Effectiveness Assessment Monitoring Buck Gully Erosion Control and Shorecliff Infiltration Gallery Projects Newport Coast ASBS

Final Report

Prepared For:

Proposition 84 Grant Administrator
City of Newport Beach
3300 Newport Boulevard
Newport Beach, CA 92663

January 2014

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ACRONYMS AND ABBREVIATIONS

^{o}C	degrees Celsius
%	percent
A	cross-sectional area
ADCP	Acoustic Doppler Current Profiler
ASBS	Areas of Special Biological Significance
b	base width
BMP	Best Management Practices
C_d	Flow coefficient
cf	cubic feet
cfs	cubic feet per second
cm	centimeter
COP	California Ocean Plan
C_s	spillway coefficient
DO	dissolved oxygen
EPA	Environmental Protection Agency
ft	feet
ft^3	cubic feet
g	gram
G	gravitational constant
H	fluid height
Imax	Instantaneous Maximum concentration
L	Liter
LC50	Lethal Concentration 50
mg	milligram
mL	milliliter
MPN	most probable number
n	Manning roughness coefficient
ng	nanogram
NS	not sampled
NTU	Nephalogenic Turbidity Units
θ	V-notch angle
P	wetted perimeter
PAH	polycyclic aromatic hydrocarbon
pH	hydrogen ion concentration
Q	Flow
QAPP	Quality Assurance Project Plan
R	hydraulic radius
S	hydraulic slope
SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
TSS	Total Suspended Sediment
µg	microgram
µS	micro-Siemans
YSI	YSI 6-Series Multi-parameter Water Quality Sonde

1.0 PURPOSE AND SCOPE

The purpose of this study was to perform effectiveness assessments of the best management practices (BMPs) recently implemented at the base of Buck Gully (erosion control and wetland treatment BMP) and along the coastal bluff at Shorecliff Road (infiltration gallery BMP) in Newport Beach, CA. These BMPs were implemented to reduce pollutant loading to Areas of Special Biological Significance (ASBS) designated as ASBS 32 and ASBS 33, located along the Newport Coast. As a result of the high level of erosion occurring along Buck Gully, grade controls and stream bank stabilization BMPs were designed to control erosion and reduce sediment loading to the ASBS from lower Buck Gully. The Shorecliff project was designed to reduce pollutant loading to the ASBS during dry weather by infiltrating dry weather runoff into the soil before it reaches a large storm drain outfall located near Morning Canyon, south of Buck Gully.

To assess effectiveness of the Buck Gully Erosion Control/Wetlands Project, wet weather and dry weather monitoring was performed at five stations located above and below the various features of the BMP, while the effectiveness assessment for the Shorecliff project consisted of dry weather monitoring upstream and downstream of the infiltration gallery. For both Buck Gully and Shorecliff projects, flow data and water quality samples were collected and observations were recorded at locations upstream and downstream of BMPs during sampling events. Results from chemical analyses and flow data were used to estimate pollutant load reductions following treatment by the BMPs.

1.1 Newport Coast Watershed – Buck Gully Erosion Control and Wetland Treatment BMP Design

Buck Gully is a natural creek, located within a coastal canyon in Newport Beach, California. The watershed draining into Buck Gully encompasses approximately 1,200 acres consisting of primarily residential, transportation, and commercial/recreation land uses. The State Water Resources Control Board (SWRCB) found that nuisance runoff flows were listed as a threat to the area's water quality. Known sources of contaminants include the over-fertilization of grassed and planted areas in residential and commercial landscaping throughout the watersheds draining to the ASBS, erosion along creek banks and earthen parking lots, residential and commercial pesticide use, and transportation runoff. Over-irrigation is a key transport mechanism which moves sediments, metals, pesticides and bacteria from the watershed to the receiving waters of the ASBS.

The Buck Gully Erosion Control/ Wetlands Project was designed to address the problems of urban runoff, erosion, and bank destabilization resulting in pollutant discharges to ASBS 32. Installation of stepped-gabion grade control structures in the lower reach of Buck Gully and bend-way weirs along the upper bend of lower Buck Gully (southwest of Pacific Coast Highway) began in the fall of 2011 (Figure 1-1). The series of three stepped-gabion structures were designed to structurally retain earth, and dissipate energy of the flowing creek such that sediment movement and erosion along the creekbed are greatly reduced. Two subsurface flow wetlands were constructed concurrently with the gabion structures and are located immediately upstream of the two downstream gabion structures. The constructed wetlands were designed to use natural processes involving wetland vegetation, soils, and associated microbial activity to provide treatment of storm water and wastewater. Subsurface flow systems were installed in sealed basins below the soil surface to support wetland macrophytes. The subsurface flow systems were designed to remove contaminants in the water by reduction to insoluble forms that are deposited in sediments, accumulated in plant tissues, and volatilized to the atmosphere through biological processes facilitated by plants and microbes (RBF, 2011).

Upstream of the stepped-gabion structures, bend-way weirs were installed along an area of the creek that has undergone extensive erosion in the past. The series of weirs will act to control and redirect currents and velocities throughout the bend, thereby limiting bed erosion, particularly along the base of canyon slopes, and reducing the potential for slope destabilization and/or failure. Together, during periods of high flow, these BMPs are designed to dissipate energy and reduce water velocity, which will subsequently reduce erosion within lower Buck Gully. During periods of low flow (non-storm events) these BMPs will create ponded areas conducive to the growth of native wetland plants which will provide habitat for local aquatic insects and animal species. Although construction on this project was completed in the spring of 2012 (Figure 1-2), vegetation in the subsurface flow wetlands did not become fully established until the end of October, 2012 (Figure 1-3).

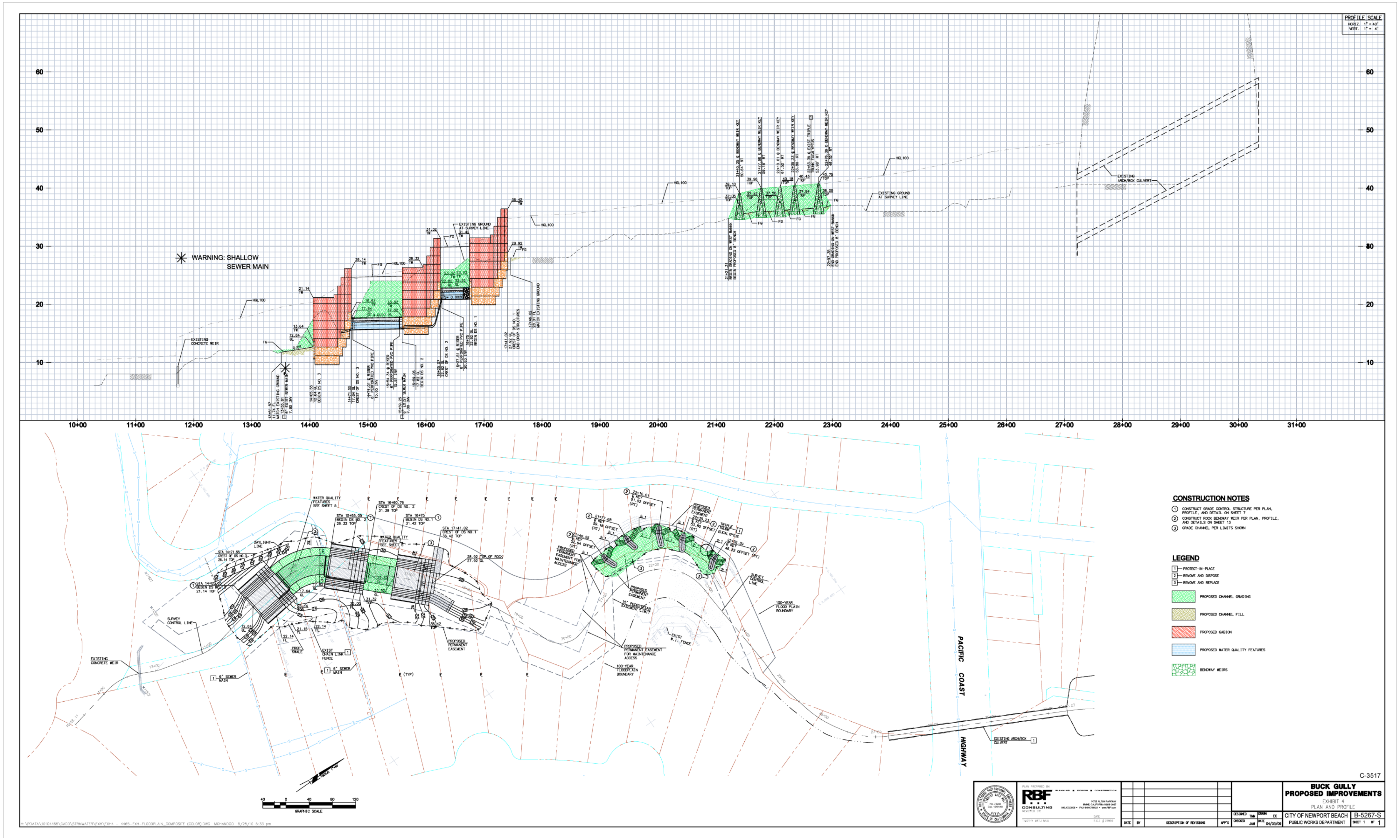


Figure 1-1. Buck Gully Erosion Control/ Wetlands Construction Plan

Figure 1-2. Construction of Buck Gully BMPs as of February 29, 2012

Figure 1-3. Completion of BMPs at Buck Gully, with Mature Vegetation as of January 16, 2013

1.2 Newport Coast Watershed – Shorecliff Infiltration Gallery BMP Design

The Shorecliffs storm drain outfall (NEW018) is an 18-inch storm drain that discharges directly onto the beach in front of ASBS 32 near Morning Canyon, south of Buck Gully. A system of BMPs was recently constructed in the storm drain system above the outfall. At the intersection of Shorecliff and Driftwood Roads there are three catch basins that convey flows collected in the roadway curb and gutters into the NEW018 discharge piping. The catch basins are connected in series, and in the most downstream catch basin, a biomedia catch basin filter screen was installed to prevent trash from entering the downstream storm drain pipe. Additionally the filter acts to provide pollutant load reductions in dry and wet weather runoff passing through the filter (Figure 1-4A).

A second BMP was constructed along the 18-inch storm drain pipe about midway between the above-mentioned catch basins and the NEW018 outfall. This BMP consists of a standard type catch basin modified with a pervious concrete bottom (Figure 1-4B). A rock reservoir was constructed below the pervious concrete bottom. The catch basin system is designed to infiltrate dry weather runoff flows, and in combination with the City's targeted outreach program, eliminate dry weather flows reaching the receiving waters. The system is designed to capture occasional dry weather runoff by allowing flows to pass through the pervious concrete and be temporary stored in the under lying rock reservoir prior to being infiltrated into the soil strata. A section of pervious concrete sidewalk was constructed near the modified catch basin BMP in order to capture surface dry weather runoff generated in the immediate area up gradient from the infiltration catch basin BMP that would otherwise bypass the infiltration catch basin. Larger flows, such as wet weather, will not be captured by the infiltration BMPs, in any significant amounts proportional to total storm runoff, but will flow over the pervious concrete and discharge at outfall NEW018.

Dry weather flow monitoring and sampling upstream and downstream of the BMP, in concert with photo documentation and visual observations, were used to assess the effectiveness of the BMP, and to calculate any resulting pollutant load reduction to ASBS 32.

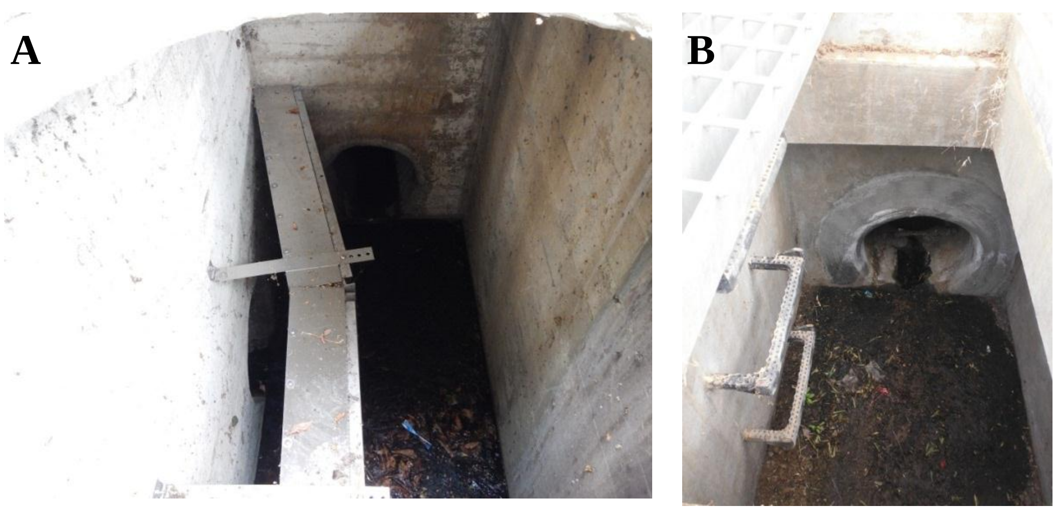


Figure 1-4. Biomedia Catch Basin Filter Screen at Shorecliff Curb Inlet (A) and Infiltration Catch Basin (B)

