Final Report

Laguna Beach Storm Drain Pollution Control Project
CBI Grant #86

Laguna Main Beach Pollution Control Project
CBI Grant #87

Proposition No. 40
Grant Agreement No. 02-218-550-4

Clean Beaches Initiative Program

Prepared by:
Will Holoman, Senior Water Quality Analyst
Water Quality Department
City of Laguna Beach
505 Forest Avenue
Laguna Beach, California
92651
wholoman@lagunabeachcity.net

October 17, 2008

Contents

A – Executive Summary

Two projects, the Laguna Beach Storm Drain Pollution Control Project and the Laguna Main Beach Pollution Control Project, were undertaken by the City of Laguna Beach, CA with funding from the State Water Quality Control Board through the Clean Beaches Initiative grant program.

The goal of the projects was to reduce indicator bacteria levels in the ocean waters along approximately 1.5 miles of beach from Heisler Park south to Mountain Road, including Main Beach. The project budget was $1,310,000 with $1,200,000 in State funds with a City Match of $110,000. The project was initiated in October 2004 and was completed in October 2008. The diversion units were first activated in early April 2007.

The two projects were combined into one contract and Scope of Work. The project scope included the construction of six urban water diversion units to reroute dry weather nuisance flows from high priority storm drains on the beach to nearby sewer lines for treatment at the regional sewer treatment plant. The project also included a monitoring requirement to assess the impacts of the diversion installations on bacteria levels in the ocean.

Monitoring efforts for the project focused on determining if project goals were met by measuring flow and bacteria levels in the diversion sumps, measuring the amount of sludge and debris removed from diversion sumps and screens, and analyzing five years of ocean bacteria data from the existing beach water quality monitoring program. Pre- and post-construction data were combined to assess the project's impacts once the diversions were online.

Flow data, including estimated flows, shows that over 11,000,000 gallons of nuisance water was diverted from the beach outfalls by the six diversions during the 2007 dry season. This diverted flow carried an average of over 40,000 CFUs of total coliform bacteria per 100mL, resulting in the removal of a total mass of over $7.2X10^{12}$ CFUs of indicator bacteria from ocean water.

Trash and debris removal data shows that more than 12,000 lbs of sludge was pumped from diversion sumps and over 70lbs of floating debris were removed from the diversion screens through September 2008. The sludge and trash caught by the diversions would otherwise have carried bacteria to ocean waters and littered the beach.

Ocean water monitoring data from 2003 – 2008 shows a dramatic decline in indicator bacteria levels in the ocean starting in May 2007, when the six project diversions, along with all other diversions in town, were activated for the 2007 wet season. The diversions are kept online as deep into the wet season as possible without risking damage to the treatment plant. The data also shows that bacteria levels spike slightly in the winter wet season, then drop dramatically again in spring 2008, as diversions come back online.

The City of Laguna Beach credits the installation of the six diversion units of the Laguna Beach Storm Drain Pollution Control Project and the Laguna Main Beach Pollution Control Project, along with the other diversion units in town, with the significant reduction in indicator bacteria levels along the Pacific

Ocean shoreline in the 1.5 miles of beach from Heisler Park south. The project met the bacteria and trash reduction goals set forth in the initial project proposal.

Funding for this project has been provided in full or in part through a contract with the State Water Resources Control Board (SWRCB) pursuant to the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002 (Proposition 40). The contents of this document do not necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

B – Introduction

Laguna Beach, CA is a world renowned tourist destination which offers incredible opportunities for water based recreation. Popular activities include diving, surfing, fishing and swimming. The waters of the Pacific Ocean along Laguna's coast are mandated by the State of California to meet the most stringent water quality standard, REC-1, for full contact aquatic recreation. The standard guidance limits levels of indicator bacteria, including total, fecal and enterococcus bacteria, allowed before beaches are posted closed by the Orange County Health Department.

Table 1 – Bacteria Limits

Bacteria Type	**REC-1 Density Limit from BASIN Plan***
Total Coliform	1000
Fecal Coliform	200
Enterococcus	24

*30-day geometric mean

Due to high bacteria level exceedance frequencies in the past, the waters along the coast of Laguna Beach are currently listed by the State on the 303d List of Impaired Water Bodies for indicator bacteria. Being on this list requires Laguna Beach to conform to the requirements of the upcoming Total Maximum Daily Load (TMDL) limits for Beaches and Creeks as established by the San Diego Regional Water Quality Control Board in 2008. Within the City of Laguna Beach, these limits apply to discharges to the ocean from City storm drains and from the Laguna Canyon Creek channel.

Currently, the biggest challenge in meeting the requirements of the California Ocean Plan is dry weather nuisance flows from City storm drains to outlets on the beach. The source of the flows is primarily irrigation overspray from residential lawn watering but also includes water from car washing, hosing of driveways and patios, dewatering operations, accidental discharges and illegal dumping. These nuisance flows pick up pollutants, trash, sediment and bacteria as they flow down street gutters and through storm pipes. Constantly wet with nutrient-rich water, the storm system serves as an incubator for additional bacterial growth.

The obvious method of dealing with the problem of nuisance flows is to stop them at the source. The City has put great effort into nuisance water source control including point source identification and eradication, new municipal codes with vigorous enforcement, construction and commercial site inspections, municipal worker training, public outreach and cooperation with local water suppliers on conservation programs. These efforts have paid dividends in reducing the flow, but it takes time to change the people's behavior. This is where diversion units are of tremendous value.

Diversion units are a connection point between the normally independent sewer and storm drain systems. The connection allows low flows from the storm drain to be diverted into the sanitary sewer system where they are transported to the sewage treatment plant for disposal. Diversions often have built-in screens and sumps to pretreat water prior to entering the sewer by removing trash, organics and sediment from the stream. Three types of diversion units were used in the project: pre-packaged, custom and seasonal.

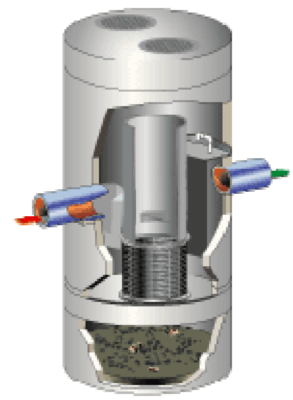


Figure 1 – CDS Diversion Unit

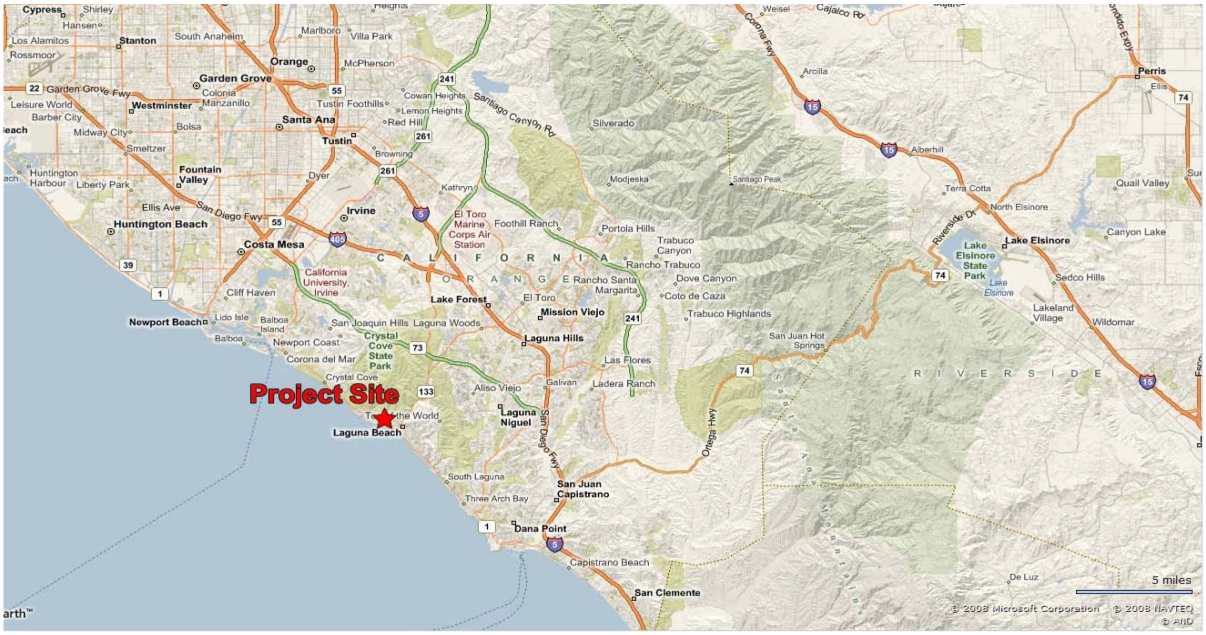
Pre-packaged diversions such as the CDS Stormceptor Vortex use centrifugal force to separate trash, allowing greater efficiency during higher flow events such as small storms. During high flow events, diversion units must be shut off or bypass the sewer connection to avoid overwhelming the sewer system. Storm flows pass through the unit without disturbing captured trash and sediment.

