WASHINGTON STATE
DEPARTMENT OF CORRECTIONS

THURSTON COUNTY **WASHINGTON**

MCNEIL ISLAND BOATYARD GENERAL PERMIT STORMWATER TREATMENT ENGINEERING REPORT

G&O #13586
REVISED SEPTEMBER 2014

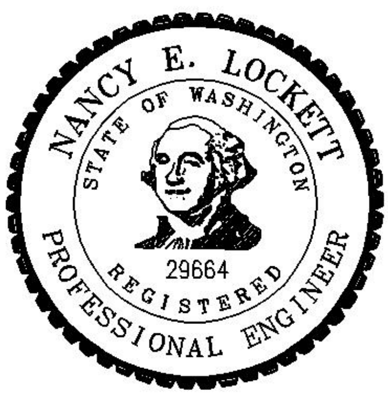
Gray & Osborne, Inc.
CONSULTING ENGINEERS

WASHINGTON STATE
DEPARTMENT OF CORRECTIONS

THURSTON COUNTY **WASHINGTON**

Working Together for Safe Communities
DOC
Washington State
DEPARTMENT OF CORRECTIONS

MCNEIL ISLAND BOATYARD GENERAL PERMIT STORMWATER TREATMENT ENGINEERING REPORT



G&O #13586
REVISED SEPTEMBER 2014

Gray & Osborne, Inc.
CONSULTING ENGINEERS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

PROJECT DESCRIPTION

The Washington State Department of Corrections owns and operates the McNeil Island Boatyard. The boatyard conducts Boat Building and Repairing activities (Standard Industrial Code 3732) on the fleet of vessels owned by the State of Washington to transport goods and personnel to McNeil Island. The boatyard is covered under NPDES Permit WAG031038 (Boatyard General Permit, WAG030000). The Boatyard General Permit includes stormwater effluent discharge limitations as well as a prohibition on discharge of pressure wash wastewater to surface water. A Level Two response requirement had been triggered under the previous Boatyard General Permit. This Stormwater Treatment Engineering Report has been prepared to discuss stormwater treatment alternatives and provide preliminary design, construction, and operation and maintenance information for the stormwater treatment alternative which will be permanently installed at the boatyard. Until such time as a permanent treatment system is installed an interim treatment system as described in this report will be in operation at the boatyard.

FACILITY LOCATION AND CHARACTERISTICS

The McNeil Island Boatyard is located on the south shore of McNeil Island at approximately latitude 47.1947 N, longitude – 122.656 W, on Still Harbour Road, McNeil Island, Washington 98303. The location of the boatyard is shown on Figure 1. Stormwater runoff from the boatyard discharges directly to Puget Sound. The boatyard covers an area of approximately 1.59 acres, approximately 69 percent of which is hard packed gravel and concrete and 31 percent is buildings. Figure 2 shows the area included in the boatyard and current stormwater discharge locations. Ninety-three percent of the boatyard is not directly affected by the vessel maintenance activities, but includes buildings with asphalt shingled roofs, hard-packed gravel driving/parking areas, and small concrete pads adjacent to the buildings. In addition, approximately 0.17 acre of building roof area outside of the designated boatyard is tributary to the boatyard. This building is not used for boatyard activities and is off limits for any use due to the presence of lead paint in the interior of the building. All vessel washing, painting, and repair activities take place in the approximately 4,800-square-foot marineway. The boatyard has the capacity to service or maintain one vessel at any given time. Approximately four vessels are hauled out of the water per year and only the vessels hauled out of the water are pressure washed. In the event of an emergency repair, i.e., broken shaft, the vessel will be hauled out, but not pressure washed, and returned to service as quickly as possible. Maintenance activity is conducted year-round; the majority of the work takes place in the spring, summer, and fall.

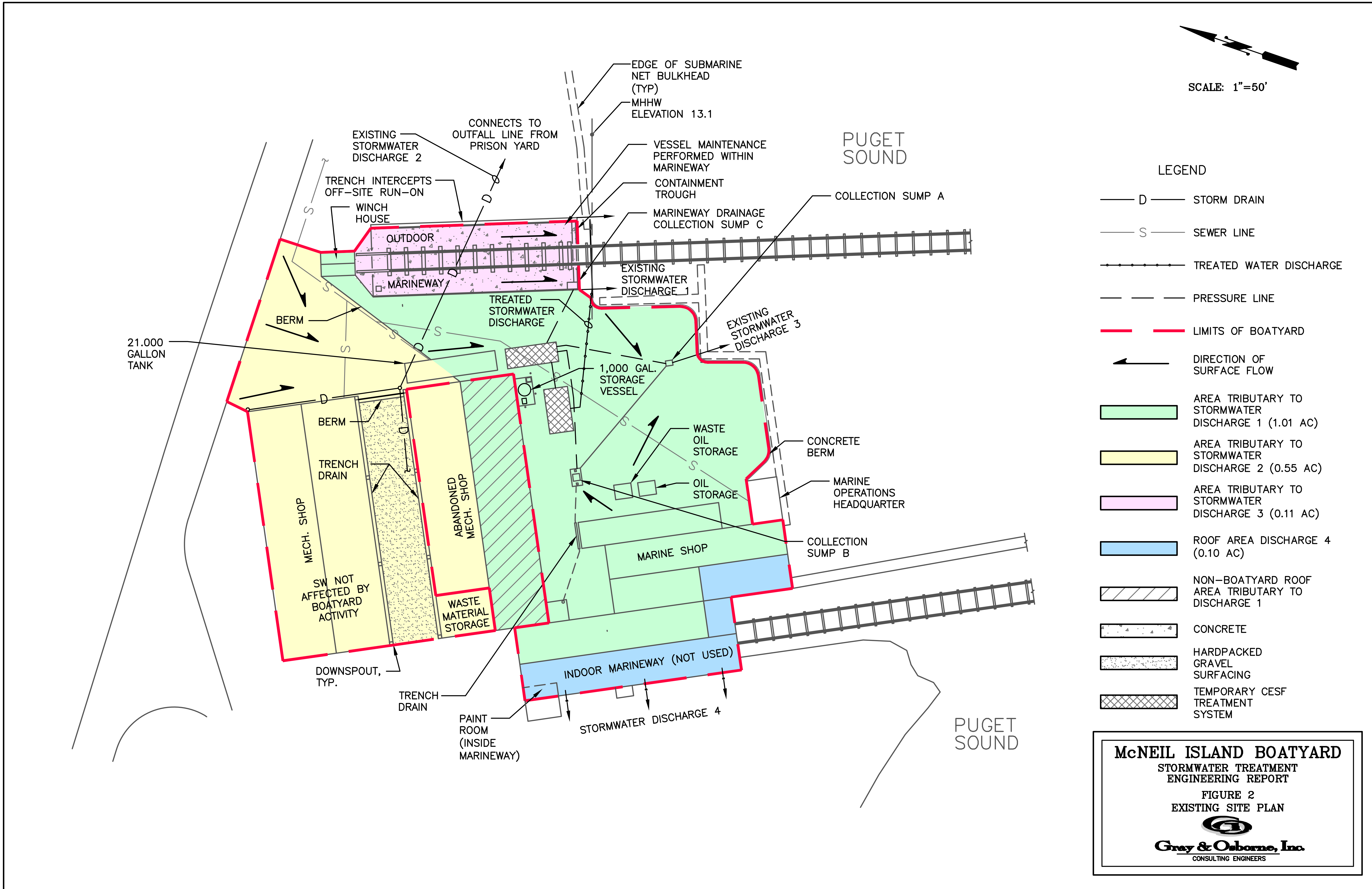
SUMMARY OF BOATYARD ACTIVITIES

The McNeil Island fleet includes three passenger ferries, three tugs and three barges. In addition to the transportation fleet, the state operates a fireboat and three patrol boats that serve McNeil Island. The fireboat and patrol boats are not hauled out at the boatyard.

Source: Washington State Coastal Atlas

N

McNeil Island Boatyard
Stormwater Treatment Engineering Report
Figure 1
Vicinity Map


SCALE: 1"=50'
PUGET SOUND
EDGE OF SUBMARINE NET BULKHEAD (TYP)
MHHW ELEVATION 13.1
EXISTING STORMWATER DISCHARGE 2
CONNECTS TO OUTFALL LINE FROM PRISON YARD
TRENCH INTERCEPTS OFF-SITE RUN-ON
WINCH HOUSE
VESSEL MAINTENANCE PERFORMED WITHIN MARINEWAY
CONTAINMENT TROUGH
MARINEWAY DRAINAGE COLLECTION SUMP C
COLLECTION SUMP A
OUTDOOR MARINEWAY
EXISTING STORMWATER DISCHARGE 1
TREATED STORMWATER DISCHARGE
EXISTING STORMWATER DISCHARGE 3
BERM
21,000 GALLON TANK
1,000 GAL. STORAGE VESSEL
WASTE OIL STORAGE
OIL STORAGE
CONCRETE BERM
MARINE OPERATIONS HEADQUARTER
COLLECTION SUMP B
BERM
TRENCH DRAIN
MECH. SHOP
ABANDONED MECH. SHOP
SW NOT AFFECTED BY BOATYARD ACTIVITY
WASTE MATERIAL STORAGE
MARINE SHOP
INDOOR MARINEWAY (NOT USED)
DOWNSPOUT, TYP.
TRENCH DRAIN
PAINT ROOM (INSIDE MARINEWAY)
STORMWATER DISCHARGE 4
PUGET SOUND
LEGEND
STORM DRAIN
SEWER LINE
TREATED WATER DISCHARGE
PRESSURE LINE
LIMITS OF BOATYARD
DIRECTION OF SURFACE FLOW
AREA TRIBUTARY TO STORMWATER DISCHARGE 1 (1.01 AC)
AREA TRIBUTARY TO STORMWATER DISCHARGE 2 (0.55 AC)
AREA TRIBUTARY TO STORMWATER DISCHARGE 3 (0.11 AC)
ROOF AREA DISCHARGE 4 (0.10 AC)
NON-BOATYARD ROOF AREA TRIBUTARY TO DISCHARGE 1
CONCRETE
HARDPACKED GRAVEL SURFACING
TEMPORARY CESF TREATMENT SYSTEM
McNEIL ISLAND BOATYARD
STORMWATER TREATMENT ENGINEERING REPORT
FIGURE 2
EXISTING SITE PLAN
Gray & Osborne, Inc.
CONSULTING ENGINEERS

Activities conducted at the facility include:

- Pressure washing;
- Bottom- and topside painting;
- Engine, prop, shaft, and rudder repair;
- Hull welding and grinding;
- Hull repair, joinery, and bilge cleaning;
- Transfer of fuel from the vessel to a tank truck;
- Lubrication; and
- Other activities necessary to maintain a vessel.

Routine maintenance of the vessels includes pressure washing of the hulls, hull and above-water exterior and interior painting, engine repair, propeller, shaft and rudder repair, bilge cutting or scaling with a pneumatic needle gun or scraping with a wire brush is done when rust removal is required prior to painting or hull repair. Painting and maintenance of the vessels is confined to the concrete outdoor marineway pad.

The boatyard work schedule is 8:00 a.m. to 4:00 p.m., 5 days per week, weather permitting. Hull maintenance activities are not conducted during periods of high tide or rain.

The boatyard has implemented Best Management Practices (BMPs) to control pollutant discharge from the boatyard. The BMPs include management of hull pressure wash wastewater separately from stormwater runoff, evaporation of the collected pressure wash water, good housekeeping practices which require thorough cleaning of the marineway at the end of each work day, the use of tarps during hull preparation and painting, indoor storage of zinc anodes and storage of all oils, and secure indoor storage of all paints and other materials utilized in the maintenance of the vessels. A full description of BMPs implemented at the boatyard are included in the McNeil Island Boatyard Stormwater Pollution Prevention Plan (SWPPP), 2014.

WASTEWATER CHARACTERIZATION

The 1.59-acre boatyard consists of entirely impervious surface. Stormwater runoff is generated from the 4,600-square-foot concrete marineway, approximately 43,000 square feet of gravel parking lot and approximately 21,500 square feet of asphalt shingled roofs. Historically, the boatyard collected stormwater samples at the waterward end of the marineway.

Approximately 0.65 acre of the boatyard includes roofs and gravel areas that are not affected by boatyard activities and discharge to Outfall 2 or to the ground to the west of the indoor marineway. This 0.65 acre is not tributary to a stormwater treatment facility and will not be included in sizing calculations for a permanent treatment facility. The

0.17 acre of non-boatyard roof area that discharges stormwater to the boatyard will be included in the sizing calculations. A total of 1.29 acres is tributary to a permanent treatment system.

Version 3 of the Western Washington Hydraulic Model (WWHM3) was used to determine the water quality treatment volume for the boatyard area. The WWHM3 model input and results are included in Appendix A.

Per the WWHM3 model the 24-hour water quality flow volume is 0.1643 acre-feet (average flow of 37 gpm over 24-hour period). The offline standard flow rate is 0.1274 cubic feet per second (cfs) (57 gpm).

Per NPDES Permit WAG031038 boatyards discharging stormwater to Waters of the State must conduct activities in a manner that is consistent with the terms and conditions of the permit, including the following:

1. General Prohibitions – All facilities must manage stormwater discharges to prevent each of the following:

    a. The discharge of synthetic, natural or processed oil, or oil-containing products;

    b. The discharge of floating materials; and

    c. A visible change in turbidity or color in the receiving water.

The discharge of process wastewater is prohibited.

2. Facilities discharging stormwater to fresh and marine waters must meet the following benchmarks:

Parameter	Seasonal Average Benchmark	Maximum Daily Benchmark
Copper, total (µg/L)	50	147
Zinc, total (µg/L)	85	90
Lead, total (µg/L)(1)	—	185

(1) Required for discharge to Lake Union and the Ship Canal only; however, this will be used as a goal.

Grab sample monitoring data reported on the Daily Monitoring Reports (DMRs) from January 2010 to present are shown in Table 1. Permit benchmarks prior to the current permit, issued on March 2, 2011, included oil/grease (6.0 mg/L), total suspended solids (21 mg/L), and total recoverable copper (229 µg/L). Historically, stormwater from the entire boatyard was not collected and stormwater runoff samples were taken at the marineway only.

TABLE 1

Stormwater Monitoring Data (Marineway Trough) (January 2010 to present)

Date	Copper, Total (µg/L)	Zinc, Total (µg/L)	Lead, Total (µg/L)	Total Suspended Solids (mg/L)	BOD (mg/L)	Oil and Grease (mg/L)	Notes
January 15, 2010	11.2			5.0		14	
April 15, 2010							No Discharge
May 24, 2010	1,670			45		<2.0	
September 30, 2010							No Discharge
October 25, 2010	168			5.0		<2.0	
January 31, 2011							No Discharge
October 31, 2011							No Discharge
February 2, 2012	180			4.0		<2.0	
May 3, 2012	390			33		<2.0	
September 30, 2012							No Discharge
October 26, 2012	294	71.3	0.6	2.0		<2.0	
December 19, 2012					2.4		No Discharge
January 31, 2013							No Discharge
April 30, 2013							No Discharge
October 2, 2013	0.7	249	4.0				
December 23, 2013 (Visqueen)	94.5	431	4.9				
December 23, 2013 (Concrete)	301	380	6.3				
February 18, 2014 (Shipway)	259	202	18.5				

Copper and zinc have historically been present in excess of discharge standards in the stormwater discharge from the marineway. Potential stormwater treatment options will target these metals.

STORMWATER COLLECTION

Stormwater is collected in sumps, two in the parking lot and one located across the waterward end of the marineway, and pumped to a 21,000 gallon holding tank.

The marineway may become flooded with brackish water from Puget Sound during high tide events. The brackish water must be excluded from entering the treatment system. A tide operated float disables the marineway sump pump when the tide reaches the elevation where inundation of the marineway is imminent. Vessel washing, repair or maintenance is not conducted during periods of high tide or rain.

