Installation and Monitoring of a Storm Water Antimicrobial Unit at Bay View, Washington

June 2011

Paul Dinnel and Jack Middleton

Skagit County Marine Resources Committee
and Skagit County Beach Watchers

County: Skagit
Grant No: G1000022

PROJECT TITLE: Installation and Monitoring of a Storm Water Antimicrobial Unit at Bay View, Washington

DELIVERABLES FOR TASK NO: 3, Low Impact Development

PROGRESS REPORT: [ ] FINAL REPORT [**X**]

PERIOD COVERED: 1 July 2009 to 30 June 2011

DATE SUBMITTED: 30 June 2011

This report was funded in part through a cooperative agreement with the National Oceanic and Atmospheric Administration.

The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA or any of its sub-agencies.

Acknowledgments

The Skagit County Marine Resources Committee thanks the following for their valuable assistance with our Storm Water Antimicrobial Project:

Project Management: Tracy Alker, Skagit County Public Works.

Project Technical Support: Chris Kowitz and staff of Skagit County Public Works, Susan Wood and staff of the Padilla Bay National Estuarine Research Reserve, Duane Cook, Hydrophix, Inc, Portland, OR and AbTech Indrusties, Scottsdale, AZ.

Volunteers: Lin Folsom and members of the Padilla Bay Storm and Stream Teams and interns at the Padilla Bay Reserve.

Partner Organizations: Padilla Bay National Estuarine Research Reserve and Skagit County Public Works.

National Oceanic & Atmospheric Administration

Washington State Department of Ecology

Northwest Straits Marine Conservation Initiative

This report was developed, in part, with funds from the National Oceanic & Atmospheric Administration. The views expressed herein are those of the authors and do not necessarily represent NOAA or any of its sub-agencies. CZM310 Grant Agreement #G1000022, administered by Washington State Department of Ecology and the Northwest Straits Commission, was awarded to Skagit County Public Works Department.

Installation and Monitoring of a Storm Water Antimicrobial Unit at Bay View, Washington

INTRODUCTION

Skagit County Marine Resources Committee (Skagit MRC) initiated a demonstration project in 2010 to assess the operation of a small experimental storm drain filter system for its ability to reduce bacterial loading in storm water. The experimental filter unit was installed in the town of Bay View, Washington, located on the eastern shore of Padilla Bay. Shellfish harvesting offshore of the town of Bay View and at the adjacent Bay View State Park has been closed for about the last decade due to periodically high concentrations of fecal coliforms in storm water originating from the Bay View area. Skagit MRC collaborated with the Padilla Bay National Estuarine Research Reserve, Skagit County Public Works and Skagit County Beach Watchers to install and monitor the filter system.

The filter unit contains a proprietary product called Smart Sponge®, which is reportedly capable of removing oil, grease, sediments, metals and other contaminants from storm water as well as being capable of reducing bacterial loading. Smart Sponge® filter paks were manufactured by AbTech Industries of Scottsdale, Arizona and supplied via the selected contractor, Hydrophix, Inc. of Portland, Oregon. AbTech's Smart Sponge® technology's unique molecular structure is based on innovative polymer technologies that are chemically selective to hydrocarbons and can reportedly destroy bacteria. According to AbTech Indrusties, Smart Sponge® fully encapsulates recovered oil, resulting in an effective response that prevents absorbed oil from leaching. It is also capable of removing low levels of oil from water, thereby successfully removing sheen. Once oil is absorbed, the Smart Sponge® transforms the pollutants into a stable solid for easy recycling, providing a closed-loop solution to water pollution (AbTech 2004, 2007; Galicki 2006; Mailloux 2008; Nolan et al. 2004).

According to AbTech Industries (http://www.abtechindustries.com/), Smart Sponge® technology provides a cost-effective best management practice (BMP) with low installation and maintenance labor costs. In comparison to other products, the Smart Sponge® technology also allows for less expensive and less problematic handling and disposal of the waste product since its technology transforms liquid oil and other pollutants into a stable solid. The Smart Sponge® filtration media was designed not to deteriorate in water, allowing for a longer product life.