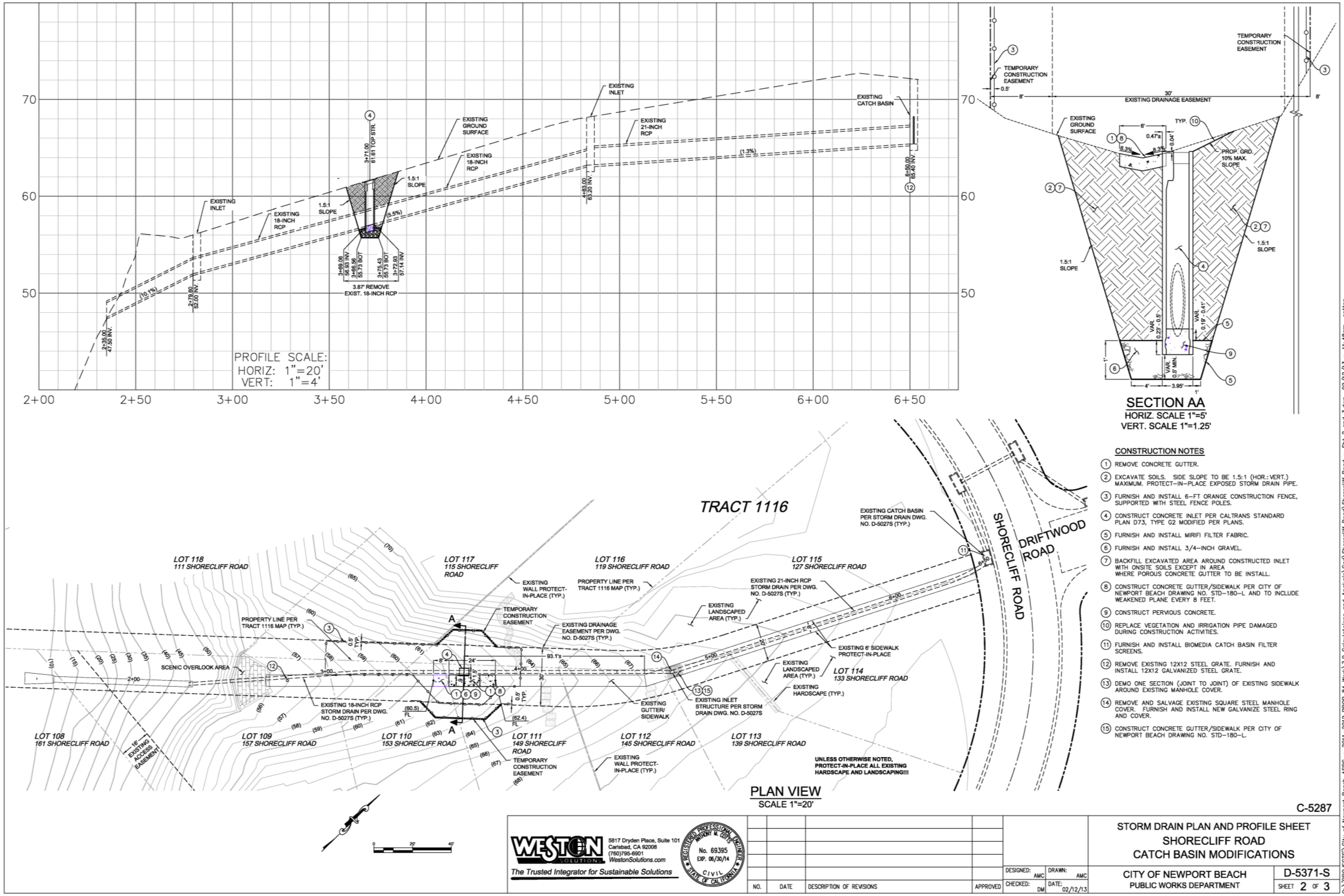


Figure 1-5. As-built drawing of Shorecliff Infiltration Gallery BMP

2.0 MONITORING APPROACH

The approaches used in assessing the effectiveness of the implemented BMPs at Buck Gully during dry and wet weather and at the Shorecliffs BMP during dry weather are discussed below.

2.1 Buck Gully

The general overview for the BMP effectiveness monitoring events for Buck Gully include estimating the total volume of flow captured by the onsite BMPs during dry weather and wet weather events, collecting and analyzing samples, and applying the results to calculate the pollutant loads removed.

Flow monitoring equipment was installed at five designated sites located above and below the various features of the Buck Gully BMPs (i.e., one at the mouth of Buck Gully, one site directly upstream of the wetland area, one site directly above the erosion control BMP area, and two sites further upstream of the erosion control area). Water depth was measured with Solinst dataloggers at each site over the period of time around each sampling event. Stream ratings were performed prior to each sampling event at the five monitoring locations in order to accurately document the cross sectional area of the stream bed at the point where the level logger was installed. Flows were able to be calculated at each site by determining the cross sectional area of the stream bed (using the stream rating and the water level data) and inserting them into standardized flow equations. Seasonal runoff volumes for wet and dry weather conditions were calculated using historical rainfall data combined with flow monitoring results and chemistry results from grab samples collected during each sampling event. Chemistry results and flow measurements upstream and downstream of the BMPs were used to estimate the average annual pollutant removal.

Samples collected at Buck Gully during both dry weather and wet weather sampling events were analyzed for synthetic pyrethroids, metals, TDS, TSS, turbidity, general chemistry parameters, and indicator bacteria.

2.1.1 Equipment Installation and Flow Monitoring

A Solinst Levelogger was installed in the main channel of Buck Gully at each site location (Figure 2-1) in order to obtain continuous monitoring data for the duration of each monitored event. The data loggers were housed in protective flow-through PVC sleeves when installed in the field, and data was downloaded in the weeks following each event. Stream ratings were completed at each monitoring site prior to each event to record the exact dimensions of the channel in order to accurately calculate flow when used in tandem with the data acquired by the Levelogger, which measures water depth. The stream ratings were conducted using standardized stream rating protocols developed by the U.S. Geological Survey (Rantz, 1982).

To accurately measure rainfall in the vicinity of the project area, a HOBO Event data logger connected to a standard tipping-bucket rain gauge was installed on a 10-ft pole at the base of Buck Gully. The data logger recorded time for each 0.01 inch of rainfall throughout the storm season. Maintenance and data downloading was performed on the data logger approximately every 2-3 months. The precipitation data collected by this equipment were used as input into the flow modeling. Seasonal runoff volumes were then able to be calculated based on these data.


Rain Gauge installed at Buck Gully

2.1.2 Sample Collection Locations

Five stations were designated for sampling at the Buck Gully BMP: Site 1 located at the mouth of Buck Gully next to a concrete weir; Site 2 located upstream of the wetland area located near the creek mouth and downstream of the most downstream gabion structure; Site 3 located upstream of the stepped-gabion structures and downstream of the bend-way weirs; Site 4 located just west of Pacific Coast Highway and upstream of the bend-way weirs; and Site 5 located approximately 570 meters northeast of Pacific Coast Highway next to a small bridge (Table 2-1, Figure 2-1). Samples were collected from the middle of the creek at all locations.

Table 2-1. Buck Gully Monitoring Locations

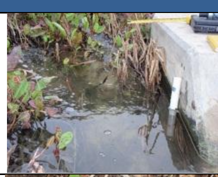
Site Name	Image	Location Description	Latitude	Longitude
Site 1		At weir next to mouth of Buck Gully	33.58999	-117.86841
Site 2		Upstream of wetland; and downstream of erosion control structure	33.59052	-117.86836
Site 3		Upstream of erosion control structure	33.59109	-117.86792
Site 4		50 meters west of PCH at constricted area of creek	33.59244	-117.86581
Site 5		East of PCH; well upstream of BMP- next to gabion wall	33.59731	-117.86190

Figure 2-1. Buck Gully Monitoring Locations

2.1.3 Sample Collection Methods

Two wet weather events and two dry weather events were monitored at Buck Gully. A wet weather event for this study was defined as an event with 0.1 inches of rainfall which had a 72-hour antecedent dry period, while a dry event was defined as an event with no rainfall and which had a 72-hour antecedent dry period. Grab sampling was performed at each of the five sites for both wet and dry weather sampling. Visual observations at the time of sampling, including atmospheric conditions, channel characteristics, and flow and water quality characteristics were recorded for each site. In addition, during each monitoring event, photographs were taken to document site conditions during the time of sampling and allow for an integrated assessment of erosive problem areas, bank stability, and the effectiveness of erosion control measures.

Samples were collected by hand by submerging appropriate sample containers beneath the surface of the water and allowing the container to fill, unless the creek was too shallow; in which case, a sterile syringe was used to collect sample water. Field staff wore clean, sterile gloves during sample collection. Each field sample was uniquely identified with sample labels in indelible ink. All sample containers were identified with the appropriate identification number, the date and time of sample collection, and preservation method. Samples were kept on ice, under chain of custody, and delivered to the appropriate laboratory within the required holding times. Buck Gully samples were analyzed for the list of constituents in Table 2-2. Also provided in Table 2-2 are the detection limits, sample volumes, and type of sample containers. Holding times and type of preservation used for each analyte are provided in the Quality Assurance Project Plan (QAPP) (Weston, 2011).

Table 2-2. Constituents Monitored in the Buck Gully BMP Assessment

Constituent	Units	Method	MDL	RL	Volume/ Container
General Chemistry					
Total hardness as CaCO3	mg/L	SM 2340-B	0.1	0.5	250-ml HDPE
Total suspended solids	mg/L	SM 2540-D	0.5	0.5	1-L HDPE
Total dissolved solids	mg/L	EPA 1664A	0.1	0.5	1-L Wide Mouth Amber Glass
Total and Dissolved Trace Metals					
Aluminum (Al)	µg/L	EPA 200.8	1.65	8.25	1-L HDPE, double bagged
Antimony (Sb)	µg/L	EPA 200.8	0.03	0.15	1-L HDPE, double bagged
Arsenic (As)	µg/L	EPA 200.8	0.09	0.3	1-L HDPE, double bagged
Barium (Ba)	µg/L	EPA 200.8	0.33	1.65	1-L HDPE, double bagged
Beryllium (Be)	µg/L	EPA 200.8	0.02	0.1	1-L HDPE, double bagged
Cadmium (Cd)	µg/L	EPA 200.8	0.005	0.01	1-L HDPE, double bagged
Chromium (Cr)	µg/L	EPA 200.8	0.01	0.05	1-L HDPE, double bagged
Cobalt (Co)	µg/L	EPA 200.8	0.01	0.05	1-L HDPE, double bagged
Copper (Cu)	µg/L	EPA 200.8	0.005	0.01	1-L HDPE, double bagged
Iron (Fe)	µg/L	EPA 200.8	1.13	5.65	1-L HDPE, double bagged
Lead (Pb)	µg/L	EPA 200.8	0.005	0.01	1-L HDPE, double bagged
Manganese (Mn)	µg/L	EPA 200.8	0.005	0.01	1-L HDPE, double bagged
Molybdenum (Mo)	µg/L	EPA 200.8	0.02	0.1	1-L HDPE, double bagged
Nickel (Ni)	µg/L	EPA 200.8	0.01	0.02	1-L HDPE, double bagged

Constituent	Units	Method	MDL	RL	Volume/ Container
Selenium (Se)	µg/L	EPA 200.8	0.02	0.1	1-L HDPE, double bagged
Silver (Ag)	µg/L	EPA 200.8	0.01	0.02	1-L HDPE, double bagged
Strontium (Sr)	µg/L	EPA 200.8	0.03	0.15	1-L HDPE, double bagged
Thallium (Tl)	µg/L	EPA 200.8	0.01	0.05	1-L HDPE, double bagged
Tin (Sn)	µg/L	EPA 200.8	0.06	0.3	1-L HDPE, double bagged
Titanium (Ti)	µg/L	EPA 200.8	0.08	0.4	1-L HDPE, double bagged
Vanadium (V)	µg/L	EPA 200.8	0.03	0.15	1-L HDPE, double bagged
Zinc (Zn)	µg/L	EPA 200.8	0.02	0.1	1-L HDPE, double bagged
Synthetic Pyrethroid Pesticides					
Allethrin	ng/L	EPA 625NCI	0.5	2	2-L amber
Bifenthrin	ng/L	EPA 625NCI	0.5	2	2-L amber
Cyfluthrin	ng/L	EPA 625NCI	0.5	2	2-L amber
Cypermethrin	ng/L	EPA 625NCI	0.5	2	2-L amber
Danitol	ng/L	EPA 625NCI	0.5	2	2-L amber
Deltamethrin	ng/L	EPA 625NCI	0.5	2	2-L amber
Esfenvalerate	ng/L	EPA 625NCI	0.5	2	2-L amber
Fenvalerate	ng/L	EPA 625NCI	0.5	2	2-L amber
Fluvalinate	ng/L	EPA 625NCI	0.5	2	2-L amber
L-cyhalothrin	ng/L	EPA 625NCI	0.5	2	2-L amber
Permethrin, cis-	ng/L	EPA 625NCI	5	10	2-L amber
Permethrin, trans-	ng/L	EPA 625NCI	5	10	2-L amber
Prallethrin	ng/L	EPA 625NCI	0.5	2	2-L amber
Resmethrin	ng/L	EPA 625NCI	5	10	2-L amber
Indicator Bacteria					
Total coliforms	MPN/100 mL	SM 9221 B and E	2	2	5 (120-mL) HDPE plastic
Fecal coliforms	MPN/100 mL	SM 9221 B and E	2	2	5 (120-mL) HDPE plastic
Enterococci	MPN/100 mL	SM 9223	1	1	5 (120-mL) HDPE plastic

A YSI 6-Series Multiparameter Water Quality Sonde (YSI) was used to measure pH, temperature, conductivity, dissolved oxygen, and turbidity for samples collected at each sampling location during the event. Field measurements at each station were taken one time per event.

2.1.4 Flow Monitoring Methods

Consistent with the wet and dry weather samples collections flow monitoring data were collected continuously during a periods prior to and then after BMP construction. The pre-construction flow monitoring occurred from November, 2011 through to December, 2011, and post-construction monitoring occurred from March, 2013 through October 2013. Flow was determined by measuring stream stage (i.e., water depth) with a Solinst Levelogger secured to the bottom of the channel as close to the stream thalweg as possible. Date collected by the levelogger was manually downloaded during site visits conducted periodically. In addition to downloading data, the site visits were used to assess the need for additional stream ratings and trouble shoot any flow or sampling-related issues. To convert stream stage data to continuous flow, a stream rating was conducted at each site during the initial installation and periodically throughout the study period, depending on changes in site conditions. The stream rating was conducted using standardized stream rating protocols developed by the USGS (Rantz, 1982).

To quantify flow rates based on stream stage, a relationship between flow and stage was derived using standardized stream rating protocols developed by the USGS (Rantz, 1982; Oberg et al., 2005). Instantaneous flow measurements were measured at various stages at each of the sites. The measurements were combined to produce a rating curve for each site.

The methodology has been improved for the measurement and accuracy of flow estimates. Due to safety issues, past estimates for high flows based on stage were made based on extrapolation of the rating curve at low flow. This extrapolation was derived using a best-fit curve approach. To accurately measure flow in streams there are three critical elements needed to develop rating curves, as follows:

- An accurate survey of the stream channel cross section and longitudinal slope.
- Accurate level measurements based on a fixed point.
- Measurements of velocity and flows at several points throughout the rating curve including low flow, mid flow, and peak flow conditions.

To measure instantaneous flows during low flow and base flow conditions, two velocity measurement instruments were used, including a Marsh-McBirney Model 2000 Portable Flowmeter connected via a cable to an electromagnetic open channel velocity sensor, and the SonTek (YSI) FlowTracker Acoustic Doppler Velocimeter. The FlowTracker is a high-precision, shallow-water flowmeter that measures velocity in three dimensions and features an automatic discharge computation.

