James V. Fitzgerald
Area of Special Biological Significance
Pollution Reduction Program

FINAL PROJECT REPORT

March 1, 2016

Proposition 84 ASBS Grant Program

Grant Agreement No. 10-402-550

Between the State Water Resources Control Board

and

County of San Mateo

Funding for this Project has been provided in full or in part through an agreement with the State Water Resources Control Board. The contents of this document do not necessarily reflect the views and policies of the State Water Resources Control Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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Executive Summary

The James V. Fitzgerald Area of Special Biological Significance (ASBS) Pollution Reduction Program (Project) was a multi-faceted project led by the County of San Mateo Department of Public Works (County) in collaboration with the San Mateo County Resource Conservation District (RCD) and the San Francisco Estuary Institute (SFEI) with Proposition 84 grant funding from the State Water Resources Control Board (State Water Board) ASBS Grant Program. The Project involved implementation of targeted stormwater Best Management Practices (BMPs), water quality studies and BMP effectiveness monitoring, and education and outreach. The Project goal was to improve water quality and protect beneficial uses of the James V. Fitzgerald ASBS and additionally assist in the County's compliance with ASBS stormwater regulations.

The first phase of the Project was a pilot to install and test effectiveness of several types of stormwater BMPs, including vegetated swales and stormwater filtration devices (flume filter boxes and filtration cartridges) at seven storm drain locations. The BMPs were designed to remove pollutants from stormwater runoff and were selected based on site characteristics. During the 2012 and 2013 rainy seasons, SFEI collected water quality samples to test the effectiveness of these pilot BMPs at removing pollutants including metals, polycyclic aromatic hydrocarbons (PAHs), pyrethroid pesticides, suspended sediment, nutrients, and fecal indicator bacteria from stormwater.

The first phase of the Project also involved completion of a Storm Drain Inventory and Assessment and Microbial Source Tracking (MST) study. The Storm Drain Inventory and Assessment involved updates to an existing storm drain geographic information system (GIS) layer, hydrologic modeling for 2-, 10-, and 100-year flood events to identify hydraulic deficiencies, providing information for design of Phase 2 Upland BMPs, identification of problem areas, and prioritization of sites for future BMPs and vegetated swale installation. For the MST study, researchers from the University of California, Davis (UC Davis) and SFEI collected samples from Martini, Kanoff, Montara, Dean/Sunshine Valley, and San Vicente Creeks. UC Davis performed genetic analysis on samples collected near the ocean confluences to test for the presence of host-associated genetic markers indicating the presence of fecal contamination sources such as human, dog, horse, bovine, and bird. SFEI analyzed samples collected at multiple locations throughout the five watersheds for fecal indicator bacteria (FIB) including total coliforms, *Escherichia coli*, and *Enterococcus* concurrently with the genetic analysis portion of the MST to gain information on hot spot locations related to land use. The results of the FIB monitoring showed that FIB concentrations in the five drainages were elevated during both the dry and wet seasons and often exceeded water quality objectives for contact recreation. The MST study revealed fecal contamination from human, dog, bovine, and horse sources within each of the five drainages. Of the four host-specific markers that were analyzed (dog, horse, bovine, and human), dog-associated *Bacteroidales* was the most frequently detected host marker. During the dry season, at all sites except

Montara Creek, the concentrations of tested host markers comprised less than 5% of the Universal *Bacteroidales* concentration targeting all warm-blooded animals, which indicated that uncharacterized fecal sources, such as wildlife or other domestic animals, likely contributed a large amount of fecal pollution. The study included recommendations for further work and BMPs.

The second phase of the Project involved targeted upland BMP implementation. BMP site selection was based on the results from the first phase of the Project (pilot BMPs, Storm Drain Inventory and Assessment, and MST). In 2014 and 2015, the County completed construction of 14 structural BMPs within the County-maintained storm drain system, including construction of a green stormwater treatment and demonstration feature at the James V. Fitzgerald Marine Reserve (FMR) Parking Lot. In 2013 and 2014, the RCD implemented two non-structural BMPs. The first non-structural BMP was implementation of a dog waste and water quality educational program at the Farallone View Elementary School during Oceans Week 2013. Program activities included distribution of the Ocean Week program notice and ASBS newsletter in the parent teacher organization newsletter, creekside lessons and walks, water quality testing experiments, and classroom activities. The program directly reached 385 students, as well as the teachers and parents. The second non-structural BMP included implementation of the Sustainable Landscape Assessments at 16 residential sites and development of Low Impact Development (LID) BMP plans (including engineered design plans, construction specifications, and landscape plans) at nine residential properties. LID plans for each site included multiple BMPs such as rainwater catchment tanks, rain gardens, drainage swales, permeable driveways, and erosion/drainage improvements to address pollutants from private upland areas. Seven of the nine residential properties were selected for implementation of the LID BMP plans. Construction and implementation began in August 2015 and continued through early 2016.

The Project also involved education and outreach activities to communicate the significance of the natural resources of the ASBS and to provide technical tools and practices to the community for pollution prevention and reduction. Activities included development of an ASBS website, three annual newsletters, a public survey, and a LID workshop for local residents and builders.

The final phase of the Project involved future planning for continuation of the Pollution Reduction Program. The future planning tasks included 1) preparation of BMP Operation and Maintenance Plans, 2) future planning and prioritization for BMP/LID implementation based on baseline pollutant load modelling output and a GIS-based LID locator tool; and 3) a review of existing policies and regulations to determine consistency and compliance with all applicable plans, programs, and regulations related to BMP design and implementation and ASBS water quality objectives and to recommend changes to promote and ensure appropriately designed and selected BMPs in conjunction with development and maintenance activities. The resulting future planning reports provide valuable information to property owners, the Planning and Building Department, Department of Public Works, and other decision makers regarding the most effective types of drainage controls and management measures that can be incorporated into future projects during development to reduce pollutant sources and protect water quality and valuable aquatic resources.

The Project goal of improving water quality and protecting beneficial uses of the ASBS through implementation of BMPs to remove pollutants and education and outreach to promote source reduction and conservation of natural resources of the ASBS was met. Based on the pilot and Phase 2 monitoring results, the County gained a better understanding of the pollutants of concern in the ASBS watershed and BMP performance, provided treatment of runoff from approximately 75 acres of land draining to the ASBS watershed, and observed measurable reductions in certain pollutant loads. For the four pilot phase primary monitoring sites, it was estimated that approximately 1,378 kg of suspended sediment, 48 grams of copper, 8.6 grams of nickel, 5.8 grams of lead, 153.5 grams of zinc, 992 mg of PAHs, and 163 mg of pyrethroids were prevented from entering the ASBS in 2013. With completion of the Phase 2 Upland Private BMPs in the last several months of the Project, there will be additional near-term pollutant load reductions throughout the watershed. These sites serve as public demonstration locations for the various types of implemented residential BMPs and will likely lead to implementation of similar measures throughout the community.

The education and outreach campaign will continue to provide the lasting benefit of source reduction through behavioral changes resulting from: 1) targeted pollution prevention outreach messages that have been disseminated throughout the community (via newsletters and the County website) and by informational signs at the demonstration sites (e.g., FMR Parking Lot); 2) future visits to the website; and 3) coordination with other programs such as the countywide stormwater program and stormwater compliance efforts. Many of the lessons learned and recommendations resulting from this Project (e.g., recommendations from the Review of County Policies/Programs and Recommendations to Reduce Stormwater Runoff and Non-Point Source Impacts to Water Quality report and Future Planning Report) have already been incorporated into the County's James V. Fitzgerald ASBS Final Compliance Plan and will assist the County in moving forward with prioritization and implementation of similar projects in the future to improve water quality in the ASBS.

Background

Project Location

The James V. Fitzgerald ASBS (ASBS) is located in unincorporated San Mateo County approximately seven miles north of the City of Half Moon Bay. It extends from 4th Street in Montara south to the Pillar Point breakwater (see Figures 1 and 2). The ASBS is located approximately 20 miles south of the Golden Gate and the confluence of the Sacramento River Basin (27,000 square mile drainage basin) with the Pacific Ocean. Coastal San Mateo County is rural in nature and presents a stark contrast to the densely urbanized areas located only 10 miles to the east along the San Francisco Bay peninsula on the opposite side of the Santa Cruz Mountains.

The Fitzgerald Marine Reserve (Reserve) with its three miles of shoreline is located within the boundary of the ASBS. The Reserve was created in 1969 to protect the mosaic of habitats and tremendous diversity of marine life that exist in the area. The Reserve receives over 150,000 visitors annually and is one of the most frequently visited rocky shorelines in California. The Reserve is currently designated as a Marine Protected Area and is jointly managed by the California Department of Fish and Wildlife and the County. The Reserve is located within the Monterey Bay National Marine Sanctuary.

A 5.5-mile band of shoreline, including the Reserve, was designated as an ASBS due to the diversity of habitat and biological assemblages, dense stands of bull kelp found along with red algae, the diverse array of invertebrates that inhabit the broad reef, and the three types of subtidal habitat that are present at this location. Past studies and monitoring efforts have recorded 164 species (or taxa) of invertebrates, 134 species of algae and marine flora, many bird species, and several mammals including harbor seals, sea lions and sea otters (State Water Board 1979, Harding Lawson and Associates 1993, Tenera Environmental 2004).

The Fitzgerald area has mild weather throughout the year. January average maximum temperature (56.9°F or 13.8°C) and September average maximum temperature (73.1°F or 22.8°C) span a narrow range based on the long-term record (NOAA National Climatic Data Center, Station 43714). Typical of the central California, most of the rainfall occurs from November through April, normally totaling more than 27 inches (69 cm). The winter season of 2013/14 was exceptionally dry with only 54% of the average precipitation between January and May. Only 13% of the average precipitation occurred between January and May 2015.

The Fitzgerald watershed is drained by relatively small creeks originating on the steep and forested west-facing slopes of the Santa Cruz Mountains. The watershed draining to the Fitzgerald ASBS is approximately 4.5 square miles (sq. mi.) or 2,880 acres. Three creeks drain directly to the ASBS (Montara Creek, Dean Creek, and San Vicente Creek (see Figure 2). For the purposes of project evaluation and future planning, the Project area was expanded beyond the ASBS watershed to the greater Fitzgerald watershed area (see Figures 1 and 2) that also includes creeks that are located adjacent to the ASBS and may impact coastal water quality. The greater Fitzgerald watershed study area extends from Martini Creek to the north to Pillar Point Marsh, Denniston Creek, San Agustin Creek, and Deer Creek which drain to Pillar Point Harbor to the south.

The sub-watersheds of the Fitzgerald study area are generally small. All creeks drain at least part of Montara Mountain, the largest peak in the northern section of the Santa Cruz Mountain Range. Martini Creek (approximately 650 acres; 1 sq. mi), Daffodil Creek (approximately 175 acres; 0.25 sq. mi), and Kanoff Creek (approximately 350 acres; 0.5 sq. mi.) drain to the Pacific Ocean just north of the ASBS boundary. The three main creeks that drain directly to the Fitzgerald ASBS are: Montara Creek, with a watershed of approximately 1,100 acres (1.7 sq. mi.); Dean Creek (also known as Sunshine Valley Creek), with a watershed of approximately 360 acres (0.6 sq. mi.); and San Vicente Creek, with a watershed of approximately 1,200 acres (1.8 sq. mi.). The Pillar Point Marsh watershed (approximately 800 acres; 1.2 sq. mi.) and Denniston Creek (approximately 2,725 acres; 4.25 sq. mi.), San Agustin Creek (approximately 300 acres; 0.5 sq. mi), and Deer Creek watersheds (approximately 450 acres; 0.7 sq. mi.) are in close proximity to the Fitzgerald ASBS but drain directly into Pillar Point Harbor, which is located just outside of the southern ASBS boundary. A map showing the Fitzgerald watersheds is included in Figure 2.

Land Use

The Fitzgerald area was originally settled by Native Americans approximately 5,800 years ago. In 1908, the Ocean Shore Railroad extended through the town of Moss Beach, allowing for residential development and establishing a tourist destination. Remains of the foundation and some original landscape features from the early-1900s can be found on the bluffs overlooking the Reserve.

In the earlier part of the 20th century, Pillar Point Marsh was dammed by farmers to prevent salt water from intruding upland farming areas and to also provide access for farmers and their farming equipment to cross over into the slopes/bluffs above the marsh for farming. The dam was approximately located where West Point Avenue is today.

The Reserve has long been a place of research and provided materials for marine biologists and collectors, so much so that, in 1969, San Mateo County urged the State of California to designate the site as a state reserve to protect the remaining flora and fauna. On August 5, 1969 the site was officially designated as a state reserve and was named after James V. Fitzgerald, former mayor of San Bruno and a longtime member of the San Mateo County Board of Supervisors.

Today, the dominant land uses are park/open space, ranching and equestrian facilities, small-scale agriculture, residential, light commercial/industrial, and a military facility (see Figure 2). The watersheds are rural in nature, although there are small commercial and residential areas located within all of the watersheds, except for Martini Creek. A large portion of the watershed is open space including McNee Ranch State Park and Rancho Corral de Tierra, part of the Golden Gate National Recreation Area managed by the National Park Service. Two unincorporated residential communities (Montara, Moss Beach including Seal Cove) are located in the ASBS watershed. The urbanized areas are primarily very-low to medium density residential. As of 2010, the combined population of Montara and Moss Beach was approximately 6,000. The southern half of the ASBS watershed is less populated with the bluffs just north of Pillar Point being occupied by a United States Air Force radar station and the Pillar Point Bluff area managed by County Parks. A municipal airport (Half Moon Bay Airport) is located in the southern portion of the ASBS watershed; however, the majority of runoff from this facility flows to Pillar Point Harbor which is located just outside of the ASBS boundary to the south. The community of El Granada is also located in the vicinity, but drains to Pillar Point Harbor.

