Long-term Performance and Effectiveness Evaluation For Three Critical Coastal Area Watersheds

This report satisfies a requirement for SWRCB Contract # 06-345-552-0, Demonstration Project in Three Critical Coastal Area Watersheds.

The Long-term Performance Evaluation and Effectiveness Evaluation Approach (PEEEA) for the three CCA watersheds was expected to evaluate how well previously submitted monitoring plans would enable the participating local governments and stakeholders to assess and improve their efforts to resolve their non-point source (NPS) pollution and impairment issues. However, the various CCA outputs, while likely effective in many regards, were not accompanied by formal monitoring plans that could be evaluated. The references to monitoring were diffuse and not detailed. They did not comprise stand-alone plans. This is evidently not uncommon among local environmental protection and correction efforts due to a variety of reasons, including the high cost of monitoring, unclear needs for the monitoring data (i.e., uncertain processes for using the data to alter the efforts), and the lack of efficient and user-friendly data management systems.

These obstacles to effective monitoring of water quality improvement actions and other environmental protection efforts are nationally pervasive and well documented (e.g., USEPA 1977, NAS 1977, USEPA 1983; Ward et al. 1990, NRC 1990, NAPA 2002). The Critical Coastal Areas (CCA) Program can help address these obstacles in coastal watersheds by fostering collaborations among local stakeholders and government agencies focused on NPS pollution. However, a framework and cost-effective tool set for coordinated monitoring is still needed.

In the six years since the conception, design, and implementation of the CCA demonstration projects, a significant effort has been initiated by the California State Water Resources Control Board (State Water Board) in collaboration with the California Water Quality Monitoring Council and USEPA to develop a comprehensive framework and tool set for surface water quality monitoring and assessment using a watershed approach. The initiative is referred to as the Wetland and Riparian Area Monitoring Plan (WRAMP) and is designed to support the State Water Board's emerging Wetland and Riparian Area Protection Policy (WRAPP). One objective of WRAPP and WRAMP is to improve the coordination of water quality programs and projects in the watershed context (http://www.swrcb.ca.gov/water_issues/programs/cwa401/wrapp.shtml) (http://www.swrcb.ca.gov/mywaterquality/monitoring_council/docs/wramp_implementation_letter.pdf) WRAMP is a comprehensive analytical framework which can meet the goals of the PEEEA, while also providing regulators and managers with a much broader set of tools to evaluate NPS pollution assessment, prevention, and reduction.

This report will describe the WRAMP framework, the management questions originally established to drive the evaluation, translate those management questions to monitoring questions, and "test" the effectiveness of the CCA Demonstration project relative to the framework for the three CCAs: Fitzgerald Marine Reserve (San Mateo County), Sonoma Creek (Sonoma County), and Watsonville Sloughs (Santa Cruz County).

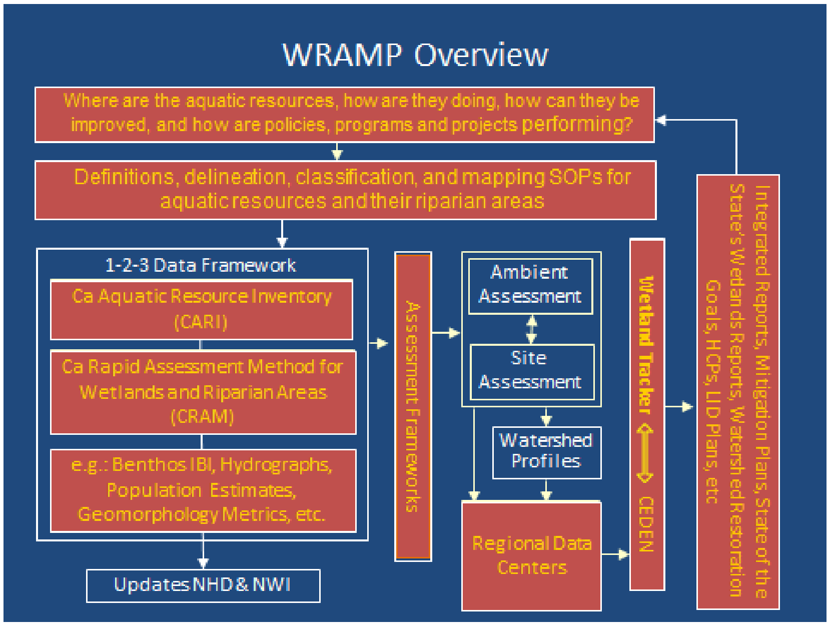
I. Comprehensive Water Quality Monitoring and Assessment Framework

A watershed approach is needed to prevent and minimize cumulative impacts; to manage uncertainty for watershed health; and to protect the beneficial uses of water. Regulatory agencies require compensatory mitigation from permit applicants for unavoidable impacts to watersheds and waterways. State and national studies of aquatic resource mitigation, however, show a disappointingly low success rate in meeting performance measures and replacing aquatic resource functions (National Research Council 2001; Ambrose et al. 2007; Mack and Micacchion 2006; Reiss, Hernandez and Brown 2007; Hruby et al. 2009, USACE & EPA 2008). The studies identify two main reasons. First, there has been an institutional bias toward on-site fixes. Past policies and practices have over-emphasized the need to replace lost functions near impacted aquatic sites rather than selecting sites that best fit with the water quality goals for the associated watershed. Second, there has been overuse of easily acquired project sites. Those sites often come with ecological constraints that limit their potential functional performance. The published studies demonstrate a clear need to modify past practices.

In the last ten years there has been a general shift in state and national policies toward using watershed-based approaches to correct water quality problems. This is especially true for NPS pollution. While this shift in approach is becoming widespread among regulatory agencies, there is a lag in practitioners using a watershed approach for making mitigation determinations. Also, there is an overall lack in availability of methods and training for the approach.

For California, WRAMP provides a set of guiding tenets and technical tools that have the potential to significantly increase the capacity of State and local agencies to assess and improve the performance of water quality protection policies, programs, and projects (WRAMP 2010).

Figure 1: Overview of the WRAMP framework.



According to the WRAMP framework, all water quality protection and improvement action are driven by clearly stated management and regulatory questions or concerns. The guiding tenet in this regard is that no data should be collected that aren't clearly and directly linked to a management or regulatory decision. This means that the managers and regulators must know how to use the data that are collected. Very broad, statewide management concerns are represented in Figure 1. When applied to a local project or watershed, the questions or concerns would tend to be much more specific.

The WRAMP framework emphasizes the need for standardized definitions of aquatic resources, and standardized methods for their identification, classification, mapping, and assessment. As part of WRAPP development, the State water Board is promulgating such standards for wetlands, streams, and their associated riparian areas (http://www.swrcb.ca.gov/water_issues/programs/cwa401/wrapp.shtml).