In the event that brackish water is collected in the 21,000-gallon holding tank the treatment system will be shut-down. Depending upon antecedent precipitation, the collected brackish water will be handled in one of two ways.

1. If there has been measureable precipitation (24-hour precipitation greater than 0.1 inches) in the previous 5 days a grab sample of the contents of the 21,000-gallon holding tank will be tested for metals content by a certified laboratory. If the levels of lead, copper and zinc are below the Maximum Daily Benchmark for discharging stormwater to fresh or marine waters (Copper, Total - 147 μg/L, Zinc, Total - 90 μg/L and Lead, Total – 185 μg/L) the contents of the 21,000-gallon holding tank will be released at the end of the marineway. Boatyard staff will notify Ecology that the contents of the holding tank will be discharged without treatment. If the level of any of the metals exceeds the Maximum Daily Benchmark the contents of the 21,000 gallon tank will be handled in one of three ways: (1) the contents of the holding tank will be sent through the stormwater treatment system and the treatment system components will be evaluated to determine which of the system components will need to be replaced as a result of treating brackish water; (2) the brackish water will be stored indoors in 55-gallon drums or in 4,000-gallon poly tanks prior to shipment to an off-island treatment system; or (3) the brackish water will be treated through the evaporation unit.

2. If there has not been measureable precipitation (24-hour precipitation greater than 0.1 inches) in the previous 5 days prior to brackish water entering the stormwater system the Boatyard staff will determine the salinity of the contents of the holding tank and Puget Sound in the immediate vicinity of the boatyard with a salinity meter. If the sample indicates that the salinity content of the holding tank is within 10 percent of the salinity concentration of the seawater in the vicinity of the boatyard, boatyard stall will notify Ecology that the contents of the holding tank will be discharged without treatment. If the salinity is not within 10 percent of the salinity of seawater in the vicinity of the boatyard a grab sample of the contents of the 21,000-gallon holding tank will be tested for metals content by a certified laboratory. If the levels of lead, copper and zinc are below the Maximum Daily Benchmark for discharging stormwater to fresh or marine waters (Copper, Total - 147 μg/L, Zinc, Total - 90 μg/L and Lead, Total - 185 μg/L) the contents of the 21,000 gallon holding tank will be released at the end of the marineway. Boatyard staff will notify Ecology that the contents of the holding tank will be discharged without treatment. If the level of any of the metals exceeds the Maximum Daily Benchmark the contents of the 21,000-gallon tank will be handled in one of three ways: (1) the contents of the holding tank will be sent through the stormwater treatment system and the treatment system components will be evaluated to determine which of the system components will need to be

replaced as a result of treating brackish water; (2) the brackish water will be stored indoors in 55-gallon drums or in 4,000-gallon poly tanks prior to shipment to an off-island treatment system; or (3) the brackish water will be treated through the evaporation unit.

INTERIM TREATMENT SYSTEM

An interim treatment system sized to treat 50 gpm consisting of mechanical filtration, granular activated carbon and ion exchange will replace the existing temporary Chitosan Enhanced Sand Filtration Package treatment system until a permanent treatment system is installed. The interim treatment system includes the following components:

Stormwater Collection Tank – 21,000-gallon above grade tank. Stormwater from the marineway and parking lot will be collected in this tank prior to pumping into the treatment system.

Treatment System Pump – (1) High pressure treatment system pump (50 gpm).

Mechanical Filtration – (2) Mechanical bag filtration housings plumbed in parallel to provide filtration down to 5 micron for reduction of TSS, turbidity, debris, and particulate matter (organic or inorganic) above 5 microns. The bag filtration step is followed in series by (2) Mechanical cartridge filtration housings plumbed in parallel to provide filtration down to 1 micron for removal of particulate turbidity and particulate phase metals.

Granular Activated Carbon (GAC) – (1) 18 cubic foot granular activated carbon (GAC) vessel to reduce dissolved organic compounds (hydrocarbons, biological agents and other compounds commonly utilized at boatyards).

Ion Exchange Resins - (1) 18 cubic foot ion-specific ion exchange vessel which acts as final polishing for reduction of dissolved metals such as copper, zinc and lead. Ion specific exchange media will be provided in sodium form to reduce the potential for media exhaustion when brackish water is encountered.

The interim treatment system is similar to the system the supplier, Clear Creek Systems, Inc., has installed at the Norland Boat Company, Tacoma, Washington in the fall of 2011. According to Clear Creek Systems Inc., the Norland Boat Company has maintained compliance with the Boatyard General Permit Benchmarks since implementation of the treatment system (Clear Creek Systems, Inc., Correspondence, July 22, 2014).

OPTIONS FOR MEETING BENCHMARKS

The McNeil Island Boatyard submitted a Level Two Response report on February 3, 2009, to address corrective actions to prevent further exceedances of the copper and solids benchmarks in effect at that time. Ecology participated in an inspection of the boatyard which occurred on December 10, 2008. The following corrective actions were identified as completed in the Level Two Response report dated February 3, 2009.

1. *The monitoring location was relocated to the marineway. The previous monitoring location was not in an area where boatyard activities were occurring. The area around the marineway was graded to prevent run on of contaminates from recent resurfacing of the areas surrounding the marineway. Regrading was completed in January 2009.*

2. *Material storage drums were relocated to a storage building. A new berm was ordered for the bilge waste tank.*

3. *A copy of the current boatyard permit was included with the Stormwater Pollution Prevention Plan (SWPPP).*

4. *Potential stormwater treatment structures proposed to reduce stormwater contaminates are:*

    a. *Grade parking lot to a level below ship railway cement to prevent runoff of contaminates onto railways.*

    b. *McNeil Island Corrections Center will submit a funding request for the next biennium process that, if approved, will enable the parking lot to be paved with asphalt.*

The current SWPPP for the boatyard addresses stormwater runoff from the entire 1.59-acre site, not just runoff generated on the marineway. Recent stormwater sampling results indicate that the discharge benchmarks for copper and zinc have not been consistently met. The corrective measures discussed in the Level Two report dated February 2009 have not been adequate to ensure compliance with the benchmark pollutant levels. The Department of Corrections will install a permanent stormwater treatment system to enable the boatyard to be in compliance with the Boatyard General Permit. This report will discuss treatment options available for the stormwater runoff from the entire boatyard and provide preliminary design of the selected treatment system.

Stormwater treatment technologies evaluated for use at the McNeil Island Boatyard include a passive adsorptive filtration technology, which for the purposes of this report is the StormwateRx® Aquip™ (Aquip), a Chitosan Enhanced Sand Filtration (CESF) system package plant consisting of a treatment train including settling tanks, a chitosan injection, a sand filtration, granular activated carbon (GAC), and Ion Exchange Resins (IX) and the Mechanical Filtration/Ion Exchange package treatment system (interim system) consisting of a bag and cartridge filter, GAC and ion exchange resins.

PASSIVE ADSORPTIVE FILTRATION TECHNOLOGY

Passive adsorptive filtration technology, such as the StormwateRx® Aquip™, is designed specifically for reduction of stormwater pollutants such as turbidity and metals from industrial sites, including boatyards. The StormwateRX® Aquip™ filter system is used in similar applications in Puget Sound and has received Conditional Use Level Designation (CULD) for Basic, Enhanced, and Phosphorous Treatment from the State of Washington Department of Ecology (January 2013). The system uses a pretreatment chamber followed by a series of inert and adsorptive filtration media to trap pollutants. The filter removes total, dissolved, and ionized pollutants within the pretreatment chamber by gravity settling or floatation, and in the filtration chamber via a combination of chemical precipitation, adsorption, microsedimentation, and filtration (Taylor, 2008). The Aquip system is a passive system that does not require chemicals or mechanical systems for treatment.

The suitability of the StormwateRx® Aquip™ system for treating boatyard stormwater runoff was evaluated in the 2008 *Boatyard Stormwater Treatment Technology Study* (Taylor Associates, Inc.) prepared for the Northwest Marine Trade Association, Puget Soundkeeper Alliance and Ecology (Study). The average percent pollutant removal for grab samples for the StormwateRx® Aquip™ reported in the Study are shown in Table 2.

TABLE 2

Average Percent Pollution Reduction for Grab and Composite Samples – Aquip Treatment System (Table 3, Boatyard Stormwater Treatment Technology Study)

Pollutant	Grab	Composite
Copper	98.0	94.9
Lead	94.4	62.3
Zinc	73.8	59.9
Copper, Dissolved	94.2	93.4
Lead, Dissolved	N/A(1)	N/A
Zinc, Dissolved	66.9	58.1
Total Suspended Solids	94.7	83.5

(1) All influent and effluent dissolved lead results from the Aquip were below the laboratory method detection limit.

The Aquip treatment system has received a CULD for enhanced treatment (dissolved copper and zinc) if the following criteria are met:

- Sized at a hydraulic loading rate of no greater than 1 gpm per square foot of media surface area;

- Using the enhanced (sorptive) media; and
- Influent by pump station or gravity flow.

The Aquip stormwater treatment system is installed in other similarly sized boatyards in the Puget Sound region. These installations are meeting the water quality benchmarks for stormwater discharge to Puget Sound through the use of the Aquip stormwater treatment system and source control BMPs (Minkov, personal communication; Riise, personal communication).

A bench-scale test to determine the capability of the Aquip stormwater treatment system to treat a representative sample of stormwater from the boatyard was conducted on March 10, 2014, by StormwateRx. The Aquip Enhanced Stormwater Filtration System media design was used for the test with the filtration rate scaled directly to full-scale applications approved in the State of Washington CULD for Basic, Enhanced, and Phosphorus Treatment (January 2013).

The details and sample results of the bench-scale Aquip Filtration System demonstration test are included in Appendix B. The results of the bench-scale test are included in Table 3. Three samples were taken at different time intervals to simulate filter performance during the life of the filter media. The Aquip Enhanced Stormwater Filtration System performance capability was confirmed during the bench-scale test to produce effluent water quality that would meet the Washington State marine discharge benchmarks for stormwater per the Boatyard General Permit (March 2, 2011).

TABLE 3

Results from the Aquip Bench-Scale Test (March 10, 2014)

Parameter	Seasonal Average Benchmark	Maximum Daily Benchmark	Aquip Column Inlet	Meets Benchmark?	Aquip Column Outlet	Meets Benchmark?
Sample 1 (Time 0)						
Turbidity (NTU)	*	*	56.2	—	<0.1	—
Total Copper (µg/L)	50	147	209	NO	<10	YES
Total Zinc (µg/L)	85	90	593	NO	<10	YES
Dissolved Copper (µg/L)	NA	NA	181	—	<10	—
Dissolved Zinc (µg/L)	NA	NA	627	—	29.9	—
Total Lead (µg/L)	NA	NA	<20	—	<20	—
Sample 2 (Time 95 minutes)						
Turbidity (NTU)	*	*	56.2	—	<0.1	—
Total Copper (µg/L)	50	147	209	NO	<10	YES
Total Zinc (µg/L)	85	90	593	NO	<10	YES
Dissolved Copper (µg/L)	NA	NA	181	—	<10	—
Dissolved Zinc (µg/L)	NA	NA	627	—	21.9	—
Total Lead (µg/L)	NA	NA	<20	—	<20	—

TABLE 3 – (continued)

Results from the Aquip Bench-Scale Test (March 10, 2014)

Parameter	Seasonal Average Benchmark	Maximum Daily Benchmark	Aquip Column Inlet	Meets Benchmark?	Aquip Column Outlet	Meets Benchmark?
Sample 3 (190 minutes)						
Turbidity (NTU)	*	*	56.2	—	<0.1	—
Total Copper (µg/L)	50	147	209	NO	<10	YES
Total Zinc (µg/L)	85	90	593	NO	<10	YES
Dissolved Copper (µg/L)	NA	NA	181	—	<10	—
Dissolved Zinc (µg/L)	NA	NA	627	—	26.6	—
Total Lead (µg/L)	**NA**	**NA**	**<20**	**—**	**<20**	**—**

* General prohibition to prevent a visible change in turbidity or color in the receiving water.
NA – Not applicable; no benchmark for this parameter.

Typical maintenance described in the Aquip StormwateRx CULD (Ecology, 2013) for the Aquip stormwater treatment system includes routine maintenance, inert media replacement and sorptive media replacement.

1. Surface media maintenance includes removal of visible surface accumulation of sediment and discolored inert media from the pretreatment and filtration chambers. Additional media must be installed, to original media height, when approximately 3 inches of filter media have been removed. The average maintenance interval for surface media maintenance is 1 month.

2. Inert media replacement includes replacement of the inert media in the filtration chamber when surface media maintenance program results in a continuous operating filtration chamber water level of more than 2 feet. Inert media replacement intervals vary from 12 to 24 months.

3. Full media replacement is required when the filtration chamber water level is greater than 2 feet or when dissolved pollutant concentrations exceed regulatory standards. The accumulated pretreatment chamber sediment should be removed at the time the sorptive media is replaced. Full media replacement interval averages 36 months but can vary from 24 to 48 months, depending on the site and routine maintenance.

The purchase price of an Aquip 50 SBE Filter is $52,700. Replacement of the pretreatment and inert media is required approximately every 12 to 24 months (approximately $1,500) and full media replacement is required approximately every 36 months (approximately $7,500). The 10-year life cycle cost of the equipment and media replacement, assuming pretreatment and inert media replacement every 12 months, is $92,450.

CHITOSAN ENHANCED SAND FILTRATION PACKAGE TREATMENT SYSTEM

A temporary CESF system was installed at the McNeil Island Boatyard in November 2013 in response to a need to provide immediate stormwater treatment. The CESF package system was provided and installed by Clear Creek Systems, Inc. The CESF system is design to treat approximately 40 gpm and utilized StormKlear^{TM} LiquiFloc^{TM}, an Ecology-approved chitosan polymer. CESF treatment systems are generally used to provide construction/dewatering water treatment, environmental remediation treatment, industrial stormwater treatment, pH neutralization and wastewater treatment,. Clear Creek Systems, Inc. has received a CULD for the chitosan polymer, FlocClear^{TM} and its use in CESF for treatment of construction stormwater runoff.

The basic CESF process includes chitosan injection, presettling of flocculated solids, rapid sand filtration, and final discharge of treated water. The CESF treatment system installed at McNeil Island Boatyard includes additional treatment steps including pH adjustment, effluent polishing with granulated activated carbon (GAC), and ion exchange (IX).

The CESF treatment system consists of the following:

- Stormwater collection.
- Pretreatment tank.
- Chitosan injection into discharge line to the settling tank. Chitosan polymer is injected into the stormwater flow at a constant rate and dosage.
- Settling tank. Solids flocculate and separate from the liquid by gravity settling, forming a layer of sediment on the bottom of the tank. The sediments are periodically removed, dewatered, and disposed.
- Chitosan injection prior to discharge to the sand filter.
- Sand filter – three 24-inch-diameter industrial sand media filtration skids with integrated valves and pressure gauges which control the frequency of backwash cycles.
- Granulated activated carbon filter to adsorb hydrocarbons.
- Ion exchange resin filter.
- Pumped discharge to outfall.

Sampling data for the effectiveness of the treatment system installed at McNeil Island is not available due to operational challenges with the system. Information regarding the performance capability of the CESF system contained in the 2011 *Industrial Stormwater Treatment System General Engineering Report*, Parametrix, indicates that CESF followed by IX is capable of providing 87 percent removal of copper and 98 percent removal of zinc.

The CESF treatment system is a highly mechanized system and requires weekly visits from the supplier to maintain the equipment. Additional operation and maintenance includes replacement of the sand filter media vessels when metals breakthrough occurs, replacement of the GAC tank and media every 6 months, and replacement of the IX media every 6 months or when fouled with saltwater.

This system is more robust than required and will not be considered further.