The majority of the Fitzgerald area is served by either the Montara Water and Sanitary District (MWSD) or the Granada Community Services District (GCSD), which are part of the Sewer Authority Mid-Coastside (SAM), a regional agency responsible for wastewater treatment. SAM operates the Wastewater Treatment Plant located in Half Moon Bay. Areas not served by MWSD or GCSD, generally located higher up in the watershed, have private septic systems.

The coast along the Fitzgerald ASBS is generally characterized by steep bluffs. Most of the bluff tops are traversed by recreational trails or public and private roads. A relatively limited network of storm drains (including both engineered systems and informal ditches and culverts) directs runoff from the developed areas to receiving waters (i.e., creek to ASBS). Portions of the coastal bluffs along the Reserve and west of Highway 1 drain directly to the ASBS.

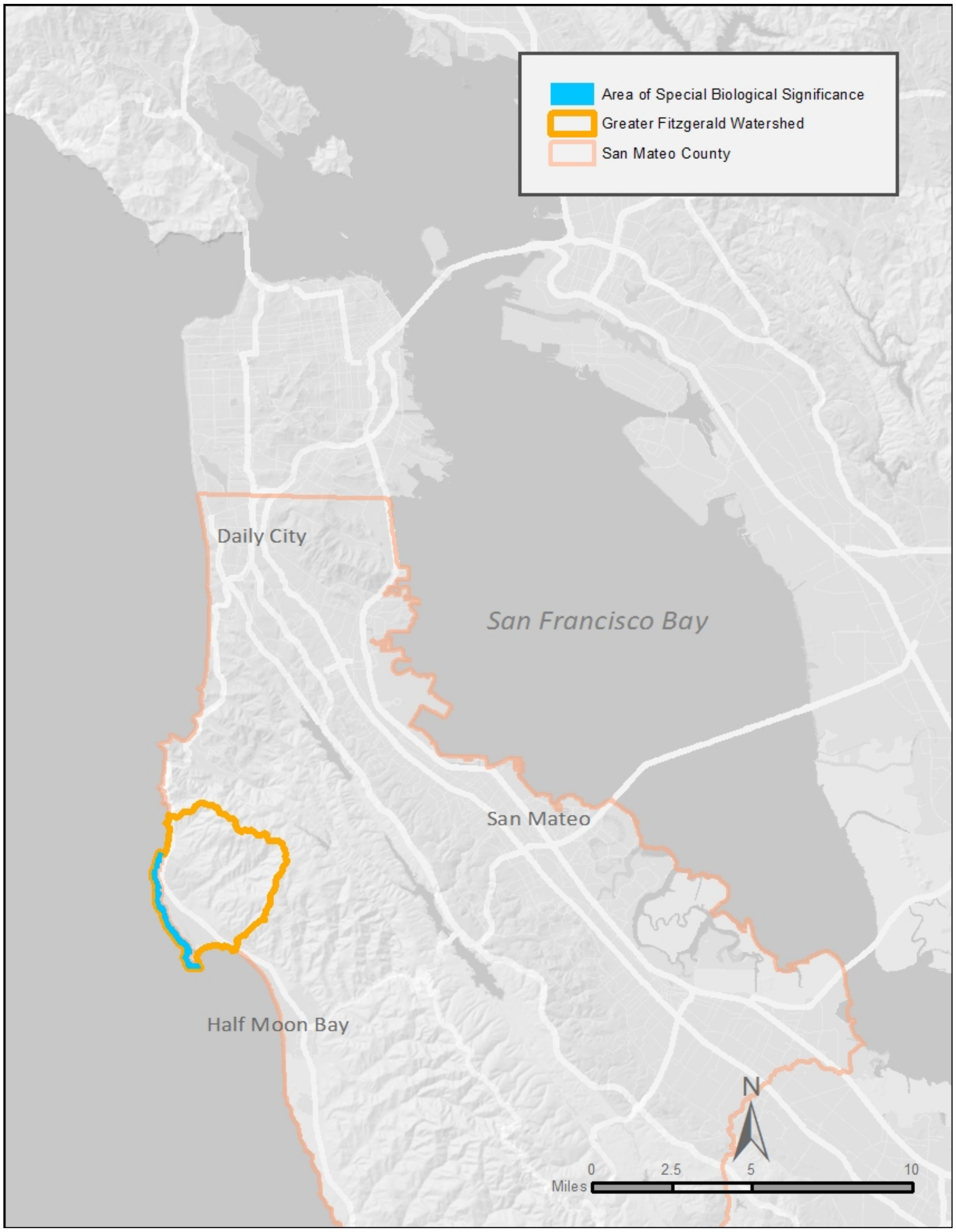

Figure 1. Map of San Francisco Bay Area showing the boundaries of the ASBS, County of San Mateo, and the greater Fitzgerald watershed study area.

Figure 2. Map of watersheds draining into James V. Fitzgerald Area of Specific Biological Significance.

Problem Statement

Stormwater runoff is known to carry substantial amounts of vehicle- and road-derived contaminants, suspended sediment, and pathogen indicators that can impact water quality. Roads, driveways, parking lots, rooftops, and other impervious surfaces prevent rainwater from soaking into the ground and significantly increase the runoff volume during winter storms. Stormwater runoff picks up and carries pollutants including vehicle-related pollutants such as oil and metals from tires and brake pads, pollutants from roadways and paved surfaces (hydrocarbons and dust debris), agriculture-related contaminants (fertilizer and manure nutrients, pesticides, bacteria), other common residential and urban pollutants like pesticides, trash, and animal/pet waste, and contaminants from atmospheric deposition (mercury and other trace metals, nitrogen compounds, and polychlorinated biphenyls) that are harmful to streams, estuaries, and the ocean.

The County developed the James V. Fitzgerald ASBS Pollution Reduction Program (Project) in 2008 to improve water quality and protect the ASBS in response to the following:

- Reserve's extensive marine life, diversity of unique habitat, and designation as an ASBS;
- EPA Clean Water Act Section 303(d) listing of San Vicente Creek and the Reserve as impaired for coliform bacteria;
- Results of the Watershed Assessment conducted as part of the Critical Coast Area Program; and
- California Ocean Plan requirements and related monitoring results in support of the County's Exception Application.

More detailed information regarding water quality issues is provided below.

I. 303d list

The Pacific Ocean at the Reserve and San Vicente Creek are on the 303 (d) list of impaired water bodies due to elevated coliform bacteria, and a Total Maximum Daily Load or Water Quality Improvement Plan is scheduled to be completed by 2019. San Vicente Creek drains a mixed-use watershed and has been chronically contaminated with coliform bacteria. A sign warning visitors that the creek water is not safe for drinking or contact due to bacteria has been a prominent feature where San Vicente Creek drains to the ASBS at the main Reserve access point. Montara Creek and Dean Creek have similar mixes of land uses and have also been periodically posted for high bacteria levels. Potential sources of fecal contamination within the watersheds include wildlife, recreation (i.e., dog walking, beach and park use), equestrian facilities, other confined animal facilities/livestock, agriculture, leaking pipes or overflows from septic and/or sanitary sewer systems, and other residential-related sources (i.e., pets, compost).

II. Critical Coastal Area

The Critical Coastal Areas (CCA) Program is a non-regulatory program that focuses on implementation of management measures to address existing or potential nonpoint source pollution impacts to coastal resources. The CCA Program is a major component of California's Nonpoint Source Pollution Control Program. It promotes a collaborative watershed approach by bringing together multiple interest groups. Over 100 CCAs, including the Reserve, have been identified based on degraded water quality and high resource value.

In 2005, the Reserve was selected as one of five Pilot CCAs where state agency staff worked with local stakeholders to test the benefits of developing watershed-based plans and implementing appropriate mitigation measures to address polluted runoff. The Fitzgerald Critical Coastal Areas Program Watershed Assessment (2008) provided a characterization of the subwatersheds, review of existing water quality data, and recommendations for an Action Plan to remediate water quality in the watersheds and to gather more monitoring data. Consistent with the 303(d) listing for San Vicente Creek and the Pacific Ocean at the Reserve, coliform bacteria was identified in the CCA Watershed Assessment as the primary pollutant of concern in the study area. Other constituents and issues of concern in the ASBS watersheds were also identified; however, there was a lack of existing water quality data. One of the main findings was that additional water quality monitoring was needed.

The Fitzgerald CCA Steering Committee identified six broad areas that could form the basis of an Action Plan:

1. Water quality monitoring
2. Targeted BMP implementation
3. Targeted Midcoast NPS Outreach Campaign
4. Outreach, input, and support on County watershed policies
5. Technical assistance to landowners and builders for implementation of watershed policies
6. Permit streamlining for restoration projects

III. California Ocean Plan

Since 1983, the California Ocean Plan has prohibited waste discharges, including stormwater runoff, to ASBS, unless the State Water Board grants an exception. Recognizing that point and nonpoint source discharges into ASBS were occurring, despite the Ocean Plan prohibition, the State Water Board contracted with the Southern California Coastal Water Research Project (SCCWRP) to survey by foot or boat all discharges into ASBS in California. SCCWRP (2003) identified 1,658 drainages into ASBS statewide, many of which were stormwater outfalls permitted under the NPDES program through Municipal Separate Storm Sewer System (MS4) permits to local governments (State Water Board 2012).

SCCWRP identified thirty-nine natural and anthropogenic drainages to the Fitzgerald ASBS. Follow up reconnaissance by the County confirmed that eleven of the drainages are storm drain discharges from County-maintained roadways. The remaining drainages are natural creeks, seeps, and gullies, or private storm drain discharges.

On October 18, 2004, following the SCCWRP study, the State Water Board notified the County that they must cease stormwater and non-stormwater waste discharges into the Fitzgerald ASBS or apply for an exception to the Ocean Plan. The County was one of twenty-seven applicants requesting an exception to discharge to various ASBS throughout California. The County submitted an exception application in December 2007. Water quality monitoring conducted in support of the application revealed elevated levels of vehicle-derived pollutants, such as copper, PAHs, and oil and grease at one of the Fitzgerald ASBS outfall locations.

On March 20, 2012, the State Water Board adopted a General Exception to the Ocean Plan waste discharge prohibition to ASBS. The General Exception (State Water Board Resolution No. 2012-0012, as amended by 2012-0031) governs point and nonpoint source waste discharges to ASBS, including stormwater runoff. It includes Special Protections for Beneficial Uses of ASBS and requires development of ASBS Compliance Plans.

IV. James V. Fitzgerald Pollution Reduction Program

In anticipation of the pending ASBS regulations, TMDLs, and to begin addressing many of the prioritized actions that were identified by the CCA Steering Committee, the County developed the James V. Fitzgerald ASBS Pollution Reduction Program (Fitzgerald ASBS Program) in 2008. The goal of the Fitzgerald ASBS Program is to protect beneficial uses, improve water quality at public beaches and the ASBS, achieve the water quality objectives outlined in the Ocean Plan, comply with the upcoming ASBS Special Protections, and work towards de-listing the Reserve and San Vicente Creek for coliform bacteria. The Fitzgerald ASBS Program takes a multi-faceted approach including water quality studies to better understand pollutants of concern in the watershed, structural and nonstructural BMP implementation, BMP effectiveness testing, education and outreach, and future planning to ensure that special protection requirements are met and the local community is educated about techniques and efforts to conserve the natural resources of the ASBS.

Low Impact Development (LID) was a primary focus of the Fitzgerald ASBS Program. LID infrastructure, such as, rain gardens, swales, and pervious pavement, provide pollutant removal and runoff detention. The successful effectiveness of an LID feature can be impacted by design, construction, and maintenance challenges, or a combination of these factors. Research of LID effectiveness is ongoing. However, LID is being recommended across the US, by the Ocean Protection Council and in municipal regional NPDES permits (including the San Francisco Bay Regional Water Quality Control Board Municipal Regional NPDES Permit) as measures to reduce pollutants in runoff from polluted sites, building roofs, and transportation infrastructure. Since the Reserve is the receiving water body for runoff from Moss Beach and Montara and is designated as an ASBS, LID was proposed as a key management measure to reduce pollutants in runoff and thus to protect aquatic organisms and the marine environment.

The County began implementing the Fitzgerald ASBS Program in 2011 with funding from the State Water Resources Control Board ASBS Grant Program. This report summarizes activities implemented between June 2011 and February 2016 under Grant Agreement No. 10-402-550 between the State Water Board and the County of San Mateo. Hereinafter, the Fitzgerald ASBS Program is referred to as "Project".

Project Description

Project Components and Goals

The Project consisted of five main components:

1. Pilot BMPs
2. Storm Drain Inventory and Assessment
3. Microbial Source Tracking
4. Phase 2 BMPs
5. Education and outreach

The Project was a multi-faceted program that evaluated contaminant concentrations including reductions due to LID and BMP implementation. Various types of LID and BMPs were studied during different storm conditions and results were summarized in water quality monitoring reports.

Project oversight, BMP storm drain implementation, and the storm drain inventory and assessment was led by the County. The MST was led by UC Davis and SFEI scientists. The private BMP component was led by the RCD. The monitoring component and project assessment forecasts were led by SFEI. The outreach and education component including newsletters, surveys, flyers, classroom work, public workshop, signage, and a tour was a combined effort with County DPW, County Parks, County Environmental Health, SFEI, and the RCD.

