Chapter 7
Collection System Maintenance

Chapter Outline

This chapter is organized into the following sections:
- Introduction
- General Discussion
- Pumping Station Maintenance
- Maintenance of Sewers and Force Mains
- Summary

Introduction

This chapter summarizes the practices used by MMSD to maintain its collection system of pumping stations, intercepting sewers, and force mains. The 17 regional pumping stations, 96 miles of intercepting sewers, and 29 miles of raw wastewater force-main sewers represent a significant investment by MMSD. The collection system is also an important part of the public-works infrastructure for the metropolitan area and is vital to protecting public health and the environment. To maintain such assets in good operating condition over a relatively long life requires a strong maintenance program and good maintenance practices.

General Discussion

MMSD has a long history of reliably maintaining its pumping stations and sewer systems. Although past maintenance practices kept MMSD’s systems reasonably reliable, improvements in technology, better (modernized) maintenance methods, and better construction materials have allowed MMSD to improve on its maintenance practices over the years. MMSD’s current maintenance practices are becoming more program-driven than in the past. Program driven maintenance (PDM) focuses labor resources on planned, preventive, and predictive activities to help reduce reactive maintenance to a small fraction of the maintenance performed. In addition, program driven maintenance relies on reliability centered maintenance practices to focus attention on those areas that are the highest priorities for sustaining a reliable system. A computer maintenance management system helps synchronize maintenance planning with inventory and tracks maintenance costs. Modern test equipment allows impending failures to be predicted with greater accuracy. Predictive testing permits repair or replacement of the failing parts to be proactively scheduled versus reacting when equipment fails. The proper balance of proactive and reactive work minimizes costs.
Pumping Station Maintenance

Overview
The purpose of MMSD’s seventeen pumping stations is to receive incoming raw wastewater and pump it to another pumping station or to the Nine Springs Wastewater Treatment Plant. The stations operate continuously, 24 hours a day, seven days a week. The pumping units within the stations run as necessary to prevent sewer backups or overflows. To operate efficiently and effectively, the mechanical and electrical equipment must remain in good working condition, and the building structure must be kept sound and leak-proof. Additionally, the building and grounds should remain well maintained and aesthetically pleasing.

Mechanical Systems
The mechanical equipment in MMSD’s pumping stations includes raw wastewater pumps, sump pumps, heating-ventilating and air-conditioning equipment, air compressors, valves, piping, gates, surge mitigating equipment, and solids handling equipment. This equipment is maintained by the Mechanical Maintenance Section. Each station is routinely visited at least once per week and inspected for proper operation. Additionally, each station is monitored via a radio telemetry system that provides information to computer screens on the process control system at the Nine Springs Wastewater Treatment Plant. Data displayed include pumping patterns, an indication of the pumps in service, the status of the electrical services, and in some cases, flow data. The telemetry system also signals the operator at the Nine Springs Wastewater Treatment Plant of any alarm conditions that occur. The operator will forward any alarm conditions to either the Mechanical or Electrical Maintenance Sections based upon the type of alarm received. If necessary a mechanic or electrician will be dispatched to the site.

During the routine site visit by the mechanic, the mechanic will look for any problems that need correction. If a problem cannot be corrected immediately, the mechanic will note the problem for follow-up work. A work order will be generated at the plant and planned and assigned for a later date. Other work orders are automatically generated for preventive and predictive maintenance of pumping station equipment. Lubrication of bearings and checking a pumping system for vibration or proper alignment are examples of preventive and predictive maintenance.

The most critical mechanical equipment at a pumping station is the raw wastewater pumping system. Therefore, it is very important that the pumps and ancillary equipment (valves, piping, surge arrestors, etc.) be well maintained to insure proper operation when needed. As part of the routine site visit, the mechanics visually inspect the pumps, listen for unusual sounds that may indicate wear or misalignment, feel the pumps to sense excess vibration or high temperature, check for plugged vent lines, and ensure that sump pumps are working properly. At recently rehabbed pumping stations, the raw wastewater pumping systems have been equipped with vibration sensors, and bearing and motor winding temperature sensors to continually monitor the pumps and the corresponding motors. During site visits, mechanics will also tighten packing on those pumps not using
mechanical seals and will read any suction or discharge pressure gages as these could help identify problems with a pump.

