SELECTING A
BOAT BOTTOM WASHING OPTION FOR YOUR MARINA
A CASE STUDY:
MANCHESTER MARINE

Project No. 04-12/319

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INTRODUCTION

Issues/Need

Ordinary maintenance of boats includes power (pressure) washing of boat bottoms to remove accumulated material that may contribute to degradation of the hull material and interfere with a boat's operation. Boat-bottom wash water contains mostly biological particles, algae and barnacles, and paint particles containing heavy metals (e.g., copper, lead, and zinc). The U.S. Environmental Protection Agency (U.S. EPA) considers boat-bottom wash water as industrial or process wastewater. Therefore, boat-washing discharges require an individual industrial discharge permit under the U.S. EPA National Pollutant Discharge Elimination System (NPDES) in addition to the permit coverage required for a marina and/or shipbuilding/repair facility by the NPDES Stormwater Multi-Sector General Permit (MSGP) for Industrial Activities. The applicable regulations stem from the Clean Water Act (33 U.S.C. 1251 *et seq*.) and the resulting regulations of 40 CFR 122.

The permits impose discharge limitations to ensure that the state water quality standards are met in the receiving water. Based on the typical concentrations of pollutants in boat-bottom wash water, some form of treatment is required to meet the discharge limitation requirements, effectively eliminating the legal direct discharge of boat-bottom wash water to Waters of the United States.

Wash water that would be discharged to groundwater either through direct discharge or infiltration requires a Massachusetts Department of Environmental Protection (MA DEP) Groundwater Discharge Permit. To meet groundwater discharge standards, treatment of typical boat-bottom wash water would be required, also eliminating the legal direct discharge of boat-bottom wash water to groundwater. Similarly, wash water discharged to a publicly-owned treatment works (POTW) would require a Sewer Use Discharge Permit and be required to meet the POTW's discharge limitations.

In 2004, the Massachusetts Office of Coastal Zone Management (CZM) indicated that most marinas in Massachusetts did not perform any type of wastewater treatment for their boat-bottom wash water. Traditionally, the wash water was allowed to discharge to nearby surface waters or to run onto the ground surface without treatment. However, since that time, many Massachusetts marinas have been working to address this issue and to come into compliance with current regulations and permits.

DEP 319 Grant

On June 1, 2004, Manchester Marine, in partnership with Ransom Environmental Consultants, Inc. (Ransom), submitted a *Boat Bottom Washing Systems, Demonstrative and Out-Reach Proposal* to the MA DEP for funding under the 319 Non-Point Source Pollution Grant Program. The proposed project strategy was twofold:

- Remedy the compliance issue regarding handling of boat-bottom wash water at Manchester Marine with the design and construction of a treatment system applicable to a typical mid-size marina; and
- Provide assistance to other regional boatyards and marine businesses confronted with similar compliance problems by disseminating the information learned during the research, design, construction, and testing of the installed system.

The ultimate goal of the project is to see regional marinas come into compliance with federal and state environmental regulations, thereby resulting in an improvement in coastal water quality.

On April 6, 2005, Manchester Marine was given a Notice to Proceed in a letter from Mr. Steven J. McCurdy, Director, MA DEP Division of Municipal Services.

ASSESSING YOUR FACILITY

The first step in selecting an appropriate boat-washing option for your facility is to complete an assessment of the current conditions, including operational practices and infrastructure. The following are some items to consider during such an assessment.

Marina Operations

Begin with an understanding of the operations at the marina. This will provide a baseline for the current conditions and will identify factors that may be critical for design.

Current Operations

- How large is your facility?
- What is the typical vessel size that is serviced?
- When does your facility perform boat-bottom washing?
- What marina operations are ongoing concurrently with boat-bottom washing?
- How many boats are typically washed at your facility?
- What is the duration of pressure washing for a typical boat, and how much water is used in the process? If site-specific information is not available, pressure washing for a "typical" boat uses 70 gallons.
- How is boat-bottom wash water currently managed?
- What percentage of the boats washed have used ablative paint? What percentage have used non-ablative paint?
- Will other types of wastewater be managed by the system (e.g., bilge water, etc.)?

Staffing

- Do you have staff dedicated to boat-bottom washing?
- What training will be required for staff if the current boat-bottom washing operation is altered?

Existing Permits

- What permits are in place at your facility?
- Do you conduct sampling to comply with discharge limitations? If so, is your discharge typically in compliance? If not in compliance, what are the upset parameters?

Future Projections

- Do you project any changes to your facility's operations (e.g., size, services, development, etc)?
- Are there other development plans in place that may impact the location or design of a wash water treatment system?

Infrastructure

Site Layout

- What is the layout of your facility?
- Where is your facility currently performing pressure washing?
- What is the facility topography and stormwater flow direction(s)?

Existing Facilities

- Does your operation have existing facilities that could be used for a treatment system?

