Assessment and Management Prioritization Regime for the Bar-built Estuaries of San Mateo County

Summary Report

Prepared for:
United States Fish and Wildlife Service
San Francisco Area Coastal Program

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BACKGROUND AND NEED

What are BBEs and Why are they Important

Bar-built Estuaries, also termed river mouth lagoons, bar-built lagoons, coastal river mouths and coastal confluences, are the terminus of creek and river mouths that flow to the coast, yet close to ocean influence periodically through the formation of a sand bar or small barrier beach (Figure 1). These bar-built estuaries represent an important and unique subset (271 in total) of estuaries within California. The unique ecological services provided by these Bar-built estuaries are influenced by the seasonal closures of their tidal inlets).

Figure 1.Conceptual figure of a) open, b) partially open, and c) closed bar-built estuary.

The frequency and duration of inlet closure can be natural or managed. Many of these systems exhibit prolonged muted or non-tidal periods when ocean and river mixing is restricted leading to highly variable salinity regimes, ranging from fresh to hypersaline (Figure 2).

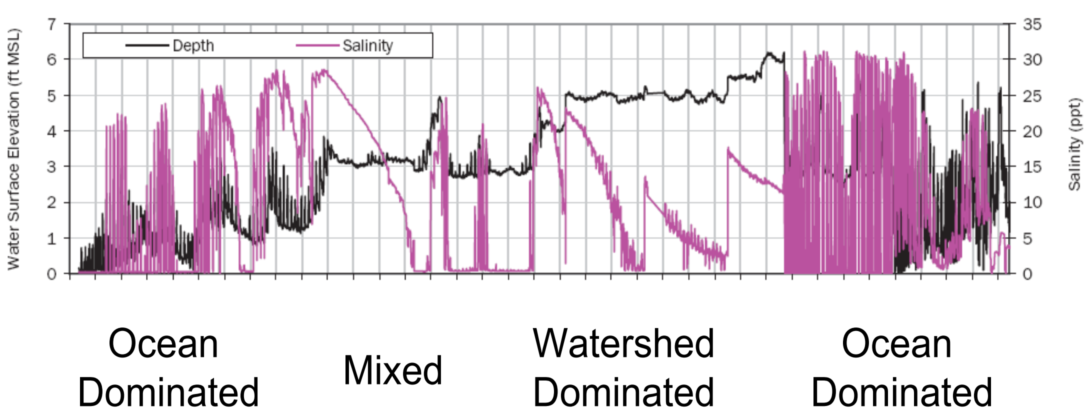


Figure 2.Hydrograph indicating variability in depth and salinity of a BBE over time.

California's Bar-built Estuaries are unique habitats that provide valuable services to important species. Water salinity within these systems fluctuates wildly, creating a mosaic of water chemistry conditions and supports a unique set of ecological services that benefit rare and endangered species including steelhead trout and tidewater gobies. Adjacent land uses and alterations to natural closure and breaching dynamics have been shown to severely impact physical diversity and reducing ecological services for many of these species.

As urban development continues to expand along the California Coast, these systems often face varying degrees of alteration to accommodate development. Alterations to upstream habitat, increasing demand for freshwater and future impacts of climate change and sea level rise all further threaten these habitats and the services they provide. Being at the bottom of watersheds bar-built estuaries accumulate impacts from upstream stressors creating both a management challenge and a monitoring opportunity.

As land uses change adjacent to and with the watershed of BBEs, some impacts and alterations (legal water diversions, flood protection for adjacent land uses and protection of coastal infrastructure including Highway 1) to these estuaries are unavoidable. However, there are a number of lagoon characteristics that can be improved even in the face of inevitable human impacts (i.e. temperature, nitrogen availability, circulation dynamics and food chain dynamics). State regulatory agencies are routinely tasked with making management decisions through permitting of construction projects and breaching activities without a full understanding of the impact of these projects. Management strategies often focus on specific species, services or environmental objectives (i.e. water quality) sometimes in ignorance of or detriment to other services and species.

BBE are the most dominant estuarine resource on the San Mateo County coastline

To support restoration, enhancement and conservation of California's estuaries, the Central Coast Wetlands Group at Moss Landing Marine Labs (CCWG), with support from The Nature Conservancy and USEPA, completed an inventory and classification of all coastal confluences in California. Previous inventories, assessments and classifications of estuaries along the West Coast have occurred but were usually limited to a subset of larger estuaries.

We completed a comprehensive inventory of estuaries from California's 576 coastal confluences. Information from previous estuarine inventories were compiled and additional estuaries were identified using National Wetlands Inventory (NWI) maps and aerial imagery interpretation. Within this inventory and associated geodatabase, we generated a georeferenced polygon, and populated an excel database with other locational information, size, and noted all estuarine classifications of previous inventories and a project specific classification using the CCWG Classification system (Table 1). This effort provided the sample frame from which sites were selected for the verification and validation of the California Rapid Assessment Method for Wetlands (CRAM) for these systems.

Table 1.CCWG Coastal Confluence Classification system

Coastal Confluence Type	**Description**
Bar-Built Estuary	In systems with a strong fluvial influence, there is sign of estuary mouth closure by the formation of a sand bar at some point during the year. A pond forms behind the bar and connection with the marine environment is reduced or eliminated.
True Lagoon	Similar to bar-built estuaries, a sand bar forms across the mouth of the system creating a pond or lake with reduced or severed connection with the marine environment. However there is a very small watershed and little fluvial influence and the system opens infrequently.
Bay/Open Estuary	open bay with fringing estuarine wetlands or semi-enclosed estuary that is always open to tidal action.
Creek Mouth	a small coastal confluence that does not close off to the marine environment from the formation of a sand bar or form a ponded system. This may be due to natural reasons (steep gradient or large grain size on the beach), or anthropogenic in that it used to be a BBE but lost all habitat and ability to close.
Open River Mouth	A very large coastal confluence that does not close to the marine environment due to large freshwater flows or local geology, but shows some effect of a bar formation.
Urban Drain	a coastal confluence in an urban setting with no obvious watershed area or historical drainage feature.

The inventory effort recorded a total of 46 coastal confluences in San Mateo County (Figure 3). Of that, 25 are bar-built estuaries, 18 are creek mouths, 1 is an open estuary, 1 is a bay/harbor, and 1 is a coastal depression. There were a total of 307.4 hectares of wetland habitat (Figure 4) mapped within the 46 systems. As calculated by total area, number of systems and range of geographic distribution, bar-built estuaries make up the dominant coastal confluence type on the San Mateo County coastline. Figure 4 illustrates how the total area of coastal confluence wetland habitat is distributed among the five confluence types.

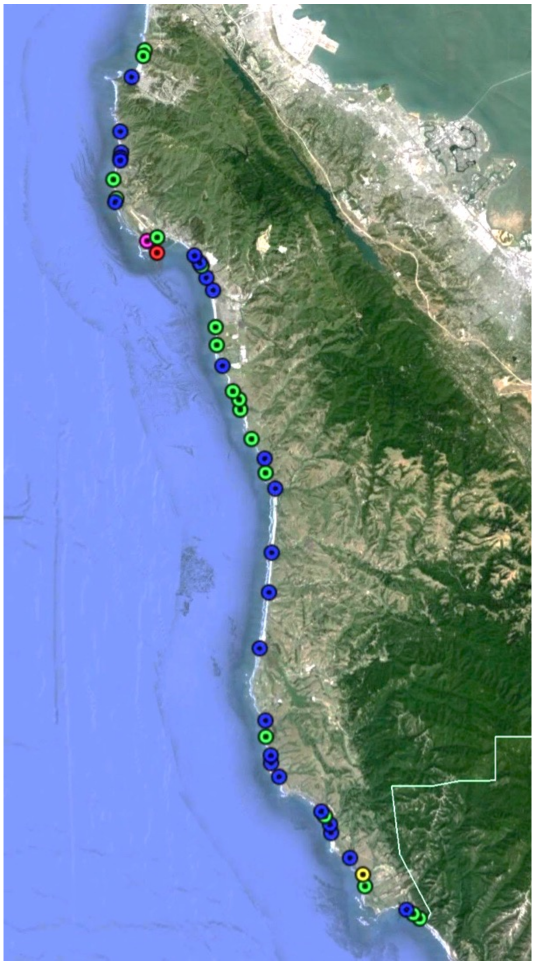


Figure 3. Locations of all coastal confluences in San Mateo County. (blue=BBE, green=creek mouth, red=bay/harbor, pink=open estuary, yellow=coastal depression).

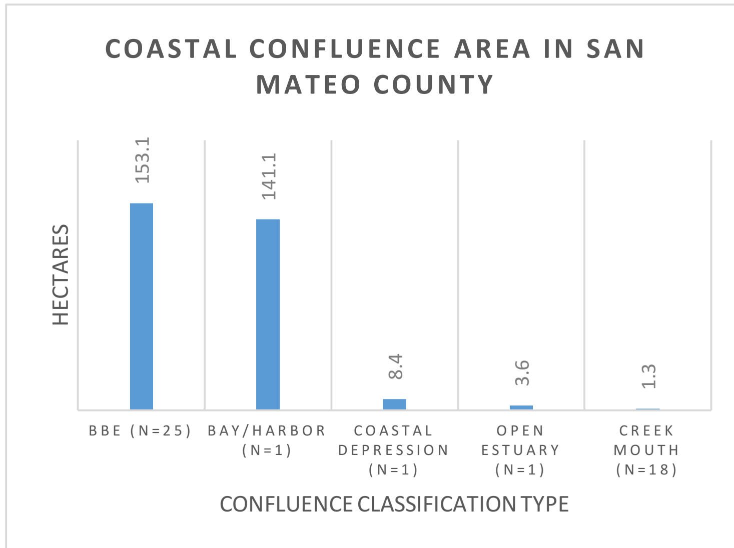


Figure 4.Coastal confluence area (hectares) by confluence classification type in San Mateo County

PURPOSE

This San Mateo County BBE Project aims to improve our regional understanding of the current ecological services these systems provide to this coastal area. To quantify the current condition and level of human degradation that has occurred within these drainages, we used the California Rapid Assessment Method for BBEs in combination with an evaluation of watershed and land cover stressors, and an analysis of wetland habitat loss since the 1850's. This project attempts to provide the information necessary for resource managers to prioritize management strategies that enhance lagoon ecosystems for multiple objectives and establish standard mechanisms to quantify the effectiveness of implemented actions.