Predictive and preventive pump maintenance that takes more time than is allowed during a routine site visit will be scheduled via periodic work orders. This maintenance includes checking pump/motor alignment, vibration testing of some of the larger pumps, exercising gates and valves, cleaning float tubes, testing backflow preventers, checking the HVAC systems, inspecting cranes, and preparing the stations for winter and summer operation. When major corrective action is necessary, the mechanics will remove a pump from service and transport it to MMSD’s maintenance facilities. MMSD’s maintenance facilities are equipped with full rebuild capabilities for pump repair.

Valves and gates play an integral role in keeping the pumping station operational. Pumping stations typically contain numerous types of valves and gates intended to divert and control the wastewater within the pumping station. Check valves allow water flow in only one direction, preventing an operating pump from pumping backwards though idle pumps and preventing the force main from draining back into the wetwell. Isolation valves on both the pump suction and discharge allow maintenance to be performed on a pump while other pumps remain in-service. If equipped, force main valves isolate the entire pumping station from the force-main, allowing work on any part of the piping system within the station. Ball valves and sometimes gate valves are used for surge mitigation on start up and primarily on shut down of pumps. Gates are generally used to control the flow from the collection system into the pumping station wetwells or to isolate half of the wetwell. This is typically done for maintenance purposes, wetwell cleaning, and in some cases, for operational purposes.

The last paragraph discussed the importance of valves and gates within the pumping system and logically it follows that these are good reasons why valves and gates should be kept in good working condition. The best way to keep valves and gates maintained is to exercise them periodically. Oftentimes, valves and gates that are relied upon for isolation or operational procedures do not work when called upon, simply because they have not been operated for a significant amount of time. That being said, it is often difficult to operate some valves or gates without disrupting normal operation of the pumping station and/or because the valves or gates are difficult to close or open. Some valves or gates may require manual operation and take hundreds of turns to open. Therefore, the District has begun to include motorized operators on its valves and gates whenever possible, and where motorized operators are not installed, has attempted to come up with easier ways to operate them, e.g., using an electric drill with a socket to drive the operator rather than manually driving it. Eventually, it is hoped that all of the valves and gates will become part of a routine exercise program that periodically verifies proper operation.

Since the 2002 facilities plan, the District has made systematic changes in its’ approach to solids handling at the pumping stations. With the Tenth Addition to the Plant, all screenings are now dealt with at the Nine Springs Wastewater Treatment Plant versus the pumping stations. The impacts of this change in operation are discussed in more detail.
in Chapter 3. In general, the change has shifted labor at the pumping stations from manual removal of screenings and maintenance of screening equipment to monitoring of pump performance and cleaning of pumps. Both of these maintenance activities are the result of a higher frequency of pump plugging. The only remaining piece of solids handling equipment within the District’s collection system is a grinder at Pumping Station 17. This grinder remains in place because of concerns related to the large solids that Pumping Station 17 can potentially receive from the county mental hospital located within its service area. Typical mechanical problems with grinders include occasional jamming and periodic overhaul of the grinder mechanisms due to the maintenance intensive process of grinding non-organic (rocks, sand, etc.) solids.

Air compressors are installed in some of the pumping stations to provide air for level sensing instrumentation or for surge mitigation systems. For the level sensing systems, a small amount of air is bled into the wetwell via a pipe or plastic tube. The backpressure is measured and calibrated to correspond to the wastewater level in the wetwell. These air compressors use very little air, but because they are critical to sensing the proper level, it is very important to keep them well maintained. The surge mitigating systems use a great deal more air. These systems inject air into a storage vessel connected to the outgoing force main. The air stored in this vessel acts as a cushion or buffer for when the pumping units start or shut off. The air in the vessel compresses or expands, helping dissipate surge energy in the force main. It is also very important to keep the air compressors attached to these systems well maintained. At the present time, only Pumping Station 7 has a surge mitigating system of this type.

