Appendix 1:

All Deliverables Submitted for the Critical Coastal Areas Program, Phase I

Task 2.3

November 27th, 2006

We invite you to take a 15 minute on-line survey to help with the ***Critical Coastal Areas* Program**. Note that survey responses must be completed by Friday, December 15 at 5pm.

The Association of Bay Area Governments is teaming with the San Francisco Estuary Institute, the California Coastal Commission, the Bay Conservation and Development Commission and the State Water Resources Control Board to provide technical assistance in three Critical Coastal Areas – James Fitzgerald Marine Reserve, Sonoma Creek, and Watsonville Slough – as part of a pilot project launched in 2006.

You are receiving this message because of your interest in California's Critical Coastal Areas Program. The CCA's mission and goals are described at the state's website – http://www.coastal.ca.gov/nps/cca-nps.html

Spatial information in each CCA coastal watershed affecting Areas of Special Biological Significance will be an important way to analyze water quality conditions and improvements. In an effort to design an effective set of Geographic Information System (GIS)-based planning and research tools for each CCA, we have enlisted the assistance of GreenInfo Network (www.greeninfo.org) of San Francisco.

Below is a link to an on-line survey that GreenInfo has designed to get your ideas during the development of what will become an interactive, on-line GIS mapping tool for stakeholders in the CCA program. Our hope is that the GIS tool will be as responsive to community needs as possible.

To take the survey, go to this site:

http://www.surveymonkey.com/s.asp?u=160252864344

This survey is 16 questions and several pages long, and will take approximately 15 minutes to fill out. The results will be analyzed by GreenInfo in preparation for a set of workshops to be held early next year.

Before you take the survey, we recommend you follow this link to browse some examples of online GIS tools:

http://www.greeninfo.org/ccasurvey.html

Please take a few minutes to assist us in developing the best possible GIS mapping tool. We appreciate your time and willingness to participate. If you have questions, please feel free to contact Kathleen Van Velsor at KathleenV@abag.ca.gov, or 510-464-7959.

Sincerely,

Lisa Sniderman, California Coastal Commission
Ross Clark, California Coastal Commission
Lindy Lowe, Bay Conservation and Development Commission
Rainer Hoenicke, San Francisco Estuary Institute
Kathleen Van Velsor, Association of Bay Area Governments

B. ONLINE SURVEY QUESTIONS

This survey has two sections – the first is about you, the second is about how you see a possible approach to providing online access to information about Critical Coastal Areas.

1. PARTICIPANT INFORMATION

1. Name (optional)
2. Agency/organization (optional)
3. Email contact (optional)
4. Organization Type (Local agency staff, other local official, State/Federal agency staff, land owner, non-profit, general public, other)
5. Location (city or community where agency/organization/home is located)
6. Level of understanding about Critical Coastal Areas program? *(High, Medium, Low, Not sure)*

2. ONLINE TOOL ASSESSMENT

INTRODUCTION: An online, interactive tool for the Sonoma Creek, Fitzgerald Marine Reserve and Watsonville Slough Critical Coastal Areas could include simple data browsing, complex modeling or anything in between. We assume that the tool would primarily be map driven, but also provide reports on any information selected. The tool could range in function from simple (just browse data for an area) to complex (user makes choices about water quality strategies and sees results of this modeling online).

1. OVERVIEW: From your own point of view, how valuable would an online tool be that could do the following for a particular CCA:

(Critical, Important, Useful, Not important, Don't know)

a) View and explore planning and natural resource information about the area
b) View best management practices information on a watershed or drainage scale
c) View and explore water quality and environmental monitoring information
d) Generate reports showing user-selected information
e) View the outcome of pre-defined policies and practices on water quality
f) Select water quality policies and practices and generate outcome scenarios
g) Add new data or information (note to reviewers – this is just looking at where expectations are, not suggesting that it is actually a desired route – Larry)
h) Download site data (GIS and other)
i) Link to related information on best policy and management practices

Comments: (open ended comment)

2. MODELING PRIORITIES: If the tool included the ability to set user-defined choices about management policies and practices, how important would it be to be able to set user-defined parameters for each of these general categories?

(one choice per line)

Critical, Important, Useful, Not important, Don't know

Urban planning and development practices
Agricultural practices
Other rural land practices (dumps, homesites, etc.)
Modification of stream beds and banks
Hydrological and habitat restoration results for watersheds
Water and sediment movement
Maritime uses (hull cleaning, boating, etc.)
Infrastructure (roads, sewers, treatment facils.)
Transportation (roads and other facilities and maintenance)
Recreational and open space uses

3. DATA PRIORITIES: As part of the tool, how important is it to just provide online browsing access to the following types of data?

(one choice per line)

Critical, Important, Useful, Not important, Don't know

Urban land uses
Rural land uses
Threatened and endangered species
Riparian zones
Designated wetlands
Storm drains
Dams/water impoundments
Groundwater extraction wells
Permitted discharge points
Construction zones
Disposal areas
Ground water basins
Timber harvesting areas
Water monitoring points
Landslide risks
Impaired water body segments
Urban growth projections
Areas served by septic systems
Watershed Management Plan boundaries

Review of Impairment Status for Three Critical Coastal Areas

The following represents a summary of existing information available regarding impairment for three Critical Coastal Areas (CCAs): Sonoma Creek, Watsonville Sloughs, and the James V. 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 on a list known as the "303(d) list". A given water body can appear on the list for one or more water quality constituents. Total Maximum Daily Loads (TMDLs) are plans developed by the Regional Water Quality Control Boards (RWQCBs) in California in order to improve water quality for a particular pollutant. The development of the TMDL is a long process including multiple reports and a public comment period, but once the TMDL is issued, regulatory action can be taken (in the form of a permit, waiver, or enforcement order) to implement the actions prescribed in the staff report. Thus, once a pollutant is put on the 303(d) list, it immediately becomes a regulatory priority (SF Bay RWQCB 2003). The pollutants that appear on the 303(d) list tend to dominate much of the research that goes into improving beneficial uses of water bodies due to the regulatory requirements attached to them. However, the list only includes narrowly-defined "pollutants" and does not include other "pollution"[1] that may come from several, diffuse sources. Diffuse, or non-point source (NPS) pollution is the focus of the CCA program, and so in the following report, we will expand our view of pollutants beyond those on the 303(d) list to also include other "issues of concern" identified by local stakeholders and relevant information sources including existing management plans, reports, city and county General Plans, and Environmental Impact Reports (EIRs). Our focus here includes any "man-made or man-induced alteration of the chemical, physical, or biological integrity of water" (Section 502(19) of the Clean Water Act). While the effort to produce this summary was thorough, it was not exhaustive, and should be updated as information emerges or changes (updated General Plans, ordinances, state legislation, etc.). A summary of this narrative is captured in the deliverable for Task 3.1, "Issues of Concern for Three Critical Coastal Areas".

Sonoma Creek

The Sonoma Creek watershed has benefited from an abundance of data collection, management plans, and projects that all have contributed to a better understanding of the status of impairment in the watershed. The Sonoma Ecology Center (SEC) manages a volunteer restoration program called Creek Salons, which enables residents of the watershed to monitor water quality, remove invasive species, and replace them with native plants. The SEC also contributes much of the research literature on the watershed, including the recent Sediment Source Analysis (2006) to determine historic and present sediment loads and sources, and the Limiting Factors Analysis (2004) to determine what

[1] The CWA defines "pollutant" fairly broadly as "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water…The term "pollution" means the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." (Clean Water Act §502).

pollutants are impairing the life cycle of steelhead trout and salmon species in the watershed. The Sediment Source Analysis assessed sediment loads from surface erosion, road erosion, and landslides and compared the current to the historic (c. 1800) sediment load in three sub-watersheds: the main stem of Sonoma Creek, Schell Creek (the tidally-influenced lower portion of the Sonoma Creek watershed), and the Carneros Creek sub-watershed (part of the Napa River watershed). The study concluded 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; SEC 2006).

The San Francisco Estuary Institute (SFEI) sampled 40 sites in the Sonoma Creek and Napa River watersheds for nutrients in 2002-03. A "Characterization Survey" sampled all sites, and a follow-up "Hotspot Survey" examined nutrient concentrations at six sites in the Sonoma Creek watershed. During the "Characterization Survey", 33% of all samples and 72% of the locations exceeded 1,100 µg/L (the concentration at which nitrate becomes toxic to aquatic life) at least once. 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 improperly functioning 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.

To inform the development of the pathogen TMDL, SFEI also conducted sampling for pathogens in the watershed in 2002-3. 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[2]. 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).

All of these reports have contributed to the listing of the creek as impaired for sediment, nutrients, and pathogens. While the implementation plan for reaching a TMDL for pathogens was completed in 2005; the sediment TMDL is currently under development,

[2] 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.

and the plan for nutrients is in an earlier stage. Both the sediment and nutrients TMDLs are slated for completion in 2008.

Other concerns related to risk factors believed to have the current or future potential for affecting aquatic life, human health, or recreational resources (besides those pollutants listed in the 303(d) list), include (listed in no particular order):

- Stream temperature
- Instream flow/hydromodification
- Pesticides
- Flooding
- Invasive species
- Groundwater supply
- Stream bank erosion (lack of riparian buffers) and incision

Protecting habitat for endangered steelhead is a high priority, in part due to the regulatory mandates associated with the Endangered Species Act (both California and federal). Thus, components of steelhead habitat which are at risk are elevated in priority, including stream temperatures, changes in streambed geomorphology, and migration barriers, including those associated with decreases in baseflow (SEC 2004). In addition to steelhead habitat-related water quality concerns are the issues of flooding and the proliferation of invasive species along riparian areas. A combination of factors including development in tidal areas and floodplains, the reduction of native species throughout the watershed, long-term ditching and draining of the land to provide for agriculture and other human uses, and sedimentation causes an intensification of storm peak flows that can result in widespread destruction of homes, businesses, habitat, and infrastructure (Dale 2007). Invasive species can impact, among other things, water chemistry, channel geomorphology, rate of erosion, water temperature, and habitat diversity. The most common species affecting the upper and middle reaches of the watershed include *Arundo donax*, *Vinca major*, acacia, tree of heaven, English ivy, and Mediterranean grasses (McKee et al, 2000). In the lower, tidally-influenced portions of the watershed, common invasives include glasswort and pepperweed. In addition to the water quality concerns listed above, future, potential threats to these sensitive resources include growing rural residential development, decreasing groundwater supply, and further aquatic and riparian habitat degradation.

There are several ongoing or new projects in the watershed that will contribute to increased awareness and information on impairment status in the future (Table 1). The combination of information collected through these projects and Phase II of the CCA Program will greatly add to existing baseline data available in the watershed.

Table 1. Ongoing and future projects that will contribute to impairment assessments in the Sonoma Creek CCA

Project	Lead Organization or Agency
City of Sonoma Creeks Plan	SEC, City of Sonoma
Community-based Watershed Management	Sonoma Ecology Center and others
Flood Control for Sonoma Creek and its Tributaries	USACE
Groundwater Management Plan	Sonoma County Water Agency (SCWA)
Recycled Water Project	SCWA and Sonoma Valley County Sanitation District
San Francisco Bay National Wildlife Refuge Comprehensive Conservation Plan	U.S. Fish and Wildlife Service
Sonoma Creek Watershed Enhancement Plan (Revision and update from 1997 version)	Southern Sonoma County Resource Conservation District
Tolay Creek Restoration	U.S. Geological Survey

Watsonville Sloughs

The drainage area of the Watsonville Sloughs, like Sonoma Creek, has benefited from several water quality monitoring programs to assess impairment status, as well as management plans to address the sources of pollution. Several groups monitor the sloughs system for a range of water quality parameters. The Coastal Watershed Council (CWC) runs two volunteer monitoring programs, Clean Streams and Snapshot Day that sample sites throughout the slough system 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 which 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 the EPA in 2006),

The original impairment assessment of Watsonville Sloughs for pesticides, particularly dieldrin and DDT, was based on data from the State Mussel Watch program (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 of use 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 are 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 with a planned release of a draft report in late 2008.

In addition to the 303(d)-listed pollutants, there are other issues of concern in the watershed, including (in no particular order):

- Sediment
- Nutrients
- Turbidity
- Dissolved oxygen

Typical reconnaissance was not possible to assess sediment in the study conducted by CSUMB's Watershed Institute (Hager et al 2005), but 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 that are both aggravated by poor circulation. CWC, as mentioned above, has consistently found elevated levels of nutrients (mostly orthophosphate) and dissolved oxygen in Harkins and Watsonville Sloughs.

The Central Coast RWQCB maintains the Central Coast Ambient Monitoring Program (CCAMP), whose results can be obtained through an online tool for reporting of Irrigated Agriculture Conditional Waiver (IACW) implementation and for evaluating the regional implementation of various agriculture management measures as defined within Farm Water Quality Management Plans. The program also has been monitoring several sites in the Watsonville Sloughs system for six years for a variety of water quality parameters and provides that data on their website. Also in response to the IACW program, Central Coast Water Quality Preservation, Inc. (Preservation, Inc.) monitors two sites in the sloughs for water quality once a month. Preservation, Inc. work in coordination with the Central Coast Agricultural Water Quality Coalition, an organization that helps farmers develop farm water quality plans to reduce runoff pollution. 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.

There are a few ongoing or new projects that will contribute to future impairment assessments of the watershed and determine what further actions might be taken to improve water quality (Table 2). The Integrated Watershed Restoration Program for Santa Cruz County, funded by $4.5 million from the Coastal Conservancy will provide funds and coordination among several restoration, education and monitoring projects implemented by over 20 organizations and agencies throughout the county (Goodnight 2004). The Watsonville Sloughs watershed is one of the targeted watersheds in the county, though no update is available for projects in the watershed that have been funded through the IWRP at this time.

The Pajaro Valley Water Management Agency (PVWMA) sells and distributes water to agricultural landowners throughout the Pajaro River watershed, including the Watsonville Sloughs complex. They are currently working with the city of Watsonville to build an addition to the city's existing wastewater treatment plant to recycle 4,000 acre-feet of treated wastewater per year and transport it to farmers for irrigation, instead of being discharged into Monterey Bay. The project was funded through the Pajaro River Watershed Integrated Regional Watershed Management Plan (Pajaro IRWMP). It includes the construction of treatment facilities, a distribution system, inland wells, public access and educational signs. In addition, they will oversee construction of Phases 2 and 3 of a 26-30 mile planned Coastal Distribution System to distribute the newly recycled water, in addition to other water supplies, to 200 agricultural parcels near the Pajaro River and Watsonville Sloughs (PVWMA 2006). This new source of water and distribution system, accompanied by water conservation, will potentially relieve pressure on groundwater resources, is expected to reverse saltwater intrusion into the aquifer, and produce other beneficial side-effects that might increase flushing of stagnant agricultural return water and speed up the degradation of legacy pesticides. It is unclear at this time, to what extent the Phase 2 expansion of the water recycling system would result in any modifications to the hydrology of the lower slough system, increased flushing of the Beach Street "ditch," and concomitant needs for upgrades to the current tide controls.

Another project funded through the Pajaro IRWMP is led by the Resource Conservation District of Santa Cruz County (SCCRCD) and addresses agricultural runoff pollution by implementing certain types of BMPs such as erosion control, vegetative treatment, and riparian restoration. This project will help to achieve TMDL targets for sediment, pesticides, and nutrients (PVWMA 2006).

Table 2. Ongoing and future projects that will contribute to impairment assessments in the Watsonville Sloughs watershed

Project	Lead Organization or Agency
Water Recycling and Coastal Distribution	PVWMA

System (part of Pajaro IRWMP)	
Santa Cruz IWRP (individual projects not determined yet)	State Coastal Conservancy, et al
Erosion Control, Vegetative Treatment and Riparian Restoration (part of Pajaro IRWMP)	SCCRCD

Fitzgerald Marine Reserve Study Area

The Fitzgerald Marine Reserve (FMR) 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 (e.g., pollution filtration/sequestration; maintenance of biodiversity; flood attenuation; groundwater recharge). Because few previous efforts have been undertaken to compile information from unpublished or widely dispersed sources, the following summary is more detailed than for Sonoma and Watsonville for which recent impairment summaries have been compiled in preparation of their respective TMDL implementation plans. The majority of the information below comes from a preliminary draft technical memo and accompanying maps and data provided by ABAG staff for the CCA project staff (Van Velsor and Strahan 2007). The information provided by ABAG originated from a variety of reports, interviews, programs, plans, and other documents, and are referenced throughout this document. A combination of business owners, non-profit, local, regional, state and federal agency programs make up the monitoring and water quality programs for the area and are summarized below. Some efforts have been underway for several years, while others have recently started or are under discussion (Table 3). San Mateo County Environmental Health Division monitors the levels of fecal indicator bacteria (E. coli) present in the creeks on a weekly basis. Sampling is conducted every Monday at the mouth of the creek. MBNMS Snapshot Day data give an overview of water quality with respect to physical, chemical and biological parameters for a single annual sample. These data are collected once per year in the spring, on as close to the same day as possible each year. Surfrider San Mateo monitored the levels of fecal indicator bacteria (E. coli and Enterococcus) in the creeks on a weekly basis. Sampling was conducted on a Saturday morning for the period of April 2005 through April 2007.

The CCA is an aggregate of seven watersheds and drainages, and their associated shoreline areas that have not, until this time, been considered one study area. These include (from north to south) Martini, Montara, Dean/Sunshine Valley, San Vicente, Denniston, and Deer Creeks and the Pillar Point Marsh drainage. Due to the variety of documented or potential impairments and quality of data for each sub-watershed and budget limitations, we were not able to analyze all of the information for the entire CCA but made a thorough attempt at identifying pertinent data and information sources. Instead, the following compilation will summarize issues of concern by drainage or shoreline area.

A number of best management practices (BMPs) have been implemented to address those issues (see the map "Current Best Management Practices for Control of Land-Based Sources of Marine Pollutants" available online at http://www.sfei.org/cca/maps.htm (Van Velsor and Strahan 2007). This map identifies general types of issues of concern these management practices are designed to address, providing parameters and sources. However, it does not show locations of specific BMPs. The narrative below will provide more detail on what the impairment status is in each drainage, its associated shoreline area, and the uncertainties associated with the available data (also summarized in Table 4). The current issues of concern are based on data from a variety of sources or on potential impacts associated with specific land uses and activities that deserve additional investigation. They include (with sources in parentheses):

- Fecal bacteria (indicators of human pathogens; Surfrider, San Mateo County Environmental Health, MBNMS Snapshot Day)
- Hydromodification and flooding (San Mateo County drainage council; technical team reconnaissance)
- Sediments (Coastside CountyWater District 2004)
- Nutrients (San Mateo County Department of Parks et al. 2002)
- Pesticides (San Mateo County Department of Parks et al. 2002)
- Mercury (San Francisco Bay RWQCB)
- 1,2,3-trichlorpropane (MWSD 2005)
- Manganese (MWSD 2005)
- MTBE (MWSD 2005)

Additional issues that deserve additional investigation were raised at the 2007 stakeholder workshop including:

- Copper
- Offshore water circulation
- Effects of stormwater on creek integrity, including impervious surfaces, and how to handle increased volumes of runoff
- Invasive species
- Emerging pollutants (e.g. personal care products, pharmaceuticals)

Three water bodies within the CCA study area that have been placed on the 2006 SFBRWQCB's 303(d) list as impaired by the following pollutants are:

- <u>San Vicente Creek</u> – Coliform bacteria

- <u>Pacific Ocean at Pillar Point Beach</u> – Coliform bacteria

- <u>Pacific Ocean at Pillar Point</u>- Mercury

- <u>Pacific Ocean at Fitzgerald Marine Reserve</u> – Coliform bacteria

More investigation is needed for each drainage and shoreline area in the study area to evaluate to what extent management practices designed to de-list the above water bodies may be applicable for others as well. The information compiled and summarized below is the result of our current efforts.

Martini Creek: In 2005, Snapshot Day sampling results showed exceedances of water quality objectives for pH, but in 2006 it was within limits (Hoover 2005 and Hoover 2006). Martini Creek is monitored weekly by County Environmental Health for fecal indicator bacteria. At the time this report was released in fall 2007, there were no water quality advisories for Martini Creek.

Montara Creek and related groundwaters: An MTBE source is located 2000 feet to the south of Montara Water and Sanitary District (MWSD) pumping well. In 2003, sampling results showed 529 µg/l of MTBE in the groundwater at Alta Vista well #1, far greater than the state standard of 13 µg/l set by the State Department of Health Services (2000). An EIR issued in 2005 by MWSD reported that the district was using a remediation system to keep the contaminated plume from migrating into the water that is pumped for domestic use (MWSD 2005). In late October 2007, MWSD announced that it would begin pumping 50-150 gallons per minute from one of the Alta Vista wells for drinking water supply, though it was unclear whether it was the same well near the MTBE source (Smydra 2007a). Montara Creek exceeded the WQO for pH during snapshot day 2005, but in 2006 it was within limits (Hoover 2005 and Hoover 2006).

Hydromodification is included as a category altering the integrity of water in the California Nonpoint Source Plan and an issue of increasing significance for the San Francisco Bay Region. While the watersheds within the pilot area have seen far fewer modifications than those in the more urban areas of the county, numerous opportunities to prevent additional hydromodification and restore key stream functions in certain locations may emerge. Future SFEI studies will quantify to what extent the natural hydrology in the study area has already been altered, and has thereby disturbed the dynamic equilibrium of streams, and to what extent additional hydromodification, if left unchecked, may contribute to continuing losses of watershed processes and functions. Technical team reconnaissance noted numerous drainage issues throughout the residential area of Montara, which are likely to contribute to hydromodification of Montara Creek and a small neighboring drainage on the north side of Montara (Kanoff Creek). Hydromodification generally exacerbates stream bank and bed erosion, sediment deposition at hydraulic constrictions, such as inadequately sized culverts, and hence contributes to flooding and loss of key stream functions. A recently-formed committee of San Mateo County officials and citizens, the Storm Drainage Council, will be investigating this issue in more detail in 2007-2008.

The California Department of Transportation (Caltrans) discharges storm water from its facilities into the Pacific Ocean at Montara Point (close to where Montara Creek drains into the ocean). Through an evaluation of the segment of Highway 1 from Pacifica to Half Moon Bay, pollutant data have become available through research completed at CSU Sacramento's Office of Water Programs, indicating that oil, grease, sediment, nutrients and coliform bacteria may be issues of concern. The exact sources and concentrations of these contaminants at the Montara outlet are unknown, as results are only summarized statewide, and in annual load instead of concentration (CSU Sacramento Office of Water Programs 2006). Further research is needed to determine if any of these constituents is a major concern for the Reserve and nearby waterways. Extensive research has been performed by the agency on coliform contamination in storm water discharge structures that drain highly urbanized areas. A regional program of road maintenance occurs pursuant to CalTrans' Stormwater Management Plan which can help minimize pollutants from entering the waterways.

Sunshine Valley/Dean Creek: Beach postings/advisories and/or closures at the mouth of the creek indicate that the creek exceeds WQOs for E. coli and coliform bacteria (San Mateo County Environmental Health). Although no data were collected, the FMR Master Plan (San Mateo County Department of Parks et al 2004) speculated about possible problems with coliform bacteria, nitrates and ammonia, and sedimentation associated with upstream ranching and equestrian operations. . Further investigation is needed to determine if problems actually exist and what the sources are.
San Vicente Creek: This watershed has received the most attention due to voluntary efforts of land managers and regular data collection by the San Mateo County Environmental Health Department. It is a highly accessible and visible area due to the location of the parking lot for the reserve at the mouth of the Creek. A collaborative monitoring effort between landowners, tenants, San Mateo County and an environmental group in the San Vicente watershed, from 1999 to the present, has monitored the creek on a monthly basis for fecal indictor bacteria. The number of samples that exceed the WQO for e. coli have consistently decreased for sites on the east side of Highway 1 since 2000 due to successful implementation of best management practices and corrective actions upstream (San Mateo County Department Environmental Health 2007). However, the mouth of San Vicente Creek at the Fitzgerald Marine Reserve is still regularly posted for exceeding WQOs for coliform bacteria. 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 west of Highway 1 may be contributing bacteria. At all sampling locations, bacteria concentrations are typically highest immediately after rains, but diminish thereafter" (San Mateo County Department of Parks 2004).

The FMR master plan mentions concerns about nitrate, ammonia, industrial chemicals, and pesticide contamination of the creek, although no recent studies have been completed with reliable data to show such elevated levels. Possible sources of nutrients speculated by Park planners, not necessarily in priority order, 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.

Denniston Creek: The mouth of Denniston Creek is monitored once annually during MBNMS Snapshot Day and was monitored by Surfrider San Mateo from September 2005 through April 2007. MBNMS Snapshot data show that the creek exceeded accepted state standards for E.coli in recreational water for the first time in 2006 (Hoover 2006). Monitoring has been taking place annually since 2001. Surfrider data exhibited regular spikes in both E.coli and Enterococcus over the period samples were collected. The San Mateo County Resource Conservation District was recently awarded a grant to perform a source-tracking analysis of bacteria into Pillar Point Harbor, which will include monitoring of Denniston Creek for bacterial contributions.

Multiple investigations of Denniston Creek have observed high sedimentation rates throughout the watershed. Possible sources include normal erosion of soils in alluvial pockets within the larger granite rock structure that are easily erodible and produce fine sand in the creek, particularly in the headwaters. The Denniston Reservoir, located in the upper watershed has been dredged by the U.S. Army Corps of Engineers to remove these inputs of fine-grained sediment. In addition, the surrounding land is steep and consists of sandy loam soils which are also highly erodible. Additional sources of sediment include channelization of the creek in sections to accommodate unpaved roads and the absences of riparian vegetation, which accelerates natural bank erosion, and sediment washed off of agricultural fields in the upper watershed through sheet flow (Coastside County Water District 2005a). Surveying of the creek by Department of Fish and Game staff confirmed the high sedimentation, particularly below one of the unnamed tributaries where turbidity was significantly higher. However, it was unclear whether the sediment came from natural erosion or from upstream land use (Department of Fish and Game 2006). More investigation is needed.

The Coastside County Water District obtains a reported 23% of its water supply from Denniston Creek (19% from surface flows, 4% from groundwater), and maintains a Denniston Creek Treatment Plant in the coastal terrace, east of the Half Moon Bay Airport. The diversions are under a SWRCB water rights permit and limit the District to no more than a total of four cubic feet per second (cfs). The amount of surface water diversion is “limited by the low flow in the creek during the summer months, and when the production is low in drought years.” It is unknown what the total watershed yield is compared to the permitted diversions. The well field is reportedly not under the control of a water rights permit, but a Coastal Development Permit limits the annual water extraction from the wells to 130 million gallons per year (mgy) (Coastside County Water District, 2005b). The combined extraction of water from both surface and groundwater sources in the Denniston Creek watershed could potentially lead to hydromodification of the channel, however so far there are no data that would indicate any changes to the channel geometry.

Deer Creek[3]: Snapshot Day sampling determined that Deer Creek exceeded WQO’s for E.coli and dissolved oxygen in 2004 and turbidity in 2006. These are also the only two years that MBNMS Snapshot Day monitoring took place. No other data have been located for Deer Creek. More research needs to be conducted to understand land uses, hydrology, biota and related water quality conditions in Deer Creek to evaluate any risks to natural and recreational resources.

[3] Also referred to as El Granada Creek.

Pillar Point Marsh: The shoreline area of the marsh is regularly posted for water quality exceedances (total coliform, E. coli, and enterococcus) based on testing performed by the San Mateo County Environmental Health Department. The marsh receives its fresh water from subsurface distributaries of Denniston Creek. The RCD's project to identify sources of coliform and other pathogens will hopefully provide information to eliminate that water quality concern.

MWSD maintains groundwater wells on the airport property that are periodically tested by the state Department of Health Services (DHS) for drinking water safety. In 2002, monitoring results indicated that the aquifer below the Airport that contributes seepage into the marsh (where MWSD draws its water from) had levels of 1,2,3-trichloropropane, also known as TCP, (a soil fumigant used in the past in agriculture areas) that exceeded advisory levels[4]. The well was again tested in 2003 and levels still exceeded the DHS action level (DHS 2003). In addition, the northernmost well has levels of nitrate that periodically exceed the maximum contaminant level of 45 mg/L (MWSD 2005). The district is working on mixing water sources to dilute the high levels of nitrate but more information is needed to indicate whether either TCP or nitrate have migrated from the aquifer to the marsh.