Guidance throughout the Project was provided through the Technical Advisory Committee (TAC). The TAC was comprised of 12 to 15 professionals from a variety of project-related disciplines (e.g., stormwater management, state and local government, water quality experts and scientists, and conservation specialists) whose input was critical to the success of this Project. Project leads from SFEI, RCD, and County DPW, Parks, EH, and Planning also participated in TAC activities as appropriate.

The mission of the TAC was to: 1) serve as the advisory body for the Project, 2) contribute expertise to various Project components such as water quality monitoring design, water quality monitoring results analysis and BMP effectiveness evaluation, MST study design and results, BMP and site selection for the upland phase of the Project, education and outreach strategies, Project alignment with existing regulations/technology, Project assessment, and 3) review and provide input on priority project documents. The TAC met biannually in September and March.

The Project was designed to reduce pollutant loads and protect natural resources and beneficial uses of the ASBS. To achieve this, targeted BMPs and LID were implemented at high threat County maintained discharge locations and throughout the ASBS watershed, and their effectiveness was evaluated. Targeted BMP implementation included both structural and non-structural elements. Options for runoff harvesting and infiltration in the residential areas of Montara and Moss Beach near the coastal bluff were limited due to cliff instability, landslide potential, and right of way issues. In areas without landslide potential, BMPs following LID and re-development principles for rain water infiltration and harvesting were identified and implemented. Non-structural BMPs were aimed at source reduction. The BMPs/LIDs reduced pollutants in stormwater runoff and aided in cleaning up stormwater before it entered the ASBS through stormwater discharges so that natural ocean water quality in the ASBS was better protected. Furthermore, dry-weather discharges to the ASBS were reduced through LID-based BMPs further protecting the Reserve.

Simultaneously, education and outreach to residents was accomplished through workshops, websites, newsletters, interpretive/demonstration signage, and collaboration with the local elementary school. Education and outreach topics included:

- information about water pollution and the significance and value of the Reserve, a protected ecosystem,
- alternatives for household pesticides
- information and techniques for the public to help encourage sustainable development
- design guidance for landscapes to reduce impervious surfaces and water use, and
- suggestions to adapt behavior for pet owners and landowners with confined animal facilities.

The additional goal of finding and broadly applying management measures and BMPs to reduce upland sources of pollutants was achieved through demonstration projects in the upper watershed. Outreach and education about the high environmental value of the Reserve and the threats that this special area is facing due to polluted stormwater runoff is very important. Combining this effort with the presentation of solutions regarding pollutant sources and treatment options is a powerful tool to achieve necessary changes. For example, an additional education opportunity was provided during this Project with the completion of the Green Street Improvement Project on Carlos Street in Moss Beach, which is adjacent to the local post office. Interpretive signs installed at this location offer information on how stormwater treatment in the constructed bioretention areas works and why it is important. Providing this kind of information to the public with the visual experience of a constructed LID helps raise awareness and encourages behavioral changes, which in the end will help improve water quality in stormwater runoff.

Project Cost

The total cost for the Project was approximately $3,391,825. The total amount awarded through the Proposition 84 ASBS Grant Program was $2,500,000, and the amount invoiced by the County was approximately $2,469,225. The County match contribution was approximately $922,600.

Project Task List & Schedule of Completion

Table 1 below lists Project tasks and associated submittal or completion dates.

Table 1. Project Task List and Submittals

Grant Agreement Task Item #	Task Description	Date Submitted
A.1	GPS Information	Pilot BMP Sites - 9/23/11 Phase 2 BMP sites - 10/21/13
A.2.1	PAEP	Draft - 9/23/11 Approved - 1/18/12
A.2.2	Monitoring Plan	Draft - 9/23/11 Revised - 11/29/11 Approved - 1/18/12 Revised - 4/6/12, 5/11/2012 Approved - 5/15/12 Revised - 3/29/13 Addendum - 10/21/13
A.2.3	QAPP	Draft - 9/23/11 Revised - 11/29/11, 12/15/11 Approved - 1/18/12 Revised - 4/6/12, 5/11/12 Approved - 5/15/12 Addendum - 10/21/13
A.3	CEQA/NEPA Documentation	
	• Pilot BMPs	9/15/11
	• Upland Private BMPs	9/15/11
	• Upland Phase	6/14/13, 7/31/14
A.4	Land Owner Agreements	8/8/14, 7/1/15
A.5	Applicable Permits	Pilot CDP - 9/23/11 Phase 2 storm drain CDP - 10/21/13 Phase 2 Carlos St and Parking Lot CDPs - 7/21/14 Phase 2 Farallone Ave swales CDFW SAA & Regional Board NOA - 10/27/14 Phase 2 Private BMPs – CDX, tree

Grant Agreement Task Item #	Task Description	Date Submitted
		removal, & encroachment permits 10/20/15
B.1.1	Project Work Plan	7/29/11
B.1.2	TAC Meeting Notes	10/20/11 4/2/12 10/19/12 4/19/13 10/1/13 3/19/14 10/27/14
B.2.1.1	Pilot BMPs Implementation Schedule	9/29/11
B.2.1.2	Pilot BMPs Report Findings	9/29/11
B.2.1.3	Pilot BMPs Design Plans and Specifications	11/23/11 8/10/12 10/19/12
B.2.1.4	Pilot BMPs Notice to Proceed	11/23/11
B.2.2.2	Pilot BMPs Pre- and Post-Construction Photo Documentation	12/3/12, 2/8/13
B.2.3.3	Pilot BMPs Analysis Summary Report	Report - 3/29/13 Addendum - 10/4/13
B.3.5	Storm Drain Inventory and Assessment Summary Report	2/11/13
B.4.2	Pathogen Source Tracking Study Summary Report	2/11/13
B.5.1	ASBS Newsletters	1st edition - 7/19/12 2nd edition - 7/19/13 3rd edition - 7/21/14
B.5.2	Web Link to ASBS Website	7/19/12
B.5.3	Community Survey	7/19/12
B.5.4	LID and Retrofit Workshop	10/19/12
B.5.5	Photo Documentation of Interpretive Signs at FMR Green Parking Lot	4/20/15
B.6.1.2	Upland Storm Drain BMPs Implementation Schedule	4/19/13
B.6.1.3	Upland Storm Drain BMPs Report Findings	3/18/14
B.6.1.4	Upland Storm Drain BMPs Design Plans and Specifications	Storm drain BMPs - 10/21/13 Carlos St - 7/21/14 FMR Parking Lot – 9/25/14
B.6.1.5	Upland Storm Drain BMPs Notice to Proceed	Phase 2 Swales - 10/21/13 Carlos St - 8/20/14 FMR Parking Lot – 10/3/14

Grant Agreement Task Item #	Task Description	Date Submitted
B.6.2.1	Upland Private BMPs Implementation Schedule	4/19/13
B.6.2.6	Upland Private BMPs Design Plans and Specifications	10/1/14, 6/18/15
B.6.2.7	Upland Private BMPs Notice to Proceed	7/1/15
B.6.3.2	Upland BMPs Pre- and Post-Construction Photo Documentation	Phase 2 Swales -1/21/15 Phase 2 Private BMPs -1/20/16
B.6.4.3	Analysis Summary Report	2/17/15
B.7.3	Project Assessment and Future Planning report	2/1/16

Project Summary

I. Pilot BMPs

In 2011, the County began the pilot phase of the Project to implement and test effectiveness of several types of structural BMPs (including LID). Existing storm drain infrastructure were retrofitted at seven locations where stormwater discharges into the protected Fitzgerald ASBS in Montara and Moss Beach (see Figure 3). The pilot BMPs included 1) native grass sod swales, 2) vegetated swales with an underdrain system, 3) BioClean® flume filters with BioMediaGREEN® media to trap and filter pollutants, and 4) a catch basin vault system with Stormwater Management StormFilter® cartridges. Pre- and post-construction photo documentation is included in Appendix A.

One round of characterization or screening monitoring was conducted in January 2012 to narrow down the list of parameters for subsequent monitoring events. During two storm events in March and April 2012, pilot BMPs were evaluated for performance (effluent water quality and pollutant removal) using a paired sampling approach with one water sample collected at the inflow of the treatment area and the other collected at the outflow. At three sites, samples were analyzed for a comprehensive suite of urban runoff constituents including metals, PAHs, pyrethroid pesticides, suspended sediment, nutrients, and fecal indicator bacteria. The remaining three sites were sampled for conventional water quality parameters (conductivity, dissolved oxygen, pH, temperature, turbidity) and suspended sediment concentration only as a surrogate for other pollutants.

Installation of the catch basin vault system with StormFilter cartridges was delayed due to additional time that was need for design and fabrication, therefore monitoring was conducted in February and March 2013. Samples were analyzed for the comprehensive suite of urban runoff constituents including metals, PAHs, pyrethroid pesticides, suspended sediment, nutrients, and fecal indicator bacteria.

SFEI reported results of the monitoring and concluded that BMPs were generally effective at reducing pollutant concentrations. The data for the pilot phase showed that the monitored BMPs/LIDs reduced contaminant concentrations and also showed spatial and temporal variability due to site specific and drainage area characteristics. Most particle-associated contaminant concentrations (i.e., polycyclic aromatic hydrocarbons, pyrethroids, copper, lead, nickel, and zinc) were reduced from the inflow of the BMPs/LIDs compared to the outflow. Detailed monitoring results can be found in the summary report included as Appendix B and in the Monitoring Data Evaluation and Pollution Load Reduction Section below. A summary of pilot BMP data was also prepared by SCCWRP (2015) as part of their assessment of Prop-84 funded ASBS projects.

In general, longer residence times in both swale types seemed to reduce contaminant concentrations more effectively than the very short residence times of stormwater in the flume filter BMP. However, the different site characteristics (e.g., slope of road surface and additional entry points for untreated water between the inlet and the outlet) seemed to result in higher contaminant concentration reduction rates at the grassy swale sites compared to the vegetated swale sites. The vegetated swale results were likely affected by inflow mid-site and possibly lack of time for plant and soil establishment.

SFEI noted that the flume filter inserts clogged quickly with leaf litter and sediment resulting in stormwater bypassing the BMPs and required frequent maintenance. The StormFilter cartridge showed the least effective treatment out of all monitored treatment types. However, the system had been installed shortly (approximately four weeks) prior to the sample collection, which may have caused the concentrations of some contaminants to be higher than expected at the inflow (e.g., PAH due to new asphalt around the installation site). Additionally, the outflow sampling point was located at the downstream end of the existing reinforced concrete pipe that transported treated runoff away from the cartridges towards San Vicente Creek. During the collection of outflow water samples, sediment deposits and plant debris were observed within the pipe. During high flow periods, sediment and pollutants may have been mobilized from within the pipe potentially leading to an increase in contaminant concentrations at the outflow.

The flume filters were relatively low cost but required frequent maintenance during the rainy season to remove sediment and debris and replace filters. The StormFilter cartridge catch basin retrofit was higher cost, especially given the small drainage area, and only annual required maintenance. The StormFilter device also required a significant treatment footprint in relation to the drainage area. Although likely effective when functioning properly, flume filter inserts and StormFilter cartridge catch basin retrofits were not recommended for Phase 2 of the Project.

Figure 3. Map of pilot phase sites for water quality.

II. Storm Drain Inventory and Assessment

To support selection of appropriate BMP types, assist with prioritizing BMP locations, and assist with BMP design, a storm drain inventory and assessment was conducted at the beginning of the Project. The storm drain inventory and assessment included updates to existing storm drain GIS maps, identification of problem areas for erosion, sedimentation, pollutant loading, litter, flooding, evaluation of ASBS discharge removal feasibility, and a prioritized list of BMP and drainage improvement projects. The report is included in Appendix C.

III. Microbial Source Tracking

The MST component of this study was undertaken due to the 303 (d) listing, numerous exceedances of water quality objectives, and the frequency of needed beach and creek postings warning visitors that San Vicente Creek and the Reserve may not be suitable for contact recreation. The main goal of the MST study was to provide information about the primary sources of fecal contamination within the ASBS watersheds and to assist with the selection of appropriate BMPs and LIDs to reduce fecal pollution.

MST involved genetic source analysis of samples from Martini, Kanoff, Montara, Dean and San Vicente Creek watersheds, was conducted to identify the appropriate mix of BMPs to address specific types of fecal sources. Researchers from the UCD collected samples from the five creeks at sites located immediately upstream of the confluences with the Pacific Ocean during a rainy season event, dry season event, and during first flush and conducted genetic analysis of host-associated *Bacteroidales* to determine the contribution of human, bovine, dog, and horse sources to fecal contamination. Fecal indicator bacteria (FIB) monitoring involving total coliforms, *Escherichia coli* (*E. coli*) and *Enterococcus* was conducted within Martini, Kanoff, Montara, Dean, and San Vicente Creeks by SFEI at multiple locations within each creek during two rainy season events and two dry season events. The purpose of the FIB monitoring was to determine FIB levels throughout the watersheds and investigate seasonal and land use-related spatial trends. SFEI collected a total of 78 water samples for FIB analysis, and UCD collected a total of 58 samples from water, sediment, and biofilm matrices for genetic analysis.