Other surge mitigating equipment includes surge arrestors that are a type of pressure release valve. Typically, these valves will open on high pressure (e.g., a pressure wave from a water hammer transient wave) releasing some wastewater, and consequently dissipating the high pressure, back into the wetwell. The amount of wastewater released in such an event is generally minimal. Since these surge mitigating devices protect the force main and the pumping station header, it is important that they remain in good working condition. In addition, another reason to keep them well maintained is that they could potentially stick in the open position and continue to release wastewater into the wetwell, causing excessive pump operation and possibly flooding the wetwell. Some of the force mains also include air release/vacuum intake valves, which provide another method of surge mitigation. Although not located within the pumping station, they can protect the pumping station’s piping from excessive positive or negative pressures by releasing extreme pressures to the atmosphere, generally at the force main’s high points. These are discussed in greater detail later in this chapter.

Ventilation and the air handling systems also provide an important function at MMSD pumping stations. Many of the older stations have little or no forced ventilation. This can lead to poor air quality within the stations, including foul and corrosive air in the dry well area. This, in turn, can lead to corrosion of sensitive electrical equipment, an unhealthy air quality, and rusting of the piping and equipment within the drywell.
To combat this, new regulations require air-handling systems that provide adequate amounts of fresh air to prevent the buildup of corrosive and/or toxic gases. All new or rehabilitated MMSD pumping stations are equipped with heating, ventilating and air conditioning (HVAC) equipment to meet these requirements. This provides a better environment for the pumping station equipment and a safer environment for personnel during site visits.

HVAC systems are maintained by the Mechanical and Electrical Maintenance Sections of the District, each taking care of their respective areas of the systems and equipment. Older controls are often manual while newer controls are typically integrated into the station’s control system and may be monitored or operated from the system’s station control center, e.g., a graphic display (operator interface terminal).

**Electrical, Controls, and Instrumentation**

The electrical equipment in MMSD’s pumping stations includes power entrance, transfer, and distribution equipment, motors and motor controls, pump and auxiliary control systems, instrumentation (including telemetry equipment), and lighting systems. MMSD’s electrical systems are maintained by the Electrical Maintenance Section with significant support from the Electrical Engineering Group. The District’s electrical staff responds to problems in a manner similar to the mechanical staff. When an alarm signals the operator of a problem at one of the pumping stations, it is determined who will respond and either an electrician or mechanic will be dispatched to the site. However, the vast majority of electrical work at the pumping stations is either planned maintenance, preemptive replacement of equipment, or new equipment installation.

The electrical staff does extensive preventive and predictive maintenance of the electrical equipment at the pumping stations. This work includes cleaning of electrical cabinets, inspection of electrical contacts, tightening of electrical terminations, thermal sensing of electrical equipment while in operation, cycling of equipment to determine proper operation (for example – power system auto transfer schemes), verification of proper signaling for alarms and other instrumentation, and verification of proper control operation for all control systems. In addition, roughly every three years an electrical testing firm is hired to test power system relays, circuit breakers, and oil testing of oil filled switches and transformers. The Electrical Engineering Group prepares specifications and provides project management services for the electrical maintenance testing process with field support provided by the Electrical Maintenance Section. Proper operation of the power systems, motors, motor controls, and pumping system controls at the pumping stations is critical.