The Half Moon Bay Airport maintains a storm water permit and has regularly submitted monitoring reports of its discharge in accordance with its NPDES permit to the RWQCB, though and currently there is no concern over the quality of discharge from the airport (Half Moon Bay Airport 2006)

A sewage pump station operated by the Sewer Authortiy Mid-Coastside (SAM, a joint powers authority responsible for operation and maintenance of sewer lines for the City of Half Moon Bay, and Granada and Montara Sanitary Districts) next to the marsh is reportedly under-sized for the amount of material it is expected to handle. "SAM has had frequent sewage overflow incidents during the wet season" throughout its service area totaling 197 between 2000 and 2005, including at least 14 that directly entered the Pacific Ocean via either Pillar Point Marsh or Montara Creek (EPA 2006). In 2006, two major spills entered the Ocean within a few weeks of each other totaling 7,000 gallons, and put beach visitors and surfers at risk of exposure to pathogen contamination. Further, the Environmental Protection Agency categorized sewer lines in El Granada, Montara and Half Moon Bay as "insufficient," prompting them to investigate the Sewer Authority Mid-Coastside for wet weather sewage overflows (Perkins 2007). In response to these overflows, SAM is installing several holding tanks to store overflow water during the wet season. At the time this report was released, they were in the process of installing six tanks in Montara and El Granada (Smydra 2007b).

Pillar Point Air Force facility is located on the headlands of Pillar Point, and its runoff drains to Pillar Point Marsh. The facility's water quality data have been submitted to the State Water Resources Control Board in response to a request for exception to the Ocean

[4] The chemical is unregulated so it does not have a Maximum Contaminant Level, but DHS has an advisory level of 0.0005 µg/L due it its identification as a possible carcinogen and acute effects on humans such as burning of skin and eyes (SWRCB 2003).

Plan Discharge Prohibitions to the Pacific Ocean. The facility's discharge through a drainage swale exceeds Ocean Plan standards, and a range of programs have been proposed to remediate storm water runoff conditions. However, NPDES permits are not required at this facility since its storm water discharges are not associated with industrial, construction or municipal activities. Transport of sediment and other constituents from Headlands to the Pillar Point marsh is one area of concern due to erosion caused by frequent foot traffic and a network of informal trails. These informal trails on the Pillar Point bluffs have developed into a substantial network of storm water conveyance channels (see deliverable for Tasks 6.1-6.3) [5]. Peninsula Open Space Trust (POST), the State Coastal Conservancy, and San Mateo County Parks have been developing plans for the trail network on POST property to control erosion and improve the trail network as part of the California Coastal Trail with appropriate erosion control measures. Management of the area to avoid further compaction and erosion should be the subject of discussion among agencies with jurisdiction in the area.

<u>Pillar Point Harbor:</u> Characteristic of commercial harbors, the Pillar Point Harbor generates waste from commercial fishing operations, recreational and residential boats, urban runoff from piers, and related structures, docks, roads, trailer parking, parking lots, boat maintenance and fueling facilities. The beach around the harbor is regularly posted for exceeding WQOs for bacteria in areas where it is monitored by the county's Environmental Health Department. At this time, the sources and pathways of the excess bacteria are unknown, but will be determined due to a recent grant award to the San Mateo County Resource Conservation District to perform a microbial source-tracking analysis.

The harbor has a capital improvements plan for maintenance and future development that includes dredging, pier replacement (subject to Coastal Commission Coastal Development Permit conditions for preventing or minimizing water quality impacts already attached to the project), shoreline erosion protections, boat docking additions, rest room replacement and enhancements to visitor-serving facilities and commercial uses. Any disturbance of the harbor's sediments can potentially affect water quality (including temperature, salinity, pH, dissolved oxygen, suspended solids, turbidity, nutrients, and trace metals and organic contaminants that are bound to sediments) and threaten species resident in the area due to the re-suspension of sediment (U.S. Navy 1990 in Levine-Fricke 2004). Some of these improvements could also have the potential to contribute non-point source pollutants; however there are many measures in place through efforts of the harbormaster, the Coastal Commission, and other groups, to implement management measures to reduce water quality impacts. Fuel spills are a significant issue for most harbors, including Pillar Point, and a management program is in place to respond to them. The Harbor does not currently have a coordinated program in place to address potential sewage disposal issues of boats that serve as permanent or semi-permanent residences. However, County Environmental Health Division staff hopes to use an existing model for a coordinated effort that is in place in Sacramento County. Abalone farming occurs in

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[5] The Mavericks Big Wave surf competition attracted 50,000 spectators in 2006 to various viewing places including Pillar Point Marsh, the harbor, and surrounding beaches, and bluffs. The competition was called off in 2007 due to small waves (Mavericks Surf Adventures LLC 2007).

the harbor and is also subject to special permitting to avoid excessive nutrients or other kinds of water contamination, which has been a problem for similar operations in other parts of the state. The permit includes prohibitions and provisions designed to protect the beneficial uses of the harbor.

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 in places. Therefore the seeps were considered to have the potential to carry nonpoint source pollutants into the ASBS/SWQPA" (SCCRWP and SWRCB 2003).

These outlet areas have not yet been investigated to determine the areas they drain and what constituents of concern they may contain.

The Reserve is subject to a Master Plan for improvements to aid with runoff control for new construction for a new interpretive center and a model parking lot for pollution prevention. A collaborative fecal indicator bacteria monitoring effort between landowners, tenants, San Mateo County and an environmental group in the San Vicente watershed, from 1999 to the present, continues. The county park staff at the Reserve is teaming with the San Mateo Countywide Water Pollution Prevention Program (formerly STOPPP) to devise low impact development techniques to assist meeting resource protection goals stated in the Master Plan for the Marine Reserve. Staff also intends to discuss with neighboring communities how they can more effectively manage storm water runoff which goes directly into the Reserve to meet the discharge prohibitions of the Ocean Plan

Pesticides and industrial chemicals (notably DDTs and PCBs) are additional possible issues of concern, though their source and current level of threat is unknown, though the master plan mentions a possible connection between pesticides and upstream nursery operations. The use of both DDT and PCBs has been banned or restricted for several decades. The latest data that indicated elevated tissue concentrations in bivalves was through the State Mussel Watch program in 1981 (San Mateo County Department of Parks et al 2002, p. 133)**.**

El Granada shoreline: Snapshot Day and First Flush volunteers found that the waters exceeded WQOs for orthophosphate, E. coli, zinc, copper, and total suspended solids.

> "E. coli concentrations for all of the time series ranged between 92,000 to >241,920 MPN/100ml at (El Granada). These were some of the highest

> concentrations measured at all of the sites during the First Flush events. Oil and grease samples were also analyzed by making a composite sample from each time series at each site. The El Granada site reported 1.8 ppm and the Half Moon Bay site 3.5 ppm. These concentrations were the highest of all the sites as well" (Hoover 2005).

While most of the El Granada shoreline is technically just south of the FMR CCA Study Area, a combination of ocean currents and an incoming tide could send runoff from creeks and storm drains that discharge to the shoreline into Pillar Point Harbor, affecting water quality in the harbor and potentially up the coast as well.

<u>Multiple watersheds:</u>
The attached map (ABAG 2007) illustrates the extent of septic systems in the area associated with rural residential development. This map does not capture retired septic systems and their leach fields. It also does not show which on-site disposal systems are relatively new and state-of-the-art, and which ones may be aging and in need of upgrades. Some areas of septic system placement are not yet illustrated (Seal Cove trailer park, for example). The cumulative effects of areas with on-site sewage disposal systems on stream and nearshore water quality are not analyzed to our knowledge**.** However, an immediate response program is in place for rapid enforcement if required.

<u>Data Gaps:</u>
Many data gaps exist in this pilot area. They are (in no particular order of importance):

- Nutrient data (San Vicente and Sunshine Valley Creeks)
- Pesticide data (San Vicente and Sunshine Valley Creeks)
- Source tracking for bacteria (entire study area)
- Sediment data (entire study area)
- Land use, hydrology, biota, and general water quality data (Deer Creek)
- Groundwater data (Pillar Point Marsh)
- Discharges from Pillar Point Air Force Station
- Water quality impacts of various marina activities including abalone farming, fish processing, sewage pump-out, etc. (Pillar Point Harbor)
- Discharge that may go directly into the Reserve from neighboring residential areas
- Information regarding on-site sewage disposal system, sewer system, and other water and wastewater infrastructure upgrades, maintenance, and implications for water quality (entire study area)
- Effect on water quality at Pillar Point Harbor (and possibly other sections of the ocean up the coast) from El Granada shoreline discharge.

Table 3. Existing and future plans, programs, and projects in the James V. Fitzgerald Marine Reserve CCA

Plan, Program, or Project	Lead Organization or Agency	Timing
Agricultural and Rural Lands Plan	NOAA (MBNMS Staff)	Completed
Fitzgerald Marine Reserve Draft	San Mateo County	Completed

Final Master Plan	Department of Parks	
Fitzgerald Marine Reserve Parking Lot and Visitors Center Low Impact Development Renovation	San Mateo County Department of Parks	Future (to be completed in 2009
Midcoast Local Coastal Program Update Project	San Mateo County Planning and Building Department	Ongoing
Montara Water and Sanitary District Public Works Plan Phase I Draft Environmental Impact Report	MHA, Inc.	Completed
Identification of Sources of Fecal Pollution Impacting Pillar Point Harbor	San Mateo County Resource Conservation District	Begins August 2007
San Mateo Countywide Pollution Prevention Program (SMCPP)	City/County Association of Governments San Mateo County and EOA, Inc.	Ongoing
Snapshot Day Water Quality Monitoring Program	Coastal Watershed Council (CWC) and NOAA (MBNMS Staff)	Ongoing
The Fitzgerald State Marine Park Resource Assessment	San Mateo County Department of Parks	Completed, 2004

Table 4. Issues of concern for shoreline areas and sub-watersheds of the Fitzgerald Marine Reserve CCA

Sub-watershed or Shoreline Area	Martini Creek and Shoreline	Montara Creek and Point	Sunshine Valley/ Dean Creek	San Vicente Creek	Denniston Creek and shoreline	Deer Creek	Pillar Point			El Granada Shoreline	Fitzgerald Marine Reserve
							Pillar Pt. Marsh/ Airport Aquifer	Pillar Point Harbor	Pillar Point Head-lands		
Known Issue(s) of concern (sources)			▪ coliform bacteria ▪ E. coli (SM County Environ-mental Health)	▪ coliform bacteria ▪ E. coli (SM County Environ-mental Health)	▪ E. coli (Snapshot Day) ▪ Enterococcus (Surfrider) ▪ Sediment (Coastside County Water District 2005; DFG 2006; Snapshot Day)	▪ Turbidity (Snapshot Day)		▪ coliform bacteria ▪ E. coli (SM County Environ-mental Health)	▪ Sediment	▪ Oil and grease ▪ Orthophos-pate ▪ E. coli ▪ Zinc ▪ Copper ▪ Total Suspended Solids (Snapshot Day and First Flush)	▪ DDT ▪ PCB (SM County Department of Parks 2005)
Potential Issues of Concern (sources)	▪ coliform bacteria ▪ E. coli (SM County Environ-mental Health)	▪ MTBE ▪ Oil ▪ Grease ▪ Sediment ▪ Nutrients ▪ Coliform bacteria (MWSD 2005)	▪ Nitrate ▪ ammonia ▪ Sediment (SM County Department of Parks 2005)	▪ Nitrate ▪ ammonia (SM County Department of Parks 2005)			▪ Nitrates ▪ Manganese ▪ 1,2,3-trichloro-propane (TCP) ▪ Sediment (MWSD 2005)	▪ Nutrients			

Acronyms

ABAG	Association of Bay Area Governments
ASBS	Area of Special Biological Significance
BMP	Best Management Practice
CCA	Critical Coastal Areas
CCC	California Coastal Commission
cfs	Cubic feet per second
CWA	Clean Water Act
EPA	Environmental Protection Agency
FMR	James V. Fitzgerald Marine Reserve
GIS	Geographic Information System
IRWMP	Integrated Regional Watershed Management Plan
MBNMS	Monterey Bay National Marine Sanctuary
mgy	Million gallons per year
MM	Management Measure
MWSD	Montara Water and Sanitary District
NPS	Non-point Source
POST	Peninsula Open Space Trust
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board
SEC	Sonoma Ecology Center
SEC	Sonoma Ecology Center
SFEI	San Francisco Estuary Institute
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load

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Issues of Concern for Three Critical Coastal Areas

CCA	Level of Issue	Issues of Concern	Portion(s) of Study Area of Particular Concern	Status	Data Source	Notes
Fitzgerald	TMDLs in Process	Coliform	San Vicente Creek; Pacific Ocean at Fitzgerald Marine Reserve; Pacific Ocean at Pillar Point Beach	Proposed completion 2019 for all	SFB RWQCB 393(d) list for 2006; Carmen Fewless	
		Mercury	Pacfic Ocean at Pillar Point	Proposed completion 2019	SFB RWQCB 393(d) list for 2006	
	Other Issues of Concern	Sediment				Extent is unknown but sources include agriculture, ranches, hiking/biking trails, and rural roads throughout watershed
		Nutrients				Extent is unknown but sources include faulty septic systems, livestock and farms along Highway 1
		Invasive Species				Noted as possible issue of concern for San Vicente Creek
		Emerging Pollutants (e.g. personal care products and pharmaceuticals)				Noted as issue of concern which is easy to mitigate and expensive to remediate; education and take-back program begun spring 2007
		Hydromodification				Expressed as concern due to flooding during winter in residential areas of Moss Beach and Montara; could be due to increasing development and subdividing of parcels with little infrastructure additions
		Pesticides				No data so far but is a fear of residential landowners; could drift from agricultural lands

Issues of Concern for Three Critical Coastal Areas

CCA	Level of Issue	Issues of Concern	Portion(s) of Study Area of Particular Concern	Status	Data Source	Notes
Sonoma	TMDLs in Process	Nutrients	Sonoma Creek between Kenwood and the city of Sonoma; Nathanson Creek near the city of Sonoma	Implementation still being formulated; Proposed completion date 2008	SFB RWQCB 393(d) list for 2006; McKee and Krottje 2005	
		Pathogens	Sonoma Creek from Kenwood to city of Sonoma; Nathanson Creek; Sonoma and Schell Creeks near Schellville	Completed 12/05; Basin Plan Amended 02/06	SFB RWQCB 393(d) list for 2006; Pathogen TMDL Final Staff Report	Loads were not analyzed in detail; instead most likely sources were identified and implementation focuses on removing or mitigating those sources
		Sediment	All except headwater tributaries (Asbury, Mill, and Sugarloaf Creeks)	Staff report due out summer/fall 2007; Proposed completion date 2008	SFB RWQCB 393(d) list for 2006	Sediment Source Analysis completed by Sonoma Ecology Center 10/06
	Other Issues of Concern	Temperature	lower Sonoma Creek, south of Madrone Road		Sonoma Creek Watershed Enhancement Plan (SSCRCD 1999); Limiting Factors Analysis (SEC 2004)	Caused by lack of shade and water diversions ; negatively affects steelhead spawning and outmigration
		Invasive Species			Sonoma Creek Watershed Enhancement Plan (SSCRCD 1999)	Eg. Arundo Donax
		Hydromodification			Sonoma Creek Watershed Enhancement Plan (SSCRCD 1999)	Eg. Decrease in # pools, sedimentation of gravels, etc.
		Pesticides				No data; could drift from ag into residential areas

Issues of Concern for Three Critical Coastal Areas

CCA	Level of Issue	Issues of Concern	Portion(s) of Study Area of Particular Concern	Status	Data Source	Notes
Watsonville	TMDLs in Process	Pesticides	below confluence of Harkins and Watsonville Sloughs	In progress; staff report issued 03/05; Proposed completion 2007	Central Coast RWQCB 303(d) list for 2006; Project Plan for Impaired Waters Listing (2004)	Monitoring 1996-2003 did not detect elevated levels of pesticides leading RWQCB staff to conclude that the pesticide problem is mostly legacy pesticides e.g. DDT and dieldrin that appear in sediment. Over time these pesticides will degrade, so the priority level was set to low in 2005
		Pathogens	"Hotspots" in 2003: lower Watsonville Slough, upper West Struve Slough, Harkins Slough @Harkins Slough Road "Hotspots" in 2004:lower Watsonville Slough, Harkins Slough @Harkins Slough Road	Approved by SWRCB 09/06; awaiting CA Office of Admin Law and EPA approval	Central Coast RWQCB 303(d) list for 2006; Hager and Watson 2004; Coastal Watershed Council 2004	
	Other Issues of Concern	Sediment	Hanson Slough and upper Galligan Slough	On 2002 303(d) list, but de-listed in 2005 due to Hager and Watson's report	Watsonville Sloughs Watershed Conservation and Enhancement Plan; Hager and Watson 2005	Typical reconnaissance was not possible, but based on suspended sediment concentrations and effects on beneficial uses, sedimentation rates were deemed "normal" and not disruptive to benthic organisms; noted uncertainty in conclusions based on difficulty collecting data typical of load analyses
		Nutrients	Middle and Lower areas of the sloughs where agriculture dominates		Watsonville Sloughs Watershed Conservation and Enhancement Plan	Eutrophication present; could be remedied with better circulation and more vegetative cover
		Dissolved Oxygen (DO)	Middle and Lower areas of the sloughs where agriculture dominates		Watsonville Sloughs Watershed Conservation and Enhancement Plan	Also due to poor circulation, eutrophication (due to increased nutrients); results in fish kills
		Poor water circulation	Middle and Lower areas of the sloughs where agriculture dominates and pumps are located		Watsonville Sloughs Watershed Conservation and Enhancement Plan	Due to series of pumps and road barriers; prevent brackish mixing and exacerbate DO and nutrient issues

Estimating Load Reductions

Introduction

"What's being done to find solutions to polluted runoff along California's coast?", is a key question for the Critical Coastal Areas (CCA) Program. We know that over the past 15 years, numerous programs and projects at the local, state, and federal levels have been established to protect the integrity of water, prevent pollution in runoff and protect and restore essential watershed functions and processes. However, until recently, the questions at the next level of detail have been left unanswered to a large extent. They are:

(1) Given the specific impairment issues in each CCA, what types of management measures (MMs) and management practices (MPs) have already been implemented to prevent further degradation, improve water quality, and restore valued natural and recreational resources?
(2) Has implementation occurred in opportunistic or strategic fashion? In other words, are implementation projects conducted on a pilot scale, tested for their effectiveness, and then expanded to cover all appropriate watershed areas where improved practices promise to result in successful outcomes?
(3) To what extent have water quality and hydrologic conditions, aquatic life, and recreational resources gotten better as a result of implementing improved practices and management measures?
(4) How much more needs to be done, and where?

To answer these questions, we compiled an inventory of existing management measures and practices within our budget constraints and collected associated documentation wherever available to evaluate to what extent any prevention, control, and restoration actions may have contributed to pollutant load reductions or recovery of valued aquatic resources (Tasks 3.2 and 3.3). We also conducted a literature search on BMP effectiveness, focused on application in the semi-arid climate that prevails in all three CCAs (Task 3.6), identified means by which to estimate load reductions based on additional BMP application and coverage, and evaluated data requirements for modeling anticipated relative performance of BMPs (Tasks 3.4, 3.5, 3.7, and 3.8).

Current MMs/MPs and Status of Tracking (Tasks 3.2 and 3.3)

The objectives of these tasks were to 1) identify the Management Measures (MMs) and Management Practices (MPs) that currently exist in the three pilot Critical Coastal Areas (CCAs) and 2) provide information on how (or if) they are being tracked.

The inventory of MMs and MPs were compiled through interviews with stakeholders, agency staff, and other technical partners (Tables 1-6). While our research was thorough, it was not exhaustive due to three limitations in addition to time and budget: 1) it is likely that MPs change with changing land use, seasons, and other environmental as well as economic factors (e.g. an agricultural operation can no longer afford to maintain dense vegetation in a filter strip for it to function properly, and instead chooses to return that land back to cropland); 2) in some cases, landowners are hesitant to report their practices as they fear regulatory action if water quality standards are not met; 3) the definitions and categories of MMs/MPs from the Plan for California's Nonpoint Source Pollution Control Program (NPS Plan), which were used in this task, do not always coincide with those of implementers in the CCAs. It is possible that with communication challenges across regions, some MMs were omitted.

As we reviewed program documentation, annual reports, stormwater management plans, agricultural waste discharge requirement waiver conditions, TMDL implementation plans, and many other documents, we concluded that project implementation has more often than not occurred in opportunistic fashion. We found that this project is the first comprehensive effort to track all six categories of MMs defined by the NPS Plan in each of the three CCAs. No other efforts to create or maintain a database of such information are available, with two exceptions. First, Stormwater Management Plans and Programs are present at the city or county level in each CCA. These plans and their annual reports, submitted to the appropriate Regional Water Quality Control Board (RWQCB) are required to contain detailed and current information regarding the MMs implemented or planned for the specific region covered by the National Pollution Discharge Elimination System (NPDES) permit that mandates the plans. However their focus is almost entirely urban, with a small portion of Wetland and Riparian Area MMs incorporated. In addition, the plans only account for the MMs implemented in the area covered by the NPDES stormwater permit and not the entire watershed or the area that we have defined by the CCA boundaries. The second exception is the forthcoming database being compiled by the Central Coast RWQCB for agricultural MMs implemented due to requirements stemming from the Waiver for Irrigated Agriculture. When complete, this database will have information on all MMs and MPs implemented on lands used for irrigated agriculture, as reported by landowners to the CCRWQCB.

Fitzgerald Marine Reserve

Table 1. Inventory of MMs/MPs currently implemented in the James V. Fitzgerald Marine Reserve CCA. MM categories and types are derived from the "Plan for California's Nonpoint Source Pollution Control Program".

MM Category	MP employed
Agriculture	Berms and ditches to divert rain/runoff away from manure
Agriculture	Covered barn stalls
Agriculture	Fencing to keep animals out of creeks
Agriculture	Filter Strips
Agriculture	Fish passage barriers removed
Agriculture	Native re-vegetation and restoration
Agriculture	Road maintenance to prevent sediment from reaching creeks
Agriculture	Storage of solids away from streams
Marinas and Recreational Boating	365 day/year, 24 hour Harbor District staff for ordinance enforcement to control dumping, painting, or to notify appropriate agency for action

Marinas and Recreational Boating	A harbor ordinance requires the use of pump out stations. This also applies to live aboards.
Marinas and Recreational Boating	Coastal Commission Clean Boater kits are distributed to existing and new tenants; harbor school tours (littering, dumping); lots of education re. boat maintenance and waste control techniques.
Marinas and Recreational Boating	Education, policies and procedures, enforcement.
Marinas and Recreational Boating	Education: Informational signage -- recycling/trash depositing; do not dump stenciling; pamphlets from S. Mateo Co. Env. Health Div. re. hazardous waste management and used oil
Marinas and Recreational Boating	Harbor manages an oily bilge water separator (first on the Cal. Coast). Cleaned water is routed to sewer.
Marinas and Recreational Boating	Restaurants are well trained in oil and grease management.
Marinas and Recreational Boating	Sewage pump out facility is free.
Marinas and Recreational Boating	The County regularly tests the harbor's water quality. They have consistently been rated with good water quality.
Marinas and Recreational Boating	The Harbor is in the process of getting certification under the state's Clean Marina Program. They believe they are mostly in compliance, and wish to score high. Completion is expected early 2008.
Marinas and Recreational Boating	There are pet litter bag dispensers and beach signage at points of shoreline entry, but little money for monitoring. They don't have a lot of jurisdiction over these activities
Marinas and Recreational Boating	There is a prohibition against dumping fish waste (three commercial fish buyers operate there), but some gets into harbor waters.
Marinas and Recreational Boating	There is a trench drain with oil/water separator across six lanes of boat ramps.
Marinas and Recreational Boating	Used oil recycling facility is free
Urban[1]	Educational materials are distributed to prevent dumping of medications.
Urban	General categories of BMPs outlined in the Storm water Management Plan for Half Moon Bay Airport: fuel spill response, general maintenance, ditch clean outs, materials storage control
Urban	Hydromodification plan in place at the county
Urban	Informational pamphlets about water conservation and sewer programs are available at Montara Water and Sanitary District's office.
Urban	Local Coastal Program proposed update: new 10%

[1] Although the NPS plan uses "urban" for a category, many of the MPs in this table are employed on rural residential lands.

	imperviousness rule, and proposed new winter grading ordinance
Urban	Threshold for sustainable water withdrawals employed by special districts.
Urban	Vegetated shoulders on Highway 1 function as filters.
Urban	City and County Association of Governments (C/CAG) manages implementation of the County Stormwater Permit with a variety of consultant and county staff programs, including the STOPP program, Watershed Protection Maintenance Standards, erosion and sediment control, construction site design and monitoring, culvert cleanouts, contract requirements for water pollution control, contract requirements for erosion control, training programs in waste management and handling.
Wetlands/Riparian Areas[2]	Beach closure action plan/beach postings
Wetlands/Riparian Areas	County Parks Divisionrestoration program on San Vicente Creek: involves bank stabilization, invasives removal, trash removal and water quality monitoring.
Wetlands/Riparian Areas	Invasive species control program for Pampas grass.
Wetlands/Riparian Areas	There are standard creek setbacks (35-50 ft) used by all agricultural users on some conservation lands. They don't address cultivation
Wetlands/Riparian Areas	Trail planning and erosion control projects; phased elimination of informal hiking trails.

Table 2. Organizations contacted to obtain current MM/MP information for the James V. Fitzgerald Marine Reserve CCA

City/County Association of Governments for San Mateo County (C/CAG)
Fitzgerald Marine Reserve
Golden Gate National Recreation Area (GGNRA)
Gulf of the Farallones National Marine Sanctuary
Half Moon Bay Airport
Montara Water and Sanitary District (MWSD)
Monterey Bay National Marine Sanctuary
Peninsula Open Space Trust (POST)
Pillar Point Harbor
San Francisco Bay Regional Water Quality Control Board
San Mateo Countywide Water Pollution Prevention Program (STOPPP)
San Mateo County Agricultural Commission
San Mateo County Department of Public Works
San Mateo County Environmental Health Department
San Mateo County Parks Department
San Mateo County Planning and Building Division

[2] Although the NPS plan uses "Wetland/riparian areas" for a category, some of the MPs in this table are employed on shoreline areas due to this CCA's location along the Pacific Ocean.

San Mateo County Resource Conservation District (SMCRCD)
Sewer Authority Mid-Coastside
Tetra Tech (consultants to Pillar Point Air Force Station)
U.S. Air Force at Pillar Point Air Force Station

Sonoma Creek

Table 3. Inventory of MMs/MPs currently implemented in the Sonoma Creek CCA. MM categories and types are derived from the "Plan for California's Nonpoint Source Pollution Control Program".

MM Category	MM Type	MP employed
Agriculture	1A-Erosion and Sediment Control	Stream setback: 25 ft required by county
Agriculture	1A-Erosion and Sediment Control	Critical area planting
Agriculture	1A-Erosion and Sediment Control	Filter strips
Agriculture	1A-Erosion and Sediment Control	Grassed waterways
Agriculture	1A-Erosion and Sediment Control	Cover crops
Agriculture	1A-Erosion and Sediment Control	Straw mulching
Agriculture	1A-Erosion and Sediment Control	Bank stabilization
Agriculture	1A-Erosion and Sediment Control	Vineyard erosion regs: Sonoma county code sec. 30-66 prohibits planting on slopes greater than 50%
Agriculture	1B-Facility Wastewater and Runoff from Confined Animal Facilities	Storage of solids away from streams
Agriculture	1B-Facility Wastewater and Runoff from Confined Animal Facilities	Berms and ditches to divert rain/runoff away from manure
Agriculture	1B-Facility Wastewater and Runoff from Confined Animal Facilities	Fencing to keep animals out of creeks
Agriculture	1C-Nutrient Management	Nutrient management plan (timing/rate of fertilizer application)
Agriculture	1F-Irrigation Water Management	Drip irrigation
Forestry	2A-Preharvest Planning	CDF Forest Practice Rules: Conversion Plans (from Forestry to other uses e.g. rural residential, parks) and THPs required when clearing trees
Forestry	2C-Road Construction/Reconstruction	CDF Forest Practice Rules: water breaks on roads required to reduce runoff
Forestry	2D-Road Management	Rural road maintenance practiced widely
Forestry	2D-Road Management	CDF Forest Practice Rules: regulations for constructing and maintaining logging roads to reduce erosion and sediment

Modeling Load Reductions (Tasks 3.4, 3.5, 3.7 and 3.8)

Introduction

Best Management Practices (BMPs) are methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources, such as pollutants carried by urban runoff (detailed for each CCA in the section above for Tasks 3.2 and 3.3; USEPA, 2000). Generally, BMP efficiencies are defined as the removal rate of specific pollutants. They are determined by sampling influent and effluent concentrations over the course of numerous storm events and then dividing the difference between the averaged pollutant concentrations by averaged influent concentration (Urbonas, 1994). Similarly, BMP efficiencies can be measured by comparing pre- and post-implementation pollutant concentrations.