Custom diversion units are built specifically to suit site conditions. Custom diversions include trough-type systems which intercept low flows in a trough in the basin below a street inlet while allowing high flows to bypass the trough.

Seasonal diversions are constructed in early spring to capture flows from larger drainages during the dry season, and then are dismantled in late fall for the winter wet season's high flow rates. Temporary diversions consist of a removable dam with a pump behind it. The pump is typically removable as well, but it utilizes permanent piping for the sewer connection.

All diversions have a positive shut off valve to isolate them from the sewer, if necessary. The valves can be automated by connecting them to the City's SCADA sewer control system. Automation allows valve closure to be activated from a remote location.

Diversions units require periodic maintenance to maintain peak performance. Laguna Beach sewer crews inspect diversions at least monthly during the dry season and clean them as needed.



Map 1 – Location Map

Map 2 – Site Map

The Clean Beaches Initiative (CBI) Projects' Grants #86 and #87 were awarded to Laguna Beach to install six Urban Water Diversion Units along the stretch of coastline which receives the most beach visitors, accepts runoff from the most highly urbanized watersheds in town and is the recipient of high volume flows from perennial Laguna Canyon Creek.

The primary purpose of the Urban Water Diversion Unit Project is to reduce bacteria levels in the ocean water by diverting nuisance storm water flow to the sanitary sewer system. Other benefits of installing diversion units include screening of floating trash and debris from storm flows during a first flush event, capturing spilled or dumped pollutants destined for the ocean and collecting sediment sludge from all flows. The goal of the project was to provide targeted and immediate ocean water quality improvement to the City's Main Beach Pacific Ocean area for the protection of public health and the environment. The secondary goal was to remove gross pollutants during the wet weather months before discharge to the ocean.

The CBI Project's budget totaled $1,310,000 of which $1,200,000 was provided through the CBI grant program. The City of Laguna Beach committed over $110,000 in matching cash and in-kind labor. Project design commenced in early 2005 and construction took place in the winter of 2006-2007. The six diversions were completed and on-line by April 1, 2007.

Table 2 – Summary of Work Completed

Task	Deliverable by Subtask #	Contract Due Date	% of Work Complete
1 - Project Management	1.1 Contract Technical and Administrative Services	June 2007	100
	1.2 Quarterly Progress Reports	Quarterly through July 2008	100
	1.5 Contract Summary Form	July 2004	100
	1.6 Subcontractor Documentation	March 2006	100
	1.7 Project Survey Form	December 2008	0
2 – CEQA/NEPA and Permits	2.1 CEQA/NEPA Documents	December 2005	100

Task	Deliverable by Subtask #	Contract Due Date	% of Work Complete
	2.2 Permits	December 2005	100
	2.3 Approval Certifications	December 2005	100
3 – QAPP and Monitoring Plan	3.1 Prepare and Maintain a QAPP	October 2005	100
	3.2 Submit a Monitoring and Reporting Plan	October 2005	100
	3.3 Conduct Pre and Post Construction Monitoring	August 2008	100
4 – Design Plans and Specifications	4.1 Prepare and Advertise RFP	February 2004 March 2005	100
	4.2 Award Design Contract	April 2004 March 2005	100
	4.3 Complete Design and Specifications	October 2005	100
5 – Project Bidding	5.1 Prepare Bidding Documents	December 2005	100
	5.2 Advertise and Award Construction Contract	February 2006	100
6 – Project Construction	6.1 Construction Completion	May 2006	100
	6.2 Start-up and Training	May 2006	100

Task	Deliverable by Subtask #	Contract Due Date	% of Work Complete
7 - Reports	7.1 Annual Progress Reports	September 2004 September 2005 September 2006 September 2007	100
	7.2 Draft Project Report	August 2008	100
	7.3 Final Project Report	September 2008	100

Table 3 – Diversion Unit Installation Information

Diversion Name	Site #	Location	Type	Valve	GPS Coordinates
Cliff/Myrtle	10	West side of Cliff Drive @ Myrtle Street intersection.	CDS	Manual	33d32’40.16”N 117d47’34.33”W
Cliff/Aster	12	Center of Cliff Drive @ Aster Street intersection.	CDS	Automated	33d32’35.25”N 117d47’20.35”W
Main Beach	15b	West side of Coast Highway under sidewalk 150’ north of Broadway Street intersection.	Custom Trough	Manual	33d32’35.11”N 117d47’11.60”W
Main Beach	13	West side of Coast Highway under sidewalk 50’ south of Broadway Street intersection.	Seasonal	Manual	33d32’32.97”N 117d47’06.34”W
Corpyard	15a	Under parking lot on north side of channel, 50’ downstream of concrete bridge.	CDS	Automated	33d32’47.52”N 117d46’54.29”W
Cress Street	24	South side of cul-de-sac at the end of Cress Street adjacent to the beach.	CDS	Manual	33d31’55.14”N 117d46’34.40”W

Cliff/Myrtle #10

The diversion installed at Cliff/Myrtle is a CDS unit. It is located in a grassy area just inside the sidewalk in Heisler Park. The storm drain normally discharges into the ASBS below the park. The CDS outlet is connected to the sewer main in Cliff Drive.

Photo 1 – Cliff/Myrtle CDS Diversion Unit manholes

Photo 2 – Cliff/Myrtle CDS chamber with typical trash and flow

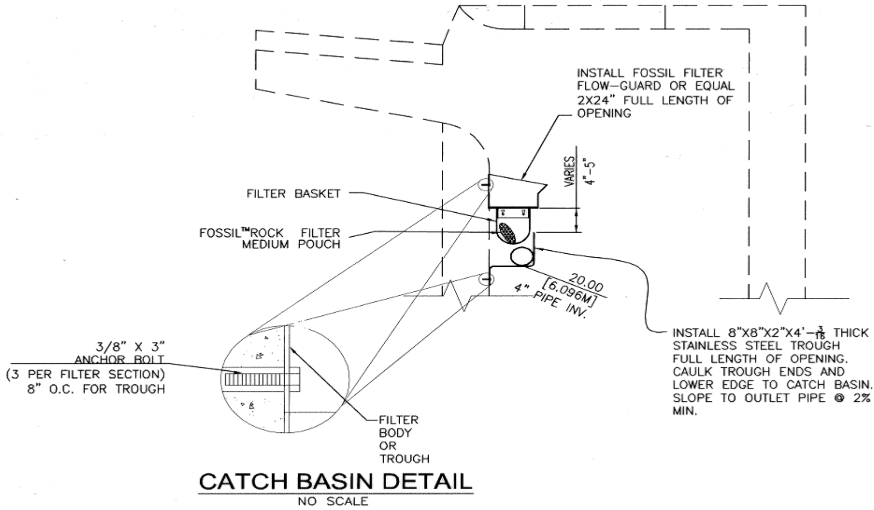
Cliff/Aster #12

A CDS unit was installed at the intersection of Cliff Drive and Aster Street. The diversion captures a storm drain which normally discharges into the Heisler Park ASBS. The CDS outlet is connected to the sewer main under Cliff Drive.