MST monitoring in creeks draining into the Pacific Ocean in Montara and Moss Beach, supported the FIB analysis in identifying possible sources of bacteria. Bacteria, such as coliform, *Enterococcus*, and *E. coli*, (although imperfect) are indicators for fecal contamination in surface waters. One of the goals of this study was to identify potential spatial loading sources of FIB in different reaches of creeks draining from Montara Mountain to the Pacific Ocean in the vicinity of the ASBS (see Figure 4) and to inform future bacterial loading reduction efforts in those creeks. FIB concentrations exceeded US EPA recommended standards at most sites during the dry and the wet season, however concentrations were generally lower in the dry season. In addition to the high total coliform concentrations at all creek sites during the wet season, some counterintuitive observations were noted for Martini and Kanoff Creek for *E. coli* and *Enterococcus*. Conceptually, source models for bacteria indicate higher bacterial loading from impervious land segments and urban areas, usually located in the central and downstream reaches of creeks. Potential sources within these reaches include equestrian facilities, other confined animal facilities, pet waste, wildlife, homeless encampments, and failing or leaking septic and sewer systems. The upper reaches have the potential for bacterial contributions from wildlife, recreational uses (i.e., equestrian and dog walking), and where present, livestock and pastures. Shorter residence times due to steeper slopes and higher precipitation usually do not allow for any degradation in the upper reaches while die-off can influence the amount of bacteria in the lower watersheds (Kim et al. 2007).

Often, the source for dry weather bacterial loading can be attributed to human sources, e.g., septic system and sewer leaks (Jensen et al. 2003), since there is very little runoff facilitated loading during the dry season. There could be a greater potential risk for septic system leaks in the studied area due to tectonic activity that could potentially lead to fractures in septic tanks or pipes.

In this study, bacterial concentrations in the upper reaches of the creeks were generally higher than downstream locations even though likely urban sources of fecal contamination (e.g., pet waste, sewer and septic system effluent) would be expected to be concentrated in the central and lower reaches of the creeks. Similar observations to the ones made in this study have been made in other watersheds. As expected, Martini and Kanoff Creek showed lower bacteria concentrations than the more urbanized watersheds of Dean, San Vicente, and Montara Creek. Montara Creek was the only creek out of the five monitored creeks where increased bacterial loading was observed from the upstream to the downstream reaches. However, the understanding of the complex bacteria loading in mountainous creeks and the transport and fate of the indicator bacteria downstream are not, at this point, well understood despite multiple decades of use of these indicators in state and federally promulgated water quality standards. The full report is included as Appendix D.

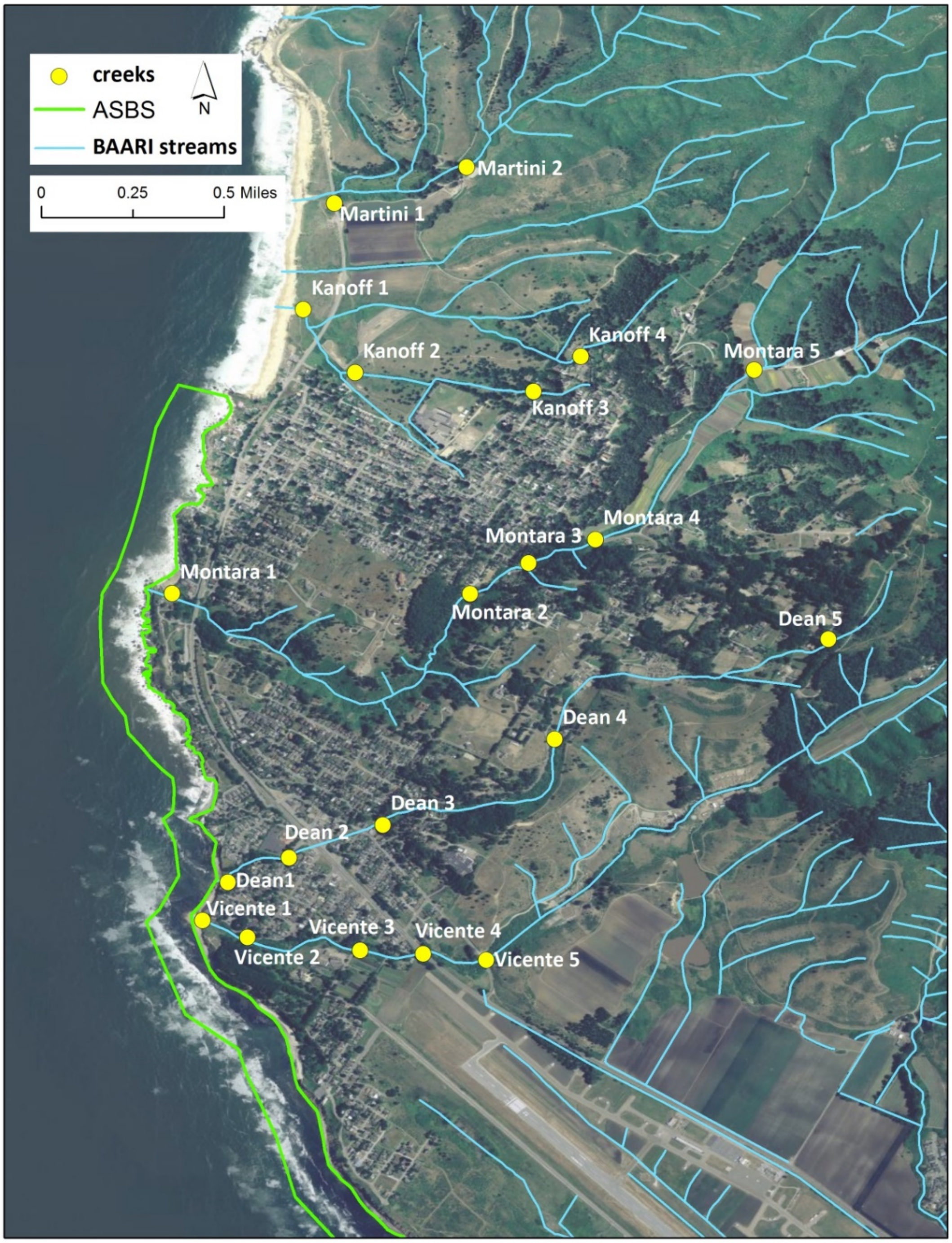

Figure 4. Map of Microbial Source Tracking sites. Dots mark SFEI sampling locations. The creek confluence sites with the Pacific Ocean (Martini 1, Kanoff 1, Montara 1, Dean 1, and Vicente 1) were also sampled University of California at Davis.

The results of the genetic analysis, conducted by UCD, showed that concentrations of the universal *Bacteroidales* marker, derived from all warm-blooded animals, increased during rain and was generally lower in the dry season. Increased levels of *Bacteroidales* were significantly higher in the wet season event in comparison to the first flush event. Differences in first flush and other rainy season events could be due to differences in microorganism survival related to environmental conditions such as temperature, differences in source loading related to the degree of ground saturation, groundwater levels, resulting runoff, and observed streamflow at the beginning of the storm season versus the end of the storm season, and/or the resuspension of sediments and release of microorganisms from sediment and biofilms as the result of higher streamflow and turbulence.

Of the four host-associated markers that were analyzed (dog, horse, bovine, and human), dog-associated *Bacteroidales* was the most frequently detected host marker in stormwater, as well as in sediment and biofilms at all sites in the wet season. On the contrary, the dog-associated marker was less frequently detected during the dry season and first flush event. The bovine-associated marker was detected in water, sediment, or biofilms at all sites during the rainy season, most notably from Kanoff and San Vicente Creeks, but was not detected during the dry season or first flush events. Horse-associated *Bacteroidales* were found at high concentrations in water at Dean and San Vicente Creeks during rain events in the wet season. The horse marker was also detected at all sites during the dry season, but did not appear to be a predominant source of fecal contamination. Human-associated *Bacteroidales* were detected in water at all sites during the first flush event, but were not present during the dry season and were only detected in two samples during the rainy season event. During the dry season, at all sites except Montara Creek, the concentrations of tested host markers comprised less than 5% of the Universal *Bacteroidales* concentration targeting all warm-blooded animals, which indicates that uncharacterized fecal sources, such as wildlife or other domestic animals, likely contributed a large amount of fecal pollution. The full results are available in Appendix D.

The results of this MST study provided good insight and a first glimpse into the understanding and control of fecal contamination sources in watersheds draining into the Pacific Ocean within or near the ASBS. This study confirms fecal contamination from human, dog, bovine, and horse sources, and of these, dog appears to be the most prevalent source during the rainy season. While there may be other more significant sources of fecal pollution that were not characterized as part of this study, such as wildlife or other domestic animals, this study provides useful information to guide the selection of BMPs to reduce fecal pollution. It may be helpful to investigate the genetic sources of fecal pollution further once more advanced tests are available to determine the dominant source for the pollution.

Recommendations for further work and future BMPs implementations included the continuation of MST within the five watersheds with additional sampling sites, increased sampling frequency, improved genetic analysis, and possible implementation of a bacterial tracer experiment. Additionally, recommendations were made for the implementation of an education and outreach program to address dog waste and the implementation of BMPs to better address horse waste. It was also recommended to investigate potential sources of bovine contamination and to develop a project to investigate the condition of septic systems and the potential for source contributions related to sanitary sewer systems.

IV. Phase 2 BMPs

Using lessons learned from monitoring, implementation, and maintenance of the Pilot BMPs and results of the MST and Storm Drain Inventory, Phase 2 BMPs were implemented within the County-maintained storm drain system as well as on private property. Phase 2 included installation of fourteen storm drain BMPs in 2013 and 2014 and upland LID BMPs at seven residential properties in 2015.

Storm Drain BMPs

As part of Phase 2 of the Project, grassy and vegetated swales were installed at 12 sites within the ASBS watershed and in the adjacent Kanoff Creek watershed in 2013 and 2014. Phase 2 also included a green street retrofit project in 2014 involving the installation of two bioretention facilities and educational signs along Carlos Street in Moss Beach and construction of a green demonstration parking lot at the Reserve. The design for the green demonstration parking lot included construction of a trench drain to capture runoff from the parking lot which is then routed to a bioretention basin to filter runoff before discharging to San Vicente Creek and the ASBS. Educational signs were installed to explain the project and drainage system process. Construction was completed in 2014. Pre- and post-construction photo documentation is included in Appendix E.

Performance monitoring of representative Phase 2 storm drain BMPs was conducted in 2013 and 2014 by SFEI. Due to construction timing, the monitoring efforts were focused on the two swale types only. Two high priority sites and one low priority site were monitored to assess LID effectiveness. Composite samples collected during the entire storm length showed only a small reduction in outflow concentrations. Suspended sediment was reduced between 6.8% at the vegetated swale site and 31% at the grassy swale site. Copper was reduced by approximately 5%, while lead was reduced between 17 and 36%. Zinc concentrations increased at the vegetated swale site by 15% but were reduced at the grassy swale site by 22%. The pyrethroid pesticide concentration for permethrin was successfully reduced between 23 and 36%. When flow data were combined with concentration data to analyze pollutant loading over an entire storm event, there was no observed load reduction when the range of error (20 to 25%) for laboratory and flow measurements was considered. The only exception was pyrethroid pesticide loads, which were reduced by approximately 50%. For some water quality constituents, such as PAHs, nitrate, and ammonium, the mean concentrations were higher in outflow composite samples.

At the two high priority sites, stormwater was able to percolate into the swales during low flow conditions. However, due to the large drainage areas and high volume of runoff during high flow conditions, stormwater passed through the swales in a stream-like manner on the surface of the features without having the chance to infiltrate through the swale system. The size of the treatment areas for the two high priority sites was not sufficient to efficiently treat the total volume of runoff during high flow conditions; therefore, contaminant reduction was minimal.

The study also found minimal reductions and in some cases input of vehicle-derived pollutants like PAHs and copper due the close proximity of roadways and near-source pathways for loading (wind, input from roadway mid-way through swale). For other pollutants, such as permethrin, with sources primarily located farther upstream of the swales, reductions were greater. Even though the composite samples did not allow for individual reduction evaluation during low flow periods, it was observed that greater amounts of runoff infiltrated during light rain, and it can be assumed that greater concentration reduction occurred within the treatment area at these times.

The monitoring report was completed in January 2015 and is included as Appendix F.

Figure 5. Map of the study area showing Phase 2 sample locations in Montara and Moss Beach.

Private Upland BMPs

The County subcontracted with the RCD for the private upland BMPs portion of the Project. Following input and recommendations from the TAC, Regional Water Board, State Water Board, and RCD Site Selection Committee, the priority BMP focus areas were to encourage voluntary conservation on public/private properties through technical assistance and financial incentive programs for landowners to install BMPs and LID measures to improve water quality to the ASBS and education and outreach.

The RCD successfully engaged nearly 500 residents of Montara and Moss Beach through outreach activities, not counting those that were reached through social media, the web, and flyers posted at community businesses and gathering places.

Oceans Week at Farallone View Elementary School provided a prime opportunity for the RCD to reach out to the local community by educating the children, parents, and teachers about the local watershed and how pets, cars, and various household activities contribute pollution to local creeks and beaches. This BMP was designed and implemented to 1) get the word out about known sources of fecal bacteria to the ASBS, 2) educate about the connection between backyard pet waste and high bacteria levels in creeks and ASBS in wet weather, and 3) build connections with the school community. The BMP directly reached roughly 385 students and 35 adults (teachers and parents) with the message that cleaning up after pets on trails and in backyards is important for decreasing the amount of bacteria entering the creeks and Fitzgerald ASBS during wet weather.

To recruit participation to the program, the RCD completed 22 site visits to private properties and equestrian facilities to assess ways to reduce stormwater runoff and reduce potential sources of pollution. The RCD implemented 25 BMPs on seven residential properties during the course of the Project. The BMPs included installing roof drainage controls to collect rainwater, replacing impervious surface with permeable surface, and infiltrating and storing stormwater runoff using rain gardens and drainage swales. The LID projects were specifically designed to reduce priority pollutants (i.e., fecal coliform from pet waste, pesticides, metals, and other vehicle- and household-derived pollutants) by capturing, storing, infiltrating, treating, and/or redirecting stormwater. It is anticipated that the projects will serve as demonstration sites for the community both through site visibility and by community leadership provided by participating landowners.

