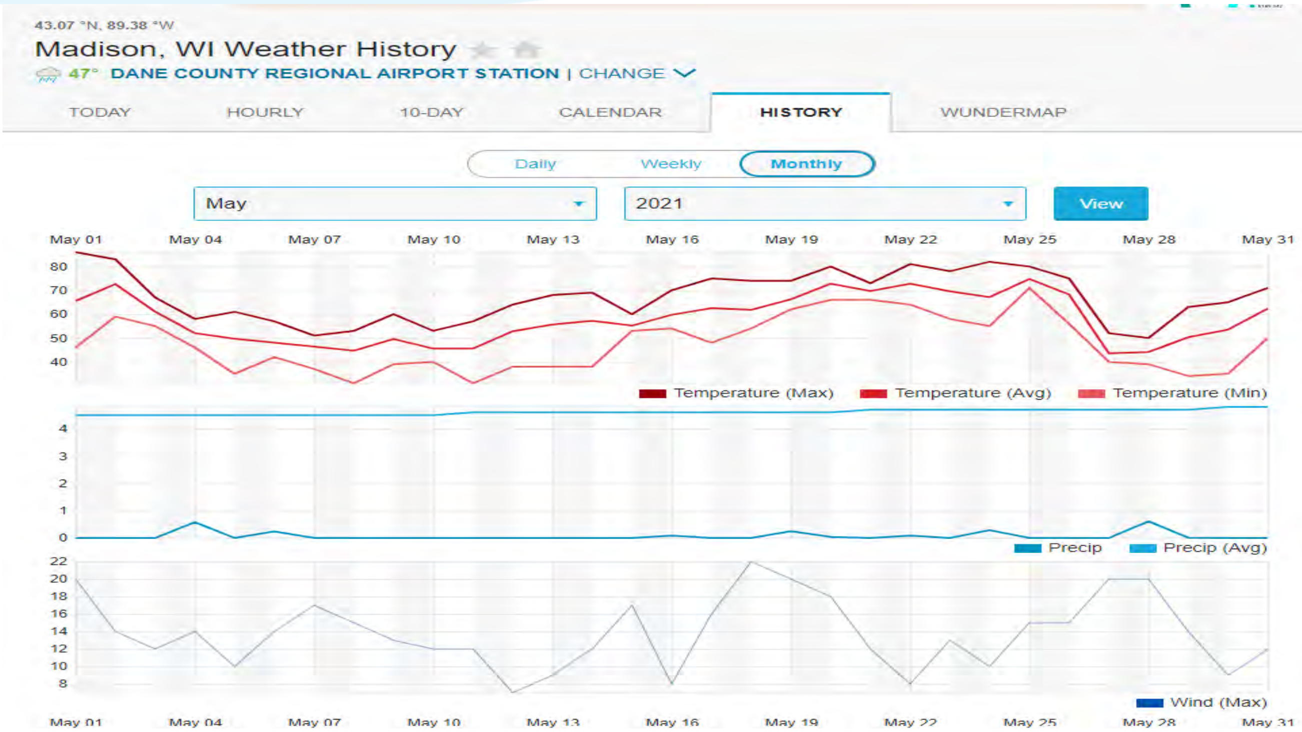


Figure 7 - Weather from May 1-May 31, 2021, Madison, Wisconsin

Flow:

Another interest of the District is flow. Specifically, we are interested in the impact of our effluent on the flow in the stream. Figure 10 illustrates that while in 2008, THE DISTRICT's effluent made up a significant portion of the BMC flow at Bruce Street, over time, that percentage has decreased. Now, even in very dry conditions like 2021, the District's flow rarely reaches 40% of the BMC flow at Bruce Street and in wetter years, it can be less than 10% (Figure 9). The shutdown period was during a dry period in a dry year. The weather data shows two small precipitation events during the shutdown period: May 23 (0.29 in) and May 28 (0.59 in) and an overall May 2021 precipitation of more than 2-inches below normal. The state climatology office graphs (Figure 10) show the relative precipitation in 2021 compared to normal and 2020 as well as 2022 to date.

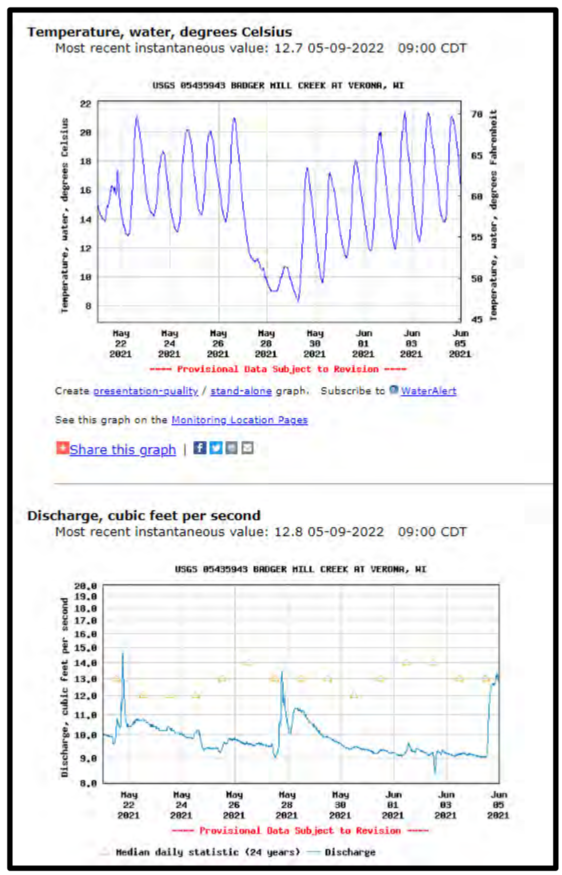


Figure 8, May and June 2021 Temp/Flow USGS Gage Bruce Street

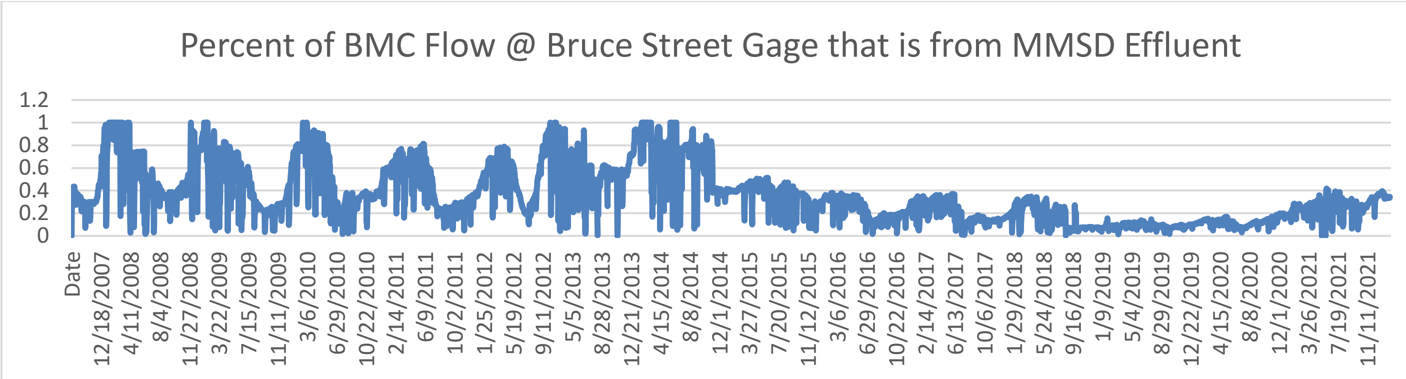
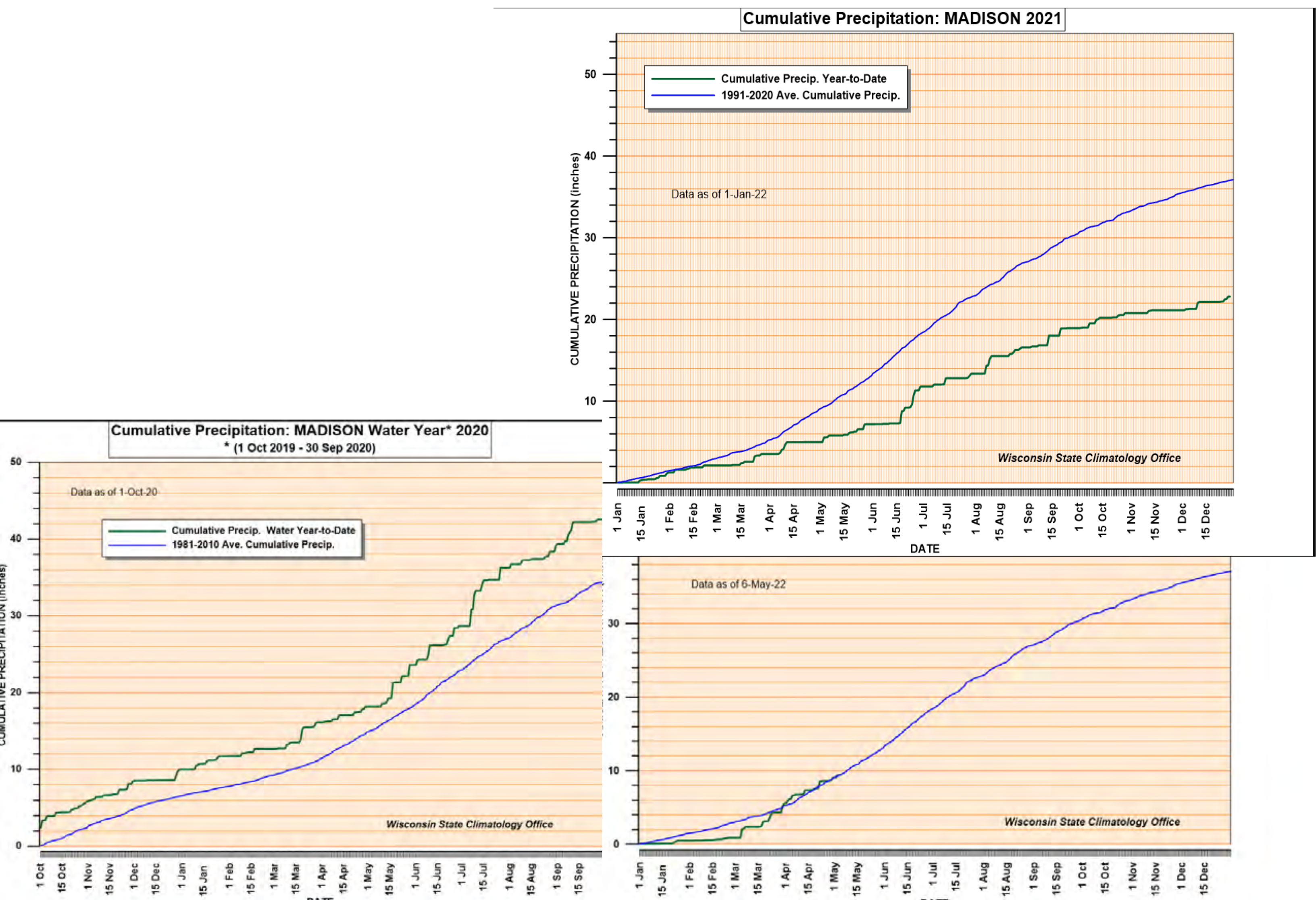


Figure 9 – Percent of BMC Flow at Bruce Street 2008-2021 that is the District's Effluent

Figure 10 Wisconsin State Climatology Office 2021 precipitation with 2020 and 2022 (to date) below



In 2021, Figure 11 shows the amount of flow that the District made up of the Bruce Street discharge, including the three weeks of shut down where the District contributed no flow to Badger Mill Creek. Even in the significantly dry year of 2021 (overall nearly 7-inches below normal), THE DISTRICT made up a maximum of 40% of the BMC flow at Bruce Street. The actual flow from THE DISTRICT and the gage readings in million gallons per day (MGD) for 2021 are included in Figure 12. The USGS Gage information and photos shown in Figures 13 (during shutdown May 2021) and 14 (normal flow April 2022) show visually what BMC looks like when there was not (Figure 13) and was (Figure 14) District flow at the first roadway crossing of BMC, Old Highway PB. The photo location is approximately 2-miles upstream of the Bruce Street gage and approximately 1/2-mile downstream of where the District's outfall 005 enters BMC.