Photo 3 - Installation of Cliff/Aster CDS unit

Main Beach #15b

The diversion at Main Beach outlet #15b is located inside a catch basin on South Coast Highway just north and uphill from Main Beach. This diversion is a custom unit which uses a trough to catch nuisance flows and debris. The outlet of the trough is connected to a nearby sewer manhole with a shutoff valve in the pipe.



Detail 1 – Main Beach #15b custom trough design

Photo 4 – Main Beach #15b trough and diversion before cleaning

Photo 5 - Main Beach #15b shut-off valve

<u>Main Beach #13</u>

Main Beach diversion #13 is the only seasonal diversion installed as part of this project. During the summer, the channel is dammed with sand to prevent nuisance flows from flowing onto the beach. Behind this dam, the diversion pump is installed within a perforated plastic can. The pump outlet is connected to a hard line, constructed under the Pacific Coast Highway as part of the project, which flows to a nearby sewer manhole.

Photo 6 – Main Beach diversion access hatch

Photo 7 – Main Beach seasonal diversion pump and hard line outlet to sewer.

Corpyard #15a

The diversion in the Corpyard parking lot is a CDS unit fed by a custom intake built within the Laguna Canyon Channel. Flow is diverted from the Channel upstream of downtown Laguna Beach in the vicinity of a major sewer pump station with adequate pumping capacity to absorb larger flows. The diversion redirects the most flow of any unit in town and connects to the North Coast Interceptor sewer main. Trash and debris are caught in both the intake and the CDS unit.

Photo 8 – Corpyard #15a CDS unit installation

Photo 9 – Corpyard #15a intake in Laguna Canyon Channel

Cress Street #24

The Cress Street diversion is located at the end of Cress Street adjacent to the storm drain outfall to the beach. The CDS unit outlet is connected to a nearby sewer main which flows parallel to the beach prior to reaching a local pump station.

Photo 10 – Cress Street CDS under construction

C – Methodology

To measure the effectiveness of the six urban water diversion units, both pre-construction and post-construction data were collected. The data collection focused on both the end goal of lowered bacteria levels in the ocean and the physical capture of flows and pollutants.

Bacteria and flow sampling in the CDS units and storm drains took place as access and conditions allowed. The configuration of the diversion at site #15b precluded sampling at that location. Three pre-construction and three post construction sampling events took place. Table 4 shows the parameters captured at each site for each sampling event.

Table 4 – Sampling Events

Date	#10	#12	#13	#15a	#24
3/27/2006 Pre-install	Flow	Flow	Flow and Bacteria	Flow and Bacteria	Flow
7/20/2006 Pre-install	Flow	Flow	Flow	Flow and Bacteria	Flow
11/21/2006 Pre-install	Flow and Bacteria	Flow and Bacteria			Flow
11/27/2006 Pre-install		Flow and Bacteria			
6/27/2007 Post-install	Flow and Bacteria	Flow and Bacteria	Flow and Bacteria	Flow and Bacteria	Flow and Bacteria
5/7/2008 Post-install	Flow and Bacteria	Bacteria	Flow and Bacteria	Flow and Bacteria	Flow and Bacteria
9/8/2008 Post-install	Flow and Bacteria	Flow and Bacteria	Flow and Bacteria	Flow and Bacteria	

The volumes of nuisance water diverted were quantified in two ways – estimates based on watershed size and actual flow measurements in the field.

Estimates based on watershed size assume that each acre of watershed contributes 70 gallons of nuisance flow per day. All flow estimates are based on the 2007 dry season which started April 3 and ended November 29, 2007. The estimate is based on field observations and measurements recorded locally in the past and is the same estimate used for the required permit with the South Orange County Wastewater Authority (SOCWA) to discharge diversions into the sewer system.

Table 5 – Flow Volume Estimates

	#10	#12	#13 & 15b	#15a	#24
Watershed Acres	21	63	132	133	21
Estimated Flow Volume (gallons per day)	1470	4410	9240	36,000	1470
Estimated Flow Volume (gallons, 2007 season)	308,700	926,100	1,940,400	7,560,000	308,700

Flow measurements in the field were taken by timing a known bucket volume to fill, by measuring flow width, depth and velocity, or by visual observation and estimation. Flow measurements were taken when flow was observed in the storm pipe or diversion sump. Due to the fluctuating nature of nuisance flows and the lack of rain in the project area during the sampling period, flow was not always observed in the project drains. Flows in the Laguna Canyon Creek channel were measured by multiplying velocity by the cross-sectional area of the flow. The cross sectional area of the flow was estimated at 24 in^2 (24" width, 2" depth, triangular shape) when other data was not available. The area calculated area is based on prior field measurements. Velocity was measured with a Flow Probe Model FP101 hand held flow meter.

The volume of debris and sediment captured by the units was quantified by tracking the mass removed during semi-annual cleaning events and monthly operation checks. Crews cleaning the diversion units noted the estimated weight of floatable debris removed. For CDS units, crews also measured the depth from the rim of the manhole to the top of the sediment in the sump. This measurement was compared to the known depth to the bottom of the sump and combined with the known dimensions of the unit. A volume of sediment was then calculated. Mass of sediment is estimated as 80 lb/ft^3.

$$V_{sediment} = (3.1416)(h_{sump} - h_{sediment})(D_{unit}/2)^2$$

Bacteria removal attributed to the diversions was estimated by assessing the concentration of bacteria in water samples taken from the units and combining it with observed and calculated flow data to interpolate a bacteria mass estimate. Often, in post-construction monitoring, a bacteria sample could be taken from the diversion sump without active flow being noted. Bacteria levels in the water samples were determined by Sierra Laboratories, Inc., a contractor for the project. Samples were either collected by Sierra field personnel or City personnel and were transported to the laboratory on ice. The samples spent no more than four hours on transit as protocol dictates. Samples were immediately analyzed using the following methods. Duplicate samples, blanks and spikes were all utilized in the study to assure quality results.

Table 6 – Bacteria Laboratory Measurement Methods

<table>
<tr><th>Parameter</th><th>Method/range</th><th>Units</th><th>Detection Limit*</th><th>Precision</th><th>Accuracy</th><th>Completeness</th></tr>
<tr><td>Total coliform – water matrix</td><td>SM 9222-B</td><td>CFU/ 100 ml</td><td>1</td><td>$\pm$ 3.27R_{log}</td><td rowspan="3">Daily and control comparative samples & semi-annual Performance Evaluation samples +/-10%*</td><td>90%</td></tr>
<tr><td>Fecal coliform – water matrix</td><td>SM 9222-D</td><td>CFU/ 100 ml</td><td>1</td><td>$\pm$ 3.27R_{log}</td><td>90%</td></tr>
<tr><td>Enterococcus – water matrix</td><td>SM 9230-C</td><td>CFU/ 100 ml</td><td>1</td><td>$\pm$ 3.27R_{log}</td><td>90%</td></tr>
</table>

*Positive controls should be positive, negative controls should be negative, and the results from Performance Evaluation samples should be within the method's acceptance criteria.