The velocity sensors were attached to a stainless-steel top-setting wading rod. To make an instantaneous flow measurement, a tape measure was stretched across the stream, perpendicular to flow and secured on both banks of the stream. The tape was positioned so that it was suspended approximately 1 ft above the surface of the water. The distance on the tape directly above the waterline (i.e., where the water met the bank) was then recorded as the initial point. The first measurement was then made at the first point where there was adequate water depth (i.e., at least 0.2 ft) and measurable velocity. At this point, three measurements were made, including water depth, velocity, and distance from the bank (the initial point). Subsequent depth, velocity, and distance measurements were then made incrementally across the entire width of the channel so that a minimum of ten points were measured per site. Water depth was determined from calibrations on the wading rod in tenths of feet. Velocity measurements were made at each point along the transect by positioning the velocity sensor perpendicular to flow at 60% of the water depth (from the surface) to attain an average velocity. The top setting wading rod is designed so that the sensor can be conveniently positioned at the appropriate depth. Water velocity was measured in feet per second.

Data from the field measurements were entered into a computer model that calculates the stream's cross-sectional profile from the depth and distance from bank measurements. Total flow across the channel was determined by integrating the velocity measurements over the cross-sectional surface area of the stream channel. The result is an instantaneous flow measurement in cubic feet per second.

A StreamPro Acoustic Doppler Current Profiler (ADCP) was used to measure high stage and flow conditions. The StreamPro ADCP is the USGS instrument of choice for measuring flows nationwide (Oberg et al., 2005). The instrument is pulled across the stream either by walking across a bridge or attaching the unit to a tagline. Data are collected in real time and transmitted via a wireless data link to a palm PC. Data can be viewed in real time and are typically post-processed following the field event in the office.

Rating curves were extended to high stream stages not measured using site-specific survey information and the Chézy–Manning formula (Linsley et al., 1982). The Chézy–Manning formula is an empirical formula for open channel flow, or flow driven by gravity, as follows:

$$Q = (1.486/n)AR^{2/3}S^{1/2}$$

where:
- Q = flow
- n = Manning Roughness coefficient
- A = cross-sectional area
- R = hydraulic radius
- S = hydraulic slope

The hydraulic radius is derived as follows:

$$R = A/P$$

where:
- A = cross-sectional area of flow (ft^2)
- P = wetted perimeter (ft)

The Chézy–Manning formula was developed for conditions of uniform flow in which the water surface profile and energy gradient are parallel to the streambed and the area, hydraulic radius, and depth remain constant throughout the reach. Field surveys of the channel geometry of each MLS were conducted to compute the channel characteristics for each site.

Channel cross-section surveys were conducted at each site to derive stream discharge using the Manning Equation. The cross-section surveys involved placing endpoints and a benchmark on the nearest overhead bridge structure or stretched line such that the endpoints were placed at the highest point of the channel on each bank. A tape was then stretched between the endpoints such that the zero end of the tape was attached to the endpoint on the left bank of the channel (looking downstream). Using a weighted tape measure, at least 20 vertical distance measurements from a standard level on the bridge or stretched line to the channel bottom were then recorded at equal horizontal distances across the creek. A DeWalt transit level was used to survey the channel thalweg. A minimum of three elevations at increasing horizontal distances from the transit level were recorded in the channel bed. A minimum of five elevations were measured at sites with irregularly sloped or curved channel surfaces. The average channel slope was calculated from the survey data.

Channel survey data were used with the Chézy–Manning formula to produce a rating curve for each sampling site. Each rating curve was calibrated using instantaneous flow measurements by adjusting the formula roughness coefficient.

2.1.5 BMP Pollutant Load Reduction Calculations

The performance of the watercourse system within the project area, from a load reduction standpoint, was evaluated by comparing the pre- and post-construction conditions for both dry and wet weather event scenarios. Pollutant loading calculations were performed for each of the five monitored sites, and for each event the fluctuations in loading from the upstream to downstream site estimated. A graphical representation, storm hydrograph, for each wet weather storm event was used to determine the length of wet weather runoff (typically to a point within 10% of the baseflow or after a clear recession and relatively steady, compared to hydrograph rise and fall, water level). For each dry event a 24-hour period was used. Event volumes were calculated by summing the incremental flow values multiplied by the time elapsed between flows as follows:

$$Volume\ (cubic\ feet) = Flow\ \left(\frac{cubic\ feet}{second}\right) \times Incremental\ Time\ (seconds)$$

The loads for each site for each event were then calculated by applying the measured pollutant concentration to the site volume as follows:

$$Load(pounds) = Volume\ (cubic\ feet) \times Conc.\left(\frac{mg\ or\ \mu g}{liter}\right) \times conversion\ factors$$

Load calculations were based upon chemistry results and in-field flow measurements. Load reductions were calculated by the following equation comparing the downstream loads to the upstream loads as follows:

$$Load\ Reduction = 1 - \frac{Downstream\ Load}{Upstream\ Load}$$

Negative load reductions indicate an increase in load from upstream site to downstream site, and this scenario most likely indicates that there were more loads flowing into the system from the urban watershed than the system was able to reduce loads (as opposed to the system actually increasing loads). The overall system load reductions were computed by comparing loads at the mouth of Buck Gully (Site 1) to the loads at Site 4, upstream of the BMPs.

Annual load reductions were then estimated by extrapolating the increase in system performance (load reductions) for both the wet and dry weather periods based upon typical annual precipitation in the area. Additionally, the amounts of fluctuations in loading for the pre-construction dry events were then compared to the fluctuations in loading for the post-construction dry events, in order to estimate the improvement in the performance of the system during dry weather conditions. Storm flows were substantially different in the pre- and post-construction wet weather monitoring, hence, a comparison to total loads at Site 1 would not be representative of the system's performance, and therefore it was not calculated.

2.2 Shorecliff Infiltration Gallery

The general overview for the BMP effectiveness monitoring for the Shorecliff infiltration gallery BMPs includes measuring the total volume of flow captured by the onsite BMPs during dry weather, collecting and analyzing samples, and using the chemistry results in combination with the dry weather flow to calculate the pollutant load reduction to ASBS 32.

Flow monitoring equipment was installed at two designated sites located upstream and downstream of the Shorecliff infiltration gallery BMPs. Water depth was measured with Solinst dataloggers at each site over approximately a two-week period of time around each sampling event. The slope and diameter of the pipe were measured in the field and were incorporated into Manning's equation, along with the estimated roughness coefficient of the pipe and the water depth, as measured by the data logger, to determine flow of the cross sectional area of the outfall pipe. Dry weather discharge loads were then calculated using flow monitoring results and chemistry results from grab samples collected during each sampling event. Chemistry results and flow measurements upstream and downstream of the BMPs were used to estimate the average annual pollutant removal.

The dry weather samples collected upstream and downstream of the Shorecliff BMP were analyzed for synthetic pyrethroids, metals, TDS, TSS, turbidity, general chemistry parameters, and indicator bacteria.

2.2.1 Equipment Installation and Flow Monitoring

A Solinst Levelogger was installed in the storm drain downstream of the catch basin biomedia filter BMP and upstream of the infiltration gallery BMP. The Levelogger was placed directly behind a custom-made wooden V-notch weir installed within the storm drain in order to accurately measure the low levels of flow expected during dry weather (Figure 2-1). A second Levelogger was installed immediately downstream of the infiltration gallery. The data loggers were housed in protective flow-through PVC sleeves, and data were downloaded in the weeks following each event.

For levels that did not overtop the install timber (i.e., flow through V-notch weir only), flows were determined using the following Kindsvater-Shen method using a 45-degree V-notch weir and level sensors installed at the two sites. The equation used is as follows:

$$Q = C_d * \frac{8}{15} \tan(\theta / 2) * 2g^{1/2} * h^{5/2}$$

Where:

Q = *flow (cfs)*
C_d = *flow coefficient (0.593)*
θ = *V-notch angle*
G = *gravitational constant (32.2 ft/sec²)*
h = *fluid height (ft)*
(Lingeburg, 2003)

Flows above the installed V-notch weir (above the timber used to support the V-notch weir) were calculated based on the Horton equation for broad-crested weirs as follows:

$$Q = C_s\, b\, H^{3/2}$$

Where:

Q = *flow (cfs)*
C_s = *spillway coefficient (3.0)*
b = *base width (ft)*
H = *fluid height (ft)*
(Lingeburg, 2003)

The equations above were used to develop a rating curve for each site based on the geometry of the weirs and the incremental water level. The flow was then calculated based on the level data collected from the field and its correlation to the developed rating curve.

2.2.2 Sample Collection Locations

Two stations were designated for sampling at the Shorecliff infiltration gallery BMP: Shorecliff Inflow in the street-side catch basin on the western side of the intersection of Shorecliff Road and Driftwood Road located upstream of the infiltration gallery BMP; and Shorecliff Outflow located downstream of the infiltration BMP in the storm drain leading to the NEW018 outfall at Little Corona Beach (Table 2-3, Figure 2-2).

Table 2-3. Shorecliff Monitoring Locations

Site Name	Image	Location Description	Latitude	Longitude
Shorecliff Inflow		Catch basin located on western side of intersection of Shorecliff Road and Driftwood Road	33.589772	-117.866425
Shorecliff Outflow		In pipe leading to outfall, immediately downstream of the infiltration gallery	33.589161	-117.866897

Figure 2-2. Shorecliff Infiltration Gallery Monitoring Locations

2.2.3 Sample Collection Methods

Two dry weather events were monitored at the Shorecliff infiltration gallery BMP. A dry event was defined as an event with no rainfall and which had a 72-hour antecedent dry period. Grab sampling was performed at each of the sampling locations. Visual observations at the time of sampling, including atmospheric conditions, channel characteristics, and flow and water quality characteristics were recorded at each site. In addition, during each monitoring event, photographs were taken to document site conditions during the time of sampling.

Samples were collected by filling the appropriate sample containers with sample water as it flowed over a custom-made weir. If for some reason sample bottles could not be filled in this manner, a sterile syringe was used to collect sample water. Field staff wore clean, sterile gloves during sample collection. Each field sample was uniquely identified with sample labels in indelible ink. All sample containers were identified with the appropriate identification number, the date and time of sample collection, and preservation method. Samples were kept on ice, under chain of custody, and delivered to the appropriate laboratory within the required holding times. Shorecliff samples were analyzed for the list of constituents in Table 2-4. Also provided in Table 2-4 are the detection limits, sample volumes, and type of sample containers. Holding times and type of preservation used for each analyte are provided in the QAPP (Weston, 2011).

Table 2-4. Constituents Monitored for the Shorecliff BMP Assessment

Constituent	Units	Method	MDL	RL	Volume/ Container
General Chemistry					
Total hardness as CaCO3	mg/L	SM 2340-B	0.1	0.5	250-ml HDPE
Total and Dissolved Trace Metals					
Aluminum (Al)	µg/L	EPA 200.8	1.65	8.25	1-L HDPE, double bagged
Antimony (Sb)	µg/L	EPA 200.8	0.03	0.15	1-L HDPE, double bagged
Arsenic (As)	µg/L	EPA 200.8	0.09	0.3	1-L HDPE, double bagged
Barium (Ba)	µg/L	EPA 200.8	0.33	1.65	1-L HDPE, double bagged
Beryllium (Be)	µg/L	EPA 200.8	0.02	0.1	1-L HDPE, double bagged
Cadmium (Cd)	µg/L	EPA 200.8	0.005	0.01	1-L HDPE, double bagged
Chromium (Cr)	µg/L	EPA 200.8	0.01	0.05	1-L HDPE, double bagged
Cobalt (Co)	µg/L	EPA 200.8	0.01	0.05	1-L HDPE, double bagged
Copper (Cu)	µg/L	EPA 200.8	0.005	0.01	1-L HDPE, double bagged
Iron (Fe)	µg/L	EPA 200.8	1.13	5.65	1-L HDPE, double bagged
Lead (Pb)	µg/L	EPA 200.8	0.005	0.01	1-L HDPE, double bagged
Manganese (Mn)	µg/L	EPA 200.8	0.005	0.01	1-L HDPE, double bagged
Molybdenum (Mo)	µg/L	EPA 200.8	0.02	0.1	1-L HDPE, double bagged
Nickel (Ni)	µg/L	EPA 200.8	0.01	0.02	1-L HDPE, double bagged
Selenium (Se)	µg/L	EPA 200.8	0.02	0.1	1-L HDPE, double bagged
Silver (Ag)	µg/L	EPA 200.8	0.01	0.02	1-L HDPE, double bagged
Strontium (Sr)	µg/L	EPA 200.8	0.03	0.15	1-L HDPE, double bagged
Thallium (Tl)	µg/L	EPA 200.8	0.01	0.05	1-L HDPE, double bagged

Constituent	Units	Method	MDL	RL	Volume/ Container
Tin (Sn)	µg/L	EPA 200.8	0.06	0.3	1-L HDPE, double bagged
Titanium (Ti)	µg/L	EPA 200.8	0.08	0.4	1-L HDPE, double bagged
Vanadium (V)	µg/L	EPA 200.8	0.03	0.15	1-L HDPE, double bagged
Zinc (Zn)	µg/L	EPA 200.8	0.02	0.1	1-L HDPE, double bagged

2.2.4 Shorecliff Drive BMP Pollutant Load Reduction Calculations

As previously described, the BMPs installed at Shorecliff Drive include both a media filter (upstream within curb side catch basin) and an infiltration gallery (downstream about mid span between catch basin and outfall within a drainage easement). Therefore, the entire dry weather volume of runoff flowing through the system is treated by passing through the media filter while some larger flows exceed the capacity of the infiltration gallery.