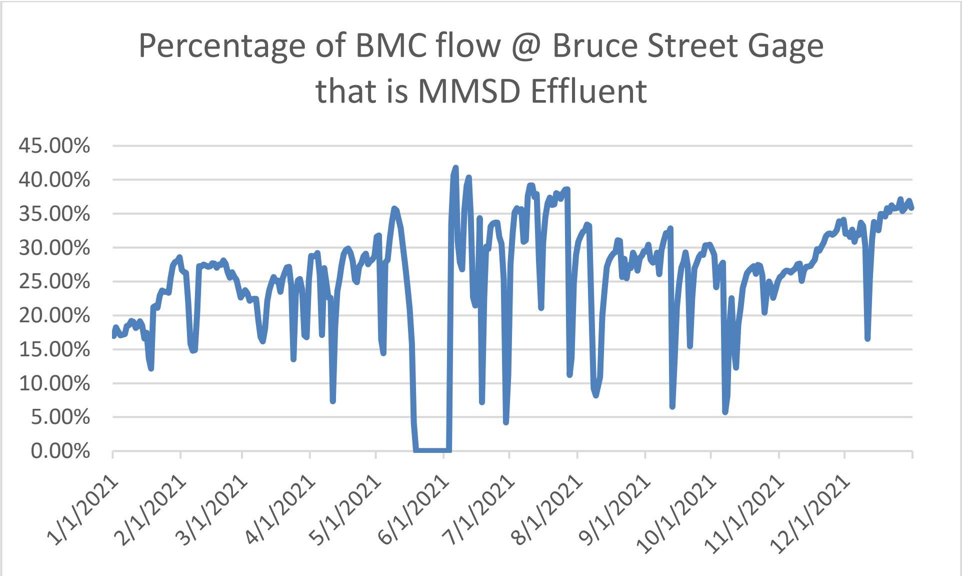


Figure 91 - Percent of BMC Flow at Bruce Street that is THE DISTRICT Effluent 2021

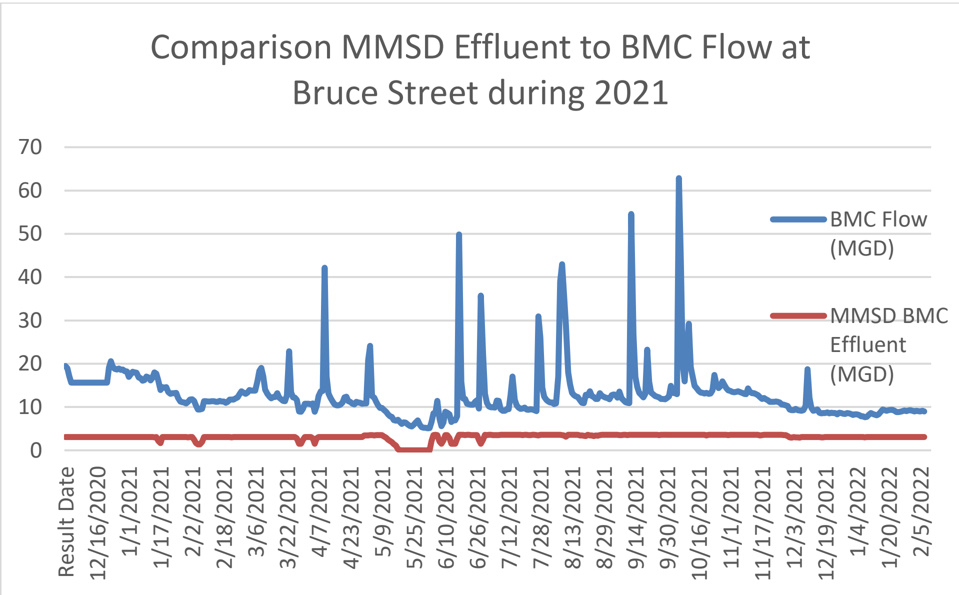


Figure 102 - Comparison of BMC to Bruce Street Flow

Discharge, cubic feet per second

Most recent instantaneous value: 13.9 04-29-2022 10:00 CDT

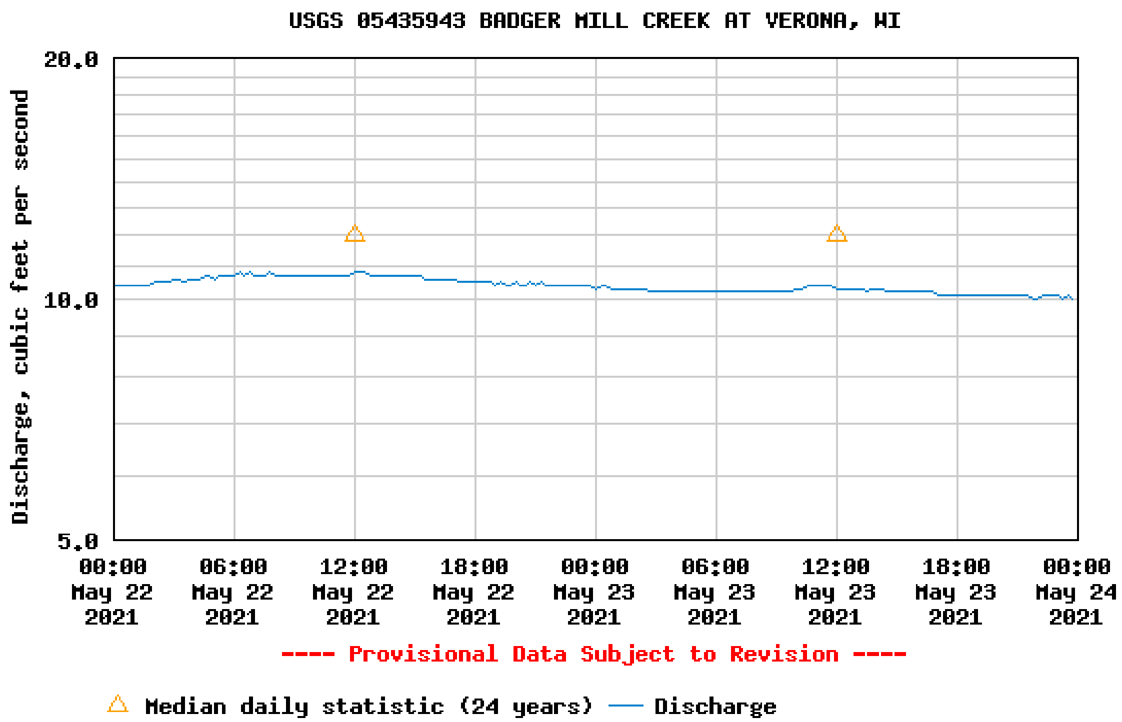


Figure 13 - Stream at Old PB on May 23, 2021, pumps shut off since May 21 – USGS Gage flow and Photo

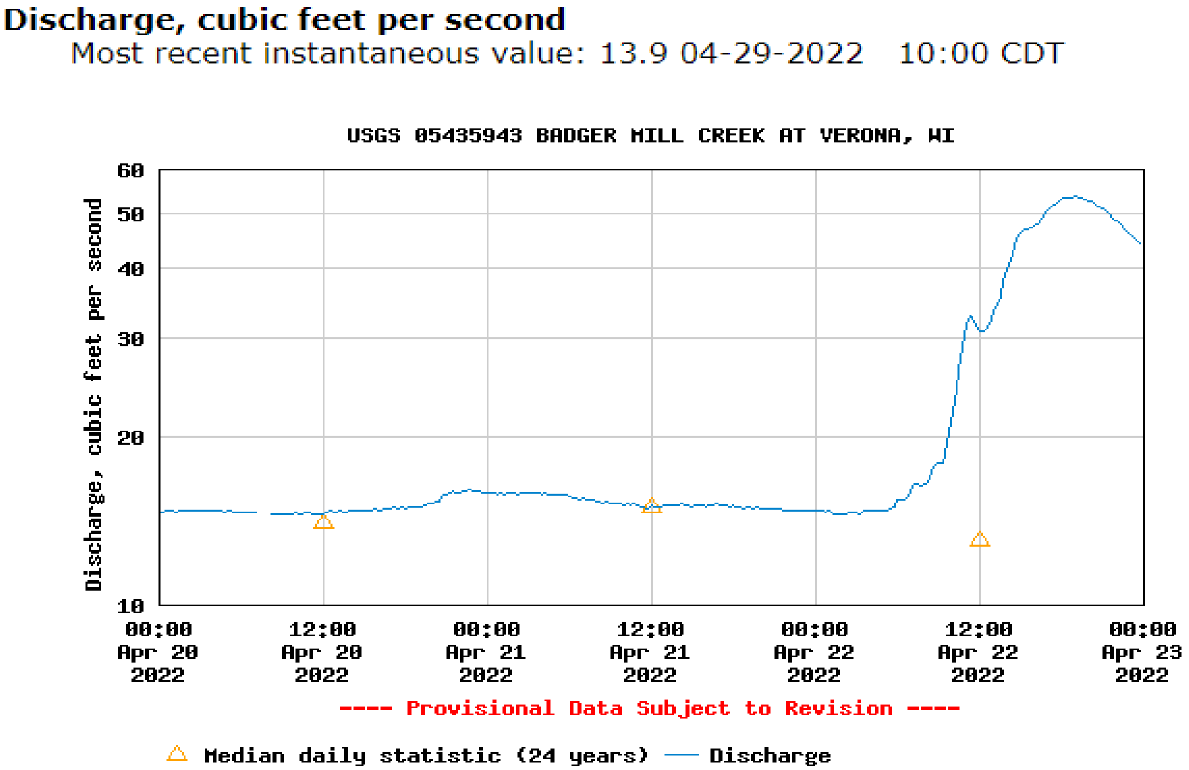


Figure 11 - BMC at Old PB on April 21, 2022 – USGS Gage flow and Photo, normal the District's operation

Other Parameters of Interest:

In addition to the assessment above, USGS tracks conductivity and dissolved oxygen (Figure 15). It is very evident when the District's effluent was discontinued to BMC with the conductivity graph below. The District's effluent contains chloride and we maintain a chloride variance in our WPDES permit. Conductivity includes that chloride contribution. When the District's is not discharging, the chloride and conductivity in BMC are significantly reduced. USGS also maintains dissolved oxygen monitoring for BMC. Assessing the two graphs below, it is clear that during the period of lower conductivity, when the District's is not discharging, the daytime highs for dissolved oxygen are reduced and the nighttime lows appear steady and slightly higher.