The most important measurement of the effectiveness of the installation is the direct measurement of beach water quality along the coastline which receives the discharge from the retrofitted storm drains. The County of Orange measures bacteria levels at three ocean water sampling sites within the influence of the project. Four years of historical data from these sites was combined with just over a year and a half of post-construction data to develop hinge plots to illustrate the effect of bringing the units online. The County's sampling and analysis methods conform to SWQCB and EPA standards.

Map 3 – Beach Bacteria Sampling Locations

D – Results

1. Diverted Volumes and Bacteria Loads

Table 7 – Measured Flow Data

Site #	3/27/2006	7/20/2006	11/21/2006	11/27/2006	6/27/2007	5/7/2008	9/8/2008
10	No Flow	No Flow	Trace	-	No Flow	No Flow	No Flow
12	No Flow	No Flow	Trace	9gpm	No Flow	-	No Flow
24	No Flow	No Flow	No Flow	-	No Flow	No Flow	-
15a	20gpm	19gpm	-	-	30gpm	45gpm	10gpm
13	Trace	No Flow	-	-	Trace	15gpm	Trace

Table 8 – Measured Indicator Bacteria Levels

Site #	Date	Fecal Coliform	Enterococcus	Total Coliform
12	7/20/2006	13000	13000	83000
12	11/21/2006	38000	26000	125000
12	11/27/2006	37000	22000	27000
12	6/27/2007	2500	9000	5000
12	5/7/2008	62000	24000	68000
12	9/8/2008	300	800	18000
10	11/21/2006	17000	7000	30000
10	6/27/2007	195	45	9700
10	5/7/2008	800	8000	170000
10	9/8/2008	2800	100	36000
15a	3/27/2006	50	270	11000
15a	7/20/2006	1700	2100	19000
15a	6/27/2007	480	450	650
15a	5/7/2008	8000	3400	10000
15a	9/8/2008	14000	5300	18000
24	6/27/2007	10	2	200
24	5/7/2008	4000	13000	140000
13	3/27/2006	180	370	18000
13	6/27/2007	140	100	200
13	5/7/2008	3000	600	7000
13	9/8/2008	200	2400	23000