This project provides the USFW San Francisco Area Coastal Program with several possible prioritization options to strategically allocate federal funding for on-the-ground efforts to improve habitat conditions of bar-built estuaries within the San Mateo coast focus area. In addition, this document provides a summary of information available within the California Coastal Confluence database which describes the region's BBE condition, use by protected species, and anthropogenic stressors of the bar-built estuaries and their watersheds.

METHODS

Site Selection

With input from USFWS staff, CCWG selected 20 of the 25 bar-built estuaries on the San Mateo County coast to investigate (Figure 5), along with one coastal depression (Cascade Creek). The estuaries range in size from .08 to 173 hectares, with an average size of 16 hectares. Sixteen of the estuaries are owned or managed by California State Parks or a local Land Trust. The remaining 5 are in private ownership.

Figure 5 Selected sites in San Mateo County

Existing plans and reports

Management plans and biological reports exist for several of the estuaries and the watersheds within the project region, written by private consultants and government agencies. CCWG compiled all existing plans and reports that reference the 21 bar-built estuaries within this study and their associated watersheds.

Wetland Habitat Condition

In 2013 CCWG produced a module for CRAM for BBEs throughout California. Unique processes such as beach bar formation, seasonal flooding, and ocean overtopping create variability in surface water elevations and salinity gradients that are unique to these systems.

Using simple, repeatable field measurements and visual indicators of ecological condition, two trained practitioners working together can assess the overall condition of a BBE within hours. Seventeen assessment Metrics, each categorically estimating the relative condition of various wetland features are organized into four functional Attributes: Buffer and Landscape Context, Hydrology, Physical Structure, and Biotic Structure. Each Attribute score is derived by a mathematical combination of its associated metric scores. An average of all four Attribute scores calculates the overall "Index" or condition score for that assessment area. Index scores can range from 25 to 100, and are meant to encompass the entire range of possible condition within California. In addition to Metric, Attribute, and Index scores, CRAM compiles a list of anthropogenic stressors found at each site which can attribute to lower condition scores and be used to develop management strategies. Assessments of wetland habitat condition were conducted at all 21 sites in 2014 and 2015. For systems less than 2.25 hectares, the assessment area covered the entire system. For BBEs larger that 2.25 hectares, multiple assessments were completed to calculate an average condition score.

Watershed Stressors

Landscape level investigations of potential stressors were conducted for each estuary. The watersheds of each estuary were demarcated using Watershed Delineation Tools in ArcGIS. The predominance of different landform modifications and land cover types that can affect the condition of downstream wetland habitat were calculated for each bar-built estuary. The effects of watershed stressors on downstream BBE resources was studied at four different scales: 1) the entire watershed; 2) a 2 kilometer area surrounding the bar-built estuary; 3) within a 30 meter buffers of all watershed streams; and 4) within a 30 meter buffers of all streams within the 2 kilometer area surrounding the bar-built estuary. These four geographic scales test the significance of various landscape scale stresses on bar-built estuary habitat. Our previous research throughout California has shown these four landscape scales to be useful in highlighting the influence of different stressors on condition and in prioritizing management actions.

Wetland Habitat Loss and Change

For each bar-built estuary we compared the current relative cover of different wetland habitat types with estimates of historical cover (approximately 150 years ago) using U.S. Coastal Survey Topographic Sheets (T-sheets) created in the mid to late nineteenth century to estimate changes and loss of wetland acreage. We used 2012 aerial imagery available from the National Agriculture Imagery Program (NAIP) to delineate the distribution of various wetland types, using the same wetland classification system applied to the historical habitat composition analysis (Appendix 1). All maps were geo-rectified and delineated using ArcGIS. Percent loss, percent change and absolute loss of each habitat type as well as total wetland acreage was calculated using R. The resulting maps and quantitative data were used to document change and prioritize restoration and conservation actions among systems within the county.

Special Status Species

For each bar-built estuary we searched through peer-reviewed literature, agency reports (e.g. USFWS, CDFWS, NMFS, USGS, County etc.). and CNDDB for the presence (or habitat provided for potential without documented occurrence) of a list of 10 focal special status species listed under the endangered species act. Species presence was recorded for each system with source information references. The species include:

- Snowy Plover
- Coho
- Steelhead
- Western Pond Turtle
- Tidewater Goby
- Red-Legged Frog
- SF Garter Snake
- Saltmarsh Common Yellowthroat
- Monarch Butterfly
- Brackish Water Snail

RESULTS

Existing plans and reports

A multitude of plans, reports and research studies have been generated for the San Mateo County Coastline. Table 2 lists reports and websites available for the larger systems along the coast. Several county wide or regional reports provide information on numerous lagoons. An overwhelming majority of the information available is for the Pescadero/Butano Lagoon and watershed. Most of the references listed in the following table for Pescadero come from the TMDL written by the SF Bay Regional Water Quality Control Board.

Table 2. Existing plans and reports for several San Mateo County Bar-Built Estuaries listed in order from north to south.

Site Name	Plans and Reports
San Pedro Creek	• Collins, Amato and Morton. 2001. San Pedro Creek Geomorphic Analysis (http://online.sfsu.edu/jerry/pedrocreek/geomorphology/Default.htm)
Pilarcitos Creek	• Todd Engineers. 2003. Lower Pilarcitos Creek Groundwater Basin Study. Prepared for the Coastside County Water District, Half Moon Bay, CA. • PWA, Ltd. 2008. Pilarcitos Integrated Watershed Management Plan. Prepared for San Mateo County RCD, Half Moon Bay, CA. • Balance Hydrologics. 2010. Pilarcitos Lagoon Habitat Enhancement Feasibility Study: Final Report. Prepared for San Mateo County RCD, Half Moon Bay, CA.
San Gregorio Creek	• Stillwater Sciences. 2010. San Gregorio Creek Watershed Management Plan. Prepared for the Natural Heritage Institute, San Francisco, CA. • San Gregorio Watershed Information System: http://sgreg.stillwatersci.com/
Pescadero/Butano Creeks	• Viollis, Frank S. 1979. The Evolution of Pescadero Marsh. Master's Thesis. San Francisco State University, San Francisco, CA. • Curry, Robert, R. Houghton, T. Kidwell, and P. Tang. 1985. Sediment and Hydrologic Analysis of Pescadero Marsh and its Watershed. Draft. University of California at Santa Cruz. Prepared for California Department of Parks and Recreation, Sacramento, CA. • Bergolar Geotechnical Consultants. 1988. Geotechnical Report, Pescadero Marsh, Pescadero State Beach, California. Prepared for the Office of the State Architect. 62 pp. • Philip Williams & Associates. 1990. Pescadero Marsh Natural Preserve Hydrological Enhancement Plan. Prepared for California Department of Parks and Recreation. • Smith, Jerry J. 1990. The Effects of Sandbar Formation and Inflows on Aquatic Habitat and Fish Utilization in Pescadero, San Gregorio, Waddell and Pomponio Creek Estuary/Lagoon Systems, 1985-1989. Prepared for California Department of Parks and Recreation. • California Department of Parks and Recreation. 1992. Pescadero Marsh Natural Preserve Hydrologic Enhancement Project. • Smith, Jerry J. and D.K. Reis. 1997. Pescadero Marsh Natural Preserve Salinity, Tidewater Goby and Red-Legged Frog Monitoring for 1995-1996. Prepared for California Department of Parks and Recreation. • Swanson Hydrology & Geomorphology. 2001. Hydrologic Issues regarding Management of Pescadero Marsh in light of Enhancement Projects completed in 1993 and 1997. Prepared for California Department of Parks and Recreation. • Environmental Science Associates. 2002. Butano Creek Cross Sections Survey Report. Prepared for California Department of Parks and Recreation, San Francisco, CA. • Pacific Watershed Associates. 2003. Sediment Assessment of Roads and Trails within the Pescadero/Memorial/San McDonald County Park Complex, Pescadero Creek Watershed, San Mateo County,