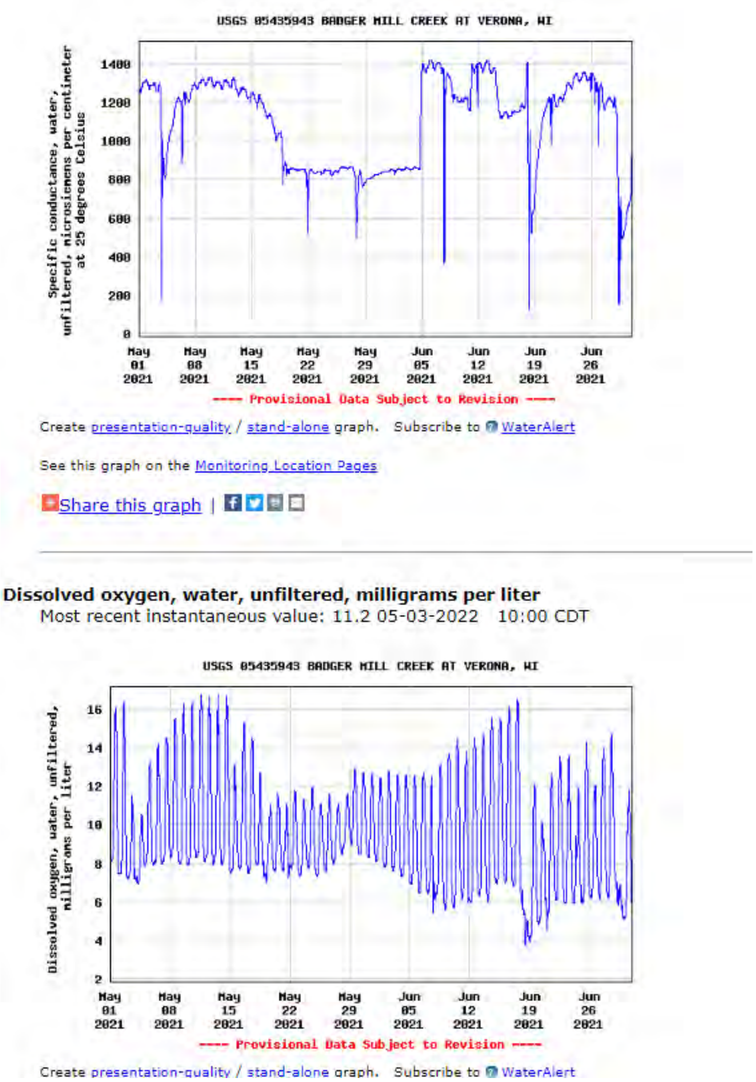


Figure 15 - Badger Mill Creek Conductance and Dissolved Oxygen May/June 2021

Phosphorus Compliance by discontinuing flow to Outfall 005:

The majority of the District's effluent (>92%) is discharged to Badfish Creek, the District's Outfall 001. This outfall location is part of the Yahara WINS Adaptive Management project. If flow and associated phosphorus increase in Badfish Creek, the District's contribution to Yahara WINS would increase per the Yahara WINS Intergovernmental Agreement. Based on current effluent flow and phosphorus concentration, if all the Badger Mill Creek flow was diverted to Badfish Creek, approximately 2,100 lbs (exhibits 21 and 22) of phosphorus per year would also be diverted. This would be a relatively small increase to the total pounds that Yahara WINS is addressing (in total Yahara WINS addresses ~96,000 lbs of phosphorus). The Intergovernmental Agreement for an Adaptive Management Plan for the Yahara River Watershed (IGA) includes a mechanism for accounting for increased wastewater treatment plant contributions. Under these requirements, the District would be responsible for paying into Yahara WINS for the added phosphorus reduction required. Using current estimates, this would be approximately $110,000 additionally each year for a 20-year present worth cost of approximately $1.7 million. The Yahara WINS project would need to accomplish reductions to offset the additional pounds of phosphorus.

Other Considerations:

The District recently completed an Energy Master Plan (Dec. 2021) which indicates that elimination of the Badger Mill Creek pumps would result in a net reduction of energy usage by the District due to the lower energy required for pumping to the BFC outfall compared to the BMC outfall. The difference in specific energy between the BMC pumps and BFC pumps is 610 kWh per million gallons (kWh/MG). This results in an energy savings of 2,010 kWh/day (730,000 kWh per year).

There do not appear to be immediate capital costs associated with implementing this alternative other than Yahara WINS contributions, demolition of the BMC pumps and associated piping and electrical equipment. Demolition costs are anticipated to be minimal if incorporated as part of a larger project to minimize contractor mobilization and overhead costs.

Additionally, once the flow is discontinued, the forcemain, associated corridor and/or easements could be availble for alternative uses for the District (e.g. corridor for a relief forcemain, etc). While the district is intending to continue assessing a discontinuation as a preferred compliance option. A significant next step to assess this option will be to engage with stakeholders. The District is assessing the potential of a professional services contract to engage a facilitator(s) for this process.

The District's Risk Assessment for Discontinuing flow to Outfall 005

Development and hydrologic change continue to occur in the Badger Mill Creek watershed. The District's effluent provides a constant flow to Badger Mill Creek. During low flow periods, this flow is quickly surpassed with any precipitation or melting. During the shut down period in May of 2021, which occurred during a period of low flows, low flows indicated at the USGS gage at Bruce Street maintained a minimum flow of approximately 9 cfs. The dissolved oxygen appeared stable and possibly reduced in variation with the lows slightly higher and the highs slightly lower. Temperature in the stream appears to correlate closely to the air temperature and the water temperature cools as the air temperature fell into the 30°s F toward the end of the shutdown period. The conductivity was the most pronounced change. Without the District's effluent there is less conductivity in the stream. This correlates directly to the current chloride contribution of the District's effluent.

The artificial stream contribution from the District's effluent provides benefits and risks. The District's effluent provides for a constant input of flow, which also maintains a relatively constant temperature. With this input, there are also challenges including the input of chloride and phosphorus into the watershed and warmer temperatures in some months than are allowed by DNR's thermal requirements.

For THE DISTRICT, there are future considerations with maintaining this discharge location. Our WPDES permit has more restrictive water quality standards for Outfall 005 (Badger Mill Creek) for the following parameters as shown in Figure 16.

	001 – BFC	**005-BMC**
CBOD	19 mg/l	7 (May-Oct) 16 (Nov-April)
TSS (monthly avg)	20 mg/l	10 mg/l(May-Oct) 16 mg/l (Nov-Apr)
Ammonia (total max)	17 mg/l	11mg/l
Thermal	No limit	Alternative Effluent Limit: Oct, Nov, Jan, Feb

Figure 1612 - WPDES permit comparison outfall 001 and 005

These are generally driven by the current classification of the two discharge locations. There has been on-going discussion regarding classification of Badger Mill Creek. If the stream is reclassified, there will be new effluent limitations calculated which could become more restrictive. Because the District operates one treatment plant which produces one effluent, our operations are based on meeting the more restrictive water quality parameters. While Badfish Creek is classified as Limited Forage Fishery, Badger Mill Creek maintains higher classifications and has been under review for even more stringent requirements. Wisconsin DNR's biologists included in their "An Examination of Fisheries Data for Badger Mill Creek To Determine the Potential for Alternative Effluent Limits for Effluent Discharge" that
"In 2005, the department conducted a comprehensive survey of multiple sites along the creek to determine its status and provide management recommendations. The department concluded that Badger Mill Creek should be considered a "Coldwater B – Class IIx" system from the Lincoln Street footbridge downstream to its confluence with the Sugar River. It also recommended the section upstream of the Lincoln Street footbridge to the effluent discharge

point be considered “Diverse Fish and Aquatic Life – Coolwater” (WDNR, 2005). In 2008, fisheries management designated Badger Mill from its mouth at the Sugar River upstream to the uppermost STH 18/151 crossing as a “Class II” trout water. As noted earlier, the water resources designation has not changed.”

Wisconsin DNR further notes that “Water quality-based effluent limitations are calculated in order to insure that discharges to waters of the state are in compliance with water quality standards. Water quality standards include water quality criteria (such as those in chs. NR 102 [exit DNR], 104 [exit DNR], and 105 [exit DNR], Wis. Adm. Code), use designations or classifications of the state's waters (examples include fish and aquatic life uses, public water supplies, recreational uses, outstanding or exceptional resource waters), and antidegradation provisions to address new or increased discharges to waters of the state. All of these standards are considered together in order to protect Wisconsin’s aquatic life, wildlife and human health from the effects associated with the discharge of toxic (poisonous) and organoleptic (adverse impacts on sensory organs) substances to the state's surface waters.” Changing an effluent dominated stream’s classification will impact the water quality standards and the requirements that dischargers will face. We foresee a future designation of a coldwater trout fishery for Badger Mill Creek. When this happens, we will have significant challenges meeting the permit requirements.

One major change would be that the thermal requirements will become more restrictive – even though DNR biologists have noted that the effluent temperatures do not appear to harm the resource. With our next WPDES permit, we will need to reapply for Alternative Effluent Limitations for the months when our effluent exceeds the current standards. Our effluent is currently warmer than allowed by DNR’s effluent standards for our current classification of Badger Mill Creek. Badfish Creek faces no thermal requirements due to its classification. The District is also operating under a variance for chloride. With two discharge locations, if our effluent exceeds the target value, we end up with two violations, one for each discharge location. In addition, we were recently informed that DNR is looking at reevaluating the chloride water quality standard due to other Midwest states having lower standards. This could make this much more difficult. During our discussions with DNR, they have routinely mentioned the potential of a TMDL for Badger Mill Creek and the Sugar River. If the District is discharging in the watershed when this is completed, the District will have requirements to meet and will have a deadline in which to complete them. DNR has tried to leverage this as an incentive for the District to work with partners now to encourage others to make improvements to their phosphorus discharge. In our current WPDES permit, we are required to submit monitoring data for nitrogen. This includes TKN, Nitrite+Nitrate and total Nitrogen. This is speculated to be leading toward future nitrogen restrictions on effluent.

