

Plant Unit Substation Improvements



Substation U11 at West Blower Building



Substation U12 at Effluent Building



Substation U13 at Maintenance Shop 1

Project Purpose:

The purpose of this project is to ensure that the portions of the Nine Springs Wastewater Treatment Plant powered by Unit Substations U11, U12, and U13 retain a continuous and reliable source of power.

Project History and Status:

The power for the Nine Springs Wastewater Treatment Plant is delivered from Madison Gas & Electric's Nine Springs Substation, located just to the northwest of the Plant on District property. A District-owned Main Substation transforms the two 13.8 kV services to 4.16 kV for distribution power throughout the Plant. Eight unit substations and various other transformers located throughout the plant further transform the voltage from the 4.16 kV system to utilization voltages of 480 volts or below for use in local areas.

Three of the unit substations, U11, U12, and U13, were constructed in the early to mid-1980s during the Seventh Addition to the Nine Springs Wastewater Treatment Plant. Substation U11 provides low voltage power (480 volts and under) to the West Blower Building and the former Grit Facility (now Storage Building 3). Substation U12 provides low voltage power (480 volts and under) to the Effluent Building and powers Aeration Control Building 4. U13 provides power for the two Maintenance Shops, the Service Building, and Storage Buildings 1 and 2. Life expectancy of outdoor unit substations of this type is roughly 30 years. Actual life can vary significantly from industry averages or from typical life expectancies. Replacement decisions should therefore be based upon actual equipment condition and availability of parts and components versus age.

The District's electrical maintenance program provides standard preventive maintenance to all District electrical equipment based upon industry standards and based upon the District's own experience with the equipment it owns. Substations are no exception to this. In addition to the routine electrical maintenance provided by District staff, the District hires electrical maintenance testing services to provide periodic testing services for circuit breakers, transformers, and other electrical equipment. The District generally procures these services on a three-year cycle.

Recent observations by District staff as well as by the District's electrical maintenance testing firm have assessed the condition of the substations as fair to marginal. In addition, the testing firm recommended replacement of these three unit substations. Thus, considering both the age and relative condition of these unit substations, District staff has included replacement of the unit substations in its list of capital projects.

This project was included in the 2016 Liquid Processing Facilities Plan.

Alternatives:

The following alternatives were evaluated in detail in the 2016 Liquid Processing Facilities Plan:

Alternative USUB No. 0—No Change (Null Alternative)

This alternative would leave existing unit substations U11, U12, and U13 in operation. Unit substation U13 now serves non-critical loads and its electrical load has been significantly reduced since maintenance operations and staff moved to the recently-constructed Maintenance Building. However, unit substations U11 and U12 serve critical processes that could significantly affect NSWWTP operation if unit substation equipment fails.

Alternative USUB No. 2—Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13

Alternative USUB No. 2 would replace unit substations U11 and U12 with one new large, indoor unit substation located approximately equidistant from both existing unit substations to serve all of the existing unit substations U11 and U12 electrical loads, except for two MCCs in Storage Building No. 3, which are currently fed from unit substation U11 but could be refed more economically from nearby unit substation U15. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

This alternative includes one new large unit substation to feed the existing 480-volt loads currently fed from unit substations U11 and U12. The unit substation would also include additional capacity to serve future equipment associated with NSWWTP process expansion on the west side of the NSWWTP. This substation would be housed in a building with a below-grade cable vault, heating and mechanical cooling, and a new concrete-encased duct bank to reroute fiber optic cabling to the building.

This alternative also includes power meters for each 480-volt main circuit, a new 480-volt MCC in the new unit substation building to serve miscellaneous building and HVAC loads, new concrete-encased duct bank from the existing manhole southeast of the Effluent Building to the new substation building, and the replacement of MCCs in Storage Building No. 3 and Shop Building No. 1. Redundant 2,000 kVA transformers with fused, medium-voltage primary switches are assumed in this alternative.

Alternative USUB No. 3—Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13

Alternative USUB No. 3 would replace unit substation U12 with one new indoor unit substation located near the Effluent Building, and unit substations U11 and U13 would be removed entirely. Unit substation U11 loads would be refeed from unit substation U14 located in the Metrogro Pump Station. The two MCCs in Storage Building No. 3 that are currently fed from unit substation U11 would be replaced with one new MCC that could be powered from nearby unit substation U15. Unit substation U13 would be removed entirely and its existing loads would be refeed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

This alternative includes one new unit substation to feed the existing 480-volt loads currently fed from unit substation U12. The unit substation would also include additional capacity to serve potential future equipment associated with plant process expansion west of the Effluent Building. This substation would be housed in an extension of the existing Effluent Building with a below-grade cable vault and heating and mechanical cooling. New concrete-encased duct bank with new power feeds to the MCCs in Aeration Control Building No. 4 (from U14 to the West Blower Building) and from the existing U12 location to the new U12 location are also provided in this alternative.