Volumes at each monitoring site for each event were calculated by summing the incremental flow values multiplied by the time elapsed between flows as follows:

$$Volume\ (cubic\ feet) = Flow\ \left(\frac{cubic\ feet}{second}\right) \times Incremental\ Time\ (seconds)$$

The results of the flow monitoring were used to estimate the difference between upstream and downstream flow volumes for each event. These differences in volume were attributed to the infiltration gallery conveying runoff in the underlying substrata. Volumes infiltrated were calculated as follows:

$$Infiltrated\ Volume\ (cubic\ feet) = Upstream\ Volume\ - Downstream\ Volume$$

These infiltrated flows are considered to have a 100 percent pollutant load reduction. The upstream pollutant concentrations were applied to the calculated infiltration volumes to determine the associated load reductions through infiltration as follows:

$$Load(pounds) = Volume\ (cubic\ feet) \times Conc.\left(\frac{mg\ or\ \mu g}{liter}\right) \times conversion\ factors$$

The remaining flows through the system (flows not infiltrated) were considered to be treated by the media filter and therefore have some associated load reductions. In order to determine the load reduction percentages, or BMP effectiveness, of the media filter the chemistry results for the upstream and downstream samples were compared. For some constituents the downstream results were higher than the upstream results, and this is attributed to the high variability of chemistry in runoff. For these cases, no load reduction percentages were applied to the constituents. The BMP effectiveness for each constituent was calculated as follows:

$$BMP\ Effectiveness\ (\%) = \frac{Upstream\ Conc. - Downstream\ Conc.}{Upstream\ Conc.}$$

The load reductions associated with flow through the system were estimated by as follows:

$$Load(pounds) =$$
$$Volume\ (cubic\ feet) \times Upstream\ Conc.\left(\frac{mg\ or\ \mu g}{liter}\right) \times conversion\ factors \times BMP\ Eff.$$

Annual load reductions were estimated by calculating the daily average results of the monitored events and extrapolating the results to the typical dry weather days per year for the area.

3.0 RESULTS

Results of four sampling events at Buck Gully (two wet weather and two dry weather) and two sampling events at Shorecliff (dry weather) are presented below as part of the BMP effectiveness assessment. Field and analytical chemistry measurements and flow measurements were collected during sampling events at all sites. Additionally, bacterial concentrations were measured at Buck Gully sites during each event. Results of these data were used to calculate estimated loads and load reductions.

3.1 Buck Gully

Dry weather sampling events occurred on November 30, 2011 and June 13, 2013, while wet weather sampling events occurred on December 12, 2011 and October 9, 2013. Construction at Buck Gully began at the end of October late summer/early fall of 2011, just prior to initial dry and wet weather sampling events. The final dry and wet weather sampling events were performed after construction had been completed and vegetation in the constructed wetlands areas had fully matured.

The December 12, 2011 storm event brought approximately 0.23 inches of rain to the project area. This rain event was the third significant rainfall of the 2011-2012 wet weather season, following storm events in October and November of that year. The October 9, 2013 storm was the first significant rainfall of the 2013-2014 storm season. Rainfall for this event was somewhat spotty in nature, with total rainfall for this event equaling 0.33 inches based on a portable rain gauge deployed at the site.

3.1.1 Analytical Results

Results of dry weather chemical and bacterial analyses are provided in Table 3-1, while results of wet weather chemical and bacterial analyses are provided in Table 3-2. Chemistry results were compared to Ocean Plan criteria, since impacts to the ASBS were the focus of this study. Bacteria and chemistry results are discussed below for each constituent group. Complete chemistry and bacteria reports are provided in Appendix A.

Table 3-1. Dry Weather Analytical Chemistry and Bacteria Results

Parameter	Units	COP Instant. Max.	Dry Weather Monitoring									
			Site 1		Site 2		Site 3		Site 4		Site 5	
			11/30/11	6/13/13	11/30/11	6/13/13	11/30/11	6/13/13	11/30/11	6/13/13	11/30/11	6/13/13
Bacteriological												
Enterococcus	MPN/100 mL		300	700	230	300	300	230	170	1700	110	500
Fecal Coliforms	MPN/100 mL		20	300	70	80	40	500	80	1100	80	130
Total Coliforms	MPN/100 mL		800	80000	2800	17000	5000	5000	750E	7000	230	500
Field												
pH	pH units		7.57	7.72	7.53	7.72	7.57	7.92	7.66	7.84	7.62	7.69
Conductivity	µS/cm		5882	5892	5917	5927	5852	5886	5851	5323	5264	5011
Dissolved Oxygen	mg/L		9.47	9.25	10.01	9.01	10.23	10.85	10.35	9.73	10.6	11.19
Salinity	ppt		3.21	NS	3.23	3.24	3.2	3.22	3.19	3.21	2.86	2.78
Turbidity	NTU		2.8	1.5	7.9	1.9	7.4	0.4	4.7	0.2	4.4	3.5
Water Temperature	Celsius		12.79	13.81	12.86	13.95	12.66	13.44	12.02	13.12	13.45	13.74
Conventionals												
Total Dissolved Solids	mg/L		4859	4199	4863	4156	4846	4121	4835	4272	4340	3451
Total Hardness as CaCO3	mg/L		2431.9	2625.7	2462.8	2623	2437.4	2586.5	2444.2	2518.6	2261.8	2267.4
Total Suspended Solids	mg/L	60*	4.2J	1.8	16.2	3.8	2.3J	4.2	19.3	2.1	0.5J	0.8
Turbidity	NTU		1.8J	NS	4.4	NS	2.2	NS	5.1	NS	<1	NS
Trace Metals												
Arsenic(As),Total	µg/L	80	1.5	1.94	1.39	2.05	1.18	1.28	0.9	1.19	1.17	1.43
Cadmium(Cd),Total	µg/L	10	2.03	1.004	2.95	1.251	2.78	2.27	2.93	2.727	2.15	2.514
Chromium(Cr),Total	µg/L		0.14J	0.13	0.16J	0.14	0.15J	0.06	0.06J	0.08	0.11J	0.07
Copper(Cu),Total	µg/L	30	1.1	1.689	1.68	1.865	1.51	1.535	1.72	1.957	1.65	2.663
Lead(Pb),Total	µg/L	20	0.09	0.077	0.29	0.134	0.04J	0.036	0.01J	0.058	<0.01	0.016
Nickel(Ni),Total	µg/L	50	14.03	7.28	14.87	7.46	11.6	8.71	11.49	9.43	9.48	7.51
Selenium(Se),Total	µg/L	150	24.27	13.39	24.62	13.38	28	14.16	28.37	15.29	28.58	11.97
Silver(Ag),Total	µg/L	7	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01
Zinc(Zn),Total	µg/L	200	3.44	6.61	4.26	8.43	3.15	5.35	3.53	5.17	3.22	5.63

Parameter	Units	COP Instant. Max.	Dry Weather Monitoring									
			Site 1		Site 2		Site 3		Site 4		Site 5	
			11/30/11	6/13/13	11/30/11	6/13/13	11/30/11	6/13/13	11/30/11	6/13/13	11/30/11	6/13/13
Dissolved Metals												
Arsenic(As),Dissolved	µg/L		1.16	1.63	1.23	1.75	1.13	1.22	1.01	1.29	0.96	1.3
Cadmium(Cd),Dissolved	µg/L		0.9	0.747	0.74	0.696	0.97	1.309	1.92	1.782	0.97	1.423
Chromium(Cr),Dissolved	µg/L		0.08J	0.07	0.06J	0.04J	0.07J	0.03J	0.08J	0.03J	0.07J	0.04J
Copper(Cu),Dissolved	µg/L		0.74	1.528	0.76	1.292	0.93	1.157	1.48	1.633	1.07	2.212
Lead(Pb),Dissolved	µg/L		0.01J	0.024	<0.01	<0.005	<0.01	0.016	<0.01	<0.005	<0.01	<0.005
Nickel(Ni),Dissolved	µg/L		13.27	6.78	14.42	6.86	11.42	8.19	11.64	8.92	9.37	7.2
Selenium(Se),Dissolved	µg/L		22.44	11.96	24.44	13.01	27.53	14.67	29.24	14.56	28.53	11.86
Silver(Ag),Dissolved	µg/L		<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01
Zinc(Zn),Dissolved	µg/L		2.53	5.01	2.71	5.46	2.58	3.98	3.21	3.93	3.09	4.99
Pyrethroids												
Allethrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bifenthrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.9	<0.5	<0.5	<0.5
Cyfluthrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cypermethrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Danitol (Fenpropathrin)	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Deltamethrin	ng/L		<0.5	NS	<0.5	NS	<0.5	NS	<0.5	NS	<0.5	NS
Deltamethrin/Tralomethr	ng/L		NS	14.7	NS	<0.5	NS	<0.5	NS	<0.5	NS	<0.5
Esfenvalerate	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fenvalerate	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluvalinate	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
L-Cyhalothrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Permethrin	ng/L		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Permethrin, cis-	ng/L		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Permethrin, trans-	ng/L		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Prallethrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Resmethrin	ng/L		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

*60 mg/L TSS value is a 7-day weekly average since no instantaneous maximum has been established.
Grey shading and **bold type** indicate value above California Ocean Plan Instantaneous Maximum criteria.

Table 3-2. Wet Weather Analytical Chemistry and Bacteria Results

Parameter	Units	COP Instant. Max.	Wet Weather Monitoring									
			Site 1 (mouth of Buck Gully)		Site 2		Site 3		Site 4		Site 5	
			12/12/11	10/9/13	12/12/11	10/9/13	12/12/11	10/9/13	12/12/11	10/9/13	12/12/11	10/9/13
Bacteriological												
Enterococcus	MPN/100 mL		13,000	170,000	8,000	28,000	8,000	49,000	5,000	14,000	2,300	7,900
Fecal Coliforms	MPN/100 mL		2,300	49,000	5,000	1,700	1,100	7,000	1,700	11,000	300	2,800
Total Coliforms	MPN/100 mL		130,000	130,000	30,000	110,000	50,000	110,000	50,000	33,000	8,000	79,000
Field												
pH	pH units		7.4	7.82	7.68	7.84	7.74	7.75	7.88	7.61	7.94	6.89
Conductivity	µS/cm		3,083	2410	2,950	4.420	2,769	3790	2,731	3770	2,021	1259
Dissolved Oxygen	mg/L		10.21	NS	14.48	NS	10.34	NS	10.59	NS	10.39	NS
Turbidity	NTU		102	37.1	85.5	15.2	41.2	24.2	9.2	36.1	6.4	23.0
Water Temperature	Celsius		12.4	16.7	11.83	16.9	11.81	17.4	12.09	18.0	12.12	18.9
Conventionals												
Total Dissolved Solids	mg/L		2260	2044	1837	3167	1665	1913	1649	2211	1176	890
Total Hardness as CaCO3	mg/L		1195.2		961.8		843.3		829		593.4	
Total Suspended Solids	mg/L	60*	**136.1**	**680.7**	**215.5**	**229.3**	**113**	56.0	21	**72.8**	8.7	**65.7**
Trace Metals												
Arsenic(As),Total	µg/L	80	3.11	13.36	3.32	6.18	2.18	3.88	1.54	5.07	1.25	2.88
Cadmium(Cd),Total	µg/L	10	3.24	**23.061**	3.82	3.885	2.86	3.158	1.63	1.871	0.81	1.307
Chromium(Cr),Total	µg/L		3.43	23.34	4.76	6.93	2.56	6.01	0.89	8.23	0.79	4.88
Copper(Cu),Total	µg/L	30	16.91	**111.194**	19.94	**99.099**	20.43	**89.074**	12.72	**139.658**	8.82	**115.543**
Lead(Pb),Total	µg/L	20	5.86	16.827	9.85	13.453	1.82	4.245	0.54	7.711	0.31	5.098
Nickel(Ni),Total	µg/L	50	15.91	**66.49**	16.37	18.08	10.72	29.41	5.67	30.63	4.27	22.25
Selenium(Se),Total	µg/L	150	15.76	14.74	10.06	10.7	9.23	8.3	8.51	6.66	6.05	3.28
Silver(Ag),Total	µg/L	7	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	0.02	<0.03	<0.01
Zinc(Zn),Total	µg/L	200	29.54	**447.48**	34.17	179.27	28.85	**317.08**	13.96	**681.43**	8.8	**378.54**

Parameter	Units	COP Instant. Max.	Wet Weather Monitoring									
			Site 1 (mouth of Buck Gully)		Site 2		Site 3		Site 4		Site 5	
			12/12/11	10/9/13	12/12/11	10/9/13	12/12/11	10/9/13	12/12/11	10/9/13	12/12/11	10/9/13
Dissolved Metals												
Arsenic(As),Dissolved	µg/L		2.17	3.29	1.7	2.38	1.47	2.79	1.3	3.82	1.17	2.93
Cadmium(Cd),Dissolved	µg/L		0.78	0.527	0.66	0.766	0.63	1.597	0.81	1.113	0.54	0.841
Chromium(Cr),Dissolved	µg/L		0.2J	0.78	0.21J	0.36	0.26	2.92	0.3	3.41	0.45	2.31
Copper(Cu),Dissolved	µg/L		4.18	10.693	5.2	16.532	7.45	52.171	7.94	83.301	5.97	71.741
Lead(Pb),Dissolved	µg/L		0.04J	0.347	0.07	0.096	0.02J	0.752	0.01J	1.247	<0.01	1.05
Nickel(Ni),Dissolved	µg/L		9.08	21.28	6.17	7.47	5.38	25.48	4.23	25.96	3.57	18.93
Selenium(Se),Dissolved	µg/L		15.61	10.66	11.04	10.09	9.23	7.96	8.16	5.42	6	3.44
Silver(Ag),Dissolved	µg/L		<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01
Zinc(Zn),Dissolved	µg/L		6.88	63.45	5.68	38.16	8.25	236.66	6.09	509.33	4.78	300.96
Pyrethroids												
Allethrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5.6	<0.5	5.4	<0.5
Bifenthrin	ng/L		38	200.4	43.4	222.5	64.5	25.4	80.2	80	42.5	113.2
Cyfluthrin	ng/L		19.4	48.6	18.2	26.8	29.6	<0.5	33	16	19.3	32.2
Cypermethrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Danitol (Fenpropathrin)	ng/L		2.1	<0.5	1.5J	<0.5	1.3J	<0.5	1J	<0.5	0.7J	<0.5
Deltamethrin	ng/L		11	NS	10.6	NS	14.3	NS	10.9	NS	13.3	NS
Deltamethrin/Tralomethr	ng/L		NS	111.1	NS	80.3	NS	15.4	NS	25.7	NS	10.5
Esfenvalerate	ng/L		<0.5	12.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fenvalerate	ng/L		<0.5	5.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluvalinate	ng/L		<0.5	<0.5	10	10.8	17.7	<0.5	11.8	<0.5	<0.5	<0.5
L-Cyhalothrin	ng/L		5.1	31.5	7.1	54.9	8.2	2.9	9.2	11.1	4.6	10.6
Permethrin	ng/L		61.8	113.5	110.8	73	165.1	<5	224	97.2	81.5	138.7
Permethrin, cis-	ng/L		18.5J	41.9	72.2	34.9	85.5	<5	142.5	38.8	51.1	53.1
Permethrin, trans-	ng/L		43.3	71.6	38.6	38.1	79.6	<5	81.5	58.4	30.4	85.6
Prallethrin	ng/L		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Resmethrin	ng/L		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

*60 mg/L TSS value is a 7-day weekly average since no instantaneous maximum has been established.
Grey shading and **bold type** indicate value above California Ocean Plan Instantaneous Maximum criteria.