Monitoring and assessment data are classified into three levels based on their specificity. Level 1data consist of inventories of aquatic resources and catalogues related information derived from maps, remote sensing, literature searches, etc. They are typically needed to determine the distribution, abundance, diversity, and location of aquatic resources and the location of data sources. Typical Level 1 data include aerial imagery and Lidar. Based on the mapping, SOPs being developed through the State Water Board and CDFG, the level 1 maps of aquatic resources (termed the California Aquatic Resource Inventory [CARI]), will be used to update the national Hydrological Dataset (NHD) of the USGS, and the national Wetland Inventory (NWI) of the USFWS. Level 2 data consist of rapid field assessments of overall aquatic resource condition, functional potential, or "health" in the broadest sense. Typical Level 2 methods include the California Rapid Assessment Method (CRAM) endorsed by the USEPA and the Pacific Division of the USACE for use in California, the United States Rapid Assessment Method (USA RAM) endorsed by USEPA for national surveys, and the Proper Function Condition Assessment method (PFC) in use by the US Forest Service. Level 3 data consist of intensive, quantitative field measures of particular aspects of condition, function or stress. Typical Level 3 monitoring methods include the Benthic Macroinvertebrate Index of Biological Integrity (BM IBI) developed by CDFG, and the gauging of streams to quantify their flow regimes. Level 3 data are often needed to validate Level 2 methodologies.

According the WRAMP framework, once data are selected to address management or regulatory concerns or questions, they are collected based on carefully designed sampling or survey programs, also referred to as assessment frameworks. WRAMP emphasizes the use of probabilistic sampling designs for projects as well as ambient surveys to account for the unequal inclusion of probabilities of sample sites. WRAMP also emphasizes the use of standard methods of data collection for both projects and ambient surveys such that projects can be compared to each other and to ambient conditions over time.

To support alternatives analysis, mitigation and restoration planning, and to help address cumulative effects of management and regulatory actions, WRAMP can be used to generate Level 1-3 "watershed profiles" of aquatic resource condition and stress. Watershed profiles are one way to visualize the overall condition of a watershed in terms of its ability to meet or support water quality objectives. Watershed profiles are primary elements of the watershed approach to water quality improvement because they indicate the full breadth and intensity of water quality management actions, including permitted projects, and they provide the basis for coordinating future actions to maintain or improve the profiles. In the cases of water bodies with multiple watersheds, the profiles can be used to prioritize actions among the watersheds. Watershed profiles can be used to develop "green-infrastructure" development scenarios. For example, the watershed approach to compensatory mitigation can complement low impact development (LID) and diversion or elimination of NPS sources.

Assessment information developed at each of the three levels of analysis will be integrated into the California Environmental Data Exchange Network (CEDEN) through Regional Data Centers (RDCs). The coastal RDCs existing at this time or the Southern California Coastal Research Project (SCCWRP), Moss Landing Marine laboratory (MLML), and the San Francisco Estuary Institute/Aquatic Science Center (SFEI/ASC).The RCDs include web-based data exchange and management systems referred to as "trackers." The Wetland Tracker (http://www.californiawetlands.net/tracker/) is an example developed by SFEI-ASC that is being extended to other RDCs. The trackers are linked together through CEDEN to simplify and improve access to California's aquatic resource monitoring data. The RDCs are developing the capacity for automated watershed delineation and basic watershed profiles to support WRAPP implementation statewide.

II. Target Sources of Pollution in CCA Areas

There are many different source of pollution that have and continue to degrade the beneficial uses for the three CCAs covered under this project. The following information was compiled from various water quality studies, watershed management plans, TMDL staff reports, citizen monitoring data collection efforts and other sources (Table 1). In Fitzgerald, the RCD took a leadership role in producing a new version of their watershed assessment report. This report updates the document that SFEI wrote with ABAG during a prior grant term (SWRCB contract #05-309-205-0) to make its technical content more accessible to the general public and to make it more of a stand-alone document separate from material on the other two pilot CCAs. The Watsonville steering committee worked in groups organized by land use/watershed priorities: watersheds/hydromodification, urban, and agricultural. This group secured funding for a hydrology study in order to gain more information regarding circulation and hydraulics in the system, a study which was then utilized to move forward on projects identified in the 2003 county-funded Watsonville Sloughs Conservation and Enhancement Plan, then later incorporated into the Watsonville Slough TMDL for Pathogens (2006), and Santa Cruz County Conservation Blueprint (2011). Change in watersheds hydrology and plant life was also identified as an "opportunity area" for restoration in our Watsonville Historical Ecology work. In Sonoma Creek, the Sonoma Ecology Center partnered with the Vineyard Workers Services to develop a stewardship group in the "Springs" area, the most densely populated reach of Sonoma Creek, just north of the city of Sonoma. Work was also initiated on designing a project on Sonoma Creek's alluvial fan in Kenwood, funded by the Sonoma County Water Agency. The Kenwood fan was identified as one of the three "opportunity areas" for restoration in our recent historical ecology broadsheet submitted previously. The project will result in flood and sediment reduction, habitat restoration, and groundwater recharge. In addition, TMDLs were completed for pathogens and sediment in Sonoma Creek.

In most cases, the identification of sources is simply based on best professional judgment, as non-point sources are very difficult to identify and track. In addition, there are most likely some still unidentified sources. This project addresses all sources of NPS pollution to varying degrees. For example, as the new State wetlands policy is implemented, including the assessment framework described above, local governments and other implementers will be able to change land use or coastal policy, implement BMPs, and otherwise educate or communicate information to the three CCA communities. This guidance will address all the identified sources of NPS pollution in the table below.

Table 1. Sources of pollution and issues of concern for three critical coastal areas

CCA	**Level of Issue**	**Issue of Concern**	**Possible Sources**
Fitzgerald	TMDLs in Process	Fecal coliform	Faulty septic systems, livestock, leaking sewer lines, wildlife
	Other Issues of Concern	Sediment	Erosion due to active agricultural production, ranches, hiking/biking trails, and rural roads throughout watershed
		Emerging Pollutants	Personal care products, pesticides, household cleaners, and pharmaceuticals
		Hydromodification	Reduction in riparian forest, erosion, encroachment of urban and agricultural development, groundwater and surface water pumping, flooding
		Nutrients	Faulty septic systems, livestock and fertilizer from agricultural areas
		Invasive Species	Intentional and accidental introductions
		Pesticides	Agricultural fields and nurseries
Sonoma	TMDLs in Process	Nutrients	Faulty septic systems, livestock, and fertilizer from agricultural areas
		Pathogens	Faulty septic systems, livestock, leaking sewer

			lines, wildlife, urban runoff
		Sediment	Erosion due to active agricultural production, urban development and ranches; hiking/biking trails, rural roads throughout watershed, landslides and gullies, and historic logging and livestock grazing practices
	Other Issues of Concern	Temperature	Lack of shade due to reduction of riparian forest and encroachment of urban and agricultural development
		Invasive Species	Intentional and accidental introductions
		Hydromodification	Reduction in riparian forest, erosion, encroachment of urban and agricultural development, groundwater and surface water pumping, flooding, ill-fitting culverts
		Pesticides	Agricultural production
Watsonville	TMDLs in Process	Pesticides	Agricultural production; possibly municipal and residential applications
		Pathogens	Faulty septic systems, livestock, leaking sewer lines, wildlife, urban runoff
		Sediment	Erosion due to active agricultural production and urban development, rural roads
	Other Issues of Concern	Nutrients	Faulty septic systems, livestock, fertilizer from agricultural areas
		Dissolved Oxygen (DO)	Poor circulation, eutrophication, elevate nutrient inputs
		Poor water circulation	Pumps and road barriers which prevent brackish mixing and exacerbate existing impairment by DO and nutrients