The final report for this component of the Project including re- and post-construction photo documentation is included in Appendix G.

V. Education and Outreach

In order to communicate the significance of the natural resources of the ASBS, highlight Project activities, and provide source reduction resources to the public, the County began a targeted education and outreach program for the Fitzgerald ASBS watershed aimed at pollution reduction. The targeted education and outreach was initiated at the start of the Proposition 84-funded work. Completed tasks for the Project, as well as planned efforts for the future, are summarized below.

Survey

A community survey was developed at the beginning of the Project to help understand the community's knowledge of nonpoint source pollution, perceived MidCoast water quality problems, willingness to participate, and to help provide additional ideas for water quality improvements. The information was used to guide subsequent education and outreach content as well as planning for the Phase 2 of the Project and will also be useful for future education and outreach. A link to the survey was included in the first newsletter, ASBS website, and partner websites. The survey was also promoted through social media (SMCWPPP Facebook and Twitter, County of San Mateo Twitter, and Nextdoor). Hard copies were made available at key locations and public events (i.e., DPW public counter, MidCoast Community Council meeting). The survey provided useful information to County staff, and as such the survey remained active throughout the entire Project.

The survey was completed by 122 respondents. Many of the respondents (68%) live or work near the Reserve and often use the Reserve area for recreational activities such as enjoying tidepools, wildlife, beaches and scenery. Approximately 50% of respondents thought there is a problem with water quality in the Reserve. The top three pollutants that were viewed as the most serious problems were pesticides and fertilizers, automobiles (leaking oil and other fluids, brake powders, tires), and fecal bacteria from animal waste. The top three underlying causes of pollution were lack of enforcement, lack of education, and lack of concern. Approximately 30% of respondents reported use of pesticides or herbicides for landscaping or household pest control. Surprisingly, approximately 20% of respondents thought runoff leaving their property from household activities such as car washing and landscape watering went into the soil, and 13% thought it went to the sewer system and was treated. 15% of respondents reported that they use their driveway to wash their car. Most respondents who were dog owners reported that they pick up pest waste; less than 2% responded that they do not pick up after their dogs. A large percentage of respondents reported their willingness to implement pollution and source reduction measures such as LID (rain gardens, cisterns, native plants) and were interested in learning more. The results demonstrated the need for increased education regarding stormwater and pollution prevention and were very encouraging in regards to the community's willingness to implement LID. Final survey summary results are included in Appendix H. Additional surveys conducted by the RCD are summarized in the RCD final report included as Appendix G.

Website Development

As part of the Project, County DPW and Environmental Health created a website dedicated to the Fitzgerald Pollution Reduction Program at www.smchealth.org/asbs. The website serves as a platform to inform the community about the ASBS and the Project with links to BMP factsheets, key regulations, grant reports, and the Fitzgerald Special Edition Newsletters (described below). The website was launched in July 2012. Links to this website are posted on other related and partner websites, such as the SMCWPPP website at (http://flowstobay.org/node/5), MidCoast Community Council (http://www.midcoastcommunitycouncil.org/watersheddrainagegroundwater/), and County Parks (http://parks.smcgov.org/press-release/learn-how-you-can-help-protect-fitzgerald-marine-reserve). Throughout the Project period, the website received over 700 views (51 between September and December 2012, 287 in 2013, 208 in 2014, 154 in 2015, and 36 in January 2016). The County plans to maintain the website following completion of the grant-funded portion of the Fitzgerald ASBS Program.

Fitzgerald Special Edition Newsletters

The County published three annual newsletters describing various aspects of the Reserve, ASBS, watershed, regulatory setting, and the Fitzgerald Pollution Reduction Program, as well as measures that local residents and businesses can take to eliminate non-stormwater discharges and reduce pollutants in stormwater runoff. Specific topics included:

- General stormwater education
- Bacteria impairments of local waters and potential sources
- Non-chemical pest control options
- Awareness of copper in architectural features
- Low impact development (LID) techniques such as permeable pavements, rain gardens, vegetated swales, and rain barrels

The annual newsletters were distributed in July 2012, 2013, and 2014. The newsletters were posted on the ASBS website and distributed electronically and via hardcopy to key stakeholder groups. Hardcopies are also left at select locations in the ASBS watershed such as coffee shops and the post office to increase community awareness. The three issues of the Fitzgerald Special Edition Newsletter are included as Appendix H. Dependent on future funding, the County may continue with production of the annual newsletters.

In a specific effort to reduce bacteria and nutrient sources, a pet waste flyer was developed and distributed as part of the 2013 issue of the Fitzgerald Special Edition Newsletter. The flyer provided information on how pet waste and fecal coliform can impact water quality and encouraged residents to pick up and properly dispose of pet waste. The flyer also included information regarding the SMCWPPP Team Effort campaign (http://www.flowstobay.org/teameffort). On the SMCWPPP site, there are additional resources related to pet waste (i.e., link to the 10-page "Horse Owners Guide to Water Quality" produced by the Council of Bay Area Resource Conservation Districts) as well as other stormwater and pollution reduction resources. SMCWPPP also addresses pet waste on their Facebook page (@flowstobay) and conducted a giveaway of dog bag dispensers through Facebook. A link to the pet waste flyer was provided on the SMCWPPP Team Effort page.

In an effort to ensure that residents and business owners in the ASBS watershed were aware of resources related to pollution prevention, the County developed a second flyer that was distributed as part of the 2014 issue of the Fitzgerald Special Edition Newsletter. The flyer provided useful web links for pollution prevention resources and provided a list of tips for measures that could be taken at home or business. The flyer also referred readers to the SMCWPPP Team Effort landing page.

LID Workshop

As part of the Fitzgerald ASBS Program, the County and SFEI hosted a Low Impact Development Workshop on August 25, 2012, entitled "Protecting Coastal Watersheds: with Focus on Residential Low-Impact Development." The workshop covered topics including rain gardens and bioswales, pervious pavement, irrigation and pesticide use, rainwater harvesting, and permits and requirements. Despite extensive advertising efforts, the workshop was not well attended by local residents. In order to reach additional MidCoast residents, business owners, and builders/contractors, the presentations were made available on the Project website (http://smchealth.org/asbs). The County, in collaboration with the RCD, plans to continue to promote residential LID in the ASBS watershed.

The following presentations were given at the workshop:

- Julie Casagrande (County of San Mateo Department of Public Works) – Introduction and Overview of Implementation of the James V. Fitzgerald Area of Special Biological Significance Pollution Reduction Program
- Nicole David (San Francisco Estuary Institute) – Monitoring BMPs for Fitzgerald Marine Reserve, Preliminary Data
- Chuck Kozak (Go Native, Inc.) – Bioswales and Rain gardens, Design and Construction
- Ryan Marlinghaus (EarthCare Landscaping) – Pervious Pavements and Desired Outcomes
- Naresh Duggal (Santa Clara County IPM Manager) - Urban Turf and Landscape, Integrated Pest Management Alternatives to Pesticide and Synthetic Fertilizers in Low Impact Development Residential Communities
- Jillian Steinberger (The Garden Artisan) – Why Greywater?
- Kristen Kerr and Laura Prickett (Eisenberg, Olivieri and Associates, Inc.) - LID for Small Projects and Requirements of the Municipal Regional Stormwater Permit

Additionally, vendor and informational booths were set up in the back of the room by the following groups for presentation of information to the public and a social hour at the end of the workshop:

- San Mateo County Harbor District (Stormwater Treatment at Pillar Point Harbor)
- The Urban Farmer Store (Efficient Irrigation and lighting for Landscapes)
- Blue Sky Design (Native California Plants and Rain Gardens)
- Coastal Range Landscaping (Sustainable Landscapes for Water Conservation and Enhancement of the Environment)

- County of San Mateo Water (Pollution Prevention Program and Environmental Health)
- County of San Mateo Recycle Works (Composting)
- Resource Conservation District (Potential Improvements for Agriculture and Confined Animal Facilities to Reduce Contaminants in Stormwater Runoff)

Figure 6. Workshop announcement and topics for presentations.

Interpretive Signs

In order to communicate the significance of the ASBS and to educate the public on stormwater quality and treatment, interpretive signs were installed at several key locations.

Two interpretive signs were installed at Green Street Improvement Project on Carlos Street. See Figures 7 and 8 below. The signs include messaging on runoff and pollutants, native plants, the treatment process for the installed bioretention facilities, and information on the how the public can prevent pollution.

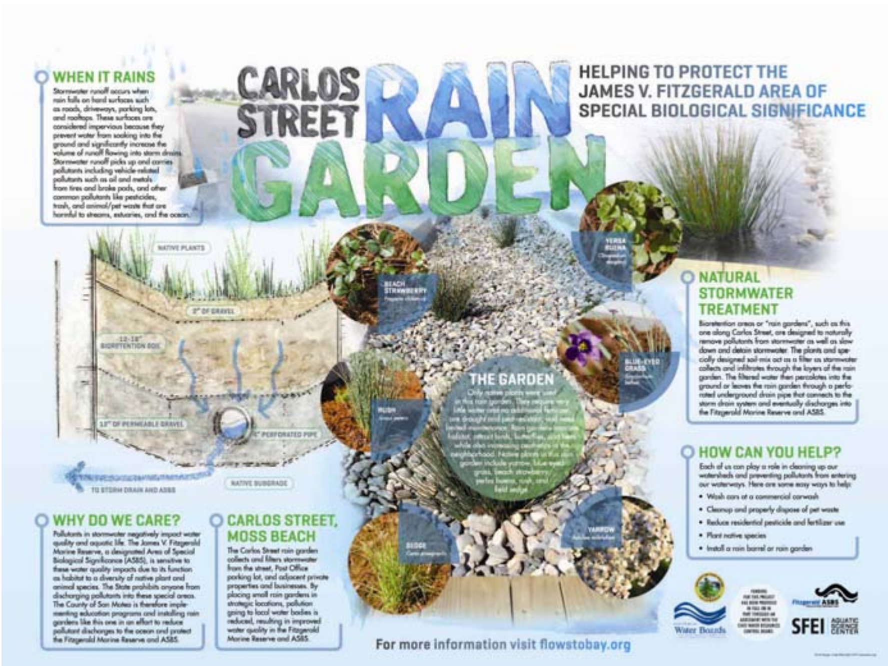

Figure 7. Interpretive sign at the Green Street Improvement Project on Carlos Street.

Figure 8. Interpretive sign at the Green Street Improvement Project on Carlos Street.

An interpretive sign was also installed at the Fitzgerald Marine Reserve Green Parking Lot. The sign includes information about the ASBS and a detailed schematic about the treatment process. See Figures 9 and 10 below.

Figure 9. Interpretive sign at the Fitzgerald Marine Reserve Parking Lot.

Figure 10. Interpretive sign at the Fitzgerald Marine Reserve Parking Lot.

Additional signage was installed at the storm drain swale locations and RCD Private Upland BMP swale and rain garden sites that includes general messaging stating that the area is a biotreatment area with plants and soils specifically designed to filter rainwater runoff. The signs include a basic schematic illustrating the treatment process. See Figure 11 below.


Figure 11. Signage at the storm drain swale sites and RCD Private Upland BMPs swale and rain garden sites.

Additional School Outreach

In addition to the education and outreach activities the RCD conducted at Farallone View Elementary during Oceans Week 2013, the County conducted follow up outreach during Oceans Week in 2014. Oceans Week at Farallone Elementary School provided a prime opportunity for the County to reach out to the local community by educating the children, parents, and teachers about the local watershed and how pets, cars, and various household activities contribute pollution to local creeks and beaches and build connections with the school community. As part of the Oceans Week activities, the County sponsored a tide pool drawing contest and developed a pledge to “Protect the Marine Reserve Together” (http://smchealth.org/sites/default/files/docs/EHS/Pledge.pdf) that was completed by students during the tide pool learning lab. Other non-grant related County-sponsored activities included: a stormwater assembly “We All Live Downstream presented by the Banana Slug String Band; an assembly led by County Park Ranger featuring his video “A Universe in a Tide Pool”; a RecyleWorks sponsored “Be Seen Keepin’ It Clean” litter pickup event and recycling truck demonstration. An article summarizing the event and highlighting samples from the drawing contest were featured in the 2014 ASBS newsletter (see Appendix H). Once the 2014 ASBS newsletter was available, the Friends of Farallone Parent Teacher Organization distributed it to parents via email, hence reaching more of the adults in this community with information about local water quality. This activity directly reached roughly 385 students as well as their teachers and parents with pollution prevention and ASBS messaging.

VI. Future Planning

BMP Operation and Maintenance Plans

The Grant Agreement with the State Water Board requires that the grantee (County of San Mateo) maintain and operate the facility and structures constructed or improved as part of the Project throughout the life of the Project, consistent with the purposes for which this Grant was made. In order to maintain function as originally designed, adequate inspection and maintenance of BMPs are required. The County prepared a BMP Operation and Maintenance Plan (BMP O&M Plan) for the storm drain BMPs to document minimum requirements and standards for inspection and maintenance of BMPs that were installed as part of the Project. The BMP O&M Plan includes a BMP inventory (e.g., location, installation data, specifications, design parameters) and documents personnel qualifications and responsibility, inspection and maintenance procedures including documentation and tracking. The BMP O&M Plan is included in Appendix I.