Several studies conducted on the East Coast of the U.S. have shown that Smart Sponge® filter units have successfully removed about 70% of the oil and grease and from 50 to 99% of various classes of bacteria (AbTech 2007, Nolan et al. 2004). In Norwalk, CT, 275 storm drains with Smart Sponge® filters removed 38,000 pounds of trash and 1,200 gallons of oil and grease, equivalent to about 4.4 gallons of oil per filter unit over a two-year period (AbTech 2007).

The goals of this project were: 1) to install a Storm Water Antimicrobial Treatment System (SWAT) unit to treat storm water drainage for bacterial loading coming from the Bay View community, 2) to monitor influent and effluent water quality in terms of bacterial attenuation, and 3) to eventually improve water quality in South Padilla Bay such that swimming and recreational harvests of shellfish are once again deemed safe at Bay View State Park and surrounding areas. According to the manufacturer, SWAT units use AbTech's Smart Sponge® technology's unique molecular structure, which is based on innovative polymer technologies that are chemically selective to hydrocarbons and can destroy bacteria. While Smart Sponge® was originally developed to remove oil products from water, AbTech has also developed an antimicrobial technology synergistic with the Smart Sponge® technology. This effort produced Smart Sponge® Plus, which features an antimicrobial agent chemically and permanently bound in a proprietary process to the Smart Sponge® polymer surface. Due to this permanent bond, the antimicrobial agent is active but does not leach or leak, avoiding any downstream toxicity issues. AbTech's antimicrobial Smart Sponge® targets bacteria such as enterococcus, *Escherichia coli* and fecal coliforms.

MATERIALS AND METHODS

SWAT Installation

The original concept of installing a fairly large experimental SWAT unit at the boat ramp next to Rozema Boat Works in Bay View was negated once the project engineers investigated the site in mid 2010 because of excessive seawater intrusion into the site during very high tides. This resulted in relocation of a smaller SWAT unit approximately two blocks east and uphill of the original site.

The new uphill site was especially interesting because it was in a roadside ditch that had been converted to a bioswale structure to "treat" a small portion of the overall storm water flow being carried inside an underground pipe. A plan evolved to install a much smaller and less expensive experimental unit to test the smaller amount of diverted storm water at this location. The plan was initiated by providing Skagit County Public Works (SCPW) personnel with conceptual drawings of the proposed experimental unit. SCPW then constructed the unit and installed it at the specified location. The unit consists of a plywood flow through trough measuring 8' long x 14" wide x 18" deep with a sediment settling sump (30" length x 24" wide x 32" deep) installed inline prior to the experimental trough (Figures 1-2). The inflow line to the trough is 2" PVC and the outflow is 4" PVC. A 2" PVC valve was installed between the sediment sump and the experimental trough to control the flows. "Horse hair" air conditioning filter material was inserted into the sediment sump to assist with removal of sediments that might clog the Smart Sponge® media.

Experiment #1

The first experiment was designed to test the efficiency of a series of Smart Sponge® paks to remove fecal coliforms from Bay View storm water. Twelve Smart Sponge® paks, each measuring one foot square x 3 inches deep, were placed in series in the experimental trough (Fig. 3). Gaps were left between each pak to allow us to assess how much clogging the paks were experiencing and to allow us to collect fecal coliform samples between sets of 3 paks. The experiment began on 6 December 2010 when the flow rate into the trough was set at 32 liters/minute. Samples for fecal coliforms and turbidity were collected daily for four days at the trough influent, effluent and at three locations between each set of 3 paks (Fig. 3). The flows through the trough were monitored to assess how many paks the water was running through versus how many of the paks were being overflowed due to sedimentation.

The samples were taken to the Padilla Bay Reserve were they were processed for fecal coliform counts and turbidity using the routine Stream and Storm Team methodology being used for similar samples being collected around the county.

Experiment #2

Because we found that the Smart Sponge® paks clogged with sediment rather quickly, we set up a second experiment to test the possibility of using straw to pre-filter the storm water to remove some of the clogging sediments. For this experiment, we removed the Smart Sponge® paks and replaced them with straw, which was then covered with a layer of horsehair filter material (Fig. 4). This experiment was started on 17 December 2010 and ran until 4 February 2011 with flow rates varying from 2 to 20 liters/minute. During this time, we monitored the flow of water through the straw, measured the depth of water in the influent compartment and collected occasional samples to measure turbidity.