III. Current Water Quality Conditions and TMDL Implementation

The following represents a summary of existing information available regarding impairment for three Critical Coastal Areas (CCAs): Sonoma Creek, Watsonville Sloughs, and the Fitzgerald Marine Reserve study area. Section 303(d) of the Clean Water Act (CWA) requires each state to identify those water bodies that do not meet water quality standards, which are put on the CWA 303(d) list as impaired waters. Thus, once a pollutant is put on the 303(d) list, it immediately becomes a priority pollutant (SF Bay RWQCB 2003). Diffuse, or non-point source (NPS) pollution is the focus of the CCA program, and so in this project, we use a much broader definition of pollutant beyond those on the 303(d) list to include other "issues of concern" identified by local stakeholders and relevant sources including existing management plans, reports, city and county General Plans, and Environmental Impact Reports (EIRs), that are perceived or documented to directly or indirectly alter the biological, physical, or chemical integrity of water.

Sonoma Creek

Sonoma Creek appears on the 303(d) list as impaired for sediment, nutrients, and pathogens. The Sonoma Ecology Center (SEC) led a study that assessed sediment loads from surface erosion, road erosion, and landslides and compared the current to the historic (c. 1800) sediment load in three subwatersheds: the mainstem of Sonoma Creek, Schell Creek (the tidally-influenced lower portion of Sonoma Creek), and the Carneros subwatershed (part of the Napa River watershed). The results indicated that current sediment loads are three to twenty times higher than they were in the 1800s from a combination of urban, agricultural, and legacy land use practices (livestock grazing and timber harvesting). About 50-90% of the current sediment load is human-caused (Lawton et al. 2006).

The San Francisco Estuary Institute (SFEI) sampled 40 sites in the Sonoma Creek and Napa River watershed for nutrients and pathogens in 2002-3. A "Characterization Survey" sampled all sites, and a follow-up "Hotspot Survey" examined nutrient concentrations at 6 sites in the Sonoma Creek watershed. During the "Characterization Survey", 33% of all samples and 72% of the locations exceeded 1,100 µg/L at least once, the concentration at which nitrate becomes toxic to aquatic life. Most of the sites sampled (13 out of 16) exceeded EPA guidelines for total nitrogen and all sites (16 out of 16) exceeded the guidelines for total phosphorus. The Hotspot Survey concluded that elevated nitrate levels in upper Sonoma Creek were related to improper use of septic systems and poor soil conditions in the community of Kenwood. On Nathanson Creek, which runs through the city of Sonoma, increased nitrate, and to a lesser extent, orthophosphate and ammonia, were sourced from "dry weather urban runoff…exfiltration from sewer lines…and additional inputs from rural areas upstream and downstream from the city during winter storms" (McKee and Krottje 2005, p. 36). A follow up study was recommended to address eutrophication that is prevalent throughout the watershed, and likely a response of these elevated nutrient levels.

Pathogen levels exceeded state guidelines along Sonoma Creek between Kenwood and the city of Sonoma, though E. coli concentrations were higher during the wet season than in the dry season[1]. This seasonal fluctuation suggests that more pollutants are carried into streams by winter storms that flush pollution off of agricultural fields and urban, impervious surfaces. In addition, the coinciding high levels of nitrate between Kenwood and the city of Sonoma suggest that sources of pathogens are mainly failing septic tanks in the Kenwood area, in addition to urban runoff. Moderate levels of E. coli were detected in the lower, tidal portion of the watershed, suggesting that sources are likely to be wildlife or cattle grazing (SF Bay RWQCB 2005).

Implementation plans for reaching TMDLs for pathogens and sediment were completed and adopted into the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) in February and December 2008, respectively. The nutrients TMDL for Sonoma Creek is still under development. Table 2 summarizes proposed implantation actions for reducing loadings in Sonoma Creek.

Table 2. Actions proposed within the Sonoma Creek CCAs to reduce pathogen loading.

Proposed Implementation Actions to Reduce Pathogen Loading from Septic Systems	
Implementing Party	Action
Sonoma County Permit and Resource Management Department	1. In cooperation with the Water Board and Sonoma Valley County Sanitation District, identify areas of greatest water quality concern from septic system failure based on proximity to impaired reaches, soil type, topography, and other factors.
	2. Submit a plan and implementation schedule to evaluate septic system performance for the watershed and to bring identified septic systems up to appropriate repair standards. Priority should be given to systems identified as posing water quality risks.

[1] Though bacteria concentrations were lower downstream of Kenwood in the dry season, lower flow in the creek results in longer transit times when bacteria can die off. Thus, lower concentrations downstream of Kenwood could be lower than actual inputs.

	3. Report progress on implementation of pathogen reduction measures.
Proposed Implementation Actions to Reduce Pathogen Loading from Sanitary Sewer Systems	
Implementing Party	Action
Sonoma Valley County Sanitation District	1. In cooperation with the Water Board and Sonoma County Permit and Resource Management Department, provide existing sanitary sewer maps to Water Board staff in order to identify potential areas of greatest water quality concern from collection system failure based on proximity to impaired reaches, soil type, topography, and other factors.
	2. Comply with provisions of general WDRs for sanitary sewer systems.
	3. Report progress on implementation of pathogen reduction measures. Priority should be given to areas identified as posing water quality risks.
Proposed Implementation Actions to Reduce Pathogen Loading from Municipal Runoff	
Implementing Party	Action
Sonoma County Water Agency, County of Sonoma, City of Sonoma, Sonoma Developmental Center, and other designated entities	1. Implement stormwater management plan.
	2. Update/amend stormwater management plan to include specific measures to reduce pathogen loading.
	3. Report progress on implementation of pathogen reduction measures.
Proposed Implementation Actions to Reduce Pathogen Loading from Livestock Grazing	
Implementing Party	Action
Owners of Livestock Grazing Operations	1. Participate in ongoing RCD/NRCS conservation programs.
	2. Implement management measures that reduce pathogen runoff.
	3. Where water quality impacts are identified, implement site-specific source control measures and conservation practices.
	4. Submit report of Waste Discharge or comply with conditions of WDRs waiver or discharge prohibition.
Proposed Implementation Actions to Reduce Pathogen Loading from Dairies	
Implementing Party	Action
Dairy Facility Owners	1. Participate in Sonoma-Marin Animal Resource

	Committee. The Committee supports dairy operators in their efforts to solve waste control problems and locate technical and financial assistance. The committee serves as a vehicle through which the Water Board and DFG can disseminate information on water quality regulations and requirements.
	2. Participate in an annual training program that identifies water quality concerns and site-specific management practices for reducing such water quality impacts (e.g., Dairy Quality Assurance Program Training).
	3. Ensure that facility is in full compliance with applicable Waste Discharge Requirements (WDRs) or waiver of WDRs.
	4. Where water quality impacts are identified, implement site-specific source control measures and conservation practices.