For the Phase 2 Private Upland BMPs, the RCD created Operation and Maintenance Handbooks (O&M Handbooks) for each of the seven sites. A copy was provided to each of the landowners. The O&M Handbooks list system components, recommended maintenance, and procedures for repair and rehabilitation. The O&M Handbooks are included in Appendix G.

Future Planning

In order to assist with future planning and continuation of the Fitzgerald ASBS Program, the County subcontracted with SFEI to conduct pollutant load reduction forecasting based on modelling of potential BMP and LID implementation scenarios. Estimating baseline pollutant loads from different land use areas within the watershed and forecasting the potential reduction of these loads through LID implementation provides a planning level maximum implementation scenario to help guide management decisions. The full report is included in Appendix J.

Maximum implementation may not be feasible in the immediate future due to costs and other unforeseen constraints, but the treatment efficiency per LID unit is very promising in regard to particulate phase metals and organic contaminants, and maximal LID implementation would be beneficial for the protection of the ASBS. The final output of the site locator tool identified suitable locations for three LID types: bioretention, vegetated swales, and pervious pavement. The area included in the tool and ranked for LID suitability within the Fitzgerald watershed included approximately 332 acres. This is the area predominantly associated with transportation infrastructure. The forecast results generated by SFEI in this report may underestimate the achievable benefits if LIDs could also be applied to other areas in addition to transportation-related land use alone. Furthermore, there are other LID techniques which can be useful under different conditions: for example, permeable pavement could be used where space alongside the roadway is limited. The analytical framework provided here could be applied to a wider range of bioretention techniques and used to test which combinations of which LID techniques could be most advantageous and cost-effective for local or regional application in San Mateo County.

Assessment of County Policies and Programs Related to Water Quality

An important component of future planning and prioritization for implementation of private and public LID and BMPs is to review existing policies, plans, and programs to identify inconsistencies, weaknesses, and areas for improvement. As part of this Project, the County contracted with EOA, Inc. to conduct an assessment of County policies and programs. The assessment involved: a) briefly summarizing the existing relevant policies and programs, b) documenting recent changes to the policies and programs, especially those resulting from water quality regulations, and c) recommending potential actions and associated improvements to the policies and programs to reduce stormwater runoff and non-point source impacts to water quality in the ASBS watershed and accommodate, encourage and where necessary require appropriately designed and selected BMPs in conjunction with development and maintenance activities.

The report is included in Appendix K. In general, the assessment found that the County has many progressive and constructive strategies already in place, many of which have seen improvements in recent years. Key recommendations and considerations for potential future improvements are listed below.

- **Confined Animal Ordinance** – The current Confined Animal Permit process requires submittal of detailed drainage and manure management plans along with compliance with several criteria related to land use. Permitted facilities are reviewed every three years and exempt facilities are not reviewed after certificates of exemption are issued. It was recommended that the frequency of permit reviews be increased to annually and that triennial reviews be implemented for exempt facilities. An education component should be added to the review process. As a related measure, it was recommended that the County develop a new ordinance or update an existing ordinance to address management of excreta from other domestic animals such as dogs and cats.
- **Public Green Infrastructure** – Past and current policies in the County followed the San Francisco Bay Regional Water Quality Control Board Municipal Regional Stormwater NPDES Permit (MRP) (Order R2-2009-0074, recently amended by Order No. R2-2015-0049) requirements for low impact development and green infrastructure (GI). The recent MRP revisions include more requirements for public GI planning and initial early implementation, including opportunistic retrofitting of existing roadways. It was recommended that the County add GI information to department websites, train employees on Bay-Friendly Landscaping practices, continue to implement GI BMPs in the ASBS watershed, and add GI policies to County plans.
- **Private Green Infrastructure** – Current policies in the County follow the MRP which requires that private development projects use GI and LID-based design strategies and source control measures. It was recommended that the County continue to refine its stormwater management review process for development projects, implement new and modify existing regulatory mechanisms to increase the pace of GI conversion and retrofitting on private property, and develop GI incentive and outreach programs targeting private properties within the ASBS watershed community.
- **Inspections** – The frequencies of construction site, industrial facility, commercial business, and storm drain outfall Inspections in the ASBS watershed were recently increased to comply with the ASBS Special Protections. It was recommended that the County consider strategies used by other ASBS jurisdictions to fund additional staff or improve efficiencies. In addition, the County may choose to coordinate selected Special Protections-required inspections each year with the routine MRP stormwater inspections conducted concurrently with food service establishment health or CUPA inspections. The County may also explore contracting selected Special Protections-required stormwater inspections for restaurants to the Sewer Authority Mid Coastside (SAM), in coordination with SAM's Fats, Oil and Grease (FOG) program inspections. Inspectors should distribute brochures and other educational materials during all of the above types of inspections.

- **Public Outreach and Education** – The County partners with SMCWPPP and implements several programs (e.g., RecycleWorks) to comply with public information and outreach requirements of the MRP. It was recommended that the County continue to develop and improve existing programs, new programs such education and outreach conducted through this Project (e.g., Fitzgerald Special Edition Newsletters, website, pet waste alerts), identify outreach opportunities through other programs (e.g., GI guidance, rebate programs, inspections), and work to better coordinate these programs.

VII. Monitoring Data Evaluation & Pollutant Load Reduction

The objective of the storm drain BMP monitoring was to evaluate potential contaminant reductions in storm water runoff that drains into the ASBS before and after treatment with BMPs. The data were collected in order to provide detailed information to the County on how effective the studied BMPs and LID prevention techniques were in reducing runoff and contaminants draining into the ASBS ultimately enabling the County to choose appropriate contaminant reduction measures to effectively manage water quality on a broader scale in the future to comply with the Special Protections.

The point of compliance for the ASBS Special Protections is ocean receiving waters, and the target for compliance is below the 85% percentile threshold of water quality data from ocean receiving water reference sites. Monitoring to establish the 85% for reference sites is in progress by the Central Coast ASBS Regional Monitoring Program. The Special Protections require that BMPs be designed to meet Table B Instantaneous Maximum Water Quality Objectives in Chapter II of the Ocean Plan (http://www.swrcb.ca.gov/water_issues/programs/ocean/) or contribute to an overall 90% reduction for core direct discharges in a given ASBS.

For this study, the monitored stormwater at the outflow of the BMPs/LIDs is freshwater that has not been diluted or discharged to the ASBS. Because the ASBS point of compliance is ocean receiving water, direct comparisons of stormwater data from this study to future ocean receiving water data cannot be made. For many of the water quality constituents in this study, comparison to San Francisco Bay Basin Water Quality Control Plan (Basin Plan) water quality objectives, which would be more applicable, is not possible because many of the Basin Plan objectives are narrative or they are yet to be established for certain parameters. Data from this study are also not directly comparable to Ocean Plan objectives as they are intended for ocean samples collected after initial dilution has occurred. However, Ocean Plan objectives have been included below for general comparison purposes. Constituents that were most frequently detected above the Ocean Plan objectives included copper, nickel, lead, zinc, PAHs, and pyrethroids. In addition to suspended sediment concentration (SSC), these parameters are considered constituents of concern and are discussed below.

This Project provided an integrated view of BMP and LID practices and addressed performance and efficiency of various practices with regard to different Project objectives. The overall goal to reduce contaminant concentrations and loads was achieved for most contaminants with the exception of copper (at three sites) and PAHs (at all sites) which did not always meet the Ocean Plan objectives (Table 2 a-f). Copper reductions ranged from 4% to 34%. Nickel reductions ranged from 2% to 61%. Lead reductions ranged from 17% to 76%. Zinc reductions ranged from 0% to 85%. Reduction of PAHs ranged from 0% to 83%. Permethrin reductions ranged from 23% to 92%. Concentration reductions for *Enterococcus, E. coli*, or Total Coliform were generally not observed. However, it is important to note that sampling was very limited due to restrictions related to analysis holding time and laboratory hours of operation.

All studied BMPs/LIDs reduced contaminant concentrations in stormwater before draining into the Reserve. However, site specific and drainage area specific characteristics resulted in effectiveness variations at the monitored sites. Overall the desirable reduction of concentrations to below Ocean Plan objectives was achieved, with the exception of copper concentrations at the flume filter site, the filter cartridge site, and the Phase 2 grassy swale site. PAH concentrations in runoff were far above Ocean Plan objectives even though they were low in comparison to other studies describing stormwater concentrations for residential land use (1,400 to 4,400 ng/L with a mean of 2,900 ng/L (Legret and Pagotto 1999; Stein et al. 2006) compared to 43 to 2,000 ng/L with a mean of 297 ng/L in this study). However, a reduction to Ocean Plan objectives for PAHs was not achieved.

In order to assess performance of each of the units, the results were compared to previously LID study sites, a rain garden in Daly City (David et al. 2011) and a rain garden in El Cerrito (Gilbreath et al. 2012) (Table 2 a-f). For some constituents, the ASBS BMPs were more effective, while for other constituents they were less effective.

Site characteristics (e.g., slope of adjacent areas that allowed for runoff inputs alongside the BMP/LID) may have confounded the results since the outflow at the discharge point of the treatment area was likely not treated in its entirety. For example, reduction of contaminants at the pilot Phase vegetated swale site was moderately effective but even during periods of moderate and smaller rainfall events, when the swale was not overflowing, higher outflow than inflow concentrations were occasionally observed. At rainfall rates <0.05 inches per hour this site showed more consistent treatment but due to lateral runoff inflow from the adjacent street, the reduction rate was biased low during higher intensity storms. In Moss Beach and Montara, many areas lack curb and gutter making it more challenging for retrofits and more likely for sites to receive lateral runoff midway through the features, as observed at several of the swale sites. This condition likely resulted in reduced performance. Effectiveness would be expected to be better if the same LID design was placed at other locations with more controlled flow patterns.

The bioswales monitored during Phase 2 of the Project showed lower efficiency in removing metals and organic pollutants from stormwater. Pollutants that originated from local sources (i.e., vehicles and weathering pavement) and had relatively high concentrations in runoff, like most metals and PAHs, seemed to be added to the treatment areas, which were located downwind of the streets and in the case of the one site (Main Street) downwind of Highway 1. This could have possibly resulted in lower treatment capacity of the swales since pollutants were not limited to entering the system through the stormwater inlet. Pollutants originating more from household sources, e.g., pyrethroid pesticides, located not directly next to the swale, entered the swale with the stormwater influent and showed more successful treatment. Sediment and contaminant concentrations were more effectively reduced when high concentrations were restricted to the inflow without nearby additions. For example, at the Phase 2 grassy swale site, sediment concentration reduction was approximately three times as high compared to the Phase 2 vegetated swale site, which had on average more than twice the influent concentration of suspended sediment due to high gopher activity directly upstream of the swale.

In general, sites that were undersized in relation to the drainage area and could not adequately treat stormwater runoff. Undersized swales were less effective because of bypass and/or extremely short residence times. Rainfall amounts of as little as 0.02 inches per hour led to those sites resembling small stream systems with most stormwater running over the surfaces of the features and without the opportunity for infiltration and treatment.

Table 2. Summary of water quality monitoring results. A) Vegetated swale (n = 5*), b) grassy swale (n = 11), c) flume filter (n = 2), d) filter cartridge (n = 3), e) Phase 2 vegetated swale (n = 5), and f) Phase 2 grassy swale (n = 5). Highlighted in yellow are exceedances of Ocean Plan Objectives.

a)*		Inflow			Outflow			Ocean Plan	Vegetated Swale	Daly City**	El Cerrito***
Parameter	**Units**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Objectives**	**% Reduction**	**% Reduction**	**% Reduction**
Copper	µg/L	7.10	24.8	14.4	5.79	16.6	9.57	12	34	83	69
Nickel	µg/L	1.54	8.09	3.13	1.93	3.94	2.94	8	6.1	20	NS
Lead	µg/L	1.18	20.7	4.56	1.28	7.04	3.05	20	33	51	NS
Zinc	µg/L	10.6	126	32.1	3.01	28.3	11.6	80	64	93	NS
SSC	mg/L	4.3	1,000	118	3.5	580	74	NA	37	29	79
PAHs (13 Ocean Plan compounds)	ng/L	8.42	119	43.2	1.87	159	43.6	8.80	-1.1	NA	NS
Permethrin	µg/L	0.000236	0.004655	0.000457	0.000243	0.000608	0.00038	NA	17	NS	50