This alternative also includes power meters for each 480-volt main circuit, a new 480-volt MCC in the new unit substation building to serve miscellaneous building and HVAC loads, and the replacement of MCCs in Storage Building No. 3 and Shop Building No. 1. Redundant 1,500 kVA transformers with fused, medium-voltage primary switches are assumed in this alternative.

This alternative would provide the District with an opportunity to upgrade the existing unit substation U14 480-volt distribution switchboards with draw-out switchgear construction. This switchgear installation is included in the opinion of probable construction cost for this alternative.

Key Risks and Issues

The key social, environmental, and other nonmonetary considerations of each alternative are summarized in Table 1.

Table 1 - Unit Substation Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
Alternative USUB No. 0– No Change (Null Alternative)	<ul style="list-style-type: none"> ▪ None 	<ul style="list-style-type: none"> ▪ Unit substation equipment is operating beyond its expected service life and the potential for equipment failure will increase as equipment ages. ▪ Unit substation equipment enclosures are severely rusted, which increases the likelihood of damage to equipment from rain, snow, and rodent intrusion.
Alternative USUB No. 2– Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13	<ul style="list-style-type: none"> ▪ Replacing aging unit substation equipment would address concerns with the potential for increased equipment failures. ▪ One new unit substation is being installed while three unit substations are being removed, two of which are currently located near roadways/parking lots. ▪ New equipment would be located inside of a building, which helps equipment last longer and provides a safer environment for operating and maintaining the equipment. ▪ Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events. 	<ul style="list-style-type: none"> ▪ The only location central to the loads served by the new unit substation impedes on an existing storage lot area and might require earthwork to avoid restricting the drainage swale.
Alternative USUB No. 3– Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13	<ul style="list-style-type: none"> ▪ Replacing aging unit substation equipment would address concerns with the potential for increased equipment failures. ▪ One new unit substation is being installed while three unit substations are being removed, two of which are currently located near roadways/parking lots. ▪ This alternative takes advantage of spare capacity in existing unit substations U2, U14, and U15 to feed loads currently served by existing unit substations U11 and U13. ▪ New unit substation U12 equipment would be located inside of a building, which helps equipment last longer and provides a safer environment for operating and maintaining the equipment. ▪ Replacing aging medium-voltage cable would address concerns with aging conductor insulation that could lead to future arc-fault events. 	<ul style="list-style-type: none"> ▪ Any NSWTP process expansion to the west would require longer power feeds from unit substation U12 and/or unit substation U14.

Economic Analysis

The opinion of capital cost developed for the Liquid Processing Facilities Plan is presented below. There are no upfront costs associated with Alternative USUB No. 0. There would be future costs associated with the time and materials required for District maintenance staff to troubleshoot and repair unit substation equipment as it fails, which are not able to be reliably estimated.

USUB Alternatives Opinion of Probable Construction Cost Summary

	Alternative USUB No. 0– No Change (Null Alternative)	Alternative USUB No. 2– Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13	Alternative USUB No. 3– Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13
Total Opinion of Capital Cost	\$-	\$3,227,000	\$3,136,000

An economic analysis comparing the use of indoor and outdoor transformers at the unit substation was also conducted as part of the 2016 Liquid Processing Facilities Plan. This analysis indicated that outdoor transformers may be more cost-effective when the increased building cost and HVAC requirements are considered for indoor transformers. A more detailed analysis during project design is recommended to determine the potential operating cost savings associated with using indoor or outdoor transformers.

Project Recommendation

The recommended unit substations U11, U12, and U13 Replacement alternative is Alternative USUB No. 3. This alternative replaces three existing unit substations with one unit substation and takes advantage of existing electrical capacity in unit substations U2, U14, and U15 to power existing loads currently served by unit substations U11 and U13.

This alternative does require some plant roadway reconstruction associated with new concrete-encased duct bank conduits that would need to be routed from unit substation U14 to the West Blower Building. However, reusing existing unit substation capacity would reduce the size of the new unit substation building and electrical equipment, which would reduce upfront equipment and installation costs.

Project Schedule:

	Start Date	Completion Date
Planning	2016	2017
Design	2018	2018
Construction	2019	2020

Financial Summary (2019\$):

Total Project Cost	
District Staff & Engineering	\$542,000
Contractor	\$2,742,000
Total	\$3,284,000

Fiscal Allocation (2019\$):

	2017	2018	2019	2020
Engineering	\$5,000	\$149,000	\$154,000	\$234,000
Construction	\$0	\$0	\$274,000	\$2,468,000
Total	\$5,000	\$149,000	\$428,000	\$2,702,000