Site Constraints

- Are there site constraints such as space limitations, floodplains, or geologic and/or topographic conditions which will impact the design of a treatment system?

Available Public Services

- What is the location and size of the closest available sewer line connection?
- What utilities are available at the site?

Results for Manchester Marine

Manchester Marine, a private marine operation located in Manchester Massachusetts, is representative of a "typical" boat repair yard and mid-sized marina, with slips available for 45 boats. The property is surrounded on the southwest, southeast, and northeast sides by seawalls and Manchester Harbor. The majority of the property is occupied by two large work sheds in which most of the boat maintenance and repair operations are conducted. Boats are stored over the winter on two adjacent parcels located to the northwest on the opposite side of active railroad tracks. The facility does not have current plans for expansion. The facility is covered by the NPDES/MSGP for Sector R, Ship and Boat Building or Repair Yards.

The marina clientele is primarily composed of private boats/yachts up to 50 feet in length. Boat washing is performed at various times throughout the operating season, but primarily occurs during fall months when boats are being hauled and prepared for winter storage. Washing is not performed during winter months. In a typical season, Manchester Marine washes approximately 200 boats. The boat-washing area is located adjacent to the boat hauling area at the southwest side of the facility. Pressure washing is performed in the open, without the use of cleaning chemicals, to mechanically remove marine growth and loose paint. Prior to installation of the current system, the resulting boat-bottom wash water flowed towards Manchester Harbor.

Manchester Marine estimates that a typical boat wash time is 20 to 30 minutes and requires approximately 40 to 50 gallons of water. During peak wash periods, total wash water used is estimated to be 400 to 500 gallons per day. Manchester Marine estimates that approximately 75 percent of the boats washed at the facility use non-ablative paint on their hulls, while the remaining 25 percent of boats use ablative paints.

The facility will continue to use an area adjacent to Manchester Harbor for pressure washing. The wash area is subject to flooding during significant storm surges. Space is available for a small treatment facility, as is electricity, water, and a municipal sewer line. However, despite the proximity of the sanitary sewer line, the Town of Manchester will not permit discharge of pressure washing wash water into the sewer line due to limitations of the POTW.

IDENTIFYING NEEDS/GOALS

Boat-Bottom Wash water

Boat-bottom wash water will vary depending on the type of paint used on the boat bottom. Boat-bottom paints used to prevent fouling growth can be separated into three general categories: antifouling hard, antifouling ablative, and non-toxic coatings. Although non-toxic coatings are the most environmentally friendly, they are not widely available. Thus, hard and ablative paints are the two most commonly used boat-bottom paints.

Hard paints contain varying levels of biocides which are released slowly. When hard or “contact leaching” paints dry, they create a porous film on the hull. Biocides are held in the pores. The paint is resistant to abrasion or rubbing but the toxins dissolve when they contact water. Speed boats are generally painted with hard paints because of their speed of operation. Pressure washing will remove fouling growth and possibly paint chips, which can be removed by filtering the wash water. Very little pigment is typically removed during pressure washing of hard paint.

Ablative paints generally contain lower levels of toxins yet they are released at a steadier rate. Ablative or “sloughing” paints are partially soluble. The active ingredient is continually leached out. The underlying film then weakens and is polished off as the boat moves through the water. Fresh antifouling paint is thus exposed. Ablative paint is most effective when a boat is used regularly. Pressure washing will remove some ablative paint and result in coloring of the wastewater.

The Seattle, Washington, Water Pollution Control Department (Seattle WPCD) completed a *Maritime Industrial Waste Project* in March 1992. In that study, the Seattle WPCD analyzed 18 samples of pressure-washing wastewater from boatyards to determine the contaminants present. In 2002, the State of Maine completed a study to determine the contaminants that were removed from boat hulls during pressure washing. The results of those studies are summarized below.

Contaminant	**Seattle WPCD Sample Results**	**State of Maine Sample Results**	**State of Maine Background Levels**
	Concentrations in milligrams per liter (mg/l)		
Copper	2.05–190	20–170	0.028
Lead	0.1–14	0.2–3.7	0.007
Zinc	0.62–22	5.4–15	0.019
Tin	0.06–1.4	Not Reported	---
Arsenic	0.07–0.1	Not Reported	---
Total Suspended Solids	34–3,100	Not Reported	---

The results from the Seattle WPCD found that suspended solids accounted for 97 percent of the copper, 94 percent of the lead, and 83 percent of the zinc present in the pressure-washing wastewater. The chemical analysis results indicate that boat-bottom wash water can be a significant source of Non Point Source (NPS) Pollution.