MECHANICAL FILTRATION/ION EXCHANGE PACKAGE TREATMENT SYSTEM

An interim treatment system consisting of mechanical filtration, granulated activated carbon and ion exchange will be installed at the boatyard to provide stormwater treatment until a permanent system is in place. The treatment system is described earlier in this report and includes collection of stormwater from the site in a 21,000 gallon above grade tank, mechanical filtration to remove particulates, TSS and turbidity, GAC to remove dissolved organic compounds including hydrocarbons and ion exchange resins to remove copper, zinc and lead. Based on the sampling data provided in Table 1, TSS and Oil and Grease do not appear to be present in significant quantity to warrant enhanced treatment such as mechanical filtration and GAC.

The mechanical filtration/ion exchange treatment system is similar to the system the supplier, Clear Creek Systems, Inc., has installed at the Norland Boat Company, Tacoma, Washington in the fall of 2011. According to Clear Creek Systems Inc., the Norland Boat Company has maintained compliance with the Boatyard General Permit Benchmarks since implementation of the treatment system (Clear Creek Systems, Inc., Correspondence, July 22, 2014).

The Mechanical Filtration/Ion Exchange package system requires monitoring and replacement of the bag filters and cartridge filter approximately two times per month, and replacement of the GAC and ion exchange resins. Boatyard staff will be required to be fully trained in operation and maintenance of the equipment or the boatyard will need to contract with the equipment supplier to provide routine maintenance.

The purchase price of a mechanical filtration/ion exchange package system is approximately $49,500 and requires change out of the filtration filter elements two times per month (approximately $150 each), replacement of the GAC every 24 months (approximately $950) and replacement of the ion exchange resin every 24 months (approximately $7,500). The 10-year life cycle cost of the equipment and filter/media replacement is $127,750.

SELECTED TREATMENT OPTION

The McNeil Island Boatyard will install a passive filtration treatment unit. This process was selected over the CESF package treatment system or mechanical filtration/ion exchange treatment system based on the results of the bench test of stormwater from the McNeil Island Boatyard, the proven record of meeting the treatment requirements at similarly sized boatyards in Puget Sound, the minimal complexity and reliance on mechanical systems of the treatment system, the 10-year life cycle cost and the level of complexity of operation and maintenance of the equipment. No chemicals will be needed to meet the stormwater treatment requirements.

CONCEPTUAL STORMWATER TREATMENT PLAN

STORMWATER COLLECTION

The stormwater from the marineway, roofs, and gravel parking areas will be commingled prior to the selected treatment system. A schematic plan view of the stormwater collection system is shown on Figure 3. Stormwater runoff generated in the boatyard that is tributary to the treatment system is currently directed to three sumps. Stormwater runoff from the gravel parking area and roofs is tributary to either the sump in the middle of the parking lot (Sump A) or the sump located immediately east of the Marine Department Building (Sump B). Stormwater runoff from the marineway is tributary to the trough at the waterward end of the marineway (Sump C). The stormwater from each of the sumps will be pumped to a 21,000-gallon holding tank prior to pumping into the treatment system. The pumping rate from each sump will be approximately 20 to 25 gpm to ensure collection of the offline water quality standard flow rate of 57 gpm. The 21,000-gallon holding tank will provide surge storage for the collected stormwater. Stormwater from the 21,000-gallon storage tank will be pumped to the stormwater treatment system at a rate of 50 gpm. Stormwater runoff in excess of the water quality flow rate will be allowed to discharge through the sump overflow systems. Pumps and piping from the sumps are currently installed. The piping is currently located above grade. The boatyard will install permanent below-grade piping from the sumps to the 21,000-gallon holding tank and to the outfall during installation of the permanent treatment system.

The marineway collection trough is susceptible to flooding by saltwater during high tide and wind events. In order to prevent pumping saltwater into the stormwater treatment system, a float which detects high tide has been installed. The float sends a signal to disable the marineway collection trough pump during high tide events. Boatyard staff will enable the pump after the high tide event.

TREATMENT SYSTEM

A passive filtration treatment system, the Aquip Model 50S treatment system, or approved equal, capable of treating up to 50 gpm will be installed at the location shown on Figure 3. The vendor-supplied standard detail for the treatment system is shown on Figure 4. Stormwater collected in the 21,000-gallon holding tank will be pumped to the treatment system. Treated stormwater will discharged from the Aquip treatment system by gravity to the surface discharge stormwater outfall located adjacent to the west bulkhead of the marineway.

OPERATION AND MAINTENANCE

Operation and maintenance of the treatment system is described in the Aquip Operation Maintenance Guidelines included in Appendix C.

REFERENCES

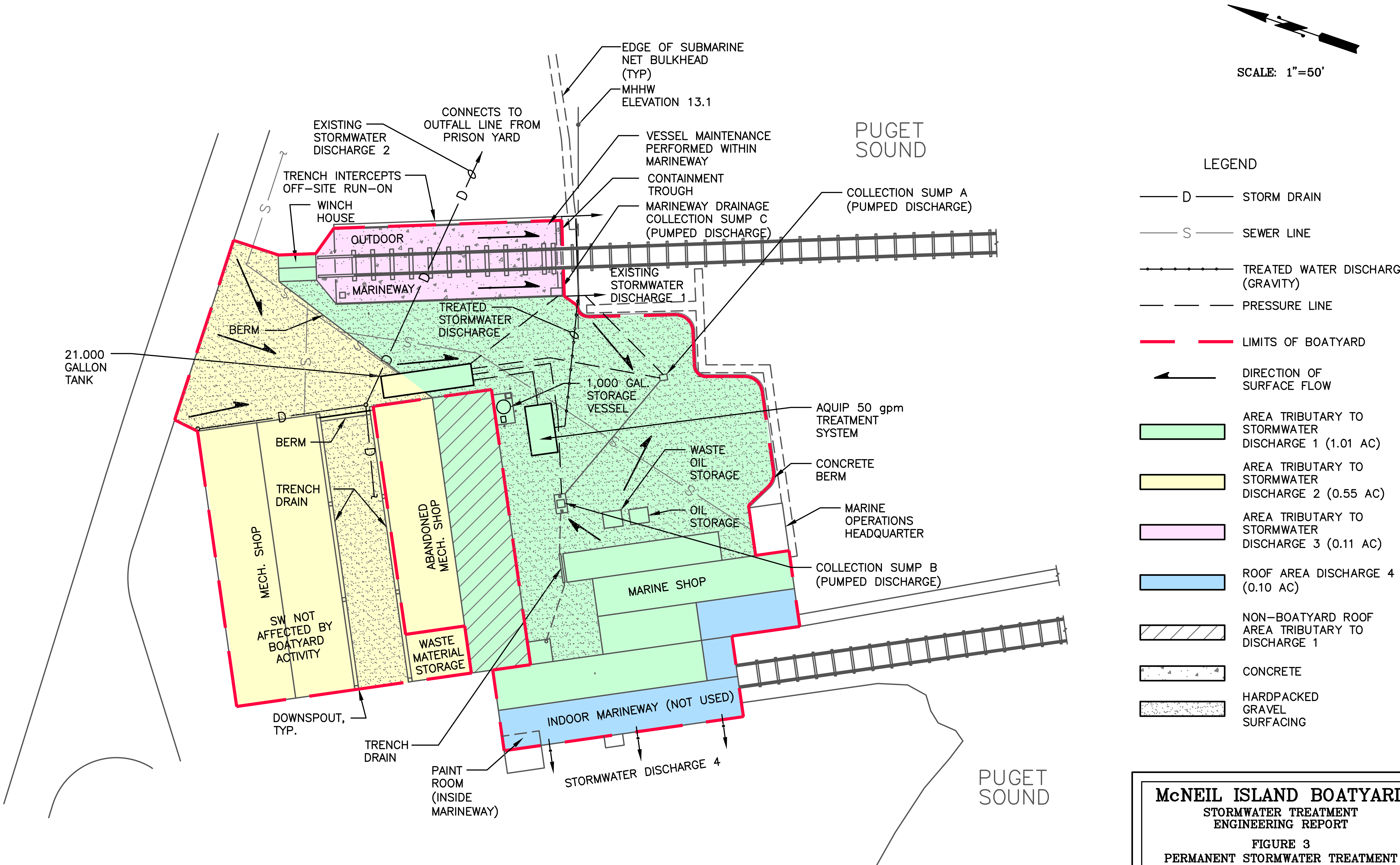
Clear Creek Systems, Inc., "Revised Industrial Stormwater Treatment Approach," letter, July 22, 2014

Minkov, Ivaylo, Canal Boatyard, personal communication, March 19, 2014.

Parametrix, 2011. Industrial Stormwater Treatment System General Engineering Report. Prepared by Parametrix, Bremerton, Washington. February 2011.

Riise, Phil, Seaview Boatyard, personal communication, March 19, 2014.

Taylor, 2008. Boatyard Stormwater Treatment Technology Study, Final Report. Prepared by Taylor Associates, Inc. March 2008.



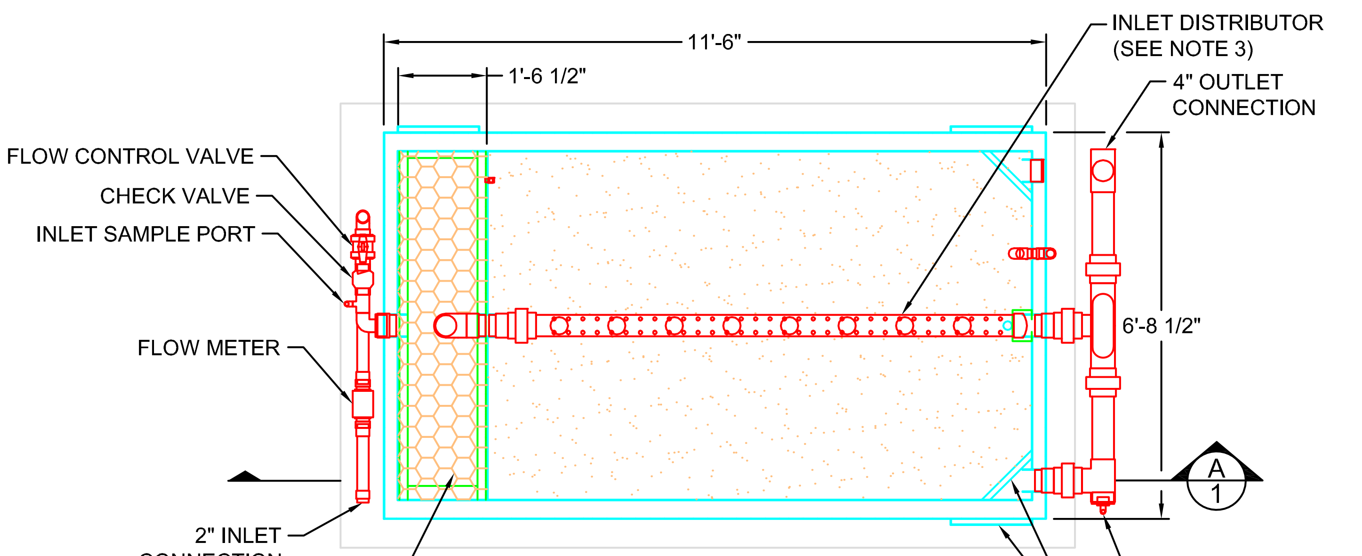
McNEIL ISLAND BOATYARD
STORMWATER TREATMENT ENGINEERING REPORT

FIGURE 3
PERMANENT STORMWATER TREATMENT SITE PLAN

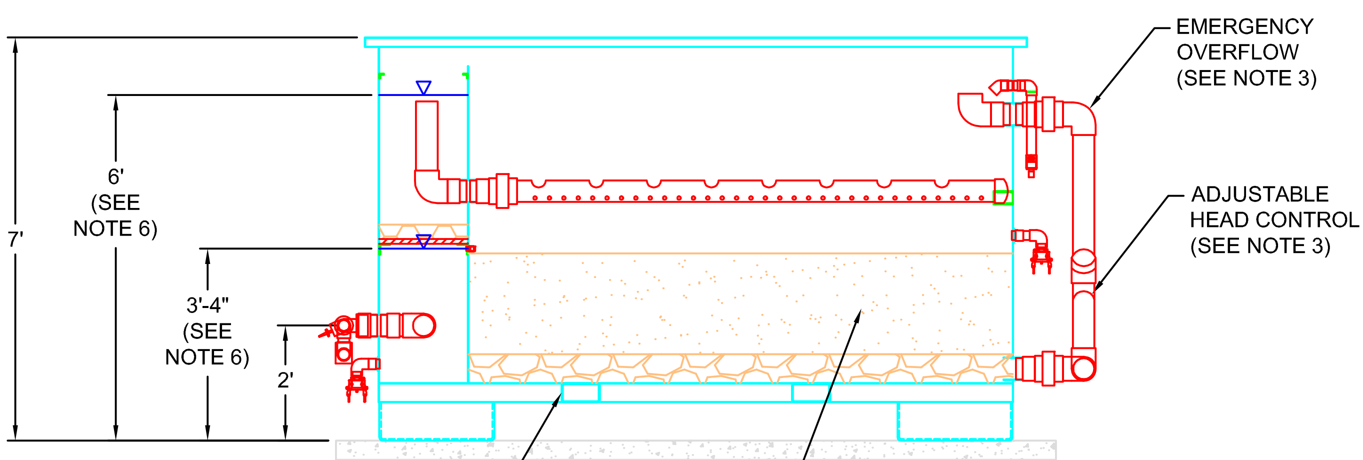
Gray & Osborne, Inc.
CONSULTING ENGINEERS

GENERAL NOTES

1. AQUIP® FILTRATION SYSTEM BY STORMWATERX LLC - PORTLAND, OREGON - 800.680.3543 (U.S. PATENT NO. 8,002,974).
2. PRETREATMENT AND FILTER MEDIA COMBINATION DEPENDENT ON POLLUTANT REMOVAL REQUIREMENTS. MODELS: SBE: BUFFERING & INERT/SORPTIVE MEDIA, SXI:SETTLING PRETREATMENT & INERT MEDIA.
3. INTERNAL APPURTENANCES BY STORMWATERX INCLUDING INLET AND OUTLET SAMPLE PORTS, INLET FLOW CONTROL & CHECK VALVES, INLET DISTRIBUTOR, UNDERDRAIN SYSTEM, EMERGENCY OVERFLOW AND ADJUSTABLE HEAD CONTROL.
4. SYSTEM REQUIRES LEVEL SURFACE FOR 11' x 6' FOOTPRINT AND LOAD BEARING CAPACITY OF 34,600 LBS.
5. INLET AND OUTLET PIPING CONNECTION SIZE AS NOTED. CONNECTION PIPING PROVIDED BY OTHERS. CENTER INLET STANDARD, INLET CONNECTION LEFT OR RIGHT (RIGHT SHOWN). OPTIONAL LEFT OR RIGHT OUTLET (LEFT OUTLET SHOWN).
6. PERMANENT POOL DEPTH IS 3'-4" ABOVE THE BOTTOM OF STRUCTURE. THE OPERATING WATER SURFACE HEIGHT IS 6' ABOVE BOTTOM OF STRUCTURE.