For this portion of the CCA program existing or potential Management Practices (MPs) were evaluated in terms of achievable pollutant load reductions. The two major goals of this task were to:

1) Estimate the degree to which existing MPs affect loads of pollutants identified as major issues of concern that reach receiving waters; and
2) Extrapolate these estimates to assess potential load reductions that may result from implementing these MPs on a larger (i.e., watershed) scale.

Examination of existing projects and region specific literature assessed the degree to which given MPs affect loads. A simple, EPA-approved watershed model was used to integrate and extrapolate these findings to the watershed scale.

Methods

Compilation of BMP Efficiencies

BMP efficiencies found in the literature are mainly determined by BMP studies in the eastern or midwestern parts of the U.S., which have a very different climate from California. Studies on BMP performance in arid or semi-arid climates have noted that there are several major differences from humid areas that impact BMP efficiencies, e.g. higher erosion rate results in more sediment for a BMP to filter or settle out and little rainfall means biofiltration vegetation needs to be drought-resistant, or irrigated, which might not be sensible or economical given scarce water resources (Caraco, 2000). To get a sense of how BMPs perform in the local climate California BMP studies were compiled from the International Stormwater Best Management Practices Database. Extreme variation was observed in performance of the same BMP type (Table 7). It seems BMP performance is highly dependent on site design, location and maintenance. Accordingly, providing a range of BMP performance efficiencies is more realistic than designating a single removal efficiency for a BMP type.

Table 7 BMP removal efficiencies for nutrients, pathogens, and sediment compiled for California sites. Data are from the International Stormwater Best Management Practices database

(www.bmpdatabase.org). Blue text indicates statistically significant removal efficiencies in the positive direction.

		Percent removal						
BMP	**CA Location**	**Nitrate Nitrogen, Total**	**Kjeldahl Nitrogen, Total**	**Phosphorous, Dissolved**	**Phosphorous, Total**	**Solids, Total Dissolved**	**Solids, Total Suspended**	**Coliform, Fecal**
Filter - Sand	Norwalk	-329%	12%	40%	35%	-40%	91%	
Filter - Sand	Vista	-66%	47%	-8%	44%	-14%	93%	
Filter - Sand	Whittier	-17%	40%	-150%	27%	-53%	78%	
Filter - Sand	Monrovia	-105%	8%	-14%	0%	35%	87%	71%
Filter - Sand	Carlsbad	-19%	53%	48%	56%	-63%	93%	100%
Filter - Sand	Escondido	-56%	45%	22%	50%	-1%	78%	
Filter - Peat mixed w/ Sand	San Dimas	-173%	20%	8%	33%	-151%	83%	24%
Filter - Peat mixed w/ Sand	Downey	23%	17%	13%	5%	-16%	73%	-194%
Filter - Other Media	San Diego	-7%	19%	7%	23%	-3%	36%	60%
Biofilter - Grass Strip	Sacremento	-7%	-4%	-6%	19%	-112%	61%	
Biofilter - Grass Strip	San Onofre	61%	34%	-400%	-111%	16%	10%	
Biofilter - Grass Strip	San Onofre	53%	40%	-425%	-108%	11%	42%	
Biofilter - Grass Strip	San Onofre	-65%	-13%	-333%	-66%	-79%	36%	
Biofilter - Grass Strip	Sacremento	18%	14%	-24%	33%	-19%	52%	
Biofilter - Grass Strip	Moreno Valley	-9%	6%	-60%	13%	-35%	-125%	
Biofilter - Grass Strip	Sacremento	38%	13%	-53%	14%	-57%	69%	
Biofilter - Grass Strip	Orange	-1%	20%	-567%	-119%	-42%	-22%	
Biofilter - Grass Strip	Orange	-99%	-7%	0%	-50%	-42%	-94%	
Biofilter - Grass Strip	Orange	-55%	14%	-250%	-54%	-63%	0%	
Biofilter - Grass Strip	San Rafael	70%	34%	14%	10%	-89%	69%	
Biofilter - Grass Strip	Orange	92%	72%				80%	
Biofilter - Grass Strip	Orange	38%	16%	-92%	-48%	59%	54%	
Biofilter - Grass Strip	Shasta	-153%	20%	29%	42%	2%	77%	
Biofilter - Grass Strip	Moreno Valle	1%	-39%	-45%	17%	-42%	-296%	
Biofilter - Grass Strip	Shasta	60%	52%	-25%	31%	-31%	91%	
Biofilter - Grass Strip	Sacremento	-280%	17%	-6%	40%	-150%	62%	
Biofilter - Grass Strip	Carlsbad	56%	49%	-77%	24%	45%	83%	
Biofilter - Grass Strip	Cerritos	25%	-38%	-692%	-600%	-27%	-47%	
Biofilter - Grass Strip	Shasta	19%	-196%	-50%	-323%	-47%	40%	
Biofilter - Grass Strip	Altadena	-109%	1%	-116%	-45%	-90%	68%	
Biofilter - Grass Strip	Shasta	68%	-148%	-275%	-469%	-158%	72%	
Biofilter - Grass Strip	Moreno Valley	26%	-28%	-45%	-35%	-8%	-805%	
Biofilter - Grass Strip	Orange	70%	40%	-750%	-162%	-17%	64%	
Biofilter - Grass Swale	Cerritos	28%	-42%		-642%		29%	
Biofilter - Grass Swale	Cerritos	-30%	20%	-136%	-6%	40%	32%	
Biofilter - Grass Swale	Lakewood	23%	18%	-175%	-192%	17%	75%	
Biofilter - Grass Swale	Vista	52%	60%	-414%	-163%	-36%	3%	42%
Biofilter - Grass Swale	Carlsbad	14%	19%	-82%	-6%	-26%	62%	
Biofilter - Grass Swale	Downey	18%	53%	-708%	-59%	60%	79%	
Detention Basin - Dry, grass-lined	San Diego	6%	28%	-43%	40%	-36%	50%	
Detention Basin - Dry, grass-lined	Escondido	25%	24%	-9%	71%	2%	72%	
Detention Basin - Dry, grass-lined	Cerritos	14%	18%	-20%	-70%	24%	61%	
Detention Basin - Dry, grass-lined	Encinitas	8%	8%	36%	53%	3%	70%	-101%
Detention Basin - Dry, concrete	Downey	7%	14%	25%	14%	7%	40%	
Retention Pond - Wet	Encinitas	13%	31%	-250%	1%	-1189%	92%	100%
Retention Pond - Wet	Fremont	-153%	-28%	-47%	47%	6%	74%	64%
Wetland Channel	Fremont	-9%	-10%	64%	36%		46%	-82%
Wetland Channel	Fremont	-2%	-17%	54%	22%	-4%	39%	-134%
Hydrodynamic Devices	Menlo Park						68%	
Hydrodynamic Devices	Lake View Terrace	-8%	-20%	0%	0%	12%	-34%	-326%
Hydrodynamic Devices	Sacremento		54%		50%		71%	
Hydrodynamic Devices	Lake View Terrace	56%	30%	0%	36%	38%	12%	9%

Model Selection

The model used to estimate potential load reductions resulting from BMP implantation at the watershed scale was the Spreadsheet Tool for Estimating Pollutant Loads (STEPL). STEPL is an EPA approved model that employs simple algorithms to calculate nutrient and sediment loads from different land uses and the potential load reductions that would result from the implementation of various BMPs. It computes surface runoff, nutrient loads, including nitrogen and phosphorus, and sediment delivery based on various land uses and management practices. The pollutant sources include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and septic systems. For each watershed, the annual nutrient load is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using BMP efficiencies. The model includes default BMP efficiencies determined from literature values. However, as noted earlier, these BMP efficiencies may not represent the region modeled. STEPL therefore allows for user-defined BMP efficiencies.

Model Setup / Watershed Selection
The San Vicente Creek watershed (Figure 2), in the Fitzgerald Marine Reserve CCA (Figure 1), was chosen as a test watershed since detailed information exists regarding land use and activities as well as the types of BMPs that have been successfully implemented. Between 2002 and 2006 the Moss Beach Ranch Equestrian Center implemented numerous BMPs including fencing in the creek to exclude livestock, allowing vegetation to grow along the creek, improving their manure management plan, and putting in vegetated filter strip barriers along fields, vegetated water channels, and sediment traps. Over the course of the BMP implementation, the amount of E.*Coli* present in the creek decreased by over a factor of ten. Unfortunately, the creek was not sampled for nutrients and sediment, but presumably the BMPs that reduced the E.*Coli* load so dramatically also reduced the other pollutant loads as well.

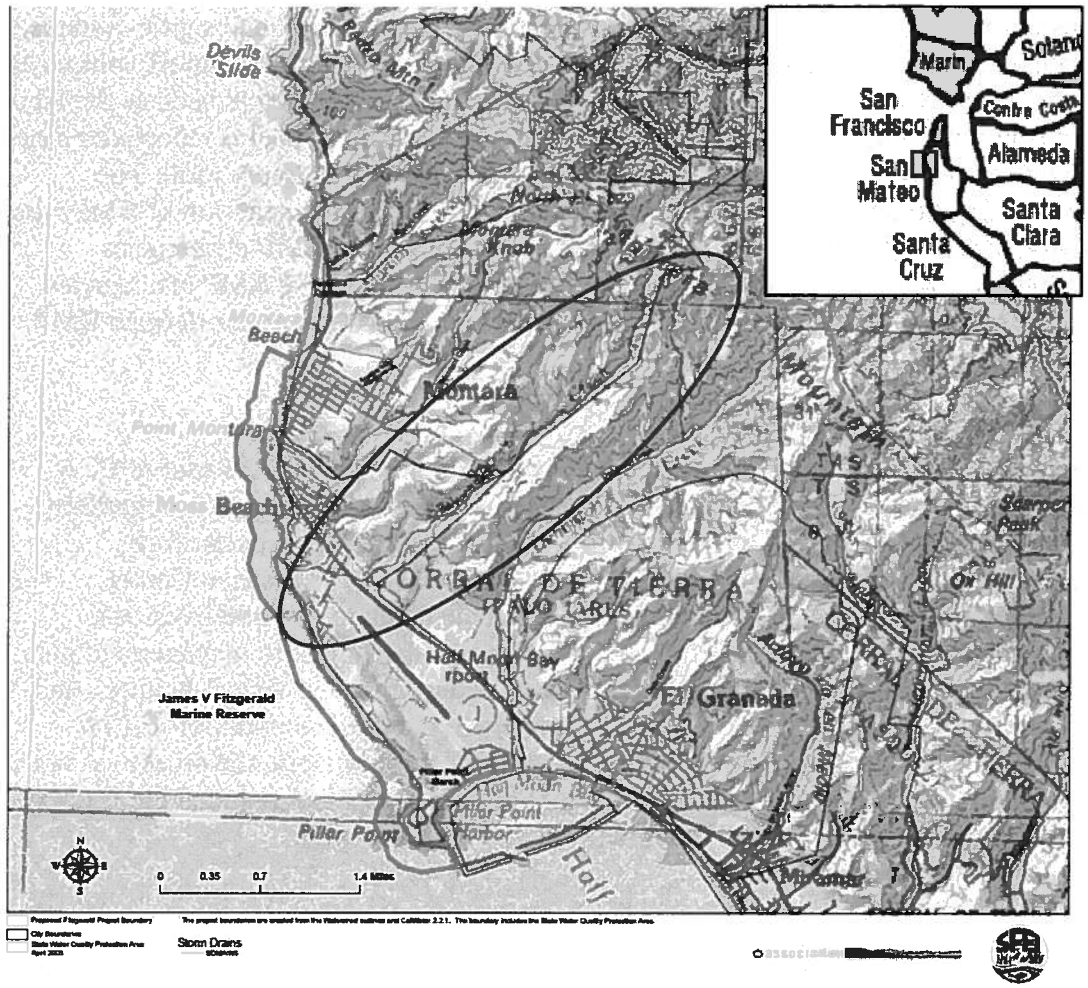

Figure 1 Fitzgerald Marine Reserve CCA boundary (with San Vicente Creek vicinity circled in red)

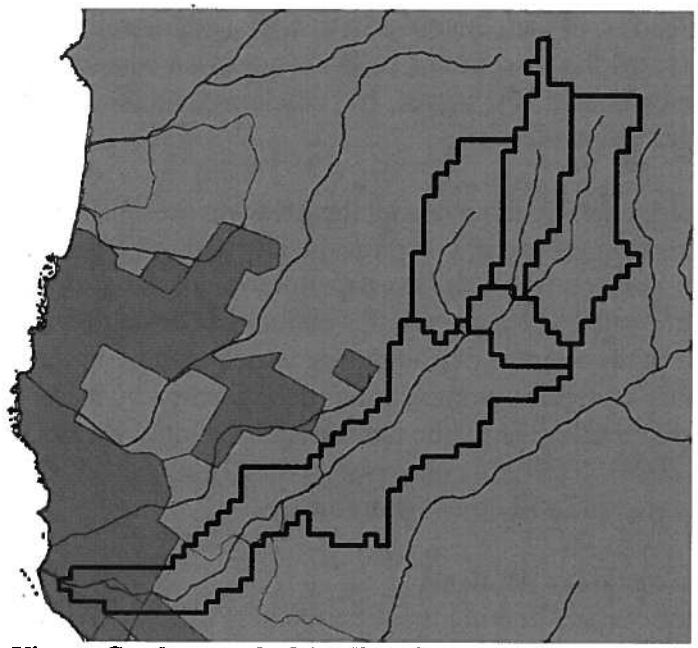

Figure 2 Map of San Vicente Creek watershed (outlined in black). The watershed contains five distinct drainage basins. The underlying map indicates general land use designations: urban development (grey); cropland (bright green); pastureland (olive). In the current model setup, forestlands were classified with pasturelands.

Table 8 summarizes the watershed specific variables used to model the San Vicente Creek watershed. Using geographical information systems (GIS) we determined the size and boundary of the San Vicente Creek watershed and associated subdrainages. Within the subwatershed, there are five distinct drainage regions, or subdrainages. Land use data were obtained from the USGS Land Use and Land Cover (LULC) database (USGS, 1986). The San Vicente Creek watershed contains about 1000 acres of pastureland (includes forest), 60 acres of cropland and 50 acres of urban area.

Table 8 – STEPL input parameters and data sources for the idealized San Vicente Creek watershed.

Input variable	Input value	Source
Subbasins	5	GIS
Pastureland*	1004 acres	USGS Landuse database
Cropland	62 acres	USGS Landuse database
Urban	51 acres	USGS Landuse database
Total area	1117 acres	GIS
Precipitation	29 in/yr	STEPL default value for San Mateo County
USLE parameters	varies	STEPL default values for San Mateo County
Soil Hydrological Group	B	Soil Survey of San Mateo
Livestock	300	Estimated by local resident
Manure application	6 months/year	Estimated from Livestock, Environment and Development (LEAD) Initiative
Septic systems	700	Estimated from US Census

* In the current model configuration, pasturelands also include forestlands.

From numerous local sources we determined that the main livestock present are horses, sheep, goats, llamas and chickens. According to a local resident, the majority of the area defined as pastureland is, in fact, devoid of livestock and instead is used for hiking and horseback riding. Given the presence of several equestrian centers and the low density of other livestock, we estimated 150 horses, 100 chickens, and 50 sheep/goats/llamas for a total of 300 livestock animals.

Manure spreading is generally done during the growing season (LEAD, 1999). However, the length of the growing season in is region specific and quite variable. We therefore used an estimate of six months for the average duration of the growing season (the sensitivity of model results to changes in this estimate is evaluated later). Six months is therefore also used as the average period during which manure is spread each year. We estimated the number of septic systems in the subwatershed by using the estimated population of the area multiplied by the percentage of people in the U.S. with septic systems (USEPA, 2004). STEPL's county-based data were used for annual precipitation, soil hydrological group and soil erosion parameters.

Sensitivity and Uncertainty Analysis

Given the uncertainties in estimating input parameters for the STEPL model (e.g, land use, precipitation, soil type, etc.) it was important to assess how these uncertainties affect model results. Such analysis was performed in two ways: sensitivity analysis assessed the degree to which changes in a single model input affect model results; uncertainty analysis estimated the aggregate uncertainty of model results given the uncertainty of model inputs. Both sensitivity and uncertainty analyses were performed on the STEPL model of the San Vicente Creek watershed.

Sensitivity Analysis

The objective of sensitivity analysis is to provide insight into the relative importance of the various model input parameters. This analysis is useful for prioritizing data needs and assessing the internal mechanics of the model. Model sensitivity (S) is defined as the percent change of model results (O) relative to the percent change in model input (I) and is given by

$$S = \frac{(\Delta O/O)}{(\Delta I/I)}. \quad (1)$$

The sign of S indicates the direction of sensitivity; A negative value of S indicates that model results are inversely related to the given model input parameter (i.e., an increase in the input parameter causes a decrease in the model outcome, or vise versa); A positive value of S indicates model results are directly related to the given input parameter. The magnitude of S indicates the relative degree to which an individual input parameter affects model results; A model input parameter with a large magnitude of S affects model outcome more than an input parameter with a small value of S. It is therefore wise to concentrate future data collection and/or research efforts on refining input parameters with high sensitivity since such refinements would result in greater improvements in model outcomes.

Sensitivity analysis of the STEPL model was performed for six watershed specific variables (Table 11) and four BMP types (Table 10). Since the California BMP efficiency data varied greatly within single types of BMPs (Table 7), BMPs were grouped by the land use class for which they are intended. A range of BMP efficiencies was then determined for each BMP type representing high, low, and best estimate efficiences (Table 9). These ranges were determined by examining both California specific literature (Table 7) and STEPL's default values. Sensitivity results were used to identify information gaps and help prioritize future data collection.

Table 9 - BMP efficiency ranges compiled for different land use classes. Removal rates are for nitrogen (N), phosphate (P), and sediment (S). Estimates incorporate authors' judgment while evaluating removal rates reported in Table 1 and do not include any reported rates that are in the negative direction (i.e., those that actually increased pollutant loads).

Landuse type	Low Removal Rate (N / P / S)	Best Estimate Removal Rate (N / P / S)	High Removal Rate (N / P / S)
Cropland	10% / 20% / 35%	40% / 40% / 60 %	75% / 70% / 85 %
Pastureland	30% / 20% / 50 %	60% / 40% / 65%	75% / 70% / 75 %
Urban	10% / 10% / 20%	40% / 50% / 70%	90% / 90% / 95%

Uncertainty Analysis

The objective of uncertainty analysis is to determine the aggregate uncertainty in model outcome due to the collective uncertainty, or variability, in model input parameters. Whereas sensitivity analysis helps rank data needs, uncertainty analysis helps put bounds (i.e., error bars) on model results. This is particularly important for evaluating the effectiveness of BMPs to reduce pollutant loads. It is difficult, and not prudent, to interpret model results without some measure of their certainty. A model result, for example, that estimates a 50% load reduction from a given BMP is of less importance to stakeholders than a model result that estimates a 50% ± 25% load reduction. The latter helps stakeholders to assess the feasibility of the given BMP relative to its likely outcomes (i.e., can assess the cost-benefit of the given BMP).

The values of watershed specific variables presented in Table 8 are best estimates based on literature review, GIS analysis, and personal communications and do not necessarily reflect the true characteristics of the San Vicente Creek watershed. In order to account for the uncertainty of these estimates, model runs used a wide range of values for each parameter. The ranges over which each watershed specific variable were varied are listed in Table 10 (in the "Modification from Baseline" column).

The uncertainty of model results was assessed by varying watershed specific input parameters over their range of variability and/or uncertainty while implementing BMPs. Parameters varied include the number of animals, number of months of manure spreading, number of septic systems within the watershed, soil hydrologic group, Universal Soil Loss Equation parameters, and precipitation. Certain watershed specific factors were kept constant: total acreage, number of sub-drainages, land use classifications and acreage, and types of animals. Results were used to put bounds on estimated load reductions for various BMPs. The uncertainty of the individual BMPs was not included in this analysis, as this was assessed as part of the sensitivity analysis.

Results and Discussion

Sensitivity Analysis

Results of the sensitivity analyses for watershed specific variables are summarized in Table 10. Focusing on the total loads columns (i.e., combined loads from all land classes), results indicate that model estimated loads of nitrogen and phosphate are most sensitive to precipitation and soil hydrologic group. These findings are not terribly surprising as both parameters determine the total volume of water discharged from the watershed and pollutant loads are defined as the product of pollutant concentration and total volume of water discharged. Fortunately, precipitation data are generally available for most watersheds in California. These results simply highlight that fact that high quality precipitation data are required for watershed modeling. Information regarding soil hydrologic group, on the other hand, is not always readily available. This parameter represents the 'runoff potential' of soils and is generally assessed at broad regional scales. High sensitivity of nitrogen and phosphate loads to soil hydrologic group indicates that detailed local soil information is required for reliable watershed modeling.

Sediment loads from combined land classes are most sensitive to the Universal Soil Loss Equation (USLE) parameters. These parameters collectively describe the long-term annual erosion rate of soils based on soil type, land use, precipitation, and topography. Sensitivity of model estimated sediment yield to these parameters highlights the need for accurate information regarding soils (e.g., soil type, erodibility), land use, precipitation, and topography. Estimated sediment loads are only moderately sensitive to precipitation, as precipitation is only one of the factors used by the USLE to estimate sediment yield.

The same general sensitivity results observed for total loads (i.e., combined from all land use classes) is seen for the individual land use classes. Results are most sensitive to soil hydrologic group, precipitation, and the USLE parameters. However, loads from the cropland land class are also sensitive to the animal density and manure spreading practices. It is not obvious why croplands are sensitive to these model parameters while loads from pasturelands are not. Intuition would say that animals graze and defecate on pastureland, not cropland, and that loads of nitrogen and phosphate from pasturelands would at least be sensitive to animal density. However, from the results of sensitivity analyses, it seems that STEPL assumes manure produced by farm animals is spread on croplands and there is no direct load of nitrogen and phosphate from pasturelands related to animal density and manure spreading. The documentation of how STEPL accounts for grazing, manure production, and manure spreading is not detailed enough to determine why this is. Further investigation into these findings is warranted if the STEPL model is to be used for further analysis of potential load reductions.

Model estimated loads of nitrogen and phosphate from the various land use classes modeled are generally insensitive to the number of septic systems in the watershed. While loads of nitrogen and phosphate are certainly related to the number of septic systems in the watershed (not shown) their effects are diluted by the significantly larger loads from pasturelands, croplands, and urban areas. Modeled loads are therefore insensitive to the number of septic systems in the watershed, at least for this particular watershed configuration and within the range of septic systems tested.

Results of the sensitivity analyses for BMP types are summarized in Table 12. Model estimated loads of nitrogen, phosphate, and sediment are highly sensitive, and negatively correlated, to the efficiencies of BMPs implemented. That should come as no surprise, as the STEPL model is specifically designed to estimate load reductions resulting from BMPs. The negative correlation results from decreasing loads as more BMPs are implemented. Moreover, sensitivities for the individual land uses are generally close to unity, indicating for example that doubling the efficiency associated with a given BMP results in half the pollutant load from that land use class. The sensitivity of total pollutant loads from the watershed is really just the weighted average of the sensitivities of the individual land use classes, with the weights representing the relative area of each land use class within the watershed and the pollutant concentration in runoff from that land use class.

The results summarized in Table 12 are not terribly informative, but rather are a check of the internal mechanics of the STEPL model. As noted earlier, the STEPL model estimates load reductions resulting from BMP implementation based on removal efficiencies. Thus, one would expect that if a BMP with a removal efficiency of 50% is implemented on a given land use within STEPL the resulting load reduction from that land use would be 50%. Indeed, that is what the results in Table 12 indicate; a value near unity indicates the percent change of model outcome is approximately equal to the percent change in the model input parameter. The deviation from unity is a function of the numerical precision of the STEPL model (e.g., round off error, significant figures) and the spatial treatment of BMP implementations (e.g., serial versus parallel implementation). The real message from these findings is that the wide range of efficiencies associated with a single BMP (Table 7) directly translates into a similarly wide range of potential load reductions from that BMP. In other words, a single BMP can yield varying results depending on how and where it is implemented.

Table 10 Results of sensitivity analyses for watershed specific variables grouped by land use class. Numbers indicate the sensitivity of pollutant loads to changes in input parameters as determined by Equation 1. Abbreviations are: nitrogen load (N), phosphate load (P), and sediment load (S).

Variable	Value	Modification from baseline	Urban			Cropland			Pastureland			Total		
			N	P	S	N	P	S	N	P	S	N	P	S
Number of animals	150	50% of best estimate												
Number of animals	600	200% of best estimate				0.4	0.3						0.1	
Manure spreading	0 months	0% of best estimate				0.5	0.5					0.1	0.1	
Manure spreading	12 months	200% of best estimate				0.5	0.5					0.1	0.1	
Num. of septic systems	350	50% of best estimate											0.1	
Num. of septic systems	1400	200% of best estimate											0.1	
Soil Hydro. Group	A (0.36 in/hr)	157% of best estimate	-0.4	-0.4	-0.4	-0.5	-0.4		-0.8	-0.6		-0.7	-0.5	
Soil Hydro. Group	C (0.1 in/hr)	43% of best estimate	-0.3	-0.3	-0.3	-0.5	-0.4		-0.7	-0.6		-0.7	-0.4	
Precipitation	14.5 in/yr	50% of best estimate	1.7	1.7	1.7	1.4	1.3		1.7	1.2		1.6	1.1	0.1
Precipitation	58 in/yr	200% of best estimate	0.2	0.2	0.2	1.7	0.2		0.3	0.2		0.3	0.2	
USLE parameters	varies	75% of best estimate				0.3	0.5	1.5	0.1	0.5	1.5	0.1	0.4	1.5
USLE parameters	varies	125% of best estimate				0.4	0.6	2.1	0.2	0.6	2.1	0.2	0.5	2.0

Note: Blank cells indicate a sensitivity of zero.

Table 11. Results of sensitivity analyses for individual best management practices grouped by land use class. Numbers indicate the sensitivity of pollutant loads to changes in removal efficiencies for various land management practices as determined by Equation 1. Abbreviations are: nitrogen load (N), phosphate load (P), and sediment load (S).

Variable	Value (N / P / S)	Modification from avg BMP	Urban			Cropland			Pastureland			Total		
			N	P	S	N	P	S	N	P	S	N	P	S
Cropland BMP	10% / 20% / 35%	56% lower efficiency				-0.9	-0.7	-1.1				-0.1	-0.1	-0.1
Cropland BMP	75% / 70% / 85%	68% higher efficiency				-0.9	-0.8	-0.9				-0.1	-0.1	-0.1
Pasture BMP	30% / 20% / 50%	41% lower efficiency							-1.8	-0.9	-1.1	-1.1	-0.4	-0.5
Pasture BMP	75% / 70% / 75%	50% higher efficiency							-0.7	-0.9	-0.6	-0.5	-0.4	-0.3
Urban BMP	10% / 10% / 20%	75% lower efficiency	-0.7	-1.1	-2.2									
Urban BMP	90% / 90% / 95%	80% higher efficiency	-1.0	-1.0	-1.0									
All BMP		57% lower efficiency	-0.9	-1.4	-2.9	-0.9	-0.7	-1.1	-1.3	-0.6	-0.8	-1.1	-0.5	-0.9
All BMP		66% higher efficiency	-1.3	-1.2	-1.3	-0.9	-0.8	-0.9	-0.6	-0.7	-0.4	-0.6	-0.6	-0.6

Note: Blank cells indicate a sensitivity of zero.

Estimated Load Reductions

Estimated load reductions resulting from implementation of various BMP types at the watershed scale are shown in Figures 3 through 5. Figure 6 indicates the estimated load reductions for combined BMP implementation at the watershed scale. These load reduction estimates were made using a single efficiency for each BMP type representing the best estimate from Table 9 while varying the six watershed specific variables listed in the previous discussion of uncertainty analysis. BMPs were implemented on all lands within the land use class for which it is designed (e.g., a cropland specific BMP was applied to all land classified as cropland; a pastureland specific BMP was applied to all land classified as pastureland).