Establishing Goals

Based on the typical boat-bottom wash water characteristics presented above, if an evaluation of your facility demonstrates that untreated wash water is being discharged on site, your facility will need to take action to comply with state and federal regulations. The goal of your project should be to prevent the discharge of contaminants to surface water and/or groundwater by either:

- <u>Treatment and Permitted Discharge</u>: The boat-bottom wash water is captured and treated prior to discharge to the environment or to a municipal sewer/wastewater treatment facility in accordance with an individual industrial discharge permit; or
- <u>Discharge Elimination</u>: Boat bottom washing is discontinued at the facility, or the discharge of boat-bottom wash water to the environment is prevented so that an individual industrial discharge permit is not required.

The goal of your project will determine the applicable wash water management options available to your facility.

Manchester Marine's Washwater

Boat-bottom wash water characterization results are summarized below for four (4) samples collected by Ransom following pressure washing at Manchester Marine. For comparison purposes only, we have included benchmark concentrations provided in the U.S. EPA NPDES Storm Water Multi-Sector General Permit (MSGP) for Industrial Activities. The benchmark concentrations provided below are not applicable to a specific Sector but instead represent typical benchmark values for various Sectors as provided in the MSGP. The U.S. EPA has determined that pollutant concentrations above benchmark levels represent a level of concern. A level of concern is a concentration at which a stormwater discharge could potentially impair or contribute to the impairment of water quality, or affect human health from ingestion of water or fish. The benchmark concentrations are *not* direct numeric effluent limitations; however, they do represent target concentrations in industrial stormwater for a facility to achieve through implementation of pollution prevention measures at the facility.

Pollutant Parameter	**Manchester Marine Wash water Sample Concentrations (mg/l)**		
	Non-Ablative Paint	**Ablative Paint**	**MSGP Benchmark Levels**
Antimony	BRL(0.006)	0.689	0.636
Arsenic	0.046–0.053	0.191	0.16854
Beryllium	BRL(0.004)	0.005	0.13
Cadmium	BRL(0.005); 0.016	0.009	0.0159
Chromium	0.01–0.04	0.13	0.1
Copper	**53–63**	**180**	0.014 - 0.0636
Lead	**0.126–0.237**	**10.5**	0.082

Pollutant Parameter	Manchester Marine Wash water Sample Concentrations (mg/l)		
	Non-Ablative Paint	Ablative Paint	MSGP Benchmark Levels
Nickel	BRL(0.025)–0.029	0.7	1.017
Selenium	BRL(0.005)	0.012	0.2385
Sodium	490–960	1100	NS
Tin	BRL(0.050)	0.102	NS
Zinc	**1.6–5.9**	**16**	0.12
pH	7.17 –7.73	7.61	6.0 – 9.0
Total Suspended Solids	**520–720**	**2,700**	100
Chloride	750–1,600	1,600	860
Ammonia Nitrogen	0.103–0.17	0.345	19
Total Kjeldahl Nitrogen	17–29	59	NS
Total Phosphorus	**4.8–7.4**	**25**	2.0
Chemical Oxygen Demand	**610–840**	**3,200**	120
Biological Oxygen Demand, 5 Day	**BRL(40)–150**	**140**	30
Oil and Grease	13–19	12	15

Notes:

1. BRL indicates below laboratory reporting limit at the reporting limit in parentheses.
2. Boldface values indicate identified pollutants of concern

Based on the results of the site-specific boat-bottom wash water characterization, Manchester Marine identified copper, lead, zinc, suspended solids, phosphorus, and chemical and biological oxygen demand as pollutants of concern at the facility.

Manchester Marine's Goals

Manchester Marine identified the need for an effective Best Management Practice (BMP) to eliminate the discharge of untreated boat-bottom wash water. Specifically, Manchester Marine's goal was to eliminate the discharge of boat-bottom wash water entirely with the installation of a closed-loop wastewater recycling system, thereby also eliminating the need for a separate individual industrial wastewater discharge permit for the facility.

BOAT-BOTTOM WASH WATER MANAGEMENT OPTIONS

The available BMPs for handling of boat-bottom wash water generally fall into two categories:

- Collection and Treatment/Disposal Options; and
- Non-discharging (closed-loop) Recycling Systems.

Each of the categories is described below, along with advantages and disadvantages.

Collection and Treatment Options

The collection and treatment options can be further subdivided into on-site discharges to surface water or groundwater, or discharge to a POTW, either directly to a municipal sewer or by truck transport from an on-site collection tank.

On-Site Discharge to Receiving Waters/Ground

In this option, an on-site treatment facility is designed to treat the wash water prior to discharge to surface water or ground/groundwater. An individual discharge permit containing effluent limits is required. A high level of treatment should be expected to reach the required very low effluent limits. Treatment will likely include the removal of dissolved metals in addition to filtration to remove suspended sediments. Options such as reverse osmosis, ultra-filtration plus ion exchange, or distillation will likely be required.