TOP VIEW 1/1



SECTION VIEW A/1

McNeil Island Boatyard
Stormwater Treatment Engineering Report
Figure 4

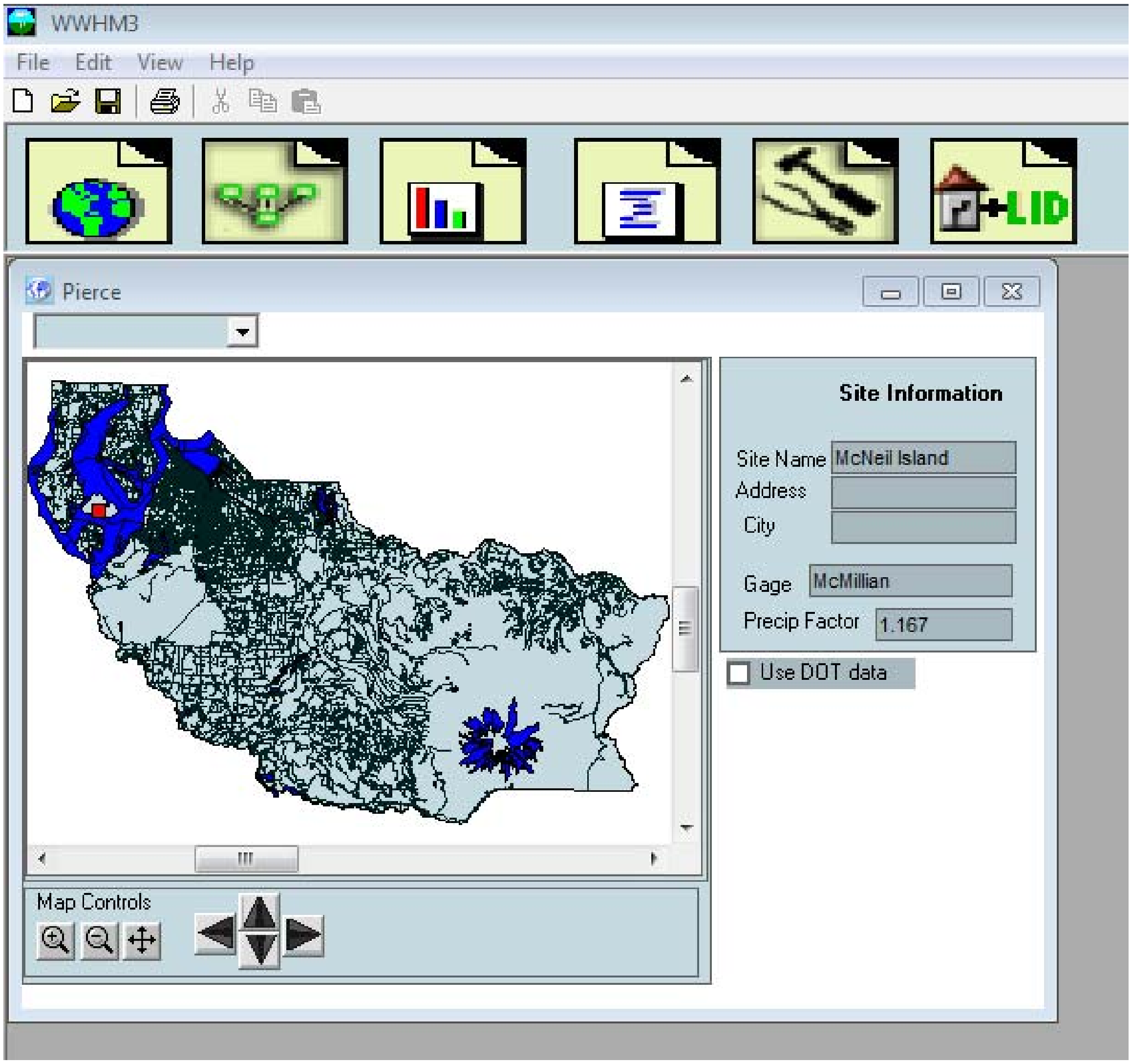
stormwateRx®
www.stormwaterx.com

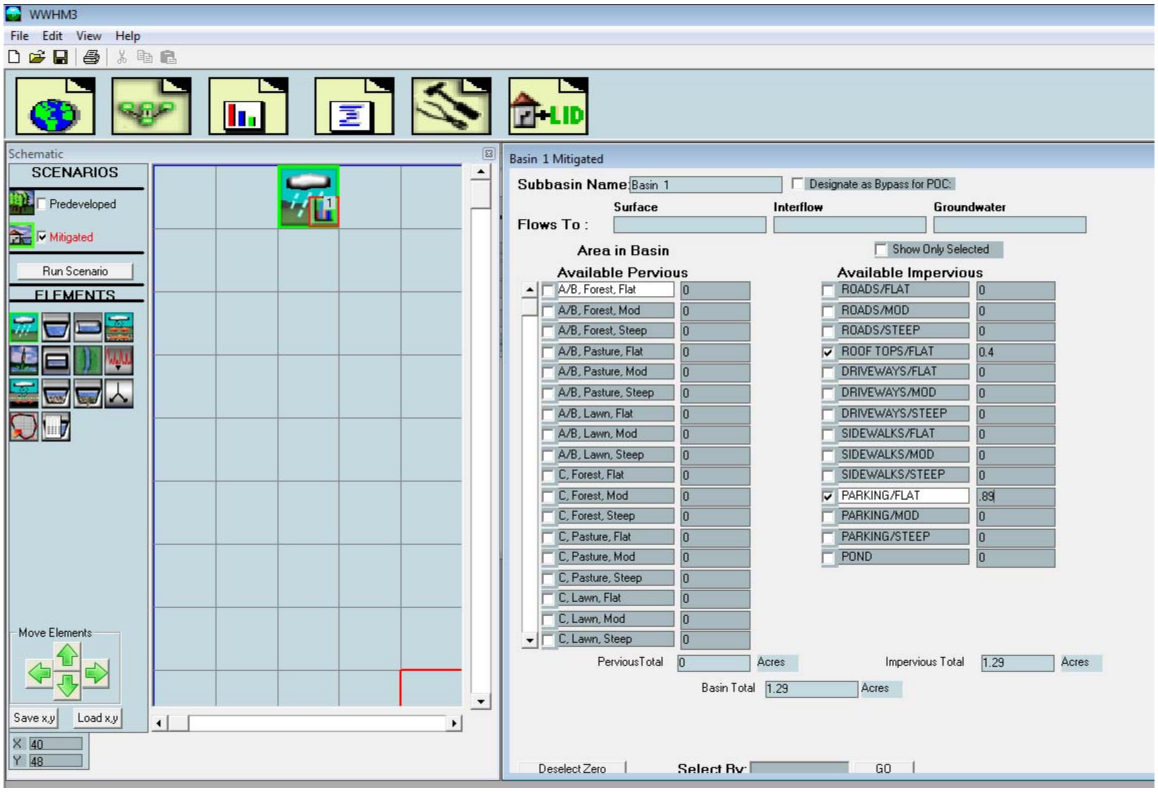
AQUIP MODEL 50S
STORMWATER FILTRATION SYSTEM
STANDARD DETAIL

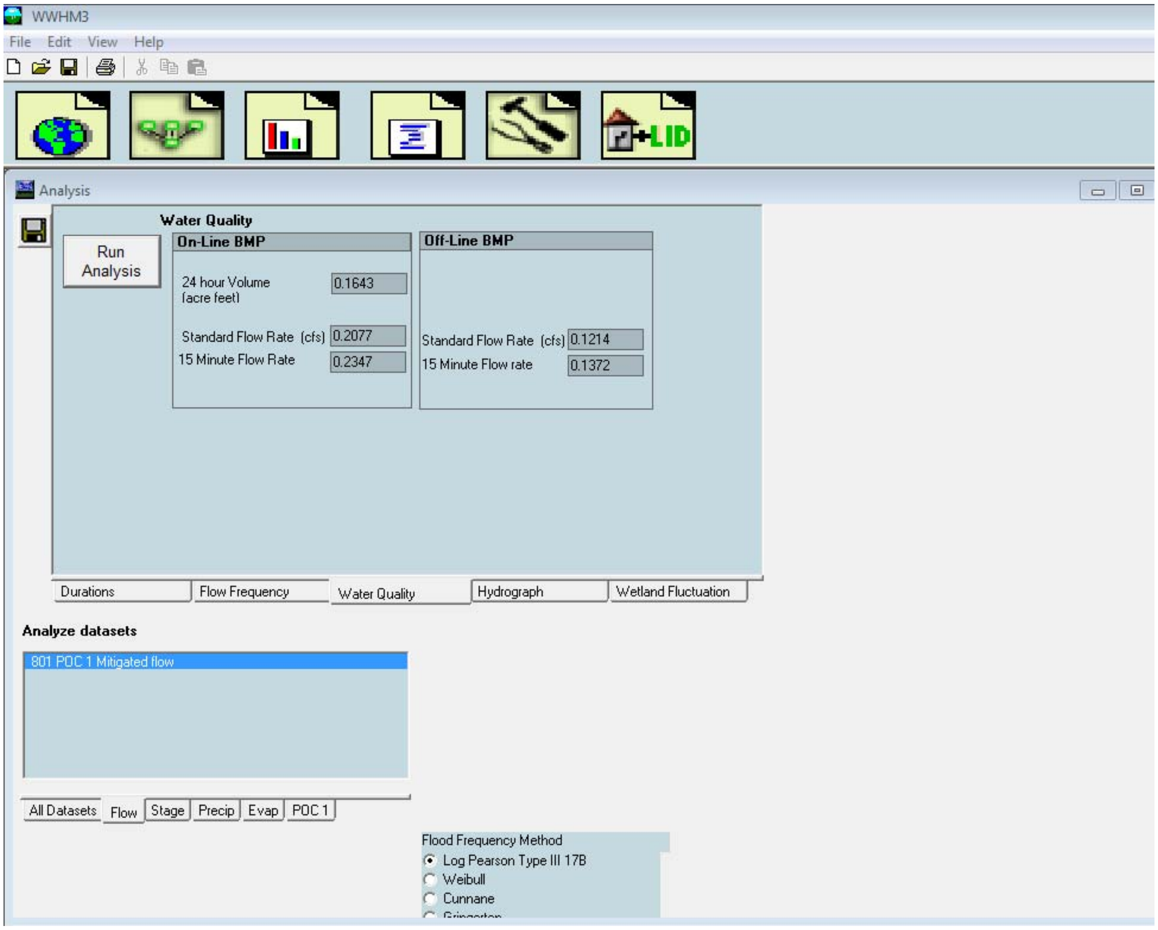
DATE:	SCALE:	FILE NAME:	DRAWN:	CHECKED:	SHEET
9/12/2012	NONE	SRX-AQUIP-50S-DTL	MJW	ARG	1 (1 OF 1)

APPENDIX A

WWHM3 MODEL INFORMATION


WWHM3
File
Edit
View
Help
Pierce
Site Information
Site Name
McNeil Island
Address
City
Gage
McMillian
Precip Factor
1.167
Use DOT data
Map Controls


WWHM3
File Edit View Help
Schematic
SCENARIOS
Predeveloped
Mitigated
Run Scenario
ELEMENTS
Move Elements
Save x,y
Load x,y
X 40
Y 48
Basin 1 Mitigated
Subbasin Name Basin 1
Designate as Bypass for POC:
Surface
Interflow
Groundwater
Flows To :
Area in Basin
Show Only Selected
Available Pervious
Available Impervious
A/B, Forest, Flat 0
A/B, Forest, Mod 0
A/B, Forest, Steep 0
A/B, Pasture, Flat 0
A/B, Pasture, Mod 0
A/B, Pasture, Steep 0
A/B, Lawn, Flat 0
A/B, Lawn, Mod 0
A/B, Lawn, Steep 0
C, Forest, Flat 0
C, Forest, Mod 0
C, Forest, Steep 0
C, Pasture, Flat 0
C, Pasture, Mod 0
C, Pasture, Steep 0
C, Lawn, Flat 0
C, Lawn, Mod 0
C, Lawn, Steep 0
ROADS/FLAT 0
ROADS/MOD 0
ROADS/STEEP 0
ROOF TOPS/FLAT 0.4
DRIVEWAYS/FLAT 0
DRIVEWAYS/MOD 0
DRIVEWAYS/STEEP 0
SIDEWALKS/FLAT 0
SIDEWALKS/MOD 0
SIDEWALKS/STEEP 0
PARKING/FLAT .89
PARKING/MOD 0
PARKING/STEEP 0
POND 0
PerviousTotal 0 Acres
Impervious Total 1.29 Acres
Basin Total 1.29 Acres
Deselect Zero
Select By:
GO


WWHM3
File Edit View Help
Analysis
Water Quality
Run Analysis
On-Line BMP
24 hour Volume (acre feet) 0.1643
Standard Flow Rate (cfs) 0.2077
15 Minute Flow Rate 0.2347
Off-Line BMP
Standard Flow Rate (cfs) 0.1214
15 Minute Flow rate 0.1372
Durations
Flow Frequency
Water Quality
Hydrograph
Wetland Fluctuation
Analyze datasets
801 POC 1 Mitigated flow
All Datasets
Flow
Stage
Precip
Evap
POC 1
Flood Frequency Method
Log Pearson Type III 17B
Weibull
Cunnane


WWHM3
File Edit View Help
Analysis
801 POC 1 Mitigated flow
10E 1
10E 0
10E-1
10E-2
FLOW (cfs)
1 10 20 30 40 50 60 70 80 90 99
Cumulative Probability
Durations
Flow Frequency
Water Quality
Hydrograph
Wetland Fluctuation
Analyze datasets
801 POC 1 Mitigated flow
All Datasets
Flow
Stage
Precip
Evap
POC 1
Flood Frequency Method
Log Pearson Type III 17B
Weibull
Cunnane
Flow Frequency
Flow(CFS) 0801
2 Year = 0.4410
5 Year = 0.5901
10 Year = 0.6959
25 Year = 0.8381
50 Year = 0.9503
100 Year = 1.0680
Yearly Peaks
1949 0.3492
1950 0.4601
1951 0.5654
1952 0.2727
1953 0.4964
1954 0.4466
1955 0.3236
1956 0.4131
1957 0.9686
1958 0.3660
1959 0.3850
1960 1.1455
1961 0.3628
1962 0.3323
1963 0.7651
1964 0.3887
1965 0.6214
1966 0.5815
1967 0.4042
1968 0.5429
1969 0.7891
1970 0.3443
1971 0.3733
1972 0.3738
1973 0.4789

APPENDIX B

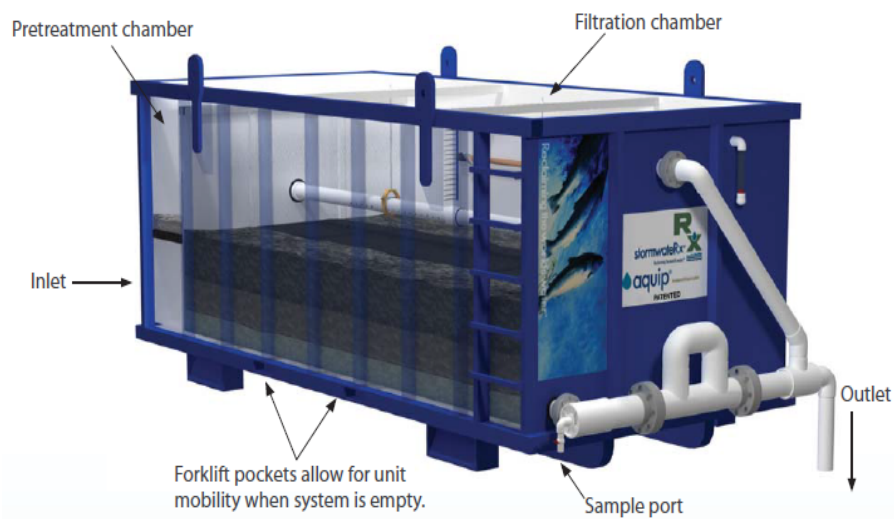
BENCH TESTING SAMPLE RESULTS

Bench-Scale Aquip Filtration System Demonstration Test

Bench-Scale Aquip Filtration System Demonstration Test

WA DOC McNeil Island Boatyard
March 10, 2014

The Aquip® Enhanced Stormwater Filtration System performance capability was evaluated through bench-scale testing of stormwater collected from the WA DOC McNeil Island Boatyard Catch Basin Shipways on February 21, 2014. The stormwater was shipped to StormwateRx for performance verification at its stormwater treatability laboratory; testing was performed on March 10, 2014. StormwateRx, LLC, Aquip® Enhanced Stormwater Filtration System media design was used for the test; filtration rate was scaled directly to full scale applications approved in the State of Washington Conditional Use Level Designation for Basic, Enhanced & Phosphorus Treatment (January 2013.)



