

APPENDIX F

TECHNICAL EVALUATION REPORT SUMMARY

MODULAR WETLAND SYSTEM STORMWATER TREATMENT SYSTEM PERFORMANCE MONITORING

Prepared for
Modular Wetland Systems, Inc.

Prepared by
Herrera Environmental Consultants, Inc.



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(FULL REPORT AVAILABLE UPON REQUEST)

MODULAR WETLAND SYSTEM STORMWATER TREATMENT SYSTEM PERFORMANCE MONITORING

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EXECUTIVE SUMMARY

Modular Wetland System - Linear filtration system (MWS-Linear) is a water quality treatment system consisting of a pre-treatment chamber, a media cartridge pre-filter, a wetland biofiltration chamber, and an outlet control device. The system is housed in a precast concrete vault and can be designed in numerous configurations including piped, curb or grated inlet structures.

From April 2012 through May 2013, Herrera Environmental Consultants, Inc. (Herrera) conducted hydrologic and water quality monitoring of a MWS-Linear for Modular Wetland Systems, Inc. at one approved test installation in Portland, Oregon. Herrera conducted this monitoring to obtain performance data to support the issuance of a General Use Level Designation (GULD) for the MWS-Linear by the Washington Department of Ecology (Ecology). Monitoring was performed in accordance with procedures described in *Guidance for Evaluating Emerging Stormwater Treatment Technologies; Technology Assessment Protocol - Ecology (TAPE)* (Ecology 2011).



Installation of the monitored MWS-Linear system at the Albina Maintenance Facility in Portland, Oregon.

This technical evaluation report (TER) was prepared by Herrera to demonstrate satisfactory performance of the MWS-Linear in meeting the minimum requirements as specified by Ecology (2011) for basic treatment, phosphorus treatment, and enhanced treatment.

Sampling Procedures

To evaluate the stormwater treatment performance of the MWS-Linear based on Ecology's TAPE guidelines, a test system was installed at the Portland Bureau of Environmental Services Albina Maintenance Facility in Portland, Oregon (Figure 1). This system is identified herein as the Albina Modular Wetland System (AMWS). Automated monitoring equipment was installed to continuously measure influent, effluent, and bypass flow volumes. Automated equipment was used to collect flow-weighted composite samples of the system's influent and effluent during 28 separate storm events in the monitoring period. The collected flow-weighted composite samples were analyzed for the following water quality parameters:

- Total suspended solids (TSS)
- Particle size distribution (PSD) (influent only)

- Total and dissolved copper
- Total and dissolved zinc
- Total phosphorus (TP)
- Soluble reactive phosphorus (SRP)
- Hardness
- pH

These data were subsequently analyzed in the following ways:

- Computation of pollutant removal efficiencies with bootstrap confidence intervals
- Statistical comparisons of influent and effluent concentrations
- Correlation analysis to examine the influence of treated flow rate on system performance

These results were then compared to TAPE minimum requirement goals for basic, phosphorus, and enhanced treatment.

Hydrologic Performance

The water quality treatment goal for the test system was to capture and treat 91 percent of the average annual runoff volume. Monitoring data showed that stormwater bypassed the AMWS test system during 49 out of 81 monitored events during the 14-month monitoring period. The system was able to treat 75 percent of the total volume that entered the system over this period. Consequently, the goal of treating 91 percent of the volume from the site was not achieved. This was most likely due to the high level of fine clay content of the runoff resulting in clogging of the media cartridge pre-filter located in the pre-treatment chamber (see *Maintenance Schedule*). In addition, analysis of the flow data at the end of the project indicated that the system was undersized for the basin. On average, a 1.54-inch storm (6-month storm for the region) produced a 102.6 gallons per minute peak discharge. The system was only sized to treat 41 gallons per minute.

During the monitoring period, it appeared that the wetland chamber's biofiltration media did not experience a substantial decrease in flow capacity indicating that the pre-treatment prevented the wetland media from clogging. There was a negative trend over time for treated flow rate during bypass due to accumulation of fine sediment on the pre-filter media. On average, the pre-filters required changing every 2 to 3 months. This frequency of maintenance was due, in large part, to the high clay content of the runoff from the Albina site. Under more typical stormwater loading conditions, it is anticipated that the pre-filter media will last 6 to 24 months before the media is required to be removed and replaced. Furthermore, since no flow decrease was observed in the WetlandMedia, it is anticipated that the wetland chamber will not require maintenance for several years. It should also be noted that with the inclusion of additional pre-filter cartridges the maintenance interval would

likely have been extended. The required number of pre-filters should be determined on a site specific basis.