	CA. • Balance Hydrologics, Inc. 2003. Water Supply Alternatives, Fish Passage and Use, and Streambed Conditions at Memorial County Park, San Mateo County, California. Prepared for San Mateo County Parks and Recreation Division and California Department of Fish and Game. • Environmental Science Associates. 2004. Pescadero-Butano Watershed Assessment. Report by Environmental Science Associates, Pacific Watershed Associates, O'Connor Environmental, Albion Environmental and D. Jackson. Prepared for Monterey Bay National Marine Sanctuary Foundation, Monterey, CA. • Pacific Watershed Associates. 2004. Sediment source analysis for Pescadero-Butano watershed in Pescadero-Butano Watershed Assessment by ESA. p 6-1 to 6-54. • Abram, D.,Clarke, D. Jordan, E., and Salmon, P. 2006. Reconstructing the sediment history of Pescadero Lagoon- preliminary report (PDF). Liverpool, University of Liverpool: 4. • Kamman Hydrology and Engineering, Inc. 2006. Data Synthesis and Hydrodynamic Model Development Feasibility Report for Pescadero Lagoon, San Mateo County, California. • Sloan, Rebecca M. 2006. Ecological Investigations of a Fish Kill in Pescadero Lagoon, California. Paper 3032. http://scholarworks.sjsu.edu/etd_theses/3032 • Environmental Science Associates. 2008. Pescadero Marsh Restoration Assessment and Recommendations for Ecosystem Management. Prepared for California Department of Parks and Recreation, Half Moon Bay, CA. • Smith Jerry J. 2008. Estuary/Lagoons as Habitat: Implications for the Pescadero Creek Estuary Complex. PowerPoint presentation. Pescadero Marsh Restoration Forum, December 9, 2008. • Smith, Keenan A. 2009. Inorganic Chemical Oxygen Demand of Re-suspended Sediments in a Bar-Built Lagoon. Master's Theses. Paper 3346. http://scholarworks.sjsu.edu/etd_theses/3346 • Smith, Keenan A. 2009. Inorganic Chemical Oxygen Demand of Re-suspended Sediments in a Bar-Built Lagoon. Master's Theses. Paper 3346. http://scholarworks.sjsu.edu/etd_theses/3346 • Center for Ecosystem Management and Restoration. 2010. Considerations for Restoration of the Pescadero Marsh. A Report Based upon the Proceedings of the December 2008 Public Forum Restoration of Pescadero Marsh: Identifying Problems and Exploring Solutions. Prepared for the Pescadero Marsh Working Group. • Atkinson, Kristine A. 2010. Habitat Conditions and Steelhead Abundance and Growth in a California Lagoon. Paper 3746. http://scholarworks.sjsu.edu/etd_theses/3746 • Donaldson, Eric T. 2011. Geomorphic Controls on Spatial Distributions of Cobbles and Boulders in Stream-Channel Networks. Master's Thesis. 112 pp. • ESA PWA. 2011. Geomorphic Evolution of Pescadero Marsh: 1987-2011, Results of Field Monitoring and Data Collection 75 pp. • SFBRWQCB. 2013. Pescadero-Butano Watershed Sediment TMDL. Oakland, CA. • Center for Ecosystem Management and Restoration. San Gregorio & Pescadero Creeks Watersheds webpage: http://www.cemar.org/SanMateoCounty.html
Gazos Creek	• Coastal Watershed Council. 2003. Gazos Creek Watershed Assessment and Enhancement Plan • Steven Singer Environmental and Ecological Services. 2010. Results of marbled Murrelet Radar Surveys in the Gazos Creek Watershed (2000-2010). Prepared for Apex Houston Trustee Council, Sacramento, CA.
Countywide	• San Mateo Countywide Storm Water Pollution Prevention Program. 2004. Assessment of Sediment Management Practices in Six High Priority Watersheds in San Mateo County • California Coastal Commission. 2006. Nonpoint Source Watershed Assessment: James Fitzgerald Marine Reserve Critical Coastal Area. Oakland, CA. • SFBRWQCB. 2007. Water quality monitoring and bioassessment in nine San Francisco Bay Region watersheds: Walker Creek, Lagunitas Creek, San Leandro Creek, Wildcat Creek/San Pablo Creek, Suisun Creek, Arroyo Las Positas, Pescadero Creek/Butano Creek, San Gregorio Creek, and Stevens Creek/Permanente Creek. Oakland, CA. • Center for Ecosystem Management and Restoration. 2008. Steelhead/Rainbow Trout (Oncorhynchus mykiss) Resources South of the Golden Gate, California. Prepared for the California State Coastal Conservancy, Oakland, CA. (http://www.cemar.org/ssrp.html)

Wetland Habitat Condition

An evaluation of the habitat condition for each of the 21 selected sites, using CRAM, revealed a range of overall condition scores (CRAM Index Score) between 46 and 76 for the bar-built estuaries of San Mateo County (Table 2). Maximum condition score within the county was significantly lower than the state maximum of 90. The San Mateo County BBEs were found to have a lower average and highest condition BBE compared with the central coast region as a whole. The highest scoring BBE in San Mateo County was Spring Bridge Gulch with a score of 76. The highest scoring BBE in the Central Coast was Little Pico Creek which received a score of 89. The highest scoring BBE in the state was Wilder Creek which received a score of 90.

*Table 3. CRAM Index and Attribute scores for all sites in order from north to south. Sites with an * show an average score from multiple assessments due to their large size. Note that Cascade Creek was assessed as a Depression, not a BBE.*

Site Name	Index Score	Buffer and Landscape Connectivity	Hydrology	Physical Structure	Biotic Structure
San Pedro Creek	72	51	67	75	97
Martini Creek	62	78	92	25	53
San Vicente Creek	62	64	83	38	61
Arroyo de en Medio	46	40	58	38	47
Frenchmans Creek	65	68	75	38	81
Pilarcitos Creek	60	69	83	38	50
Canada Verde	54	63	75	38	42
Lobitos Creek	67	77	92	38	64
Tunitas Creek	74	81	100	50	67
San Gregorio Creek*	70	85	75	56	64
Pomponio Creek	68	78	83	50	61
Pescadero Marsh*	75	92	58	75	77
Lake Lucerne	69	75	50	63	89
Spring Bridge Gulch	76	81	92	63	69
S. Spring Bridge Gulch	64	81	83	38	53
Yankee Jim Gulch	56	70	83	25	44
Creek Mouth SW Pigeon Point	61	74	92	25	53
Gazos Creek	75	61	92	63	83
Whitehouse Creek	74	81	92	50	75
Cascade Creek*	78	96	75	50	93
Ano Nuevo Creek	67	88	92	38	53
AVERAGE SCORE	**67**	**74**	**81**	**46**	**65**

Through creation of a cumulative frequency distribution of CRAM Index scores the relative range in condition of San Mateo County BBEs can be put into context with BBEs throughout the Central Coast region and throughout the state. When compared to an ambient assessment of 30 sites along the Central California Coastline, BBEs for the San Mateo County coastline exhibit a similar distribution of low condition scores (up until the 50^{th} percentile condition score) (Figure 6).

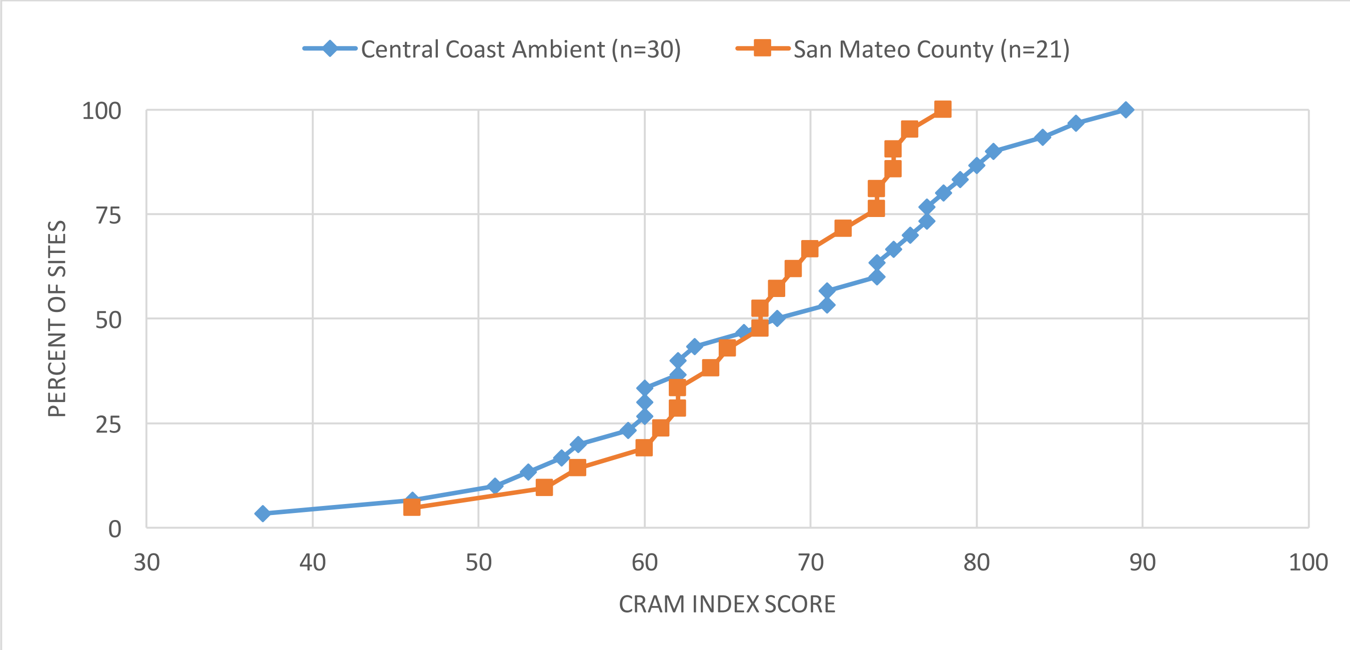


Figure 6.Cumulative Frequency Distribution of BBE CRAM scores for San Mateo County (orange) and the central coast of California (blue).