*n = number of samples. The Fitzgerald ASBS results used for this table were low rainfall intensity (<0.05 inches per hour) samples only because higher rainfall intensity caused lateral runoff that biased the outflow results high. Both comparison studies had curbs and controlled inlet and outlet points.
**David et al. 2011
*** Gilbreath et al. 2012b
NS – Not sampled

b)		Inflow			Outflow			Ocean Plan	Grassy Swale	Daly City	El Cerrito
Parameter	**Units**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Objectives**	**% Reduction**	**% Reduction**	**% Reduction**
Copper	µg/L	2.29	29.7	11.4	1.97	8.56	3.92	12	66	83	69
Nickel	µg/L	1.15	19.3	6.99	1.09	5.8	2.71	8	61	20	NS
Lead	µg/L	0.436	6.57	2.65	0.163	1.53	0.62	20	76	51	NS
Zinc	µg/L	6.52	282	61.3	4.38	24	9.46	80	85	93	NS
SSC	mg/L	24	2100	650	7.1	480	71.9	NA	89	29	79
PAHs (13 Ocean Plan compounds)	ng/L	30.2	1,490	307	11.3	176	53.5	8.80	83	NA	NS
Permethrin	µg/L	0.00451	0.225	0.0772	0.00194	0.0139	0.00583	NA	92	NS	50

c)		Inflow			Outflow			Ocean Plan	Flume Filter	Daly City	El Cerrito
Parameter	**Units**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Objectives**	**% Reduction**	**% Reduction**	**% Reduction**
Copper	µg/L	13.7	32.1	23.9	16.4	18.4	17.6	12	26	83	69
Nickel	µg/L	4.96	12.3	9.22	5.73	6.19	6.03	8	35	20	NS
Lead	µg/L	2.76	5.39	4.22	1.86	2.47	2.20	20	48	51	NS
Zinc	µg/L	46.5	134	95.2	61.3	69.7	66.6	80	30	93	NS
SSC	mg/L	72	760	340	41	190	88	NA	74	29	79
PAHs (13 Ocean Plan compounds)	ng/L	140	335	209	50.0	97.2	61.7	8.80	71	NA	NS
Permethrin	µg/L	0.00358	0.00358	0.00358	0.000895 (MDL)	0.000895 (MDL)	0.000895 (MDL)	NA	75	NS	50

d)		Inflow			Outflow			Ocean Plan	Filter Cartridge	Daly City	El Cerrito
Parameter	**Units**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Objectives**	**% Reduction**	**% Reduction**	**% Reduction**
Copper	µg/L	20.3	128	57.9	18.2	106	49.9	12	14	83	69
Nickel	µg/L	1.61	12.2	5.40	2.01	12.2	5.66	8	-5	20	NS
Lead	µg/L	0.79	2.89	1.81	1.18	2.53	1.91	20	-5	51	NS
Zinc	µg/L	18.9	82.8	47.2	26	60.5	41.3	80	12	93	NS
SSC	mg/L	27	240	100	36	110	76	NA	28	29	79
PAHs (13 Ocean Plan compounds)	ng/L	66.4	420	204	105	352	191	8.8	7	NA	NS
Permethrin	µg/L	0.00343	0.00626	0.00485	0.00226	0.00226	0.00226	NA	53	NS	50

e)		Inflow			Outflow			Ocean Plan	Vegetated Swale	Daly City**	El Cerrito***
Parameter	**Units**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Objectives**	**% Reduction**	**% Reduction**	**% Reduction**
Copper	µg/L	5.3	13	9.05	5.2	13	8.7	12	4.2	83	69
Nickel	µg/L	2.6	5.9	4.1	2.8	5.4	4.0	8	2.6	20	NS
Lead	µg/L	1.7	4.1	2.5	1.5	3.2	2.0	20	17	51	NS
Zinc	µg/L	19	52	35	23	55	40	80	-15	93	NS
SSC	mg/L	26	86	43	21	86	41	NA	6.8	29	79
PAHs (13 Ocean Plan compounds)	ng/L	120	560	210	98	500	340	8.8	-57	NA	NS
Permethrin	µg/L	ND	0.0046	0.0016	ND	0.0018	0.001	NA	36	NS	50

f)		Inflow			Outflow			Ocean Plan	Grassy Swale	Daly City**	El Cerrito***
Parameter	**Units**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Objectives**	**% Reduction**	**% Reduction**	**% Reduction**
Copper	µg/L	16	39	23	15	34	22	12	5.0	83	69
Nickel	µg/L	2.9	12	5.5	2.8	8.5	4.7	8	14	20	NS
Lead	µg/L	2.4	23	7.3	2.7	8.5	4.7	20	36	51	NS
Zinc	µg/L	40	160	72	35	110	56	80	22	93	NS
SSC	mg/L	95	1,100	360	84	240	140	NA	27	29	79
PAHs (13 Ocean Plan compounds)	ng/L	564	3,900	2,000	250	3,400	1,600	8.8	20	NA	NS
Permethrin	µg/L	0.00088	0.011	0.0053	0.0016	0.0048	0.0041	NA	23	NS	50

Project Assessment

At the start of the Project, a Project Assessment and Evaluation Plan (PAEP) was developed to define Project goals, and performance measures including desired outcomes, output indicators, and targets.

The specific goals of this Project were to:

1. Increase understanding of functionality and effectiveness of different stormwater BMPs and LIDs.
2. Educate the landowners, residents, and the community about the role that treated stormwater contributes to the reduction of nonpoint source pollution.
3. Demonstrate the beneficial value of BMPs/LIDs on the watershed.
4. Reduce the contaminant load by implementing BMPs/LIDs at 10 pilot locations and 20 to 40 upland locations.
5. Increase in treated stormwater acreage in the Project area.

PAEP Elements are shown in Table 3. A detailed discussion of selected performance measures is included below.

Output Indicator 1

Effective classification of appropriate runoff BMPs for various site characteristics.

The classification of appropriate BMPs and LIDs for different site characteristics (Output Indicator 1) was achieved. All studied BMPs/LIDs reduced contaminant concentrations in stormwater before it drained into the Reserve. However, site specific and drainage area specific characteristics resulted in effectiveness variations at the monitored sites. Overall, the desirable reduction of concentrations to below Ocean Plan objectives were achieved, with the exception of copper concentrations at several of the sites and PAHs at all monitored sites.

Effective contaminant reduction was observed for the studied LIDs, most notably for the vegetated swales with an underdrain even though street slope/tilt and drainage area size did not always allow for the full treatment of the runoff water. The vegetated swales and grassy swales functioned well and required relatively low maintenance between storms during the wet season. General maintenance (e.g., weeding) was needed periodically.

In comparison, the flume filters needed frequent maintenance due to clogging of the filter material with leaf litter and debris. The performance of the BMPs was in general less successful than the contaminant reduction observed at the LID sites. Additionally, the LID sites with their native plant composition are more aesthetically pleasing and provide good potential for educational outreach. The non-LID BMPs are beneficial in areas where there is not enough space for the installation of a swale or some other types of green infrastructure because they do take up less space and can still be utilized in treating stormwater runoff in areas where LID is not feasible or possibly in addition to stormwater LID.

Output Indicator 2

Number of pathogen source categories identified for prioritizing source remediation actions

Pathogen source categories were identified for prioritizing source remediation actions. Of the tested markers, Dog-associated *Bacteroidales* was the most frequently detected host marker in water, as well as in sediment and biofilms at all sites in the wet season. However, detection was less during the dry season and first flush. Dog feces are a likely contributor to water quality issues in creeks and at beaches. Educational outreach to pet owners was identified as a priority for source reduction. Additionally, the horse-associated indicator was found in high concentrations in Dean and San Vicente Creek during rain events. Equestrian-related BMPs were identified as a priority. The RCD is actively working with private land owners and horse boarding facilities in the ASBS watersheds to remediate the effects of confined animal facilities. Human-associated *Bacteroidales* were detected in water at all sites during the first flush event, but were not present during the dry season. Potential sources for the bacteria are leaky sewer lines, septic systems, and homeless encampments. Overall, less than 5% of the universal *Bacteroidales* concentrations were comprised of the tested host-specific markers, which indicate that uncharacterized fecal sources, such as wildlife or other domestic animals, likely contributed a large amount of fecal pollution. Thus, based on this preliminary evidence, improving management of pet waste and confined animal facilities in the ASBS watershed and further investigating the condition of sewage infrastructure have the potential for improving water quality.

Output Indicator 3

Fully updated maps of storm water conveyance and "trouble spots" to be used for prioritization of BMPs and drainage improvements.

The Storm Drain Inventory and Assessment (Appendix C) conducted at the beginning of the Project resulted in a detailed GIS storm network layer that includes modelled hydrology. The study provided a list of locations with hydraulic deficiencies or "trouble spots" and recommendations for BMP implementation. The storm drain network data layer was later incorporated into the load reduction forecast modelling and BMP/LID prioritization conducted by SFEI as part of the Future Planning task. A detailed discussion of the modelling and prioritization is included in a separate, more comprehensive report produced by SFEI. The report is attached in Appendix J.

Output Indicator 4

Number of "entries" through new ASBS web portal on County's website.

As described above, there were more than 700 views of the ASBS website throughout the Project period. Project website access in combination with newsletter distribution, workshops, flyers, school outreach, social media posts, cross-posting by Project partners, and extensive outreach by the RCD in support of private upland BMPs, led to widespread dissemination of project-related information and pollution prevention education resources to the community.

Output Indicator 5

Number of households reached with ASBS newsletters.

In addition to distribution of over 1,000 hard copies, additional electronic distribution occurred via website posting, electronic mailing, cross-posting on partner websites, and distribution via the Farallone View Elementary Friends of Farallone PTO newsletter following Ocean Week activities. Please see the Education and Outreach section this report for more detailed info related to Output Indicator 5.

Output Indicator 6

Number of regulation revisions and development review applications based on LID principles and information gained from this Project.

As part of the Review of County Policies/Programs and Recommendations to Reduce Stormwater Runoff and Non-Point Source Impacts to Water Quality prepared by EOA, Inc. (Appendix K), existing relevant policies and programs were reviewed and recommendations were made for potential actions and associated improvements to policies and programs to reduce stormwater runoff and non-point source impacts to water quality in the ASBS watershed and to encourage (or where necessary require) appropriately designed and selected BMPs and LID in conjunction with development and maintenance activities. The assessment found that the County has many progressive and constructive strategies already in place, many of which have been improved in recent years as part of MRP compliance. Key recommendations and considerations for future improvements included: revisions to the confined animal ordinance (i.e., increased frequency of permit reviews, education component); new or updated ordinance to address animal excreta from other domestic animals; development of support resources (i.e., addition of GI information to department websites, employee training on Bay-Friendly Landscaping practices, tools to prioritize selection and implementation of GI BMPs in the ASBS watershed) for public GI; improvements to stormwater management review process and support resources for private development projects (i.e., implementation of new and modified regulatory mechanisms to increase the pace of GI conversion and retrofitting on private property, implementation of new rebate programs to incentivize retrofitting existing properties with rain barrels, rain gardens, pervious pavement, and green roofs, development of an LID/GI guidance brochure or booklet primarily targeted to small-scale and residential projects). Many of the recommendations for improvements of policies and programs related to GI will be incorporated into upcoming GI master planning efforts that will be conducted in relation to the recent MRP Provision C.3 revisions. The RCD-led private LID component of this project provided useful 'lessons learned' for small-scale private residential projects during the County permitting and review process and during implementation (see "Lessons Learned" section of RCD report included as Appendix G). The lessons learned in combination with community demonstration aspect of the project provided great momentum for facilitating and encouraging future implementation of private GI in the ASBS watershed. Many of the recommendations from the policy review report were included in the Fitzgerald ASBS Compliance Plan (County of San Mateo 2015), and as such are being incorporated into County planning decisions and program development as the County prepares to comply with the ASBS Special Protections, MRP, the upcoming San Vicente Creek TMDL/Water Quality Improvement Plan.

Output Indicator 7

Percent of property owners participating in BMP implementation program

The RCD successfully engaged nearly 500 residents of Montara and Moss Beach through outreach activities, not counting those that were reached through social media, the web, and fliers posted at community businesses and gathering places. The RCD-led outreach during Farallone Elementary School Oceans Week event in May 2013 involved outreach to approximately 385 children, 35 adults, and an unknown number of parents who received information via flyers and the PTO newsletter. To recruit participation in the Project, the RCD completed 22 site visits to private properties and equestrian facilities to assess ways to reduce stormwater runoff and reduce potential sources of pollution. Sustainable backyard site assessments were completed for 16 properties. The RCD implemented 25 BMPs on seven residential properties during the course of the project. The RCD hosted a site demonstration tour for the private BMPs in January 2016 and 19 participants, most of whom are property owners in the upland watershed area, attended. The associated on-line community survey had 27 respondents. Many respondents (42 to 62%) indicated that they were willing to add features such as those implemented through the project, specifically capturing rainfall, adding rain gardens or bioswales, planting native plants, or replacing concrete with permeable alternatives. For more detailed information related to private BMPs, see the RCD report included as Appendix G.

Outcome Indicators

The percent decrease in AB 411 standard violations (Outcome Indicator 1) refers to beach sanitation under the Health and Safety Code. The monitored sites were all storm drains that discharge directly into the ocean within the ASBS, and these areas would not be captured by regular beach monitoring for bacteria. Additionally, a thorough assessment of beach sanitation issues and improvements would require at least ten years of data after implementations of BMPs/LIDs to account for climatic variation and rainfall.

The percent decrease in receiving water standard exceedances for monitored contaminants (Outcome Indicator 2) and the goal for all high threat discharges to approach water quality objectives (Outcome Indicator 3) could not be evaluated at this time. The Central Coast Areas of Special Biological Significance Regional Dischargers Monitoring Program is currently in progress. Monitoring associated with that program will characterize and provide background pollutant levels for high threat discharges and ocean receiving waters as well as define natural water quality based on reference site sampling.

Table 3. PAEP Elements for load reduction activities in Treatment of Stormwater Runoff that discharges into the Fitzgerald Marine Reserve, a designated Area of Special Biological Significance.