Advantages:

- Will reduce the pollutant discharge to the receiving water

Disadvantages:

- Individual discharge permit required from U. S. EPA
- Very low effluent limits are required
- May be very difficult to reach effluent limits required by discharge permit
  High capital cost of on-site treatment system
- High operational cost
- Holding tank required
- Ongoing effluent monitoring required
- May require a MA DEP certified operator to run the treatment system
- Liability resulting from the potential for groundwater contamination
- Filtered solids may require disposal as a hazardous waste

Discharge to a Municipal Sewer

In this option, the wastewater passes through an on-site pretreatment facility designed to reduce the pollutant loading prior to discharge to a sanitary sewer. A sanitary sewer permit containing effluent limits is required from the local POTW; however, these limits will be higher than those required for direct discharge to receiving waters. Therefore, a moderate level of treatment should be expected to remove the major portion of the suspended solids. Treatments such as settling and filtration, chemical flocculation and settling, or filtration, dissolved-air flotation, or ultra-filtration will likely be required.

Advantages:

- Will eliminate discharge to the receiving water
- Low holding-tank capacity required

Disadvantages:

- Sanitary sewer permit required (moderate effluent limits)
- Requires the availability of a municipal sewer line and capacity at the POTW
- May require a MA DEP certified operator to run the treatment system
- Moderate capital cost
- Moderate operational cost
- Ongoing effluent monitoring required
- Filtered solids may require disposal as a hazardous waste

Discharge to On-Site Holding Tank/Hauled to POTW

This option is used in lieu of the discharge to a municipal sewer in locations where a municipal sewer line is not readily available. In this option, the wastewater passes through an on-site pretreatment facility as with the municipal sewer option above. However, the effluent is stored in a holding tank until it is pumped and hauled to the local POTW for treatment. Surrounding POTWs may only be used if the effluent is transported under manifest by a licensed waste hauler.

Advantages:

- Will eliminate discharge to the receiving water
- Does not require the availability of a municipal sewer line

Disadvantages:

- Receiving facility approval required
- May require a MA DEP certified operator to run the treatment system
- Low to moderate capital cost
- Moderate to high operational cost
- Ongoing effluent monitoring required
- Filtered solids may require disposal as a hazardous waste

Discharge to On-Site Holding Tank/Hauled to Disposal Facility

In this option, the wastewater is not treated prior to leaving the site but is instead disposed of as industrial wastewater at a hazardous waste facility. The wastewater is stored in a holding tank until it is pumped and hauled to a disposal facility.

Advantages:

- Avoids the capital costs associated with installation of a treatment system
- May be a viable option for facilities that generate low volumes of wash water
- Will eliminate discharge to the receiving water
- Low permit requirements
- Low capital cost

- Low maintenance

Disadvantages:

- Availability of a disposal facility
- On-site storage capacity required
- Industrial wastewater holding-tank certification required
- High ongoing disposal costs
- May need to be transported by a licensed hauler as industrial wastewater

Non-Discharging Recycling Systems

In this option, the boat-bottom wash water is collected at the facility, treated, and reused as wash water in the pressure washer. A moderate to high level of treatment is required to remove particulates. Some form of odor control will be required, such as chemical additives and/or aeration. Solids generated through the filtration process should be tested to determine appropriate disposal options.

Advantages:

- Will eliminate discharge to the receiving water
- No U.S. EPA or discharge permit requirements
- Water conservation

Disadvantages:

- High capital costs
- High maintenance requirements
- Potential for bacterial problems and odors
- Filtered solids may require disposal as a hazardous waste

Solution for Manchester Marine

For Manchester Marine, the preferred strategy was to discharge wastewater to the sanitary sewer located on the site. However, this option was not permissible with the Town of Manchester due to various limitations at the POTW. Rather than pursue the level of treatment, permitting, and ongoing monitoring required for discharging to Manchester Harbor, Manchester Marine opted to pursue a non-discharging system.

Manchester Marine further decided that they wished to reclaim and treat the wash water for re-use as pressure wash water in a closed-loop system rather than incur the ongoing high costs for disposing of large quantities of untreated wastewater. This approach was determined to be:

- Cost-effective;
- Easy to incorporate into the existing facility layout;
- Minimally disruptive to marina operations, due to less frequent system pump-outs; and
- Economically and environmentally responsible with respect to water conservation.

CHOOSING A TREATMENT SYSTEM

Treatment System Technologies and Selection Considerations

There are numerous vendors offering a variety of technologies for wash water treatment systems. The majority of the available systems will use one or more of the following processes:

- Filtration;
- Flocculation;
- Biological treatment with microorganisms;
- Carbon adsorption; and/or
- Aeration.

Each of these approaches has its relative merits and limitations. The selection of the most appropriate technology should consider various factors including:

- Volume of water to be processed;
- Pollutant concentrations in wash water;
- Other wastewaters handled by the system;
- Pollutant discharge limits, if any;
- Ease of use;
- Purchase and installation costs;
- Operation and maintenance costs;
- Handling of hazardous wastes, if any;
- Reliability;
- Available space;
- Climate; and
- Client preference.