Bacteria

Concentrations of enterococci and fecal coliforms remained fairly consistent (within 1 order of magnitude difference) between the five sites during the dry weather sampling events, while total coliform concentrations during the dry weather events differed by two orders of magnitude between Site 5, upstream of the BMPs and Site 1, at the mouth of Buck Gully downstream of the BMPs (Figure 3-1).

In wet weather, concentrations of enterococci, fecal coliforms each varied by approximately one order of magnitude between the five sites, while concentrations of total coliforms varied by approximately two orders of magnitude (Figure 3-2). During the December 12, 2011 storm event, bacterial concentrations of enterococci and total coliforms were substantially higher at the mouth of Buck Gully (Site 1), than at upstream locations. Fecal coliform concentrations during the December 12, 2011 storm event were highest at Site 2. The storm event of October 9, 2013 followed construction of the various BMPs along the lower reaches of Buck Gully. During this event, bacterial concentrations of enterococci and fecal coliforms were highest at Site 3 and Site 4, respectively. A decline of approximately 73 percent in enterococci concentration occurred from Site 3 to Site 1 (where Buck Gully discharges to ASBS 32 at Little Corona Beach) during the October 9, 2013 event. Similarly, fecal coliform concentrations declined by approximately 79 percent from Site 4 to Site 1, while total coliform concentrations peaked at Site 1. In general, wet weather bacterial concentrations were approximately one to two orders of magnitude higher than dry weather concentrations.

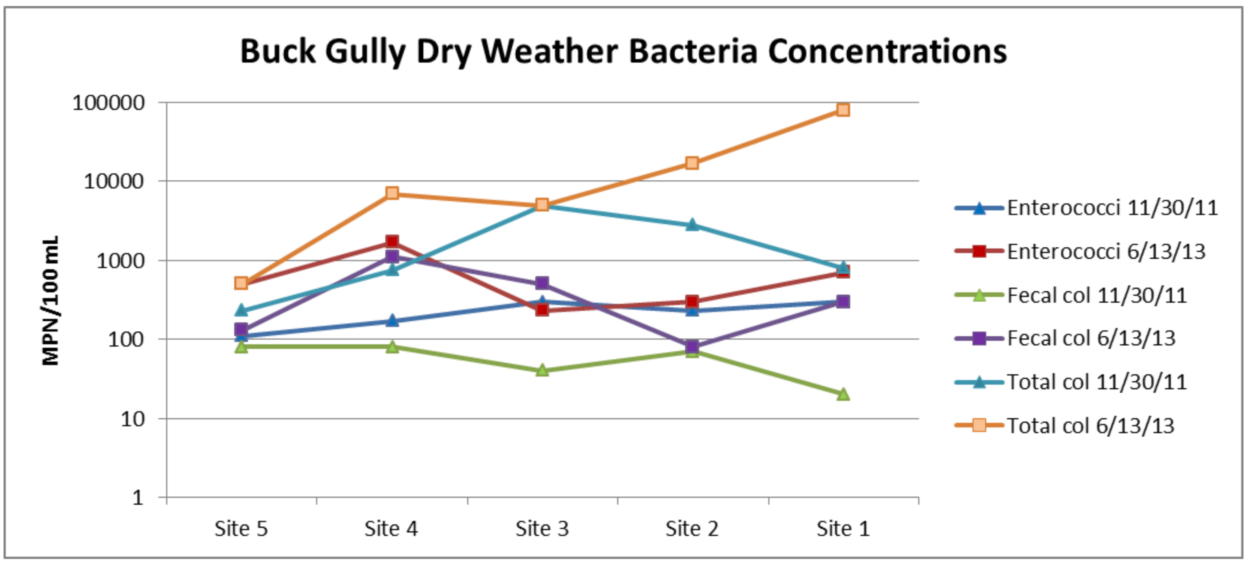


Figure 3-1. Dry Weather Bacteria Concentrations at Buck Gully

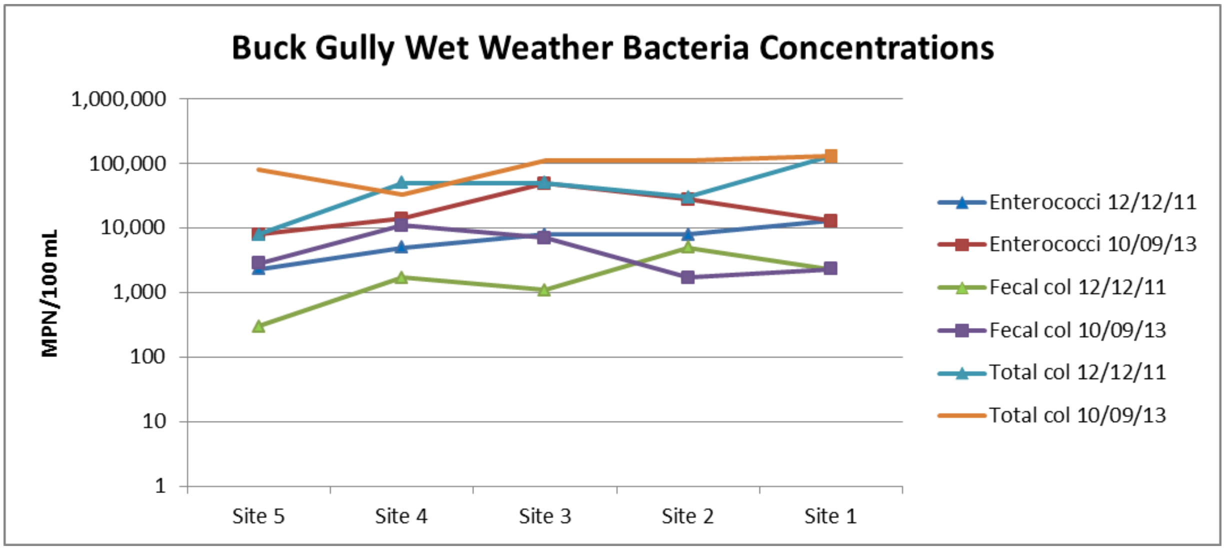


Figure 3-2. Wet Weather Bacteria Concentrations at Buck Gully

Total Metals

Total metals concentrations during dry weather sampling events varied somewhat for nickel and selenium between sites, while other metal constituents had substantially less variability (Figure 3-3). During the November 30, 2011 storm, nickel concentrations were highest near the mouth of Buck Gully, while selenium concentrations were slightly higher at the upstream site locations.

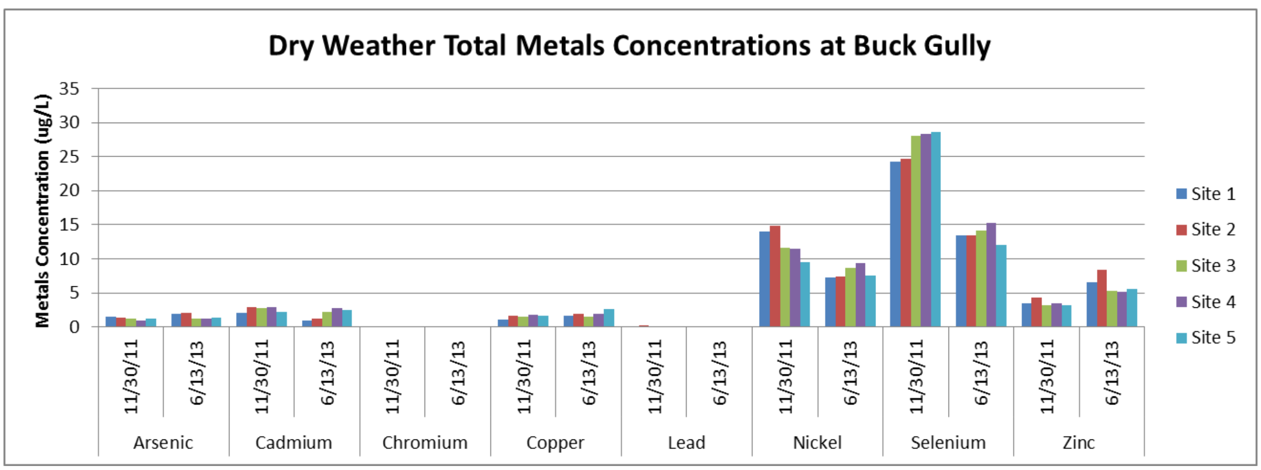


Figure 3-3. Buck Gully Total Metals Concentrations during Dry Weather

Wet weather total metals concentrations tended to be higher at the downstream locations (Sites 1 through 3) than at upstream locations during the December 12, 2011 event (Figure 3-4). Construction activity occurring during this time may have contributed to higher metal concentrations downstream of BMPs. For all metals during the December 12, 2011 event, concentrations at Site 5 were lower than at any of the other sites, while concentrations at Site 4 were next lowest in comparison to all other sites. During this event, no total metals concentrations exceeded COP Imax values.

Metals results from the October 9, 2013 event indicated there were elevated copper concentrations above COP Imax values across all sites and elevated zinc concentrations at four of five sites. Cadmium and nickel concentrations were above the COP Imax values at Site 1. Copper concentrations ranged from 89 ug/L at Site 3 to 139.7 ug/L at Site 4 while zinc concentrations ranged from 179.3 ug/L at Site 2 to 681.4 ug/L at Site 4. In Figure 3-4, zinc concentrations were only shown up to a maximum of 200 ug/L for purposes of scale. In general, metal concentrations were slightly higher toward the base of the watershed at the mouth of Buck Gully than in the upper portion of the watershed during the October 2013 event. Additionally, metals concentrations during the "first flush" event of October 9, 2013 were higher than during the December 12, 2011 event.

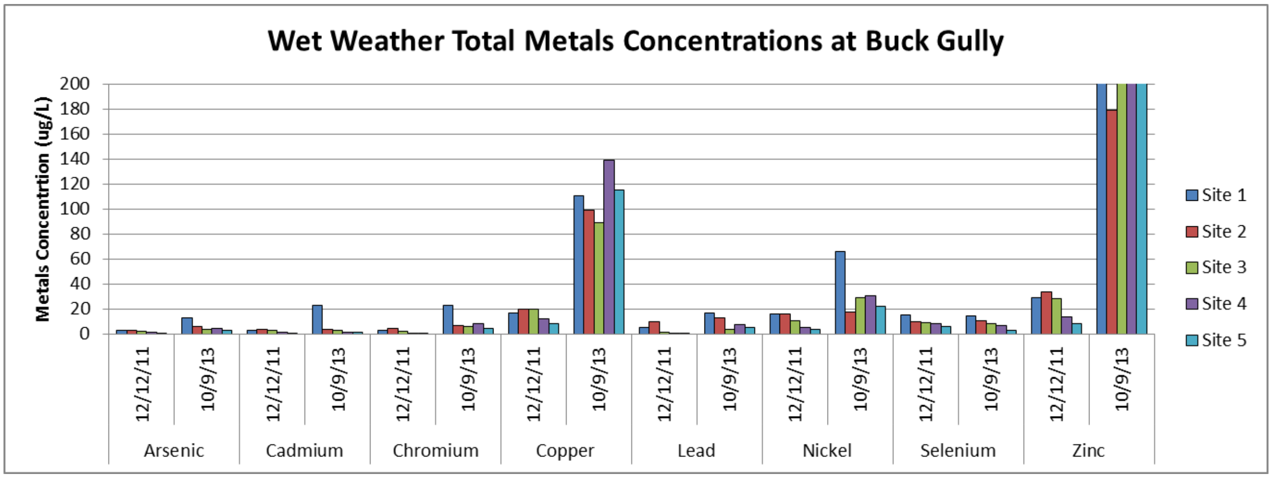


Figure 3-4. Buck Gully Total Metals Concentrations during Wet Weather

Dissolved Metals
With the exception of Selenium and nickel, dissolved metals concentrations during dry weather varied only slightly between sites and between sampling events. Selenium concentrations ranged from 11.86 ug/L to 29.24 ug/L and nickel concentrations ranged from 6.78 ug/L to 14.42 ug/L across all sites and both dry weather sampling events. With the exception of dissolved copper and zinc during the 10/9/13 storm event, wet weather dissolved metal concentrations were either similar or slightly higher than dry weather concentrations for most constituents. Dissolved copper and zinc concentrations were somewhat higher than dry weather concentrations during the December 12, 2011 wet weather event and substantially higher during the October 9, 2013 event. Dissolved copper and zinc were substantially higher in the upper watershed than in the lower watershed during the October 9, 2013 storm event.

Pyrethroids
During dry weather, Bifenthrin and Deltamethrin/Tralomethrin were the only pyrethroids detected. Each was detected at a low concentration at only one site. Wet weather concentrations of pyrethroids were substantially higher, with concentrations of Bifenthrin ranging from nine to 20 times the published LC_{50} value for a marine invertebrate (4.0 ng/L for mysid shrimp; USEPA 2002) during the December 12, 2011 event, and from six to 50 times the LC_{50} value during the October 9, 2013 event. Bifenthrin concentrations were above the LC_{50} value across all sites during both monitored storm events. Cyfluthrin concentrations were above the published LC_{50}

value for a marine invertebrate (2.4 ng/L for mysid shrimp; USEPA 2002) across all sites during both events, with the exception of Site 3, during the October 9, 2013 storm event.

3.2 Shorecliff

Dry weather sampling events at the Shorecliff Infiltration Gallery BMP occurred during the morning and early afternoon hours on November 13 and November 20, 2013. Samples were collected upstream of the BMP at the curb inlet catch basin located on the west side of Shorecliff Road where it intersects with Driftwood Road, and in the storm drain pipe, immediately downstream of the infiltration gallery BMP, that leads to the NEW018 storm drain outfall.

3.2.1 Analytical Results

Complete analytical results of total hardness, total metals and dissolved metals, and QA/QC data are provided in Appendix A. Results of a subset of the constituents analyzed for the BMP assessment are provided below in Table 3-3. Grey shading indicates concentrations that were above COP Imax values.