Watsonville Sloughs

The drainage area of the Watsonville Sloughs appears on the 303(d) list as impaired for pathogens and pesticides. In addition to the 303(d)-listed pollutants, there are other issues of concern in the watershed, including:

- Sediment
- Nutrients
- Turbidity
- Dissolved oxygen

The Coastal Watershed Council (CWC) runs two volunteer monitoring programs, Clean Streams and Snapshot Day that bring volunteers out in the watershed to sample sites for several water quality parameters. Data from the Clean Streams program since 2004 have consistently showed elevated levels of nutrients and pathogens at certain sites on Harkins, West Struve, and Watsonville Sloughs. Areas of Concern are defined as those stations that exceed three or more of the water quality parameters for Snapshot Day (Hoover 2006). Watsonville and Harkins Sloughs had sites identified as Areas of Concern for five of the past six years (including 2006, the most recent data available) and Struve Slough had Areas of Concern from 2001-2004. The Watershed Institute at California State University, Monterey Bay (CSUMB) also monitored pathogens in the watershed (Hager and Watson 2005). Most of their pathogen sampling sites coincided with those of CWC, and indicated similar water quality objective (WQO) exceedences. They also performed a source-tracking analysis, and concluded that for those sites that exceeded the E. coli WQO, the main sources were birds and dogs, and in wet weather, cows. Their studies have informed the development of the TMDL for pathogens (approved by EPA in 2007), which regulates fecal coliform discharges from livestock sources, irrigated lands, and grazing management (see Table 3 for proposed pathogen TMDL implementation actions).

The original impairment of Watsonville Sloughs for pesticides, particularly dieldrin and DDT, was based on data from the State Mussel Watch (SMW) in the 1980s. However, studies since 1993 have not detected levels of the two pesticides in bivalves above federal guidelines. A later study sampled water at several sites in the sloughs system and along the Pajaro River and tested toxicity by exposing colonies of a small resident estuarine crustacean (*Neomysis mercedis*) to the sampled water for 96 hours and recording percent mortality. In samples taken from four sites within the lower Watsonville Sloughs watershed in January 1995, *N. mercedis* mortality was high and levels of DDT and dieldrin exceeded the 4-day limit of the California Toxics Rule. Levels of these two pesticides were especially high in the Beach Street Ditch (Hunt 1999). The results of this study and the SMW data from the 1980s lead the RWQCB staff to conclude that the pesticide problem is mostly due to legacy pesticides (both DDT and dieldrin were phased out in the 1970s and 1980s) and are likely to be emerging in pulses during the wet season because they are prevalent in sediments. Over time these chlorinated legacy pesticides will degrade, and since there is no new inputs of them to the system, pesticides were lowered on the priority list of pollutants to be actively reduced through a variety of source reduction and restoration actions in 2005 (Central Coast RWQCB 2004). Despite the lower priority, the pesticides TMDL is still being developed.

Typical reconnaissance was not possible for sediment in the study conducted by CSUMB's Watershed Institute (Hager et al 2005) to assess the impairment status of sediment in the sloughs complex. However, based on suspended sediment concentrations and effects on beneficial uses, sedimentation rates were deemed "normal" and not disruptive to benthic organisms. The report notes that there is a level of uncertainty in their conclusions due to the difficulty in collecting data typical of sediment load analyses. Despite this uncertainty, their report resulted in the removal of sediment from the 2006 303(d) list.

In the middle and lower portions of the watershed, eutrophication is present in agricultural ditches and the sloughs, prompting several groups to raise concerns about elevated nutrient levels and dissolved oxygen, which are both aggravated by poor circulation. CWC, as mentioned above, has consistently found elevated levels of nutrients (mostly orthophosphate) and low levels of dissolved oxygen in Harkins and Watsonville Sloughs. Central Coast Water Quality Preservation Inc monitors two sites in the sloughs for water quality once a month. Both sites monitored by Preservation Inc. in the watershed exceeded WQOs for dissolved oxygen in a majority of the samples (Preservation Inc. 2006). Both of these monitoring programs cite poor water circulation in addition to polluted agricultural runoff as the cause for eutrophication.

Table 3. Proposed implementation actions for reducing pathogen loadings in the Watsonville Slough CCA.

<table>
<tr><th colspan="2">Proposed Implementation Actions to Reduce Pathogen Loading
from Sanitary Sewer Systems, Septic Systems, and Municipal Runoff</th></tr>
<tr><td>Implementing Party</td><td>Action</td></tr>
<tr><td rowspan="3">County of Santa Cruz and City of Watsonville</td><td>1. Educate the public, including the homeless, regarding sources of fecal coliform and associated health risks of fecal coliform in surface waters of the Watsonville Slough Watershed. Educate the public regarding actions that individuals can take to reduce pathogen loading in the Watershed. Revise Stormwater Management Plan and submit to Water Board for approval, monitor, and report.</td></tr>
<tr><td>2. Maintain the sewage collection system, including identification, correction, and prevention of sewage leaks into tributaries to Watsonville Slough. Revise Sewer System Management Plan and submit to Water Board for approval, monitor, and report.</td></tr>
<tr><td>3. Develop and implement enforceable means (e.g., an ordinance) of reducing/eliminating fecal coliform loading from pet waste. Educate the public regarding actions that individuals can take to reduce loading in the Watershed. Revise Stormwater Management Plan and submit to Water Board for approval, monitor, and report.</td></tr>
<tr><th colspan="2">Proposed Implementation Actions to Reduce Pathogen Loading
from Livestock Grazing and Dairies</th></tr>
<tr><td>Implementing Party</td><td>Action</td></tr>
<tr><td rowspan="2">Operators or owners of livestock facilities and animals</td><td>1. Develop and implement strategies to reduce/eliminate fecal coliform loading from farm animal and livestock facilities (e.g., pens, corrals, barns) into surface waters of the Watsonville Slough Watershed. Submit Nonpoint Source Control Implementation Program to the Executive Officer of the Water Board and monitor and report, or, document and report to the Water Board that no discharge is occurring from animal facilities.</td></tr>
<tr><td>2. Protect sensitive areas (including streambanks, sloughs, wetlands, and riparian zones) by reducing direct loadings of animal wastes from grazing areas into surface waters of the Watsonville Slough Watershed. Submit Nonpoint Source Control Implementation Program to the Executive Officer of the Water Board and monitor and report, or, document and report to the Water Board that no discharge is occurring from grazing activities.</td></tr>
</table>

Table 3 [continued]:

Proposed Implementation Actions to Reduce Pathogen Loading from Irrigated Lands	
Implementing Party	Action
Operators or owners of irrigated lands who land-apply non-sterile manure	1. Develop, implement and report on measures to reduce/eliminate fecal coliform loading from land-applied non-sterile manure into surface waters of the Watsonville Slough Watershed. Document and report to the Water Board that measures are in place and monitor to demonstrate effectiveness.