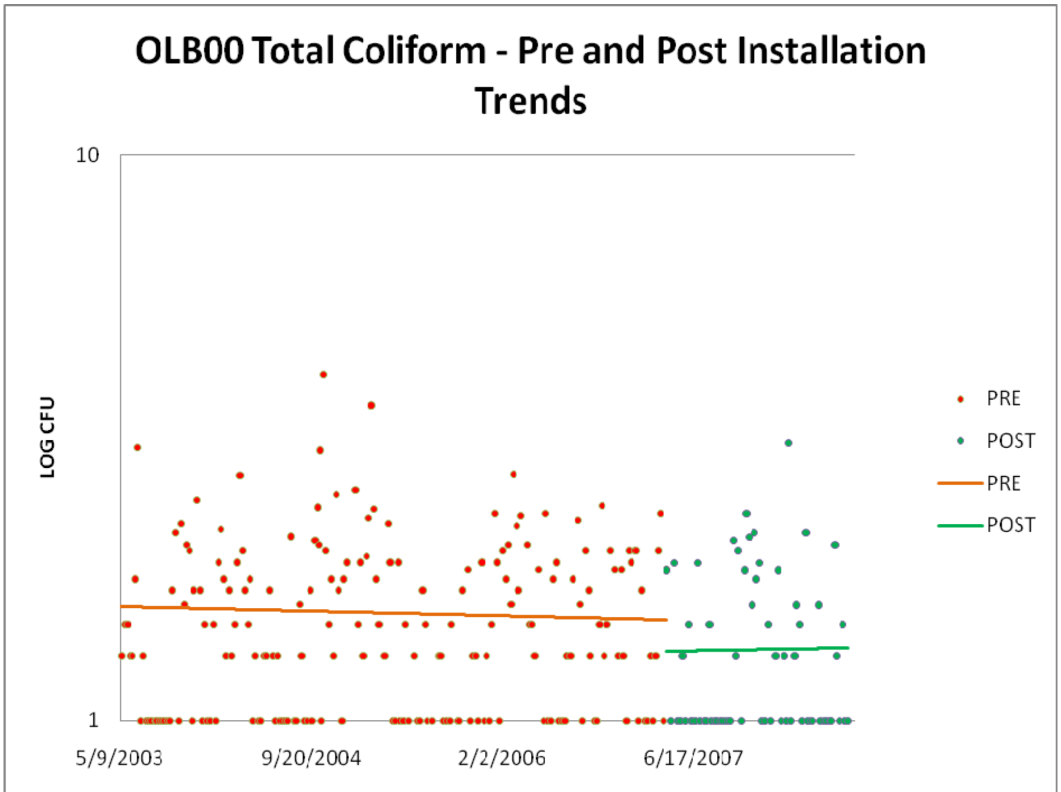
2. Volume of Trash and Debris Removal

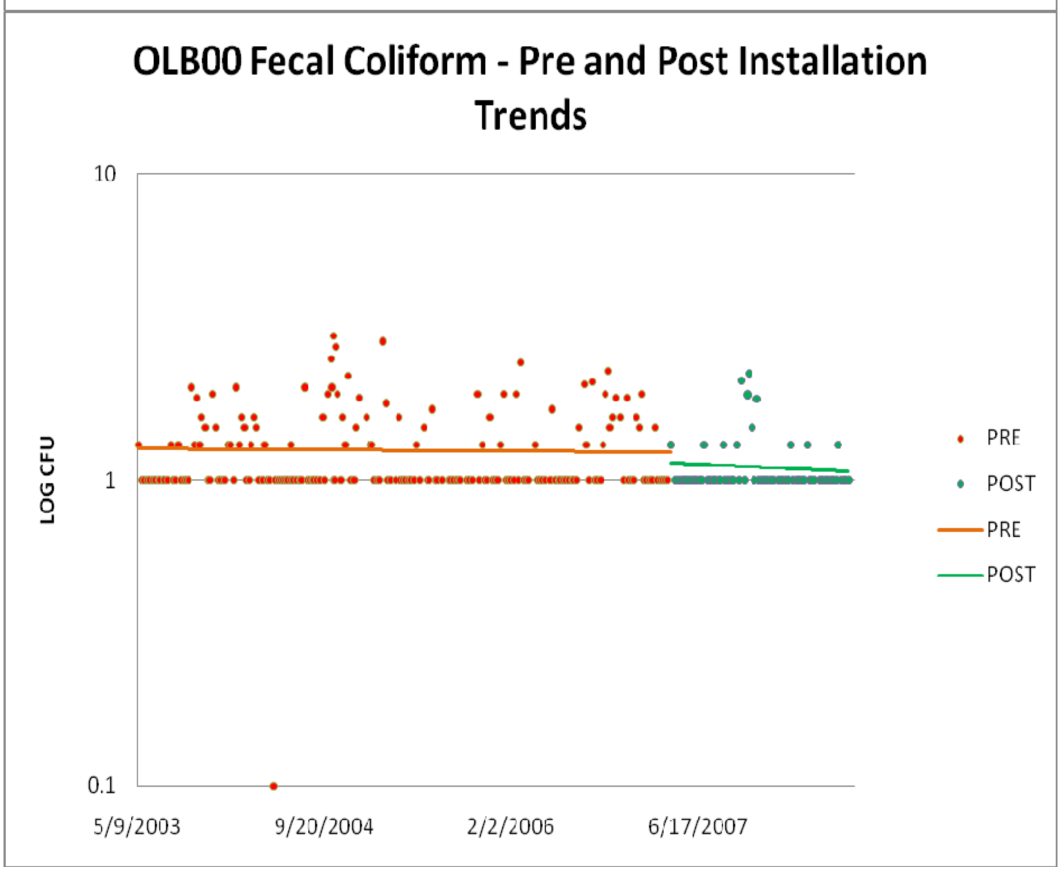
Table 9 – Trash and Debris Data

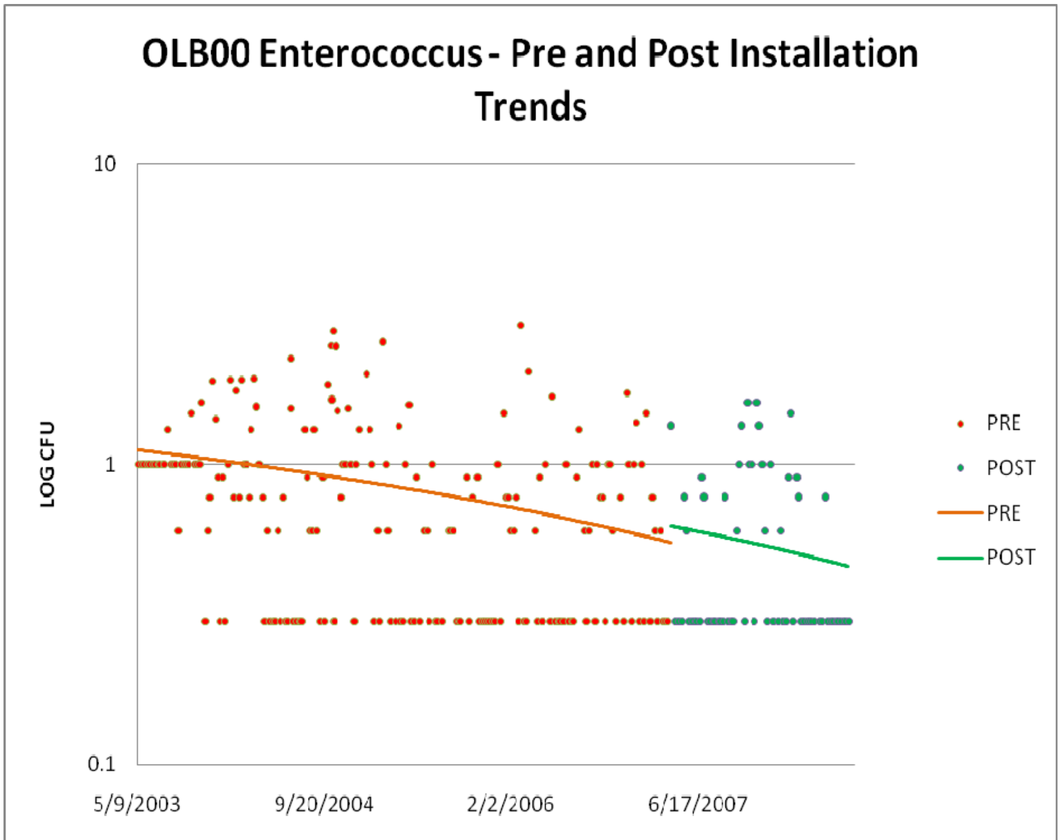
	Date	#10	#12	#15a	Total	
Debris (lbs)	10/19/07				0.0	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Volume (ft^3)					0	ft^3
Debris (lbs)	11/15/07	10.0	10.0	5.0	25.0	floating lb
Vac'd?		No	No	Yes	3181	lbs vac'd
Volume (ft^3)		15	28	40	82	ft^3
Debris (lbs)	12/4/07	0.0	0.0	0.0	0.0	floating lb
Vac'd?		yes	yes	yes	3393	lbs vac'd
Volume (ft^3)		15	28	0	42	ft^3
Debris (lbs)	1/14/08	1.5	0.1	0.0	1.6	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Volume (ft^3)		4	91	94	190	ft^3
Debris (lbs)	2/3/08	1.0	1.0	2.0	4.0	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Volume (ft^3)		19	83	89	191	ft^3
Debris (lbs)	3/2/08	0.1	0.8	2.5	3.4	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Volume (ft^3)		16	89	83	188	ft^3
Debris (lbs)	4/15/08	0.0	1.0	0.0	1.0	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Volume (ft^3)		195	91		286	ft^3
Debris (lbs)	5/6/08	0.0	1.0	0.0	1.0	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Volume (ft^3)		195	94		289	ft^3

	Date	#10	#12	#15a	Total	
Depth (in.)	6/22/08	0	115			
Debris (lbs)		0.0	0.0	0.0	0.0	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Depth (in.)	7/6/08	114	121	160		
Debris (lbs)		2.0	0.5	10.0	12.5	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Depth (in.)	8/31/08	126	0	139		
Debris (lbs)		2.0	0.0	20.0	22.0	floating lb
Vac'd?		No	No	No	0	lbs vac'd
Depth (in.)	9/10/08	146	162	168		
Debris (lbs)					0.0	floating lb
Vac'd?		yes	yes	yes	5513	lbs vac'd
					12086	**Total lbs vac'd**
					70.4	**Total floating lbs removed**

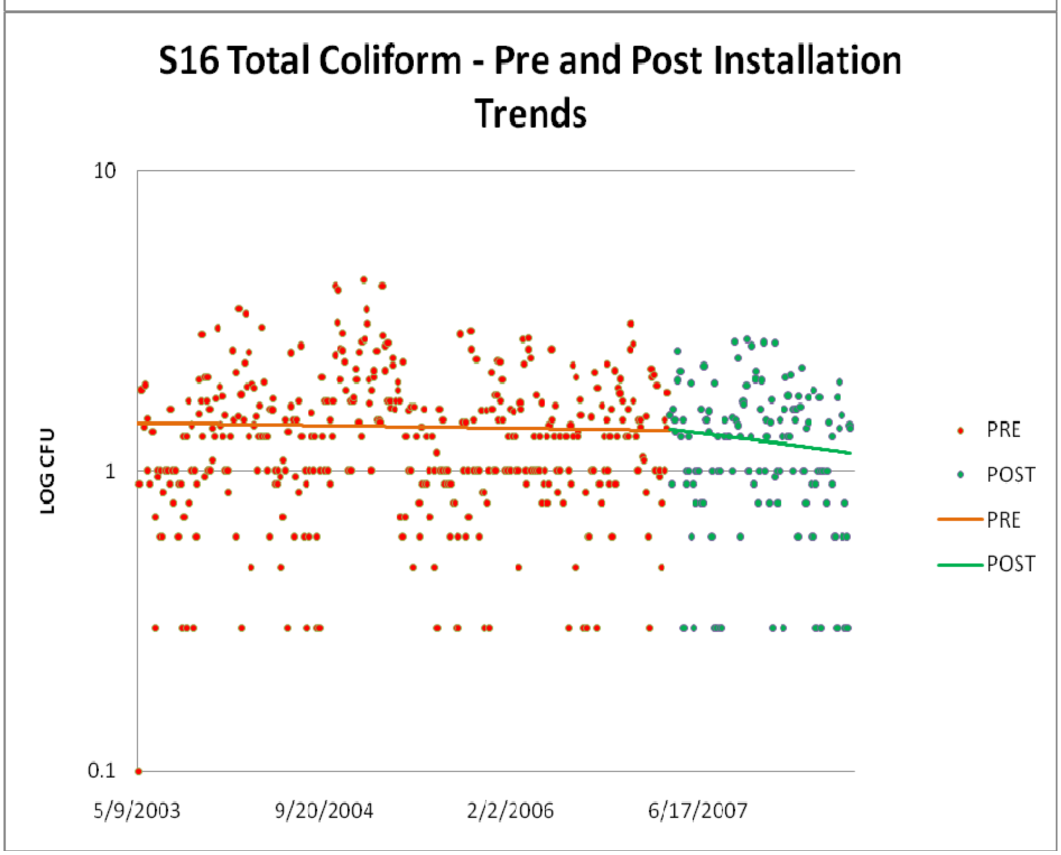
3. **Beach Bacteria Data** – Plots of ocean water monitoring data with inflection points at April 3, 2007, the time at which the diversions were fully functional and online. Inflection points are generated in the graphs by separating the raw data from each sampling location into pre- and post-activation groups based on the April 3, 2007 date. Each group of data is plotted with a "best fit" line generated by Microsoft Excel using a standard linear regression. Data is plotted on the Logarithmic scale due to the massive range of bacteria level numbers. Each graph combines the pre- and post-activation data for the site, along with the corresponding trendlines. The graphs, while dramatic, are meant to illustrate broad trends in the levels of bacteria in the ocean. A more rigorous statistical analysis of the data would need to account for many variables outside the scope of this project report.