A 1.5" diameter column built with the StormwateRx, LLC, Aquip® Enhanced Stormwater Filtration System media design was used for the test. The 50-gallon sample of stormwater from the WA DOC McNeil Island Boatyard was continuously mixed during the four hour test.

Results

Below are the results from the Aquip bench-scale test using stormwater from WA DOC McNeil Island Boatyard. Results are compared to the benchmarks referenced in the Boatyard General Permit – March 2, 2011 (WAG030000), S2.D. Boatyards Discharging Stormwater to Waters of the State, 3. Facilities discharging stormwater to fresh or marine waters.

Table 1. Results from the Aquip bench-scale test, Sample 1 [March 10, 2014, 14:05]

Parameter	Seasonal Average Benchmark	Maximum Daily Benchmark	Aquip Column Inlet	Meets Benchmark?	Aquip Column Outlet	Meets Benchmark?
Turbidity (NTU)	*	*	56.2	-	<0.1	-
Tot Copper (ug/L)	50	147	209	NO	<10	YES
Tot Zinc (ug/L)	85	90	593	NO	<10	YES
Dis Copper (ug/L)	NA	NA	181	-	<10	-
Dis Zinc (ug/L)	NA	NA	627	-	29.9	-
Tot Lead (ug/L)	NA	NA	<20	-	<20	-

*General Prohibition to prevent a visible change in turbidity or color in the receiving water.

NA – Not applicable; no benchmark for this parameter.

Table 2. Results from the Aquip bench-scale test, Sample 2 [March 10, 2014, 15:40]

Parameter	Seasonal Average Benchmark	Maximum Daily Benchmark	Aquip Column Inlet	Meets Benchmark?	Aquip Column Outlet	Meets Benchmark?
Turbidity (NTU)	*	*	56.2	-	<0.1	-
Tot Copper (ug/L)	50	147	209	NO	<10	YES
Tot Zinc (ug/L)	85	90	593	NO	<10	YES
Dis Copper (ug/L)	NA	NA	181	-	<10	-
Dis Zinc (ug/L)	NA	NA	627	-	21.9	-
Tot Lead (ug/L)	NA	NA	<20	-	<20	-

*General Prohibition to prevent a visible change in turbidity or color in the receiving water.

NA – Not applicable; no benchmark for this parameter.

Table 3. Results from the Aquip bench-scale test, Sample 3 [March 10, 2014, 17:15]

Parameter	Seasonal Average Benchmark	Maximum Daily Benchmark	Aquip Column Inlet	Meets Benchmark?	Aquip Column Outlet	Meets Benchmark?
Turbidity (NTU)	*	*	56.2	-	<0.1	-
Tot Copper (ug/L)	50	147	209	NO	<10	YES
Tot Zinc (ug/L)	85	90	593	NO	<10	YES
Dis Copper (ug/L)	NA	NA	181	-	<10	-
Dis Zinc (ug/L)	NA	NA	627	-	26.6	-
Tot Lead (ug/L)	NA	NA	<20	-	<20	-

*General Prohibition to prevent a visible change in turbidity or color in the receiving water.

NA – Not applicable; no benchmark for this parameter.

Figure 2. Results from the Aquip bench-scale test. Left photo is untreated; right is treated.

Conclusions

The Aquip® Enhanced Stormwater Filtration System performance capability was confirmed during this bench scale treatability test using WA DOC McNeil Island Boatyard stormwater to produce effluent water quality that would meet the Washington State marine discharge benchmarks for stormwater per the Boatyard General Permit – March 2, 2011 (WAG030000.)

Attachment 1 – Laboratory Analytical Results

Specialty Analytical

11711 SE Capps Road, Ste B
Clackamas, Oregon 97015
TEL: 503-607-1331 FAX: 503-607-1336
Website: www.specialtyanalytical.com

March 18, 2014

Dan Joseph
StormwateRx
122 SE 27th Avenue
Portland, OR 97214

TEL: (503) 233-4660
FAX
RE: McNeil

Dear Dan Joseph: Order No.: 1403091

Specialty Analytical received 4 sample(s) on 3/11/2014 for the analyses presented in the following report.

There were no problems with the analysis and all data for associated QC met EPA or laboratory specifications, except where noted in the Case Narrative, or as qualified with flags. Results apply only to the samples analyzed. Without approval of the laboratory, the reproduction of this report is only permitted in its entirety.

If you have any questions regarding these tests, please feel free to call.

Sincerely,

Marty French
Lab Director

Specialty Analytical

Date Reported: 18-Mar-14

CLIENT: StormwateRx **Lab Order:** 1403091
Project: McNeil

Lab ID: 1403091-001 **Collection Date:** 3/10/2014 2:05:00 PM
Client Sample ID: A-in #1 **Matrix:** WATER

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-DISSOLVED RECOVERABLE		**E200.7**				Analyst: **VAS**
Copper	0.181	0.0100		mg/L	1	3/12/2014 2:43:10 PM
Zinc	0.627	0.0100		mg/L	1	3/12/2014 2:43:10 PM
ICP METALS- TOTAL RECOVERABLE		**E200.7**				Analyst: **ZL**
Copper	0.209	0.0100		mg/L	1	3/13/2014 5:35:31 PM
Lead	ND	0.0200		mg/L	1	3/13/2014 5:35:31 PM
Zinc	0.593	0.0100		mg/L	1	3/13/2014 5:35:31 PM
TURBIDITY		**SM2130 B**				Analyst: **EFH**
Turbidity	56.2	0.100		NTU	1	3/11/2014 4:03:00 PM

Lab ID: 1403091-002 **Collection Date:** 3/10/2014 2:05:00 PM
Client Sample ID: A-out #1 **Matrix:** WATER

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-DISSOLVED RECOVERABLE		**E200.7**				Analyst: **VAS**
Copper	ND	0.0100		mg/L	1	3/12/2014 3:03:53 PM
Zinc	0.0299	0.0100		mg/L	1	3/12/2014 3:03:53 PM
ICP METALS- TOTAL RECOVERABLE		**E200.7**				Analyst: **ZL**
Copper	ND	0.0100		mg/L	1	3/13/2014 5:40:44 PM
Lead	ND	0.0200		mg/L	1	3/13/2014 5:40:44 PM
Zinc	ND	0.0100		mg/L	1	3/13/2014 5:40:44 PM
TURBIDITY		**SM2130 B**				Analyst: **EFH**
Turbidity	ND	0.100		NTU	1	3/11/2014 4:05:00 PM

Specialty Analytical

Date Reported: 18-Mar-14

CLIENT: StormwateRx **Lab Order:** 1403091
Project: McNeil

Lab ID: 1403091-003 **Collection Date:** 3/10/2014 3:40:00 PM
Client Sample ID: A-out #2 **Matrix:** WATER

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-DISSOLVED RECOVERABLE		**E200.7**				Analyst: **VAS**
Copper	ND	0.0100		mg/L	1	3/12/2014 3:09:07 PM
Zinc	0.0219	0.0100		mg/L	1	3/12/2014 3:09:07 PM
ICP METALS- TOTAL RECOVERABLE		**E200.7**				Analyst: **ZL**
Copper	ND	0.0100		mg/L	1	3/13/2014 5:45:57 PM
Lead	ND	0.0200		mg/L	1	3/13/2014 5:45:57 PM
Zinc	ND	0.0100		mg/L	1	3/13/2014 5:45:57 PM
TURBIDITY		**SM2130 B**				Analyst: **EFH**
Turbidity	ND	0.100		NTU	1	3/11/2014 4:07:00 PM

Lab ID: 1403091-004 **Collection Date:** 3/10/2014 5:15:00 PM
Client Sample ID: A-out #3 **Matrix:** WATER

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-DISSOLVED RECOVERABLE		**E200.7**				Analyst: **VAS**
Copper	ND	0.0100		mg/L	1	3/12/2014 3:14:20 PM
Zinc	0.0266	0.0100		mg/L	1	3/12/2014 3:14:20 PM
ICP METALS- TOTAL RECOVERABLE		**E200.7**				Analyst: **ZL**
Copper	ND	0.0100		mg/L	1	3/13/2014 5:51:08 PM
Lead	ND	0.0200		mg/L	1	3/13/2014 5:51:08 PM
Zinc	ND	0.0100		mg/L	1	3/13/2014 5:51:08 PM
TURBIDITY		**SM2130 B**				Analyst: **EFH**
Turbidity	ND	0.100		NTU	1	3/11/2014 4:09:00 PM

QC SUMMARY REPORT

WO#: **1403091**

18-Mar-14

Specialty Analytical

Client: StormwateRx

Project: McNeil

TestCode: 200.7

Sample ID: **ICV** SampType: **ICV** TestCode: **200.7** Units: **mg/L** Prep Date: RunNo: **14112**

Client ID: **ICV** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/13/2014** SeqNo: **185996**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.483	0.0100	0.5000	0	96.6	95	105				
Lead	1.01	0.0200	1.000	0	101	95	105				
Zinc	0.511	0.0100	0.5000	0	102	95	105				

Sample ID: **CCV** SampType: **CCV** TestCode: **200.7** Units: **mg/L** Prep Date: RunNo: **14112**

Client ID: **CCV** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/13/2014** SeqNo: **185997**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.514	0.0100	0.5000	0	103	90	110				
Lead	1.01	0.0200	1.000	0	101	90	110				
Zinc	0.506	0.0100	0.5000	0	101	90	110				

Sample ID: **MBLK-7015** SampType: **MBLK** TestCode: **200.7** Units: **mg/L** Prep Date: RunNo: **14112**

Client ID: **PBW** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/13/2014** SeqNo: **185998**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	ND	0.0100									
Lead	ND	0.0200									
Zinc	ND	0.0100									

Qualifiers:
B Analyte detected in the associated Method Blank
H Holding times for preparation or analysis exceeded
ND Not Detected at the Reporting Limit
O RSD is greater than RSDlimit
R RPD outside accepted recovery limits
S Spike Recovery outside accepted recovı

QC SUMMARY REPORT

WO#: **1403091**

18-Mar-14

Specialty Analytical

Client: StormwateRx

Project: McNeil **TestCode:** 200.7

Sample ID: **LCS-7015** SampType: **LCS** TestCode: **200.7** Units: **mg/L** Prep Date: **3/13/2014** RunNo: **14112**

Client ID: **LCSW** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/13/2014** SeqNo: **185999**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.512	0.0100	0.5000	0	102	89.7	117				
Lead	1.03	0.0200	1.000	0	103	93.1	112				
Zinc	0.503	0.0100	0.5000	0	101	92.3	111				

Sample ID: **1403085-001DDUP** SampType: **DUP** TestCode: **200.7** Units: **mg/L** Prep Date: **3/13/2014** RunNo: **14112**

Client ID: **ZZZZZZ** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/13/2014** SeqNo: **186001**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.0139	0.0100						0.01270	9.02	20	
Lead	ND	0.0200						0	0	20	
Zinc	0.0200	0.0100						0.02030	1.49	20	

Sample ID: **CCV** SampType: **CCV** TestCode: **200.7** Units: **mg/L** Prep Date: RunNo: **14112**

Client ID: **CCV** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/13/2014** SeqNo: **186003**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.510	0.0100	0.5000	0	102	90	110				
Lead	1.03	0.0200	1.000	0	103	90	110				
Zinc	0.508	0.0100	0.5000	0	102	90	110				

Qualifiers:

B	Analyte detected in the associated Method Blank	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
O	RSD is greater than RSDlimit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recov

QC SUMMARY REPORT

WO#: **1403091**

18-Mar-14

Specialty Analytical

Client: StormwateRx

Project: McNeil

TestCode: 200.7

Sample ID: **ICV** SampType: **ICV** TestCode: **200.7** Units: **mg/L** Prep Date: RunNo: **14112**

Client ID: **ICV** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/14/2014** SeqNo: **186291**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.491	0.0100	0.5000	0	98.2	95	105				
Lead	1.02	0.0200	1.000	0	102	95	105				
Zinc	0.515	0.0100	0.5000	0	103	95	105				

Sample ID: **CCV** SampType: **CCV** TestCode: **200.7** Units: **mg/L** Prep Date: RunNo: **14112**

Client ID: **CCV** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/14/2014** SeqNo: **186292**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.488	0.0100	0.5000	0	97.7	90	110				
Lead	1.03	0.0200	1.000	0	103	90	110				
Zinc	0.525	0.0100	0.5000	0	105	90	110				

Sample ID: **1403085-001DMS** SampType: **MS** TestCode: **200.7** Units: **mg/L** Prep Date: **3/13/2014** RunNo: **14112**

Client ID: **ZZZZZZ** Batch ID: **7015** TestNo: **E200.7** **E200.7** Analysis Date: **3/14/2014** SeqNo: **186293**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.503	0.0100	0.5000	0.01270	98.0	92.7	114				
Lead	1.01	0.0200	1.000	0	101	91.9	112				
Zinc	0.526	0.0100	0.5000	0.02030	101	93	110				

QC SUMMARY REPORT

WO#: **1403091**

18-Mar-14

Specialty Analytical

Client: StormwateRx

Project: McNeil **TestCode:** 200.7

Sample ID: 1403085-001DMSD	SampType: MSD	TestCode: 200.7	Units: mg/L	Prep Date: 3/13/2014	RunNo: 14112
Client ID: ZZZZZZ	Batch ID: 7015	TestNo: E200.7	E200.7	Analysis Date: 3/14/2014	SeqNo: 186294

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.511	0.0100	0.5000	0.01270	99.6	92.7	114	0.5025	1.58	20	
Lead	1.01	0.0200	1.000	0	101	91.9	112	1.008	0.495	20	
Zinc	0.529	0.0100	0.5000	0.02030	102	93	110	0.5256	0.569	20	

Qualifiers:

B	Analyte detected in the associated Method Blank	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
O	RSD is greater than RSDlimit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recov

QC SUMMARY REPORT

WO#: **1403091**

18-Mar-14

Specialty Analytical

Client: StormwateRx

Project: McNeil

TestCode: 200.7_D

Sample ID: **ICV**	SampType: **ICV**	TestCode: **200.7_D**	Units: **mg/L**	Prep Date:	RunNo: **14078**
Client ID: **ICV**	Batch ID: **7003**	TestNo: **E200.7**	**E200.7**	Analysis Date: **3/12/2014**	SeqNo: **185442**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.481	0.0100	0.5000	0	96.3	95	105				
Zinc	0.512	0.0100	0.5000	0	102	95	105				

Sample ID: **CCV**	SampType: **CCV**	TestCode: **200.7_D**	Units: **mg/L**	Prep Date:	RunNo: **14078**
Client ID: **CCV**	Batch ID: **7003**	TestNo: **E200.7**	**E200.7**	Analysis Date: **3/12/2014**	SeqNo: **185443**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.466	0.0100	0.5000	0	93.3	90	110				
Zinc	0.497	0.0100	0.5000	0	99.3	90	110				

Sample ID: **MBLK-7003**	SampType: **MBLK**	TestCode: **200.7_D**	Units: **mg/L**	Prep Date:	RunNo: **14078**
Client ID: **PBW**	Batch ID: **7003**	TestNo: **E200.7**	**E200.7**	Analysis Date: **3/12/2014**	SeqNo: **185444**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	ND	0.0100									
Zinc	ND	0.0100									

Sample ID: **1403091-001CDUP**	SampType: **DUP**	TestCode: **200.7_D**	Units: **mg/L**	Prep Date: **3/12/2014**	RunNo: **14078**
Client ID: **A-in #1**	Batch ID: **7003**	TestNo: **E200.7**	**E200.7**	Analysis Date: **3/12/2014**	SeqNo: **185446**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.174	0.0100						0.1808	3.72	20	

Qualifiers:

B Analyte detected in the associated Method Blank
H Holding times for preparation or analysis exceeded
ND Not Detected at the Reporting Limit
O RSD is greater than RSDlimit
R RPD outside accepted recovery limits
S Spike Recovery outside accepted recov