It is important to verify manufacturer's claims with testimony from regional marina operators with similar facilities. Costs for individual systems can also be widely variable.

Results for Manchester Marine

Manchester Marine received proposals from five vendors and conducted interviews with each before selecting a system. The majority of the systems considered relied primarily on filtration for pollutant removal, combined with aeration for odor control. This approach is appropriate for boat-washing since the washing process is primarily mechanical and most of the pollutants will be contained in the suspended solids in the wastewater, as opposed to being dissolved in the water itself. Because Manchester Marine was installing a closed-loop system, it was not required to meet permitted discharge limits, and further processing or polishing with activated carbon or other processes was not warranted. Manchester Marine selected their system based on the:

- Effective treatment technology;
- Testimony from regional users;
- Simplicity of use and installation;
- Purchase price; and
- Manufacturer's support.

DESIGN CONSIDERATIONS FOR MANCHESTER MARINE

Required Site Improvements

Manchester Marine determined that some site improvements would be required in conjunction with the design of the system. Therefore, the overall design included reconstruction of the seawall, support for the travel lift, and construction of a suitable wash pad, along with installation of drains, tanks, and other systems necessary to capture and reclaim the wash water.

For Manchester Marine, a design objective was to continue the historical practice of washing boats on the travel lift in the immediate haul-out area. Long before the start of this project, Manchester Marine recognized that the stone seawall on the west side of the facility was failing and in need of replacement/ repair. Because of the proximity of the proposed wash-system structures to the seawall, Manchester Marine was concerned that the construction activities proposed for the project could further compromise the damaged seawall. Therefore, the replacement/repair of the seawall was completed prior to initiating the current project.

Upgrades were required in the wash area itself to provide an appropriate surface for capturing the wash water, and structural support for the travel lift. The wash-pad surface was designed with a minimally sloped surface so that runoff would flow away from the harbor to a drainage grate located at the end of the travel lift. The original design for the wash pad included constructing a concrete pad to provide both functions. The design was later modified to consist of two 6-foot by 25-foot reinforced concrete slabs beneath the travel-lift wheel paths, and an asphalt surface as the wash pad. The asphalt surface was designed to be relatively flat, to enable much of the larger wash debris to be retained on the wash pad rather than be filtered by the reclaim system.

Washing Operations

The degree of automation of the system is an important design consideration. As the degree of automation is increased, the need for specialized training and the potential to mismanage wastewater due to operator errors is reduced. However, higher degrees of automation come with a higher system cost. To reduce the cost of the system, Manchester Marine accepted some additional operational obligations, such as manually removing accumulated debris from the wash pad at the end of each day of washing. By manually capturing the larger debris before it entered the treatment system, the efficiency of the treatment system would be improved and additional system components could be eliminated. Where possible, the overall system was designed to minimize operational responsibilities for boat-washing personnel.

Stormwater Management

A primary system design challenge was the management of stormwater within the wash area to minimize the co-mingling of pressure wash water and solids with stormwater that falls within the wash area. The wash area is in an open yard; therefore, the drain within the wash area has the dual functions of collecting wash water during pressure washing, and stormwater during storm events. Manchester Marine wants to maintain the option of washing boats in the rain to minimize disruption to their routine operations; thus, wash water and stormwater collection can also occur simultaneously. Because of the occasional need for simultaneous collection of wash water and stormwater, the two systems could not be physically separated; therefore, the design was required to address three operating conditions:

1. Wash water collection only;

2. Stormwater collection only; and
3. Wash water collection during a storm event.

The overall design objective was to separate stormwater from wash water to the greatest extent practicable by minimizing stormwater contact with residual wash water in the system.

Wash water Collection Only

The wash area was re-graded to direct the boat-bottom wash water away from the harbor and to a single collection trench located at the end of the wash area. The wash-pad trench drain discharges first to a system manhole (manhole), and then to a pump chamber which returns the collected wash water to the treatment system for processing. The trench drain has a deep sump to collect solids within the wash water. The manhole has a minimal sump so that solids present within the wash water will tend to be carried into the pump chamber before settling out in that chamber's sump. Wash water entering the bottom of the pump chamber will be pumped through the system for treatment. Refer to attached Figure 1 for a schematic diagram of the system when operating in Recycling Mode only.

Any closed-loop wash water recycling system has a finite water storage capacity. When washing boats with a pressure washer, a certain amount of water will be lost to evaporation, wind, or carry-off with the vessel after it is washed. Therefore, when washing in the dry, the wash water in the system's aeration tank will decrease as washing progresses. If the wash water level drops to the minimum level necessary to continue pressure washing, makeup water is obtained from the municipal water supply. Makeup water can also be obtained from a clean water rinse which may be used on the topsides of some dark-hulled boats.