When compared with condition scores for sites along the entire California Coastline, BBEs for the San Mateo County coastline show a similar distribution of low scores (i.e. the lowest 25th percentile) (Figure 7). BBEs in San Mateo within the upper 75% of scores however show a lower cumulative increase in condition compared with BBEs statewide. The average CRAM Index Score (50th percentile score) for San Mateo BBEs is 67 while the average score for all sites assessed in California is 71. The highest scoring BBE in San Mateo County received a 76, while the highest scoring BBE in California received a score of 90.

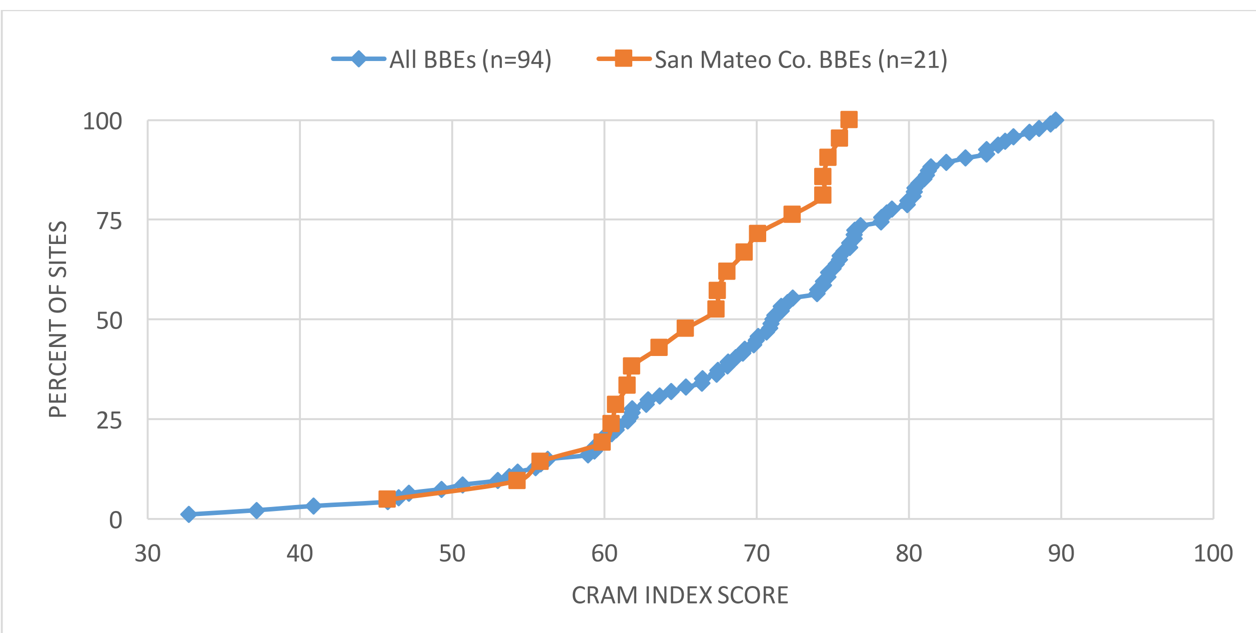


Figure 7.Cumulative Frequency Distribution of BBE CRAM scores for San Mateo County (orange) and California as a whole (blue).

Because CRAM evaluates each wetland based on a number of different characteristics, no wetland is expected obtained a score of 100. Statewide, scores for all CRAM wetland classes commonly only reached the low 90s. The fact that conditions scores converge at a high score of 76 suggest that San Mateo systems may not exhibit a complexity of services or functions present within other parts of the state. This observation suggests that there are similarities among BBEs within a local geographic range.

The CRAM Attribute Scores showed a wider range of condition. Buffer and Landscape Context ranged from 40 to 94, Hydrology from 50 to 100, Physical Structure from 25 to 75 and Biotic Structure from 42 to 97 (Table 2). Average scores for the CRAM attributes were variable. Average scores for the Hydrology Attribute were high (81), were low for the Physical Structure Attribute (46) and intermediate for the Biotic Structure and Buffer and Landscape Context Attributes (65 and 74 respectively).

A ranking of sites independently by CRAM Index and Attribute scores revealed differing results. In general, the larger systems were given higher Index scores. Spring Bridge Gulch, however, is small BBE just north of Point Año Nuevo that receive the highest CRAM Index score. When ranked by the Buffer and Landscape Context Attribute, larger, more isolated systems ranked higher, while BBEs closer to HWY or urban areas ranked lower. Isolated systems with intact watersheds were ranked highest by Hydrology Attribute score, while BBEs near urban or agricultural land uses had lowest scores. The rankings by Physical Structure Attribute and the Biotic Structure showed similar rankings due to a strong relationship between the physical complexity of a wetland and the resulting biotic community (Table 4).

Table 4.Sites ranked by CRAM Index and Attribute scores. Note that Cascade Creek was assessed as a Depression, not a BBE.

Condiiton Rank	Index Score	Buffer and Landscape Connectivity	Hydrology	Physical Structure	Biotic Structure
1	Cascade Creek	Cascade Creek	Tunitas Creek	San Pedro Creek	San Pedro Creek
2	Spring Bridge Gulch	Pescadero Marsh	Lobitos Creek	Pescadero Marsh	Cascade Creek
3	Pescadero Marsh	Ano Nuevo Creek	Ano Nuevo Creek	Spring Bridge Gulch	Lake Lucerne
4	Gazos Creek	San Gregorio Creek	Spring Bridge Gulch	Gazos Creek	Gazos Creek
5	Tunitas Creek	Spring Bridge Gulch	Whitehouse Creek	Lake Lucerne	Frenchmans Creek
6	Whitehouse Creek	Tunitas Creek	Martini Creek	San Gregorio Creek	Pescadero Marsh
7	San Pedro Creek	Whitehouse Creek	Creek Mouth SW Pigeon Point	Tunitas Creek	Whitehouse Creek
8	San Gregorio Creek	S. Spring Bridge Gulch	Gazos Creek	Whitehouse Creek	Spring Bridge Gulch
9	Lake Lucerne	Pomponio Creek	S. Spring Bridge Gulch	Pomponio Creek	Tunitas Creek
10	Pomponio Creek	Martini Creek	Pomponio Creek	Cascade Creek	San Gregorio Creek
11	Lobitos Creek	Lobitos Creek	Yankee Jim Gulch	Lobitos Creek	Lobitos Creek
12	Ano Nuevo Creek	Lake Lucerne	Pilarcitos Creek	Ano Nuevo Creek	Pomponio Creek
13	Frenchmans Creek	Creek Mouth SW Pigeon Point	San Vicente Creek	S. Spring Bridge Gulch	San Vicente Creek
14	S. Spring Bridge Gulch	Yankee Jim Gulch	Cascade Creek	Pilarcitos Creek	Ano Nuevo Creek
15	Martini Creek	Pilarcitos Creek	San Gregorio Creek	San Vicente Creek	S. Spring Bridge Gulch
16	San Vicente Creek	Frenchmans Creek	Frenchmans Creek	Frenchmans Creek	Martini Creek
17	Creek Mouth SW Pigeon Point	San Vicente Creek	Canada Verde	Canada Verde	Creek Mouth SW Pigeon Point
18	Pilarcitos Creek	Canada Verde	San Pedro Creek	Arroyo de en Medio	Pilarcitos Creek
19	Yankee Jim Gulch	Gazos Creek	Pescadero Marsh	Martini Creek	Arroyo de en Medio
20	Canada Verde	San Pedro Creek	Arroyo de en Medio	Creek Mouth SW Pigeon Point	Yankee Jim Gulch
21	Arroyo de en Medio	Arroyo de en Medio	Lake Lucerne	Yankee Jim Gulch	Canada Verde

Stressors

Watershed Stressors

Watershed size ranged from 1 km^2 for the small creek south of Spring Bridge Gulch to 209 km^2 for Pescadero Marsh. Three of the coastal confluences (Pilarcitos, Pomponio, and Pescadero) have functioning dams within their watersheds which can starve BBEs of sediment and alter storm flows. Pilarcitos BBE has the greatest proportion of the watershed (14%) behind a dam. Mines are not common in the watersheds of the San Mateo County outer coastline. Only five of the 21 systems have mines present in their respective watershed (Arroyo de en Medio, Frenchman's, Pilarcitos, Tunitas and Pescadero) (Table 5).

Coastal confluences located in the urban areas, not surprisingly, showed higher percent cover of urban land cover and impervious surfaces, while more remote systems showed higher percent cover of forested and scrub/grassland land cover (Table 5).