For each land use class, the estimated load reduction is approximately equal to the efficiency of the BMP implemented on that land use class. This is the same result that was discussed in the previous section on sensitivity analysis, where the sensitivity of model results to changes in BMP efficiencies was near unity. Again, this is not terribly interesting or informative. Of more importance are the magnitudes of the error bars in each figure. These error bars represent the uncertainty of model results due to the uncertainty and variability of watershed specific input parameters. The measure used to calculate the uncertainty of model estimates was the standard deviation of all model simulations for a given land use and BMP type. One standard deviation indicates that approximately 70% of model results were within the range of the error bars.

For each pollutant, the uncertainty of the estimated load reduction is approximately half the estimated load reduction itself. It is important to keep in mind that these results only include the uncertainty of watershed specific parameters, not the uncertainty of the BMP efficiencies. In other words, if the efficiency of a given BMP is known, uncertainties in characterization of the watershed alone translated into considerable uncertainty in estimating potential load reductions resulting from BMP implementation. From Table 1, we know that large variation exists in the efficiencies of a given BMP type. Combining this uncertainty with the uncertainty of model estimates due to watershed variation would result in an extremely large uncertainty in STEPL predictions.

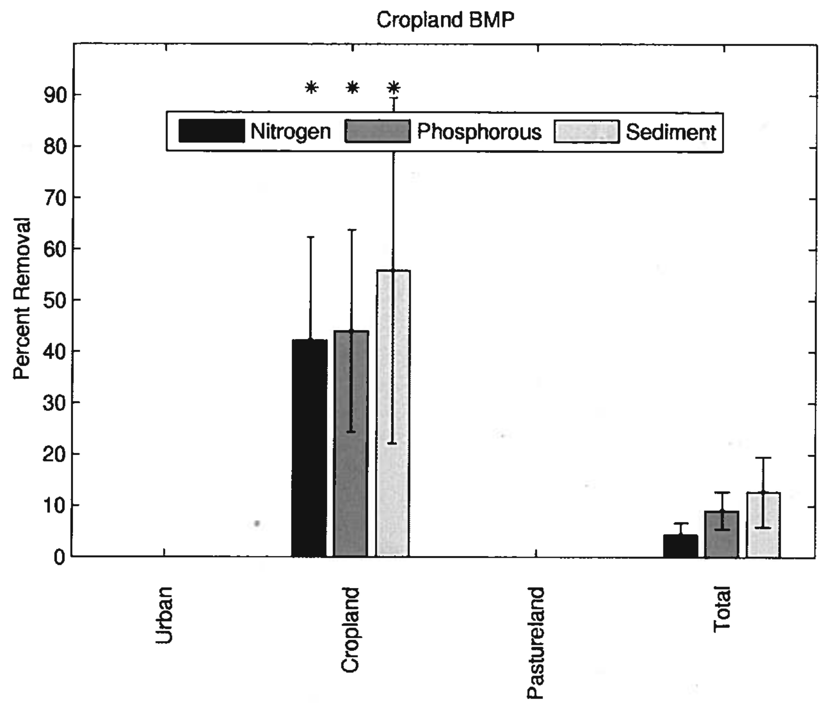

Figure 3. Estimated pollutant load reductions resulting from cropland based management practices. Error bars indicate the uncertainty of the model estimates based on the variability of watershed specific input parameters. Stars indicate a significant load reduction (i.e., different from zero) at the 95% confidence level.

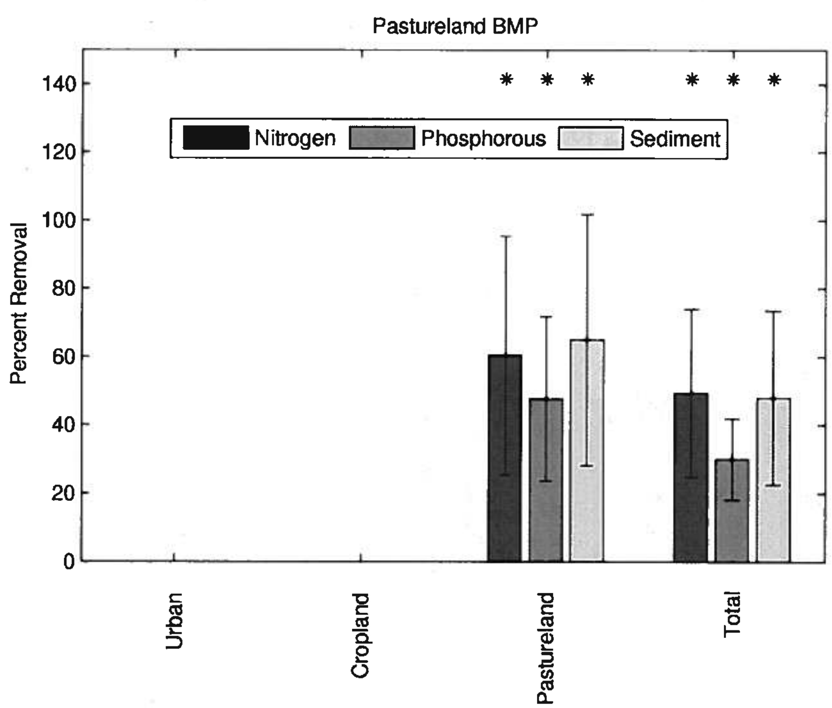

Figure 4. Estimated pollutant load reductions resulting from pastureland based management practices. Error bars indicate the uncertainty of the model estimates based on the variability of watershed specific input parameters. Stars indicate a significant load reduction (i.e., different from zero) at the 95% confidence level.

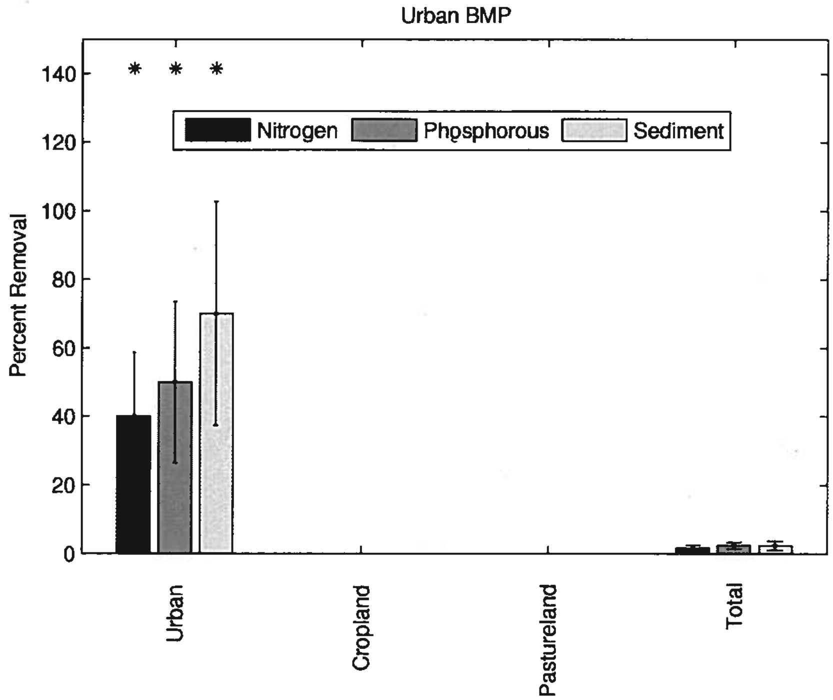

Figure 5. Estimated pollutant load reductions resulting from urban based management practices. Error bars indicate the uncertainty of the model estimates based on the variability of watershed specific input parameters. Stars indicate a significant load reduction (i.e., different from zero) at the 95% confidence level.

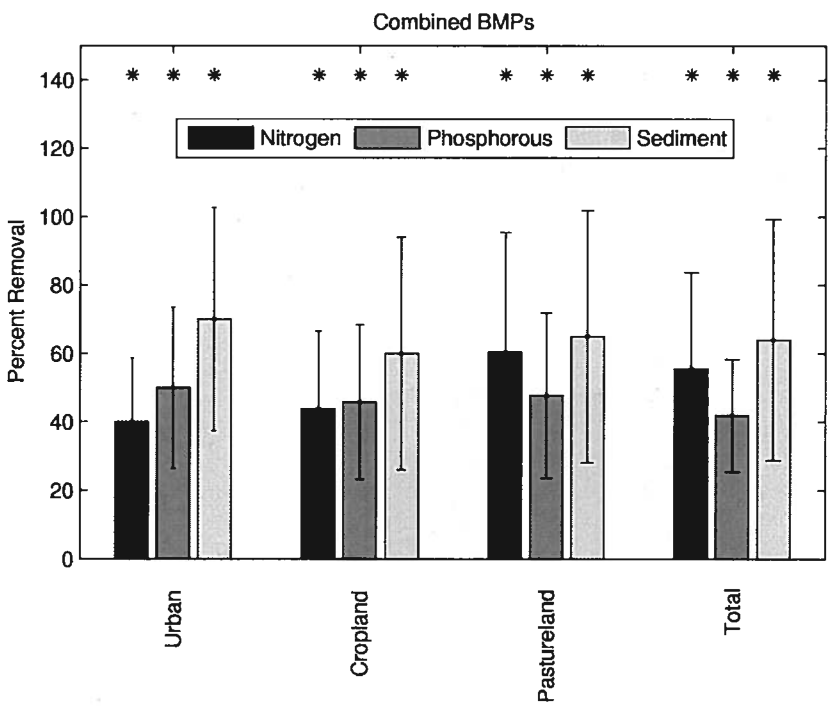

Figure 6. Estimated pollutant load reductions resulting from combined (cropland, pastureland, and urban) management practices. Error bars indicate the uncertainty of the model estimates based on the variability of watershed specific input parameters. Stars indicate a significant load reduction (i.e., different from zero) at the 95% confidence level.

Summary and Recommendations

The objectives of this report were to estimate the degree to which existing MPs affect loads of pollutants identified as major issues of concern that reach receiving waters and to extrapolate these estimates to assess potential load reductions that may result from implementing these MPs on a larger (i.e., watershed) scale.

Examination of existing projects and region specific literature assessed the degree to which given BMPs affect loads. Results are summarized in Table 7. In general, reported efficiencies for a single BMP type varied drastically. BMPs were then grouped by the land use class for which they are designed and measures of the range of reported efficiencies were developed for each general BMP type (Table 8).

A spreadsheet-based watershed model (STEPL) was used to estimate the potential load reductions that might result from implementing the general BMP types at the watershed scale (i.e., to all lands within the watershed for which the given BMP type is designed). Detailed sensitivity and uncertainty analysis were performed on the STEPL model so that estimated load reductions could be viewed with measurable confidence. Results indicate that considerable uncertainties are associated with using the STEPL model for extrapolation of BMPs to the watershed scale.

Uncertainties in estimating BMP efficiencies combined with difficulties in characterizing the watershed (i.e., determining soil types, infiltration rates, soil erodibility, etc.) resulted in considerable uncertainty in the predictions of the STEPL model. The STEPL model is a 'lump-sum' model that intentionally reduces input data requirements. As a result, model results are highly sensitive to the inputs that are required. Further, short of intense data collection efforts, no real means exist to constrain the sensitivity of the model.

A physically based watershed model would allow for model calibration and ultimately improved certainty in model predictions. The downside is that a physically based watershed models have greater data needs (e.g., spatially and temporally resolved precipitation, detailed topography and land use, streamflow). Still, in light of the results of the STEPL model presented here, a physically based watershed model (such as the freely available BASINS suite; www.epa.gov/waterscience/BASINS) is more appropriate for evaluating potential load reductions resulting from BMP implementation.

Given the findings of this report we make the following recommendations:

1) Region specific, or, even better, watershed specific, information regarding land use, soil type, topography, precipitation, evaporation, and agricultural and livestock practices are needed. Some of these data are available (e.g., precipitation, topography); others will require special studies and communication with project stakeholders.
2) Streamflow data for any watersheds to be modeled should be obtained. The higher temporal resolution the better. Many California streams are already gauged and when appropriate data from nearby streams can be used to

estimate flow in ungauged streams. In some cases it may be necessary to install gauges at some ungauged streams.

3) Continue water quality monitoring efforts in Critical Coastal Areas watersheds. These monitoring results will be important for calibrating and validating future modeling efforts.
4) Improve monitoring and documentation of implementation and management practices of existing BMPs. Guidelines for BMP monitoring and documentation exist on the International Stormwater Best Management Practices website (www.bmpdatabase.org).
5) Where detailed prediction capabilities are needed, and/or where possible, develop physically based watershed models for CCA watersheds. The freely available, EPA approved BASINS (**B**etter **A**ssessment **S**cience **I**ntegrating Point and **N**on-Point **S**ources) modeling suite is recommended for future modeling efforts.

Management Practice Comparisons (Task 3.6)

The objective of this task is to compare the relative effectiveness of types of management practices (MPs) that can or are being implemented to reduce pollutant loads from reaching water bodies or to protect and restore the integrity of water and resources dependent on it. This analysis builds on the prior estimation of load reductions using the STEPL model and recommends more specific types of MPs that are commonly implemented in the CCAs and could be effective at reducing pollutant loads. The focus is on how these MPs perform in the semi-arid coastal California climate, and specifically three pilot Critical Coastal Areas (CCAs): Fitzgerald Marine Reserve, Sonoma Creek, and Watsonville Sloughs. By meeting this objective, we hope to provide environmental managers within the CCAs with recommendations on the continued or expanded selection and application of MPs to achieve or maintain water quality standards and protect beneficial uses.

Comparing effectiveness among MPs (most frequently referred to as best management practices (BMPs) in the literature) is difficult and not very useful due to a variety of reasons, as summarized below:

> "Extreme caution should be exercised when stormwater management performance studies are compared. Individual studies often differ in the number of storms sampled, the manner in which pollutant removal efficient is computed…the monitoring technique employed, the internal geometry and storage provided by the practice design, regional differences in soil type, rainfall, latitude, and the size and land use of the contributing catchment. In addition, pollutant removal percentages can be strongly influenced by the variability of the pollutant concentrations in incoming stormwater. If the concentration is near the 'irreducible level' a low or negative removal percentage can be recorded" (Scheuler 2000, p. 371-2)

Due to these limitations, this deliverable discusses the relative effectiveness among BMPs qualitatively and makes recommendations based on the best available information for BMPs to be implemented in the three pilot CCAs.

In order to assess the effectiveness of various MPs in coastal California, we reviewed the stormwater and agricultural water quality treatment literature, and interviewed federal and state agency staff, local public works agencies, scientific experts from universities and other organizations, and other stakeholders active in the CCAs. The data that were available from projects in California varied significantly among BMPs and for various pollutants, (discussed in the section for Tasks 3.4, 3.5, and 3.7). While some information from the literature is technically feasible in the CCAs, the following analysis relies more heavily on research that indicates which MPs are realistically feasible. We believe that this type of analysis will be more useful in the pilot CCAs as well as other CCAs as the program continues, especially since implementers will benefit more from practical advice and anecdotal evidence of success as opposed to technical references from the literature.

First we provide general guidelines for MPs in a semi-arid climate. Next, we identify which types of MPs are applicable for certain land uses, since there is an important distinction between the types of MPs suitable for agricultural versus urban land uses (due to differences in land management practices and potential pollutants and their pathways). Then we identify the specific MPs within a land use that are potentially effective, and any further limitations based on studies or demonstration sites in California. The most commonly used metric for assessing BMP efficiency is percent rate of removal of a given pollutant (e.g. suspended sediment, nitrogen, or bacteria; explained in more detail in the section above for Tasks 3.4, 3.5, and 3.7). There are alternative metrics that may be more suited to this analysis (described in the deliverable for Tasks 4.2 and 5.3 that was submitted on 06/15/07). However, given that percent removal is overwhelmingly the most popular metric used in the literature this deliverable will rely on it for analysis and comparison.

Guidelines for MPs in Semi-Arid Climates

There are several major differences between semi-arid and humid climates (described in detail in the deliverable for Task 4.1 that was submitted 06/15/07). In general, MPs in semi-arid climates should:

(1) Be easy and cost-effective to maintain;
(2) Require small amounts of land;
(3) Not require irrigation or vegetation maintenance due to long dry seasons and frequent droughts;
(4) Treat multiple pollutants if possible; and
(5) Be suitable for coastal soils (many soils on the coast are hard clays).

There are some exceptions to these guidelines, and they are discussed in the following sections.

Agricultural MPs

There are a wide variety of MPs suitable for agricultural land, and their application depends on the type of farming and presence of animals, as well as neighboring land uses and natural resources. For example, sloping land will require more erosion control for both water and sediment than flatter land. In addition, cropland that is tilled regularly will require erosion control such as cover crops to retain soil, while pasture or other land that has year-round vegetation will require less soil retention control. When livestock (e.g. horses, cows, llamas, goats, and sheep) are present, additional MPs such as fences to keep livestock out of sensitive water resources, and manure management must be implemented to protect water quality and other resources.

Runoff from agricultural land produces non-point source (NPS) pollution, which is very difficult to monitor or identify the source to remediate, so there is not a lot of data available which links specific MPs on agricultural land to load reduction. Instead, many landowners implement a combination of MPs, and qualitatively assess the improvements instead of monitoring for load reduction at a more precise scale. Interviews with landowners, and staff from Resource Conservation District (RCD) and Natural Resource Conservation Service (NRCS) offices in the CCAs report that the MPs that may be technically feasible are not always practical to implement and an individual MP that may not be effective on its own could be very effective when used in combination with other practices. In addition, it is important to note that the MPs or suite of practices that may be successful in reducing a particular pollutant on one property are not necessarily transferable to other properties, even within the same watershed[3] (James Howard, Carolann Towe, Rich Allan, Kellyx Nelson, Dave Steiner; Personal Communications).

The data that we were able to obtain for specific agricultural MPs (Appendix A, attached) indicates that filter strips are the most effective for the three pollutants with available data (nitrogen, phosphorous, and sediment), in addition to reducing peak flow. However, since the data for grassed waterways and filter strips were from a study in Pennsylvania, they probably are not as reliable as anecdotal evidence from the three pilot CCAs. In the CCAs, agricultural landowners tend to use filter strips for many different types of land uses (including equestrian facilities, row crops, vineyards) as well as mulching, riparian setbacks, cover crops, and swales along roads (Susan Haydon, Lea Haratani, Chris Goodson, and Kellyx Nelson; Personal Communication). (Please see sections for Tasks 3.2 and 3.3 for a more detailed list of current MMs and MPs in place and the sources of that data.)

Other MPs are possible on agricultural land in the CCAs, even some which go against the recommended guidelines presented above. For example, some areas of agricultural land tend to stay wet through the dry season due to natural dips in the land or the ponding of irrigation runoff. These areas are preferable for MPs that require water year-round and would otherwise dry up such as constructed wetlands, wet detention basins, and vegetated swales. Another exception applies to those MPs that would normally take up a large tract of land, such as a wet extended detention basin or constructed wetland. In some cases,

[3] NRCS staff indicate that the following factors (in addition to climatic differences) may prevent MPs from performing as indicated in the literature or at other sites: quality of installation, timing of installation, quality and ecological compatibility of vegetative materials used, operation and maintenance of the installed BMP, the dynamic nature of temporal and spatial logistics associated with an agricultural operation, and the combination of all these (Howard, personal communication).

agricultural or rural residential landowners prefer the wildlife that these year-round pools of water and vegetation attract, and willingly give up a piece of their land for such a practice to be implemented. Landowners also must be willing to maintain the pond properly to avoid problems linked to having year-round standing water that is meant to trap pollutants such as sediment buildup, nuisance algal blooms, pathogen contamination due to the creation of wildlife habitat, and mosquito breeding.

Urban MPs

There is a significant amount of data available for MPs employed in urban settings due to various reasons. First, federal stormwater regulations and permits (through the National Pollution Discharge Elimination System (NPDES)) require municipalities with a population greater than 50,000 to implement a suite of MPs to reduce pollution in waterbodies. Second, it is easier to measure influent and effluent pollutant loads as well as flow due to inlet and outlet structures present on most MPs. Third, there is an abundance of literature and other forms of information available to managers on the proper design, maintenance, and monitoring of urban MPs (e.g. CASQA 2003, Clary et al 2001, Taylor and Wong 2001). These factors, but mostly federal requirements have prompted the sharing of data among municipalities throughout the U.S. and the compilation of this data into several sources accessible to the public, including the International Stormwater BMP Database.

Urban MPs can be grouped into five main types: Infiltration, Detention, Biofiltration, Slope Control, and Source Control. Appendix A (attached) summarizes efficiency data (if available), the pollutants that each MP can treat, and any limitations or "lessons learned" from use in California. The synthesis of this data leads to a few general conclusions.

First, based on pollutant removal efficiencies listed in Appendix A, infiltration and slope protection MPs are the most successful in reducing pollutant loads, while detention MPs are the least successful. Most of the reasoning behind this conclusion has to do with rainfall patterns in northern California (wet winter followed by a dry summer and fall), causing detention basins and wetlands to be dry and thus ineffective for a majority of the year (Stein and Tieffenthaler 2005). In addition, infiltration devices require no vegetation that could dry up without regular rainfall or irrigation. Slope protection MPs are critical due to higher rates of both erosion and development in California which produce excessive sediment year round (Dunne and Gabit 2002). The four slope protection MPs that are listed in Appendix 1 all have removal rates of at least 54% for total suspended solids (TSS) and all but one MP, sediment traps, have average TSS removal rates in the 90% range. This is important since pathogens, pesticides, and metals can all adsorb onto sediment particles and thus, treatment of TSS can also reduce those other pollutants. This fits well within general guideline number four.

Second, MPs that require small or no land will be the most feasible due to the high cost of land in California and high population density. It is unlikely that a developer or city engineer will approve installation of large detention MPs when, instead, they can implement small sediment traps or filter strips that only require the use of a small piece of land. It is an especially easy choice when MPs like filter strips or swales can be made attractive through the planting of native flowers.

Third, some detention and biofiltration MPs are large and made of complicated structures (like a hydrodynamic separation device) are undesirable because they could require a large amount of maintenance to keep them functioning properly. It is unlikely that a city engineer would want to take on the burden of increased maintenance costs and staff when other options are available. As mentioned above, MPs that can reduce pollutant loads and add to the aesthetic value of a property or city will be favored over those that are unsightly *and* expensive or complicated to maintain.

Fourth, it is difficult to recommend individual MP types for treating a specific pollutant since the range of efficiency is so large. For example, the removal efficiency for total phosphorus for vegetated swales varies between 4.5% and 99% and for bacteria, -100% to -33%. This illustrates the fact that there is high uncertainty in performance of MPs and testing in the field is the only way to know the performance for a certain location.

Fifth, as mentioned in the section on agricultural MPs, it is not necessarily one MP that will produce sufficient load reduction results, but rather a combination of MPs and changes in local ordinances to affect building and site design that will produce the desired reductions. The Center for Watershed Protection (CWP) has worked with numerous municipalities as well as environmental groups and federal agencies in the Chesapeake Bay region to implement the ideas of "Better Site Design" (BSD). This suite of MPs (detailed in Kwon 2000) includes many of the MPs in Appendix A and has collectively been successful in reducing paved areas, distributing stormwater effectively, and conserving natural areas which all lead to pollutant reduction in an urban or rural residential setting. In addition, case studies analyzed by CWP have shown that implementing BSD also increases property values and reduces infrastructure and maintenance costs in urban environments (Kwon 2000).

Conclusion and Critical Gaps in BMP Evaluations (Task 3.8)

The answer of "how much more needs to be done where?" could only be answered qualitatively for all three CCAs. We recommend three strategies for improving beneficial uses and reducing load reductions, although many more exist and will be detailed in our Phase II work:

(1) Enhance prevention and mitigation of additional hydromodification through better zoning, permitting, and application of low impact development principles;
(2) Find and, where possible, remove additional sources of bacterial inputs into the runoff conveyance system; and
(3) Expand the geographic coverage of BMPs for excess sediment and nutrient transport and generation.

Many of the gaps in information necessary to complete more specific and comprehensive evaluations of MPs are mentioned in the sections above. To summarize, these gaps include:

(1) Region specific, or, even better, watershed specific, information regarding:

- Land use
- Soil type
- Topography
- Precipitation
- Evaporation rates
- Agricultural and livestock practices (especially the geographic coverage of such practices e.g. percentage of each watershed covered by a particular MM and the relationship to the critical coastal condition and beneficial use).

Some of these data are available (e.g., precipitation, topography, land use); others will require special studies and communication with project stakeholders.

(2) Streamflow data for any watersheds to be modeled should be obtained. The higher temporal resolution the better. Many California streams are already gauged and when appropriate data from nearby streams can be used to estimate flow in ungaged streams. In some cases it may be necessary to install gauges at some ungaged streams.

(3) Continue water quality monitoring efforts in Critical Coastal Areas watersheds at the sub-watershed level. These monitoring results will be important for calibrating and validating future modeling efforts.

(4) Improved monitoring and documentation of implementation and management practices of existing BMPs. Guidelines for BMP monitoring and documentation exist on the International Stormwater Best Management Practices website (www.bmpdatabase.org).

(5) Where detailed prediction capabilities are needed, and/or where possible, develop physically based watershed models for the CCAs. The freely available, EPA approved BASINS (**B**etter **A**ssessment **S**cience **I**ntegrating Point and **N**on-Point **S**ources) modeling suite is recommended for future modeling efforts.

As mentioned previously, at this time no database exists that compiles all the information needed to further evaluate MP effectiveness in the CCAs and obtaining this information would entail a considerable effort, especially since some data, such as streamflow would involve installing, maintaining, and monitoring expensive gages on streams that are at this time, lacking gages. We recommend that state agencies and other major funding sources make available funds for data compilation that would assist our efforts and make the CCAs priority watersheds. By the end of Phase II of this project (funded by our Proposition 50 grant), we hope to provide local government with enough information and guidance so that they can more accurately track MMs and MPs by both geographic coverage and type (Table 12). We also hope to help local governments to better determine where additional MMs/MPs are needed in order to protect beneficial uses and help achieve load reductions. This will be achieved through a "how-to" guidance document we will prepare for local governments. In addition, continued communication with stakeholders and collaboration with local government, special districts, and conservation groups will aid these efforts by helping us to continue sharing data for further evaluation of MPs, and increasing our ability to more accurately predict load reductions in order to restore the biological integrity to surface waters. Appropriate information can then be included in an action plan for each CCA that will direct further activities at the conclusion of Phase II in 2010.

Table 12. Suggested format for a database to be maintained by local governments in order to track MM and MP implementation and status in CCAs.

MM Category	MM Type	MP Employed	% of Watershed Covered by MP	% or # of Participating Landowners

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Adapting BMPs to Semi-arid Climates

The selection of appropriate best management practices (BMPs) to reduce pollutant loads in streams and rivers and protect or restore beneficial uses is an integral part of managing landscapes and controlling non-point source pollution in both urban and agricultural settings. However, due to climate, soils, geology, and other factors, BMP effectiveness can vary greatly depending on location. In addition, the types of BMPs necessary will depend on land management styles such as whether row crops or pasture dominate the agricultural landscape, or whether new residential developments are traditional or follow low-impact development principles. In the United States, much of the research for both urban and agricultural areas is focused on the more humid eastern half of the country where rainfall tends to be fairly evenly distributed over the year. However the coastal California climate differs substantially and it is important to examine how BMPs can be tailored to reflect the different rainfall and runoff patterns in the semi-arid Southwest. The Critical Coastal Areas (CCA) pilot area watersheds are also unique in that they contain a mix of land uses including agriculture, rural residential, open space, industry, marinas (in the case of the watersheds in the Fitzgerald Marine Reserve CCA) and small urban centers. This makes it even more difficult to compare BMP effectiveness to studies which have been conducted in watersheds totally dominated by one type of land use, or at much smaller scales such as a field or plot.

Definitions for semi-arid climate vary, and take on a wide range of characteristics and sub-classes. Semi-arid is defined by level of precipitation (e.g. Caraco; Websters), type of agricultural practices (SAHRA), or a combination of climatic factors (e.g. Koppen, Thornthwaite). However for the purposes of this project, the climate of coastal California will be defined generally as semi-arid with precipitation and runoff occurring primarily during a distinct wet season. The three CCA pilot areas' annual average precipitation ranges from about 23 to 30 inches per year (NOAA 2004), which mostly falls between October and April, requiring irrigation to support year-round agriculture. The pattern of precipitation and agricultural practices also means that the area must deal with unique challenges, summarized below.