Table 3-3. Analytical Chemistry Results for Shorecliff BMP Assessment

Parameter	Units	COP	Shorecliff Inflow A	Shorecliff Outflow	Shorecliff Inflow A	Shorecliff Outflow
		Instantaneous Maximum	11/13/2013	11/13/2013	11/20/2013	11/20/2013
Convention						
Total Hardness as CaCO3	mg/L		250.6	251.2	226.9	242.6
Total Metals						
Arsenic (As)	µg/L	80	2.83	2.65	3.08	2.93
Cadmium (Cd)	µg/L	10	0.095	0.091	0.127	0.14
Chromium (Cr)	µg/L		1.28	1.05	1.25	1.42
Copper (Cu)	µg/L	30	**67.715**	**50.703**	**65.233**	**51.1**
Lead (Pb)	µg/L	20	1.317	1.25	1.129	0.478
Nickel (Ni)	µg/L	50	2.41	2	2.17	2.85
Selenium (Se)	µg/L	150	1.23	1.23	1.4	1.75
Silver (Ag)	µg/L	7	<0.01	<0.01	<0.01	<0.01
Zinc (Zn)	µg/L	200	49.57	112.02	32.49	110.96
Dissolved Metals						
Arsenic (As)	µg/L		*	*	3.74	2.81
Cadmium (Cd)	µg/L		*	*	0.061	0.101
Chromium (Cr)	µg/L		*	*	0.46	0.5
Copper (Cu)	µg/L		*	*	40.475	32.942
Lead (Pb)	µg/L		*	*	0.06	<0.005
Nickel (Ni)	µg/L		*	*	1.69	2.39
Selenium (Se)	µg/L		*	*	1.12	1.26
Silver (Ag)	µg/L		*	*	<0.01	<0.01
Zinc (Zn)	µg/L		*	*	11.87	70.03

*Not recordable as the result of a laboratory error during sample preparation

General Chemistry

Hardness concentrations were nearly identical during the initial sampling event on November 13, 2013 (Event 1), ranging from 250.6 mg/L at the inflow sampling location to 251.2 mg/L at the outflow sampling location. During the second sampling event on November 20, 2013 (Event 2), results were slightly lower, particularly at the inflow location. Hardness during this event ranged from 226 mg/L at the inflow location to 242.6 mg/L at the outflow location.

Total Metals

Total metal concentrations were generally lower at the outflow sampling location than the inflow location during both sampling events for most metals. The exceptions to this pattern were concentration of zinc which were higher than at the outflow location during both events and the concentrations of selenium and nickel which were higher at the outflow during the second event. The selenium concentration remained static at the inflow and outflow locations during Event 1. Copper was the only metal which was measured above COP Imax criteria (Figure 3-5). Red line indicates COP Imax for copper). Copper concentrations ranged from 67.7 mg/L at the inflow during Event 1 to 50.7 mg/L at the outflow during Event 1. All other metals, with the exception of zinc, were one or more orders of magnitude below COP Imax criteria. Silver concentrations were below detection limits at both sampling locations during both monitoring events.

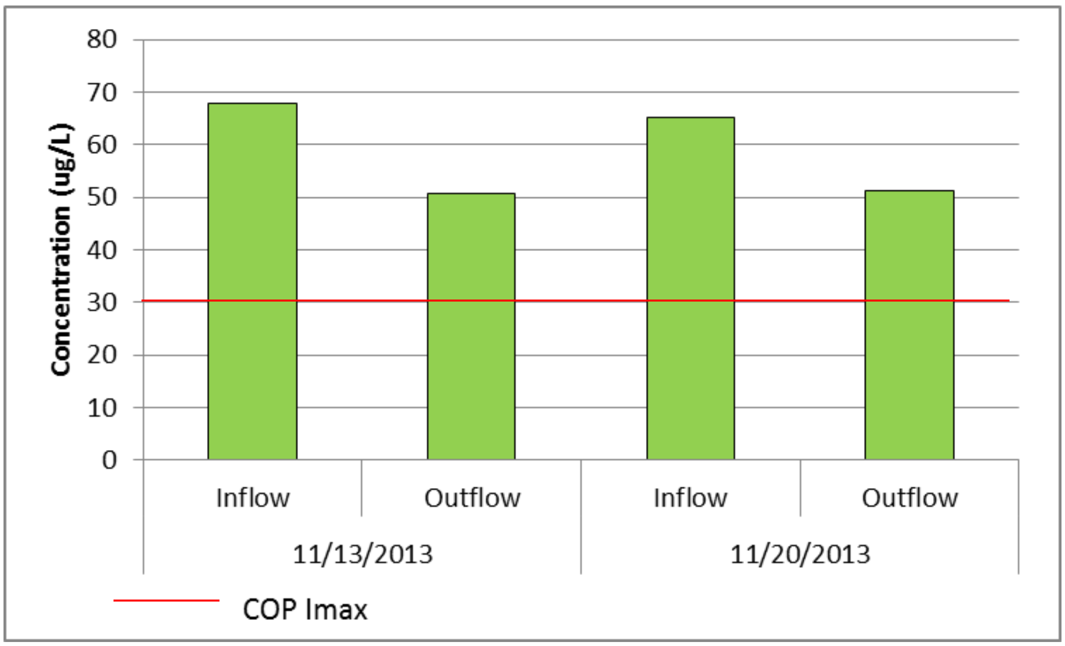


Figure 3-5. Total Copper Concentration at Shorecliff BMP

Dissolved Metals

No dissolved metal concentrations were recordable during Event 1 as the result of a laboratory error in preparing the sample. While dissolved metals results are desirable to demonstrate the phase of the metals, the COP does not provide dissolved metals water quality criteria. As a result, the effect of the missing analyses should not impact the overall BMP assessment. During Event 2, dissolved metals concentrations at the inflow location were higher than at the outflow location for arsenic, copper, and lead. In contrast, cadmium, chromium, nickel, selenium and zinc concentrations were highest at the outflow location.

3.3 Flow Data

Level monitoring data was collected continuously during each sampling event at Buck Gully and Shorecliff for the purpose of estimating the constituent loads and calculating associated load reductions. Chemistry results were used in combination with measured flows in the field to derive load estimates. Methods used to calculate flow and loads are discussed in sections 2.1.4 and 2.1.5 for Buck Gully and in sections 2.2.1 and 2.2.4 for Shorecliff.

3.3.1 Buck Gully

Dry weather
Dry weather monitoring was performed on November 30, 2011 as construction activities for BMP installation were underway along Buck Gully. Although construction was completed in the late spring of 2012, vegetation had become fully established until approximately November 2012. Post-construction dry weather monitoring was performed on June 13, 2013.

Dry Weather Monitoring Event 1
Load and load reduction estimates are shown in Table 3-4 for total metals, TSS, and bacteria. Since there is no COP criteria for dissolved metals and since no pyrethroids were detected, loads for these constituents were not calculated. In general, TSS and metals loads decreased with decreasing flow from Site 5 to Site 4 and from Site 4 to Site 3 for nearly all constituents. Flow increased slightly from Site 3 to Site 2, leading to negative load reductions for nearly all constituents, and especially TSS. From Site 2 to Site 1 flow decreased slightly and load reductions were greater than 10% for nearly all constituents. Overall load reductions were somewhat variable. There was an 85% overall load reduction for TSS, while metals reductions ranged from -64% for chromium to 51% for cadmium. The loads for total copper, lead and zinc were reduced by 55%, 0% and 32%, respectively. For Bacteria, overall loads of fecal coliforms and total coliforms were reduced by 82 and 25%, respectively ($0.7x10^9$ MPN and $1.9x10^9$ MPN, respectively), while overall loads of enterococci increased by 24% ($0.4x10^9$ MPN).

Table 3-4. Summary Load and Load Reduction Estimates for Dry Weather 1

	Dry Weather Monitoring Event 1: November 30, 2011									Overall	
	Site 5	Site 4		Site 3		Site 2		Site 1			
Flow Volume	45,699	35,471		25,607		27,165		24,895			
Constiuent Loads											
	Site 5	Site 4		Site 3		Site 2		Site 1			
	Load (g/Day)	Load (g/Day)	Load Reduction (%)	Load (g/Day)	Load Reduction (%)	Load (g/Day)	Load Reduction (%)	Load (g/Day)	Load Reduction (%)	Load Reduction (g/ Day)	Load Reduction (%)
Arsenic	1.5	0.90	40%	0.86	5%	1.07	-25%	1.06	1%	-0.15	-17%
Cadmium	2.8	2.94	-6%	2.02	32%	2.27	-13%	1.43	37%	1.51	51%
Chromium	0.1	0.06	58%	0.11	-80%	0.12	-13%	0.10	20%	-0.04	-64%
Copper	2.1	1.73	19%	1.09	37%	1.29	-18%	0.78	40%	0.95	55%
Lead	0.0	0.00	0%	0.03	0%	0.22	-669%	0.06	72%	-0.06	0%
Nickel	12.3	11.54	6%	8.41	27%	11.44	-36%	9.89	14%	1.65	14%
Selenium	37.0	28.50	23%	20.30	29%	18.94	7%	17.11	10%	11.39	40%
Silver	0.0	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Zinc	4.2	3.55	15%	2.28	36%	3.28	-43%	2.43	26%	1.12	32%
TSS	647	19,386	-2896%	1,668	91%	12,462	-647%	2,961	76%	16,425	85%
	Site 5	Site 4		Site 3		Site 2		Site 1		Overall	
	Load (MPN $x10^9$/Day)	Load (MPN $x10^9$/Day)	Load Reduction (%)	Load (MPN $x10^9$/Day)	Load Reduction (%)	Load (MPN $x10^9$/Day)	Load Reduction (%)	Load (MPN $x10^9$/Day)	Load Reduction (%)	Load Reduction (MPN $x10^9$/Day)	Load Reduction (%)
Enterococcus	1.42	1.71	-20%	2.18	-27%	1.77	19%	2.11	-20%	-0.4	-24%
Fecal Coliforms	1.04	0.80	22%	0.29	64%	0.54	-86%	0.14	74%	0.7	82%
Total Coliforms	2.98	7.53	-153%	36.26	-381%	21.54	41%	5.64	74%	1.9	25%

Dry Weather Monitoring Event 2

Load and load reduction estimates are shown in Table 3-5 for total metals, TSS, and bacteria. Since there is no COP criteria for dissolved metals and since only one pyrethroid was detected (low level of Deltamethrin at Site 1), loads for these constituents were not calculated. In general, loads of metals and TSS increased between Site 5 and Site 4 upstream of the BMP installations, and decreased markedly at each subsequent downstream site. Following initial increases in loads from Site 5 to Site 4, loads for all metals (with the exception of silver) decreased by 20% or more from Site 4 to Site 3, while the load for TSS increased by 43%. At Site 2, the loads for cadmium, copper, nickel, and selenium decreased, while the loads for arsenic, chromium, lead, and zinc increased. Loads for all constituents, with the exception of non-detect silver and enterococcus, were substantially lower at Site 1 at the mouth of Buck Gully, than upstream of the wetlands at Site 2. Overall load reductions were fairly consistent across all metals constituents, ranging from a 44% load reduction for total arsenic and chromium to an 87% load reduction for cadmium (Figure 3-6). The overall TSS load was reduced by 79% between Site 4 and Site 1. For bacteria, overall loads of fecal coliforms and enterococci were reduced by 91% and 86%, respectively (13.7×10^9 MPN and 20.1×10^9 MPN, respectively), while overall loads of total coliforms increased by 293% (282.3×10^9 MPN). Most of the increased bacterial load for total coliforms occurred immediately upstream and downstream of the wetlands area at Sites 2 and 1, respectively.

Table 3-5. Summary Load and Load Reduction Estimates for Dry Weather 2

	Dry Weather Monitoring Event 2: June 13, 2013									Overall	
	Site 5	Site 4		Site 3		Site 2		Site 1			
Flow Volume	19,229	48,586		34,839		26,088		16,711			
Constiuent Loads											
	Site 5	Site 4		Site 3		Site 2		Site 1			
	Load (g/Day)	Load (g/Day)	Load Reduction (%)	Load (g/Day)	Load Reduction (%)	Load (g/Day)	Load Reduction (%)	Load (g/Day)	Load Reduction (%)	Load Reduction (g/ Day)	Load Reduction (%)
Arsenic	0.78	1.64	-110%	1.26	23%	1.51	-20%	0.92	39%	0.72	44%
Cadmium	1.37	3.75	-174%	2.24	40%	0.92	59%	0.48	49%	3.28	87%
Chromium	0.04	0.11	-189%	0.06	46%	0.10	-75%	0.06	41%	0.05	44%
Copper	1.45	2.69	-86%	1.51	44%	1.38	9%	0.80	42%	1.89	70%
Lead	0.01	0.08	-816%	0.04	55%	0.10	-179%	0.04	63%	0.04	54%
Nickel	4.09	12.97	-217%	8.59	34%	5.51	36%	3.44	37%	9.53	73%
Selenium	6.52	21.04	-223%	13.97	34%	9.88	29%	6.34	36%	14.70	70%
Silver	0.00	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Zinc	3.07	7.11	-132%	5.28	26%	6.23	-18%	3.13	50%	3.99	56%
TSS	436	2,889	-563%	4,143	-43%	2,807	32%	852	70%	3,292	79%
	Site 5	Site 4		Site 3		Site 2		Site 1		Overall	
	Load (MPN x10^9/Day)	Load (MPN x10^9/Day)	Load Reduction (%)	Load (MPN x10^9/Day)	Load Reduction (%)	Load (MPN x10^9/Day)	Load Reduction (%)	Load (MPN x10^9/Day)	Load Reduction (%)	Load Reduction (MPN x10^9/Day)	Load Reduction (%)
Enterococcus	2.7	23.4	-759%	2.3	90%	2.2	2%	3.3	-49%	20.1	86%
Fecal Coliforms	0.7	15.1	-2038%	4.9	67%	0.6	88%	1.4	-140%	13.7	91%
Total Coliforms	2.7	96.3	-3437%	49.3	49%	125.6	-155%	378.6	-201%	-282.3	-293%

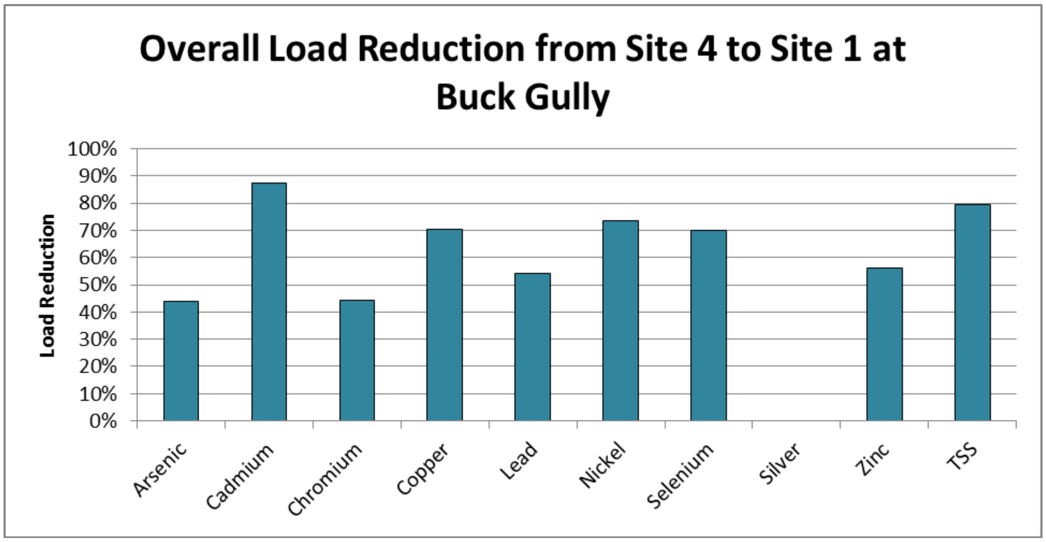


Figure 3-6. Buck Gully Overall Dry Weather Load Reductions Monitoring Event 2

Annualized Dry Weather Load Reductions

Overall post-construction (Event 2) load reductions were multiplied by 330 dry weather days to derive annual dry weather load reductions (Table 3-6). Annual load reductions for cadmium, copper, nickel and zinc, the four metals which had measured concentrations above COP Imax criteria during wet weather, were substantial, resulting in removal of over 1 kg of cadmium, nickel, and zinc, and over 625 g of copper from the waters of Buck Gully prior to it flowing into the ASBS. Additionally, the BMPs installed in Buck Gully removed over 1000 kg of suspended sediment, 6.625×10^{12} MPN of enterococci, and 4.526×10^{12} MPN of fecal coliforms. An increase of 9.3×10^{13} MPN of total coliforms occurred between Site 4 and Site 1. The vast majority of the increased total coliform load occurred in the wetlands area between Site 2 and Site 1, a popular location for birds and other wildlife (Figure 3-7).