Table 5. Quantification of land cover and watershed stressors for a 30 m buffer along streams within a 2 km portion of the watershed surrounding each coastal confluence

Site Name	Index Score	watershed Area (km2)	DamDrainage (% of total WS)	Mines (#)	2k/30m-DensRoads_ALL (km/km2)	% Impervious-2k/30m	% Urban Landcover-2k/30m	% Natural Forested-2k/30m	% Shrub/Grassland-2k/30m	% Ag Land-2k/30m
San Pedro Creek	72	21.24			3.25	75	74.3	6.8	19.3	0.0
Martini Creek	62	2.57			0.31	4	3.8	47.1	46.6	0.0
San Vicente Creek	62	4.74			7.26	46	45.4	2.5	34.7	2.5
Arroyo de en Medio	46	2.85		1	5.20	44	47.7	2.1	25.3	11.9
Frenchmans Creek	65	10.80		2	4.81	35	41.0	5.8	9.6	0.6
Pilarcitos Creek	60	74.03	14.2%	3	2.29	40	40.5	0.0	18.8	8.9
Canada Verde	54	5.99			4.49	41	43.5	5.8	28.4	17.1
Lobitos Creek	67	10.48			1.79	15	12.1	49.2	22.2	0.0
Tunitas Creek	74	30.14		2	0.67	5	5.4	78.5	13.2	0.0
San Gregorio Creek	70	134.99			5.24	12	10.4	28.9	23.0	11.4
Pomponio Creek	68	18.34	7.6%		1.30	7	6.9	41.7	44.6	4.1
Pescadero Marsh	75	209.79	0.3%	3	4.97	5	4.4	15.2	6.9	14.2
Lake Lucerne	69	10.45			1.65	9	6.9	29.0	12.2	0.0
Spring Bridge Gulch	76	1.81			1.49	5	4.2	39.5	16.7	16.3
S. Spring Bridge Gulch	64	1.05			0.49	7	6.3	11.9	21.6	55.1
Yankee Jim Gulch	56	2.61			0.53	2	1.7	59.8	22.6	4.6
Creek Mouth SW Pigeon Point	61	1.67			1.14	6	5.7	46.2	37.7	11.4
Gazos Creek	75	30.02			7.04	35	11.3	70.3	8.6	5.3
Whitehouse Creek	74	10.99			1.03	4	4.9	40.1	28.2	16.3
Cascade Creek	78	8.59			6.18	9	9.3	12.0	10.2	48.1
Ano Nuevo Creek	67	6.13			2.10	17	14.0	76.6	8.0	0.8

Landscape level investigations at multiple scales revealed several interesting relationships (Table 6). The most noteworthy finding it that only one correlative relationship between condition and stress was found significant at more than one landscape scale. The CRAM Index Score showed a negative relationship with the percent cover of shrub/grassland land cover located in a 30m buffer of streams within 2 km of the estuary but now within broader estimates (i.e. entire watershed).

The Hydrology Attribute had a negative relationship (as expected) with % impervious cover and % urban land cover within the whole watershed but not within less comprehensive evaluations of the watershed. Density of localized roads was significant but not for roads further than 2 km of the estuary. The Hydrology Attribute also showed positive relationships with the percent cover of shrub/grassland land cover located within 2 km of the estuary and with natural forested land cover located in a 30m buffer of streams within 2 km of the estuary. The Physical Structure Attribute showed a negative relationship with the percent cover of shrub/grassland land cover located in a 30m buffer of streams within 2 km of the estuary. The Biotic Structure Attribute showed a positive relationship with the percent cover of natural forested land cover located within the whole watershed. The Biotic Structure Attribute showed a negative relationship with the percent cover of shrub/grassland land cover located in the watershed and in a 30m buffer of streams within 2 km of the estuary.

Table 6. Relationships between bar-built estuary condition (CRAM) and watershed stressors/land cover at three scales. Positive relationships are in green, negative relationships are in black.

CRAM	GIS Data	Watershed		2km Buffer		2km with 30m stream buffer	
		Corr. Coef.	p	Corr. Coef.	p	Corr. Coef.	p
Index	% shrub/grassland					-0.358	0.023
Buffer	% impervious					-0.392	0.014
Buffer	% urban					-0.412	0.01
Hydrology	% impervious	-0.393	0.019				
Hydrology	% urban	-0.372	0.016				
Hydrology	desity of all roads			-0.341	0.041		
Hydrology	% shrub/grassland			0.372	0.026		
Hydrology	% natural forested					0.497	0.003
physical	% shrub/grassland					-0.387	0.022
biotic	% natural forested	0.32	0.045				
biotic	% shrub/grassland	-0.34	0.034				
biotic	% shrub/grassland					-0.369	0.021

CRAM Stressor Checklist

The purpose of the CRAM Stressor Checklist is to identify stressors within a CRAM Assessment Area (AA) or its immediate vicinity that might help account for any low CRAM scores. In some cases, a single stressor might be the primary cause for low-scoring conditions, but poor conditions are usually due to influence from multiple stressors. The three most common CRAM stressors found in San Mateo County were 1) transportation corridor (i.e. Highway 1), 2) passive recreation, and 3) lack of treatment of invasive plants adjacent to AA or buffer (Table 7).

Table 7. Ten most common CRAM stressors observed at San Mateo County coastal confluences

Stressor type	**# sites with stressor**
Transportation corridor	20
Passive recreation (bird-watching, hiking, etc.)	20
Lack of treatment of invasive plants adjacent to AA or buffer	18
Grading/ compaction (N/A for restoration areas)	9
Non-point Source (Non-PS) discharges (urban runoff, farm drainage)	8
Engineered channel (riprap, armored channel bank, bed)	8
Excessive human visitation	7
Trash or refuse	6
Urban residential	6
Intensive row-crop agriculture	6

Sites found to have the greatest number of CRAM stressors were generally located in urban landscapes (Canada Verde, Arroyo de en Medio, San Pedro), or the estuary (Lake Lucerne, Yankee Jim Gulch) experienced an engineered change in hydrology or physical structure (Table 8). The relationship between the total number of CRAM Stressors and the CRAM Index Score for San Mateo County was less (R^2=0.3) than that found for systems throughout California (R^2 = 0.37)(Figure 8).

Table 8. Total number of CRAM stressors observed at each site.

Site Name	Total CRAM Stressors
Canada Verde	17
Lake Lucerne	17
Arroyo de en Medio	16
Yankee Jim Gulch	16
San Pedro Creek	14
Frenchmans Creek	12
Pomponio Creek	11
Pescadero Marsh	11
Lobitos Creek	9
Pilarcitos Creek	9
S. Spring Bridge Gulch	9
San Vicente Creek	9
Gazos Creek	8
Spring Bridge Gulch	8
San Gregorio Creek	7
Creek Mouth SW Pigeon Point	6
Martini Creek	6
Ano Nuevo Creek	5
Tunitas Creek	5
Cascade Creek	3
Whitehouse Creek	3

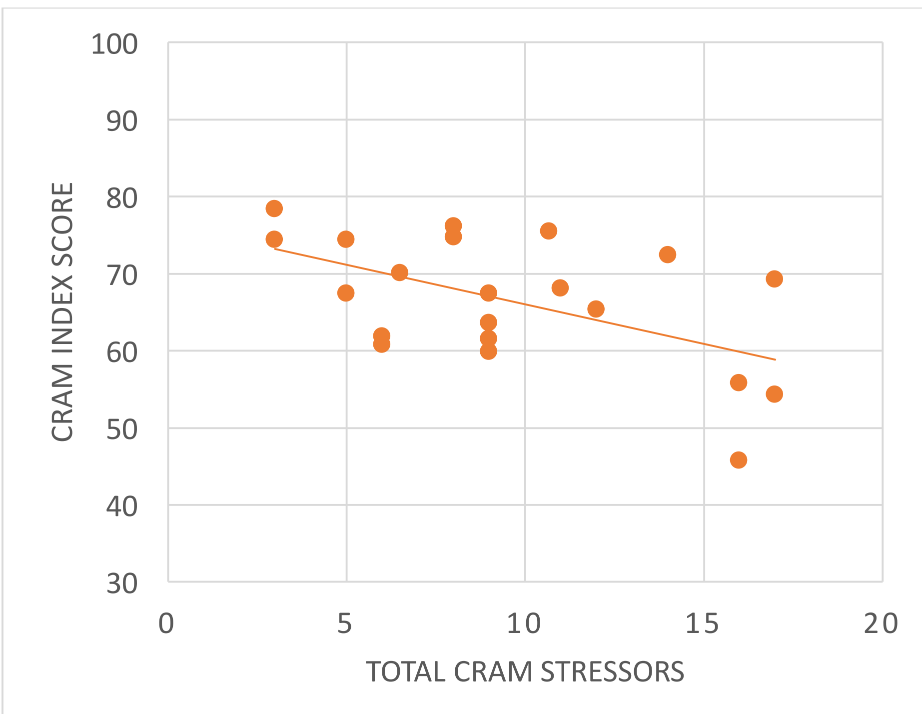


Figure 8. Graph of total number of CRAM stressors compared to CRAM Index Score for all sites.

Wetland Habitat Loss and Change

Historical change analysis of estuaries provides evidence of how previous land form changes and current land use has affected the size and shape as well as the diversity of wetland features within the estuary. A GIS analyses of the historical (1850's) and current (aerial imagery) size and class of wetland habitat (Figures 9-11) was estimated using the CCWG wetland classification system (Appendix 1).

The T-Sheet analysis documented a strong correlation between the size of San Mateo BBEs and the size of the watershed that drains to the estuary (1850s -R^2=0.53, 2010s R^2=0.69). Statewide, the strength of these correlations ranged greatly with higher correlations found in northern California (SF Bay and North Coast - R^2 0.83 - 0.80) and decrease southward (South Coast - R^2 of 0.12) (Sutula et al. 2008). These data suggest that the regional variation in the correlation between watershed size and wetland area is likely associated with changes in wetland acreage (stemming from urbanization) which is limited on the San Mateo County coast and variations in annual rain fall with the county experiencing higher rain fall (20-32 inches for coastal San Mateo) than systems to the south.