Not all the potential impacts are to aquatic biological organisms. There are also human recreational uses, including fishing and kayak rentals, that currently engage with BMC. Considering all risks and threats, public perception and interpretation are the most critical. The District needs to engage with stakeholders in order to move a compliance option for Badger Mill Creek forward, especially when considering whether a discontinuation of flow is a possible option. Stakeholders must be heard and their concerns need to be considered. At this point, District staff is evaluating the potential of an outside expert or firm to assist in the development and implementation of our stakeholder engagement approach.

Reference reports:

RESOURCE ASSESSMENT AND DEVELOPMENT ANALYSIS FOR THE UPPER SUGAR RIVER AND BADGER MILL CREEK SOUTHWEST OF VERONA, WI JUNE 2008, By: Montgomery Associates for the City of Verona

An Examination of Fisheries Data for Badger Mill Creek,
To Determine the Potential for Alternative Effluent Limits for Effluent Discharge
from the Madison Metropolitan Sewerage District
By: Wisconsin DNR, Water District South, February 2017

Watershed Alternatives:

Badger Mill Creek is a HUC 12 watershed in the Upper Sugar River Watershed, 070900040201. At the point of the District's discharge, Badger Mill Creek is an effluent dominated stream. Upstream areas contribute stormwater to the creek. This HUC 12 is rapidly urbanizing. The majority of the watershed is included in the urban service area. Land values are high and demand for development is intense. These factors limit the opportunities to utilize watershed approaches in 070900040201 for phosphorus compliance.

While there have been on-going discussions about the health of Badger Mill Creek and its fishery, discussions with the department's biologists have not shown that nutrients are causing impairments to the local fishery. These same discussions have indicated that additional nutrients could impact downstream waters and therefore, approaches that reduce nutrient run-off in the broader watershed area could achieve overall nutrient reduction goals and help achieve point source compliance.

During our preliminary assessment and in meetings with stakeholders, we found potential projects and partners in the Badger Mill Creek HUC 12 (070900040201). Our initial assessment also identified less urban development pressure, longer commitment potential and includes projects that are desired by landowners, agencies and ready to go forward in the adjacent watershed 070900040202 (expanding the watershed to the HUC 10 = 0708000402). One specific project is already being scoped by DNR, Dane County, the Farmers for the Upper Sugar River Watershed and the Upper Sugar River Watershed Association. The location map as well as types of projects and estimated costs are shown in Exhibits 24 and 25. The relative cost and increased desire and longevity of these practices compared to those in the BMC HUC 12, illustrate how significant the point of standards applicability is to the viability of watershed approaches.

Adaptive Management:

One available watershed compliance option is Adaptive Management. The District's Badger Mill Creek discharge is eligible for adaptive management because:

1. the receiving water exceeds the state water quality criterion,
2. the District would need to install filtration to comply with the water quality standard,
3. non-point sources contribute more than fifty percent of the load to the watershed.

Badger Mill Creek is on Wisconsin DNR's 303d list as impaired for phosphorus, but does not currently have an established phosphorus budget called a total maximum daily load or TMDL. Until a TMDL is established, the only entity in the watershed that is required to make further phosphorus reductions is the District. Stormwater dischargers are required by NR 151 to meet a 20% TSS reduction and eventually a 40% TSS and associated total phosphorus reduction. There are currently five MS4's tributary to Badger Mill Creek: City of Madison, City of Fitchburg, City of Verona, Town of Middleton, and Town of Verona. During this alternatives assessment, we met with the Cities of Fitchburg, Verona and Madison, the Town of Verona and groups like the Upper Sugar River Watershed Association (USRWA). There are potential projects and some interest in partnering but without a driver, like a TMDL or permit requirements, the discussions have focused on examples of how the District could help pay for these entities' desired projects. DNR has noted that an adaptive management project could help put in place practices to eliminate the need for a future TMDL. However, as of yet, we have not found success in advancing this line of reasoning with potential partners.

The success of an adaptive management program requires meeting in-stream water quality criterion for phosphorus. Existing water quality data indicates that Badger Mill Creek does not meet the applicable water quality criterion upstream of the District's outfall location and the Sugar River does not appear to meet the applicable water quality criterion downstream of the confluence with Badger Mill Creek. This indicates that there are additional sources of phosphorus which an adaptive management plan could work to reduce. While the variety of phosphorus reducing practices increases as the watershed is expanded, the number of pounds of reduction required to achieve water quality compliance and the complexity of the project increases as an adaptive management project increases in scale.

Figure 17 illustrates the Badger Mill Creek Watershed acreages, land use types and modeled pounds needed to achieve adaptive management compliance with various scale adaptive management projects. In general, as the project compliance point moves downstream, the approximately number of pounds of phosphorus that would need to be reduced increases.

Discussion:

Adaptive management requires meeting in-stream water quality standards. This would mean that for 6-month averaging periods, the stream would need to remain below 0.075 mg/l. For the District, this could occur at the location where our effluent meets Badger Mill Creek or at a series of locations downstream from there. Based on the instream water quality measurements, the number of pounds that would need to be offset would increase as the tributary area increases. To determine how many pounds would need to be reduced to achieve the water quality standard, we assessed our stream monitoring data. This data includes grab samples taken at points along Badger Mill Creek and the Sugar River as shown on Figure 18. Our WPDES permit requires that the six-month averaging periods. DNR states that the six-month average concentration and mass limits are applicable to the periods of May 1st through October 31st and November 1st through April 30th each year. Therefore, we have assessed our data based on those time periods. Figure 17 includes the instream total phosphorus for four points on Badger Mill Creek (Location map is included as the Upper Sugar River Watershed on Exhibit 23) from the past five years of the District's stream sampling. Figure 18 includes average flow from USGS's gaging stations for the Bruce Street and Sugar River at Hwy 69 gages.

	BM7 (Bruce St)		BM-9 (Hwy 69 & BMC)		SR-7 (Hwy 69 & SUGAR)		BM-5 (most upstream)
May-October	0.20		0.19		0.15		0.25
Nov-April	0.12		0.14		0.09		0.18

Figure 17 - BMC instream Total Phosphorus Concentrations for 6-month averaging periods

Flow at Bruce Street Average over May-October	Flow at Bruce Street Average November – April.	Flow at Sugar River Hwy 69 May to October	Flow at Sugar River Hwy 69 November – April (Exhibit 27)
31.0 MGD	**24.1 MGD**	91.7 CFS = **59.2 MGD**	79.5 CFS = **51.4 MGD**

Figure 18 – USGS Flow at various points along BMC by 6-month averaging period

Location & Avg Period	Flow (MGD)	Phosphorus Conc	WQS	Pounds to offset per half year
Bruce Street May-Oct	31.0	.20	.075	5940.38
Bruce Street Nov-Apr	24.3	.12	.075	1676.34
Sugar River @69 May-Oct	59.2	.25	.075	15881.88
Sugar river @69 Nov-Apr	51.4	.18	.075	8273.60

Figure 19 - Pounds to be Offset based on Averaging Period and Location

Figure 19 uses this data to calculate the approximate pounds needed to be offset at different adaptive management compliance points. Based on these calculations, for adaptive management to work in the watershed upstream of Bruce Street, approximately (5940+1676) 7617 pounds per year would need to be reduced by the end of the Adaptive Management period (which by statute is 20-years). If the Adaptive Management plan is expanded to include the watershed upstream of STH 69 on the Sugar River, the total pounds we would need to achieve would be around 24,155 pounds per year. The district is discharging approximately 2100 pounds per year more phosphorus than would be allocated to our discharge.

Putting this in perspective of the size of the watershed, the majority of the watershed's shared urban acres are within the Badger Mill Creek watershed. An adaptive management program that incorporates the entire Badger Mill Creek watershed would be cost prohibitive for the District to do alone as significant urban treatment practices will be required to meet the required phosphorus reductions. Moving downstream and incorporating the Upper Sugar River as well as Badger Mill Creek will add both significant additional pounds of phosphorus as well as additional non-urbanized acres with the potential desire for watershed improvement. The attached plan and projects, Exhibits 24 and 25, show existing energy and planning in the adjacent watershed 070900040202 that would possibly lead to significant landscape changes, water quality improvements and create synergy for additional improvements.

While adaptive management remains a possibility, it also includes significant challenges. The driver of District phosphorus compliance alone has not been the needed catalyst to advance the broad partnership required to implement a successful adaptive management plan in this area. Since our discharge is to Badger Mill Creek, we have been guided to believe we could work only in the Badger Mill Creek HUC 12 alone (070900040201). A target area in that upstream watershed (070900040202) or broadening the area to encompass the HUC 10 watershed may make this compliance option more practical and help to improve overall water quality. The approximate pounds that The District needs to offset are approximately 2100 pounds per year. The number of pounds estimated to need to be reduced to meet water quality standards in the combined Sugar River and Badger Mill Creek is estimated to be nearly 25,000 pounds. Based on these broad discrepancies, the District would consider working in the Upper Sugar River as an Action or Target Area but working in the overall area with the end goal of meeting instream water quality does not appear to be in the District's best interest. Without a TMDL or a timeline to comply with the DNR's NR 151 standards, the District anticipates that it would be challenging to establish a viable adaptive management plan for permit compliance. Thus, while the District continues to evaluate Adaptive Management possibilities, it is not the District's currently preferred compliance option.

Water Quality Trading:

The excess phosphorus load to Badger Mill Creek could be offset through a water quality trading program. The Wisconsin Department of Natural Resources (WDNR) guidance for implementing a water quality trading program includes the application of a trade ratio to account for a variety of uncertainties associated with trading. The trade ratio is a multiplier that is applied to initial phosphorus load reduction (in our case, approximately 2,100 lbs/yr, Exhibits 21 and 22) to come up with a total phosphorus load reduction that must be accomplished. Using the WDNR guidance document, we have estimated that a minimum trade ratio in the range of 1.0-3.0 could be applied to the District's required load reduction, with a higher trade ratio possible. Based on an effluent flow rate of 3.6 mgd, the amount of phosphorus that would have to be offset through trades would be in the range of 2100-6300 lbs/year depending on the trade ratio. The amount of flow going to Badger Mill Creek is directly related to the amount of phosphorus offset required. If the effluent flow discharged to Badger Mill Creek was reduced by 50%, the amount of phosphorus required to offset by trades would also be reduced by 50% (1000-3,150 lbs/yr).