Table 3-6. Annualized Dry Weather Load Reductions for Buck Gully

Constituent	Load Reduction (g/ Day)	Load Reduction (g/ Year)
Arsenic	0.72	237
Cadmium	3.28	1,081
Chromium	0.05	16
Copper	1.89	625
Lead	0.04	14
Nickel	9.53	3,145
Selenium	14.70	4,851
Silver	0.00	0
Zinc	3.99	1,315
TSS	3,292	1,086,255
Bacteria	**Load Reduction ($MPN\ x10^9$/Day)**	**Load Reduction ($MPN\ x10^9$/Year)**
Enterococcus	20.1	6,625
Fecal Coliforms	13.7	4,526
Total Coliforms	-282.3	-93,145

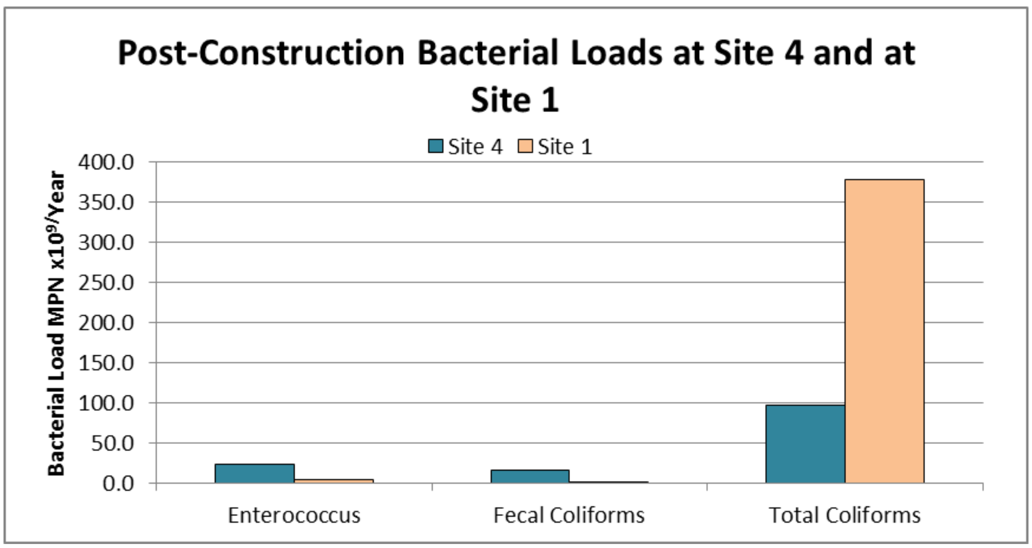


Figure 3-7. Annual post-construction Bacterial Loads at Buck Gully

A comparison of loads at the base of the watershed (Site 1) was performed to determine the daily and annual dry weather load reductions that can be directly attributable to the installations of the BMPs along Buck Gully (Table 3-7). Annual TSS loads were calculated to have decreased by 695 kg, while metals loads ranged from slight to moderate increases in copper (7.9 g) and zinc (231.9 g) loads to slight decreases in chromium, lead, and arsenic loads, and substantial decreases in cadmium, nickel, and selenium loads. Annual load increases occurred for the three bacterial indicators. Enterococcus loads increased 395 x 10^9 MPN, while fecal coliform and total coliform loads increased by 422 x 10^9 MPN and 123,065 x 10^9 MPN.

Table 3-7. Daily and Annual Post-project Dry Weather Load Reduction Estimates

Constituent	Pre-Project Load at Site 1 (g/Day)	Post-Project Load at Site 1 (g/ Day)	Post-Project Load Reduction (g/Day)	Annual Post-Project Load Reduction (g/year)
Arsenic	1.06	0.92	0.14	46.0
Cadmium	1.43	0.48	0.96	315.5
Chromium	0.10	0.06	0.04	12.3
Copper	0.78	0.80	-0.02	-7.9
Lead	0.06	0.04	0.03	8.9
Nickel	9.89	3.44	6.45	2,127
Selenium	17.11	6.34	10.77	3,555
Silver	0.00	0.00	0.00	0.0
Zinc	2.43	3.13	-0.70	-231.9
TSS	2,961	852	2,109	695,979
Bacteria	**Pre-Project Load at Site 1 (MPN $x10^9$/Day)**	**Post-Project Load at Site 1(MPN $x10^9$/Day)**	**Post-Project Load Reduction (MPN $x10^9$/Day)**	**Annual Post-Project Load Reduction (MPN $x 10^9$/year)**
Enterococcus	2.11	3.3	-1.2	-395
Fecal Coliforms	0.14	1.4	-1.3	-422
Total Coliforms	5.64	378.6	-372.9	-123,065

Wet Weather

Wet weather monitoring was performed on December 12, 2011 as construction activities for BMP installation were underway along Buck Gully. Although construction was completed in the late spring of 2012, vegetation had become fully established until approximately November 2012. Post-construction wet weather monitoring was performed on October 9, 2013.

Wet Weather Monitoring Storm 1

Pre-construction load estimates are shown in Table 3-8 for total metals, TSS, total pyrethroids, and bacteria. Since there are no COP criteria for dissolved metals, loads for these constituents were not calculated. In general, constituent loads increased with increasing flow. Beginning at Site 5, flows progressively increased in a downstream manner, and were highest at Site 1, located at the base of the watershed. Site 1 event loads for metals ranged from 18.4 g for arsenic to 174.9 g for zinc. The total TSS load at Site 1 was 805.8 kg, while the total pyrethroids load was 1.07g. Loads of fecal coliform and enterococcus bacteria at Site 1 were 1.36×10^{11} MPN and 7.70×10^{11} MPN, respectively, while the load of total coliform bacteria was 7.70×10^{12} MPN.

Table 3-8. Summary Load Estimates for Wet Weather 1

Constiuent Loads					
Constiuent	Site 5 Load (g/Event)	Site 4 Load (g/Event)	Site 3 Load (g/Event)	Site 2 Load (g/Event)	Site 1 Load (g/Event)
Arsenic	3.1	4.70	7.92	17.87	18.4
Cadmium	2.0	4.98	10.39	20.56	19.2
Chromium	2.0	2.72	9.30	25.62	20.3
Copper	22.2	38.85	74.23	107.33	100.1
Lead	0.8	1.65	6.61	53.02	34.7
Nickel	10.7	17.32	38.95	88.11	94.2
Selenium	15.2	25.99	33.54	54.15	93.3
Silver	0.0	0.00	0.00	0.00	0.0
Zinc	22.2	42.64	104.83	183.92	174.9
TSS	21,899	64,139	410,595	1,159,940	805,852
Total Pyrethroids	0.63	1.83	1.69	1.67	1.07
Constiuent	Site 5 Load (MPN x10^9/ Event)	Site 4 Load (MPN x10^9/ Event)	Site 3 Load (MPN x10^9/ Event)	Site 2 Load (MPN x10^9/ Event)	Site 1 Load (MPN x10^9/ Event)
Enterococcus	58	153	291	431	770
Fecal Coliforms	8	52	40	269	136
Total Coliforms	201	1527	1817	1615	7697

Wet Weather Monitoring Storm 2

Post-construction load estimates are shown in Table 3-9 for total metals, TSS, total pyrethroids, and bacteria. Loads for dissolved metals were not calculated since there are not currently COP criteria for these. In general, constituent loads increased with increasing flow, similar to Storm 1. In contrast to Storm 1, most constituent loads decreased between Site 4 and Site 3, likely because the volume of flow at Site 3 (180,755 ft^3) was only slightly higher than flow at Site 4 (160,968 ft^3). Flows at Site 1 at the base of the watershed, were 1.94 times those at Site 4, and 2.4 times those at Site 5.

Event loads for metals at Site 1 ranged from 118.3 g of arsenic to 3961.7 g of zinc. The copper load at Site 1 was slightly less than 1 kg, while the TSS load was 6,026 kg. The vast increase in TSS which tends to bind to pollutants, likely increased the overall pollutant loads by a significant amount. Loads of fecal coliform and enterococcus bacteria at Site 1 were 4.34 x 10^{12} MPN and 1.50 x 10^{13} MPN, respectively, while the load of total coliform bacteria was 1.15 x 10^{13} MPN.

Table 3-9. Summary Load Estimates for Wet Weather 2

Wet Weather Monitoring Event 2: October 9, 2013					
	Site 5	**Site 4**	**Site 3**	**Site 2**	**Site 1**
Flow Volume	132,777	160,968	180,755	295,182	312,649
Constiuent Loads					
	Site 5	**Site 4**	**Site 3**	**Site 2**	**Site 1**
Constituent	**Load (g/Event)**	**Load (g/Event)**	**Load (g/Event)**	**Load (g/Event)**	**Load (g/Event)**
Arsenic	10.83	23.11	19.86	51.66	118.28
Cadmium	4.91	8.53	16.16	32.47	204.17
Chromium	18.35	37.51	30.76	57.93	206.64
Copper	434.42	636.58	455.92	828.34	984.43
Lead	19.17	35.15	21.73	112.45	148.97
Nickel	83.66	139.62	150.53	151.12	588.65
Selenium	12.33	30.36	42.48	89.44	130.50
Silver	0.00	0.09	0.00	0.00	0.00
Zinc	1423.25	3106.05	1622.95	1498.46	3961.67
TSS	247,022	331,832	286,633	1,916,643	6,026,429
Total Pyrethroids	1.67	1.49	0.22	4.52	5.63
	Site 5	**Site 4**	**Site 3**	**Site 2**	**Site 1**
Constituent	**Load (MPN x10^9/ Event)**	**Load (MPN x10^9/ Event)**	**Load (MPN x10^9/ Event)**	**Load (MPN x10^9/ Event)**	**Load (MPN x10^9/ Event)**
Enterococcus	297.0	638.1	2508.0	2340.4	15,051
Fecal Coliforms	105.3	501.4	358.3	142.1	4,338
Total Coliforms	2970.3	1504.2	5630.3	9194.5	11,509

3.3.2 Shorecliff Infiltration Gallery

Monitoring Event 1

Figure 3-8 shows the measured dry weather runoff flow reaching the curbside catch basin upstream of the BMPs, the cumulative volume of water entering the BMP (volume upstream), the flow downstream of the BMPs (i.e., flow treated through biomedia filter but not infiltrated), and the cumulated volume downstream of the infiltration gallery during Event 1. The graphs show peak flows occurring in the early morning hours with sporadic smaller flows throughout the day and minimal flow between 6pm and 12am.

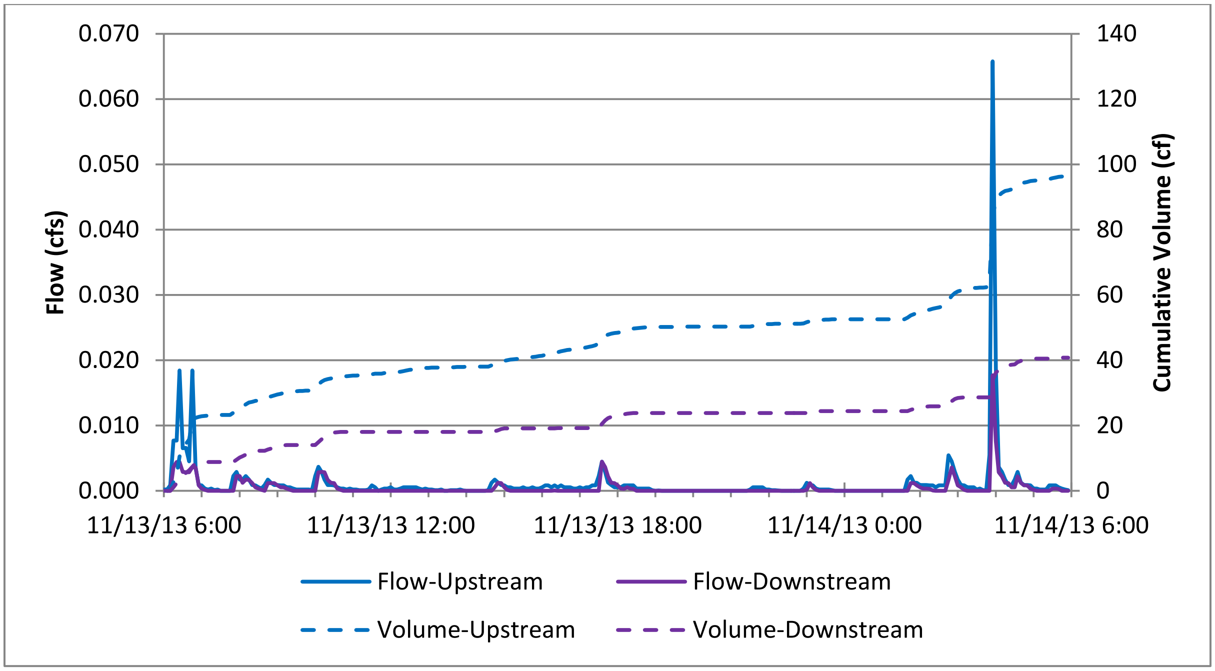


Figure 3-8. Upstream and Downstream Event 1 Flows and Total Volumes for Shorecliff BMP

Table 3-10 provides a summary of the Event 1 flow calculations. Total upstream and downstream flows, which represent flow from 6am on November 13, 2013 to 6am on November 14, 2013 were 96.3 cubic feet (cf) and 40.7 cf, respectively. The volume infiltrated was calculated from the total flow captured by the BMP minus the BMP treated discharge flow. A total of 57.7% flow was reduction was realized.