Project Goals	Desired Outcomes	Output Indicators	Outcome Indicators	Measurement Tools and Methods	Targets
1. Prevent dry-weather discharges of polluted water 2. Prevent introduction of wastes into storm water runoff 3. Intercept and filter nonpoint source waste during wet weather as adjunct to prevention 4. Education and outreach to communicate significance and values of ASBS to increase enjoyment of resources, and to provide the community with resources, technology, and tools for protecting resources.	1. Zero discharge from all high-threat discharges into the ASBS during dry season. 2. Bring wet-weather runoff into compliance with water quality standards. 3. Reduce storm water runoff.	1. Effective classification system of appropriate runoff BMPs for various site characteristics. 2. Number of pathogen source categories identified for prioritizing source remediation actions. 3. Fully updated map of storm water conveyance and "trouble-spots" to be used for prioritization of BMPs and drainage improvements. 4. Number of "entries" through new ASBS web portal on county's website. 5. Number of households reached with ASBS newsletters. 6. Number of regulation revisions and development review applications based on LID principles and information gained from this project. 7. % of property owners by land uses class participating in BMP implementation program.	1. % decrease in AB 411 standard violations. 2. % decrease in receiving water standard exceedances for monitored contaminants. 3. All high-threat discharges approaching water quality objectives.	1. AB 411 indicators following standard BEACHES protocol 2. Results of survey modeled after Michigan DEQ – Social Monitoring and Evaluation Guidance 3. SWAMP-compatible methods for water quality constituents and methods provided in monitoring plan and QAPP 4. Workshop attendance and private landowner participation in BMP program	1. Dry-season flow reduction or elimination at high-threat discharge locations by end of project. 2. A minimum of 20 structural and non-structural storm drain BMPs have been tested and evaluated by end of project. 3. A minimum of five landowners in ASBS drainage area have signed up for BMP implementation by end of project. 4. Pathogen source tracking study shows likely pathogen sources by Spring 2013. 5. >2,000 web portal entries by end of project. 6. All appropriate ASBS and feasible alternative storm water management measures have been reviewed by Planning and Building Department for future development reviews and regulation updates. 7. 100% of mid-coast households have received ASBS newsletter. 8. Zinc, copper, lead to not exceed 200, 30, and 30 ppm, respectively as outlined in the Basin Plan Objective; 9. Total suspended solids (TSS) not to exceed 500 ppm (Basin Plan Objective)

Conclusions

As demonstrated above, the Project was very successful. Pollutants of concern in stormwater runoff were identified. The County gained a better understanding of sources of bacterial contamination. Hydraulic deficiencies within the storm drain system were identified. Twenty-one storm drain BMPs were implemented resulting in measurable load reductions to the ASBS. Sixteen sustainable backyard assessments were conducted. Twenty-five residential LID BMPs were implemented. An extensive education and outreach program was initiated. Future planning studies and load reduction forecasts resulted in recommendations for future projects, policy changes, and program to continue with water quality improvements in the watershed. While these accomplishments are very clear based on the summary provided above and the data and summaries presented in the Project-related reports, another invaluable result of the project is the lessons learned. Lessons learned and next steps are detailed below.

Lessons learned

It is widely recognized that stormwater treatment measures such as stormwater diversion to the sanitary sewer system with subsequent treatment at a POTW or a typical LID bioretention system designed to comply with MRP C.3 requirements (i.e., treatment surface area of approximately 4% of the impervious surface for tributary drainage area, infiltration rate of 5” per hour, 18” biosoil layer, 12” drain rock layer and underdrain, extensive curb work, and native vegetation - SMCWPPP (2014)) are the most effective options for water quality improvement, particularly from a treatment prospective and given secondary benefits such as aesthetics, greening, traffic calming, etc. However, they are not always feasible given existing site conditions and can be cost prohibitive. While the standard LID bioretention design may have better load reduction capability and is a good long-term goal as new roadway projects come on-line, in the short-term for this Project, the County was interested in examining other lower cost retrofit options such as vegetated swales and filtration devices. We found that retrofit opportunities can be limited for those BMP types as well due to multiple factors described below.

The MidCoast is unique in that it is still rural in nature. The majority of the area lacks sidewalks, curb and gutter, and instead has a system of informal ditches, roadside drainages, and culverts. The swales implemented as part of the Project were retrofits of ditches or informal shoulder drainages. To keep costs down and to allow the County to test and implement a larger number of BMPs, the retrofits were implemented as design/build (not fully engineered plans) projects and were often constrained by site conditions such as:

- short distance of existing ditch segments
- narrow right-of-way widths
- slope limitations due to existing culvert and driveway pipe inverts
- lack of engineered storm drain system for underdrain system connection
- permeability of existing soils
- existing utilities
- existing roadway drainage patterns (i.e., storm water inflow mid-way along existing ditch)
- construction cost
- presence of environmentally sensitive habitat and special-status species (i.e., existing wetlands, California red-legged frog)

One lesson learned with regards to the swales was that sizing influenced treatment effectiveness. Even though all BMPs/LIDs contributed to some extent to cleaner runoff discharging into the ASBS, the most successful concentration and load reductions were achieved with vegetated swale sites that included an underdrain and where the treatment area was roughly between two and four percent of the discharge area. This size ratio prolonged the residence time of the stormwater runoff within the swale long enough for successful filtration and absorption of pollution. In general, prolonged residence times for stormwater runoff within a treatment system seemed to aid reduction in contaminant concentrations. For the future, if site characteristics allow for greater infiltration and the swale length can be maximized thereby reducing flow and velocity, then treatment effectiveness will likely be improved. Reducing velocities of stormwater within the swale will also help to avoid scouring and resuspension of filtered sediment and contaminants, as well as plant material.

The installation of larger treatment areas closer to the recommended ratio of 1:25 (4% of the catchment area) would likely provide more effective treatment and contaminant reduction and is recommended for future projects. For this Project however, there was not enough adequate right-of-way space for retrofitting existing ditches with vegetated swales of the appropriate treatment size in the desired direct ASBS outfall drainages. To do so, would have increased the cost drastically beyond the scope for this Project's budget.

Another option to increase treatment effectiveness is the placement of multiple BMP features within a given drainage to increase treatment area for sites with larger drainage areas; however, such site configurations have not been well studied. Such configurations could be given more attention and a thorough monitoring and evaluation of their effectiveness should be completed since they may be an innovative, effective, and more feasible approach considering space and budgetary constraints of LID projects.

Another lesson learned from this Project was the challenges of monitoring to determine BMP effectiveness. Monitoring was challenging due to variations in site characteristics and large variations in influent concentrations. As summarized by SCCWRP (2015), influent concentrations were variable among BMPs. For example, the pilot phase grassy swale had the greatest concentration of TSS, but the lowest concentration of copper amongst the four BMPs. The StormFilter had the greatest concentration of copper, but the lowest concentration of TSS. The vegetated swale had the greatest concentration of lead, but the lowest concentration of nitrate. Concentration reductions also varied by BMP and by constituent. Therefore, it was challenging to draw conclusions and make recommendations when one BMP was very efficient at reducing a given pollutant, and less efficient at reducing another pollutant.

Site characteristics proved to be another major challenge. Near source pollutant inputs were a concern. For example, at some locations there were likely inputs of vehicle-derived pollutants like PAHs and copper due to the close proximity of roadways and near-source pathways for loading (wind, input from roadway mid-way through swale). For several of the sites, runoff entry mid-way into the swale during larger rainfall events was observed. Therefore, portions of the flow were not treated, and there may have been additional pollutant inputs. Even though the composite samples did not allow for individual reduction evaluation during low flow periods, it was observed that greater amounts of runoff infiltrated during light rain, and it can be assumed that greater pollutant reduction occurred within the treatment area at these times. For other pollutants, such as permethrin, with sources often located farther upstream of the swales, reductions were greater. Other observed near-sources inputs included sediment from gopher activity upstream and within the swales, pet waste within the treatment areas, and at the StormFilter site, an accumulation of sediment within the existing outflow pipe.

The Green Street Improvement Project on Carlos Street involved installation of two bioretention systems that were designed per C.3 guidelines. This was the County's first green street installation, and there were many lessons learned. One lesson learned was to investigate utility conflicts early on, including utility lateral connections. Another concern that was voiced from local property owners was future access and development. There was concern that construction of the bioretention facility would prohibit access to the property for future development or would increase costs for future access and utility connections. Another major issue was safety concerns in relation to pedestrians (i.e., swale crossings, curbs and tripping hazard). The County was proactive in including two crossings over each bioretention area, but there were still concerns as pedestrians tried to traverse the bioretentions areas rather than using the designed crossings. Plant growth was limited due to the drought, so the plants did not reach desired height and fullness in the short-period following construction. Taller plants are more likely to deter foot traffic. Following complaints, the County added additional plants to deter foot traffic through the swale and added signage cautioning about the uneven surface. For future projects, a recommendation would be to have pre-project community meetings to gain input early on, to provide more crossings, when feasible to choose a design that reduces the need to traverse the area or limits extensive curb work, and to plant larger, taller plants early on.

Other lessons learned included the high cost and frequency of maintenance, especially given the drought conditions during the project period. The swales required more supplemental watering than was expected due to the lack of rain during they typical rainy season. The swales have also required routine weeding, supplemental planting, and sediment removal at constructed weirs. The flume filters required frequent maintenance including sediment and debris removal and filter replacement. The required frequency is likely to vary based on site conditions. To date, the StormFilter site has only required maintenance once per year. However, the site does not have a high amount of leaf litter, debris, or trash. If installed at another more impacted location, maintenance frequency may increase. More details are provided in the O&M Plan included in Appendix I.

In general, all of the installed BMPs resulted in pollutant reductions. Based on the pilot phase monitoring, vegetated swales were recommended for Phase 2 based on effectiveness, a short period of observation for maintenance, and aesthetics, but it is important to note that the filter-based BMPs are a useful option as well. The flume filters were a good, low cost option for the very small bluff drainage areas where infiltration-based and higher cost options were not practical. The StormFilter cartridge retrofits were very costly in relation to treatment area and required a larger footprint than other BMPs but provide an alternative to vegetated swales, especially in areas with engineered catch basins. We also anticipate better performance than what was observed during this project due to the potential input of pollutants from the outflow pipe after exiting the treatment system.

Deviations from the C.3 LID design guidelines allowed for more widespread low cost implementation of BMPs/LIDs within 10 of the 11 direct ASBS storm outfall drainage areas and testing of a variety of BMP/LID types to help guide future implementation. Two of the BMPs that were implemented were designed to meet C.3 criteria, Green Street Improvement Project on Carlos Street and the FMR Parking Lot. For reference, the Carlos Street site treats approximately 0.6 acres, and construction costs were approximately $225,000. For the Bay Area, costs of pilot green streets projects typically ranged from $200,000 to $500,000 per acre (BASMAA 2013). For reference, the swales were approximately $8,000 per acre with the grassy swales on the low end, and the more complex vegetated swales with underdrain systems and weirs on the high end. While the swales may not have had as high of treatment efficiency as the more engineered systems, pollutant reductions were observed, and that is very useful information as the County moves forward with future BMP planning efforts and compliance with the ASBS Special Protections.

Future LID planning is important, and the site locator tool output by SFEI, provides a useful planning tool for the County to consider multiple types of BMPs. The County is interested in installing more C.3-type LID projects but implementation will require more targeted siting and a long-term planning effort to coordinate with transportation entities, incorporate multi-benefit 'complete street' elements, and to coordinate funding. Because of the high cost of LID systems such as what was installed at Carlos Street, municipalities often look for grant funding. However, that can be challenging due to the long-planning efforts versus typical stormwater granting time frame. There are several upcoming planning efforts that will offer opportunities to incorporate LID and green infrastructure (e.g., Connect the Coastside and the newly adopted MRP C.3.j Green Infrastructure Planning and Implementation requirements). The output from future planning study and other lessons learned from this study will facilitate the planning and prioritization process.

The most important lesson learned is that there is no single solution for water quality improvement, and a 'one size fits all' approach does not work for unique, more rural communities like Montara and Moss Beach. We learned that given the challenges with storm drain BMP siting, limitations with retrofit opportunities, and the high cost for treatment once in the storm drain system, source reduction measures are essential and that behavioral change through education and outreach and a demonstration-based model are equally as important given the challenges related to implementation of storm drain BMPs.

Additional lessons learned and challenges related to private LID BMP implementation are detailed in the final RCD report included as Appendix G.

Next Steps

Recommended next steps for continuation of the Fitzgerald ASBS Pollution Reduction Program include:

- Continued education and outreach particularly in regards to source reduction actions like pet waste management, alternative household pesticide products, residential LID opportunities, equestrian BMPs, and sewer later/septic system maintenance
- More LID implementation based on the prioritization results from the Future Planning Report
- Implement recommendations from MST Study
- Implement recommendations from the Assessment of County Policies and Programs Related to Water Quality

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Appendices

Appendix A

Pilot BMP Pre- and Post-Construction Photo Documentation

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20A%20Pilot%20Photos.pdf

Appendix B

Pilot Storm Drain BMP Summary Report

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20B%20Pilot%20Summary.pdf

Appendix C

MidCoast Storm Drain Inventory and Assessment Project
Drainage Report

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20C%20Storm%20Drain%20Inventory1.pdf

Appendix D

Microbial Source Tracking Study

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20D%20MST.pdf

Appendix E

Phase 2 Storm Drain BMPs
Pre- and Post-Construction Photo Documentation

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20E%20Phase%202%20Photos.pdf

Appendix F

Phase 2 Storm Drain BMP Summary Report

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20F%20Phase%202%20Summary.pdf

Appendix G

Phase 2 Upland Private BMPs
Final Report

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20G%20Phase%202%20Upland%20Private%20BMPs%20Final%20Report.pdf

Appendix H

Education and Outreach Materials

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20H%20Ed%20%26%20Outreach.pdf

Appendix I

BMP Operation and Maintenance Plan

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20I%20Fitzgerald_BMP_O%26M_0216161.pdf

Appendix J

Future Planning Report

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20J%20Future%20Planning%20Report.pdf

Appendix K

Assessment of County Policies and Programs Related to Water Quality

http://smchealth.org/sites/default/files/docs/EHS/Appendix%20K%20Policy.pdf