Water Quality Performance

Basic Treatment

The basic treatment goal in the TAPE guidelines is 80 percent removal of total suspended solids for influent concentrations ranging from 100 to 200 milligrams per liter (mg/L). For concentrations less than 100 mg/L, facilities must achieve an effluent goal of 20 mg/L pursuant to TAPE guidelines.

Total suspended solids removal rates ranged from 61 to 98 percent, with a mean value of 84.9 percent. The upper 95 percent confidence interval about the mean effluent concentration was 12.8 mg/L. The TAPE effluent goal is 20 mg/L or less, therefore the Basic water treatment criteria were met. Analyses of flow and water quality data indicated the treatment goal for total suspended solids removal was met up to and through the design flow rate of 41 gallons per minute (gpm) (equivalent of 1 gpm/ft² of media loading rate) for the MWS-Linear and even exceeded treatment goals at 50 gpm (1.21 gpm/ft²).

Phosphorus Treatment

The phosphorus treatment goal in the TAPE guidelines is 50 percent removal of total phosphorus for influent concentrations ranging from 0.1 to 0.5 mg/L.

A bootstrap estimate of the lower 95 percent confidence limit (LCL95) of the mean total phosphorus reduction was 61.7 percent. Consequently, it can be concluded that the mean percent removal was significantly greater than the 50 percent goal specified in the TAPE guidelines. The system also exhibited removal rates greater than 50 percent up to and through the design flow rate of 41 gpm and even exceeded treatment goals at 50 gpm (1.21 gpm/ft²).

Enhanced Treatment

The dissolved zinc treatment goal in the TAPE guidelines is 60 percent removal for influent concentrations ranging from 0.02 to 0.3 mg/L. The dissolved copper treatment goal is 30 percent removal for influent concentrations ranging from 0.005 to 0.02 mg/L. The lower 95 percent confidence limit of the mean percent removal was 60.5 and 32.5 percent for dissolved zinc and dissolved copper, respectively. These data indicate that the TAPE removal criteria were met for both dissolved zinc and dissolved copper. Treatment above the TAPE criteria of 60 percent removal was evident in the dissolved zinc results from treated flow rates up to and including the design flow rate of 41 gpm. Dissolved copper treatment was only evident up to 28 gpm; however, if lab data from 2007 are added to the data set, the flow rate at which 30 percent dissolved copper reduction can be achieved increases to the design flow rate of 41 gpm (1 gpm/ft² of media).

INTRODUCTION

The Modular Wetland Systems - Linear (MWS-Linear) is a structural stormwater treatment system developed by Modular Wetland Systems, Inc. The MWS-Linear utilizes a multi-stage treatment processes, including a pre-treatment chamber that houses a settling basin and a media cartridge pre-filters that are designed to remove coarse to fine sediment and hydrocarbons from entering the subsequent wetland chamber. The wetland chamber media provides chemical and biological filtration and secondary physical filtration. This system is housed in a modular precast concrete structure that can be designed in many inlet configurations. The MWS-Linear provides water quality treatment of captured flows through the processes of separation, sedimentation, filtration, adsorption, absorption, sequestration, volatilization, ion exchange, biological remediation, and uptake.

The Washington State Department of Ecology (Ecology) has established specific use level designations for emerging stormwater treatment technologies like the MWS-Linear in accordance with guidelines that are identified by Ecology (2011) in *Technical Guidance for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol - Ecology (TAPE)*.

There are three use level designations: pilot, conditional, and general. Pilot and conditional use level designations allow limited application of emerging stormwater treatment technologies in western Washington to facilitate field testing. If the testing shows that the treatment technology meets minimum treatment goals as identified in the TAPE, Ecology may issue a general use level designation (GULD) for the treatment technology, permitting its widespread use in Washington.

TAPE guidelines indicate that a technical evaluation report (TER) must be completed for any stormwater treatment system under consideration for a GULD. Specifically, the TER should document treatment performance of a technology to show that it will achieve Ecology's performance goals for target pollutants, as demonstrated by field testing performed in accordance with the TAPE.

This document is the TER for the MWS-Linear, and was prepared by Herrera -to demonstrate satisfactory performance of the MWS-Linear in meeting treatment goals specified by Ecology (2011) for basic treatment, total phosphorus and enhanced treatment. It specifically presents data from a test MWS-Linear installed at the Portland Maintenance Bureau Albina Maintenance Facility (Figure 1). This monitoring was performed over a 14-month period, from April 14, 2012, through May 31, 2013.