Table 1. Unique Conditions of Semi-arid Climates

Issue	Unique Condition Characteristic of Semi-arid Climates	Citation
Water supply	Heavy reliance on groundwater to supplement dry weather flows and high evaporation rates of surface water resources during the dry season is exacerbated by the prevalence of small and large reservoirs	Caraco 2000
Sediment transport	Sparse vegetation during the dry season exacerbates erosion	Dunne and Gabit 2002
Climate variability	El Nino and La Nina patterns exacerbate sediment transport and water supply issues	Beighley et al 2003
Water quality impacts	Groundwater and surface water resources are diminished during the dry season, and the concentrated pollutants are flushed out during the first rains, making stormwater in the fall/winter highly polluted	Caraco 2000

An extensive literature search revealed only a few articles, from which the following suggested adaptations for management practices in semi-arid regions are summarized:

(1) Any practices that require dense vegetation will either need to be irrigated or abandoned in the dry season.
(2) Erosion control practices are ideally incorporated into a comprehensive plan that incorporates various BMPs. These practices will help to prevent upland erosion and other types of sediment mobilization and transport. Conditions of long dry periods followed by a short, yet intense, storm can exacerbate sediment transport and create rills and gullies, making erosion control a top priority.
(3) Source control should be widely practiced to prevent pollution in the first place. Although this is not unique to areas with semi-arid climate conditions, it is especially important to mitigate the highly polluted “first flush” of fall rains that can make stormwater toxic.
(4) Limited precipitation necessitates more innovative site planning to incorporate drought-tolerant native plants, water recycling, and storage to provide irrigation during the dry season and to recharge groundwater resources.
(5) Sediment transport may clog infiltration systems, porous pavement, and filter strips, so maintenance must be considered in implementation plans. (Summarized from Caraco 2000; Urbonas 2003)

For the three pilot CCAs investigated here, these adaptations and special considerations are especially important to keep in mind when attempting to recommend treatment and mitigation options for pollutants, predict effectiveness of BMPs, and reduce pollutant loads. It is also important to keep in mind the difference in needs of urban stormwater and agricultural runoff treatment. For example, stormwater treatment in most parts of the country focuses on reducing peak flow and channeling water into streams. In the west, however, stormwater is a precious commodity capable of recharging aquifers. It is also nearly non-existent in the dry season. Thus, detention BMPs are better utilized to treat stormwater in the wet season, while infiltration, bio-filtration, and source control practices can be more effective in the dry season with some minor adaptations (Stein and Tieffenthaler 2005). Filter strips and porous pavement may even provide most of the reduction in peak flow and pollutants necessary for some storms, provided there are overflow areas or small pools available (Urbonas 2003). The focus in the dry season should be less on reducing peak flow and instead, reducing pollutants loads. It is likely that a majority of dry season flow is wastewater effluent or so-called nuisance water from inefficient residential or agricultural irrigation practices instead of precipitation and associated runoff, and so filter strips are a good addition to treat excess nutrients before entering biofiltration or infiltration systems (Stein and Tieffenthaler 2005). This will also protect groundwater resources from contamination and prevent algal blooms.

In agricultural areas, the greater movement of sediment in semi-arid regions makes erosion control a top priority. Sediment is on the 303(d) list for Sonoma Creek, and is a pollutant of concern in the other two pilot areas. Erosion control plans are necessary and need to include provisions for any BMPs to be implemented prior to the onset of the rainy season, so construction or other disturbance of the soil and associated weather-induced erosion can be minimized. Most cities and counties address this in grading, erosion control, and other ordinances or stormwater management plans. It is also important to favor practices that maintain or increase soil moisture during the dry season to lessen dependence on irrigation while maintaining crop yields.

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tasks 5.1, 5.2

DRAFT
Review of Scenario-Planning Tools
to Estimate Pollutant Load Reduction
John Oram, San Francisco Estuary Institute

Watershed assessment and modeling tries to determine what the sources and factors are that affect delivery of critical pollutants in a watershed. Geographical Information System (GIS) land use/land cover research often plays a critical role in such watershed assessment and modeling efforts. A number of watershed assessment and modeling tools have been developed to evaluate the effects of land use and development practices and policies on water quality and ecological integrity. Development of many of these tools is government-supported (ie., by the US EPA, NOAA, or State Universities) and the tools are therefore freely available for download from the internet. The Critical Coastal Areas project proposes to configure one (or more) of these models for the drainage area of Sonoma Creek watershed, Watsonville Sloughs, and the Fitzgerald Marine Reserve in an effort to estimate impacts of current land and water management practices and predict environmental outcomes under alternative prevention, mitigation, protection, and control scenarios (e.g., low-impact urban development, natural treatment systems, stream buffers, etc.). Following is a list of a few potential assessment tools that are well suited for this project. This list is not exhaustive. Rather, it represents some of the most commonly used tools for assessing the effects of land use practices on watershed water quality.

- **The Impervious Surface Analysis Tool (ISAT):** An ArcView extension used to calculate the percentage of impervious surface area of user-selected geographic areas (e.g., watersheds, municipalities, subdivisions). The model incorporates land cover change scenarios to examine how these changes influence impervious surfaces. Research has shown the amount of impervious surface in a watershed to be a reliable indicator of the impacts of development on water resources (e.g., increases in stream "flashiness," decreased ground water recharge, increased flooding frequency, accelerated sediment inputs from bed incision and bank erosion, increased input of heavy metals and trace organic contaminants). ISAT is helping communities minimize impervious surface as a result of land use change therefore protecting watershed health and water quality.
- **Storm Water Management Model (SWMM):** A comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. Both single-event and continuous simulation can be performed on catchments having storm drains, or combined storm drains and natural drainage, for prediction of flows, stages and pollutant concentrations. SWMM can simulate all aspects of the urban hydrologic and quality cycles, including rainfall, snowmelt, surface and subsurface runoff, flow routing through drainage network, storage and treatment. Statistical analyses can be performed on long-term precipitation data and on output from continuous simulation. SWMM can be used for planning and design. Planning mode is used for an overall assessment of urban runoff problems or proposed abatement options. SWMM is well suited for evaluating the effectiveness of best management practices (BMPs) for reducing wet weather

pollutant loadings. However, problems have been reported when applying SWMM to rural watersheds. SWMM is an EPA-supported model.

- **Spreadsheet Tool for Estimating Pollutant Loads (STEPL):** Employs simple algorithms to calculate nutrient and sediment loads from different land uses as well as the load reductions that would result from various BMPs. Sediment and pollutant load reductions resulting from BMPs are computed using BMP efficiencies compiled from literature. This spreadsheet model approach is best suited for estimating long-term loads. STEPL is an EPA-supported model.
- **Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT):** Allows users to predict potential water quality impacts to rivers and streams from nonpoint source pollution and erosion.
- **Better Assessment Science Integrating Point and Nonpoint Sources (BASINS):** A multipurpose environmental analysis system designed for use by regional, state, and local agencies in performing watershed and water quality-based studies. This system makes it possible to quickly assess large amounts of point source and nonpoint source data in a format that is easy to use and understand. BASINS allows the user to assess water quality at selected stream sites or throughout an entire watershed. This is a valuable tool that integrates environmental data, analytical tools, and modeling programs to support development of cost-effective approaches to watershed management and environmental protection, including TMDLs. The BASINS suite is supported by the EPA. Process models in the BASINS suite include:
    - **Soil Water Assessment Tool (SWAT):** A hydrologic distributed model with proven success in the assessment of both agricultural and urban watersheds. SWAT includes the ability to assess management effects on water quality and is based on over 30 years of USDA modeling experience. SWAT can be used to predict the impact of land management practices on water, sediment, and chemical yields in complex watersheds.
    - **Hydrologic Simulation Program Fortran (HSPF):** Simulates hydrologic and associated water quality processes on pervious and impervious land surfaces and in streams and well-mixed impoundments. It is a comprehensive package developed by the EPA for simulating water quantity and quality for a wide range of organic and inorganic compounds from complex watersheds to receiving waters.
    - **PLOAD:** A simplified, GIS-based model to calculate pollutant loads for watersheds. Estimates nonpoint sources of pollution on an annual average basis for any user-specified pollutant. Commonly evaluated pollutants include total suspended solids (TSS), total dissolved solids (TDS), nutrients (Nitrogen and Phosphorous), fecal coliform, lead, and zinc. Effectiveness of management practices are assessed using user-defined BMP efficiencies.

Summary and Recommendations:

Minimal data requirements and ease of application are the principal advantages of simple models. However, in spite of their more complex data needs, conceptual models (such as SWMM or HSPF) have the advantage of superior hydrologic and hydraulic simulation capabilities. This usually leads to better load predictions. SWMM and HSPF are the most widely used watershed models. SWMM is best suited for urban areas, while HSPF is more appropriate for large multiple land use watersheds and where rainfall induced erosion is significant. SWMM and HSPF have the additional advantage of limited support from the EPA Center for Exposure Assessment Modeling.

To date, watershed model testing conducted as part of the Critical Coastal Areas effort has focused on the BASINS suite and the HSPF model. BASINS was selected because of its GIS interface, EPA support, and ability to model multiple pollutants (specifically sediment, nutrients, and pathogens). In spite of its complex data requirements, the BASINS suite is well suited to evaluate potential management practices in Watsonville Sloughs, Fitzgerald Marine Reserve, and Sonoma Creek. On the other hand, less complex models (such as STEPL) can be implemented if stakeholders so desire and the uncertainties associated with such models are acceptable. CCA stakeholders and decision-makers on private and public lands will have to determine the kind of precision they would like to achieve to compare the predicted load reductions and resource restoration and protection outcomes relative to the costs of implementing alternative management actions (e.g., do stream buffers achieve greater sediment retention efficiencies than reducing drainage density relative to the cost of each?).

Framework for Assessing California's Management Measures:
What is "Sufficient" to Address NPS Impacts or Threats?

Introduction and Background

Nonpoint source pollution is the largest source of degradation to the country's waters (EPA 2006). Current solutions to reducing the impacts caused by polluted runoff are not sufficient, as 55% of coastal waterways are impaired (NRDC 2006). Improving coastal water quality and mitigating the effects of human development is a complex task that requires continuous adaptation. Thus it is necessary to develop criteria to assess the effectiveness of a BMP. This task is difficult for a number of reasons:

1) The "man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water" (Clean Water Act Section 502(19)) can be caused by a wide variety of stressors that not only include individual chemicals or whole chemical classes above certain threshold levels or at toxic amounts, but also invasive species, modification of the hydrology and hydrologic functions of a water body, pathogen contamination, excessive sediment and plant nutrients, and many others. The ranges of practices, uses, and activities that can minimize these "alterations of the integrity of water" are therefore just as varied.
2) The performance of practices designed to minimize alterations is also highly variable and depends on a number of factors including maintenance, precipitation and climate, influent pollutant loads, topography, and soils.
3) Cost-effectiveness is an important consideration in the selection of management measures and practices. Decision-makers are often overwhelmed by the range of options and frequent lack of available information related to relative implementation costs and environmental benefits.

The goals of this paper, therefore, are: (a) to suggest a simple, yet effective, framework for linking existing or projected water quality or beneficial use conditions to stressors that fall under the Clean Water Act definition of "pollution" (see above) and alternative management measures and practices that have been documented to prevent "alterations to the integrity of water" or restore valued resources dependent on the integrity of water. ; and (b) to suggest appropriate criteria, which can be applied to overcome the challenges outlined above.

The Framework

We used a two-step process for assessing the status of existing management measures and to evaluate if they are likely to be sufficient to restore the integrity of water and the uses associated with it. First, we identified basic information requirements needed to match land and water use categories in the CA NPS Implementation Strategy with those that actually are present in the study areas. Second, we modified the "Pressure-State-Response" (PSR) model (OECD 1993) to assist us in our evaluation of whether steps taken so far to reduce existing or projected pressures on valuable resources have been sufficient to restore the integrity of water and beneficial uses dependent on it.

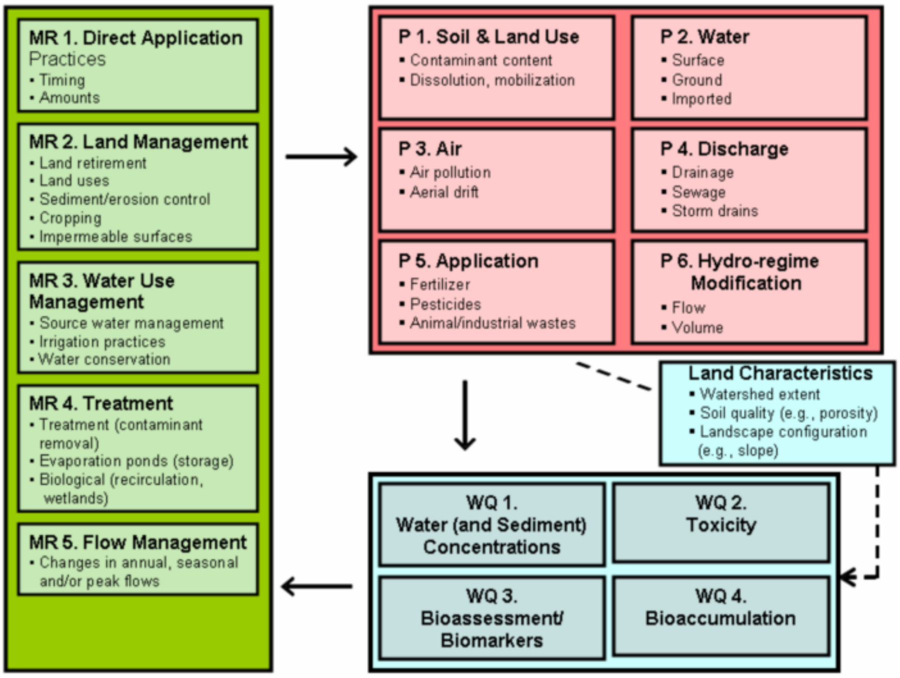

Figure 1 Pressure-State-Response: A monitoring and assessment framework diagram.

In the PSR model description, management "responses" address impairments of water quality and beneficial uses by reducing "pressures" on beneficial uses (e.g., aquatic life, drinking water, recreation; Figure 1). The "system response" to reduced "pressure" is measured as the resulting change in the condition of water quality condition or beneficial uses ("state"; see Figure 1). The PSR model presents an intentionally simplified view of the complex connections between natural systems and their responses to human activities. In the context of this effort to develop an evaluation system for whether private or public investments of certain management measures and specific management practices provide outcomes commensurate with the investment, we applied the framework to describe diffuse sources of pollution "pressures" from agricultural, urban, and industrial landscapes with the explicit understanding that not all model components would be equally relevant for all of these land uses or for all contaminants or "alterations of the integrity of water.". Selection of the PSR model was partly due to its simplicity, which allows developing clear messages about the hypothesized linkages between environmental outcomes and the application of management measures and practices. It was also based on previous examples, where it had been applied successfully in facilitating the evaluation of environmental concerns and subsequent development of environmental policy and management activities and monitoring their outcomes (Barker, 2001). Based on a real-world “road-test” of the framework as an organizational tool for identifying broadly applicable contaminant and water quality related “pressures”, appropriate “state” variables, and a comprehensive suite of potential management “responses,” (Jabusch et al., 2007), we took this approach one step further and linked existing undesirable conditions in the three CCA Pilot Areas (as expressed in 303(d) listings and stakeholder concerns articulated in focused workshops held in each Pilot Area in the winter of 2007) with likely “pressures.” We also identified potential future risks to maintaining beneficial use conditions currently considered “acceptable” by using land use projections based on General Plans build-out scenarios that are likely to degrade or impair beneficial uses if not mitigated and managed appropriately.

Evaluation Steps

I. Research land use, natural and artificial drainage network, wetlands, riparian areas and, other aquatic resources (Watershed Condition Assessment)

1) First, identify all land uses that exist throughout the watershed, using most current GIS data and/or aerial photos. This will help identify risks to beneficial uses and link the management measure (MM) classification system to the types of activities associated with certain land and water uses. This first step also facilitates the elimination of certain categories that don’t apply. For example, the Sonoma Creek watershed drains to San Pablo Bay by way of the San Pablo Bay National Wildlife Refuge. Due to its protection status, the shoreline is undeveloped without the presence of commercial or recreational boating facilities. In addition, there are no large reservoirs with designated recreational access or boat launches. Therefore, it is easy to eliminate MMs associated with marinas from the list. It is also important to understand the types of land use associated with activities within the six major categories. For example, there is a large amount of agricultural land in the Watsonville Sloughs watershed; however it is almost entirely row crops, with no active grazing. This eliminates the need to identify grazing MMs. However due to the presence of row crops, it is highly likely that there will be some measures to control pesticides, nutrients, and erosion which are all common by-products of cultivating row crops.

2) Inventory all water bodies and the drainage network (natural and artificial) to obtain a picture of potential pollutant transport and deposition.

*II. Identify public planning and management agencies and major public and private landowners***,**

1) With maps used for identifying land use, make a list of jurisdictions and major land owners in watershed including:
   - Cities
   - County
   - Public lands, e.g. state/county parks, Wildlife Refuges
   - Special districts (e.g. flood control, Resource Conservation Districts, water and sewer agencies, rural road organizations, airports)
   - Timber harvesting areas
   - Marina facilities
   - Military bases
   - Others

2) This list will help "map out" and simplify the usually confusing network of jurisdictional responsibilities and mandates for various watershed management functions and the underlying federal, state, and local statutes under which various organizations operate. After the jurisdictional organization chart is drafted, it will help you identify the appropriate organizations, agencies, and individuals to contact regarding implementation or policies that regulate land use and affect and /or mandate MMs. For example, if the watershed contains a significant urban population, the main city or county will most likely have a National Pollutant Discharge Elimination System (NPDES) permit for discharging stormwater (either Phase I or Phase II, depending on population) approved by the state, and a stormwater management and pollution prevention plan that includes several MMs that must be tracked. If there are no incorporated towns large enough to merit a stormwater program, there might still be a county or regional program that is important to research. However, there are often several overlapping jurisdictions and types of land ownership, so it is important to consult someone locally who knows the watershed well to make sure no entity has been left off. Knowledge of the jurisdictions and land ownership will also help to form hypotheses about potential water quality issues, sources of pollutants, and other threats to natural resources.

III. Identify Management Measures and Specific Management Practices

1) Management measures are essentially human responses to undesirable water quality or of resource condition. In order to identify those responses (and assess their status), it is necessary to organize all the identified or potential pressures on the environment along with the status of resources, in order to properly identify which resources are in a state that is considered undesirable, what is known about the pressures that are believed to directly or indirectly cause undesirable conditions, what kind of management responses have been implemented, and what, if any, monitoring activities have been undertaken to determine the effectiveness of investments. The

PSR Model is a reasonable and relatively straight-forward tool to organize information and inform stakeholders about how a watershed may react to natural factors and management actions, so that they can continue to adapt management responses as needs change in the future. This conceptual model is particularly helpful for identifying MMs, because it helps narrow down the types of information necessary to collect. For example, simply contacting the city or county and inquiring about programs, policies and projects that may affect resources in the watershed is an incredibly vague request. However if you know that there much of the watershed is comprised of agricultural land and steep slopes (pressures) and a dwindling salmon population (state) you would want to ask about erosion control ordinances or standards (responses). Sometimes without knowing the state of water quality, you could still identify MMs by first identifying pressures. For example, any agriculture that uses fertilizers will likely produce excess nutrients, which could lead to eutrophication, increases in biological oxygen demand, and other undesirable states.

2) With a better idea of the states and pressures in the watershed, and a rough idea of typical or possible management responses, it is much easier to then identify the major programs, policies, and projects. Using the list of jurisdictions and landowners (from Step 2) and the checklist in the box below (Figure 2) as guides will further help the process. The final step will involve breaking down management responses into more specific measures. For this step, it is useful to use the list of 61 MMs to cross-check relevant and possible MMs (Table 1).

Table 1 California's 61 management measures to address non-point source pollution

Management Measures
1. Agriculture
A. Erosion and Sediment Control
B. Confined Animal Facilities Wastewater and Runoff
C. Nutrient Management
D. Pesticide Management
E. Grazing Management
F. Irrigation Water Management
G. Education/Outreach
2. Forestry (Silviculture)
A. Preharvest
B. Streamside Management Areas
C. Road Construction/Reconstruction
D. Road Management
E. Timber Harvesting
F. Site Preparation and Forest Regeneration
G. Fire Management
H. Revegetation of Disturbed Areas

Management Measures
I. Forest Chemical Management
J. Wetlands Forest
K. Postharvest Evaluation
L. Education/Outreach
3. Urban Areas
3.1 Runoff from Developing Areas
A. Watershed Protection
B. Site Development
C. New Development
3.2 Runoff from Construction Sites
A. Construction Site Erosion/Sediment Control
B. Construction Site Chemical Control
3.3 Runoff from Existing Development
A. Existing Development
3.4 On-site Disposal Systems
A. New On-site Disposal
B. Operating On-site Disposal Systems
3.5 Transportation Development: Roads, Highways, and Bridges
A. Planning, Siting, and Developing Roads and Highways
B. Bridges
C. Construction Projects
D. Construction Site Chemical Control
E. Operation and Maintenance
F. Road, Highway, and Bridge Runoff Systems
3.6 Education/Outreach
A. Pollution Prevention/Education: General Sources
4. Marinas and Recreational Boating
4.1 Assessment, Siting, and Design
A. Water Quality Assessment
B. Marina Flushing
C. Habitat Assessment
D. Shoreline Stabilization
E. Storm Water Runoff
F. Fuel Station Design
G. Sewage Facilities

Management Measures
H. Waste Management Facilities
4.2 Operations and Maintenance
A. Solid Waste Control
B. Fish Waste Control
C. Liquid Material Control
D. Petroleum Control
E. Boat Cleaning and Maintenance
F. Maintenance of Sewage Facilities
G. Boat Operation
4.3 Education/Outreach
A. Public Education
5. Hydromodification
5.1 Channelization and Channel Modification
A. Physical and Chemical Characteristics of Surface Waters
B. Instream and Riparian Habitat Restoration
5.2 Dams
A. Erosion and Sediment Control
B. Chemical and Pollutant Control
C. Protection of Surface Water Quality and Instream and Riparian Habitat
5.3 Streambank and Shoreline Erosion
A. Eroding Streambanks and Shorelines
5.4 Education/Outreach
A. Educational Programs
6. Wetlands, Riparian Areas and Vegetated Treatment Systems
A. Protection of Wetlands and Riparian Areas
B. Restoration of Wetlands and Riparian Areas
C. Vegetated Treatment Systems
D. Education/Outreach

Figure 2. Checklist for items to review in identifying and assessing management responses

A) Policies: express on paper what local government wants to achieve

- ❑ General Plan (county and/or city)
- ❑ County and city zoning ordinances that affect environmental resources and implement state policies, e.g. stream buffers, building restrictions in the flood zone, etc.
- ❑ Building codes

B) Programs: translate policies into more specific guidance

- ❑ Special districts' programs
- ❑ Local Coastal Program
- ❑ Stormwater management program (can be at city, county or regional level)
- ❑ NRCS programs: EQIP, etc.
- ❑ TMDLs

C) Projects: represent (a) actual, on-the-ground implementation of practices; (b) studies and conceptual designs; (c) specifications for engineering, restoration, and other plans

- ❑ Permit requirements for construction (e.g., erosion control, reducing impervious area)
- ❑ City and county wastewater, sewer, landfill, and stormwater facilities maintenance practices
- ❑ Water quality monitoring data (from government agencies at all levels, non-profit environmental groups, recreational groups, etc.)

Based on this initial inventory of applicable management measures, the watershed-specific condition assessment, and the identified existing or projected pressures on valued resources, more specific practices can be identified and linked in hierarchical fashion to the management measures within each of the six MM categories listed in Table 1.

Another useful tool is to create a matrix of "assessment questions" (which enable decision-makers to be more systematically guided in their search for information), "data requirements" (structuring the assessment), and level of uncertainty (Attachment 1). This matrix will not only help define what data are required to solve resource issues and to what degree of certainty those questions need to be answered, but it will also be a helpful guide in identifying what kind of information to collect. A key point is that the more expensive a MM is to implement ("expensive" meaning loss of current or anticipated revenue, cash outlays, tax increases, etc.) the lower the tolerance for uncertainty. A good example would be the stream "buffer" ordinance debates. People owning property in the riparian zone are loathe to give up certain property rights that those who don't live in the riparian zone would be allowed to continue to enjoy. The "public" is unlikely to compensate them for the "loss" of use unless they can be fairly certain that the values and services they “buy” (wildlife corridors, flood protection, increased groundwater storage, more fishe, etc.) are commensurate with the price.

IV. Assess the status of MM Implementation

1) Identifying the variety of MMs that exist in the watershed is most of the work. Assessing the status of MM implementation can be as simple as following up with relevant people and asking them to estimate the level of implementation (by geography, time, and/or stage of implementation). Since every watershed and every MM will be in different stages, it is necessary to categorize the MMs into tiers, as follows:

Tiers of MM Implementation

Tier 1: Policies are in place that mandate MM

Tier 2: Program in place with outcome-based performance measures

Tier 3: On-the-ground MM (can be reinforced by a policy or program in place to encourage MM implementation)

Tier one indicates that there is some type of policy in place that mandates or encourages a MM. In this tier, MMs are often stated as goals or broad policy objectives, but don’t necessarily have a specific measurable target or performance measure. One example of this is a zoning ordinance mandating erosion control measures be taken during construction. Another example is a stated goal (at the local government level) to protect riparian areas but no specific performance measures.

Tier two indicates that a policy has been taken to the next level of specificity, with a program in place that helps implementers with specific guidance and outcome-based performance measures. An example of second tier implementation is the same riparian area protection policy used above for tier one, but with the appropriate Standard Operating Procedures in place that help translate the policy into tangible steps and measurable targets. Ideally, programs have quantifiable performance measures associated with them, such as acres of protected land or stream buffer width. Another example is a trash reduction program with a goal to divert a certain volume of mass of trash from entering storm drains.

Lastly, tier three represents those MMs that are actually implemented on the ground. These MMs are often prompted by a policy or program, but not always. For example, Resource Conservation Districts, the NRCS, and other agricultural organizations often provide technical assistance and cost-sharing incentives to help landowners install field strips or grassed waterways for erosion control along or within fields of crops. An example of a MM that is implemented as a response to a policy is a berm and ditch system to direct runoff away from streams and through paddocks for more natural filtration of nutrients and pathogens on a dairy farm or horse ranch.

Operations in California with enough livestock to qualify as a confined animal feeding operation (CAFO) are required through their waste discharge requirements issued by the SWRCB to take certain measures to reduce the impact of animal waste products on water quality. Categorizing the MMs in this manner will enable comparison across watersheds and across MM categories. For example, one could roughly estimate the potential for sediment reductions in a watershed given the percentage of land that has MMs implemented at the third tier.

2) The next step in this process is to categorize all 61 MMs into the three tiers using a chart, such as the one below (Table 2). It is important to explain or indicate somewhere which MMs do not apply to the watershed.