Fitzgerald Marine Reserve Study Area (FMR)

The Fitzgerald Marine Reserve study area has received the least attention in terms of characterizing impairment of natural resources, recreational uses, or watershed functions and processes that might affect key ecosystem support services. A combination of landowner, non-profit, local, regional, state and federal agency programs make up the monitoring and water quality programs for the Fitzgerald Marine Reserve Study Area. Some efforts have been underway for several years, while others have recently started or are under discussion.

Since the study area is an aggregate of eight small watersheds and associated shoreline areas, the following analysis will discuss impairment status by sub-watershed or shoreline area. Three of these watersheds have beneficial uses that are impaired by the following pollutants and appear on the Clean Water Act Section 303(d) list:

- San Vicente Creek – Coliform bacteria and nutrients
- Pacific Ocean at Pillar Point Harbor – Sediment and nutrients
- Pacific Ocean at Fitzgerald Marine Reserve – Coliform bacteria

San Vicente Creek: A combination of citizen and San Mateo County water quality monitoring has produced several evaluations of water quality conditions in San Vicente Creek from 1998 to the present. The mouth of San Vicente Creek at the Fitzgerald Marine Reserve is regularly posted for exceeding WQOs for bacteria, but corrective actions taken upstream by property owners and the County of San

Mateo have reportedly led to lower bacteria concentrations along upstream reaches of the creek and downstream to the west side of Highway 1. Bacteria concentrations remain high at the creek mouth and the largest peak in bacteria concentrations to date occurred in early 2000 – prior to watershed improvements. According to the same source, similar peaks have not occurred since then but events "with elevated concentrations have continued to occur, but (are) slightly less frequent. These high concentrations of bacteria at the creek mouth may be "from residual sources, tributaries not sampled, or other sources. It is also suspected that storm drains that receive runoff from residential and public areas wet of Highway 1…are contributing factors. At all sampling locations, bacteria concentrations are typically highest immediately after rains, but diminish thereafter".

There is conflicting information regarding the damage done to aquatic life by the exceedences of WQOs. A report written by the SWRCB states, "San Vicente Creek runoff does not appear to have significant long-term effects on the intertidal biota near the creek mouth" (SWRCB 1979). But a more recent report counters this statement:

"…during the reconnaissance survey of the intertidal (sic), high turbidity water was present, over which a surface film (detritus material) was present in tide pools near the creek mouth. In addition, many algal species appeared to be under physiological stress, evidenced by bubbles (gas production) on the fronds, bleaching, and discoloration, compared to the same algal species in areas further away not under the influence of creek runoff. The above conditions were noted when San Vicente Creek runoff was high. Accordingly, the effects to the algae likely stemmed from lowered salinity and/or the presence of a chemical or biological pollutant conveyed to the ocean via San Vicente Creek." (Tentera 2004)

Excessive nutrients in the form of nitrates and ammonia in San Vicente Creek is a concern for FMR Park planners since they can result in nuisance algal blooms and shifts in the composition of the biological community. Possible sources identified by Park planners include:

- equestrian facilities,
- fertilizers applied to farmlands,
- septic leach fields,
- underground broken sewer pipes,
- runoff from impervious surfaces associated with a range of land uses.

Park planners also point to evidence of pesticides and herbicides in San Vicente Creek (notably DDT and PCB).

Pillar Point Harbor receives runoff from a wide range of sources that may be contributing several different pollutants to the creeks that drain to the harbor as well as the harbor itself. The beach around the harbor is regularly posted for exceeding WQOs for bacteria in areas where it is monitored. At this time, the sources and pathways of the excess bacteria are unknown, but might be determined if a grant application to CALFED from the San Mateo County Resource Conservation District is accepted. Denniston Creek at Pillar Point Harbor has had beach postings, advisories and closures (based on State Water Board, San Mateo County and Surfrider data), and exceeded the WQO for E. coli in 2006 (Hoover 2006).

Technical team site reconnaissance resulted in some hypotheses about sources of bacteria and other contaminants along the shoreline of the harbor, including uncollected animal waste, a disabled discharge pipe from Pillar Point headlands, stagnant shoreline waters behind the breakwater, and soil compaction issues associated with very heavy visitation by locals and during the Mavericks Big Wave surf competition. Consultants to San Mateo County have described impacts associated with Mavericks.

Half Moon Bay Airport maintains a storm water discharge point near the marsh (at the west end of the harbor) and is reportedly in discussions with the San Mateo County Parks Department about methods to reduce sedimentation from its many ditches, and runoff from its runways. Airport staff estimates that 15% of the facility is impervious. Half Moon Bay Airport tests storm water periodically per its NPDES permit. Annual reports are located at the County and the Bay Area Regional Water Quality Control Board. The Stormwater Management Plan for the HMB Airport has flagged sediment and fuel as two areas where more information is needed.

A sewage pump station next to the marsh is reportedly beyond capacity and discharges raw sewage when Pillar Point marsh is routinely flooded. The Association of Bay Area Governments' (ABAG's) Local Hazard Mitigation Plan Annex describes sewage overflows from the Sewer Authority Mid-Coastside (SAM) facilities and specific information about related hazards is contained in the Wet Weather Flow Management Program Facility Plan and studies on the Intertie Pipeline System.

A sewage pump station next to the marsh is reportedly under-sized for the amount of material it treats, and consequently discharges raw sewage when Pillar Point marsh is flooded. Sewage overflows are common, resulting in putting the thousands of beach visitors at risk of bacterial contamination. Further, the Environmental Protection Agency categorized sewer lines in Granada, Montara and Half Moon Bay as "insufficient", and the SAM is under EPA scrutiny for wet weather sewage overflows

Fitzgerald Marine Reserve receives runoff from storm water discharges emanating from 38 points along the FMR shoreline (28 discharges, three outlets, and seven potential non-point source springs/seeps; SWRCB 2001).

The 28 discharges included 19 municipal storm drains (serving multiple properties), four nonpoint source discharges (anthropogenic gully formation and road or pathway runoff), and five small storm drains (from individual properties). All 28 of these discharges are prohibited. Furthermore, since the area is quite developed there is the potential that the groundwater may be contaminated. Therefore the seeps were considered to have the potential to carry nonpoint source pollutants into the ASBS/SWQPA (SCCRWP and SWRCB 2003).