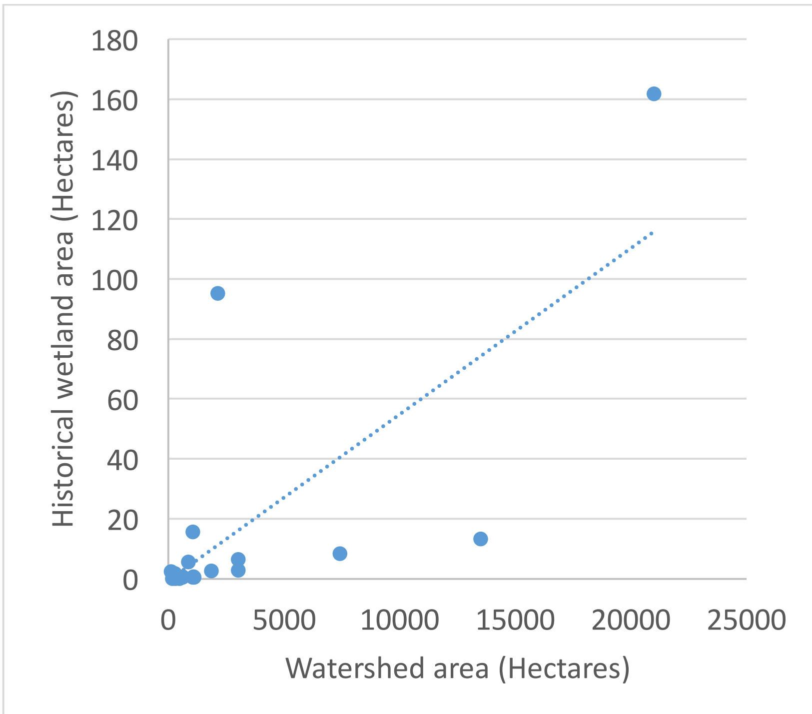


Figure 9. Graph of watershed area compared to historical wetland area for all sites.

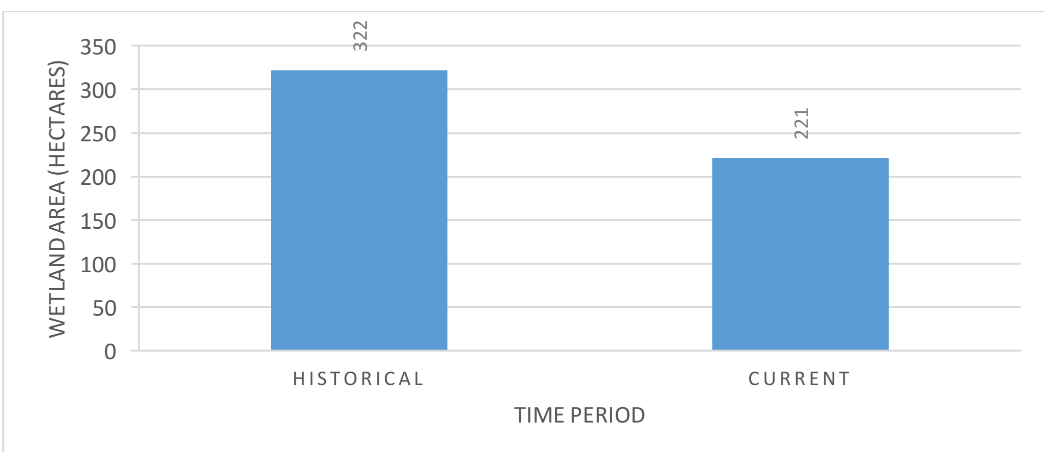


Figure 10. Total wetland area for all sites for the historical (1850's) and current time periods.

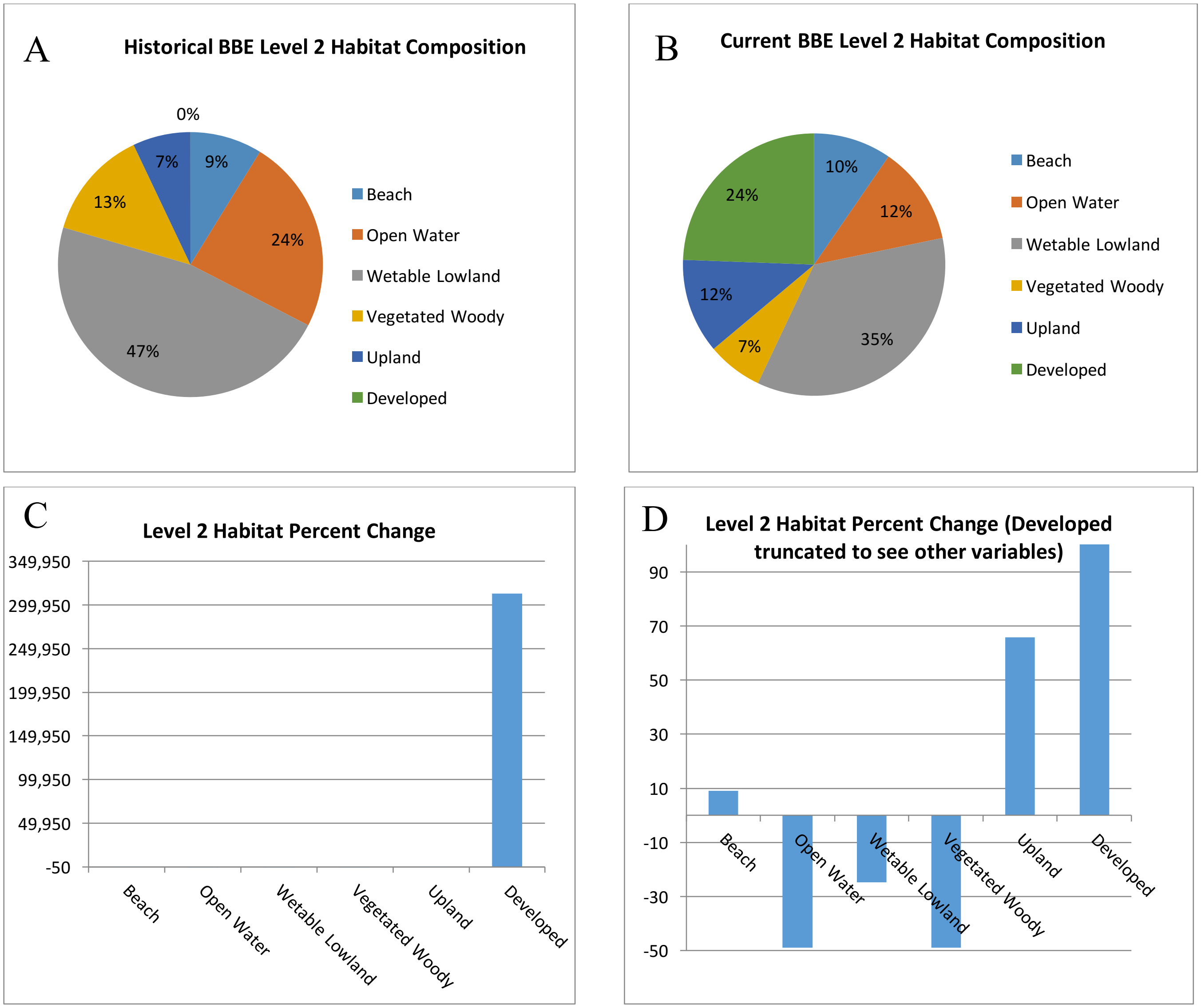


Figure 11. Historical (A) and current (B) Level 2 habitat composition for all sites. Percent change in Level 2 habitat composition between time periods (C and D).

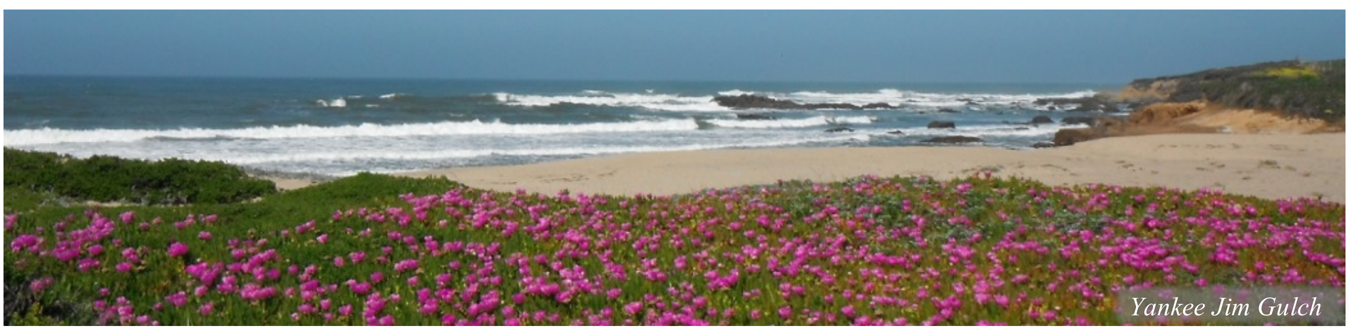
Special Status Species

An investigation of the California Natural Diversity Data Base (CNDDB), local recovery plans, reports on locations of species status and input from local researchers documented (or assumed high probability) that ten special status species of interest were present within the studied estuaries. All ten of the selected species were reported to be present in one or more of the 21 sites (Table 9). Pescadero Marsh supported the greatest number of special status species. Four sites did not currently support any of the selected species (Arroyo de en Medio, Spring Bridge Gulch, S. Spring Bridge Gulch and Cascade Creek). Red-Legged frogs and San Francisco Garter snakes are more commonly found in the watershed upstream of the estuary. Steelhead was the most common species (present in 12 of the 21 sites), while the Brackish water snail and Western pond turtle only have records of being present at Pescadero Marsh.

Table 9. Presence of ten special status species of interest at project sites (P=present, HP= Not observed, but high potential for habitat, W= Present in watershed, but not observed in estuary).