QC SUMMARY REPORT

WO#: **1403091**

18-Mar-14

Specialty Analytical

Client: StormwateRx

Project: McNeil **TestCode:** 200.7_D

Sample ID: **1403091-001CDUP** SampType: **DUP** TestCode: **200.7_D** Units: **mg/L** Prep Date: **3/12/2014** RunNo: **14078**

Client ID: **A-in #1** Batch ID: **7003** TestNo: **E200.7** **E200.7** Analysis Date: **3/12/2014** SeqNo: **185446**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Zinc	0.618	0.0100						0.6268	1.41	20	

Sample ID: **CCV** SampType: **CCV** TestCode: **200.7_D** Units: **mg/L** Prep Date: RunNo: **14078**

Client ID: **CCV** Batch ID: **7003** TestNo: **E200.7** **E200.7** Analysis Date: **3/12/2014** SeqNo: **185452**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.452	0.0100	0.5000	0	90.4	90	110				
Zinc	0.473	0.0100	0.5000	0	94.6	90	110				

Sample ID: **1403091-001CMS** SampType: **MS** TestCode: **200.7_D** Units: **mg/L** Prep Date: **3/12/2014** RunNo: **14078**

Client ID: **A-in #1** Batch ID: **7003** TestNo: **E200.7** **E200.7** Analysis Date: **3/12/2014** SeqNo: **185590**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.586	0.0100	0.5000	0.1808	81.1	92.7	114				S
Zinc	1.02	0.0100	0.5000	0.6268	78.8	93	110				S

Sample ID: **1403091-001CMSD** SampType: **MSD** TestCode: **200.7_D** Units: **mg/L** Prep Date: **3/12/2014** RunNo: **14078**

Client ID: **A-in #1** Batch ID: **7003** TestNo: **E200.7** **E200.7** Analysis Date: **3/12/2014** SeqNo: **185591**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.581	0.0100	0.5000	0.1808	80.0	92.7	114	0.5864	0.942	20	S
Zinc	1.02	0.0100	0.5000	0.6268	77.8	93	110	1.021	0.491	20	S

Qualifiers:
B Analyte detected in the associated Method Blank
H Holding times for preparation or analysis exceeded
ND Not Detected at the Reporting Limit
O RSD is greater than RSDlimit
R RPD outside accepted recovery limits
S Spike Recovery outside accepted recov

QC SUMMARY REPORT

WO#: **1403091**

18-Mar-14

Specialty Analytical

Client: StormwateRx

Project: McNeil

TestCode: 200.7_D

Sample ID: **1403091-001CMSD**	SampType: **MSD**	TestCode: **200.7_D**	Units: **mg/L**	Prep Date: **3/12/2014**	RunNo: **14078**
Client ID: **A-in #1**	Batch ID: **7003**	TestNo: **E200.7**	**E200.7**	Analysis Date: **3/12/2014**	SeqNo: **185591**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID: **CCV**	SampType: **CCV**	TestCode: **200.7_D**	Units: **mg/L**	Prep Date:	RunNo: **14078**
Client ID: **CCV**	Batch ID: **7003**	TestNo: **E200.7**	**E200.7**	Analysis Date: **3/12/2014**	SeqNo: **185592**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Copper	0.468	0.0100	0.5000	0	93.7	90	110				
Zinc	0.487	0.0100	0.5000	0	97.3	90	110				

Qualifiers:

B	Analyte detected in the associated Method Blank	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
O	RSD is greater than RSDlimit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recov

QC SUMMARY REPORT

WO#: **1403091**

18-Mar-14

Specialty Analytical

Client: StormwateRx

Project: McNeil

TestCode: **TURB_WW**

Sample ID: **LCS-R14060** SampType: **LCS** TestCode: **TURB_WW** Units: **NTU** Prep Date: RunNo: **14060**

Client ID: **LCSW** Batch ID: **R14060** TestNo: **SM2130 B** Analysis Date: **3/11/2014** SeqNo: **185236**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Turbidity	10.0	0.100	10.00	0	100	95	105				

Sample ID: **MB-R14060** SampType: **MBLK** TestCode: **TURB_WW** Units: **NTU** Prep Date: RunNo: **14060**

Client ID: **PBW** Batch ID: **R14060** TestNo: **SM2130 B** Analysis Date: **3/11/2014** SeqNo: **185237**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Turbidity	ND	0.100									

Sample ID: **1403088-001BDUP** SampType: **DUP** TestCode: **TURB_WW** Units: **NTU** Prep Date: RunNo: **14060**

Client ID: **ZZZZZZ** Batch ID: **R14060** TestNo: **SM2130 B** Analysis Date: **3/11/2014** SeqNo: **185239**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Turbidity	44.5	0.100						43.60	2.04	20	

Qualifiers:

B	Analyte detected in the associated Method Blank	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
O	RSD is greater than RSDlimit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recov

KEY TO FLAGS

Rev. May 12, 2010

A This sample contains a Gasoline Range Organic not identified as a specific hydrocarbon product. The result was quantified against gasoline calibration standards

A1 This sample contains a Diesel Range Organic not identified as a specific hydrocarbon product. The result was quantified against diesel calibration standards.

A2 This sample contains a Lube Oil Range Organic not identified as a specific hydrocarbon product. The result was quantified against a lube oil calibration standard.

A3 The result was determined to be Non-Detect based on hydrocarbon pattern recognition. The product was carry-over from another hydrocarbon type.

A4 The product appears to be aged or degraded diesel.

B The blank exhibited a positive result great than the reporting limit for this compound.

CN See Case Narrative.

D Result is based from a dilution.

E Result exceeds the calibration range for this compound. The result should be considered as estimate.

F The positive result for this hydrocarbon is due to single component contamination. The product does not match any hydrocarbon in the fuels library.

G Result may be biased high due to biogenic interferences. Clean up is recommended.

H Sample was analyzed outside recommended holding time.

HT At clients request, samples was analyzed outside of recommended holding time.

J The result for this analyte is between the MDL and the PQL and should be considered as estimated concentration.

K Diesel result is biased high due to amount of Oil contained in the sample.

L Diesel result is biased high due to amount of Gasoline contained in the sample.

M Oil result is biased high due to amount of Diesel contained in the sample.

MC Sample concentration is greater than 4x the spiked value, the spiked value is considered insignificant.

MI Result is outside control limits due to matrix interference.

MSA Value determined by Method of Standard Addition.

O Laboratory Control Standard (LCS) exceeded laboratory control limits, but meets CCV criteria. Data meets EPA requirements.

Q Detection levels elevated due to sample matrix.

R RPD control limits were exceeded.

RF Duplicate failed due to result being at or near the method-reporting limit.

RP Matrix spike values exceed established QC limits; post digestion spike is in control.

S Recovery is outside control limits.

SC Closing CCV or LCS exceeded high recovery control limits, but associated samples are non-detect. Data meets EPA requirements.

* The result for this parameter was greater that the maximum contaminant level of the TCLP regulatory limit.

CHAIN OF CUSTODY RECORD

Specialty Analytical
11711 SE Capps Road
Clackamas, OR 97015
Phone: 503-607-1331
Fax: 503-607-1336

Contact Person/Project Manager: Dan Joseph
Company: StormwateRx LLC
Address: 122 SE 27th Ave
Portland, OR 97214
Phone: 800.680.3543 Fax:
Project No.: Project Name: McNeil
Project Site Location OR: WA: X Other:
Invoice To: StormwateRx P.O. No.:

Collected By:
Signature: [signature]
Printed: Dan Joseph

Signature:
Printed:

Turn Around Time
☒ Normal 5-7 Business Days
☐ Rush ______ Specify

Rush Analyses Must Be Scheduled With The Lab In Advance

For Laboratory Use
Lab Job No.: 1403091
Shipped Via: Specialty
Air Bill No.: —
Temperature On Receipt: 6 °C
Specialty Analytical Containers? Y / N
Specialty Analytical Trip Blanks? Y / N

Date	Time	Sample I.D.	Matrix	No. of Containers	Turbidity	Tot Cu	Tot Zn	Tot Pb	Dis Cu	Dis Zn					Comments	Lab I.D.
3/10/14	2:05	A - in #1	H_2O	2	X	X	X	X	X	X						
"	2:05	A - out #1	"	2	X	X	X	X	X	X						
"	3:40	A - out #2	"	2	X	X	X	X	X	X						
"	5:15	A - out #3	"	2	X	X	X	X	X	X						

Relinquished By: [signature] Company: StormwateRx	Date: 3/10/14	Time: 1155	Received By: [signature] Company: SA	Relinquished By: [signature] Company: SA	Date: 11MAR14	Time: 1300
				Received For Lab By: Nikki Bupper	Date: 3/11/14	Time: 1300

Unless Reclaimed, Samples Will Be Disposed of 60 Days After Receipt.
Samples held beyond 60 days subject to storage fee(s)

APPENDIX C

AQUIP OPERATION AND MAINTENANCE MANUAL

Stormwater Filtration System Operation & Maintenance Manual

stormwateRx®
Reclaiming the world's water.®
122 Southeast 27th Avenue
Portland, OR 97214
www.stormwaterx.com
(800) 680-3543

Ver12

Table of Contents

Important!

Do not neglect upstream source control and stormwater management once Aquip is installed. This may result in the premature fouling of the Aquip filtration and pollutant reduction capacity, shortening bed life.

Do not flush spills or otherwise use Aquip to capture pollutants from stormwater drain line jetting or pavement washing.

Lifting Aquip once the media has been installed may result in damage to the tank. All the media except the underdrain gravel should be removed before attempting to move Aquip.

Regular maintenance of the media surface will ensure optimal performance results as well as increase the lifespan of the media bed. The removed media needs replacement after removing more than 2". Media replacement should not be done in the place of seasonal maintenance.

Do not pressure-wash or rinse the inside of the Aquip prior to removing the filtration media.

Stormwater sampling should be done with care. Use new sampling bottles and avoid contaminating samples with dirt from the Aquip sample port or your hands.

Freezing conditions can cause damage to the external plumbing on Aquip. Please refer to this manual to take the necessary precautions.

1 Introduction and System Description

Aquip is a passive adsorptive depth filtration technology designed specifically for reduction of stormwater pollutants such as suspended solids, turbidity, heavy metals, nutrients and organics from industrial sites. Aquip is a patent pending system that uses a pre-treatment chamber followed by a series of inert and adsorptive (depending on the configuration) filtration media to effectively trap pollutants in a pre-configured package. The Aquip structure is typically concrete (C), steel (S) or pre-cast concrete blocks for high flow applications (HF). Pollutant removal within the pre-treatment chamber occurs by gravity settling; pollutant removal within the filtration chamber occurs through a combination of chemical complexing, co-precipitation, adsorption, absorption, micro-sedimentation, filtration and biological degradation.

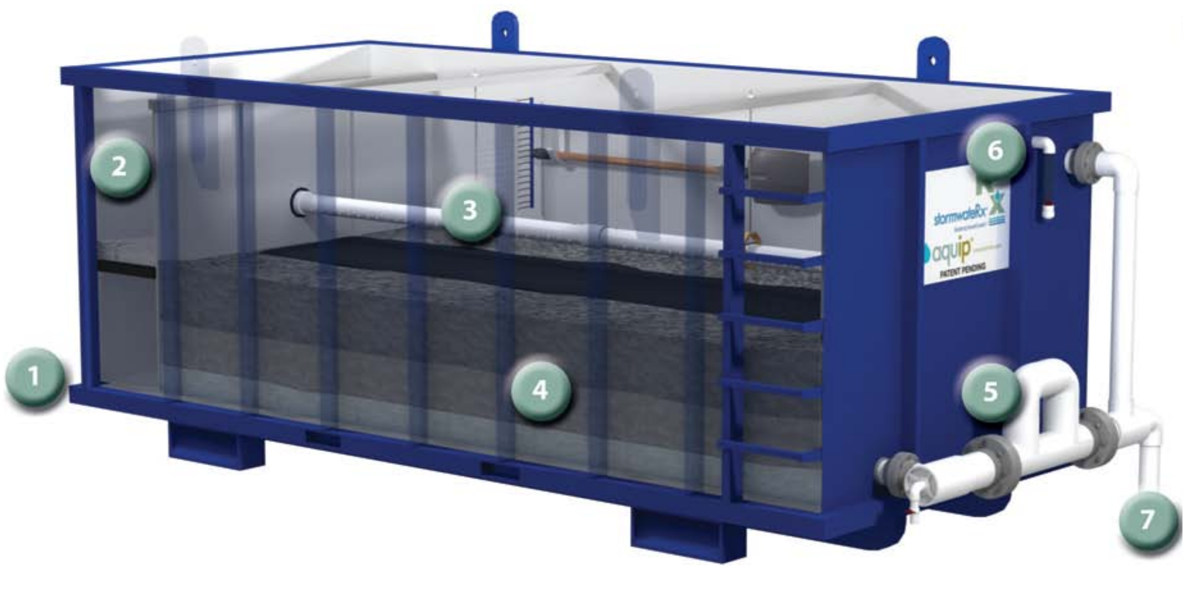


Figure 1: Aquip Stormwater Filtration System

1.1 Aquip Features

(1) **Inlet:** Polluted stormwater flows into the Aquip via the inlet pipe which controls and monitors the flow into the system.
   a. **Inline Flow Meter:** An electromagnetic flow meter displays the operating flow rate and the total volume of water treated by the Aquip. The volume of water treated should be recorded at regular intervals to help in planning maintenance intervals.
   b. **Flow Control Valve:** The valve used to calibrate the proper flow rate into the Aquip.
   c. **Inlet Check Valve:** This check valve keeps the standing water level in the pretreatment chamber at the correct level.
   d. **Inlet Sample Port:** Allows for the convenient sampling of the inlet stormwater.

(2) **Pretreatment:** This chamber is customized to improve the quality of the stormwater prior to treatment in the filtration chamber. The pretreatment chamber can be configured for settling

coarse solids, skimming free floating oil, conditioning the stormwater for dissolved metals removal, or optimizing organics removal, or any combination thereof.

The **buffering** option is the most common configuration. Aquip uses a passive pH buffering process which accelerates the output of alkalinity, an important constituent in natural waters. This buffering works synchronously with several of the adsorptive filtration media layers within the filtration chamber. The buffered water helps positively charged metallic ions find negatively charged alkalinity complexes. Some of these positive and negative ions form insoluble complexes that are then filtered out in the filtration chamber. Within the Aquip filtration treatment chamber some of the metals are removed as precipitates by micro-sedimentation. Because of the low alkalinity common to most stormwater, particularly those from facilities where most of the surface is paved, the pH buffering effect is temporary.

Other options are the basic solid settling configuration or the oil water separator design. All configurations come standard with a precautionary **oil skimmer** that helps to trap and absorb free oil inside of the pretreatment chamber.

(3) **Inlet Distributor:** Water from the pretreatment chamber flows into the inlet distributor and is dispersed along the full length of the filter media bed optimizing the contact area of stormwater with filtration media. The **energy dissipation fabric** lies beneath the distributor to prevent scouring of the media bed.

(4) **Filtration Treatment:** Layers of inert and adsorptive media make up the **media bed** which filters out stormwater pollutants such as metals, particulates, oil, organics and nutrients. Once filtered through the media bed, clean stormwater flows into the **underdrain** located along the bottom of the media bed.

(5) **Outlet Manifold:**
   a. **Outlet Sample Port:** Allows for the convenient sampling of treated stormwater.
   b. **Adjustable Head Control:** Clean stormwater leaving the filter bed passes through the adjustable head control. This device can be adjusted in the field and assures optimal water-filter media contact under a range of operating conditions.

(6) **Emergency Overflow:** The upturned elbow provides a means of bypass for stormwater if the media bed is no longer draining at a rate that keeps pace with the influent design flow rate. A passive **overflow indicator** on the outside of the Aquip tank visually indicates when an emergency overflow of the Aquip has occurred. After each overflow event, this feature needs to be reset by releasing the water stored inside the overflow indicator by turning the petcock valve located at the bottom of the device.