Stormwater Collection Only

In conjunction with the design of the wash pad, the site grading was modified to minimize the stormwater subcatchment area contributing runoff to the wash pad and ultimately to the collection system. This measure constrained the area available for boat washing; however, Manchester Marine determined that the benefit received from reducing the volume of stormwater flow draining to the system offset the cost of a smaller wash area.

During a storm event that occurs without concurrent pressure washing, stormwater enters the wash-pad trench drain, manhole, and pump chamber as described above. However, because no pressure washing is occurring, the pump is not operating and the water levels in the pump chamber and manhole rise simultaneously. As additional stormwater flows into the trench drain, the water in the manhole and pump chamber continues to rise until the water in the manhole overflows through a storm drain outlet pipe. The discharged stormwater from the manhole then flows through one more stormwater manhole equipped with a sump before being discharged to Manchester Harbor.

When water in the manhole begins to discharge through the storm drain outlet pipe, a flapper valve on the pipe connecting the manhole and pump chamber prevents water contained in the pump chamber from flowing back into the manhole. This configuration minimizes the potential for stormwater that is being discharged to contact residual wash water in the drain system. Stormwater held within the pump chamber by the backflow valve will be pumped to the treatment system during the next wash cycle and will serve as makeup water for the system.

The stormwater bypass for Manchester Marine's recycling system is enabled by the water level rising in the drain collection system when the sump pump is disabled because wash operations are not occurring. This system was designed to be entirely passive and not rely on boat wash operators or complex equipment to perform any specific tasks for the system to function as intended. Refer to attached Figure 1 for a schematic diagram of the system when operating in Stormwater Discharge Mode only.

Washing in the Rain

The sump pump is active when boat-washing operations are occurring so water entering the drain collection system will be pumped to the treatment tank. If water is entering the system at a slower rate than the maximum pumping rate from the sump and if capacity is available in the system's aeration tank, then the water entering the drain collection system will be pumped to the aeration tank. The stormwater entering the drain will serve as makeup water for the system, and no stormwater discharge will occur. The schematic for the system operation will appear similar to the Recycling Mode shown in attached Figure 1. The water level in the aeration tank will increase if the rainfall volume is greater than the typical losses associated with pressure washing.

If, however, stormwater accumulates in the pump chamber faster than the pump can return the water to the reclaim-system tank, the water level could rise enough in the pump chamber to enable the system to enter the Stormwater Discharge Mode described above. In this event, combined wash water and stormwater in the pump chamber would be retained in the pump chamber by the flapper valve and pumped to the aeration tank, but additional stormwater and wash water entering the system manhole would be discharged from the system as long as the inflow to the manhole exceeded the pump's capacity. A high inflow volume of stormwater would be needed to surpass the pump capacity and result in such a combined discharge. Although possible, this situation is unlikely because of the limited subcatchment area surrounding the wash pad and the rainfall intensity required to generate enough water to exceed the pumping rate. The additional stormwater pumped while washing in the rain becomes makeup water in the reclaim system. If the capacity of the reclaim system's aeration tank is reached, pressure washing will be discontinued.

To facilitate continued operation of the system during a storm event, the collection system incorporated two design elements. First, as noted above, the site grading was modified to reduce the volume of stormwater entering the system as much as possible. Second, Manchester Marine elected to provide the largest practical aboveground storage tank to maximize the storage capacity of the reclaim system and thereby maximize the potential to wash in the rain. Additional storage capacity could have been provided by a larger underground tank; however, it was determined that the additional benefit did not offset the incremental construction costs.

Contingency Planning

The wash area at Manchester Marine is located adjacent to a bulkhead and Manchester Harbor. The elevation of the marina yard is low enough that it can be flooded during significant storm surges. Therefore, the design needed to consider storm protection for the treatment system equipment. To address this issue, the system was designed to be portable so that it could be relocated prior to a significant storm event.

INSTALLATION /IMPLEMENTATION

System Installation

The installation proceeded in three steps: site preparation, shed location, and equipment installation.

Site Preparation

The site preparation included the following activities:

Seawall Reconstruction: Repair/reconstruction of the seawall adjacent to the wash area was completed prior to construction for the treatment system because of concerns that the construction could further compromise the deteriorated seawall.

Site Grading: The area surrounding the wash pad was re-graded to redirect stormwater away from the wash pad so that stormwater flow to the treatment system was minimized. The wash-pad area itself was re-graded to direct flow from the wash pad to a single drainage trench.

Excavation: Limited excavation was required to install the wash pad trench, the equilibrium chamber, and the pump chamber.

Utility Construction: Installation of the underground structures required installation of new drainage pipes associated with these structures. Underground electrical conduits were installed to supply the treatment system shed and the pump chamber.

Paving: Following completion of the above activities, the construction area was repaved with asphalt.