The Reserve is subject to a Master Plan for improvements to aid with runoff control for new construction and a communication effort is underway to address upstream contamination of San Vicente Creek and the Pillar Point Marsh. The county park staff at the Reserve is teaming with the San Mateo Stormwater Pollution Prevention (STOPP) Program to devise low impact development techniques to carry out its Master Plan, has developed a San Vicente Creek restoration program for the lower reach, and is reportedly in communication with neighboring communities which discharge directly to the Reserve.

The remaining shoreline areas, watersheds, wetlands and drainages are not formally listed by the State of California, but have water quality conditions described by various agencies and organizations. The County of San Mateo Environmental Health Department samples water quality regularly in multiple locations and in two watersheds (San Vicente and one other, unidentified watershed location) at both the mouth of the creeks and upstream. The County posts its shoreline sampling data at a public web site (Earth911). Surfrider Foundation and Heal the Bay also post information on mid-coastside water quality as part of routine environmental scorecards. The following table summarizes the possible issues of concern for the remaining watersheds and shoreline areas not already discussed above (Table 4). At this time, however, more analysis is needed to fully understand the level of threat of these water quality concerns.

Table 4. Issues of Concern for which specific data are not available in the Fitzgerald Marine Reserve CCA

Sub-watershed or Shoreline Area	Martini Creek and Shoreline	Dean Creek	San Vicente Creek	Denniston Creek and shoreline	Seal Cove and Vicinity	Airport Aquifer/ Pillar Pt. Marsh	Deer Creek	El Granada Shoreline	Air Force Facility	Pillar Point Harbor	Montara Creek and Point
Issue(s) of concern (data source)	▪ coliform bacteria ▪ E. coli	▪ coliform bacteria ▪ E. coli ▪ Nitrates ▪ ammonia	▪ coliform bacteria ▪ E. coli ▪ Nitrates ▪ ammonia ▪ DDT ▪ PCB	▪ coliform bacteria ▪ E. coli ▪ aluminum ▪ turbidity	▪ un-monitored stormwater discharges	▪ Nitrates ▪ Manganese ▪ 1,2,3-trichloro-propane (TCP)	▪ Tur-bidity	▪ Oil and grease ▪ Orthophos-pate ▪ E. coli ▪ Zinc ▪ Copper ▪ Total Suspended Solids	various	▪ coliform bacteria ▪ E. coli	▪ MTBE (in groundw ater) ▪ others

IV. Prevention and reduction of pollution in the three CCAs

Based on our work under the 319(h) grant, we identified policy and technical barriers as two of the main hurdles for local government and other stakeholders to make progress in reducing nonpoint source pollution in the CCAs. Stakeholders have now been provided with the necessary tools (predictive models, GIS maps, historical analysis of land use, recommended policy language and changes to ordinances, etc.) to overcome barriers to implementation that may arise going forward.

With implementation of our tools and analysis, in addition to the implementation of the new Wetland and Stream Protection Policy, we believe that the result will be a more streamlined, open process of identifying areas of concern and implementing management measures to reduce the degradation of beneficial uses in the CCAs. The remaining technical needs and data collection tasks that would significantly improve the depth of analysis in an assessment to inform an adaptive implementation are described below in Table 5, including the need to develop more site-specific load reduction forecasts (through modeling efforts) as well as identifying specific management practices that will be able to accomplish those load reductions. Measuring the effectiveness of those appropriate management practices will also require more site-specific calibration and field verification to design an appropriate monitoring plan. Most of these tasks (historical analysis of land use and management, modeling pollutant loads, analysis of policy barriers to implementation of MMs, and identification of priority areas for MM implementation) have been completed and provided to stakeholders.

Preliminary assessment work, integration of data sources, and forecasts of expected load reductions will result in recommendations. These will include both non-structural and structural measures. Examples of the former are adjustments to Local Coastal Plans, updates to General Plans, or watershed-specific customization of new policies (such as the forthcoming Wetland and Stream Protection Policy in Region 2) that provide incentives and guidelines for NPS mitigation, prevention, and restoration activities. Examples of the latter are construction of detention and infiltration basins, impervious surface retrofits, or decreasing the drainage density of the stream and storm drain network via restoration of distributaries and watersheds. Forecasting the anticipated benefits of management measures and BMPs will require additional data that can then be used to calibrate the recommended models and reduce uncertainty in the anticipated performance of various BMP options (e.g., degree of reduction of sediment inputs into stream channels via road and culvert retrofits vs. enhanced rainwater infiltration devices).

It's important to note that many of the issues and concerns can probably be addressed with relatively inexpensive Level 1 or Level 2 data. This does not diminish the importance of the Level 3 data where they are certainly needed, but it does suggest that The WRAMP framework can provide absolute cost reductions for monitoring while also promoting cost sharing and improved data access and visualization for all interests.

Table 5. Matrix of issues, assessment questions, and data needs based on the WRAMP framework.
Blue: Questions associated with management responses
Green: Questions associated with environmental conditions or "state"

Potential and Recognized Water Quality Issues	Assessment Questions	Data Requirements	Level 1,2,3
Pathogens	1. What levels of pathogen indicators are considered "natural background" during dry- and wet-weather flows?	1. Storm flow samples from representative creek reaches. 2. Dry-weather baseflow samples from representative creek reaches.	3 3
	2. What does the drainage network look like that represents transport pathways of pathogens?	1. Combined routed hydrography and stormdrain map	1
	3. Where are potential pathogen-generating land uses located in relation to drainages?	1. Land use and routed hydrography/stormdrains	1
	4. Where are seabird rookeries, landfills, and other bird congregation places located in relation to surface water bodies?	1. Map of congregation places 2. Bird counts. 3. Pathogen indicator samples	1 3 3
	5. Where are sewers and septic systems located in relation to the natural and man-made drainage network?	1. Map of sewers and septic systems and routed hydrography/stormdrains 2. Infrastructure age data and maintenance records	1 2
	6. What types of control measures have been implemented for potential pathogen-generating land uses?	1. List of BMPs 2. Extent of BMP implementation (acres per drainage area)	1 1
	7. What is the relative contribution of "controllable" vs. "uncontrollable" pathogen indicator inputs into surface waters?	1. Pathogen indicator data from water bodies with high bird and wildlife use.	3
	8. What mechanisms exist to identify potential sewer and septic system malfunctions?	1. Maintenance and replacement statistics, inspection records	1
	9. What was "baseline" prior to BMP implementation?	1. Pathogen indicator data in representative stream reaches and water bodies prior to implementation	3
	10. What kinds of performance measures are being collected after BMP implementation?	1. Time series of pathogen indicator data in representative stream reaches and water bodies	3