One challenge for implementing water quality trading is the capacity of the watershed to accomplish the necessary phosphorus offsets. If the point of compliance is placed in a location that limits trading to the Badger Mill Creek HUC 12 watershed (070900040201) that becomes more challenging. For example, there appear to be less than 6,000 acres of non-urban land uses upstream of the confluence of Badger Mill Creek and the Sugar River and development pressures continue to reduce this number. If this location is the point of compliance, a significant number of these acres would need to be placed under improved practices in order to accomplish the needed phosphorus reduction. In addition, those practices would need to remain in place in order for the district to continue to achieve compliance based on these trades.

We have consulted with agricultural producers in the watersheds. While we have found that there are some viable trading opportunities with agricultural producers and/or owners in the BMC watershed, but because of the significant development pressure, these do not appear to be guaranteed for over ten years. If the District continues to discharge to Badger Mill Creek and uses water quality trading as our compliance option, we will need assurance that our trades will remain into the future. Dane County has one trade that could be possible on a longer-term basis, but that is currently restricted to their 12-acre parcel which limits the available number of pounds. To move forward with trading as a compliance option, the district would need more assurance and longevity. With the continuing growth of the urban service area and urbanization of the watershed, the BMC watershed area (HUC 070900040201) introduces significant future risk as relying on long-term continuation of those trades is not certain.

There is also an opportunity for urban based practices to be funded under a trading program. However, urban phosphorus reduction practices are generally more expensive and not as efficient as agricultural practices at addressing phosphorus on a cost per pound basis. On the other hand, urban projects that fall into the category of point-to-point trades could achieve a trade ratio closer to 1:1, reducing the number of pounds of required offset.

During this analysis, we have assessed a point-to-point trading option with the City of Madison (Figure 20) that could involve active or passive treatment of stormwater to remove additional phosphorus. Preliminary estimates indicate that this major project could provide up to 1600 pounds of phosphorus reduction per year (about 1300 pounds at a 1.2:1 ratio), yet the 20-year present worth cost is estimated to be over $10 million (Figure 21), and that assumes that in this very urban area, that all dredged sediments are clean enough to be land applied. If dredged sediments need to be taken to a special landfill or treated, the cost could increase significantly.

Historically, stormwater ponds are designed for flood control and/or total suspended solids removal. Some phosphorus is removed in stormwater ponds, but unless there is an intentional design, this is generally minimal. One specific trading opportunity for the District in the Badger Mill Creek watershed is with the city of Madison’s stormwater pond near Nesbitt Road, which is north of STH 151 and upstream of our discharge location. In order to be redesigned to increase the phosphorus removal, this pond would need to have its southwest cell (Figure 26) dredged approximately four feet to allow sufficient storage depth. According to the city’s stormwater designers, this pond is not ideally situated to use a passive treatment system, like iron filings, because those would need to be able to dry out and not remain saturated.

Figure 13 - Nesbitt Pond and its Southwest Cell Size

Annual TP Removal Above Existing (lbs)	1600
Dredging and Disposal Costs	$3,000,000
Capital Costs	$1,500,000
Annual O&M Costs	$326,300 ($4,850,100 PW at 3%)
Engineering and incidentals	$1,125,000
Total Cost Opinion	$10,500,000

Figure 14 - Construction Cost Opinion to enhance Nesbitt Pond's phosphorus removal

Adding additional phosphorus removal capability to this pond will include adding a flocculating system, such as alum treatment, and a way to capture and sequester the phosphorus laden floc (what settles out). The city of Madison has tentatively engaged with similar phosphorus treatment systems and is gaining experience, yet, these are not common and can be misunderstood in the community. If THE DISTRICT is looking at pursuing a trade that includes adding phosphorus treatment at the city's pond, the city would like the District to take the lead. The city would like the District to reach out to the Alder and if there is the ability to go ahead, the city would like the DIstrict to enter into a memorandum of understanding (MOU) with the city to pursue consulting services to undertake a preliminary design study. If the findings of that study lead to a desire to pursue construction, the city would like the District to work with them to amend the MOU to include construction and management agreement which would work to divide the total suspended solids (TSS) and TP credits from existing conditions and the future treatment system and for THE DISTRICT to have the right to enter and operate that system on city property.

These are very serious considerations. The city currently is not required to remove additional total suspended solids or total phosphorus from this pond. If a treatment system is designed for their stormwater pond, the District would be asked to own and operate that system on city property. In addition, if adding this treatment system to the pond could remove 1600 pounds of phosphorus each year, we understand that at least that amount of phosphorus is entering Badger Mill Creek above our discharge location and there are no requirements for any entity other than the District to reduce phosphorus discharges to the stream. There are other potential urban trades, but these appear to carry similar burdens.

The point of compliance will be an important aspect in determining the viability of water quality trading. Water quality trading becomes more viable if the point of compliance is determined to be downstream of Badger Mill Creek's confluence with the Sugar River (ie: includes the entire HUC 10 0709000402 shown on Exhibit 23). As noted above, there are interested participants and trading potential with longer time horizons in the adjacent watershed. While the District is intending to continue to pursue water quality trading as a preferred compliance option at this time, it is interesting to note that the cost of urban trades are similar to the cost for treatment for wastewater phosphorus removal. Since the district could undertake the phosphorus treatment without the engagement of partners and the pounds removed would be reliable, if the trading area is restricted to the Badger Mill Creek watershed, the district would need to reconsider treatment to remove phosphorus at the treatment plant. The increased burden to rate-payers for major investments that impact only 8% of our effluent will need to be seriously considered as well.

Variance:

Facility-specific variances to water quality standards, referred to as variances, must be approved by both DNR and USEPA. Variances may be given on a facility-specific basis for the length of a Wisconsin Pollutant Discharge Elimination System (WPDES) permit term. A variance requires working toward water quality criteria and requires reissuance each permit term. A variance may allow extra time for a facility to come into compliance with a water quality standard based on one or more of the six factors listed in s. 283.15(4), Wis. Stats. The District has been unsuccessful in receiving economic variances in the past, and the facts around granting the District variances under one of the six criteria have not changed. Based on the learnings gathered during the District's recent experience with a chloride variance, a variance does not appear to be a probable compliance solution. The other type of variance option called multi-discharger variance is not applicable in Dane County and therefore not available to the District. The District is not intending to pursue a variance as a preferred compliance option at this time.

Site-specific Criterion:

Wisconsin Administrative Code, NR 102.06 (7) allows for the development of site-specific criteria for phosphorus. This is a process where site-specific data and analysis using scientifically defensible methods and sound scientific rationale demonstrate that a different criterion is protective of the designated use of the specific surface water segment or waterbody.

During the District's last permit term reissuance, DNR staff compiled and evaluated multiple years of fish monitoring information in the context of considering Alternative Effluent Limitations for thermal requirements (DNR's "Examination of Fisheries Data for Badger Mill Creek, February 2017"). In this evaluation, DNR concluded that: "The effluent discharge from the District to Badger Mill Creek has caused no appreciable harm to the resource based on the fact that 1) it has not appreciably altered the fish community from its historic state in the absence of effluent; 2) a balanced indigenous community remains which includes the presence of native or introduced important species, mottled sculpin and brown trout, respectively, and 3) the resource is in a healthy state based on the appropriately applied IBI." In addition, at the request of the DNR, the district recently conducted sampling for benthic algae and diatoms to provide additional data to aid in the initial site-specific criteria evaluation.

The district is aware that there is a downstream criterion for phosphorus of 0.10 mg/l on the Sugar River which DNR has indicated will limit the site-specific criterion for phosphorus in the watershed. This means that any site-specific criterion for phosphorus in the watershed would likely not exceed 0.10 mg/l, but would likely remain between the current criterion of 0.075 mg/l and 0.10 mg/l. This information has led the District to conclude that a site-specific criteria closer to the current effluent concentration is not possible, even if the biology were to support it. These values (0.1 and 0.075 mg/l) are very close to each other and therefore either of these values would require similar treatment processes and similar number of pounds to offset via trading. The District is not intending to rely on a site-specific criteria as a preferred compliance option at this time.

Summary:

Based on the findings of this assessment, water quality trading and adaptive management may be potential compliance options with a broader definition of the applicable watershed. Confining watershed approaches to areas upstream of the District's outfall appear to require mainly urban stormwater phopshorus projects. These raise a variety of challenges, including jurisdiction and ownership. In addition, they raise the cost of the project to the level of treating effluent to remove phsophorus, which would make us rethink that assessment. In addition, while discontinuing flow to Badger Mill Creek remains a possibility, if this is the direction that the District wants to pursue, a strategic communications strategy will be necessary to engage with stakeholders, including DNR, to futher assess it.

Additional Figures:

Month	Influent Avg. Flow (MGD)	Influent Avg. TP Concentration (mg/L)	Influent TP Mass (lb/day)	Effluent Avg. Flow (MGD)	Effluent Avg. TP Concentration (mg/L)	Effluent TP Mass (lb/day)	Target TP Concentration (mg/l)	Effluent TP Mass (lb/day)
Jan	41.13	5.33	1828.15	3.07	0.26	6.75	.075	6.75
Feb	41.15	5.37	1842.24	3.09	0.20	5.24	.075	5.24
Mar	43.93	4.77	1750.11	3.09	0.20	5.27	.075	5.27
Apr	40.71	5.11	1732.57	3.08	0.24	6.07	.075	6.07
May	43.17	4.96	1773.97	3.44	0.29	8.33	.075	8.33
Jun	45.32	4.91	1854.02	3.57	0.26	7.60	.075	7.60
Jul	47.38	4.34	1712.64	3.59	0.34	10.22	.075	10.22
Aug	42.00	5.02	1756.09	3.55	0.31	9.18	.075	9.18
Sep	41.89	5.15	1800.42	3.58	0.29	8.79	.075	8.79
Oct	39.90	5.74	1907.77	3.59	0.26	7.79	.075	7.79
Nov	38.62	5.83	1879.94	3.58	0.26	7.68	.075	7.68
Dec	37.14	5.66	1754.79	3.09	0.37	9.63	.075	9.63
Avg	41.86	5.18	1799.39	3.36	0.27	7.71	.075	7.71

Figure 15 - Baseline 2020 THE DISTRICT phosphorus Influent and Discharge Data for Outfall 005