MMSD’s pumping stations typically have two redundant utility power services. The two exceptions include Pumping Stations 3 and 17. However, Pumping Station 17 does have a backup generator on-site to provide redundant power. Each redundant service or the backup generator, as in the case of PS 17, will automatically connect to provide power in the event of a normal power outage. Since the pumping stations operate continuously, it is important that these automatic transfer systems are well maintained and function.
properly when required. To insure this, the transfer schemes are inspected and tested at least semi-annually and the generator at Pumping Station 17 is tested monthly by the mechanics. The mechanics start the generator manually and verify that it is providing power to the station. The generator runs for two hours and then automatically shuts off and the station is switched back to utility power. The Metrogro mechanics perform an annual inspection of the generator, which includes an oil change. If the generator would run more than normal, another oil change would be scheduled at other times during the year as needed. The Metrogro mechanics are familiar with large diesel engines and therefore, familiar with the engine that drives the generator at Pumping Station 17 as well as the portable generators that the District owns.

The motor control systems, starters, and or adjustable frequency drives (AFDs), especially for the wastewater pumps, are routinely inspected for bad components, loose connections, and worn contacts. Components in poor condition are repaired or replaced prior to failure. Although it is sometimes difficult to assess the condition of solid-state equipment such as solid-state starters and adjustable speed drives, these enclosures are also cleaned and the equipment inspected for signs of overheating or other damage. The equipment is checked for proper operation prior to returning it to service.

Most of the control systems, such as the pump control system, are now controlled via programmable logic controllers or another programmable device. Since these generally either work or they do not work, it is important to have a backup control system or backup plan in the event of equipment failure. It is generally difficult to predict when this type of equipment will fail. Although older control systems have more individual components, it is generally not any easier to predict failures. After proper operation of the control and alarm systems is initially verified, keeping the instrumentation components calibrated and working well, and testing alarm functionality periodically is probably as much as can be done. The periodic testing of alarms should include testing of the telemetry system to verify that all alarms show up properly on the operator’s screen at the plant.

The lighting systems, although important from the standpoint of allowing maintenance personnel to see what they are working on, probably receive less attention than most of the other systems, simply because they require little maintenance and they play a supporting role versus a critical role to the mission of the pumping station. Burnt out lamps are generally replaced by the Building and Grounds Crew. If there is something wrong with the fixture, e.g., bad ballast, a work order is generated for the electricians to take corrective action.

**Buildings and Grounds**

The pumping station structure, building exterior, roof, and site maintenance are taken care of by MMSD’s Building and Grounds Crew.

The Building and Grounds Crew annually inspects each pumping station’s roof and exterior for structural damage and leaks. Any leaks or damages that are reparable by the
crew are fixed, while those that are not are either contracted for repair or budgeted for repair during the next year. Leaks or damage that require immediate attention are repaired while those that can wait are budgeted for.

The interiors of wetwells and drywells typically require little maintenance. However, occasional repairs to damaged concrete are required. If these are not too extensive, the Buildings and Grounds Crew may make these small structural repairs. If extensive rehabilitation is required, it is generally dealt with as a contracted service managed by the Engineering Department. Painting of piping, equipment, and sometimes walls, is done as necessary, usually on a rotating basis, and may be done internally or contracted out depending upon the size of the project and the pending workload. A good fresh coat of paint adds significantly to the neat and tidy appearance of the pumping station.

The Building and Grounds Crew keeps the pumping stations aesthetically pleasing externally and internally. Trash within the building is removed and floors swept and cleaned periodically. The lawn and landscaping are well cared for. MMSD’s pumping station sites are often located near neighborhoods or parks, and it is important that the site be kept clean, well landscaped, and well groomed. A good appearance is less likely to bring negative attention to the pumping station. A good internal appearance also provides for a better working environment for the mechanics and electricians.

To minimize the build up of grease and solids in Pumping Station wetwells, some stations have an automatic well cleaning sequence programmed into the station control system. This sequence runs during the nighttime hours and results in the station pumps lowering the well level to a lower than normal level. The pumping station’s pumps then pump most of the floating and settled material from the well under these conditions. Unfortunately, some wetwells are more susceptible to solids and grease build-up than others and therefore need more cleaning than can be provided using the pumping systems. To deal with this issue, the Buildings and Grounds Crew periodically hires the City of Madison to provide a vactor truck to assist in cleaning these wetwells. Typical solids include grease, rags, and other non-organic materials. The method of removal is to high-pressure spray the wells while pumping the wash water into the vactor truck.