RESULTS

Experiment #1

The results of this four day experiment are summarized in Table 1. Storm water flow rates were low to moderate during the first two days and the fecal coliform concentrations were very low (4-12 colonies/100 ml), with low turbidity values (5.4-9.7 NTU). Rainfall and storm water runoff increased substantially during the last two days, with an increase in coliform levels to 256 to 368 colonies/100 ml on the last day of the experiment (Table 1). Turbidity increased to 19.1 to 20.5 NTUs as well.

The one day (day 4) where any meaningful comparisons can be made between the influent and effluent coliform concentrations showed that there was no decrease in coliform concentrations from influent to effluent sampling points. Indeed the highest coliform concentration was at the effluent end of the experimental trough, suggesting that the Smart Sponge® media did nothing to reduce bacterial loading (Table 1). Experiment #1 was terminated at day 4 due to rapid sedimentation of the Smart Sponge® pak covers, which resulted in the storm water overflowing all 12 of the paks instead of flowing through them (Fig. 5). Sediment also made its way inside the pak covers into the matrix of the filter media (Fig. 6).

Experiment #2

Experiment #2 was carried out over a 50 day period from December 2010 to early February 2011. For this experiment the trough was completely filled with straw (Fig. 4) to determine if this matrix could be used to filter sediments out of the storm water prior to its contact with the Smart Sponge® media. The sediments in the storm water did not clog the straw matrix during the test period, but also did not have a noticeable effect on turbidity values between the influent and effluent ends (Table 2). However, when the straw experiment was disassembled, we noted that the straw had trapped a substantial amount of sediment underneath and within the straw matrix. Therefore, future experiments will be set up using a straw pre-filter and then Smart Sponge® matrix that has been removed from the covering material.

Remaining Experiments

One or more experiments remain to be completed to get a better assessment of the ability of the Smart Sponge® paks to remove coliforms. This is due to the low concentrations of coliforms being found in the storm water, especially during the winter of 2010-2011, which saw fairly continuous rain. The consequence of frequent rain and continuous runoff is that fecal coliforms have largely been washed out of the watershed on a continuous basis. What is needed is a lengthy period of dry weather followed by a good "flush" of the watershed after coliforms have built up. As of this report date (June 2011), the experimental trough is set up to conduct the final experiment(s) when the timing is right. The present configuration consists of about 1/3 straw at the influent end to capture excess sediments followed by 2/3 Smart Sponge® matrix that has been extracted from the paks by removing the pak covers that were clogged with sediments in experiment #1.

The remaining experiment(s) will be conducted during the latter half of 2011 at no additional cost. Enough coliform monitoring media and lab supplies are already in stock to complete the experiments and monitoring will be accomplished entirely with the help of volunteers and Padilla Bay Reserve interns supported by Reserve programs. An updated final project report will be submitted at the conclusion of testing.

Volunteer Hours

Skagit MRC, Skagit Beach Watcher and Padilla Bay Reserve interns donated a total of 84 hours to this project in 2010 and 2011. Activities included monitoring the first two experiments, collection of samples for analyses, analysis of the samples at the Padilla Bay Reserve, data entry and analysis and progress and final report preparation.

DISCUSSION

The results of this project to date suggest that Smart Sponge® technology will not be useful for reducing bacterial loading coming from storm water. First, there was no reduction in coliform concentrations during the one time when we had a reasonable bacterial loading running through the experimental unit (see Table 1, 12/9/2010 coliform values). Second, the Smart Sponge® paks were substantially clogged after just four days during the 1st experiment, and third, the cost of the Smart Sponge® paks for this one very small experimental unit was about $6,000. It would likely require at least 10 to 20 times more Smart Sponge® media to begin to treat the amount of runoff coming from Bay View for just one storm water pipe if, indeed, the media did actually reduce fecal coliform levels and it could be protected from sedimentation.