Month	Effluent Avg. Flow (MGD)	Effluent Avg. TP Concentration (mg/L)	Effluent TP Mass (lb/day)	Effluent TP WQS @0.075 (mg/L)	Effluent TP Mass (lb/day)	Effluent TP Mass (lb/month)
Jan	3.07	0.26	6.75	1.92	4.83	149.72
Feb	3.09	0.2	5.24	1.93	3.31	92.60
Mar	3.09	0.2	5.27	1.93	3.34	103.45
Apr	3.08	0.24	6.07	1.93	4.14	124.30
May	3.44	0.29	8.33	2.15	6.18	191.53
Jun	3.57	0.26	7.6	2.23	5.37	161.01
Jul	3.59	0.34	10.22	2.25	7.97	247.21
Aug	3.55	0.31	9.18	2.22	6.96	215.74
Sep	3.58	0.29	8.79	2.24	6.55	196.52
Oct	3.59	0.26	7.79	2.25	5.54	171.88
Nov	3.58	0.26	7.68	2.24	5.44	163.22
Dec	3.09	0.37	9.63	1.93	7.70	238.61
Avg - yearly	3.36	0.27	7.71	2.10	5.61	171.32
					Approx. yearly total	**2055.8 lbs**

Figure 16 - Approximate Yearly Pounds to Offset

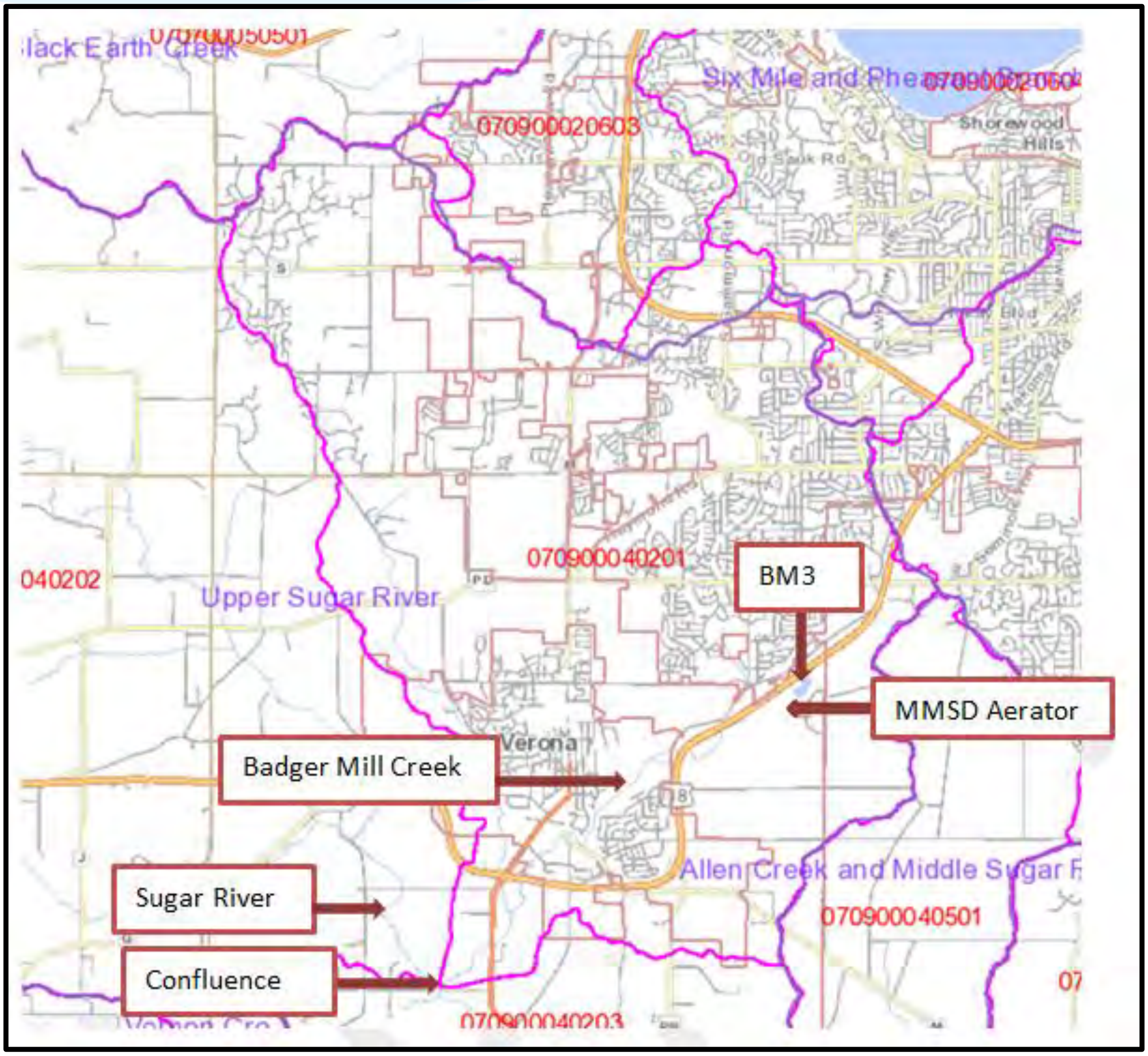


Figure 23 - Location Map for HUC 12s, THE DISTRICT Aerator (Outfall 005)

Figure 24 - Location Map for Upper Sugar River Watershed Improvements

Practice/Program	Acres	Cost ($) per acre	Total Cost ($)	Notes
329- Residue Mgmt-No-Till/Str	262.0	$89	$23,315	All farmable acres. Could cover cost of no till drill.
340- Cover Crops	844.6	$367	$309,983	All acres with at least one year cover crops could be planted but currently are not in the nutrient management plan.
342- Critical Area Planting	8	$550	$4,400	13 potential locations.
412- Grassed Waterways	8	$4,750	$38,000	13 potential locations with 4 being very small.
Practice/Program	**Acres**	**Cost ($) per acre**	**Total Cost ($)**	**Notes**
484- Mulching	8	$1,500	$12,000	13 potential locations.
590- Nutrient Management	260.1	$53	$13,784	All acres in agricultural land use not currently in an NMP.*
638- Water and Sediment Control Basin			$12,500	1 WASCOB on * land east of his farmstead
Conservation Cover Program	Potential acres	$150		Possibly for Various Producers
LDMI toolbar			~$80,000	Cost for LDMI toolbar (including hoses), flow meter, and corresponding sensors, and GPS mapping and equipment
TDR “Prime”**	1,901.5			Based on appraisals and other information. 104 landowners.
TDR “Prime if Drained”***	56.7			Based on appraisals and other information. 12 landowners.
Total			**$413,982.45**	

Figure 25 - Project estimate for Upper Sugar River Watershed Improvements

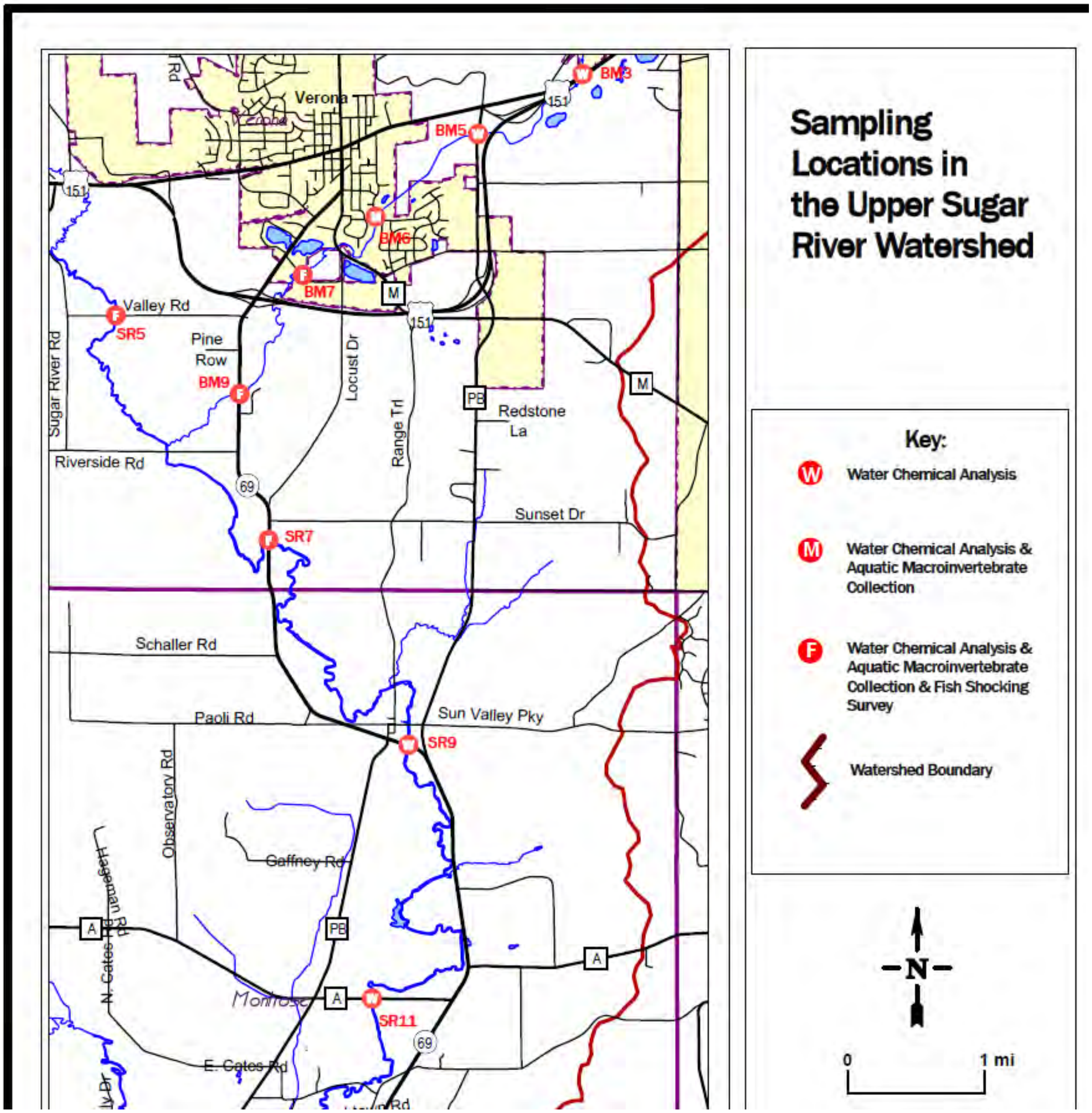


Figure 26 - THE DISTRICT Water Quality Monitoring Location Map BMC & Sugar River

USGS Surface-Water Monthly Statistics for Wisconsin

The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications. The user is responsible for assessment and use of statistics from this site. For more details on why the statistics may not match, click here.