SAMPLING PROCEDURES

This section describes the sampling procedures that were used to evaluate the performance of the MWS-Linear. It begins with a general overview of the monitoring design and describes the specific goals Ecology has established for the types of treatment that are being sought under the GULD. Separate sections then describe in more detail the site location, test system, monitoring schedule, and the specific procedures used to obtain the hydrologic and water quality data, respectively. Analytical methods, quality assurance and control measures, data management procedures, and data analysis procedures are also discussed.

Monitoring Design

To facilitate performance monitoring pursuant to the TAPE procedures, a 4- by 13-foot (ID) MWS-Linear unit (Model # MWS-L-4-13) was installed for testing purposes at the Portland Bureau of Maintenance Albina Maintenance Facility, which is located at North Mississippi and North Monroe Street in Portland, Oregon (Figure 1). This system is identified herein as the Albina Modular Wetland System (AMWS).

Automated equipment was installed in conjunction with the AMWS system to facilitate continuous monitoring of influent, effluent, and bypass flow volumes over a 14-month period extending from April 14, 2012, through May 31, 2013. In association with this hydrologic monitoring, automated samplers were also employed to collect flow-weighted composite samples of the influent and effluent during discrete storm events for subsequent water quality analyses.

Using the data obtained from the AMWS monitoring, removal efficiencies and effluent concentrations were characterized for targeted monitoring parameters. These data were subsequently compared to goals identified in the TAPE to support the issuance of a GULD for the MWS-Linear.

These treatment goals are described below for the three types of treatment that are under consideration for inclusion in the GULD:

1. **Basic Treatment** - 80 percent removal of total suspended solids for influent concentrations that are greater than 100 mg/L, but less than 200 mg/L. For influent concentrations greater than 200 mg/L, a higher treatment goal may be appropriate. For influent concentrations less than 100 mg/L, the facilities are intended to achieve an effluent goal of 20 mg/L total suspended solids.
2. **Phosphorus Treatment** - 50 percent removal of total phosphorus for influent concentrations ranging from 0.1 to 0.5 mg/L
3. **Dissolved Metals Treatment** - 30 percent removal of dissolved copper when influent concentrations range from 0.005 to 0.02 mg/L and 60 percent removal of dissolved zinc when influent concentrations range from 0.02 to 0.3 mg/L

Site Location

The AMWS system was installed at the Portland Bureau of Maintenance Albina Maintenance Facility, which is located at North Mississippi Avenue and North Monroe Street in Portland, Oregon (Figure 1). The Facility includes a parking lot for trucks and heavy equipment as well as outdoor storage of stockpiles of rock and dirt debris and miscellaneous snow removal equipment. Stormwater from the parking area for trucks and heavy equipment on the south side of the facility is collected in a series of catch basins along the western edge of the lot. Stormwater was conveyed from this system to Portland's municipal drainage system. The AMWS system received stormwater runoff from this parking area, and the treated effluent from the system was then discharged into the existing municipal drainage system before discharging via outfall to the Willamette River.

The drainage area for this parking lot and storage areas is approximately 0.45 acres (see site map in Figure 6 for delineation), and generally slopes from the east to the west with a grade of approximately 5.0 percent. The installation location for the MWS-Linear system within this drainage basin is designated "AMWS" in Figure 6.

Monitoring Schedule

Hydrologic and water quality monitoring were conducted at the AMWS test system over a 14-month period April 14, 2012, through March 31, 2013. During this monitoring period, 28 separate storm events were successfully sampled.

Test System Description

The AMWS test unit consists of a 4- by 13-foot ID vault with an 18.4-foot perimeter biofiltration bed (WetlandMedia), and had a piped inflow configuration (Figure 3). The Modular Wetland System Linear was constructed with an 8-inch smooth-walled PVC inlet pipe that enters the northeast wall of the pre-treatment chamber. Water exits the system through a 12-inch smooth-walled PVC outlet pipe located on the northeast wall of the discharge chamber.

In order to simplify monitoring, the AMWS was installed with an upstream external bypass weir (Figures 6 and 7). This configuration made it possible to segregate treated and bypassed flows for quantity and quality monitoring. The bypass weir was adjustable in order to maintain a specified driving head in the AMWS. The weir was adjusted to route the design flow rate of 41 gpm to the system before bypass occurred. The internal bypass piping was capped to prevent internal bypass flows from affecting estimates of treated effluent flow rates and chemistry.