Table 3-10. Summary of Event 1 Flow Results, Pavement BMP

Parameter	Value
Total Upstream Flow Volume	96.3 ft^3
Total Downstream Flow Volume	40.7 ft^3
Flow Volume Infiltrated	55.6 ft^3
Total Flow Reduction	57.7%

Table 3-11 provides a summary of the Event 1 load calculations for the Total Load entering the Shorecliff BMP, the load that was infiltrated, the treatment load reduction, and the total load reduction realized from installation of the BMP. There was a 60% or greater load reduction for arsenic, cadmium, chromium, copper, lead, and nickel, and a 58% load reduction for selenium. The total load reduction for zinc was 4%, resulting from a substantially higher outflow concentration (112 ug/L) than inflow concentration (49.6 ug/L). Because silver was not detected at either the inflow or outflow, the was no load reduction.

Table 3-11. Summary of Event 1 Load and Load Reduction Results, Shorecliff BMP

Analyte	Total Load (mg)	Infiltrated Load		Treatment Load Reduction		Total Load Reduction	
		(mg)	(%)	(mg)	(%)	(mg)	(%)
Arsenic(As),Total	7.7	4.5	58%	0.2	3%	4.7	60%
Cadmium(Cd),Total	0.3	0.1	58%	0.0	2%	0.2	60%
Chromium(Cr),Total	3.5	2.0	58%	0.3	8%	2.3	65%
Copper(Cu),Total	184.7	106.6	58%	19.6	11%	126.2	68%
Lead(Pb),Total	3.6	2.1	58%	0.1	2%	2.2	60%
Nickel(Ni),Total	6.6	3.8	58%	0.5	7%	4.3	65%
Selenium(Se),Total	3.4	1.9	58%	0.0	0%	1.9	58%
Silver(Ag),Total	0.0	0.0	0%	0.0	0%	0.0	0%
Zinc(Zn),Total	135.2	78.0	58%	-72.0	-53%	6.1	4%

Monitoring Event 2

Figure 3-9 shows the measured dry weather runoff flow reaching the curbside catch basin upstream of the BMPs, the cumulative volume of water entering the BMP (volume upstream), the flow downstream of the BMPs (i.e., flow treated through biomedia filter but not infiltrated), and the cumulated volume downstream of the infiltration gallery during Event 2. The graph shows peak flows occurring in the early morning hours with sporadic smaller flows throughout the remainder of the morning between 7am and 12pm. Only minor flow occurred between 12pm and approximately 5am.

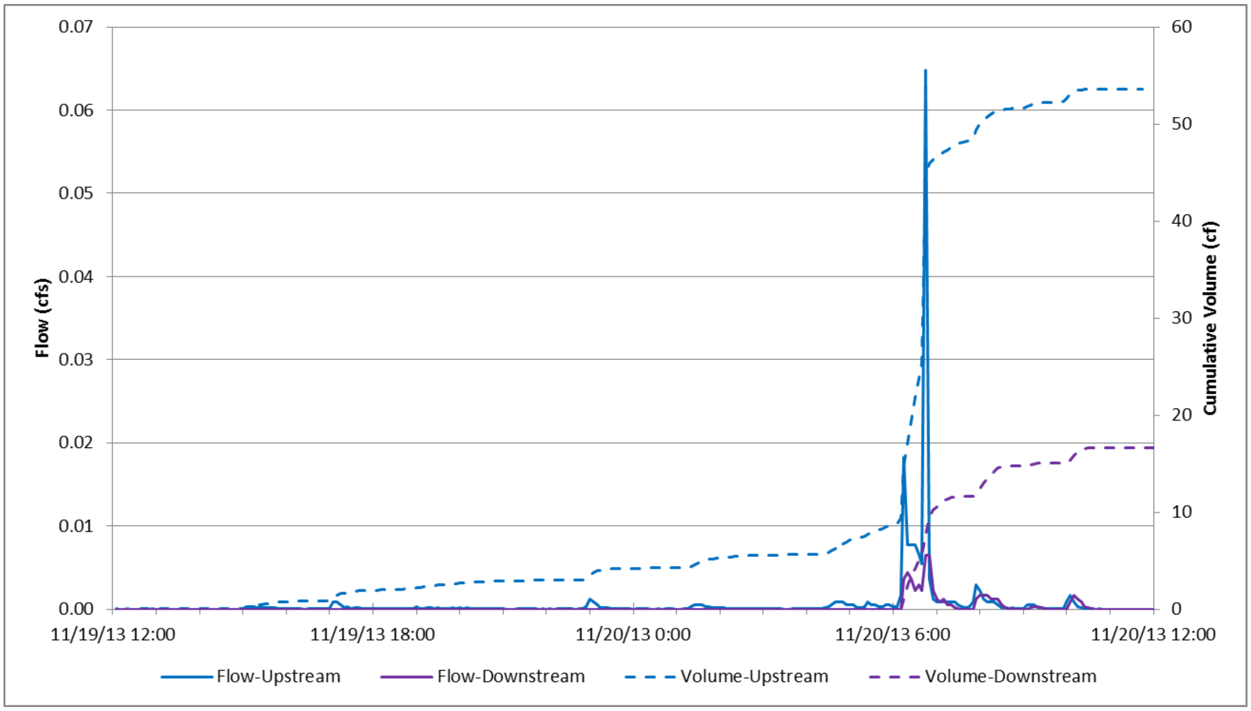


Figure 3-9. Upstream and Downstream Event 2 Flows and Total Volumes for Shorecliff BMP

Table 3-13 provides a summary of the Event 2 flow calculations. Total upstream and downstream flows, which represent flow from 12pm on November 19, 2013 to 12pm on November 20, 2013 were 53.6 cf and 16.6 cf, respectively. The volume infiltrated (36.9 cf) was calculated from the total flow captured by the BMP minus the BMP treated discharge flow. In total, a 69% reduction in flow was realized.

Table 3-12. Summary of Event 2 Flow Results, Shorecliff BMP

Parameter	Value
Total Upstream Flow Volume	53.6 ft^3
Total Downstream Flow Volume	16.6 ft^3
Flow Volume Infiltrated	36.9 ft^3
Total Flow Reduction	69.0%

Table 3-13 provides a summary of the Event 2 load calculations for the Total Load entering the Shorecliff BMP, the load that was infiltrated, the treatment load reduction, and the total load reduction realized from installation of the BMP. There was a 60% or greater load reduction for arsenic, cadmium, chromium, copper, lead, and selenium, and a 59% load reduction for nickel. The total load reduction for zinc was -6%, resulting from a substantially higher outflow concentration (111 ug/L) than inflow concentration (32.5 ug/L). Because silver was not detected at either the inflow or outflow, there was no load reduction for that constituent.

Table 3-13. Summary of Event 2 Load and Load Reduction Results, Shorecliff BMP

Analyte	Total Load (mg)	Infiltrated Load		Treatment Load Reduction		Total Load Reduction	
		(mg)	(%)	(mg)	(%)	(mg)	(%)
Arsenic(As),Total	4.7	3.2	69%	0.1	2%	3.3	71%
Cadmium(Cd),Total	0.2	0.1	69%	0.0	-3%	0.1	66%
Chromium(Cr),Total	1.9	1.3	69%	-0.1	-4%	1.2	65%
Copper(Cu),Total	99.0	68.2	69%	6.8	7%	75.0	76%
Lead(Pb),Total	1.7	1.2	69%	0.3	18%	1.5	87%
Nickel(Ni),Total	3.3	2.3	69%	-0.3	-10%	2.0	59%
Selenium(Se),Total	2.1	1.5	69%	-0.2	-8%	1.3	61%
Silver(Ag),Total	0.0	0.0	0%	0.0	0%	0.0	0%
Zinc(Zn),Total	49.3	33.9	69%	-36.8	-75%	-2.8	-6%

Annualized Load Reductions

Event mean load reductions for Shorecliff were multiplied by 330 dry weather days to derive annual dry weather load reductions (Table 3-14). The annual load reduction for copper, the only metal which had measured concentrations above COP Imax criteria, was substantial, resulting in removal of over 33 g of copper from dry weather flows and preventing it from flowing into the ASBS. The calculated annual load reductions of other metals were smaller, ranging from a load reduction of 46 mg of cadmium to 1.3 g of arsenic. Silver was not detected during sampling and therefore had no load reduction.

Table 3-14. Annual Load Reduction for Shorecliff BMPs

Constituent	Total Load Reduction (mg/day)		Average Daily Dry Weather Load Reduction (mg/day)	Yearly Dry Weather Load Reduction (mg/yr)
	11/13/2013	11/20/13		
Arsenic (As)	4.7	3.3	4.0	1,313
Cadmium (Cd)	0.2	0.1	0.1	46
Chromium (Cr)	2.3	1.2	1.8	579
Copper (Cu)	126.2	75.0	100.6	33,199
Lead (Pb)	2.2	1.5	1.8	601
Nickel (Ni)	4.3	2.0	3.1	1,026
Selenium (Se)	1.9	1.3	1.6	534
Silver (Ag)	0.0	0.0	0.0	0
Zinc (Zn)	6.1	-2.8	1.6	532

5.0 DISCUSSION

BMPs installed along Buck Gully and at Shorecliff promenade were evaluated for their ability to reduce pollutant loading to ASBS 32 located along the Newport Coast. Both wet weather and dry weather conditions were evaluated at Buck Gully while dry weather conditions were evaluated at Shorecliff. The findings of these evaluations are presented below.

Buck Gully

The Buck Gully Erosion Control/ Wetlands Project was designed to address the problems of urban runoff, erosion, and bank destabilization resulting in pollutant discharges to ASBS 32. The BMP effectiveness monitoring for the Buck Gully Erosion Control/ Wetlands Project included measuring flow volumes and collecting chemistry samples upstream and downstream of the various BMP features during dry and wet weather and calculating pollutant loads.

During dry weather, the results of load calculations indicate that the BMPs are functioning well, substantially reducing loads for the majority of constituents that were analyzed. The comparison of the pre-project dry weather monitored event to the post-project event, the increase in annual dry weather metal load reductions ranged from 14 g/yr for lead to 4,851 g/yr for selenium. The increase in yearly load reduction of 1,086 kg TSS likely drove load reductions in metals, due to their tendency to bind to sediment particulates. Annual bacterial load reductions were somewhat mixed. Enterococcus and fecal coliform annual loads, were reduced by 6.6×10^{12} MPN and 4.5×10^{12} MPN, respectively while total coliform loads experienced an increase of 9.3×10^{13} MPN. Monitoring results from Sites 1 and 2 showed an increase in fecal indicator bacteria during Dry Weather Event 2 by approximately 133%. During Dry Weather Event 1, this same area reduced fecal indicator bacteria by 43%. Given the variability of bacterial concentrations and environmental conditions for regrowth, it is difficult to speculate as to why some species may experience a substantial load reduction while others experience a significant load increase based on the somewhat limited data in this assessment.

Results of load calculations during wet weather indicate that the load reducing functions of the BMPs at Buck Gully may be overwhelmed by the volume of flow entering the system. Storm flows increased substantially from one station to the next in a downstream progression which resulted in increased loads for all measured constituents including metals, TSS, pyrethroids and fecal indicator bacteria for both the pre- and post-project monitoring. Any infiltration that may have occurred as storm water flowed down Buck Gully was masked by the volume of storm water that was added to the system between each monitored site, thus making it difficult to determine if the BMPs were having an appreciable effect on reducing wet weather pollutant loading to the ASBS. However, field observations made during and after the final storm event showed that the BMPs did appear to achieve a primary project goal of providing sustainable armoring to the bank along the lower portion of Buck Gully by controlling and redirecting currents and velocities throughout the bend, thereby limiting/preventing bed erosion through the use of energy dissipaters. In doing so, the potential for slope destabilization and/or failure should be greatly reduced. Staff did not observe slope sloughing or other system degradation, and after the wet weather the system returned to low flow conditions the wetland functionality of the ponded areas created by the BMPs returned. It should be noted that rainfall quantity, intensity, duration, and antecedent dry weather days can significantly affect runoff concentrations and pollutant loads. The calculated wet weather loads in this report were based on just two storm events, both of which were small to moderate in size and duration, and occurred near the beginning of the wet weather season. Therefore, measured loads generated by storms of varying sizes and intensities throughout the year could differ substantially from predicted loads. Similarly, load reductions by the BMPs at Buck Gully will vary with changing flow conditions.

Shorecliff

The BMP effectiveness monitoring for the Shorecliff media filter and infiltration gallery BMPs included measuring the total volume of flow captured by the onsite BMPs during dry weather, collecting and analyzing samples, and using the chemistry results in combination with the dry weather flows to calculate the pollutant load reductions to ASBS 32. During the two monitored events, peak flows occurred in the early morning hours with sporadic smaller flows throughout the day and generally minimal flow between 6pm and 2am. Flow results indicate that the infiltration BMP does convey flows into the soil strata as designed; however, during peak flow conditions the capacity of the infiltration BMP is exceeded and some runoff flows past the infiltration BMPs. The upstream media filter was designed to treat all flows entering the storm drain pipe, and therefore some load reductions were realized the flow not infiltrated. Based on the two monitored storm events, load reductions of 58% or higher were calculated for all metals with the exception of silver and zinc. Silver was not detected in during sampling and therefore did not have a load that could be reduced, while zinc had a load reduction of 4%. The copper load, which was by far the largest metals load, was reduced by 33.2 g per year. This is a substantial load reduction, as total copper concentrations were above COP Imax values during both events. Overall, the BMP appears to be functioning as designed, and is significantly reducing dry weather metals loads, particularly copper loads, to the ASBS through infiltration. Further load reductions may be achieved through targeted enforcement of home owners during the 1:00 AM to 7:00 AM timeframe.

6.0 REFERENCES

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