(7) **Outlet:** Clean stormwater is discharged from Aquip through the outlet pipe to an existing conveyance line or to an infiltration gallery or other means of disposal or reuse.

The “Installed Aquip Project Specifications” sheet at the beginning of this manual will provide the details of the system installed at your site. Refer to this document for details on your site-specific Aquip system. A description of the Aquip model numbers are provided in Table 1 below.

Table 1: Aquip Model Descriptions

System Size	Tank Material	Pretreatment Media	Filtration Chamber Media
50	S: Steel	B: Buffering	E: Enhanced (inert & sorptive)
80	C: Concrete	O: Coalescing	I: Inert
110	U: Owner Supplied	X: Settling (no media)	
160	HF: High Flow		
210			
400			
800			
Example: Model 210SBE			

1.2 Typical Installation Configuration

In most applications, the Aquip system is installed as a retrofit and installation is above ground. In this case, stormwater needs to be pumped from a below-ground vault or catch basin to the Aquip. In some cases stormwater is first pumped to an above-ground storage tank and stormwater is drained by gravity through Aquip. A configuration with a storage tank is referred to as “Storage Discharge” (Figure 2). Configurations without a storage tank are called “Direct Discharge” (Figure 3).

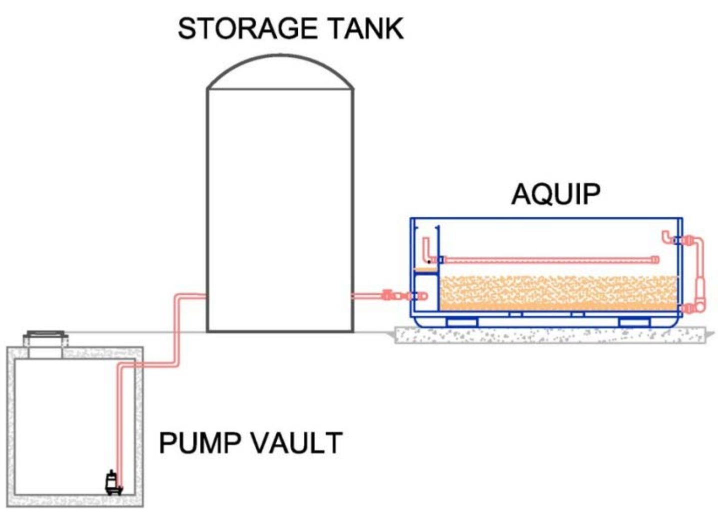


Figure 2. Storage Discharge configuration

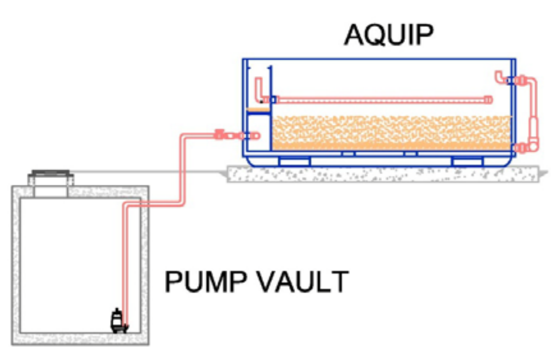


Figure 3. Direct Discharge configuration

2 Aquip Operations

Regular inspection and maintenance is required for the proper operation of the Aquip. Site conditions vary such that the maintenance requirements cannot be prescribed without regular inspections. Inspections determine the type and frequency of maintenance required and regular maintenance keeps the Aquip operating at optimal conditions to improve the performance and media longevity.

2.1 Wet Start-Up Procedures

The Aquip is typically installed during dry weather when there is not sufficient stormwater available to complete the final steps to put the Aquip online. StormwateRx LLC personnel will leave the Inlet Flow Control Valve set to half open until the flow rate to the system can be calibrated. During the first storm event it is imperative that the owner calibrate the flow rate through the system to that designated in the Installed Aquip Project Specification sheet at the front of this manual.

Step 1. **Fill Above Ground Storage Tanks:** For Storage Discharge configurations only. For Direct Discharge, proceed to Step 2. Close the outlet valve from the storage tank (or the Inlet Flow Control Valve to Aquip) and fill the above ground storage tank(s) until the water level is near the top of the tank(s).

Step 2. **Flow Calibration**: Adjust the Inlet Flow Control Valve until the Inline Flow Meter indicates the design/nameplate flow rate as noted on the flow meter (Figure 4). The design flow rate is listed in the Installed Aquip Project Specification sheet at the front of this manual.

Step 3. **Inlet Distributor Adjustment**: Adjust the height of the Inlet Distributor until each arc of water is roughly uniform across the entire length of the Aquip filtration chamber (Figure 4). This is done by tightening or loosening the plastic washers on the threaded rod suspending the Inlet Distributor.

Step 4. **System Operation:** Monitor system throughout the first storm event to confirm stormwater is passing through Aquip. Inspect outfall point of stormwater conveyance line to confirm there is free discharge. Note that the Aquip filter performance improves (outlet water clarity should improve) after the first or second storm event. This occurs because the stormwater particulates that are captured by the Aquip filtration bed in early storm events actually assist the particle filtration process, thereby producing better water clarity with time. This process is known as “bed seasoning.”

Step 5. **After Storm Inspection:** Inspect Aquip after the storm event. Normally, owners observe an accumulation of fine solids over the top of the filtration chamber. If the thickness is greater than 1/4-inch, additional upstream source control may be beneficial to reduce sediment loading to the system (see Section 7).

Figure 4. Inlet piping with flow meter (right); Uniform flow out the inlet distributor (left)

2.2 Inspections

During the first rainy season, inspections should be conducted weekly or every two to three storms to establish site-specific inspection and maintenance intervals. Regular inspections will verify that the system is in good operating condition and should be recorded as part of the monthly inspection program and the facility Stormwater Pollution Prevention (or Control) Plan (SWPPP or SWPCP). Inspections are also recommended after every major storm event. An Inspection Report is included at the end of this manual to assist with record keeping.

AN INSPECTION DURING A RAIN EVENT IS THE BEST METHOD OF ASSESSING HOW WELL THE AQUIP SYSTEM IS OPERATING

Flow meter

- Verify that the flow rate to Aquip matches the design flow rate. Operating Aquip at a rate other than the designated design flow rate will affect the system performance and may not be allowable under the stormwater permitting rules. Adjust the flow rate as necessary. Opening the flow control valve such that the flow rate is increased will decrease system performance. The flow rate should only be adjusted when the storage tank(s) are full for the Storage Discharge system configuration.

Pretreatment Chamber

For Aquip SBE- with buffering media

- Inspect the amount and distribution of the buffering media. There should be at least 3 inches of buffering media evenly distributed across the media grates.
- Inspect for the accumulation of solids and debris on top of the buffering media. Before removing accumulated debris, drain down the pretreatment chamber through the inlet sample port.
- Inspect for solidification of the buffering media. If present, clumps of buffering media should be broken up with a shovel or the provided maintenance rake.

For Aquip SOI or SOE- with oil coalescing packs

- Inspect the water surface for heavy oil sheen. If a heavy sheen is present, remove the accumulated oil from the surface.
- Inspect the side walls of the Pretreatment Chamber for heavy oil and debris accumulation. If heavy oil and debris are present, follow the maintenance steps described in the Section 3.3.

Inlet Distributor

- Inspect the perforations for the accumulation of debris. The accumulation of any debris should be removed by hand.
- During a storm event, verify that the flow of water out of the perforations is uniform the entire length of pipe. For Storage Discharge configurations, the Inlet Distributor should only be adjusted when the storage tank(s) are full.

Media Bed

- During a storm event, observe the water level above the media bed relative to the Inlet Distributor. Note that the water level may increase during the first 15 minutes of operation.
- Inspect the accumulation of solids on the surface of the media (Figure 5). Observe the appearance of the solids and its distribution across the media surface. If more solids than sand are visible on top of the media, refer to Routine Surface Maintenance Section 3.1.1.
- Check for a hardened or brittle media surface in the absence of solids accumulation. If the media surface is hardened, rake the media to help restore hydraulic capacity.
- Verify that the Energy Dissipation Fabric is clean and laying flat beneath the Inlet Distributor. The Energy Dissipation Fabric may be re-anchored by pushing small amounts of filter sand over the fabric at various intervals.

Outlet Sample Port

- Collect the effluent from the Aquip to observe changes in water clarity. The clarity of the water is best observed using a clear glass/plastic container. As mentioned earlier, water clarity should improve after the first few storms.

Figure 5. Accumulation of solids on the media bed surface

2.3 Optimal Operating Conditions

The Aquip should be maintained regularly for optimal performance and media longevity. Observe the water level within the Filtration Chamber to determine optimal operation. Both of the following conditions need to be met for the Aquip to be operating at optimal conditions:

- Water has been draining through the Inlet Distributor continuously for 15minutes or more.
- The water level within the filter is above the surface of the media but is not within 3 inches of the lowest point on the Inlet Distributor (Figure 6)

However, for LIGHT RAIN or INTERMITTENT RAIN conditions, neither of the two conditions may be established.

Should the water level within the Filtration Chamber reach the Inlet Distributor, maintenance should be performed to re-establish the proper flow through Aquip (see Section 3).

Figure 6. Best operating water level in filtration chamber for optimal pollutant removal conditions

2.4 Freezing Weather

The external piping components are empty or nearly so between storm events with the exception of sample ports. If a hard freeze occurs as water is draining down from Aquip, external plumbing on the Aquip can freeze and temporarily impair its operation. The steps below should be followed to minimize damage to external plumbing and get the Aquip back on-line as quickly as possible.

The influent plumbing leading to the Aquip may be susceptible to damage during freezing conditions if a weep hole has not been installed at the pump discharge. For systems installed in freezing climates, StormwateRx LLC recommends heat tracing all above-ground connecting piping to and from Aquip.

The media bed will likely become icy during freezing conditions which will temporarily impair the flow and treatment capability of Aquip. It is important to allow the media bed to fully thaw before conducting stormwater quality sampling. Following are some additional operating tips for freezing conditions.

<u>For Aquip systems with Storage Discharge</u>

1. Insulate or heat-trace the force main lines for this condition.
2. Close the shut-off valve between the above ground storage tank and the Aquip.
3. If no shut off valve has been installed, open the plug between the pretreatment chamber and the filtration chamber to drain down water from the storage tank through Aquip.
4. Once the storage tank has fully drained down, open the inlet sample port located on the inlet pipe to the Aquip. This will drain down the pretreatment chamber.
5. Open the outlet sample port to drain any water that still may remain in the filtration chamber.

Warning: For systems without a shut-off valve between the detention tank and Aquip, the storage tank will drain down through the inlet sample port spilling onto the ground. Owners may favor heat tracing the plumbing instead of emptying the storage tanks for freeze protection.

For Aquip systems with Direct Discharge

1. StormwateRx recommends insulating or heat-tracing all above-ground piping to the Aquip system.
2. Turn off pump.
3. Open the inlet sample port located on the inlet pipe to the Aquip to drain down the pretreatment chamber.
4. Open the outlet sample port to drain any water that still may remain in the filtration chamber.

2.5 Sampling Protocol and Methodology

Water quality samples should be taken only when the system has been maintained and is operating effectively (see Section 2.3). The inlet and outlet sample ports on Aquip provide a convenient and reliable method of taking samples.

AFTER INSTALLING NEW FILTRATION MEDIA, OPERATE THE AQUIP FOR TWO HOURS BEFORE COLLECTING AN EFFLUENT SAMPLE

Use caution when collecting water quality samples to prevent contamination of the sample bottles. A small amount of dirt goes a long way to contaminating a stormwater sample. Make sure the sample port and your hands or gloves are clean BEFORE collecting your compliance sample. The following precautions should be taken immediately before sampling:

1. Using a CLEAN cloth, wipe off any visible dirt from the sample port valve spigot.
2. Open sample valve and allow water to flush through the port for a minimum of 10 seconds.
3. Use the proper unused sample bottle – do not reuse sample bottles.
4. Do not touch the sample bottle to the sample port.
5. Do not put fingers inside or around the sample port or the mouth of the sample bottle.
6. For sample bottles with liquid preservative inside, do not allow the bottle to overflow.
7. Cap the sample bottle as quickly as possible. Store on ice. Ice helps reduce the amount of metals that move from particulate to dissolved phase and reduces the rate of growth of biological organisms within the sample bottles.

StormwateRx recommends sampling the inlet to the Aquip each time that the outlet is sampled. Without the inlet sample data, StormwateRx LLC cannot diagnose or provide recommendations on tuning system performance. The inlet should be sampled approximately 15 minutes before sampling the outlet to get the most representative inlet/outlet sample pair.

3 Maintenance Guidelines

The Aquip, like all filtration systems, requires periodic maintenance to restore the system to its original effectiveness. The type and frequency of maintenance required for the Aquip varies significantly from site to site due to differences in facility operations, upstream stormwater management, and rainfall frequency. Routine inspections conducted on the Aquip will help to determine how frequently to maintain your Aquip stormwater filter (see Section 2.2).

LOADING TO AND MAINTENANCE OF AQUIP CAN BE REDUCED BY IMPROVING UPSTREAM SOURCE CONTROL BMPS.

3.1 Filter Media Maintenance

Maintaining the filter media is the most important step for achieving the optimal results from your Aquip filtration system. The media can be maintained either by cleaning and leveling the surface or replacing specific layers of media. The type of maintenance required is based upon the flow rate through the Aquip and/or the type of pollutants entering the system. Media maintenance is done to provide uniform flow downward through the media, preventing preferential flow and utilizing the entire surface area of the media bed. By providing uniform flow, treatment is maximized.

The layers of media have been configured in a specific arrangement to provide treatment for the identified pollutants in your stormwater. Refer to Figure 7 for media layer nomenclature.

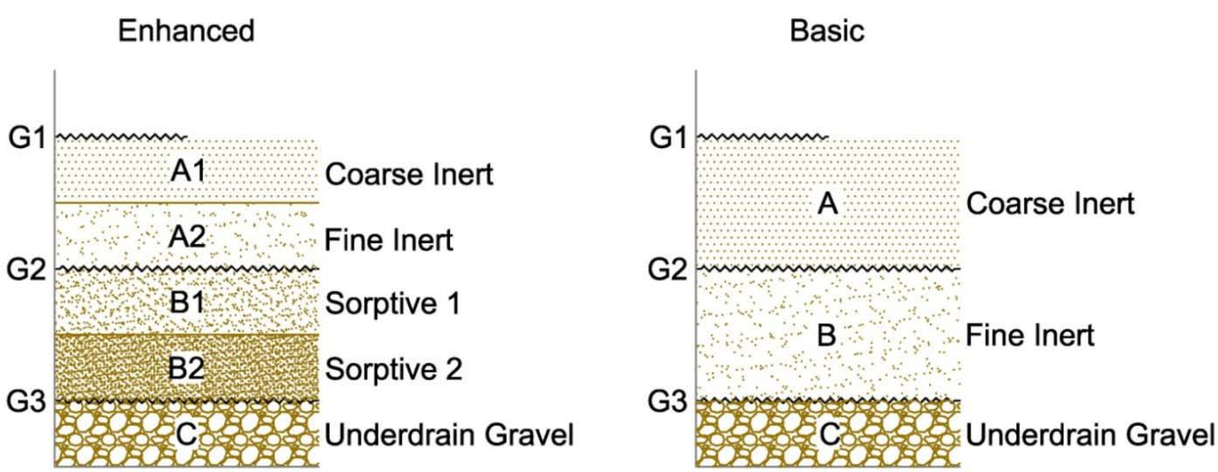


Figure 7. Enhanced and basic media bed configurations

3.1.1 Maintenance Type I – Routine Surface Maintenance

Refer to Figure 7 (page 13) to identify the media and fabric layers described in this section.