Potential and Recognized Water Quality Issues	Assessment Questions	Data Requirements	Level 1,2,3
Excessive Nutrients	1. Which stream segments, wetlands, or other receiving waters show elevated nutrient levels or signs of eutrophic conditions?	1. Nutrient data from representative stream reaches. 2. Visual observations of excessive algal growth.	3 2
	2. What is the distribution of land uses potentially contributing to elevated nutrients in receiving waters?	1. Land uses. 2. Routed hydrography and stormdrain map.	1 1
	3. What does the drainage network look like that represents transport pathways of nutrients?	1. Routed hydrography and stormdrain map.	1
	4. Where are sewers and septic systems located in relation to the natural and man-made drainage network?	1. Map of sewers and septic systems in relation to creeks and stormdrains.	1
	5. What types of control measures have been implemented for land uses with the potential of nutrient loadings?	1. List of MMs and BMPs. 2. Extent of BMP implementation by drainage basin	1 1
	6. What mechanisms exist to identify potential sewer and septic system malfunctions?	1. Maintenance and replacement statistics, inspection records.	1
	7. What was "baseline" prior to BMP implementation?	1. Nutrient data prior to BMP implementation.	3
	8. What kinds of performance measures are being collected after BMP implementation?	1. Nutrient data at appropriate time scales and locations after implementation	3
Pesticides	1. Which stream segments, wetlands, or near-coastal areas are likely to be affected by pesticide runoff?	1. Pesticide use statistics by land use. 2. Width and extent of buffer areas near water bodies.	1 1
	2. What are pesticide use statistics in the watershed?	1. Pesticide use statistics	3
	3. Is there evidence of elevated legacy pesticides in the watershed?	1. Historical pesticide use statistics. 2. Sediment or tissue samples (e.g. Mussel Watch, TSMP)	3 3
	4. Is there evidence of aquatic or sediment toxicity?	1. Toxicity samples	3
	5. Is there evidence of altered benthic macroinvertebrate communities?	1. Benthic macroinvertebrate data	3
	6. What types of control measures have been implemented for land uses with the potential of pesticide loadings to the drainage system?	1. List of MMs and BMPs. 2. Extent of BMP implementation by drainage basin	1 1
	7. What kinds of performance measures are being collected after BMP implementation?	1. Time series of appropriate indicators in representative stream reaches and water bodies	2,3

Potential and Recognized Water Quality Issues	Assessment Questions	Data Requirements	Level 1,2,3
Excessive Erosion, Sediment Supply to Streams Stream Flow Alterations, Hydromodification Invasive Non-native Species	1. Where are highly erosive soils located within the watershed?	1. NRCS soil maps.	1
	2. What is the topography, and which areas have slopes > 5%?	1. Digital Elevation Models 2. Maps showing extent of watershed with slopes > 5%.	1 1
	3. What is the rainfall distribution, intensity, and frequency in the watershed?	1. Rainfall statistics	3
	4. What is the land cover distribution in the watershed?	1. Land cover and land use maps.	1
	Which stream segments, wetlands, or other receiving waters show elevated sedimentation rates?	1. Dredging and stream maintenance records. 2. Time-series data for wetland size and in-fill rates.	1 1
	5. What are the land uses potentially contributing to excessive erosion?	1. Land use maps linked to erodible soils maps	1
	6. Where are paved and unpaved roads located?	1. Road maps by jurisdiction, age, and type.	1
	7. What is the drainage density in the watershed and how has it changed over time?	1. Historic and current maps of channel network length compared to watershed area.	1
	8. What are the relative contributions of sheet and rill erosion from hillslopes, road cuts, and bed and bank erosion?	1. Stream bed elevation and lateral stream migration data over time. 2. Road maintenance records and assessment data.	1,2 1
	9. What types of control measures have been implemented by land uses with the potential of excessive sediment loadings to the drainage system?		1
	10. What was "baseline" prior to BMP implementation?		1-3
	11. What kinds of performance measures are being collected after BMP implementation?		1-3
	12. What types of control measures have been implemented by land uses with the potential of excessive sediment contributions to the drainage system?	1. List of MMs and BMPs. 2. Extent of BMP implementation by drainage basin	1 1
	13. What was "baseline" prior to BMP implementation?	1. Sedimentation and erosion indicator data in representative stream reaches and water bodies prior to implementation	2
	14. What kinds of performance measures are being collected after BMP implementation?	1. Time series of appropriate indicators in representative stream reaches and water bodies	2,3
	1. What does the drainage network look like?	1. Routed hydrography and stormdrain system	1

Potential and Recognized Water Quality Issues	Assessment Questions	Data Requirements	Level 1,2,3
Excessive Erosion, Sediment Supply to Streams Stream Flow Alterations, Hydromodification Invasive Non-native Species (continued)	2. How does it compare to conditions prior to alterations?	1. Historic and current maps of channel network length compared to watershed area.	1
	3. How have stream hydrographs changed over time?	1. Historic and current flow data (base flow persistence, flood frequency, extent, duration)	3
	4. Where are the floodplains and the 20-year and 50-year inundation zones?	1. Floodplain maps	1
	5. How much flow is being diverted for each stream and at what time of year?	1. Permitted diversion database. 2. Locations and timing of diversions.	1 1
	6. Which stream reaches are ephemeral and perennial?	1. Map of stream reaches.	1
	7. What is the distribution of various hydromodification features throughout the watershed?	1. Map of armored banks. 2. Location and extent of in-stream and off-stream reservoirs and storage ponds. 3. Discharge points of imported water. 4. Timing and locations of alterations in tidal regime. 5. Pumping plants.	1 1 1 1 1
	8. Where and by how much have stream channels incised or aggraded?	1. Stream bed elevation changes over time	1,3
	9. What MMs and BMPs have been implemented to restore floodplain structure and functions?	1. List of MMs and BMPs. 2. Extent of BMP implementation and restoration projects by drainage basin.	1 1
	10. To what extent have opportunities for multiple NPS pollution reduction steps been identified?	1. List of BMPs implemented and considered that have been shown to be effective for multiple pollutants (e.g. pathogens, pyrethroids, sediment).	1
	11. What kinds of performance measures are being collected after MM or BMP implementation?	1. Time series of appropriate indicators in representative stream reaches and water bodies	2,3
	1. What are the extent and distribution of riparian ecosystem-altering invasive species?	1. Maps showing extent and distribution of invasives.	1
	2. What kind of control mechanisms are in place?	1. Inventory of control programs/projects	1