Table 2. NPS Management Measure Evaluation Status

NPS Category	Management Measures	MM Implementation[1]				
		1	2	3	None	Need More Info
Agriculture	1A Erosion and Sediment Control					
	1B Facility Wastewater and Runoff from Confined Animal Facilities					
	1C Nutrient Management					
	1D Pesticide Management					
	1E Grazing Management					
	1F Irrigation Water Management					
	1G Education and Outreach					
Forestry	2A Preharvest Planning					
	2B Streamside Management Areas (SMAs)					
	2C Road Construction/Reconstruction					
	2D Road Management					
	2E Timber Harvesting					
	2F Site Preparation and Forest Regeneration					
	2G Fire Management					
	2H Revegetation of Disturbed Areas					
	2I Forest Chemical Management					
	2J Wetlands Forest Management					
	2K Postharvest Evaluation					
	2L Education/Outreach					

NPS Category	Management Measures	MM Implementation				
		1	**2**	**3**	**None**	**Need More Info**
Urban Areas	3.1 Runoff From Developing Areas 3.1A Watershed Protection 3.1B Site Development 3.1C New Development					
	3.2 Runoff from Construction Sites 3.2A Construction Site Erosion and Sediment Control 3.2B Construction Site Chemical Control					
	3.3 Runoff from Existing Development 3.3A Existing Development					
	3.4 Runoff from Onsite Wastewater Treatment Systems (OWTSs) 3.4A New OWTSs 3.4B Operating OWTSs					
	3.5 Transportation Development (Roads, Highways, and Bridges) 3.5A Planning, Siting, and Developing Roads and Highways 3.5B Bridges 3.5C Construction Projects 3.5D Chemical Control 3.5E Operation and Maintenance 3.5F Road, Highway, and Bridge Runoff Systems					
	3.6 Education/Outreach 3.6A Pollution Prevention/Education: General Sources					

NPS Category	Management Measures	MM Implementation				
		1	2	3	None	Need More Info
Marinas and Recreational Boating	4.1 Assessment, Siting, and Design 4.1A Marina Flushing 4.1B Habitat Assessment 4.1C Water Quality Assessment 4.1D Shoreline Stabilization 4.1E Storm Water Runoff 4.1F Fueling Station Design 4.1G Sewage Facilities 4.1H Waste Management Facilities					
	4.2 Operation and Maintenance 4.2A Solid Waste Control 4.2B Fish Waste Control 4.2C Liquid Material Control 4.2D Petroleum Control 4.2E Boat Cleaning and Maintenance 4.2F Maintenance of Sewage Facilities 4.2G Boat Operation					
	4.3 Education/Outreach 4.3A Public Education/Outreach					

NPS Category	Management Measures	MM Implementation				
		1	2	3	None	Need More Info
Hydromodification	5.1 Channelization and Channel Modification 5.1A Physical and Chemical Characteristics of Surface Waters 5.1B Instream and Riparian Habitat Restoration					
	5.2 Dams 5.2A Erosion and Sediment Control 5.2B Chemical and Pollutant Control 5.2C Protection of Surface Water Quality and Instream and Riparian Habitat					
	5.3 Streambank and Shoreline Erosion 5.3A Eroding Streambanks and Shorelines					
	5.4 Education/Outreach 5.4A Educational Programs					
Wetlands, Riparian Areas, and Vegetated Treatment Systems	6A Protection of Wetlands and Riparian Areas					
	6B Restoration of Wetlands and Riparian Areas					
	6C Vegetated Treatment Systems					
	6D Education/Outreach					

3) The final step in this process is to evaluate if the existing management measures are sufficient to either bring undesirable conditions to a specified benchmark or quantifiable goal (e.g., TMDL implementation targets, water quality standards, species recovery targets, etc.) or prevent future degradation through increased urban or agricultural development. This is often the most difficult step. With few exceptions, no evaluation system exists to date that is capable of establishing a weight of evidence for linking desirable or undesirable water quality, natural resource, or socio-economic conditions, watershed functions, and ecosystem processes to

management activities intended to move undesirable conditions toward an improved state capable of supporting and sustaining essential ecosystem support services. More often than not, management measures and "fixes" are implemented in a non-systematic approach via trial-and-error without concerted efforts to learn from the errors and reinforce successful outcomes in "adaptive management" fashion. Also, few entities keep specific records that are easily retrievable, and that track management responses, so they can be linked to environmental improvements over time. Only recently have public management agencies begun to develop "performance measures" or watershed health indicators, equivalent to "leading economic indicators," that could tell them if their investments are likely to pay off and which ones, among the long menu of applicable alternative land and water management practices, are delivering the most "bang for the buck." Here, too, the PSR model can be of assistance in identifying candidate indicators of pressure, state, and management response, so public and private entities can collaboratively keep track of the linkage between investments in management measures and practices and desired outcomes (either reduction of pressures or improvements in beneficial use condition).

4) Examples: The California Stormwater Quality Association (CASQA) developed a useful guidance document that assists municipal managers in deciding performance measures for assessing effectiveness of individual BMPs to control stormwater or larger stormwater management programs (2005). First, managers need to decide what type of outcome they desire from the BMP or program, and then they can choose appropriate performance measures to assess effectiveness (Table 1).

Table 3. Suggested outcome levels and performance measures for assessing BMP and stormwater program effectiveness (adapted from CASQA 2005)

Level of Outcome	Suggested Performance Measures	Examples
1) Activity-based	• Task completion (Y/N) • Implementation (# or %) • Change	• Completed update of source inventory • # inspections completed • Increase since 2001
2) Changing attitudes, knowledge and awareness	• Knowledge • Change • Action	• Knowledge of storm drain vs. sanitary sewer • Increase in awareness since last survey • Number of hotline calls/website hits
3) Behavioral change and BMP implementation	• Implementation (# or %) • Change	• Installation of storm drain inserts • Increase since beginning of program
4) Load reduction	• Loading • Change	• Pathogen load • Decrease since 1996
5) Urban runoff and discharge quality	• Benchmark • Loading • Change • Concentration	• Comparison of e.coli count to water quality objective • Phosphorous loading in municipal storm drain • Increase since last year • Sediment concentration in runoff
6) Receiving water quality	• Benchmark • Concentration • Biological condition • Physical habitat	• Comparison of nitrate level to water quality objective • Nitrate concentration • Stream biodiversity • Scouring of stream bank

The most common indicator used to assess pollutant reduction effectiveness is percent removal. However, Urbonas (2003) concludes that there is no scientific basis for using it. Schueler (2000) agrees, especially when loads are very small (at the "irreducible" level) to begin with and percent removal ends up being very small or sometimes negative. Current stormwater programs are largely unsuccessful in reaching sufficient removal efficiencies. Taylor and Wong (2002) report that "city-wide urban stormwater quality management programs are thought to range from roughly 25% to 40% in their cumulative pollutant removal efficiency" (p. 28). The program implemented by the City of Tulsa, Oklahoma, is in its eighth year and has only been successful in reducing suspended solids and nutrients by 12-18%. The current method of assessing performance lacks a scientific basis, is not comparable across practices, or watersheds, and is ineffective, given that no pollution reduction programs are reaching acceptable levels of removal.

Total Maximum Daily Loads (TMDLs) recommend target maximum contaminant levels (MCLs) for waterbodies, and are often considered the benchmark against which to measure BMP effectiveness. However, they are often set very high and can be unrealistic. Most pollutants exist in nature, at certain background levels, and often it is impossible to reach the target loads given the combined effects of current land uses, human actions, and natural loadings. For example, in the Watsonville Sloughs watershed, an analysis was done to determine the sources of pathogen contamination in preparation for the Pathogen TMDL staff report (Hager et al, 2004). The main sources were found to be birds, cattle, and dogs, with humans as the smallest fraction. While cattle and dog pathogen contamination is a direct result of human activity, birds are less directly linked and represent a natural background level that would be very difficult to reduce. Fecal contamination from birds would probably not be an issue without human development, but when coupled with trace contamination from other species, the result is an impaired waterway. For this reason, many waterbodies remain on the 303(d) list and are unable to meet the TMDL targets. In addition, TMDLs address one specific pollutant, while most watersheds are impaired by a variety of pollutants, and it is more efficient to address a suite of impacts with one effectiveness measure.

A new indicator or criteria set is needed. Urbonas (2003) suggests two alternative means of assessing performance of urban BMPs: 1) compare the influent and effluent pollutant loads or 2) measure the volume of stormwater treated compared to the entire volume of runoff for a given area. In the first alternative, "influent" pollutant loads (calculated as the concentration times the volume of water) are measured at a point before the water enters the BMP. "Effluent" loads are measured at the outlet of the BMP, and calculated in the same way as influent loads. In the second alternative, the amount of runoff treated by the BMP will serve as a sample of total runoff, so that the total pollutant load reduction can then be extrapolated to a larger area, given further BMP implementation.

One important thing to note is that these alternative metrics are designed for structural BMPs, and would be difficult to use for non-structural BMPs such as education programs to promote pollution prevention, or alternative housing development designs that preserve open space. For the latter type of methods for reducing stormwater pollutants, it is possible to tie their effectiveness to other metrics. Some examples include reduced impervious surface and increased open space. Indirect measurements are possible. For example, a green parking lot design (that reduces impervious surface and increase bioretenetion or infiltration) functions similarly to a grass swale and should have the same effectiveness. Since swales have a direct inlet and outlet point it is easy to measure the reduced pollutant load, which can be applied to green parking lots (EPA in Taylor and Wong 2002).

When measuring specific pollutant loads is not possible, for example in an agricultural setting, another set of criteria can be used that should indicate sufficient effort at reducing the effects of runoff pollution. In addition to simply reducing pollutant loads, the following criteria will also help to address overall watershed protection goals such as reducing hydromodification and flooding. BMPs should:

1. Control <u>rates</u> of runoff
2. Reduce runoff <u>volumes</u>
3. Remove TSS smaller than 60 μm in size
4. Make structural BMPs visible by providing multi-use opportunities (e.g. underground grease traps are ineffective because they tend to be forgotten)
5. Be accessible and visible for easy inspection and maintenance

(Urbonas 2003, p. 3-4)

In addition, it would be helpful if practices also met the following criteria:

6. Require little maintenance
7. Be easily replicable in a variety of watersheds (i.e., work in a variety of climates and land use patterns)
8. Require little, if any, technical expertise to implement or install (i.e., easy enough for installation by a landowner or local government with little prior training)
9. Produce measurable load reduction within five years
10. Enable a simple monitoring plan to track load reductions
11. Be cost-effective (e.g., should not require taking large tracts of land out of agricultural production/development)

The first five criteria listed above are particularly appropriate for the Mediterranean, or semi-arid climate of the California coast. In much of the literature on BMP effectiveness, the case studies are located in the more humid east where runoff is year-round. However, in California, the case is quite different. There are a few climatic conditions that make the area unique from the rest of the country (see the report, "Adapting BMPs to Semi-Arid Climates for a complete explanation), however, three conditions in particular apply to defining sufficient treatment of NPS pollution. First, precipitation (and the resulting runoff) is essentially seasonal, so that BMPs will be heavily used in the wet, winter season. This factor will affect maintenance routines and costs. Second, due to the prominence of precipitation in the winter, dry weather flows can be non-existent or mainly composed of wastewater effluent or irrigation nuisance water. Thus in dry weather, urban BMPs should focus more on treating metals and pathogens (that are often picked up from impervious surfaces) and not focus as much on peak flow reduction. Third, sediment movement is greater, so that the ability of a BMP to trap sediment is very important. This condition is even more important considering the presence of anadromous fish species like salmon and steelhead throughout the state's coastal watersheds. Excess sediment and siltation are one of the most common causes for destruction of those species' habitats (BASMAA 1997). (Stein and Tieffenthaler 2005).

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This document summarizes the status of California's 61 management measures in three CCA pilot areas: Fitzgerald Marine Reserve, Sonoma Creek, and Watsonville Sloughs. For further explanation of how the matrix was developed and what the tiers of implementation mean, please see the report, "Framework for Assessing California's Management Measures"

NPS Management Measure Evaluation Status
Fitzgerald Marine Reserve CCA

NPS Category	**Management Measures**					
		Tier 3	**Tier 2**	**Tier 1**	**None**	**Need More Info**
Agriculture	1A Erosion and Sediment Control	X				
	1B Facility Wastewater and Runoff from Confined Animal Facilities			X		
	1C Nutrient Management				X	
	1D Pesticide Management	X				
	1E Grazing Management				x	
	1F Irrigation Water Management					X
	1G Education and Outreach		X			
Forestry	2A Preharvest Planning					
	2B Streamside Management Areas (SMAs)	X				
	2C Road Construction/Reconstruction					
	2D Road Management	X				
	2E Timber Harvesting					
	2F Site Preparation and Forest Regeneration		X			
	2G Fire Management			X		
	2H Revegetation of Disturbed Areas					
	2I Forest Chemical Management					
	2J Wetlands Forest Management					
	2K Postharvest Evaluation					
	2L Education/Outreach					

NPS Management Measure Evaluation Status
Watsonville Sloughs CCA

NPS Category	Management Measures	MM Implementation				
		Tier 1	Tier 2	Tier 3	None	Need More Info
Agriculture	1A Erosion and Sediment Control	X	X	X		
	1B Facility Wastewater and Runoff from Confined Animal Facilities	X		X		
	1C Nutrient Management	X	X	X		
	1D Pesticide Management					X
	1E Grazing Management	N/A				
	1F Irrigation Water Management	X	X	X		
	1G Education and Outreach	X	X	X		
Forestry	2A Preharvest Planning	N/A				
	2B Streamside Management Areas (SMAs)					
	2C Road Construction/Reconstruction					
	2D Road Management					
	2E Timber Harvesting					
	2F Site Preparation and Forest Regeneration					
	2G Fire Management					
	2H Revegetation of Disturbed Areas					
	2I Forest Chemical Management					
	2J Wetlands Forest Management					
	2K Postharvest Evaluation					
	2L Education/Outreach					

NPS Category	Management Measures	MM Implementation				
		Tier 1	Tier 2	Tier 3	None	Need More Info
Urban Areas	3.1 Runoff From Developing Areas 3.1A Watershed Protection 3.1B Site Development 3.1C New Development	X				X
	3.2 Runoff from Construction Sites 3.2A Construction Site Erosion and Sediment Control 3.2B Construction Site Chemical Control	X	X	X		
	3.3 Runoff from Existing Development 3.3A Existing Development	X	X			
	3.4 Runoff from Onsite Wastewater Treatment Systems (OWTSs) 3.4A New OWTSs 3.4B Operating OWTSs	X	X			
	3.5 Transportation Development (Roads, Highways, and Bridges) 3.5A Planning, Siting, and Developing Roads and Highways 3.5B Bridges 3.5C Construction Projects 3.5D Chemical Control 3.5E Operation and Maintenance 3.5F Road, Highway, and Bridge Runoff Systems					X
	3.6 Education/Outreach 3.6A Pollution Prevention/Education: General Sources	X	X	X		

<table>
<tr><th rowspan="2">NPS Category</th><th rowspan="2">Management Measures</th><th colspan="5">MM Implementation</th></tr>
<tr><th>Tier 1</th><th>Tier 2</th><th>Tier 3</th><th>None</th><th>Need More Info</th></tr>
<tr><td rowspan="3">Marinas and Recreational Boating

N/A</td><td>4.1 Assessment, Siting, and Design
4.1A Marina Flushing
4.1B Habitat Assessment
4.1C Water Quality Assessment
4.1D Shoreline Stabilization
4.1E Storm Water Runoff
4.1F Fueling Station Design
4.1G Sewage Facilities
4.1H Waste Management Facilities</td><td colspan="5" rowspan="3">N/A</td></tr>
<tr><td>4.2 Operation and Maintenance
4.2A Solid Waste Control
4.2B Fish Waste Control
4.2C Liquid Material Control
4.2D Petroleum Control
4.2E Boat Cleaning and Maintenance
4.2F Maintenance of Sewage Facilities
4.2G Boat Operation</td></tr>
<tr><td>4.3 Education/Outreach
4.3A Public Education/Outreach</td></tr>
<tr><td rowspan="4">Hydromodification</td><td>5.1 Channelization and Channel Modification
5.1A Physical and Chemical Characteristics of Surface Waters
5.1B Instream and Riparian Habitat Restoration</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5.2 Dams
5.2A Erosion and Sediment Control
5.2B Chemical and Pollutant Control
5.2C Protection of Surface Water Quality and Instream and Riparian Habitat</td><td colspan="5">N/A
No impoundments or water control structures meet the SWRCB definition of dam[2]</td></tr>
<tr><td>5.3 Streambank and Shoreline Erosion
5.3A Eroding Streambanks and Shorelines</td><td></td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>5.4 Education/Outreach
5.4A Educational Programs</td><td></td><td></td><td></td><td>X</td><td></td></tr>
</table>

[2] Definition of dam is: a "either 25 feet or greater in height and greater than 15 acre-feet in capacity **or** 6 feet or greater in heigh and greater than 50 acre-feet in capacity" (CA NPS Encyclopedia, p. 147)

NPS Category	Management Measures	MM Implementation				
		Tier 1	Tier 2	Tier 3	None	Need More Info
Wetlands, Riparian Areas, and Vegetated Treatment Systems	6A Protection of Wetlands and Riparian Areas	X	X	X		
	6B Restoration of Wetlands and Riparian Areas			X		
	6C Vegetated Treatment Systems			X		
	6D Education/Outreach	X		X		

Impervious Area Analysis

1. Intro
    1.1. What is impervious area?

Non-point source (NPS) pollution is the number one cause for water quality impairment in California (SWRCB 1998) and the United States as a whole (EPA 2007). It is difficult to pinpoint the origin of NPS pollution, so most researchers try to identify the broad types of surfaces (such as agricultural fields, parking lots, rooftops, lawns, and roads) that could be pollution sources. Numerous studies have established that increasing impervious surfaces (those which do not allow for natural infiltration of water into the ground) in a watershed is correlated with declining integrity of aquatic biological communities, as well as other physical (e.g. riparian forest intact, size of buffer from other uses) and hydrologic characteristics of otherwise healthy, natural aquatic systems (e.g. Center for Watershed Protection 2003; Arnold and Gibbons 1996; Paul and Meyer 2001). There are two key detrimental aspects of imperviousness affecting beneficial uses: (1) increased pollutant loading into the drainage network and receiving waters, and (2) alteration of the physical and biological integrity of water via bank and bed erosion, increased flood risk, reduced groundwater recharge, and adverse in-stream habitat impacts (some examples of hydromodification). Even areas that are not otherwise defined as impervious can function like they are impervious at certain times. For example, a residential lawn would normally allow for runoff to slowly filter into the ground. After a certain threshold of saturation from large precipitation events or exacerbated by hydromodification, the lawn would become saturated, function like an impervious area, and cause runoff to flow directly into the street or a driveway., just as if it were made of concrete. Since impervious surfaces make up a large portion of the landscape altered by humans, aquatic degradation is also linked to “developed areas” (including agriculture, residential, industrial, etc.; Hill et al 2003). Based on these relationships between impervious area and aquatic degradation, the percentage of impervious area (IA) in a watershed has emerged as an indicator used to predict the degradation of stream health.

1.2. Why and how is imperviousness used? (Bay Area and other regional examples)

The Center for Watershed Protection (CWP), based in Maryland, and the Non-Point Education for Municipal Officials (NEMO) program at the University of Connecticut have emerged as two of the leaders in the development and use of IA as an indicator of human-induced stressor on watershed function and processes. Both organizations conduct research and provide technical assistance to help local government agencies amend their land use planning strategies in order to better protect water quality and prevent beneficial use impairment. Better Site Design is a planning process suggested for use by local governments and designed by CWP in which one of the three guiding principles is reduction of IA (CWP 2007). Predicting future impacts to waterways from urbanization and mitigating the current impacts of urbanization is the one of the main applications for the use of IA as in indicator which NEMO suggests (NEMO 2007). Although CWP has kept its focus on the greater Washington, D.C. metropolitan area, NEMO has established a national network that now spans from Main to California and includes 31 states (NEMO 2007). The bulk of most of the research and tools designed to use IA as an indicator is still based in the more humid East, Pacific Northwest and Mid-West, though there are some initiatives to bring the tools from NEMO to California. The Local Government Commission (LGC), California Water and Land Use Partnership (CAWALUP), associations and councils of governments, and the UC Davis Center for Water and Land Use are all groups of agencies and other interested parties using many of the same tools and resources as NEMO and CWP to promote Low Impact Development (LID) ideas to protect and restore water quality in California. Reducing IA is an important component of the Ahwahnee Principles that these groups, and other organizations use to guide their outreach and education efforts.

The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) hosted a workshop in 2005 to discuss the possible uses of impervious area (IA) estimates in predicting impacts of urbanized areas on water quality and determining appropriate management responses. Workshop participants reviewed existing practices at the City of Palo Alto, Town of Los Gatos, and Zone 7 Water District, which all use percent IA to determine building permit fees for projects adding or replacing at least 500 square feet of IA. The point of this practice, along with other agencies that use percent IA to calculate flood control fees, is to discourage increases to existing IA through proportionally higher fees. Although there was consensus that current data collection methods need to be refined for more accurate results, the participants expressed interest in exploring other ways to use IA in a variety of management actions and decisions (SFBRWQCB workshop notes). The RWQCB concluded from this workshop, and states on their website, "Impervious surface data can serve as an indicator of stream health, an effectiveness measurement of stormwater program effectiveness in pollutant and flow controls, and as a parameter to prioritize stormwater management activities and stream restoration efforts, etc." (SFBRWQCB 2005).

The RWQCBs for the North Coast (Region 1) and San Francisco Bay (Region 2) are currently considering a policy that recognizes stream functions that are impaired by increasing IA. These include flood attenuation, pollution filtration, and groundwater recharge. If there are policies which recognize these functions as beneficial uses for water, the applications for using percent IA as in indicator of impairment is likely to increase.

1.3. How imperviousness relates to the CCA program

The use of IA as an indicator of degraded aquatic systems could be an excellent match for the Critical Coastal Areas (CCA) Program, as its stated goals are to "identify coastal areas where water quality is threatened or impacted by new or expanding development and to accelerate the implementation of…California's NPS Program Plan" (SWRCB Contract to SFEI #05-309-550-0, p. 2). Through a contract from the State Water Resources Control Board (SWRCB), the San Francisco Estuary Institute (SFEI), along with its technical partners, is in the process of completing watershed assessments for three CCA watersheds: Sonoma Creek, Watsonville Sloughs, and the Fitzgerald Marine

Reserve. We are also investigating the current status of management measures in the watersheds in order to better predict current, and potential future pollutant load reductions. IA could be used as an indicator to help identify sources of current pollutant loads, and where they might increase in the future. Absent intervention techniques to reverse or prevent accompanying changes in stream hydrographs and treat storm water runoff, future pollutant loads into receiving waters could be predicted based on management actions that change the location and composition of IA in the watershed. Additionally, the location and type of management measures and particular structural or non-structural practices that might be appropriate to mitigate and prevent further pollutions could be identified.

Another application for using IA is to predict the impacts of hydromodification. Hydromodification is "the modification of a stream's hydrograph, caused in general by increases in flows and durations that result when land is developed (e.g. made more impervious)" (SFBRWQCB 2007, p. vi). The management of water in developed areas which straightens rivers and streams, pumps water between basins, disrupts or diverts flows, pumps groundwater, puts creeks in storm drains, and tiles agricultural fields to reduce soil saturation and ponding, can severely alter normal watershed form and function, resulting in an artificially re-engineered network of water ways (Stein and Zaleski 2005). After studying the effects of IA and hydromodification in a small watershed in southern California, Coleman, et al (2005) concluded that limiting IA, controlling runoff, and allowing for more natural stream channel processes were the best management strategies to limit the effects of hydromodification. A watershed that is not managed in these ways will be hydrologically modified and will suffer degradation of the aquatic system, its beneficial uses, and water quality.

1.4. Information sources reviewed

We reviewed a diverse body of literature in order to understand the impacts of increasing urbanization, how IA is measured, and how it relates to various other complementary indicators of stream health. The objective of each previous study we reviewed varied. For example, some studies sought to define a relationship between IA in a watershed and indicators of water quality (Clausen et al 2003), hydrology (White and Greer 2000; Bredehorst 1981; Coleman et al 2005), or a combination of factors (Gergel et al; Shuster et al 2005; Schueler in Schueler and Holland 2002). Other studies aimed to refine methods to more accurately calculate IA based on region-specific data (Slonecker and Tilley 2004; Bird et al 2002; Cablk and Minor 2003; Hurd and Civco 2004; Hill et al 2003). We also reviewed literature that discussed the uses of IA in resource management decisions (HRWC 2004; Rowe and Schueler 2006; Otto et al 2002; Booth et al 2002; Booth and Jackson 1997; Committee for Green Foothills 2005). Finally, we reviewed studies that examined the utility of IA in determining management response, or whether IA was a reliable indicator for protecting the integrity of aquatic communities (Arnold and Gibbons 1996; Jones et al 2005; Ladson et al 2004; Pettigrove 2006; CWP 2003; Walsh 2004). From this review we conclude that the impacts of increasing urbanization on IA are variable, there are many methods of measurement, and the influences of IA on stream health are variable. There are a range of reasons for this apparent lack of consensus; many will be discussed in more detail below. However, it is important to recognize from the outset that this lack of consensus does not render IA inapplicable as an indicator, rather it challenges us to define the circumstances under which is can or cannot be used.

1.5. Summary of the rest of the report

The objectives of this report are to identify the appropriate definitions, methods and uses of impervious area for the CCA program and consider its applicability as a tool to predict impacts to the CCA watersheds. In this analysis, we discuss a range of issues related to impervious area and its application to the CCA program as a tool to analyze and forecast NPS pollution and its impacts on coastal watersheds. First, we evaluated percent impervious area as a suitable indicator for the effects of hydromodification and other changes to aquatic systems in the West. This section also includes a discussion of what types of management decisions can and cannot be made using percent IA in a watershed. Second, we reviewed the utility of "effective impervious area," which, in contrast to total impervious area, only includes those impervious areas that are directly connected to the drainage system including natural channels. Third, we reviewed current methodologies for calculating IA (both total and effective) and the status of efforts to calculate percent IA in three CCA watersheds. Finally, and using a chosen method, we estimate the percent IA in the three watersheds and recommend the next steps for refining this estimate and using IA in the future for selecting appropriate management actions.

2. Evaluation of the suitability of impervious area as indicator for the effects of hydromodification and other changes to aquatic systems

2.1. The 10% rule and its limits

The Center for Watershed Protection (CWP) has popularized the idea that watersheds consisting of more than 10% impervious area, tend to exhibit impaired stream health. Further, after an approximate threshold of 25%, the system may be "non-supporting" to aquatic life (Schueler 2000). This rule has been confirmed by about 50 other studies, but there are also many exceptions to this rule. CWP discloses that this threshold has not been tested in California or other semi-arid regions of the country and that it only applies to 1st-3rd order streams (CWP 2003), as the impacts of imperviousness for higher order streams will be more cumulative. Two studies in the West (Austin, TX, and the Rocky Mountain region of Colorado) revealed that the 10% IA threshold rule does not necessarily apply (Maxted 2000; Maxted and Scoggins 2004). In both case studies, streams appeared to be more resistant to urbanization than eastern watersheds. In other studies based in southern California, streams have been more sensitive than the CWP threshold, with "physical degradation of stream channels…[detected] when basin impervious cover is between 3% and 5%." However, biological effects are probably occurring at even lower levels" (Stein and Zaleski 2005). Some studies have concluded that *any* amount of IA, under existing management practices, will negatively affect aquatic systems (Booth et al 2002). Clearly the range of IA that affects stream health is wide-ranging and depends on many factors, concisely summarized by Pettigrove (2006).

Pettigrove discusses several reasons why IA is not always the best indicator for stream health:

a) The impact of IA varies greatly among watersheds, and will ultimately depend on a range of factors, including its proximity to receiving waters, type of connection to stormwater or other drainage infrastructure, the type of land uses and pollutants throughout the watershed, as well as a range of local conditions such as soil permeability and climate,

b) The methods for calculating IA (discussed in more detail below) vary widely, and so it is difficult to compare studies when the accuracy of each could be quite different (CWP 2003).

c) Pervious areas can be the source of stream degradation, as they can essentially function as impervious when saturated during or after large precipitation events[1],

d) The reliability of imperviousness to indicate pollutant loadings is also limited because in general, only certain pollutants, like metals and hydrocarbons, accumulate on impervious surfaces and subsequently get washed off and transported into the drainage system. The major source of nutrients and pathogens, on the other hand, is runoff from agricultural fields, golf courses, and residential lawns, and the like. These two pollutants impair many California water bodies, but reducing IA will not necessarily reduce these loadings. In order to reduce the loadings of metals and hydrocarbons, reductions in IA might help, but it is also likely that controlling the source of them (such as encouraging automobile oil recycling or reducing the metal content of brake pads) may be more effective, not only in preventing pollution in the first place, but also in reducing maintenance and clean-up costs.

2.1.1. Suitability of imperviousness as in indicator in semi-arid climates

There are concerns about the utility of using percent IA as an indicator of stream health in semi-arid regions such as California. A comparison of semi=arid streams and those in more humid regions that are more commonly studies is discussed in detail in a report entitled "Adapting BMPs to Semi-Arid Climates". Coleman et al (2005) examined the response of southern California streams to increasing IA and the accompanying hydromodification. They found two key aspects of a watershed affected this response: 1) the size of the watershed[2], and 2) the seasonality of a stream channel. Most watersheds in

[1] For example, heavily compacted soil in feeding areas of dairy operations, in stabling areas, or on public playing fields can generate runoff after even small storms. Another example is when agricultural row crops are covered by plastic during the growing season. Rain hitting the plastic will run off in sheets, eventually creating rills along the rows that can result in increased sediment, pesticides, and nutrients entering streams at a higher velocity and volume than when the rows are uncovered. The increased velocity and volume can contribute to destabilization of stream banks, and bed incision. The increased sediment can also clog spawning gravels or contain toxic contaminants that can further degrade the system.

[2] Of the three pilot CCAs covered by this analysis, both Watsonville Sloughs and the Fitzgerald Marine Reserve watersheds are less than 20 square miles. "Hydromodification from changes in impervious area are most recognizable in watersheds smaller than about 20 square miles", and management of IA is most critical in watersheds less than 2.5 square miles (p. 54). While this latter finding does not apply to the three pilot CCAs in this analysis, it could have implications for applying management measures at the sub-watershed level.

the study had at least some channels with ephemeral or intermittent flow, since they are very common in semi-arid climates, even in larger watersheds that have more contributing runoff. They found that ephemeral channels are more sensitive to change in total IA, and exhibit signs of degradation at 2-3% IA, in contrast to perennial channels in humid regions in the literature, which start to degrade at 7-10%.