USGS 05435950 SUGAR RIVER NEAR VERONA, WI

Available data for this site Time-series: Monthly statistics GO

Dane County, Wisconsin
Hydrologic Unit Code 07090004
Latitude 42°56'57", Longitude 89°32'39" NAD83
Drainage area 82.7 square miles
Gage datum 906.09 feet above NAVD88

Output formats
HTML table of all data
Tab-separated data
Reselect output format

YEAR	00060, Discharge, cubic feet per second, Monthly mean in ft3/s (Calculation Period: 2009-05-01 -> 2021-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009					109.5	102.9	76.5	66.8	60.8	86.3	67.3	65.7
2010	66	55	95.5	99.6	88.3	121.6	119.2	116.5	87.8	70.3	63.3	68.8
2011	65.9	85.2	113.6	106.1	81.6	75.8	58.3	46.1	52.3	45.2	66.9	59.5
2012	45.7	49.1	62.8	57.4	58.6	46.7	39.1	32.5	30.2	41.4	42.5	37.6
2013	56.4	58.8	111.8	157.6	90.2	132.5	87.7	60.1	49.4	45.6	50.1	30.2
2014	24.3	25.7	65.5	80	60.7	87.4	83.3	57.3	80.1	48.6	46.3	53
2015	42.8	34.1	52.6	62.4	64.6	58.3	57.2	46.5	64.7	57	90.3	105.8
2016	70.8	78	91.5	72.5	54.1	87.8	121.8	73.5	67.6	82.2	70.9	65.6
2017	111.2	90.4	93.9	105.9	93.7	93.4	254.7	114.1	75	83.5	67.6	56.4
2018	67.9	160.7	61.8	66.8	144.1	209.5	113.6	305.6	186.9	227.4	132.5	104.2
2019	109	114	250.1	110.6	133	107.8	134.4	120.4	153.6	203.6	134.3	111.7
2020	90.6	82.8	145.5	101.6	115.2	113.3	126.6	77.7	87.3	85.1	73.9	63.3
2021	57.6	51.7	85.3	73	59.4	53.7	47.9	46.7	44.7			
Mean of monthly Discharge	67	74	102	91	89	99	102	90	80	90	75	68

** No Incomplete data have been used for statistical calculation

Figure 17 - Summary Statistics from USGS at Sugar River Hwy 69

FIGURE 28 – Phosphorus Optimization Report, March 2021

PHOSPHORUS OPTIMIZATION REPORT WORKSHEET
Facility Name: Madison Metropolitan Sewerage District
WPDES Permit #: WI-0024597-09-0
PART 1—BACKGROUND INFORMATION
(A) Briefly describe wastewater treatment facility processes and operations and the means of treating phosphorus, including any chemicals used. Attach a flow schematic which shows the point(s) of chemical addition for TP control. Include both liquid and solids treatment trains.
Wastewater is conveyed to THE DISTRICT's Nine Springs Wastewater Treatment Plant via 18 District-owned pumping stations, averaging approximately 42 MGD of influent. Preliminary treatment consists of fine screening followed by grit vortex tanks to remove debris and other inorganic material, which is subsequently landfilled. Primary liquid-solids separation is accomplished using settling tanks. Sludge from this process is thickened with gravity thickener tanks. Secondary treatment follows primary settling, achieving biological phosphorus removal. Aeration tanks are arranged in a modified University of Cape Town configuration, which reduces total phosphorus from approximately 5 mg/L to 0.3 mg/L following secondary settling. Treated effluent is disinfected using UV on a seasonal basis before being discharged to Badger Mill Creek (4 MGD) and Badfish Creek (38 MGD). Solids handling occurs in the following order; thickening of waste activated sludge (WAS) with gravity belt thickeners (GBT), acid-phase anaerobic digestion of WAS combined with thickened primary sludge, then digestion at mesophilic temperatures with about 15% of solids continuing to thermophilic digestion for the intermittent production of a centrifuged thickened Class A cake. The remaining 85% of digested sludge is thickened via GBT to approximately 5% total solids for land application as a Class B liquid. Phosphorus-rich filtrate from both the WAS and digested sludge GBTs (and centrate from Class A cake production when operating) are conveyed to an Ostara process, where nutrients are recovered in the form of struvite. Effluent from struvite harvesting is recycled through the liquid treatment stream.

(B) Baseline Year: 2020 **Month**	**Influent Avg. Flow (MGD)**	**Influent Avg. TP Concentration (mg/L)**	**Influent TP Mass (lb/day)**	**Effluent Avg. Flow (MGD)**	**Effluent Avg. TP Concentration (mg/L)**	**Effluent TP Mass (lb/day)**
Jan	41.13	5.33	1828.15	3.07	0.26	6.75
Feb	41.15	5.37	1842.24	3.09	0.20	5.24
Mar	43.93	4.77	1750.11	3.09	0.20	5.27
Apr	40.71	5.11	1732.57	3.08	0.24	6.07
May	43.17	4.96	1773.97	3.44	0.29	8.33
Jun	45.32	4.91	1854.02	3.57	0.26	7.60
Jul	47.38	4.34	1712.64	3.59	0.34	10.22
Aug	42.00	5.02	1756.09	3.55	0.31	9.18
Sep	41.89	5.15	1800.42	3.58	0.29	8.79
Oct	39.90	5.74	1907.77	3.59	0.26	7.79
Nov	38.62	5.83	1879.94	3.58	0.26	7.68
Dec	37.14	5.66	1754.79	3.09	0.37	9.63
Avg	41.86	5.18	1799.39	3.36	0.27	7.71

(C) Possible Contributors: For municipalities, list all possible industries, other commercial buildings and hauled in wastes that could be introducing phosphorus into the collection system Name Source	Type of Process	Already Contacted?	If so, possible cont
Graber Manufacturing Inc.	Metal Finishing	Yes	Yes
Electronic Theatre Controls	Metal Finishing	Yes	Yes
Latitude Corp.	Metal Finishing	Yes	Yes
Bock Water Heaters	Metal Finishing	Yes	Yes

Water supply: What are the phosphorus levels within your water supply? Does the water utility add phosphorus for corrosion control or iron and manganese sequestration?
Only one of the District's customer communities adds phosphorus to their water supply. The city of Fitchburg manages iron and manganese in their North System by targeting a 2 mg/L dose of polyphosphate. Water usage in this system is approximately 1.5 MGD. Assuming the entirety of this flow is conveyed to NSWWTP, total phosphorus from Fitchburg's water supply accounts for less than 0.5% of daily loading. Since the city of Fitchburg uses an appropriate, recommended polyphosphate dose, and is not a significant contributor to influent phosphorus loading, benefit from further optimization work would be negligible.

PART 2—OPTIMIZATION ACTION PLANS
List the items that will be addressed to reduce the phosphorus in the effluent and provide a schedule for accomplishing each item. Note that all items must be completed by no later than 3 years after the date of permit reissuance. For each optimization action fill out a separate plan sheet.
1. Optimization Action: (example: Address Phosphorus from Industries)
Continued optimization of Ostara struvite harvesting process to reduce phosphorus in side stream flow.
Briefly describe optimization action plan: (example: determine contributors of phosphorus throughout the sewer area and work with them to reduce the incoming phosphorus. Parts of the plan include meeting with the industries, etc.)
When the Ostara struvite harvesting process went into service in 2016, removal of total phosphorus from sludge dewatering filtrate was less than 40%. The District and Ostara have worked together to trial a number of equipment modifications and process optimizations to improve phosphorus capture. Through this work, total phosphorus removal is now approximately 65% with over 80% orthophosphate recovered from sludge dewatering filtrate. District staff continues to participate in monthly meetings with Ostara to further this progress. While it is advantageous to both parties to increase struvite production, improvement to phosphorus removal will likely have minimal impact to biological treatment and subsequent effluent loading to Badger Mill Creek. The unrecovered phosphorus in the Ostara effluent stream only increases plant influent concentration by approximately 0.2 mg/L at current removal efficiency. Potential to meet the new permit limit is not significantly improved even if complete phosphorus removal via Ostara process was possible.

Anticipated Time Frame for Optimization Action	Date Start	Date Complete

Plan: Main Item to Complete		
Optimize struvite harvesting process	2016	Ongoing

Overall Optimization Action Plan Time Frame: Ongoing
Overall Completion Date: Ongoing
Outcome hoping for:
Identify sources of hauled waste that have the potential to inhibit THE DISTRICT's phosphorus removal processes.
Anticipated reduction and/or comments:
While the District will continue to monitor and evaluate hauled waste acceptance, current septage receiving rates are not a significant source of phosphorus. Due to the relatively small volume of hauled waste, significant reduction or even complete elimination of septage receiving would have a negligible impact on effluent phosphorus loading to Badger Mill Creek.

PART 3—OPTIMIZATION APPROVAL
Facility Name: Madison Metropolitan Sewerage District **WPDES Permit #:** WI-0024597-09-0
Name and Contact Information of Person Preparing Report:
Name: Drew Suesse **E-mail Address:** Drews@madsewer.org
Telephone #: 608.222.1201 ext. 226
OPTIMIZATION ACTION PLANS
Please provide a summary of the proposed action items and projected completion dates. The completion dates should be developed to enable the incorporation of the action items into the Preliminary Facilities Plan that is required in the WPDES Permit Phosphorus Compliance Schedule.
Action Item Proposed Date of Completion
Optimize struvite harvesting process Ongoing
Continued monitoring of industrial waste streams Ongoing
Continued monitoring of hauled waste Ongoing

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S.A.M.

Sustainable Action Map

Leadership Required
Manageable Risks
Value Delivered

Name: BMC Divert to Badfish Creek **Decision:**

Healthy Environment	Strong Community		Vital Economy
Natural: *How does it impact environmental health?*	**Individual:** *How does it directly impact the well-being of people?*	**Community:** *How does it impact relationships, effective government, social justice, and overall livability?*	**Economy:** *How does it impact the local economy and at what long and short term costs?*
S: BMC more ecological natural southern Wisconsin stream - not artificial through pumping from Nine Springs. WOuldn't have to reapply for AEL for BMC in next permit. Stream wouldn't be warmer in winter.	**S:** less cost to rate payers (energy, maintenance & phosphorus compliance) no treated effluent in BMC or Sugar River	**S:** BMC no longer tied to MMSD (BMC quality not based on effluent dominated stream, MMSD not part of a future TMDL)	**S:** One MMSD discharge point decreases O&M (pipeline and pump maintenance, future expenditures), pumping, energy costs (?), permitting work - permit restrictions
W: potential disruption in low flow for BMC Interbasin wastewater transfer. reduced opportunity for beneficial reuse of effluent Stream wouldn't be cooler in Summer.	**W:** Water story goes untold in Verona/Sugar River. Perhaps less (reliable) flow in BMC	**W:** Discontinuation of the golf course irrigation project. Less opportunities for reuse of effluent from that route.	**W:** resiliency?
O: Diversion of treated effluent from BMC reduces chloride, phosphorus,...temperature in the winter. Potential reuse of pipeline or corridor from existing BMC return line.	**O:** Rate payer money allocated to other challenges	**O:** Expand relationship with BFC? Friends of BFC? Neighbors?	**O:** More rate payer money to be allocated to other priority projects. Staff time allocated to other priority projects. Ability to reuse main or easement for relief force main - saving time and money.
T: Diversion of treated effluent raises stream temperature in the summer. Possible reduction in baseflow - interbasin transfer to Yahara.	**T:** Lack of future effluent discharge location.	**T:** Future discharge location in Sugar River basin would be very challenging to achieve if we give up this location.	**T:** If Yahara WINS doesn't work out, we would need to achieve compliance for more effluent.