The low levels of coliforms in the winter storm water was unexpected due to previously known higher concentrations, but also encouraging in that this may be indicative of a community success in reducing septic system discharges spurred by the stimulus to do so by the County and State health departments pursuant to a new emphasis on septic system repairs and monitoring near sensitive shellfish growing areas.

Source controls on septic systems and farm animal and pet wastes will likely remain the most important strategy for reducing bacterial loading to nearby marine waters and harvestable shellfish resources. However, source controls may ultimately not be enough to reopen presently closed shellfish beds in the Bay View area and at Bay View State Park, where oysters have been planted as a recreational resource in the past (but not since the health department closure).

One interesting possibility for the Bay View area is the possible diversion of storm water from Padilla Bay to a vegetated bioswale or leach field system installed in the farming area bordering the southern portion of the bay. Although this area is saturated by rainfall during the winter and early spring months, it does dry up during the late spring, summer and early fall months and could possibly receive storm water runoff for infiltration into the farm lands. Most shellfish recreational activities take place during the spring and summer day time low tides, so diversion of the substantial amounts of winter runoff would not be needed.

REFERENCES

AbTech Industries and Asbury Environmental Stormwater Division, Fontana, CA. 2004. Smart Sponge® Plus antimicrobial technology. Background and field test results. Summary Report, Feb. 26, 2004 by AbTech Industries, Scottsdale, AZ. 8 pp.

AbTech Industries and Asbury Environmental Stormwater Division, Fontana, CA. 2007. City of Norwalk filter project report. Final Report, December 3, 2007 by AbTech Industries, Scottsdale, AZ. 12 pp. + appendices.

Galicki, S. 2006. Hydrocarbon removal efficiency in simulated stormwater runoff using Smart Pak® blocks. Final Report by Millsaps College Sorbent Laboratory, Jackson, MS. 3 pp.

Mailloux, J.T. 2008. AbTech Industries Smart Pak® filter verification testing. Final Report by Alden Research Laboratory, Holden, MA for AbTech Industries. 34 pp.

Nolan, S., S. Jones and N. Landry. 2004. Evaluating the stormwater treatment performance of AbTech industries Smart Sponge® Plus in Seabrook, New Hampshire. Final Report for New Hampshire Department of Environmental Services and U.S. EPA. 42 pp.

Table 1. Bay View Smart Sponge® fecal coliform and turbidity monitoring -- Experiment #1. Twelve Smart Sponge® paks were inserted in series in the experimental trough. Monitoring was for fecal coliforms and turbidity daily. See Figure 3 for the locations of the five sampling points.

Flow rate = 31.4 liters/min, Temperature = 4.5 °C

Date	Sample Location	Volume Tested (ml)	Fecal Coliforms Per 100 ml	Turbidity (NTU)
12/6/2010	1	5	0	6.9
"	2	10	0	7.7
"	3	20	0	7.5
"	4	25	4	9.7
"	5	25	4	6.8

Water flowing through all 12 paks

Date	Sample Location	Volume Tested (ml)	Fecal Coliforms Per 100 ml	Turbidity (NTU)
12/7/2010	1	5	0	5.5
"	2	10	0	5.5
"	3	20	0	6.0
"	4	25	0	5.4
"	5	25	12	6.0

Water flowing over first one of 12 paks

Date	Sample Location	Volume Tested (ml)	Fecal Coliforms Per 100 ml	Turbidity (NTU)
12/8/2010	1	33	3	NM
"	2	50	10	NM
"	3	50	2	NM
"	4	100	3	NM
"	5	100	4	NM

Water flowing over first 3 of 12 paks

Date	Sample Location	Volume Tested (ml)	Fecal Coliforms Per 100 ml	Turbidity (NTU)
12/9/2010	1	50	256	20.5
"	2	50	260	19.5
"	3	50	264	19.1
"	4	50	260	19.3
"	5	50	368	19.4

Water flowing over all 12 paks. End Experiment #1.

Table 2. Experiment #2. Removed Smart Sponge® paks and filled trough with straw to assess effectiveness of pre-filtration. Experiment began 17 December, 2010.