Maintenance Description

A Routine Surface Maintenance consists of cleaning the entire media surface by shoveling off and removing the top ¼ - ½ inches of media. The media below the Energy Dissipation Fabric should also be clean at this time. The surface of the media should then be leveled using the filter rake provided.

The Inlet Distributor and Energy Dissipation Fabric should also be inspected and cleaned if necessary at the time of Routine Surface Maintenance (see Section 2.2).

The removed media should be replaced after 2" of the top inert layer is removed as a result of routine surface maintenances. Replenish the removed media with new media if less than 7" of inert media remains on top of the media bed.

SURFACE MAINTENANCE AND MEDIA REPLENTISHMENT DO NOT SERVE AS A REPLACEMENT TO SEASONAL MAINTENANCE BUT DO EXTEND SYSTEM RUN-TIMES

Maintenance Timing/Frequency

A Routine Surface Maintenance should be conducted when the water level within Aquip begins to stack up. Optimal operating conditions for Aquip occur when the following conditions exist:

1. The Aquip has been operating for more than more than 15 minutes.
2. The water level within the Filtration Chamber reaches a point within 3 inches of the lowest point on the Inlet Distributor (Figure 6).

A Routine Surface Maintenance may need to be done as frequently as every 3 – 4 weeks depending on the amount of loading on the Aquip.

Maintenance Steps

The steps in conducting a Routine Surface Maintenance are:

1. Remove and set aside the Energy Dissipation Fabric (Fabric Layer G1, see Figure 7).
2. Clean the Energy Dissipation Fabric if necessary.
3. Clean the entire surface of the media by shoveling off the accumulated solids and the top ¼ - ½ inches of media (approximate). The newly exposed media should look cleaner than the removed media. Remove more depth if necessary.
4. Dispose of the removed media and accumulated debris.
5. Level the surface of the media.
6. Measure the depth of the remaining inert media layer by inserting a shovel directly down into the media until it reaches the lower-lying fabric layer. This will indicate the depth of the inert media layer.

7. Replenish the removed media with new media if less than 7” of the inert layer remains (more than 2” of the inert layer has been removed over the course of several surface maintenances).
8. Re-install the Energy Dissipation Fabric beneath the Inlet Distributor using scoops of sand to hold down the edges.

ROUTINE SURFACE MAINTENANCE HELPGS TO AVOID MORE COSTLY FULL MAINTENANCES AND IMPROVES TREATMENT PERFORMANCE

Figure 8. Surface cleaning during a Routine Surface Maintenance

3.1.2 Maintenance Type II – Seasonal Maintenance

Refer to Figure 7 (page 13) to identify the media and fabric layers described in this section.

Maintenance Description
During a Seasonal Maintenance, the inert media on top (Media Layer A) is replaced to restore the proper flow rate through the Aquip. Typically, dirt and debris are trapped within the top layer of media which eventually causes the media to plug.

Maintenance Timing/Frequency
Media replacement is necessary when the proper flow rate through the Aquip cannot be established by a Routine Surface Maintenance or lowering the Adjustable Head Control (see Section 3.2). Seasonal Maintenance is recommended when stormwater sampling shows consistent pollutant reductions and solids loading in the lower-lying media (Media Layer B) is not appreciable.

Maintenance Steps

StormwateRx can provide a quotation for Seasonal Maintenance which includes the new media, filter fabric, and optional technical supervision at the time of the maintenance. The steps to conduct a Seasonal Maintenance are:

1. Set up safety equipment if the system is near vehicle and pedestrian traffic.
2. Sparingly pressure-wash or hand-wipe the side walls of the Aquip prior to removing any media. Cleaning the inside walls of the Aquip will allow the operator to observe the system's most recent operating water level based upon the scum line left behind inside of the Aquip. No detergent or hot water should be used when cleaning the insides of the Aquip.
3. Remove and dispose of the Energy Dissipation Fabric (Fabric Layer G1, see Figure 7).
4. Excavate the spent filter media (Media Layer A) down to the first layer of geotextile fabric (Fabric Layer G2). A shovel or vactor truck may be used to remove the filter media. See Section 5 for media disposal.
5. Remove Fabric Layer G2 and inspect the underlying filter media (Media Layer B).
6. Rake the top three to six inches of media to regenerate Media Layer B. Level and smooth the filter media.
7. Re-install Fabric Layer G2 on the top of Media Layer B.
8. Install the new inert filter media (Media Layer A). Media should be added in uniform, level layers using the level indicators on the side walls of the Aquip as a guide. Each media layer should be leveled before adding the next media layer.
9. Install the new Energy Dissipation Fabric (Fabric Layer G1) on top Media Layer A using scoops of sand to hold down the edges.

When conducting a Seasonal Maintenance, the pretreatment chamber should also be maintained (see Section 3.3).

NO DETERGENT OR HOT WATER SHOULD BE USED WHEN CLEANING THE INSIDES OF THE AQUIP

Figure 9. Vactor service removing the top layers of sand during a Seasonal Maintenance

3.1.3 Maintenance Type III – Full Maintenance

Refer to Figure 7 (page 13) to identify the media and fabric layers described in this section.

<u>Maintenance Description</u>
A Full Maintenance replaces all of the filtration media (Media Layers A and B) not including the underdrain gravel (Media Layer C). The filtering capacity of the media can be exhausted due to a combination of heavy loading, inadequate maintenance of the Aquip, and extended Aquip run-times.

<u>Maintenance Timing/Frequency</u>
Full Maintenance is recommended when a decline in treatment is observed in the water quality sampling and Routine Surface Maintenance is no longer capable of restoring the proper flow. Significant loading in the lower-lying media layers (Media Layer B) will often accompany a decline in treatment.

<u>Maintenance Steps</u>
StormwateRx can provide a quotation for a Full Maintenance which includes the new media, filter fabric, and optional technical supervision at the time of the maintenance. The steps to conduct a Full Maintenance are:

1. Set up safety equipment if the system is near vehicle and pedestrian traffic.
2. Sparingly pressure-wash or hand-wipe the side walls of the Aquip prior to removing any media. Cleaning the inside walls of the Aquip will allow the operator to observe the system's most recent operating water level based upon the scum line left behind inside of the Aquip. No detergent or hot water should be used when cleaning the insides of the Aquip.

3. Remove and dispose of the Energy Dissipation Fabric (Fabric Layer G1, see Figure 7). Use a vacuum truck or shovel to remove all spent media (Media Layers A and B). Stop at the geotextile fabric above the underdrain gravel (Fabric Layer G3). The underdrain gravel (Media Layer C) should ***not*** be removed.

DO NOT PRESSURE WASH OR RINSE THE SIDE WALLS OF THE AQUIP ONCE THE FILTRATION MEDIA HAS BEEN REMOVED

4. Remove the PVC plugs located at each of the ends of the underdrain. Also remove the Adjustable Head Control located on the outlet end of the Aquip by loosening the flanges located on both sides of this PVC loop (see Figure 1).
5. Pressure-wash the insides of the underdrain to flush its insides.
6. Reinstall all of the PVC plugs on the underdrain and the Adjustable Head Control.
7. Install new geotextile fabric (Fabric Layer G3) on top of Media Layer C.
8. Install the new media layers and filter fabric layers as shown in Figure 7. Media should be added in uniform, level layers using the level indicators on the side walls of the Aquip as a guide. Each media layer should be leveled before adding the next media layer.
9. Install a new Energy Dissipation Layer (Fabric Layer G1) on top layer of the media using scoops of sand to hold down the edges.

When conducting a Full Maintenance, the pretreatment chamber should also be maintained (see Section 3.3).

3.2 Adjustable Head Control

The flow rate through the Aquip may be increased using the Adjustable Head Control. This should be done only when the proper flow rate cannot be established with Routine Surface Maintenance. By lowering the Adjustable Head Control, the back pressure within the media bed is reduced allowing the water to flow more freely through the system. The steps to lowering the Adjustable Head Control are:

1. Loosen all of the bolts on the two flanges located on both sides of the Adjustable Head Control. Some bolts may need to be loosened further after the flange assembles change their positioning.
2. Rotate the Adjustable Head Control downward away from the Aquip so that it is positioned parallel to level ground.
3. Evenly tighten the bolts on both flanges. Do not over tighten the bolts. The rubber gasket between the flange assembles will create a seal with even pressure around the flange.

3.3 Pretreatment Chamber Maintenance

The pretreatment chamber should be maintained when performing a Seasonal or Full Maintenance. Inspections of the pretreatment chamber should be performed as part of your routine inspections. The maintenance procedure for each type of pretreatment configuration is described below.

For Aquip SBE- with loose buffering media

1. Remove and dispose of the solids that have accumulated on the surface of the buffering media.
2. Shovel the loose media to one side of the pretreatment chamber.
3. If the walls of the pretreatment chamber are coated in mud or debris, hose down the walls.
4. Lift up and remove the grate exposed by shoveling aside the media.
5. Suspend a pump off of the floor of the pretreatment chamber and pump down the water beneath the buffer media grates.
6. Shovel or vactor out the accumulated solids on the floor of the pretreatment chamber.
7. Replace grates and level the buffering media across the surface of the grates.

Figure 10. Pretreatment chamber (with buffering media) in need of maintenance (left); buffering media after maintenance (right)

For Aquip SOI or SOE- with oil coalescing packs

1. Remove the accumulation of any heavy oil sheen on the water's surface using an oil adsorbent pad(s) or vactor service.
2. Drain down the pretreatment chamber using the inlet sample port.
3. Remove the coalescing packs from pretreatment chamber.
4. Remove the plastic media blocks from stainless steel frame.
5. Clean the plastic media blocks and stainless steel frame using a low pressure hose.
6. Collect and dispose the removed oil and debris.

7. Reassemble coalescing packs and reinstall in pretreatment chamber.

For Aquip SXI - with pretreatment settling

1. Drain down the pretreatment chamber using the inlet sample port.
2. If necessary, hose down the walls of the pretreatment chamber.
3. Suspend a pump off of the floor of the pretreatment chamber and pump down the water beneath the buffer media grates.
4. Shovel or vactor out the accumulated solids on the floor of the pretreatment chamber.

3.4 Oil Skimmer Maintenance

The oil sorbent pad on the oil skimmer should be routinely checked. The sorptive media within the pad will expand when reacting with oil causing the pad to swell in size. The oil sorbent pad should be replaced once the pad has swollen to its maximum size.

3.5 Flow Meter Maintenance

The inside of the flow meter should be cleaned at a minimum of once a year to remove accumulating oil and dirt. Any accumulation on the surfaces of the electrodes will impede the proper operation of the flow meter. Remove the flow meter from the influent line on the Aquip and clean the small metal surfaces (electrodes) and all other surfaces inside of the flow meter using a soft cloth and a 50/50 solution of denatured alcohol and water.

The user manual for the installed flow meter is attached at the end of this O&M manual.

Table 2. Replacement batteries for Aquip flow meters

Type of Flow Meter	Batteries Required
Seametrics 2” Flow Meter	6 AA batteries
Seametrics 3” Flow Meter	6 AA batteries
Seametrics 4” Flow Meter	Battery pack of 2 Lithium XL-205F batteries

4 Troubleshooting

The table below provides a quick reference to address specific issues confronted with the operation of the Aquip. Sections 2 and 3 should be reviewed to reduce the onset of these issues.

Table 3. Aquip Troubleshooting

Symptom	Probable Cause	Recommended Action
Water is spilling over the baffle wall between the Pretreatment Chamber and the Filtration Chamber.	The flow rate into the system is not correct. The Inlet Distributor needs to be cleaned of accumulated debris.	Adjust the flow control valve (see Section 2.2). Remove the accumulated solids within the Inlet Distributor (see Section 2.2).
There is an uneven distribution of water across the media surface or from the Inlet Distributor.	The media surface is not level. Water is channeling unevenly across the media surface. The Inlet Distributor is not properly adjusted. More water is flowing out of one end of the Inlet Distributor more than the other.	Clean the media surface by removing accumulated debris and then level the top of the media to reduce uneven channeling. When the system is operating at the design flow rate, adjust the height of the Inlet Distributor so that the flow out of the pipe is even on both ends (see Section 2.1).
The water level within the Aquip is significantly higher than the inlet distributor (up to the emergency overflow) during Aquip operation.	The flow rate into the system is not correct. Too much solids have accumulated on the media surface. This can be observed as a thin brittle crust or as heavy solids accumulation. Solids have migrated deep within the media bed.	Adjust the flow control valve (see Section 2.2). In either of these cases, use a square point shovel to remove the top 1/4" of sand (approximate, see Section 3.1.1). The Adjustable Head Control should be lowered (see Section 3.3). A Seasonal Maintenance may also be necessary (see Section 3.1.2).

Table 3 continued. Aquip Troubleshooting

The Aquip is not draining water through the media bed.	Solids accumulation on the media surface is preventing flow through the media.	From the outside edge of the tank, use a shovel to disturb the media surface in several locations. Conduct a Routine Surface Maintenance once the water drains down completely (see Section 3.1.1). A Seasonal Maintenance may be necessary (see Section 3.1.2).
The buffer media racks within the Pretreatment Chamber have been moved out of place.	Heavy oil and/or solids accumulation has accumulated on the bottom side of the buffer media racks allowing the water to push them out of place.	Conduct Pretreatment Chamber Maintenance (see Section 3.4). Clean both sides of the racks by spraying them down with water.
The metals removal efficiency from the Aquip is beginning to decrease.	Loading on the media surface is preventing uniform flow downward through the media. The sorptive media within the media bed is beginning to reach its capacity.	For a brittle or hardened media surface, rake the media to regain the hydraulic capacity. For heavy solids loading (i.e. more solids than sand visible on top), remove the top1/4” of sand (approximate, see Section 3.1.1). A Full Maintenance will be necessary (see Section 3.1.3).

5 Material Disposal

Water and sediment removed from the Aquip filter must be disposed of in accordance with all applicable waste disposal regulations. The removed accumulated sediment in the Aquip can typically be sent to the local landfill. Follow local regulations for standard guidelines for solid waste disposal.

6 Maintenance Support

If you have any questions about maintenance procedures, contact StormwateRx LLC at (800) 680-3543.

7 Best Management Practice Requirements

Achieving the benchmarks consistently requires rigorous implementation of best management practices (BMPs) including source control, structural and treatment BMPs. Treatment BMPs (i.e. the Aquip filtration system) are not designed to operate in the absence of other BMPs. Employing source control practices on a regular basis is essential in extending the life of the Aquip system as heavy pollutant loading can result in a shorter maintenance cycle than expected. The Aquip system is not designed as an all-in-one treatment device for all types and quantities of stormwater pollution.

Your Stormwater Pollution Prevention (or Control) Plan (SWPPP or SWPCP) should address the BMPs appropriate for your facility. During normal business operation, make sure that all best management practices are deployed and maintained. When engaging in operations that are atypical of standard business practices, please utilize source control measures to prevent heavy pollutant loading into the Aquip. The following are a few examples of typically employed practices.

- **Sweeping:** Sweep site on a regular basis, such as daily, weekly or bi-monthly, especially in areas of heavy industrial activities.
- **Covering activities:** When practical, cover significant materials or industrial operations that are outdoors, to prevent stormwater contact with potential pollutants.
- **Spill control:** When a spill occurs, contain and use onsite spill kits to dispose of material.

DO NOT FLUSH SPILLS OF ANY KIND INTO THE AQUIP FILTRATION SYSTEM

- **Catch basin and stormwater conveyance clean out:** When cleaning out catch basins and jetting stormwater conveyance lines turn off the pump that diverts water to the Aquip system. This water should not enter the Aquip system.

JETTING YOUR STORMWATER LINES INTO THE AQUIP FILTRATION SYSTEM IS NOT ADVISED.

Trademarks and Disclaimers

This document is subject to change without notice.

StormwateRx LLC
122 Southeast 27th Avenue
Portland, Oregon, 97214
(800) 680 - 3543