SWOT: **S=Strengths** **W=Weaknesses** **O=Opportunities** **T=Threats**

Madison Metropolitan Sewerage District

Figure 29 - Strategic Action Map discontinue Outfall 005

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S.A.M.

Sustainable Action Map

Name: BMC Trading

Decision:

Leadership Required
Manageable Risks
Value Delivered

Healthy Environment	Strong Community		Vital Economy
Natural: *How does it impact environmental health?*	**Individual:** *How does it directly impact the well-being of people?*	**Community:** *How does it impact relationships, effective government, social justice, and overall livability?*	**Economy:** *How does it impact the local economy and at what long and short term costs?*
S: Auxilliary projects in the watershed could improve ecosystem, environment and provide on-going phosphorus reductions. Improving Non-developed land may be able to remain that way, providing on-going benefits for water quantity and quality	**S:** Continued contribution to baseflow of BMC Potential improvement for recreation.	**S:** Consistency of BMC improves Verona's natural resource - BMC. Potential improvement in tourism, recreation, etc.	**S:** Possible cost savings due partnerships. Ecological improvement increases value of resource.
W: Effluent still in BMC	**W:** maintaining effluent in BMC makes us party to future TMDL and we will face Nitrogen and other requirements which could increase rates.	**W:** Reliability of trade? inability to use the FM or corridor for relief	**W:** Significant development in the region reduces viable trades and potentially increases cost per pound.
O: Ability to partner on some great projects. Maybe make things happen that wouldn't have without us. Keep effluent in BMC. Continue to tell the water cycle story in the Sugar River.	**O:** potential less cost trade could be permanent	**O:** Potential to make some great projects happen with additional partnership from MMSD. Visibility of reclaimed water helps protect water (district messaging.)	**O:** Partnerships with projects and partners strengthen our Reduces uncertainty?
T: Effluent still in BMC - future regulation. New forcemain construction ?	**T:**	**T:** Cost to rate payers for future investments in the watershed or if trade ceases to function.	**T:** Trades must continue to achieve compliance. Development pressure and land values are challenges.

SWOT: S=Strengths W=Weaknesses O=Opportunities T=Threats

Madison Metropolitan Sewerage District

Figure 30- Strategic Action Map Water Quality Trading

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S.A.M.

Sustainable Action Map

Name: Treatment Alternative for BMC Low TP Limit **Decision:**

Leadership Required ✓
Manageable Risks
Value Delivered

	Healthy Environment	Strong Community		Vital Economy
	✓ **Natural:** *How does it impact environmental health?*	✓ **Individual:** *How does it directly impact the well-being of people?*	✓ **Community:** *How does it impact relationships, effective government, social justice, and overall livability?*	✓ **Economy:** *How does it impact the local economy and at what long and short term costs?*
S:	-Technology exists to meet TP limits as defined by DNR -Reduction of nutrients to Sugar, Rock River watersheds -Continues to meet District's goal of high quality effluent	-BMC is a popular location for recreational water activities. Treatment maintains high quality effluent for this purpose.	-Continues to supply flow to BMC that had been diverted w/ closure of Verona WWTP. Agreement w/ Verona in 90's. -Maintains BMC as a permitted outfall for the District. Re-permitting for BMC would be unlikely if treatment is not pursued and flow is discontinued.	-Large construction project that would employ engineers, construction workers, skilled labor, etc. -highly treated effluent used by business as an alternative to groundwater could be a cheaper source (lower cost of water to businesses).
W:	-Increased energy consumption. Treatment and pumping is estimated to be 1,099,000 kWh/yr (depending on treatment option)	-Added complexity and maintenance requirements for District staff to operate treatment alternatives - process/equipment would be new to staff	-Conflicts with District's goal (and many communities' goal) of reducing energy consumption and reliance on fossil fuel derived chemicals -Increased solids production will need to be handled by Metrogro	-High capital and O&M costs (~ $15M in treatment equipment, ~ $130k/yr in chemicals, ~$31k/yr treatment energy, ~$63k/yr in pumping energy) -Increased solids handling costs
O:	-Potential improvement for aquatic species in BMC through reduction of algal growth -Small step towards advanced tertiary treatment for all NSWWTP flow (if required in the future) -Sustainability option for water reuse in the area from groundwater recharge to direct potable reuse and everything inbetween conserving water resources	-Educational/showcase opportunity of high level of treatment - Wastewater transformed to popular kayaking/fishing/etc. destination -Sustainability option for water reuse in the area from groundwater recharge to direct potable reuse and everything inbetween.	-DNR has interest in maintaining aquatic biology -Customer communities' interest in recreational stream -Further partnerships/coordination with these groups -Sustainability option for water reuse in the area from groundwater recharge to direct potable reuse and everything inbetween -Increased solids production is more opportunity for an alternative reuse product that decrease the reliance on mined fertilizer	-Some treatment options provide resource recovery opportunities - added revenue source through sale of algal biomass
T:	-No significant reduction in other key effluent parameters aside from TP. -Would need additional treatment/plant modification for future BMC low level limits (e.g. TN, chlorides) -BMC limits currently dictate level of treatment	-Improves water quality health through reduction of phosphorus, but does not treat for CECs. Future concerns of pharmaceuticals and PCPs, microplastics, etc., exist if primary goal of maintaining BMC discharge is for public recreation and aquatic biology	-Conflicting goals and community interests -Questions of environmental justice - who's benefiting vs. who's being burdened (expensive, energy intensive treatment to maintain recreational stream in wealthier, white community)	-Fluctuations in chemical costs -Uncertainty of resource recovery markets (depending on treatment alternative) -Rate payers' concerns: expensive option to maintain voluntary outfall that only accounts for 10% of NSWWTP flow

SWOT: S=Strengths W=Weaknesses O=Opportunities T=Threats

Madison Metropolitan Sewerage District

Figure 31 - Strategic Action Map - Treatment

	Blue PRO Sand Filtration	CLEARAS Algal Photobioreactor	CoMag Ballasted Settling	AquaDisk Cloth Media Filtration
Strength	• Consistent treatment below TP limit (0.05 mg/L average • Well-known, established technology • Relatively small footprint	• Best TP removal (avg eff TP: 0.04 mg/L) • Algae resource recovery • Steady, consistent discharge to BMC is well suited for this technology	• Recoverable ballast material • Achieved TP removal target (0.065 mg/L avg)	• Simple, well established technology • Compact footprint • Low capital cost
Weakness	• Requires alum or ferric addition, though less than other alternatives and no polymer required to meet effluent TP goal • Limited "auxiliary" benefits beyond TP removal	• Very large footprint (~1 acre). Would be the largest installation of this process by far. • Energy intensive process for algae solids handling (Large dryers or cold storage building) • Need to make our current treatment worse for more favorable algae growth conditions (more nutrients sent to tertiary treatment results in higher algae yield, and is more economical)	• Demands a significant amount of polymer and ferric • More complex system from an O&M perspective • High capital costs – additional tankage required	• Did not reliable achieve TP removal target. Ranged from 0.05 – 0.09 mg/L • Demands a significant amount of polymer and ferric
Opportunity	• Single or dual stage option if further treatment is required in future (single stage unit achieved <0.075 mg/L target during pilot)	• Similar technologies exist. Not as established, but have smaller footprints and less chemical requirements • Revenue from algae sales • Bleeding edge technology	• Good technology if we had extra tankage available or if we had excessive I/I and large peaking factor	• Aqua continuing to develop new cloth media. MMSD pilot tested two. Potential for better TP removal in future.
Threat	• Fluctuations in chemical cost • Increased solids handling due to chemical sludge	• Uncertainty of algae market • Biological system is more susceptible to plant upsets • Partnership with Clearas. Would rely on them to purchase and market algae • Unknown how product may be regulated (EPA Part 503?) • Very few full-scale installations. Currently none at our size. Most projects in design are < 1 MGD	• Fluctuations in chemical and ballast costs • More specialized parts and equipment than other alternatives • Increased solids handling due to chemical sludge	• Risk of violating permit due to minimal treatment • Chemical cost fluctuations • Would not provide sufficient treatment if faced with more stringent limits in the future • Increased solids handling due to chemical sludge

Figure 18 - SWOT Analysis Treatment Options

Yahara WINS

1610 Moorland Road • Madison, WI 53713-3398 • P: (608) 222-1201 • F: (608) 222-2703

April 24, 2023

Kathy Lake
Madison Metropolitan Sewerage District Pollution Prevention Manager
1610 Moorland Rd.
Madison WI 53713

Re: MMSD Phosphorus Compliance Options for Badger Mill Creek and Potential Impacts to Yahara WINS

Dear Kathy Lake,

At the March 21, 2023 Yahara WINS meeting, executive committee members were presented with information from MMSD around the potential impacts that one of the phosphorus compliance solutions being considered by MMSD, moving flow from Badger Mill Creek to Badfish Creek, would have for Yahara WINS. The Yahara River watershed is home to Yahara WINs, an adaptive management project aimed at improving water quality through phosphorus and TSS reductions. Any change in the District discharge in the Yahara Watershed will impact Yahara WINS.

As outlined by MMSD the impacts to Yahara WINS if the flow is discontinued from Badger Mill Creek and sent to Badfish Creek would be:

- The District would be responsible for paying additional funds to Yahara WINS to account for this addition of phosphorus to the Yahara watershed.
- The approximate cost per pound of phosphorus under the Yahara WINS model is $50 per pound for the 2023 calendar year. With 2,200 pounds of phosphorus tied to this redirection of flow, it would cost the District an addition $110,000 each year on top of what they are already contributing.
- If the decision by the district commission is to move the flow, the District will recalculate its full allocation for 2024 before September 1, 2023 per the Yahara WINS intergovernmental agreement guidance.

The impact to Yahara WINS adaptive management project as outlined by the District is acceptable to the Yahara WINS executive committee. The Executive committee looks forward to further discussions with MMSD when the final compliance option is chosen.

Sincerely,

Tom Wilson

Tom Wilson
Yahara WINS Vice-President, Village of Waunakee Administrator, Ret.

1610 Moorland Road • Madison, WI 53713-3398 • P: (608) 222-1201 • F: (608) 222-2703

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Yahara WINS Vice-President, Village of Waunakee Administrator, Ret.