OLB00 Total Coliform - Pre and Post Installation Trends
10
1
LOG CFU
5/9/2003
9/20/2004
2/2/2006
6/17/2007
PRE
POST
PRE
POST

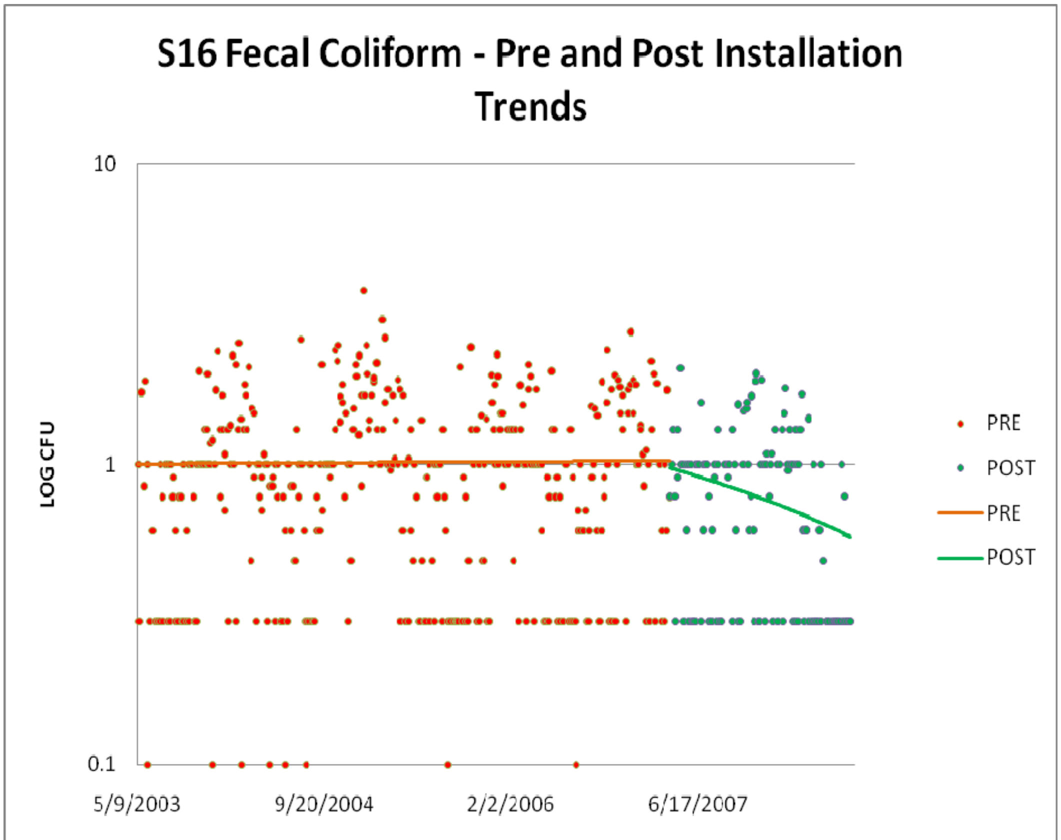

OLB00 Fecal Coliform - Pre and Post Installation Trends
10
1
0.1
LOG CFU
5/9/2003
9/20/2004
2/2/2006
6/17/2007
PRE
POST
PRE
POST



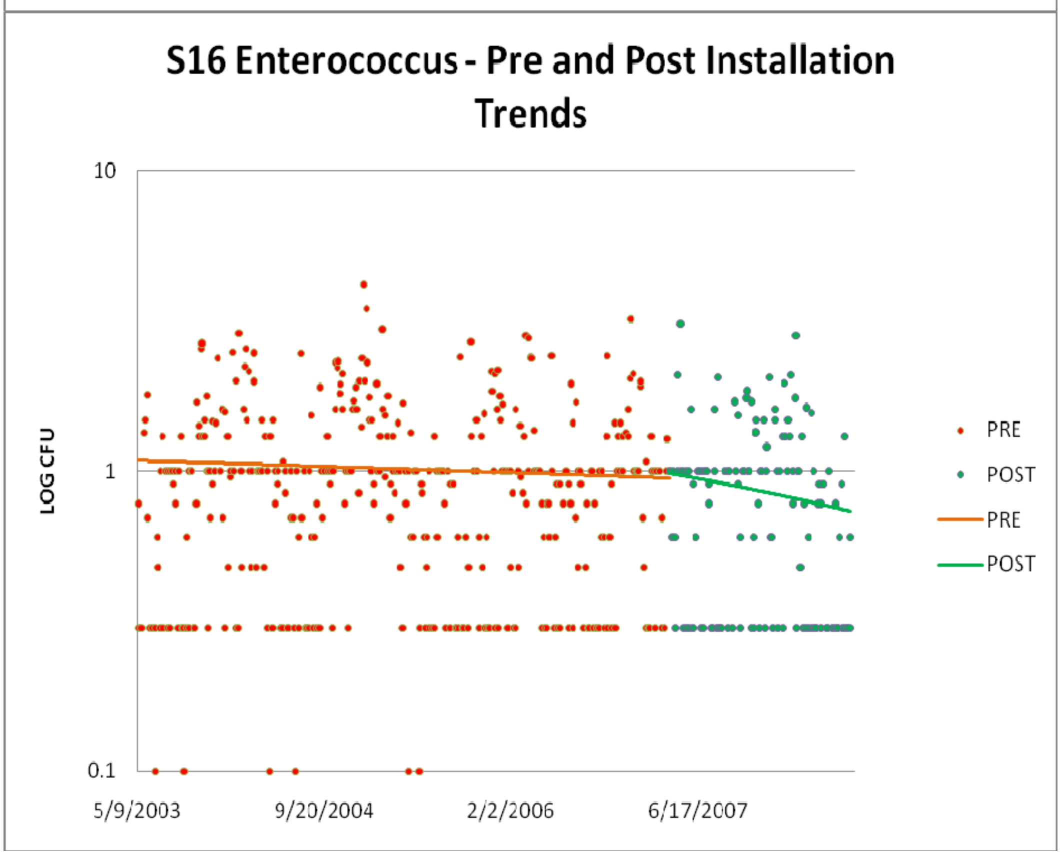
OLB00 Enterococcus - Pre and Post Installation Trends
10
1
0.1
LOG CFU
5/9/2003
9/20/2004
2/2/2006
6/17/2007
PRE
POST
PRE
POST