In addition to climate, there are two other major considerations when evaluating a watershed's response to increasing IA. First the effects of hydromodification are much more pronounced in small storms than in larger storms. This is due in part to the common state of artificially increased drainage connectivity in a watershed. In urban settings, increased connections come from a variety of sources, including storm drain systems, swales and ditches along roads, concrete channels, and other conveyance infrastructure for flood control or water supply. In agricultural or other rural areas, tile drains placed in fields to reduce soil saturation can increase conveyance of runoff and increase the connection between small ephemeral streams, to major channels. In undeveloped areas where increased connectivity is rarely the case, runoff from small storms would naturally infiltrate into the ground or form small ponds that would eventually evaporate or infiltrate. However increased connections throughout the watershed, created to accommodate increasing impervious areas, funnel runoff through the various infrastructures into larger channels instead of allowing for natural infiltration. Increased runoff volume leads to increased velocity that invariably results in severely altered channel geometry. In large storms, connections between tributary streams and main channels are made whether the landscape is developed or not, due to natural topography and infiltration capacity of the soils being exceeded over larger areas for longer periods of time. The accumulation of effects over many small storms often surpasses the damage done by one, large storm.

Another major consideration when evaluating the effects of hydromodification is spatial location of the impervious areas in a watershed relative to other land uses and the outlet of the basin. If a large percentage of the watershed's IA is located in the upper reaches of the watershed, the impacts to aquatic biology will accumulate throughout and, overall, be more pronounced. If the IA is concentrated farther down or even at the mouth of a watershed, such as in an estuary, the effects will be more localized and perhaps less severe. In this scenario, the upland reaches should remain relatively unaffected, assuming they are less developed. Most watersheds, however, have impervious areas unevenly distributed throughout the landscape, mostly in the form of roads and houses, with perhaps a few urban centers. In this case the effect of IA cannot be easily determined except on a case-by-case basis.

3. Effective Impervious Area

3.1. What is effective impervious area and is it better than total impervious area?

The use of the term "impervious area" most often includes all the areas with urban infrastructure (e.g. streets, parking lots, roofs, etc.) in a watershed. However, total impervious area (TIA) is the more accurate term. Effective impervious area (EIA), a subset of TIA, may be considerably different, because it only includes the impervious surfaces that are directly connected to streams and other water bodies. There are several possible means of connection, including a storm drain system, or agricultural areas with extensive engineered hill slope drainage or plastic covering for crops, which direct runoff directly into ditches and streams. EIA excludes those areas that direct runoff into some sort of treatment area because it is less likely that those areas contribute a significant amount of pollution to receiving waters (Booth and Jackson 1997; Walsh 2004).

It can be argued that EIA is the more accurate indicator of stream health (Brabec et al 2002). The argument against TIA comes from the fact that watersheds with a comparable percentage of TIA can have a wide range of biological conditions, due in part to the varying percentages of impervious areas that directly feed runoff into streams without some kind of pretreatment. This is particularly relevant in watersheds with little urban development (Walsh 2004; Booth et al 2002). Walsh conducted a study in 16 watersheds near Melbourne, Australia to test this theory (2004). His results showed that the amount of storm water connections, or degree of drainage connectivity, was a better predictor of macroinvertebrate taxa richness and composition that simply TIA. He also suggested that in order to restore stream health and improve degraded watersheds in an urban setting, local governments should focus first on reducing the amount of direct connections between streams and the storm water system and then later address habitat restoration. Even if riparian buffers and other natural filters for runoff are implemented, their potential for filtration might not be fully utilized as long as storm water systems bypass these areas. Further, the offsite causes of habitat degradation would still be in place without first reducing drainage connectivity.

3.2. Current research

To calculate EIA accurately, the process can be very resource-intensive, however there are a few recent studies that propose some more streamlined methods for estimating EIA. Most studies to date have used TIA to predict impacts on stream health because there is an abundance of literature on the subject, and it is fairly simple to estimate using land cover and a set of coefficients for those land uses. Past efforts to calculate EIA (e.g. Alley and Veenhuis, 1983; Taylor, 1993 in Brabec et al 2002) use a much more inaccurate, though simpler method of a ratio of TIA to arrive at a figure for EIA. Alley and Veenhuis (1983) measured IA in 19 highly urbanized watersheds near Denver, Colorado and, performed a regression analysis to establish the local relationship between EIA and TIA:

$$EIA=0.15(TIA)^{1.41}$$

However since there was no field investigation involved (only aerial photographs and zoning maps), it is just as inaccurate as using TIA. Further, this ratio is highly specific to the Denver area, and would not be accurate in other regions.

Two studies have used some combination of aerial photos, land use data, storm drain maps, and field investigations to calculate EIA. However, there is little information on the exact amount of effort necessary (though we can predict the effort level is high due to the need for field investigation) or the level of accuracy possible. The Rouge Program Office (1994) used a combination of aerial photos and ground surveys to determine whether surfaces were directly connected to the storm system. A project by Walsh, et al (2002) is a more recent study that used storm drain maps from local governments in combination with ground surveys. However, this binary classification system (labeling areas as connected or unconnected), presumably used by the Rouge Program Office as well, proved to be oversimplified. This was especially the case in land outside of urban areas where pavement drained to a pipe but then that pipe drained to a grassy swale. Without field investigations, this area would mistakenly be considered connected even though “partially connected” or something similar is a more accurate description. Methodology involving a more sophisticated classification system for connection using hydrological models is under development by Walsh’s team and will hopefully provide a more accurate idea of the different levels of connection between storm systems and impervious surfaces in a watershed (Walsh, personal communication, December 10, 2006). Due to the gap in reliable information for estimating EIA in an efficient manner, we will rely on the calculation of TIA for the remainder of the paper due to budget and time constraints.

4. Review of methodology for estimating IA

There are a range of methodologies for estimating or calculating imperviousness including using satellites, ground surveys, global positioning system technology, aerial interpretation, or a combination of methodologies, but just one has been applied at the California state level. The “Statewide Initiative to Ground truth Impervious Surface Coefficients” project, commissioned by the state Office of Environmental Health Hazard Assessment (OEHHA) and conducted by the consulting firm, Tetra Tech, included an extensive review of methods for calculating percent IA in 2006. There are two major objectives of the study: 1) to verify whether a previous study conducted by OEHHA staff to identify IA coefficients for land use categories (LUCs) in the Sacramento metropolitan area is indeed the most suitable method, and 2) if the coefficients can be applied to the entire state in order to estimate a statewide figure for IA. The summary report addressing the first goal reviewed the methodologies employed by 11 other studies to date. Taking into account time involved, cost, and ease of replicating throughout the state, Tetra Tech identified OEHHA’s original method as the most feasible method. Briefly, this method employed a random sampling system and identified 1700 points in the Sacramento area. Then, using aerial photos and a set of 44,000 square-meter sample areas; they calculated the TIA for each of the land uses in the sample area. Lastly, they took the data on percent TIA figures from all the samples and land uses and averaged it to get an average percent TIA (a coefficient) for each land use category in the region. Using that information, they were able to compute the percent TIA for the Sacramento area. (For more details on methodology, please see Attachment 1). Making the assumption that population density, topography, vegetation, and other factors are consistent across the state of California, the coefficients calculated statically for each land use could be applied to estimate impervious area for the entire State. At this time, these assumptions have not been fully tested especially with regards to precision.

4.1. Precision

Given the many methods used to generate information on IA, variable distribution within a watershed, and varying recognition of impacts, precision may not always be important. Many applications do not require the use of IA as a precise indicator, but instead apply it more broadly as a screening device used to make a rough estimate of where in a watershed pollutant loads or other impacts could be high, where effects of hydromodification might be more pronounced, or where to prioritize the implementation of management measures in order to identify current and predict future impacts so they can be mitigated or prevented, To make coarse calculations, it is not necessary to have a precise means of measurement. This is why averaging percent IA over land uses in a large metropolitan area like Sacramento is argued as an acceptable methodology for first stage analysis, and also the reason why it will most likely be helpful to have those coefficients of percent IA for LUCs across the entire state. At this coarse scale, risk evaluations and subsequent decisions involving prioritization of intervention and prevention steps can still be made. For more specific, sub-watershed scale decisions, a much more in-depth, locally-based analysis may be required to select the most cost-effective mitigation or prevention alternatives.

4.2. Current versus future estimation of IA

In 2005, the Information Center for the Environment (ICE) at UC Davis compiled county-specific land use classifications to develop a standardized map of the state of California that depicts land use based on build-out scenarios proposed in each county's General Plan. Due to differing LUCs for each county, the goal of the project was to standardize all 58 counties' LUCs into thirteen categories that could be used uniformly across the state for analysis and cross-county comparisons of various types using Geographic Information Systems (GIS; ICE 2005). We used these data, along with the OEHHA IA coefficients to estimate future percent IA in the Sonoma Creek and Fitzgerald Marine Reserve watersheds. Santa Cruz County land use data were not included in the ICE project, however we were able to estimate future percent IA using the City of Watsonville's General Plan. The results of our analysis will be discussed below by individual watershed.

4.3. Limitations to reviewed methodologies

There are other limitations in the use the OEHHA method and most other methodologies used to estimate TIA. Though the ICE project provided a valuable means to estimate future IA in multiple counties, there is still the issue of agreement over LUCs. In order to streamline all the counties' various LUCs into just thirteen for the entire state, some professional judgment, averaging, and other estimating techniques were required. Due to the amount of averaging necessary, it was difficult for the ICE researchers to define their LUCs as well. At the time this report was written the definitions for LUCs were not available (Bob Johnston, personal communication, 6/10/07). Even though two counties could have the same names for LUCs such as low-, medium-, and high-density residential, the definitions could be very different depending on what that county considers as the range of number of housing units per acre in each LUC. For example, Santa Cruz County defines low-density residential land uses as consisting of 2-4 units per acre and high-density residential as more than 20 units per acre (Santa Cruz County code). In contrast, Sonoma County designates low-density residential as 1 unit per acre and high-density residential with a range between 12 and 20 units per acre (Sonoma County code). This example highlights one of the main issues with comparing percent IA across watersheds, counties, and states. The ICE project is the first project of its kind that we found to standardize the LUCs for an entire state. Not only does this gap in the research mean that LUC definitions differ, but the number of categories also can differ greatly. This issue gets even more complicated when trying to match up LUCs to coefficients for IA. For example, Rantz (1971) provides coefficients for the San Francisco Bay Area, and a separate list for Santa Clara County, which tends to be the same or lower than for the rest of the region. He explains that the figures for Santa Clara County came from the county's master drainage plan, and the Bay Area-wide figures were adjusted slightly upward due the Rantz's knowledge of urban design differences between the two areas. When compared with the OEHHA coefficients for Sacramento, there are plenty of differences among LUCs (some are greater, some are smaller, sometimes by as much as 16%). It is unclear if the 35-year span between the two studies is a factor, however since some coefficients in Rantz are higher than OEHHA, this seems unlikely (Table 1).

Table 1 Comparison of land use categories and impervious area coefficients among major studies throughout the U.S.

Study (location)	**Number of Land Use Categories**	**Low-Density Residential (# units/acre)**	**Percent Impervious Area**	**High-Density Residential(# units/acre)**	**Percent Impervious Area**
NEMO 2003 (Connecticut)	29	<500 people per square mile	25.98%	>1800 people per square mile	38.49%
OEHHA 2005 (Sacramento)	17	4.1-8.0	40%	12.1 and above	60%
Rantz, 1971 (Santa Clara County)	13	3-6	15%	11-20	32%
Rantz, 1971 (SF Bay Area)	13	3-6	10%	11-20	40%
Cappiella and Brown 2001 in CWP 2003 (Chesapeake Bay)	18	1 and under[3]	10.6-14.3	"multifamily"	44.4
STOPPP 2002 (San Mateo County)	74	1 and under	10%	9 and above	64%

5. Field data and aerial imagery required to estimate TIA and EIA.

Calculating TIA is a relatively simple exercise, compared to on-the-ground field work or relying completely on aerial photographs, if you are able to obtain GIS land use data. The main materials necessary are a few GIS layers, aerial photographs and current or future zoning information from a county or city zoning map (for current IA) or general plan (for future IA). The necessary GIS layers are a watershed boundary layer, and a layer depicting land use. Assuming that the OEHHA coefficients for Sacramento are valid for the state , we can estimate TIA by calculating the area of each land use category and then multiplying it by the IA coefficient.

$$\% \text{ IA} = (\text{IA Area}/\text{Total Area of LUC}) * 100$$

(OEHHA 2005)

[3] Includes 2-acre and 1-acre land use categories

Calculating EIA accurately for a particular region is a bit more complicated and resource-intensive, though simpler methods have been used. Walsh's study (Walsh et al 2002) is the most recent and most complete calculation of EIA found in the literature to date, though it is not without some application difficulty. The two major issues with his method is 1) the lack of field work to verify results 2) the binary classification system that identified an impervious area as either connected or disconnected from the storm system even though there may be some instances where the connection is only partial. Field verification is especially necessary for this step. However, Walsh's study still has the most feasible methodology to date considering that any effort through the CCA program will have limited funds for field verification. Thus, an estimation of effort will be based on that study's data. Walsh and his team used the following pieces of data: 1) digital aerial photographs of the study area; 2) roads layer; 3) parcel and planning zone map; 4) contour data; and 5) map of storm drains and waterways. From these five data sources the team created three layers of impervious areas and calculated the size by making each area into a polygon using GIS: buildings, parking lots, and roads. The appendices of Walsh's paper include instructions to replicate their methods in other watersheds: Appendix A of the report summarizes the methods and Appendix B is a manual for calculating the EIA in a GIS program (See Attachment 2).

6. Current efforts to calculate imperviousness or incorporate imperviousness into policies or other management decisions for each CCA

There is variable application of IA into policies and management decisions between each of the three CCA watersheds that are covered in this report. The following is a summary of the current efforts to calculate IA and how IA is incorporated into policies and other management strategies. This information is based on a variety of sources, including interviews with relevant city and county staff, general plans, zoning ordinances, etc.

In addition, we have calculated the percent IA for all three watersheds using the OEHHA coefficients and the LUCs for the state developed by Bob Johnston and his colleagues at UC Davis. Due to budget and time limitations, this is the best estimate that we could get. A second method was used to calculate IA for the Fitzgerald Marine Reserve watershed by staff from the Association of Bay Area Governments, (ABAG) and the Metropolitan Transportation Commission (MTC). Their methods and a discussion of how they compare to the other two watersheds is described below along with the figures for IA.

6.1. Watsonville Sloughs

6.1.1. Impervious Area Estimates

In 2004, Santa Cruz County (where the Watsonville Sloughs watershed is located) submitted a Stormwater Management Plan to the Central Coast Regional Water Quality Control Board (CCRWQCB) in accordance with the National Pollutant Discharge Elimination System (NPDES), Phase II, regulations. This plan covers most of the

Watsonville Sloughs CCA, as a majority of the land is under county jurisdiction. The southeast portion of the watershed is within the city limits of Watsonville, which is covered under a separate stormwater management plan, currently under review by the CCRWQCB. The city's stormwater management plan does not directly address impervious areas and includes no plans to estimate imperviousness, reduce the coverage in the watershed, or prevent or mitigate future increases (City of Watsonville 2003). The county's plan, however, identifies the need to evaluate the amount of impervious area in the county and to develop strategies to reduce existing imperviousness where re-development is taking place, and prevent or mitigate its effects in areas slated for new development. The planned implementation schedule calls for a workgroup to begin deliberations in fiscal year 2006-2007 and finish assessment by fiscal year 2008-2009. The workgroup's activities are designed to address "new and re-developments" (p. 7-3). Most of the watershed under county jurisdiction is undeveloped, agricultural, or rural residential land. However, there are serious plans to develop some of the rural residential and agricultural land just outside the City of Watsonville's current city limits near the airport. If those areas are developed within the time limits of the plan, they would be subject to the recommendations of the workgroup. It is unclear whether this analysis will include the City of Watsonville, or just currently unincorporated areas (Santa Cruz Co. and City of Capitola Stormwater Pollution Prevention Plan 2004).

Tetra Tech, the consulting firm that has been investigating OEHHA's methodology, chose the city of Santa Cruz as a pilot area for testing the Sacramento impervious coefficients. At the time this report was written, the results of their study were not yet available. Obtaining those results will be a priority for further analysis on this topic.

Our preliminary estimate revealed that 24.72%, of the watershed is comprised of impervious area (Table 2). The ICE project did not contain General Plan land use data for Santa Cruz County, so instead, we obtained the city of Watsonville's General Plan[4] GIS layer depicting projected land use through 2030. We combined the LUCs as necessary to fit the categories to that of the ICE project. The city limits occupy 57.62% of the area of the Watsonville Sloughs study area (Figure 1). For the remaining portion, we estimated land use based on previous field visits and best professional judgment.

[4] Santa Cruz County' General Plan does not include any portion of the Watsonville Sloughs watershed.

Table 2. Estimated impervious area in the Watsonville Sloughs Watershed

City of Watsonville General Plan Land Use	**ICE Project Land Use**	**Total Acres**	**IA Coefficient (%)**[a]	**IA (% of watershed)**
Agriculture	Agriculture and Grazing	5,800.58	4	1.86%
General Commercial	High Density Commercial	188.46	85	1.28%
High Density Res (17-42 du/acre)	High Density Residential	142.72	69	0.79%
Industrial and Public/Quasi Public	Industrial	1,252.27	88	8.79%
Neighborhood/Corridor Mixed Use	Low Density Commercial	43.67	75	0.26%
Low Density Res (up to 9.99 du/acre)	Low Density Residential	3,081.87	40	9.89%
Med Density Res (10-16.99 du/ac)	Medium Density Residential	369.96	55	1.63%
Downtown Mixed Use	Mixed Use	31.64	82	0.21%
N/A	Planned Development	N/A	N/A	0.00%
Public Park	Public Lands and Open Space	37.77	2	0.01%
Specific Plan Area	Urban Reserve	469.26	N/A[b]	0.00%
Environmental Mgmt	Water	1,051.47	0	0.00%
Total		**12,469.67**		**24.72%**

[a] OEHHA, 2005

[b]The Specific Plan Areas undetermined but look to be areas for potential future expansion of the city limits. Until the land uses are determined, they remain excluded form the IA calculations

Figure 1. Portion of Watsonville Sloughs watershed covered by City of Watsonville General Plan 2030

6.1.2. Incorporating Percent IA in Management Decisions

The only major initiative related to incorporating percent IA into management decisions began in May 2005, when the Santa Cruz Flood Control and Water Conservation District decided to change its fee structure for new buildings in a newly created zone 7A, which includes the portion of the watershed outside of the City of Watsonville. The fee distinguishes between newly developed areas that are pervious and impervious: 95 cents per square foot of new impervious area built, and 47 cents for semi-pervious area. This fee will increase to $1.00/sq ft for impervious area on 07/01/07 (Santa Cruz County Department of Public Works Fee Book 2006).

The Watsonville airport is a significant clustering of impervious area in the northeastern corner of the city boundaries with seemingly little management action proposed to curb the effects of increased IA. Currently it is about 63% impervious, with 217 acres of runways, buildings, and other hard surfaces. The master plan for 2001-2020 includes expanded facilities that would add more than 311,000 square feet (just over 7 acres) of new impervious area for runways, new access roads, up to 100 new hangars, an expanded terminal, and other facilities. The Master Plan recognizes the impact on stormwater infrastructure, as well as water quality and surrounding biological resources that this increase in impervious area would create at the headwaters of West Struve, and nearby

Struve and Harkins Sloughs. The mitigation measures are somewhat vague, though they call for certain BMPs to reduce runoff (including pervious pavement), and a revision to the city's stormwater management plan to address theses changes (2-2 and 2-3). In a Draft Environmental Impact Report (DEIR) published in 2002, three alternatives were discussed, and the superior alternative (the "Modified Project Design Alternative") would only entail adding 162,500 square feet of new impervious area (3.73 acres; about half of the 311,750 square feet (7 acres) proposed in the full master plan design). It would also reduce the acreage of jurisdictional wetlands to be filled from 1.47 acres to 0.08 acres, though mitigation measures would still be implemented (Duffy 2002).

Currently the CCRWQCB does not have any provisions in Phase II stormwater permits to ban prevent additional hydromodification (Phase I permits do). However, the permits will expire in one year, and it is projected that the new Phase II permits will include provisions to mitigate for hydromodification (Jennifer Bitting, CCRWQCB, personal communication 6/6/07). Currently the airport and the city are embroiled in a debate over the city's plans to develop the Buena Vista area that is now rural residential land west of the airport. The city plans to approve 2,250 new homes over the next 20 years, which has representatives from the local pilots union and other aviation community members concerned about potential threats to safety for airport activities (Jones 2007). It is likely that the plans to expand the airport will be put off until these development plans are settled.

Despite the lack of a comprehensive plan in the Watsonville area to estimate and mitigate IA, there are some resources that could help the area with low-impact development (LID) and smarter site design ideas that could reduce the impact of development on water quality. Local construction vendors are interested in installing LID infrastructure, especially pervious pavement in the Watsonville area and throughout the state. The new storm water fees associated with IA in Watsonville have attracted developers to vendors who sell LID infrastructure due to the prospect of saving money while meeting storm water regulations, and may attract the interest of the city to install some pervious concrete for public projects. However, pervious concrete is not a panacea for existing IA and it cannot perfectly mimic the natural infiltration properties of soil, especially sandy alluvial soils that occur throughout the watershed. Other BMPs that sequester or degrade pollutants in runoff, reduce runoff volume and velocity, or otherwise mimic the natural filtration properties of soil might be better suited to this growing urban area.

6.2. Sonoma Creek

6.2.1. Impervious Area Estimates

Although there are some initiatives to promote low impact development and construction plans that limit IA in the Sonoma Creek watershed, there haven't been any studies specifically aimed at estimating and reducing impervious cover in the watershed. Our preliminary estimate (based on OEHHA coefficients and the ICE Project LUCs and map) concluded that 11.61%, of the watershed is comprised of impervious area (Table 3).

Table 3. Estimated impervious area in the Sonoma Creek watershed

ICE Project Land Use	Total Acres	IA Coefficient (%)	IA (% of watershed)
Agriculture and Grazing	73,882.16	4	2.78%
High Density Commercial	197.53	85	0.16%
High Density Residential	155.38	69	0.10%
Industrial	244.99	87.5	0.20%
Low Density Commercial	1,333.75	74.5	0.94%
Low Density Residential	14,821.28	40	5.59%
Medium Density Residential	3,106.82	55	1.61%
Mixed Use	0.00	82	0.00%
Planned Development	0.00		0.00%
Public Lands and Open Space	12,384.31	2	0.23%
Urban Reserve	0.00	N/A	0.00%
Water	1.92	0	0.00%
Total	**106,128.17**		**11.71%**

6.2.2. Incorporating Percent IA in Management Decision

In 1997, the Southern Sonoma County Resource Conservation District (SSCRCD) published the *Sonoma Creek Watershed Enhancement Plan* to identify the natural resources of the watershed and guide landowners to properly care for the creek and its resources. Although the main body of the report did not directly address impervious areas and the effect on stream health, one of the accompanying "Implementation Guidelines" sections did. "Start at the Source: Design Guidance Manual for Stormwater Quality Protection" (BASMAA 1999) provides tips on how to limit runoff and pollution from entering the creek by using low-impact development and design techniques, and for using vegetation as a natural filter. It clearly indicates the linkage between increasing development, storm water runoff, water pollution, and impervious area, as well as hydromodification :

> "Streams receive greater flows more frequently. For example, flow equal to a pre-development 2-year storm may occur every 2-3 months after development…The stream channel, which is usually bank full in a 2-year storm, must enlarge itself to contain increased flows, causing bank erosion and loss of habitat" (p. 6)

The manual also includes several design schemes that limit IA and consider streambank protection and flood attenuation in landscape designs. It is an excellent site planning guidance document that could provide municipal managers and architects with a range of ideas for site design and land use planning.

The Sonoma County Water Agency submitted its Stormwater Management Plan in 2004. This plan, like the plan for Santa Cruz County, meets the requirements of the Phase II NPDES regulations, which are uniform throughout the state. It covers the city of Sonoma and most of the unincorporated area in the Valley of the Moon, about 31.5 square miles, or about 5% of the total watershed area. The rest of the Sonoma Creek watershed (which is mostly agricultural land or state parks) does not fall under the Phase II regulations due to low population, and is also excluded from the county's Phase I permit. One small component of the Stormwater Management Plan addresses the issue of IA at constructions sites: those sites that create more than one acre of IA must employ source control structures to mitigate for the increased runoff and other affects of the impervious surfaces (p. 68). A lengthy list of source control BMPs is included that details ideas for better-designed developments that can effectively reduce IA. However, the Plan does not address the cumulative effects of numerous projects smaller than one acre that could, in piece-meal fashion, comprise much greater areas without mitigation requirements than those currently covered by them.

6.3. Fitzgerald Marine Reserve

6.3.1. Impervious Area Estimates

There have been significantly more efforts to estimate TIA in the Fitzgerald Marine Reserve watershed than in the other two CCAs. The following analysis of these efforts is composed of four components: review of the STOPPP impervious estimates, Half Moon Bay airport, roads, Pillar Point Air Force Base, rural areas with compacted soils, and finally a comparison using the OEHHA IA coefficients and the ICE Project LUCs.

The San Mateo County Stormwater Pollution Prevention Program (STOPPP) and its consultants, EOA, Inc., characterized IA within selected watersheds of San Mateo County, including four of the six sub-watersheds that comprise the Fitzgerald Marine Reserve CCA. The STOPPP, in general, is primarily focused on watersheds that flow to San Francisco Bay (the "Bay-side" communities). These were selected to include most of the major urban creek drainages on the Bay-side …and "the watersheds on the coast-side facing development pressure." (Konnan, personal communication).

The stated objective of the STOPPP study was: "To help planners minimize future development impacts on creek resources." Another objective (though not stated) is compliance with non-point source pollution and hydromodification control regulations.

STOPPP consultants (EOA Inc.) developed creek channel modification categories[5] to help characterize each watershed based on limited field data and interviews. Extensive watershed channel modification surveys were not conducted due to budget limitations.

STOPPP study authors correctly note that the, "methods used for estimating imperviousness have not been standardized" and that the land use designations in the Bredehorst study (1981) of IA "did not always exactly match those used by ABAG. Interpretation was required when applying Bredehorst's imperviousness coefficients to ABAG land use classes. Some [percent IA] coefficients [for land use categories] were based on best professional judgment" (Bredehorst 1981 p. 6).

When interpretation was necessary, the study authors relied on aerial photos, U.S. Geological Survey topographic maps, and ABAG land use descriptors to estimate TIA for the Denniston, San Vicente, Montara, and Dean Creek sub-watersheds (Figure 2). It was also assumed that all IAs were either completely impervious or completely pervious (while noting some grey areas like hardened construction site soils). "Imperviousness gradients" were approximated based on interpretation of topographic contour lines. Notably, ABAG land use types were reclassified into groups of similar land uses.

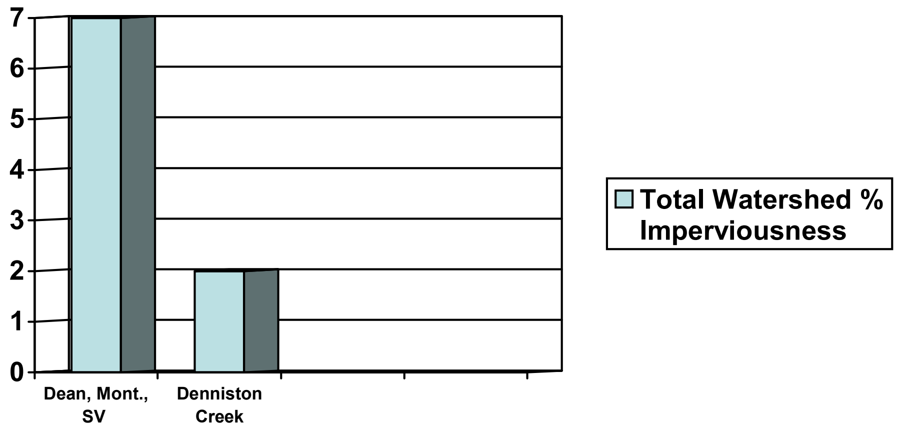

Figure 2 STOPPP Imperviousness Estimates for Selected Mid-Coast Watersheds

STOPPP study authors are transferring to the mid-coast some assumptions made in their analysis of bayside watersheds. Density of residential housing, for example, is thought by the authors to be a key factor in the degree of imperviousness in the bulk of the bayside watersheds. They also note that "cumulative imperviousness" in watersheds takes into account the influence of upstream drainages (which were discovered to be less developed than downstream areas in San Mateo County) and act as an offset to more developed areas.