Shed Installation

The treatment system was located directly adjacent to the wash pad. For aesthetic and security reasons, a dedicated shed was constructed to house the wash system equipment. As noted in Section 5.5 above, the shed location can be flooded during a significant storm surge. Therefore, to protect the reclaim equipment from storm damage, the equipment shed is mounted on a skid which can be relocated in an emergency. The need for portability required that the underground electricity and drain lines be easily disconnected to allow movement and easily reconnected when the shed was returned to its operating location.

The minimum shed dimensions were based on the location of the tanks, pump, and filters required for the proposed treatment system; however, to derive the maximum benefit from the shed, Manchester Marine increased the shed's dimensions so that it could also be used to store other related boat maintenance equipment close to the boat lift area. The dimensions of the shed installed at Manchester Marine are 12 by 20 feet.

Equipment Installation

The final step in this process was the installation of the treatment system equipment by the manufacturer. Equipment positioning, plumbing and electrical work, as well as any troubleshooting, was performed by the manufacturer prior to system start-up. The equipment installation was completed in two days.

Training

Following installation, the manufacturer's representative remained on site to provide training to Manchester Marine regarding system start-up, operation, maintenance, and seasonal decommissioning of all systems components. Manchester Marine identified two key employees to be the operators and caretakers of the bottom wash system. These employees and Manchester Marine management participated in the training sessions. In addition, the manufacturer provided a complete set of instructions which detail all aspects of system use and care.

Operation

Following installation and training, Manchester Marine operated the system between mid-October through mid-December to wash 90 boats prior to storage. Regular operation of the pressure wash water treatment system includes the following activities:

Monitoring Water Levels: Manchester Marine personnel monitor water levels in the tanks during the operation of the system. If the water level in the aeration tank drops to the minimum required for washing as a result of losses during washing, the operator will fill the aeration tank to a suitable level using water from the municipal water supply. When washing during a storm event, the operator will monitor the water level in the aeration tank to ensure that the aeration tank does not reach capacity, at which time it would overflow to the pump chamber. In addition, the operator will check the equilibrium chamber to ensure that water is not accumulating to the level at which the stormwater bypass drain would begin to flow. Manchester Marine has adopted a policy of not washing boats during intense rainstorms to minimize the potential for the discharge of combined stormwater and wash water from the system.

Minimizing Overspray: Manchester Marine personnel make an effort to direct the wash water to the wash pad.

Cleaning of the Wash Pad: At the end of each day of boat washing or more frequently as needed, the operator will clean the wash pad of larger bottom-wash debris such as barnacles, seaweed and sea grass from the asphalt surface in the wash pad area. At the end of each day of boat washing, the operator will wash the smaller debris accumulated on the pad into the trench drain.

System Backwashing: At the end of each day of boat washing or as needed based on the manufacturer's requirements, the operator will perform backwashing of the system and other minor system maintenance, if needed. The backwashing cycle takes 15 to 20 minutes to complete.

Removal of Residue: Manchester Marine has adopted a policy of cleaning out residue collected in the trench, the manhole, and the pump chamber at least seasonally or if the accumulation reaches at least 1 inch. Minimizing the volume of residue in the trench and manhole are important factors in controlling pollutants that may be discharged with stormwater passing through the system.

Waste Management: Manchester Marine will handle residue removed from the trench, the chamber, and the system filters as hazardous waste. The wastes will be properly stored at the facility until removed by a licensed hazardous waste hauler.

LESSONS LEARNED

Manchester Marine operated their boat washing system during the fall 2007 season to wash approximately 90 boats. The following are some lessons learned during the installation and initial operation of the system. However, Manchester Marine acknowledges that there may still be lessons left to learn as they gain additional experience with their chosen boat bottom wash water recycling system.

Required Post-Installation Design Changes

New pre-cast concrete manhole structures were installed as part of the underground infrastructure improvements; however, these manholes failed to perform as intended. The conventional manhole structures initially specified at the facility required traditional mortaring of all side-wall penetrations. With the higher groundwater elevations present during high tides, Manchester Marine discovered that water was entering the new manholes around the mortared joints. This caused water to enter the treatment system's pump chamber, which was then either pumped into the reclaim wash water tank or discharged through the overflow port to the harbor. Re-mortaring of the affected joints was performed to remedy the problem.

For future designs, Ransom and Manchester Marine recommend the use of a pre-cast sewer manhole with flexible sleeves at all pipe connections. The use of a flexible sleeve will provide a more watertight penetration, yet will still provide a flexible connection to allow for slight movements due to thermal and/or load-bearing forces.