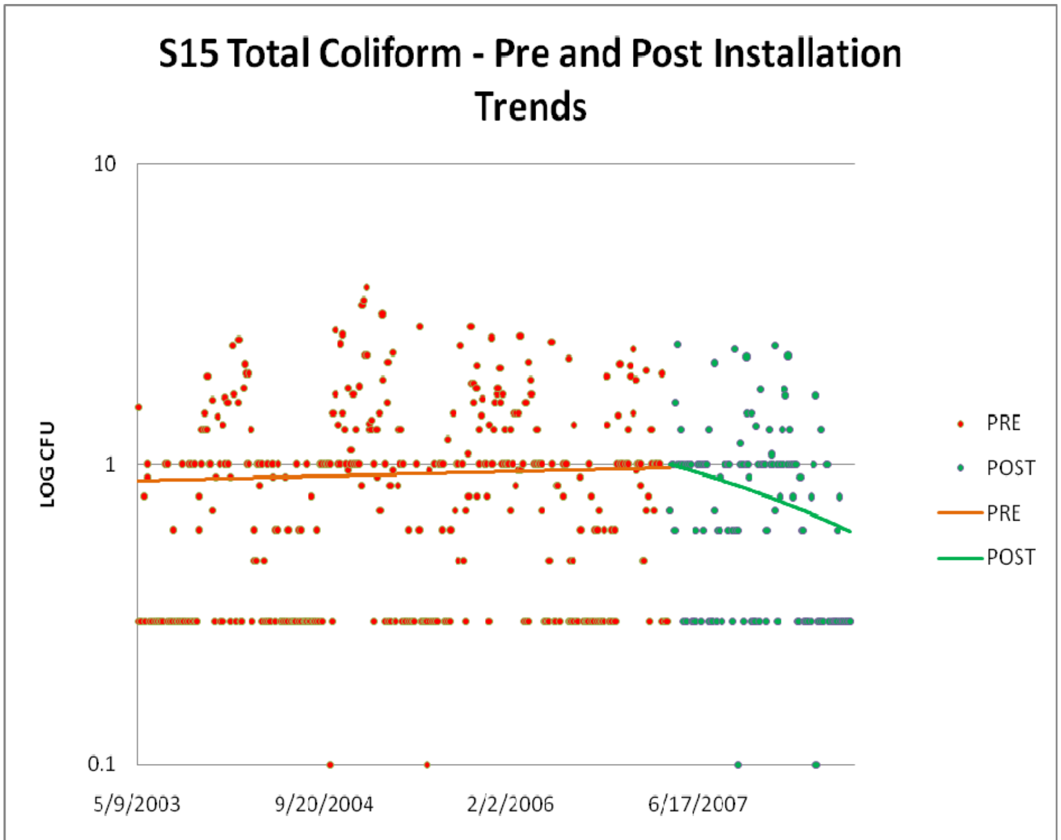
S16 Total Coliform - Pre and Post Installation Trends
10
1
0.1
LOG CFU
5/9/2003
9/20/2004
2/2/2006
6/17/2007
PRE
POST
PRE
POST

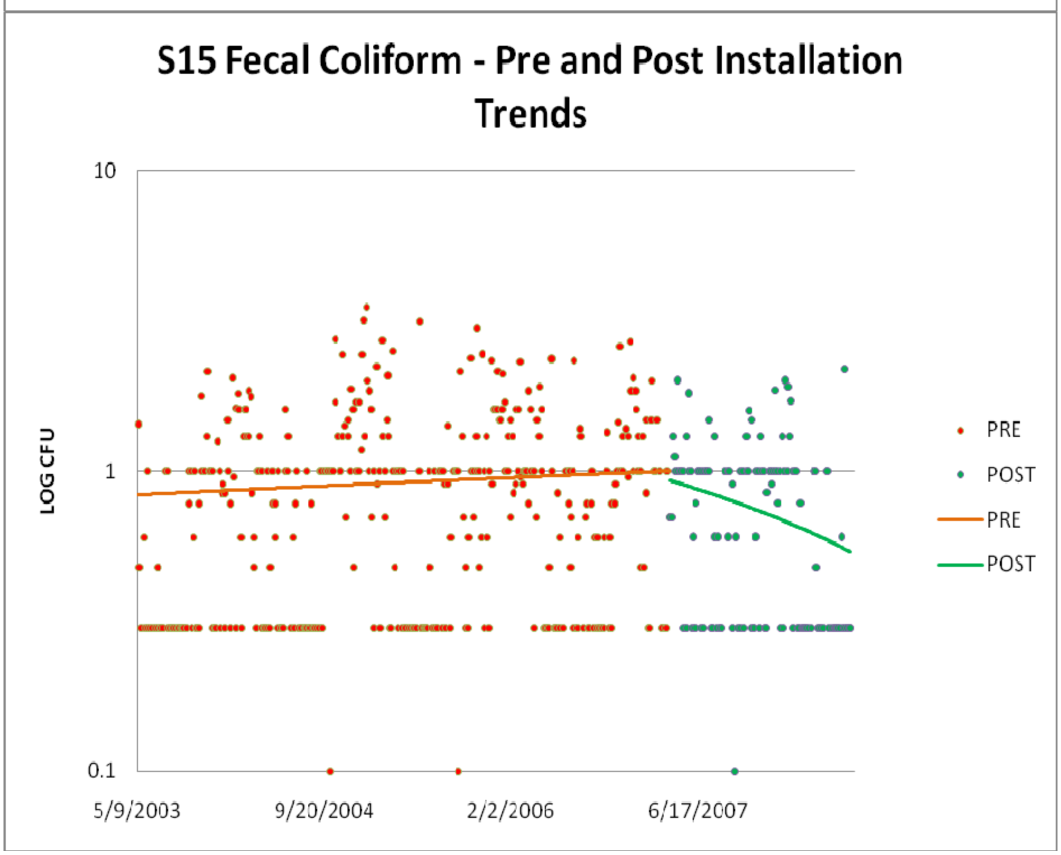


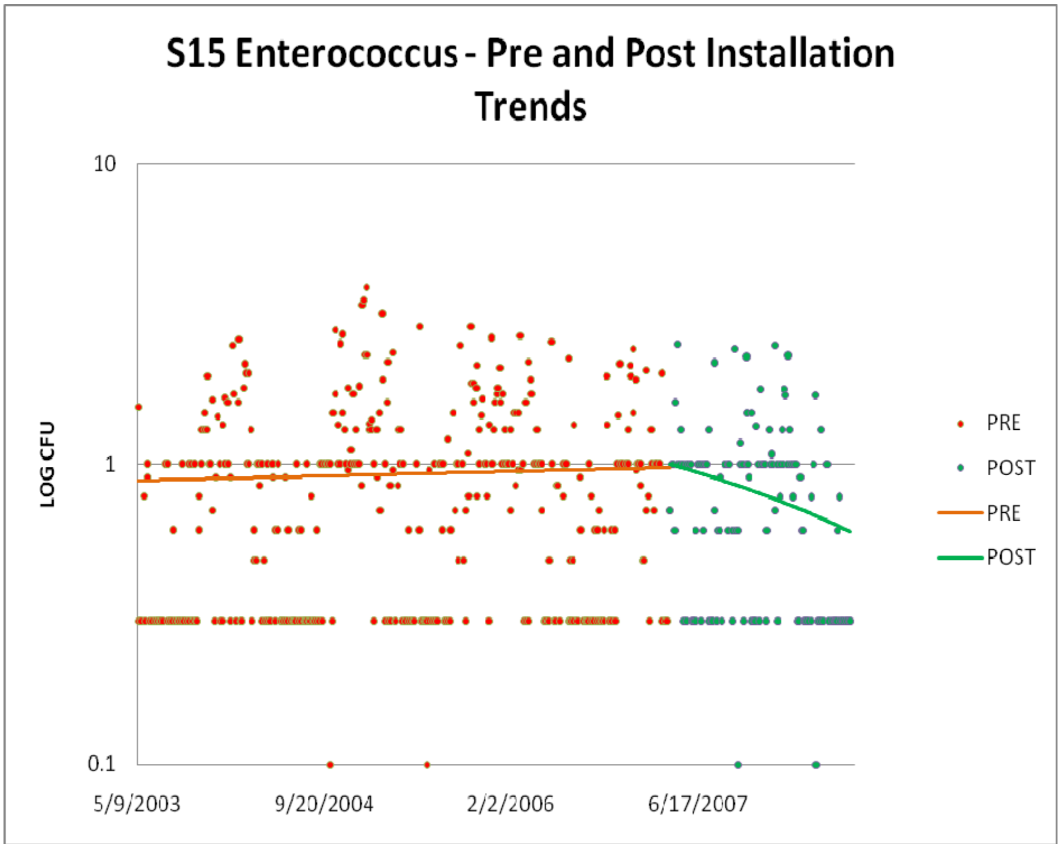
S16 Fecal Coliform - Pre and Post Installation Trends
10
1
0.1
LOG CFU
5/9/2003
9/20/2004
2/2/2006
6/17/2007
PRE
POST
PRE
POST