Date	Flow Rate (liters/min)	Turbidity NTU	Intake Water Level, inches	Comments
12/17/10	9.3			Water not overflowing straw
12/18/10			1.75	Water not overflowing straw
12/20/10				Water not overflowing straw
12/22/10			1.75	Water not overflowing straw
12/23/10	6.1	5.4 in, 10.6 out		Water not overflowing straw
12/27/10	7.3			Water not overflowing straw
12/29/10				Water not overflowing straw
1/3/11	5.3			Water not overflowing straw
1/5/11	12.7			Water not overflowing straw
1/6/11	20.0			Water not overflowing straw
1/7/11	19.4		3.50	Water not overflowing straw
1/9/11	8.1		2.50	Water not overflowing straw
1/10/11	6.3			Water not overflowing straw
1/12/11	16.5		3.00	Water not overflowing straw
1/13/11	12.2	8.5 in, 10.2 out	3.00	Water not overflowing straw
1/15/11	9.7		2.50	Water not overflowing straw
1/17/11	7.3		2.50	Water not overflowing straw
1/19/11	2.8		2.00	Water not overflowing straw
1/21/11	13.5	18.1 in, 23.7out	3.00	Water not overflowing straw
1/22/11	2.7	6.7 in, 6.2 out	2.00	Water not overflowing straw
1/23/11	3.2		1.75	Water not overflowing straw
1/30/11	2.1		1.50	Water not overflowing straw
2/4/11	2.7	8.8 in, 8.7 out	1.50	Water not overflowing straw

Figure 1. Location of the Smart Sponge® SWAT unit in Bay View.

Figure 2. Detail of the SWAT experimental unit installed at Bay View. The sediment retention sump (with filter material) is in the foreground. In the middle is the well holding the 2” PVC flow control valve and the SWAT experimental trough is in the background.

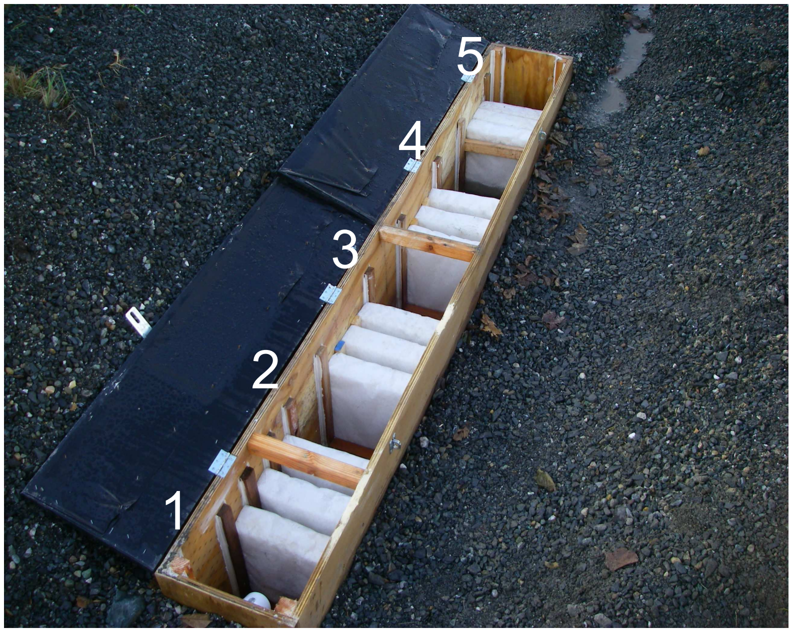

Figure 3. The SWAT experiment trough with the Smart Sponge® paks installed. The design allows the water to flow through up to 12 paks. If the leading paks clog due to sedimentation, then the storm water will flow over the clogged paks to the next sets. The white numbers indicate the locations where coliform and turbidity samples were collected, #1 being the influent and #5 being the effluent.

Figure 4. Following clogging of the Smart Sponge® Paks with sediment during a heavy rainfall, a second experiment was set up to test the ability of straw to act as a pre-filter for the Smart Sponge® media.

Figure 5. Photograph showing sediments coating the covers of the Smart Sponge® paks following a period of very high storm water flows.

Figure 6. Photograph showing the popcorn like filter matrix inside the Smart Sponge® paks following a period of very high storm water flows. Note the accumulation of fine sediments within the filtration matrix.