Treatment System Waste Characterization

It is important to understand that treatment systems, and particularly reclaim systems, do not make pollutants disappear; instead, they typically just separate them from the wastewater. Therefore, treatment systems will invariably generate some solid waste in the form of sludge from the filters and/or solids that settle in a collection tank or trough. Since these solid wastes consist of pollutants removed from the wash water, they will most likely contain high concentrations of heavy metals (e.g., copper, lead, and zinc) as well as particulate matter that may give off volatile organic compounds. This waste may meet the criteria for classification as a hazardous waste which would require disposal by a licensed waste company. At a minimum, boat wash residuals must meet the disposal requirements established by the MA DEP Division of Solid Waste Management. Site-specific testing of the waste stream for each individual facility will be required to determine its waste characteristics.

On March 17, 2008, Manchester Marine collected a composite sample of solids which settled out in the drainage trough at the end of the wash pad. The sample was submitted to Eastern Analytical, Inc. for hazardous waste characterization, including leachability as determined by the Toxicity Characteristic Leaching Procedure (TCLP). The following is a summary of the waste characterization results from Manchester Marine's recycling system:

Hazardous Characteristic	**Result**	**Regulatory Limit**	**Comment**
Flashpoint	> 200 ºF	> 140 ºF	Pass
Corrosivity (pH)	8.6 SU	2 < pH < 12.5	Pass
Reactive Cyanide (mg/kg)	< 0.4	< 0.4	Pass
Reactive Sulfide (mg/kg)	< 10	< 10	Pass
Arsenic, TCLP (mg/l)	< 0.5	5	Pass
Barium, TCLP (mg/l)	<0.5	100	Pass
Cadmium, TCLP (mg/l)	<0.1	1	Pass
Chromium, TCLP (mg/l)	<0.1	5	Pass
Lead, TCLP (mg/l)	**5.8**	5	**Fail**
Mercury, TCLP (mg/l)	<0.01	0.2	Pass
Selenium, TCLP (mg/l)	< 0.1	1	Pass
Silver, TCLP (mg/l)	< 0.1	5	Pass

Based on the waste characterization sampling, Manchester Marine is managing the solid waste generated to date by the wastewater treatment system as a hazardous waste. Manchester Marine will conduct TCLP testing of the washwater solids after collection to determine the appropriate method of handling and disposal.

So long as the quantity of hazardous waste generated remains less than 100 kilograms or 220 pounds per month, the generator is considered a Very Small Quantity Generator (VSQG). Wastes must be stored in labeled containers and can be taken to disposal sites in a private vehicle. If the waste generated is in excess of 100 kg but not more than 1,000 kg then the generator is considered a Small Quantity Generator (SQG) and must follow more stringent disposal regulations.

Need for Clean Water Rinse

Toward the end of the first season of boat washing, Manchester Marine began to observe a thin opaque residue being left on the washed surfaces, which was particularly noticeable on dark-colored hulls. Manchester Marine used a short freshwater rinse with municipal water to remove the residue on topsides quickly and easily. Reclaim systems typically produce such a residue as a result of dissolved solids in the wash water. Visual observation of the pressure washer wash water indicates some minor discoloration (light green), but no cloudiness or opaqueness is evident, suggesting that there are no solids in suspension. Manchester Marine will incorporate a final municipal-water rinse with a separate, non-pressurized hose in their boat-washing procedure when a residual film is present on the topsides of dark-colored hulls, which they estimate is approximately 10 percent of the boats washed. Ransom and Manchester Marine will consider periodic replacement of the wash water to reduce the residue.

Potential for Success

Ransom's experience with prototype programs for wastewater treatment systems at truck and car washes has indicated that the owners/operators who reported the highest levels of satisfaction with their wastewater treatment systems were associated with facilities at which someone took "ownership" of the treatment system by becoming thoroughly familiar with its operation and attending to it on a regular basis. Owners/operators who installed wastewater treatment systems with the expectation that they could be turned on and forgotten reported the lowest levels of user satisfaction. Ransom's conclusion is that a system's success will depend on the success of the facility's operation and maintenance program. Therefore, simplicity in the operation and maintenance of the system coupled with a diligent maintenance program are key elements in choosing and operating a successful wastewater treatment system.

System Evaluation

Based on the installation and operation of the system to date, Ransom and Manchester Marine conclude that the system meets the design and operational criteria established at the start of the project, namely:

1. Elimination of the discharge of boat-bottom wash water into Manchester Harbor;
2. Regulatory compliance;
3. Controlled monitoring and disposal of bottom wash process byproducts;
4. Significant water conservation through recycling; and
5. Minimal impact to existing daily operations.

With the installation and operation of the wash water recycling system, Manchester Marine has implemented the hull maintenance and cleaning guidelines provided in the *Massachusetts Clean Marina Guide*, Section 4.1, published by Massachusetts Coastal Zone Management and the Executive Office of Environmental Affairs, and has come into compliance with U.S. EPA regulations regarding industrial discharges. Installation and operation of the wash water recycling system further demonstrates Manchester Marine's commitment to protecting and preserving the coastal waters of Massachusetts.

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