**Maintenance of Intercepting Sewers and Force Mains**

MMSD’s wastewater collection system currently includes 96 miles of gravity intercepting sewers, 29 miles of raw wastewater force mains, and 1,551 manholes. These pipelines and manholes are responsible for collecting and transmitting the wastewater from the various communities to and between MMSD’s 17 pumping stations, and ultimately to the Nine Springs Wastewater Treatment Plant. MMSD staff follows a written interceptor maintenance guideline that has been used and revised since 1992. This section presents a summary of MMSD’s *Interceptor Maintenance Program Guidelines* (latest (3rd) revision – Nov. 2009), which is included as Appendix A4. The interceptor maintenance program defines seven areas that are each addressed with a separate plan. The seven areas and their separate plans are summarized in turn:
Interceptor Evaluations

MMSD has developed a formalized interceptor evaluation program that keeps staff members informed about the physical condition and hydraulic adequacy of its individual gravity interceptors, and allows informed decisions regarding the need for rehabilitation or replacement projects. The program includes televising, cleaning, manhole inspection, flow documentation, and various other work. Interceptor evaluations are performed on roughly 10% of MMSD's gravity sewers each year. The program includes systematic recordkeeping and organization of the work. The program has been successful in identifying system needs prior to their becoming emergencies, and has allowed MMSD to more efficiently plan, budget and carry out the necessary repairs and rehabilitation projects.

As noted above, approximately 10%, or nine miles, of MMSD interceptors are evaluated each year. During this process, the interceptors are cleaned (e.g., grit and roots are removed) and televised. Following televising of the interceptors, MMSD receives video documentation of the televising. MMSD personnel then view the results in detail and enter any defects noted into a database. The database assigns a score to the interceptor based on the condition observed during the televising results. The scores are used to rank the overall condition of the interceptor and prioritize the need for any repairs. As interceptors are re-inspected every 10 years or so, new scores will be assigned and condition of the interceptor can be compared to the previous inspection.

Force Main Isolation Valve Exercising

Eighteen exterior isolation valves presently exist on MMSD’s force main sewers (an up-to-date listing of the actual number and status of these valves is maintained in MMSD’s Interceptor Maintenance Program Guidelines – the most recent version is included in Appendix A4). Some of these valves are located immediately outside of pumping stations and were designed to limit possible pumproom flooding in the event of a burst header inside the pumping station. Several others were added at specific forcemain junction points to allow diversion of flow as part of a construction project. Most of MMSD’s older isolation valves are double-disc gate valves. Newer valves are resilient-wedge gate valves or plug valves. Since the seating area can become filled with grit and solids that can prevent full seating of any type of valve, each valve is regularly exercised and inspected by MMSD twice per year. Valve exercising verifies that the valve is operational and in working order, but does not automatically verify that the valve is fully sealing off the flow. Some valves may leak even though their valve stem exercises freely to closure, and may require additional rehab work when needed. The valve exercising program is intended to maintain the valves in good working condition and to help insure, but not guarantee, that the valves will work and seal properly when they are needed.
**Air Valve Inspection and Maintenance**

There are twenty-eight air release valve installations on MMSD’s raw wastewater forcemains (an up-to-date listing of the actual number and status of these valves is maintained in MMSD’s Interceptor Maintenance Program Guidelines – the most recent version is included in Appendix A4). Most of MMSD’s air valves are “combination” valves, i.e. they perform both a vacuum breaking function and an air release function. The vacuum breaking function admits air into the forcemain during low pressure conditions (such as during pump shutdowns), thus preventing possible vapor cavity formation & water column separations which could lead to waterhammer failures. The air release function prevents air pockets from accumulating and potentially restricting the flow at forcemain high points. To ensure that each valve remains in working order, each air valve is inspected and cleaned twice each year, or more frequently when the valves are prone to plugging. If possible the valves are cleaned and repaired in the field. In most cases, the valve must be removed and returned to the shop where it can be inspected and cleaned prior to reinstallation at the site.