Coastal Drainage Name	Snowy Plover	Coho	Steelhead	Western Pond Turtle	Tidewater Goby	Red-Legged Frog	SF garter snake	Saltmarsh common yellowthroat	Monarch Butterfly	Brackish water snail
San Pedro Creek			P		HP	P				
Martini Creek			P							
San Vicente Creek						W	W			
Arroyo de en Medio										
Frenchmans Creek			P			W	W		P	
Pilarcitos Creek			P		HP		P	P		
Canada Verde						W				
Lobitos Creek			P					P		
Tunitas Creek	P		P		P	W	W			
San Gregorio Creek		P	P		P	W	W	P		
Pomponio Creek			P		P					
Pescadero Marsh	P	P	P	P	P	P	P	P		P
Lake Lucerne					P	P			P	
Spring Bridge Gulch										
S. Spring Bridge Gulch										
Yankee Jim Gulch					P					
Creek Mouth SW Pigeon Point										
Gazos Creek	P		P		P					
Whitehouse Creek			P			W	P			
Cascade Creek										
Ano Nuevo Creek	P		P			W	W			

PRIORITIZATION STRATEGY



Yankee Jim Gulch

Along the San Mateo County coastline, changes to the landscape dating back to the 1800s have reduced the quantity and quality of wetland habitat available for fish and wildlife species. As a result, ecosystem-based restoration of these estuaries has become a priority. CCWG used the compiled BBE survey data to create a set of three Management Prioritization Strategies to aid USFWS Coastal Program and its regional partners to prioritize ecosystem-based habitat restoration efforts on the San Mateo coast. Each of the prioritization strategies accounts for various combinations of 1) current estuarine condition, 2) level of watershed stress, 3) current support of special species, and 4) restoration opportunities and resiliency to sea level rise. These data can be used in combination, or as stand-alone tools, depending on the focus and goals of the user. These strategies are intended to provide decision makers with means to integrate diverse habitat information systematically to ensure funding dollars support strategically located projects that provide the greatest overall benefit to the San Mateo BBE ecosystem.

Description of Prioritization Methods

Initial Steps

The three methodologies were used to develop to prioritize BBE restoration and management actions. The Threshold Evaluation Method reviewed each site based on a set of minimum qualifications, and iteratively removed sites that did not meet these requirements. The second prioritization method used graphical analysis of Condition-Vulnerability Evaluation. Each site was graphically represented based on current wetland condition (CRAM) and the watershed and adjacent stress posed to the site by current land use. The third method utilized the Recovery Potential Screening (RPS) Tool developed by USEPA designed to "compare watersheds and plan efforts for greater likelihood of restoration and protection success".

All of the information collected for this study was compiled within a single data file including columns for CRAM Attribute and Index scores, all watershed land use and stressors based on three different watershed "influence buffers", data from the wetland habitat change analysis, and a tally of special status species present at each site. Several additional columns were added to assist in the prioritization of the estuaries, including:

- Opportunity/space for restoration of wetland area (value of 0, 1, or 2, with 2 having the highest potential for restoration of wetland area)
- Capacity to migrate inland in response to sea level rise (yes or no)
- Occurrence of artificial breaching (yes or no)
- Presence of off-channel habitats (yes or no)
- Presence of anthropogenic channelization of the main channel (yes or no)
- Presence of mouth constriction preventing mouth migration (yes or no)
- Land ownership (public, private-land trust, private)

Prioritization #1: Threshold Evaluation

The Threshold Evaluation Method, modeled after efforts by the Nature Conservancy to assess conservation efforts in west coast Estuaries (Gleason et al., 2011), used numerous criteria to screen sites and remove those that did not meet those thresholds. The Threshold Evaluation Method intended to select sites that would benefit from restoration efforts that would lead to an "ecologically significant" improvement in San Mateo BBE condition. Specifically, wetlands were selected to meet a minimum size with all sites of less than 1 hectare removed. Sites were prioritized that had lost more than 50% of marsh plain habitat (wetable lowland: area seasonally inundated by lagoon water elevation dynamics) and that had space for marsh plain restoration and the capacity to migrate inland in response to sea level rise. Finally, sites were prioritized that supported selected special status species. This process resulted in the list of sites being cut from 21 coastal confluences to 5 sites of interest. This method could be modified to prioritize a different subset of thresholds to prioritize a different set of restoration goals.

Prioritization #2: Condition-Vulnerability Evaluation

The Condition-Vulnerability Evaluation method, based on the EPA's Healthy Watersheds Initiative (Ode et al., 2014), used the habitat condition data and the watershed stressor data to generate a habitat "condition-vulnerability" graph. Sites self-selected into one of four quadrants based on vulnerability and health thresholds, each leading to a call for different management actions:

- Low vulnerability/low health: implement habitat restoration actions
- Low vulnerability/ high health: ensure proper management plans and ongoing actions are taking place
- High vulnerability/high health: emphasize protection of resources and address buffer stress
- High vulnerability/low health: low priority sites

The CRAM Index score was used for the site "condition score" and the "vulnerability score" was calculated as the total percent cover of Impervious surfaces, Urban land cover, and Agricultural land cover (within a 30-meter wide buffer along all streams within 2 kilometers of the estuary) within the watershed. The resulting vulnerability score was then "corrected" for on-site stresses through use of correction factors of 1.2 if there was the presence of anthropogenic channelization in the main channel, and/or the presence of mouth constrictions preventing mouth migration. Each sites condition and vulnerability scores were graphed and a final subset of sites was selected that also met the following criteria:

- Presence of space for restoration of wetland area (value of 1 or 2 in the database)
- Marsh migration is possible due to sea level rise
- Presence of tidewater gobies and/or steelhead
- Estuary land in public or land trust ownership

This process resulted in the list of sites being cut from 21 coastal confluences to 6 sites of interest.

Prioritization #3: EPA Decision support tool

The Recovery Potential Screening (RPS) Tool was developed by the U.S. Environmental Protection Agency (EPA) (www.epa.gov/rps) to enable restoration planners to systematically compare relative differences in the restorability of water bodies or watersheds using GIS data and other georeferenced monitoring information. The tool is used to compare differences among watersheds or streams based on assessments of *ecological capacity, stressor exposure,* and *social context*. These three indices were combined to obtain an overall recovery potential integrated (RPI) score, which summarized the restorability of each BBE as compared with the others in San Mateo County. Originally developed to support the prioritization of restoration projects as part of Total Maximum Daily Load (TMDL) and impaired waters listing programs, the tool can also support a variety of other prioritization efforts.

CCWG used an early version of the tool which allows the user to use field data collected to estimate ecological capacity, stressor exposure, and social context. To evaluate ecological capacity and BBE management opportunities we used the following parameters:

- CRAM Index score
- CRAM attribute scores (4)
- watershed size
- wetland area size
- total number of special status species
- presence of space for restoration of wetland area
- % Shrub/Grassland- with in 2km of estuary
- % Natural Forested- within a 30 m buffer of streams within 2km of estuary
- % Natural Forested for the entire watershed

For the stressor exposure we used the following parameters:

- within a 30 m buffer of streams within 2km of estuary:
  - Density of all roads (km/km2)
  - % Impervious surface
  - % Urban Land cover
  - % Agricultural Land cover
- presence of channelization within the estuary
- presence of a mouth constriction
- total number of CRAM stressors

For the social context metric, we ranked sites based on current ownership. Public ownership was assigned a 2, private land trust was assigned a 1, and private land was assigned a 0. The EPA RPS Tool resulted in three ranked lists of sites, based on Ecosystem Index, Stressor Index and a combined Restoration Priority Index, of which the top six from each list are presented.

Results

Prioritization #1: Threshold Evaluation

The threshold evaluation method resulted in prioritization of the following five sites, presented here in order of number of special status species present in the estuary and/or watershed:

- San Gregorio Creek (6 Special Status Species)
- Frenchman's Creek (4 Special Status Species)
- Gazos Creek (3 Special Status Species)
- Pilarcitos Creek (3 Special Status Species)
- Yankee Jim Gulch (1 Special Status Species)

Prioritization #2: Condition-Vulnerability Graph

The Condition-Vulnerability Evaluation method (Figure 10) resulted in the following list of sites, grouped by proposed management action:

Habitat restoration actions (low vulnerability/low health): Yankee Jim Gulch
Address stress in buffer (high vulnerability/high condition): Gazos Creek and San Gregorio Creek
Ensure proper management is in place (low vulnerability/ high health): Pescadero Marsh, Pomponio Creek, and Whitehouse Creek