Potential and Recognized Water Quality Issues	Assessment Questions	Data Requirements	Level 1,2,3
Wetland and Riparian Habitat Degradation	1. What are the extent and distribution of wetland and riparian habitat?	1. Maps of extent and location of wetland and riparian habitat classes, following NWI conventions.	1
	2. What is their condition?	1. Data on selected wetland and riparian habitat attributes (e.g., CRAM)	2
	3. What are the land uses adjacent to wetlands and riparian habitat?	1. Extent and location of land uses in relation to wetlands and riparian habitat.	1
	See also Flow Alteration and Hydromodification Section		
	4. What MMs and BMPs have been implemented to protect and restore wetlands and riparian habitats?	1. List of MMs and BMPs. 2. Extent of BMP implementation by drainage basin	1 1
	5. What kinds of performance measures are being collected after MM or BMP implementation?	1. Time series of appropriate indicators in representative stream reaches and water bodies	2,3
Trash	1. Where are current trash "hot spots?"	1. Map of trash accumulation areas	1
	2. Has trash been characterized to provide clues for points of origin?	1. Inventory according to likely sources (e.g., fast food; commercial areas; marinas, etc.)	1,2
	3. What are likely transport routes?	1. Analysis of likely trash-generating areas and linkage to storm drains or drainage channels.	1
	4. What MMs and BMPs have been implemented to protect and restore wetlands and riparian habitats?	1. List of MMs and BMPs. 2. Extent of BMP implementation by drainage basin	1 1
	5. What kinds of performance measures are being collected after MM or BMP implementation?	1. Time series of appropriate indicators in representative stream reaches and water bodies	2,3

References Cited

Ambrose, RF, JC Callaway and SF Lee, 2007. An Evaluation of Compensatory Mitigation Projects Permitted Under Clean Water Act Section 401 by the California State Water Resources Control Board, 1991-2002. Final Report to California State Water Resources Control Board. http://www.swrcb.ca.gov/water_issues/programs/cwa401/docs/mitigation_finalreport_wo_app081307.pdf

Central Coast Regional Water Quality Control Board (CCRWQCB), 2004. Project Plan for Impaired Waters Listing: Watsonville Sloughs Pesticides.

Central Coast Regional Water Quality Control Board (CCRWQCB), 2006. Watsonville Slough TMDL for Pathogens, Resolution No. R3-2006-0025.

Hager, J, J Le, and B Olson, 2005. Watsonville Sloughs Pathogen Problems and Sources. Watershed Institute: Seaside, CA

Hager, J and F Watson, 2006. Watsonville Sloughs Sediment Problems and Sources. Watershed Institute: Seaside, CA

Hoover, B, 2006. *Snapshot Day May 6th 2006: Results of a Sanctuary-Wide Water Quality Monitoring Event* Monterey Bay Sanctuary Citizen Watershed Monitoring Network: Monterey, CA.

Hruby, T, K Harper, and S Stanley, 2009. Selecting Wetland Mitigation Sites Using a Watershed Approach. Washington State Department of Ecology Publication #09-06-032. http://www.ecy.wa.gov/biblio/0906032.html

Hunt, JW, BS Anderson, BM Phillips, RS Tjeerdema, HM Puckett, and V deVlaming, 1999. Patterns of aquatic toxicity in an agriculturally dominated coastal watershed in California. Agriculture Ecosystems & Environment 75, 75-91.

Lawton, R and the Sonoma Ecology Center (SEC), 2006. Sediment Source Analysis, Sonoma Creek Watershed, California. Final Report. Sonoma, CA.

Mack, JJ and M Micacchion, 2006. An ecological assessment of Ohio mitigation banks: Vegetation, Amphibians, Hydrology, and Soils. Ohio EPA Technical Report WET/2006-1. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio http://www.epa.state.oh.us/dsw/wetlands/WetlandEcologySection.html

Mackenzie, A, J McGraw, and M Freeman, 2011. *Conservation Blueprint for Santa Cruz County: An Assessment and Recommendations from the Land Trust of Santa Cruz County*. Land Trust of Santa Cruz County. Santa Cruz, CA. 180 pages. http://www.landtrustsantacruz.org/blueprint.

McKee, LJ and P Krottje, 2005. Human influences on nitrogen and phosphorus concentrations in creek and river waters of the Napa and Sonoma watersheds, northern San Francisco Bay, California. San Francisco Estuary Institute Contribution 421. Richmond, CA.

NAPA, 2002. *Understanding what states need to protect water quality*. National Academy of Public Administration, Project Number 2001-001, Washington DC.

NAS, 1977. Environmental monitoring: analytical studies for the U.S. Environmental Protection Agency, Volume IV. National Academy of Sciences, Washington, DC.

National Research Council, 2001. *Compensating for Wetland Losses under the Clean Water Act.* National Academy Press, Washington DC. http://books.nap.edu/openbook.php?record_id=10134&page=1

NRC, 1990. Managing troubled waters. Committee on a Systems Assessment of Marine Environmental Monitoring, National Research Council, National Academy Press, Washington, DC.

Preservation, Inc., 2006. Results from 2006 Monitoring Program for Watsonville and Struve Sloughs.

Reiss, K. C., E. Hernandez, and M. T. Brown. 2007. An evaluation of the effectiveness of mitigation banking in Florida: ecological success and compliance with permit criteria. Final report to the Florida Department of Environmental Protection. Prepared by the H.T. Odum Center for Wetlands, University of Florida, Gainesville, FL, USA.
Available at: http://www.dep. state.fl.us/water/wetlands/mitigation/.

San Francisco Bay Regional Water Quality Control Board (RWQCB), 2005. *Total Maximum Daily Load for Pathogens in the Sonoma Creek Watershed: Project Report.* Oakland, CA: San Francisco Bay RWQCB

State Water Resources Control Board (SWRCB), 2001. *California Ocean Plan.*

Southern California Coastal Watershed Research Project (SCCWRP) and State Water Resources Control Board (SWRCB) 2003. *The Final Report: Discharges into State Water Quality Protected (sic) Areas*

Tentera, 2004. *Fitzgerald State Marine Park Resource Assessment*.

USEPA. 1977. *Basic water monitoring program.* Standing Work Group on Water Monitoring, U.S. Environmental Protection Agency, EPA 440/9-76-0252, Washington DC.

USEPA. 1983. Results for the national wide urban runoff program Volume 1 – Final Report. U.S. Environmental Protection Agency, Water Planning Division, Washington DC.

U.S. Army Corps of Engineers (USACE) and Environmental Protection Agency (EPA). 2008. *Compensatory Mitigation for Losses of Aquatic Resources; Final Rule.* 33 CFR Parts 325 and 332 and 40 CFR Part 230. Published in Federal Register April 10, 2008. http://www.epa.gov/owow/wetlands/pdf/wetlands_mitigation_final_rule_4_10_08.pdf

Ward, R.C., J.C. Loftis and G.B. McBride. 1990. Design of water quality monitoring systems. Van Nostrand Reinhold Company, New York.

WRAMP. 2010. California wetland monitoring workgroup tenets of a state wetland and riparian are monitoring program (WRAMP). Draft 2.0. California Wetland Monitoring Workgroup. http://www.waterboards.ca.gov/mywaterquality/monitoring_council/wetland_workgroup/docs/2010/tenetsprogram.pdf