S16 Enterococcus - Pre and Post Installation Trends
10
1
0.1
LOG CFU
5/9/2003
9/20/2004
2/2/2006
6/17/2007
PRE
POST
PRE
POST


S15 Total Coliform - Pre and Post Installation Trends
10
1
0.1
LOG CFU
5/9/2003
9/20/2004
2/2/2006
6/17/2007
PRE
POST
PRE
POST


S15 Fecal Coliform - Pre and Post Installation Trends
10
1
0.1
LOG CFU
5/9/2003
9/20/2004
2/2/2006
6/17/2007
PRE
POST
PRE
POST



E – Discussion

The installation of the five diversion units in Laguna Beach using CBI funds has had tangible positive effects on ocean water quality. The effects can be seen in the evaluation of the pre- and post-project bacteria and flow data from the diversions, trash and debris removal data and in the bacteria data from the beach bacteria monitoring program.

Flow in diversion units is difficult to measure due to large fluctuations and unpredictable times. Anecdotal evidence supports the notion that the highest flows occur in the early morning hours, between 1:00 AM and 6:00 AM, when residential lawn irrigation systems are running. Diversions serving smaller watersheds are more difficult to measure than those serving larger watersheds. Larger watersheds, such as Laguna Canyon Creek, may flow continuously throughout the dry season making flow measurements more reliable. Using data from larger watersheds, the City, in cooperation with SOCWA, calculated an estimated nuisance water flow rate of 70 gallons/acre/day for developed watersheds within Laguna Beach. This estimate is used for permitting purposes and treatment plant capacity calculations as well as this study.

Despite seven attempts, flow within the six diversions was rarely directly measured with the exception of Laguna Canyon Creek #15a, which flows continuously year-round. Evidence of flow, however was always present on the form of accumulating trash and debris and ever-present water in the sump of the units. Flows estimated using the SOCWA permit method for smaller watersheds combined with actual flow data from Laguna Canyon Creek demonstrate that the six diversion units redirected nearly 52,000 gallons of nuisance flow per day to SOCWA's Coastal Treatment Plant. In one year, flows diverted from the beach outlets to the sewer exceed 11,000,000 gallons.

Bacteria counts associated with this diverted flow were measured from samples taken in the sumps of the CDS units, directly from the flowing influent stream or behind the temporary diversion dam. Bacteria data typically varies widely from site to site and sample to sample. For the purposes of the study, flow data and estimates are combined with bacteria data on a site-by-site basis to quantify the amount of bacteria diverted from the beach outlets to the sewer system. Diversions serving smaller watersheds typically had higher bacteria levels in the sumps. These higher levels correspond to lower flow rates which allow nuisance water to stagnate, evaporate and concentrate nutrients. The conditions within the lower-flowing, closed storm drains such as #10, #12 and #24, appear to promote bacteria growth and subsequent pollutant concentration. Higher flowing diversions such as #15a and #13, both located within Laguna Canyon Channel, have lower bacteria concentrations. Faster moving, aerated, open channel flow with a component of groundwater or subterranean ocean water influx dilutes bacteria and possibly nutrient levels. Lower flowing diversions are near equal to higher flowing diversions in total mass of bacteria diverted due to their exponentially higher bacteria levels. Three of the five diversion watersheds produced nearly the same total mass of bacteria by this estimate. Data from #13 and #15b were combined because the watersheds are adjacent and the sumpless custom design of #15b prevents flow and bacteria data from being collected at that site.

Table 10 – Bacteria Mass Calculations

	#10	#12	#13 & 15b	#15a	#24
Average Total Coliform Bacteria Concentration (MPN/100mL)	61,000	54,000	12,000	10,000	70,000
Estimated Flow Volume (gallons, 2007 season)	308,700	926,100	1,940,400	7,560,000	308,700
Total Mass Flow Estimate (MPN/year)	$7.1X10^{11}$	$1.9X10^{12}$	$8.8X10^{11}$	$2.9X10^{12}$	$8.2X10^{11}$

The volume of trash and debris removed from the diversions during routine maintenance activities is easy to quantify form direct field measurements by cleaning crews. Combined, the diversion units prevented over 12,000lbs of trash, sludge and debris from entering the ocean. Over 70lbs of floating debris was also removed from the diversion in the first year and a half. The large volume of debris captured by the diversions is a tremendous success story with this project.

Another tremendous success story attributed to this project is the beach bacteria monitoring program data. The bacteria data taken from the ocean water monitoring, when separated into pre- and post-construction periods then plotted on the same graph, clearly shows that once the six diversions were activated at the beginning of the 2007 dry season, beach water quality immediately improved.

The improvement is attributed to two factors: direct bacteria diversion and debris capture. Bacteria mass directly diverted by rerouting nuisance flows to the sewer system removes terrestrial bacteria input from the beach bacteria system, lightening the bacteria load the ocean must assimilate and thereby lowering measured bacteria levels in the ocean waters. Bacteria are known to cling to particles of organic materials, sediments and trash. Removal of the particles and other debris by capturing them within the diversions accounts for an unquantifiable, but no doubt significant, reduction in bacteria mass reaching the ocean as well.

It should be noted, when analyzing the beach bacteria graphs, that the 2007-2008 monitoring period for the project occurred during exceptionally dry conditions in the Laguna Beach area. Also, the diversions constructed in Laguna Canyon Channel represent improvements upon existing diversions which were in place in prior years. The project represents a significant piece of a substantial stormwater program in this area of the City which includes more than 10 other diversions, an aggressive sewer system maintenance and improvement program, street sweeping and other BMP implementation, water quality enforcement and public outreach programs. While the contributions of the six diversions to ocean water quality, particularly on popular Main Beach, are undeniable, the numbers of variables in the complex ocean bacteria system may make attribution of overall bacteria reduction to specific sources somewhat speculative.

Based on the success of this and other diversion projects, the City has committed to installing two more diversion units in watersheds adjacent to Cress St., pending funding. The City is also upgrading a custom diversion at Fisherman's Cove, just north of Heisler Park, to a CDS unit. Significant improvements to large portions of Heisler Park, including site design and structural BMPs as well as sewer system upgrades, were completed in July 2008 and more are slated for the coming two years. In light of these efforts by the City, continued exceedences of bacteria standards in the ocean water around Heisler Park and Main Beach are not anticipated. If future exceedences do occur, the City's stormwater program will need to refocus on source identification.

Another lesson learned from this study is that future studies of diversion performance should focus on a more detailed flow analysis. Some form of flow meter with a data logger, or other means of measuring sporadic flow events, would supplant flow estimates based on watershed area. By nature, each watershed is unique, so accurate flow measurements at each installed unit are necessary to gain finer resolution in the flow arena. Better flow information would also allow for sampling of inflows at arrival time and more detailed characterization of watershed nuisance flow as a function of development type.

The success of the Laguna Beach Storm Drain Pollution Control Project in meeting the goal of reducing the bacteria levels in the adjacent ocean waters is supported by an analysis of the pre- and post-construction bacteria and flow data, the trash and debris removal data, and the ocean water bacteria data.