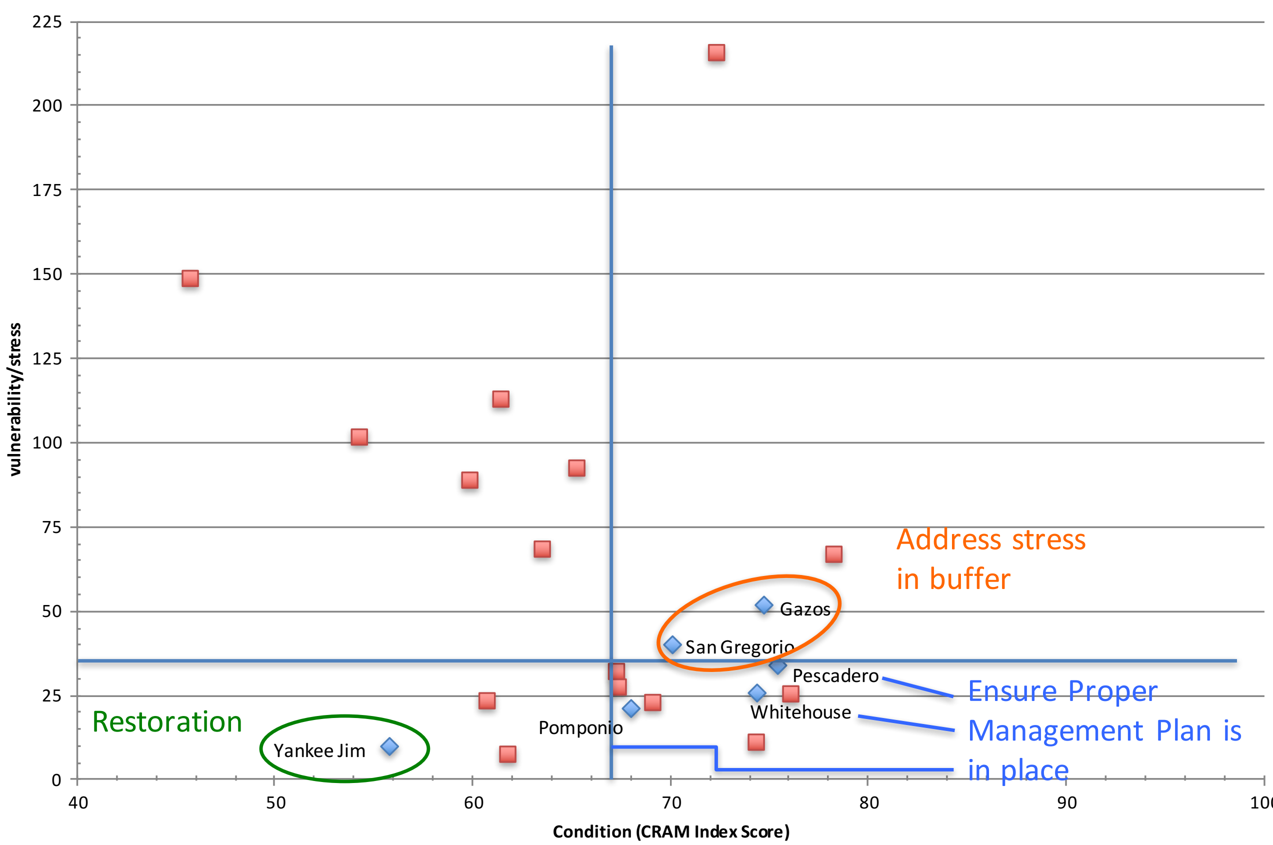


Figure 12.Results of Health-Vulnerability graph prioritization.

Prioritization #3: EPA Decision support tool

The Recovery Potential Screening (RPS) Tool resulted in the following list of sites, ranked in order and group by Index output from the RPS tool.

Table 10. Results of EPA RPS Tool for San Mateo County BBEs.

Ecosystem Index Rank	Stressor Index Rank	Restoration Priority Index Rank
1. Pescadero Marsh	1. Martini Creek	1. Martini Creek
2. Tunitas Creek	2. Tunitas Creek	2. Whitehouse Creek
3. San Gregorio Creek	3. Whitehouse Creek	3. Ano Nuevo Creek
4. Gazos Creek	4. Creek SW Pigeon Point	4. Tunitas Creek
5. Ano Nuevo Creek	5. Ano Nuevo Creek	5. Creek SW Pigeon Point
6. Whitehouse Creek	6. Spring Bridge Gulch	6. S. Spring Bridge Gulch

Prioritization Support Tool

The three prioritization methods relied on various amounts of the data collected for these sites. Prioritization #1 uses only GIS-based data to narrow the number of sites down to five. It is a relatively simple process and the cutoffs for each data type can be set and any desired point. In addition, more screening levels can be added that meet the needs of the party interested.

Prioritization 2 incorporates site-specific field data on marsh condition as well as stress in the watershed. This allows for a ranking based on condition and stress. Additional threshold data were used (restorable area, habitat migration, etc.) to further reduce the list of sites.

Prioritization 3 attempts to rate ecological condition, stress and social context independently using multiple factors, and then combine them to come up with a more holistic ranking of priority sites for management action.

The results of each prioritization method were combined to identify common themes among methods and sites.

MANAGEMENT OPPORTUNITIES

General Priority Actions

Wetland Habitat Condition-CRAM

Low CRAM Attribute scores can be improved by eliminating the current or historical stress on that system. The main stressors leading to lower CRAM attribute scores at the sites were as follows:

Buffer and Landscape Context:
- Transportation corridor
- Passive recreation
- Urban residential land use
- Intensive row crop agriculture land use

Hydrology:
- Non-point source discharges

Physical Structure:
- Grading/compaction
- Engineered channel
- Trash/refuse

Biotic Structure:
- Lack of treatment of invasive plants
- Excessive human visitation

Categories of actions that could be taken to mitigate the impacts of identified stressors on current wetland condition include: 1) enhancing buffer, 2) public education, 3) restoration of natural physical structure, and 4) restoration of hydraulic processes in the estuary. Enhancements to the buffer area between the estuary and adjacent land uses may reduce the effects urban and agricultural land uses, reduce the effects of non-point source discharges, reduce the impact of invasive plant species, and mitigate the impacts of a major transportation corridor (Hwy 1). Expanded education programs and better management of public access can reduce the trampling and recreational impacts in the estuary. The restoration of natural physical structure in the estuary through the removal or mitigation of engineered channels and restoration of compacted areas (trails, parking lots, etc.) can enhance the overall physical condition of these estuaries. Finally, changes or upgrades to culverts and reductions in water extraction activities within the watershed can benefit estuarine hydrology.

Watershed Stressors

The watershed stressor correlation analysis revealed that expanding the width of protective buffers (30 m) along streams within 2 km of the estuary may lead to an increase in wetland condition as represented by the CRAM Index and CRAM Buffer and Hydrology Attribute Scores. Restoring forested riparian zones may also lead to an increase in the Biotic Structure Attribute Score of the estuary.

Wetland Habitat Loss and Change

The habitat loss and change assessment found the greatest change in open water, wetable lowland and vegetated woody (riparian) acreage, with much of that area being converted upland and “developed” land use (buildings, parking lots, agriculture, etc.). Given the obvious importance of these habitat types on the overall condition of the estuarine ecosystems and the flora and fauna that rely up on them, efforts should be made to restore and enhance these habitat types (including removal of limited value development) where possible.

Prioritization of Sites for Restoration Actions

A summary table of all three site prioritization methods and the CRAM Index score was compiled. Sites that were identified within multiple prioritization methods and that have higher CRAM Index scores were highlighted (Table 11). This “preponderance of priorities” evaluation identified 5 BBEs in San Mateo County that will benefit from timely management action, including:

1. San Gregorio Creek
2. Yankee Jim Gulch
3. Pescadero Marsh
4. Gazos Creek
5. Whitehouse Creek

Site-specific Management Actions for these five estuaries are located on the site-specific summary sheets (Appendix 2).

Table 11. Summary and combination of all three prioritization schemes.

Site Name	Index Score	Prioritization 1	Prioritization 2	Prioritization 3	Total
San Gregorio Creek	70	1	1	1	3
Yankee Jim Gulch	56	1	1	1	3
Pescadero Marsh	75		1	1	2
Gazos Creek	75	1	1		2
Whitehouse Creek	74		1	1	2
Spring Bridge Gulch	76			1	1
Tunitas Creek	74			1	1
Pomponio Creek	68		1		1
Ano Nuevo Creek	67			1	1
Frenchmans Creek	65	1			1
S. Spring Bridge Gulch	64			1	1
Martini Creek	62			1	1
Creek SW Pigeon Point	61			1	1
Pilarcitos Creek	60	1			1
Cascade Creek	78				0
San Pedro Creek	72				0
Lake Lucerne	69				0
Lobitos Creek	67				0
San Vicente Creek	62				0
Canada Verde Creek	54				0
Arroyo de en Medio	46				0

Assessment of Selected Sites

Habitat Loss and Recovery

All five sites showed a loss of wetland habitat from the 1850’s, while four of the sites show a greater than 50% loss of wetable (Table 12). Of those four sites, three of them (San Gregorio, Yankee Jim and Gazos) have the opportunity and space for wetland restoration (a value of 1 (fair) or 2 (good) in Table 12). Potential habitat restoration actions include:

- San Gregorio: the area east of Highway 1 and north of the main cannel could be reconnected with the estuary, as is shown in historical maps.
- Yankee Jim Gulch: remove the cement channel along with some fill associated with HWY 1.
- Gazos Creek: reduce the size of the parking lot to the east of HWY 1 to allow for a larger marsh plain.

In addition, there is area within San Gregorio and Yankee Jim estuaries, east of HWY 1, to allow for marsh migration in response to sea level rise. Area for marsh migration exists within Gazos Creek east of HWY 1 as well, but is currently used for parking.

Table 12. Habitat change analysis results for 5 priority sites.

Site Name	HISTORICAL WETLAND AREA	CURRENT WETLAND AREA	% change wetland area	% change wetable lowland	current % vegetated woody (most were 0% historically)	opportunity /space for wetland restoration (area)	SLR Marsh Migration possible?
San Gregorio Creek	13.33	9.14	-31.44	-56.54	0.00	2	Y
Pescadero Marsh	161.97	153.14	-5.45	4.36	5.55	2	Y
Yankee Jim Gulch	1.91	1.57	-17.86	-96.02	7.94	2	Y
Gazos Creek	6.52	4.09	-37.26	-91.24	5.44	1	Y
Whitehouse Creek	0.52	0.45	-13.13	-93.30	40.55	0	Y

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APPENDIX 1: CCWG WETLAND CLASSIFICATION CHART

APPENDIX 2: SITE-SPECIFIC DATA SUMMARIES