**Siphon Cleaning**

Eleven active inverted siphons currently exist in MMSD’s collection system (an up-to-date listing of the actual number and status of the siphons is maintained in MMSD’s Interceptor Maintenance Program Guidelines – the most recent version is included in Appendix A4). The purpose of a siphon is to carry the wastewater flow beneath an obstacle (such as a streambed or a major utility line) that would otherwise block the interceptor’s gravity profile. Unfortunately, a siphon typically carries a lower velocity (since it always flows full) and thus creates greater potential for solids deposition. Newer siphons with multiple barrels are designed to minimize the potential for solids deposition. MMSD began contracting out the regular annual cleaning of its siphons in 1998. Prior to 1998, siphons were cleaned only if specific problems occurred. Annual contracted siphon cleaning helps to catch any problems before they become serious. The contractor’s cleaning operations are closely observed, and the adjacent siphon manholes are visually inspected at the time of cleaning to determine if any additional work is needed.

**Stoplog & Gate Structures**

There are eight stoplog and gate structures on MMSD interceptors (an up-to-date listing of the actual number and status of these structures is maintained in MMSD’s Interceptor Maintenance Program Guidelines – the most recent version is included in Appendix A4). Some of these structures were constructed at junction points between adjacent interceptor projects. Others were originally constructed as flushing manholes (no longer used) for the purpose of periodic flushing of the interceptor with adjacent surface water. To ensure that the stoplog and flapgate structures remain in good repair, MMSD inspects each structure annually and provides any stoplog or gate replacements or repairs that are needed.
**Special Projects, Events, and Repairs**

In addition to the regular planned maintenance activities, there are numerous specific projects, repairs and events that occur every year in the operation and maintenance of interceptors and force mains. Examples include high flow events, emergency repairs, connection inspections, odor complaints, backup events, I/I work, specific manhole repairs, surface route inspections, and other events. These specific events are an important aspect of the interceptor maintenance program. Therefore, specific records of these events are kept for future decisions and management of the MMSD program.

**Program Coordination and Management**

Coordination and management of the interceptor maintenance program includes numerous functions needed to make the program successful. Examples include the following:
- Preparing annual program budget and tracking it during the year
- Tracking of work performed and work outstanding
- Updating interceptor GIS database and maps
- Managing inventory
- Managing contractors
- Managing Diggers’ Hotline membership and locating services
- Organization of emergency preparedness
- Screening outside projects via UTILITY log.
- Organizing cross-training activities
- Recommending periodic improvements to the program

The interceptor and forcemain maintenance program is carried out as a joint effort of MMSD’s Operations and Maintenance Department, MMSD’s Engineering Department, and outside contractors. MMSD’s Collection System Supervisor currently handles oversight of the entire program. MMSD’s Monitoring Services/Sewer Maintenance Crew carries out most of the field activities, including inspection and maintenance of valves and stop logs, manhole repairs, and response to odor or backup complaints. Locates and field marking are handled as a contracted service, presently provided by United States Infrastructure Corporation (USIC). Televising and cleaning work is annually bid and contracted. MMSD’s Engineering Department provides engineering and assistance for major projects and special events, and maintains system maps and the Geographical Information System (GIS). Major repairs, excavation, heavy construction and specialty services are contracted out to private construction firms.

**Summary**

MMSD’s collection system represents a significant investment and an important asset for the protection of public health and the environment. To preserve that investment requires a diligent and thorough maintenance program. MMSD uses a program driven approach to maintenance intended to reduce the number of emergency maintenance events. All components of MMSD’s collection system are inspected and maintained to insure that
proper operation of MMSD’s system continues. Components that are found in poor condition are repaired or replaced prior to failure. Detailed records of maintenance, high flow events, and failures are kept for future reference and decision-making. MMSD’s program will not prevent all failures; however, a sound maintenance program has and will continue to maximize the life and usefulness of MMSD’s collection system components.