[5] Creek channel modification classifications: culvert, concrete-lined channel, earth channel, modified but not channelized, unmodified channel.

The Half Moon Bay Airport occupies about a mile along Highway One between Princeton and Seal Cove. (See Attachment 3 for facility map). The airport is comprised of 290 total acres, of which staff at the San Mateo County Airports District estimate that approximately 43.5 acres, or 15% of the total airport facility, is impervious (James Wadleigh, personal communication). A master plan for the facility was prepared under the direction of prior management, and is now ten years old. Due to the age of the master plan and the change in management, we assume that it is no longer valid, and therefore we were not able to obtain more information on the future plans for the airport such as build-out scenarios or stormwater management.

Roads, as a large part of the transportation network, are often the largest contributor to impervious area in any area, given the automobile-based infrastructure of the U.S. (Arnold and Gibbons 1996). In the pilot area, roads include both California State Highway One and local roadway networks associated primarily with residential and commercial development. (See Attachment 4 for a map of the road network).

It should be noted that shoulder widths can vary, depending on which Highway One segment is under study. This is due to a history of policy changes within the agency that reflect changes in highway design standards. As segments are updated, it is expected that the shoulder width will be ten feet. Field verifications will be required to confirm existing shoulder widths.

In addition to the state highway roads layer, MTC staff used the TeleAtlas road layer to classify the total miles of roadway by road type in order to capture the total amount of IA attributable to roads for the Fitzgerald pilot area. An analysis was performed using the TeleAtlas dataset[6], overlaid with an aerial photograph of the project area to determine the "average road widths" by road type (Table 1).

Table 4. Road type classification and widths used for impervious area analysis

Road Type	Range of Road Width	Example
Arterials	65 feet wide	Hwy 1
Collectors	40 – 45 feet wide	California Ave
Local Roads	25 – 35 feet wide	Palma St, 10th St

Using the data in Table 1, each roadway functional class was assigned an "average road width" value for each road segment. The length and width of each segment was then multiplied to produce a total area for each segment (Table 2).

[6] Roadway Classifications are based upon the definitions supplied by the Base map vendor, TeleAtlas North America.

Table 5 Area covered by roads in the Fitzgerald Marine Reserve pilot area

Road Class	Linear Miles	Acres
Arterials	6.3371	50.1266
Collectors	2.9072	10.1785
Local Roads	49.4979	172.2462
Total	**58.74**	**232.55**

The Pillar Point Air Force Station (PPAFS) is located on the Pillar Point bluff that makes up the northern edge of Half Moon Bay and the western edge of Pillar Point Harbor. It houses radar equipment, and other instruments to support missile and space launches. Using a memo to the State Water Resources Control Board from the Air Force (2006) and a presentation at the Air Force facility attended by ABAG and Coastal Commission staff (Tetra Tech 2006), we were able to estimate the impervious area of the Pillar Point Air Force Satellite Tracking Station (PPAFS) to be 8.3 acres. The volume of water running off this acreage is estimated to be 28.34 cfs. (See Attachment 5 for a map of the facility and related IA).

Incorporating all the pieces of the watershed reviewed above (which comprise about 62.38% of the total watershed area), we estimated that the Fitzgerald Marine Reserve watershed is comprised of 9.35% impervious area (Table 6).

Table 6. Estimate of impervious area for certain components of the Fitzgerald Marine Reserve watershed

Component	Total Acres	% of Watershed	IA (acres)	IA (%)
San Vicente, Dean, and Montara sub-watersheds[7]	2,496.00	28.64%	174.72	7.00%
Denniston Creek sub-watershed	2,368.00	27.17%	47.36	2.00%
Half Moon Bay airport	290.00	3.33%	45.30	15.62%
Roads	232.55	2.67%	232.55	100.00%
Pillar Point Air Force Base	48.96	0.56%	8.30	16.95%
Total	**5,435.51**	**62.38%**	**508.23**	**9.35%**

Some of the main gaps in this estimate of TIA (Table 6) are attributable to the limited nature of the STOPPP study of imperviousness, the limitations of the scope of this grant, natural constraints to watershed IA analysis (e.g. vegetative cover that obscures surfaces in aerial reviews), and budget limitations of local government. Additionally, surface

[7] The STOPPP estimate of impervious area for Dean, Montara, and San Vicente Creek watersheds (Figure 2) represents roughly 50% of the estimated build- out of the mid-coastside LCP planning study area. The Denniston Creek watershed estimate of impervious area amounts to roughly one third that of Dean, Montara, and San Vicente Creek watersheds. These conditions are contrasted with other watersheds in northern San Mateo County with greater population densities in the attached set of graphs, "Comparative Imperviousness and Population/Household Size and Population Projection at Buildout (ABAG Jan. 2007)." A graphic illustration of population densities in northern San Mateo County is provided in the ABAG 2005 Population Densities map (Attachment 7)

impacts from huge seasonal visiting populations (e.g. impromptu parking lots) can be overlooked in IA analyses.

The following areas have not been comprehensively studied, and make up the major information needs related to providing a more complete IA analysis for the Fitzgerald CCA:

- Fitzgerald Marine Reserve
- Martini Creek watershed
- Popular shoreline recreation areas
- Deer Creek watershed (proposed for the FMR study area)
- Pillar Point drainages, including the Pillar Point marsh
- Seal Cove
- Princeton By the Sea and Pillar Point Harbor
- Montara[8]
- Rural areas that can function as impervious areas after reaching saturation (including rural roads, trails, paddocks, and staging areas)

Based on the method to estimate IA in the other two watersheds using the OEHHA coefficients and the ICE project map and LUCs, we also estimated that the Fitzgerald Marine Reserve watershed is comprised of 15.34% impervious area, a difference of about 7% (Table 7). The largest and most important difference between these two methods and the two IA estimates is that the first method (Table 6) depicts the current IA in the watershed whereas the second method (Table 7) predicts the future IA in the watershed, based on San Mateo County's general plan.

[8] The STOPPP study covered a small, southern segment of Montara.

Table 7. Estimation of impervious area in the Fitzgerald Marine Reserve watershed

ICE Project Land Use	Total Acres	IA Coefficient (%)	IA (% of watershed)
Agriculture and Grazing	480.79	4	0.22%
High Density Commercial	196.99	85	1.92%
High Density Residential	942.94	69	7.47%
Industrial	345.61	87.5	3.47%
Low Density Commercial	0.00	74.5	0.00%
Low Density Residential	163.52	40	0.75%
Medium Density Residential	0.00	55	0.00%
Mixed Use	0.00	82	0.00%
Planned Development	0.00	N/A	0.00%
Public Lands and Open Space	6,578.98	2	1.51%
Urban Reserve	5.13	N/A	0.00%
Water	0.00	0	0.00%
Total	**8,713.96**		**15.34%**

6.3.2. Incorporating Percent IA in Management Decision

There was no attempt made in the limited STOPPP study to address the relationship between imperviousness and expected degradation of beneficial uses caused by increased pollutant loadings and effects of changes in the hydrologic regime. For this reason, a number of agencies were asked to determine where data may exist that could shed light on these issues. The result of this research is summarized in Attachment 6).

A draft proposal by the Air Force suggests re-routing the stormwater discharges from an unpermitted drainage area on the cliff face of the PPAFS to the vicinity of the Pillar Point marsh – just outside of the CCA study area boundary. It should be noted, however, that existing natural wetlands cannot be used as runoff treatment systems and any plans to route urban runoff without pre-treatment may run into conflict with the anti-degradation policy in the SF Bay Region's Basin Plan. Also under discussion is the possibility of some onsite retention of stormwater, diversion to Pillar Point Harbor, diversion/collection for injection at the PPAFS Boresight Facility, and pre-treatment of the runoff.

The Half Moon Bay airport's stormwater management plan contains multiple best management practices to address stormwater runoff and water quality around the site, though there is currently no estimate of pollutant loadings (Wadleigh, personal communication 4/05/07). Half Moon Bay Airport is reportedly a small aviation facility relative to other aviation facilities on the Peninsula, but sees its share of activity during clear weather conditions.

The San Mateo County Draft Local Coastal Program Update (Oct. 2006) has outlined a scenario for future development in the coastside communities based on an expected near doubling of population growth within the foreseeable future. County planners have proposed a 10% rule[9] (maximum amount of imperviousness for a given development site) for Coastal Commission consideration, a wet-season grading ordinance to help reduce stormwater runoff within the planning area, and a vegetated area floodwater control provision. An estimate of the amount of "offset" from expected runoff associated with new development has not been provided by the county in this planning document. Even with this proposed rule, overall imperviousness under future development scenarios would nevertheless increase watershed imperviousness by x% above its current extent.

6.3.3. Gaps in Impervious Area Estimates

A significant set of impervious area information gaps remain. First, the estimates provided for each watershed based on the OEHHA coefficients and the ICE Project LUCs and map are only future predictions, and are not based on any real changes in land use. This method was chosen in an effort to use standardized LUCs for the Sonoma and Fitzgerald study areas. Second, the OEHHA coefficients for IA on LUCs have not yet been validated for the entire state and are still under investigation. Again, due to budget and time limitations, as well as best professional judgment, they were the best match for this coarse-level exercise. Third, even though the estimates for future IA seem high compared to, for example current estimates in a portion of the Fitzgerald watershed, they may still be low since federal highways were excluded from them. Roads contribute a significant amount of IA to an area, since they are considered 75% impervious (CWP 2003; Rantz 1971). In future analyses it would be beneficial to calculate both current and future IA and compare the projected areas of increasing IA to predict future impacts to beneficial uses, water quality, and the effects of hydromodification.

7. Conclusions

This analysis has presented a large amount of information that local governments can use to consider the utility of IA in making management decisions. We discussed how to evaluate whether using percent IA is a valuable tool to indicate the current or future state of their watersheds and techniques used to estimate percent IA. Finally, we reviewed three CCA pilot area watersheds as case studies for how IA estimates are currently used in management decisions and how they could be used in the future, and we provided a preliminary estimate of percent IA in each watershed based on available information. The most important information that local government agencies and other organizations need is guidance on what types of management decisions can and cannot be made based on knowing the percent IA in a watershed.

[9] Note: the 10% rule has an exceptions provision.

It would be of great benefit to local decision-makers to what extent imperviousness can be used as an effective indicator in a particular watershed. Very broadly, IA is useful for rapidly urbanizing areas, since the rate of change in IA is much larger than an already built out urban area. All three of the pilot watersheds addressed in this analysis have portions which are rapidly developing and at risk of over-burdening the aquatic system (ABAG2006). In built-out areas, such as major urban centers, streams have already reacted to severe hydromodification, and re-established their channels in whatever confines the urban setting has given them. In many cases, natural channels no longer exist, and instead, water flows through pipes underground. Especially in this extreme example, but for all built-out areas, increasing IA will not help to predict impairment, and other indicators or management strategies should be explored. However, many urban areas are considering stream restoration and rehabilitation. In those cases, the expected environmental and socio-economic benefits might be of interest to planners and decision-makers to place restoration costs in a context of reduced maintenance costs, enhanced flood protection, and social benefits associated with restoration activities. Ultimately, the use of IA in management decisions will also depend on other factors particular to a watershed or smaller area such as resources available (computer capabilities, and staff time and resources allocated to enforce actions, conduct research and field work, etc.) and current local, state, and federal laws and permits that may limit or encourage development.

In much of the literature that addresses the use of IA to predict impairment, the solutions can be summarized easily since for every place the ultimate goal is to protect or restore beneficial uses, such as aquatic life, recreation, flood attenuation, pollutant filtration functions, and riparian and wetland habitat protection. The best solution for undeveloped watersheds is to change zoning laws and building ordinances now to limit future IA. This usually also includes mandating riparian buffers to mitigate for polluted runoff from existing impervious surfaces, and other mitigation mechanisms (CWP). Urban sprawl is a factor in the impacts of imperviousness. In some cases, unabated or poorly planned, urban sprawl can cause increases in imperviousness that are high relative to the accommodated population partly because road infrastructure is a large portion of the connected imperviousness (Schueler 1995). In addition, larger lots that are typical of exurban communities consume 16 times more water than do smaller, urban residential lots, mostly due to outdoor landscaping (Otto et al 2002). For already developed watersheds, zoning laws and building ordinances will help, but the reality is that changing those might be politically difficult in an established urban area. Other solutions suggested widely in the literature are implementation of enforceable pollution prevention programs and the use of both structural and non-structural BMPs or low-impact development and re-development techniques to reduce runoff volume, runoff velocity, and the pollutant loads that enter stream channels (Coleman et al 2005; CWP)

The NPDES Municipal Regional Stormwater Permit (MRP; SFBRQCB 2007)[10] is a policy document that could provide further suggestions and examples of how to

[10] The MRP covers several cities in Alameda, Contra Costa, Solano, San Mateo, and Santa Clara counties. Although it does include any of the three CCA watersheds, it is still a useful model for how highly urbanized areas of the region are incorporating IA into their resource management decisions.

incorporate IA into management decisions for all three watersheds. The goals of the document are to encourage builders and city or county staff to consider the impacts of further development or re-development when making permit and other decisions.

> "Urban development begins at the land use planning phase; therefore, this phase provides the greatest and most cost-effective opportunities to protect water quality in new and redevelopment. When a Permittee incorporates policies and principles designed to safeguard water resources into its General Plan and development project approval processes, it has taken a critical step towards the preservation of local water resources for current and future generations"
> (SFBRWQCB 2007, p. 8)

The MRP set thresholds for new or replaced IA at 10,000 square feet (which will be reduced to 5,000 square feet after 4 years), above which appropriate stormwater best management practices (either structural or non-structural; qualifying options are provided throughout the document). In addition, the MRP holds municipalities accountable for hydromodification, stating that new projects must not contribute more stormwater runoff than the before the project was built (SFBRWQCB 2007 p. 41).

7.1. Next steps: how to use this information in Phase II of CCA

Many ideas can be taken from this analysis, applied to, and built upon during the continuing work of SFEI and its technical partners under Phase II of the CCA program work, under a grant agreement with the SWRCB. The list below is a short summary of some of the proposed next steps, though more will be added as analysis for different tasks of this contract progress. A more complete list will accompany the final report due in August 2007.

(1) Continue research into methodology that uses LUCs to estimate percent IA. Follow up with OEHHA/Tetra Tech to see if their study results in a statewide percent IA figure.
(2) Follow literature to identify more studies that examine relationship between percent IA and hydromodification in the West.
(3) Apply existing information to help guide predictions of future load reductions.
(4) Perform a sensitivity analysis to test the difference in estimating IA using various coefficients (e.g. Rantz 1971, CWP 2003, NEMO 2002) and analyze how the results would affect management decisions.
(5) Apply existing information about IA and placement in watershed to help prioritize where and which kind of management measures should be implemented.
(6) Assist local governments who want to estimate IA and inform them of the pros, cons, and applications.
(7) Recommend other feasible applications of percent IA in building permit, flood control, and other fees as well as relevant city and county ordinances that affect land use.

(8) The total pollutant loading with existing impervious conditions is unknown. For this reason, explore the feasibility of an interactive mapping and modeling tool to evaluate potential pollutant loadings based on existing land use classifications.
(9) Explore how IA has altered landscape from historical conditions and use that information to identify opportunity areas for restoration
(10) Follow the development of new policies at the RWQCBS (such as the final draft of the Municipal Regional Permit) and provide staff with suggestions on how to more accurately predict impacts to water quality and beneficial uses using IA as in indicator
(11) Explore whether estimating EIA would be feasible and a superior alternative to TIA for this project.

8. Acronyms

ABAG	Association of Bay Area Governments
CASQA	California Stormwater Quality Association
CCA	Critical Coastal Areas
CCRWQCB	Central Coast Regional Water Quality Control Board
CWP	Center for Watershed Protection
EIA	Effective Impervious Area
LID	Low-impact development
LUCs	Land use categories
MRP	NPDES Municipal Regional Stormwater Permit
MTC	Metropolitan Transportation Commission
NEMO	Non-Point Education for Municipal Officials
NPDES	National Pollutant Discharge Elimination System
PPAFS	Pillar Point Air Force Station
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SSCRCD	Southern Sonoma County Resource Conservation District
STOPPP	Stormwater Pollution Prevention Program
SWRCB	State Water Resources Control Board
TIA	Total Impervious Area

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Attachment 1

ESTIMATING WATERSHED IMPERVIOUSNESS FOR CURRENT AND BUILD-OUT CONDITIONS

A CASE STUDY IN THE SACRAMENTO METROPOLITAN AREA

(A WORKING DRAFT)

Introduction

An impervious surface coefficient (ISC) is a value that reflects the average percent of hardscape in a single generalized land use category. By multiplying these coefficients by the area (acres) of the relevant land use type, one can estimate the amount of impervious cover for each land use category. The coefficients can be used to estimate impervious cover in any area of interest, such as a city or a watershed. The calculations can be made for both current and future or build out conditions. This fact sheet summarizes the methods used to develop the ISC.

Methods Used for Determining the Coefficients

Step 1: Assemble necessary GIS layers

The coefficients were calculated using **geographic information systems (GIS)**. The GIS layers used for the calculations were:

- Digital **orthophotograph** of the watershed with 2-foot resolution
- Layer of watershed boundaries
- Land use layer with area for each land use type calculated
- Layer of randomly selected sample sites with a unique identifier and an assigned land use type within the watershed.

The General Land Use Category (GLUC) GIS data layer used to calculate the coefficients for the Sacramento region was provided by the Sacramento Area Council of Governments, the regional planning organization. They were based on the current and planned uses of land and derived from existing **zoning, general and specific plans**. The majority of the sites used for these ISC calculations were located within the Dry Creek watershed in western Placer and northern Sacramento Counties.

Step 2: Select sample sites and digitizing methods

With assistance from the Dr. Tony Olsen, Western Ecology Division, Environmental Monitoring and Assessment Program, US EPA, we used a probabilistic sampling design to identify 1700 sample sites for digitizing on the land use map of the watershed. For each site used in this analysis, a 40,000 m^2 square was drawn around each sample point. Although multiple GLUCs were typically found within each square, only impervious cover (IC) within the GLUC in which the sample point was located, were digitized. For example, if the sample point was located in the low density residential GLUC, all the impervious areas within the square that were designated low density residential were digitized. By layering the land use categories over the aerial photo, the impervious surfaces were identified and outlined digitally. If the selected site fell on vacant or undeveloped land, data from the site was disregarded.

Step 3: Digitize all impervious areas for each land use category

Imperviousness within all 19 GLUC was identified in a pilot study of 15 to 30 sites per GLUC. Based on the variability of the initial coefficients for each GLUC, the total number of sample site required to achieve 90 percent confidence was calculated using standard statistical methods. Percent of IC for each sample site's GLUC was then calculated using the formula:

(IC Area / Total Area of GLUC within grid) * 100 = ISC

The average of each GLUC's ISCs determined the GLUC's final coefficient.

Table 1. Final Impervious Surface Coefficients

LAND USE TYPE	Density	ISC (%)
Agriculture	N/A	4
Community/Neighborhood Commercial Office	N/A	71
Community /Neighborhood Retail	<.03	80
Forest	N/A	0
Heavy Industrial	N/A	91
High Intensity Office	1.1+	85
Low Density Residential	4.1-8.0	40
Light Industrial	N/A	84
Medium Density Residential	8.1-12.0	55
Medium-High/ High Density Residential	12.1+	60
Medium Intensity Office	.3-1.0	69
Mixed Use	N/A	82
Open Space	N/A	2
Public/Quasi- Public	N/A	26
Rural Residential	<=1.0	6
Roads	N/A	*
Very-Low Density Residential	1.1-4.0	26

* Note that currently the road coefficients are being analyzed. We will be determining one coefficient for existing development and a second for new development, both residential and commercial, that considers various types of roadways (highways, arterials, collectors, and locals).

USING THE ISC TO DETERMINE IMPERVIOUS AREA

1. Calculating Imperviousness

To determine impervious area within a watershed or within a city, the impervious areas for each land use type within the designated boundaries are calculated. This value is the product of the total area x ISC. For example:

Total low density residential (LDR) area within watershed = 1200 acres
ISC for LDR = 35
1200 x .35 = 420 acres are impervious

This process is repeated for all land use categories. The sum of these values will yield the total impervious area. The total percent imperviousness within the watershed can then be calculated by dividing the total impervious acres by the total acres.

2. Future Imperviousness

This calculation reflects the impervious area at build out. Build out refers to the condition that will exist when all land is built according to the region's **general plan**. General plans have a long-range emphasis on how development and where development will occur in a region. Although they do not reflect any given date in the future, general plans typically reflect the community's next 10 to 20 years of development. Thus the land use outlined by the general plan is the independent variable in the equation. If the general plan outlines 1200 acres of low density residential within a watershed, then the percent of imperviousness is calculated as follows:

In a 1500-acre watershed:

Total low density residential (LDR) (planned and existing use) = 1200 acres
ISC for LDR = 35
1200 x .35 = 420 acres are impervious

Total Community/ Neighborhood Retail (CRET) (planned and existing use) = 300 acres
ISC for CRET = 71
300 x .71 = 213 acres are impervious

(420 + 213) / (1200 + 300)
OR
(633 / 1500) = 42% build out impervious cover in a watershed

3. Current Imperviousness

At any one time, a certain percentage of the land remains vacant or less developed. For example, many times agricultural land is **zoned** for residential development but will remain under cultivation for many years before houses are built. To determine the current amount of imperviousness, the area of undeveloped parcels needs to be subtracted from the total area for each zoned land use type. By subtracting the area of undeveloped parcels within any single GLUC from the total area of the GLUC, an estimate can be made of the current developed acreage. It is this area which is multiplied by the ISC to determine current amount of impervious cover. This adjustment, termed the *undeveloped parcel correction factor (UPC)*, can be identified in a variety of ways.

Method 1: Visual Selection

The simplest method for identifying undeveloped parcels is a visual method. Beginning with an **orthophotograph**, overlay a land use layer. Developed parcels can be visually identified, the area of each calculated and subtracted from the total area for each land use type. Finally, the corrected area is then multiplied by the ISC to determine current IC.

Method 2: Database Selection

This approach relies on obtaining data, from the appropriate local government department, that identifies vacant parcels. This information may be found in one or more of the following locations:

- The housing element in a general plan or general plan update, which contains a vacant land inventory
- County assessor's office which maintains a list of parcels on the tax roll with an improvement value of < $10,000.

This data will permit calculation of the total area of those parcels in each land use category that are unimproved or undeveloped. The UPC is subtracted from the total area of each GLUC prior to multiplying it by the ISC. The result is an estimate of current impervious cover.

In a 1500-acre watershed:

Total low density residential (LDR) (zoned use) = 1200 acres
1200 acres - 400 acres of vacant or undeveloped land *(UPC)* = 800 acres
ISC for LDR = 35
800 x .35 = 280 acres are impervious

Total Community/ Neighborhood Retail (CRET) (planned and existing use) = 300 acres
300 acres - 200 acres of vacant or undeveloped land *(UPC)* = 100 acres
ISC for CRET = 71
100 x .71 = 71 acres are impervious

(280 + 71) / (1200 + 300)
OR
(351 / 1500) = 23% Current impervious cover in a watershed

In the analysis performed in the Sacramento area, the UPC was based on data from the county assessor's office. We found this data was 98 accurate in identifying vacant parcels, based on visual inspection of the identified parcels.

Caveats: Some underlying assumptions

The following assumptions were made about the growth and land use patterns in the watershed.

- Growth patterns of unoccupied land will be developed in manner consistent with existing trends; at build out under-utilized land will persist at existing rates.
- Undeveloped or vacant land is defined as lots without structures, or having structures with an accessed value of less then $10,000.
- Development techniques to reduce impact through either choice or use of materials (low impact development) were not considered.
- Only paved surfaces were considered impervious, impermeability due to nature soil characteristics or anthropogenic compaction was not calculated.
- The roads GLUC contained only public and right-of-way roads. All other GLUCs absorbed private roads in the calculation of the ISCs (e.g., rural residential).

Results

Table 2. BUILD OUT CONDITIONS

LAND USE TYPE	TOTAL AREA (Acres)	ISC	IMPERVIOUS SURFACE AREA
Agriculture	3.998	4	0.16
Community/Neighborhood Commercial Office	222.963	71	158.30
Community /Neighborhood Retail	643.543	80	514.83
Forest	1.276	-	0
Heavy Industrial	106.611	91	97.02
High Intensity Office	53.064	85	45.10
Low Density Residential	1,155.38	40	462.15
Light Industrial	249.585	84	209.65
Medium Density Residential	109.486	55	60.22
Medium-High Density Residential	18.59	60	11.15
Medium Intensity Office	55.035	69	37.97
Mixed Use	45.529	83	37.79
Open Space	911.989	2	18.24
Public/Quasi- Public	377.618	26	98.18
Rural Residential	8,894.29	6	533.66
Roads	1,025.31	58	594.68
Very-Low Density Residential	574.493	26	149.37
TOTALS	**14,448.76**		**3028.47**

3,028.47 / 14,448.76 = 15% Build out impervious cover in a watershed

Table 3. CURRENT CONDITIONS

LAND USE TYPE	TOTAL AREA (Acres)	UPC	ISC	IMPERVIOUS SURFACE AREA
Agriculture	3.998	0.52	4	0.139274051
Community/Neighborhood Commercial Office	222.963	79.14	71	102.1111503
Community /Neighborhood Retail	643.543	324.64	80	255.1190605
Forest	1.276	0.00	-	0
Heavy Industrial	106.611	13.25	91	84.96025863
High Intensity Office	53.064	3.44	85	42.17615762
Low Density Residential	1,155.38	279.41	40	350.3886723
Light Industrial	249.585	144.90	84	87.93448688
Medium Density Residential	109.486	16.47	55	51.15772983
Medium-High Density Residential	18.59	4.48	60	8.468196517
Medium Intensity Office	55.035	45.06	69	6.879841175
Mixed Use	45.529	4.68	83	33.905595
Open Space	911.989	339.34	2	11.45296895
Public/Quasi- Public	377.618	40.88	26	87.55243388
Rural Residential	8,894.29	1,872.02	6	421.3364299
Roads	1,025.31	43.73	58	569.3149342
Very-Low Density Residential	574.493	430.84	26	37.35100708
TOTALS	**14,448.76**			**2150.248197**

2150.248197 / 14,448.76 = 21% Current impervious cover in a watershed

Note: In the above analysis, we used a preliminary estimate of 58% imperviousness for roads. As noted above, a final set of ISC for roads are being developed.

References

(1) Nissen, S. 2001. "A Citizen's Guide to Planning." Governor's Office of Planning and Research, Sacramento, CA.
(2) Schuler, T. 1994. "The Importance of Imperviousness." *Watershed Protection Techniques* 1(3).
(3) Environmental Systems Research Institute website: www.esri.com.

Glossary

General plan- A statement of polices, including text and diagrams setting forth objectives, principles, standards and plan proposals for the future physical development of the city or county. (Reference 1)

Geographic Information Systems-An integrated collection of computer software and data that people use to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a geographic framework for gathering and organizing spatial data and related information into layers of data that can be displayed and analyzed. (Reference 3)

Orthophotograph - A perspective aerial photograph from which distortions owing to camera tilt and ground relief have been removed. An orthophotograph has the same scale throughout and can be used as a map. (Reference 3)

Specific plan- A plan addressing land use distribution, open space availability, infrastructure, and infrastructure financing for a portion of the community. Specific plans put the provisions of the local general plan into action. (Reference 1)

Zoning- Local codes regulating the use and development of property. The zoning ordinance divides the city or county into land use districts or "zones", represented on zoning maps, and specifies the allowable uses within each of those zones. (Reference 1)

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COOPERATIVE RESEARCH CENTRE FOR FRESHWATER ECOLOGY

Attachment 2

Methods for the determination of catchment imperviousness and drainage connection

CHRISTOPHER J. WALSH[1], PUA TAI SIM[1,2], AND JAEYONG YOO[2]

[1]*Cooperative Research Centre for Freshwater Ecology, Water Studies Centre, Monash University, Clayton 3800, Australia*

[2]*Centre for Geographic Information Systems, School of Geography and Environmental Science, Monash University, Clayton 3800, Australia*

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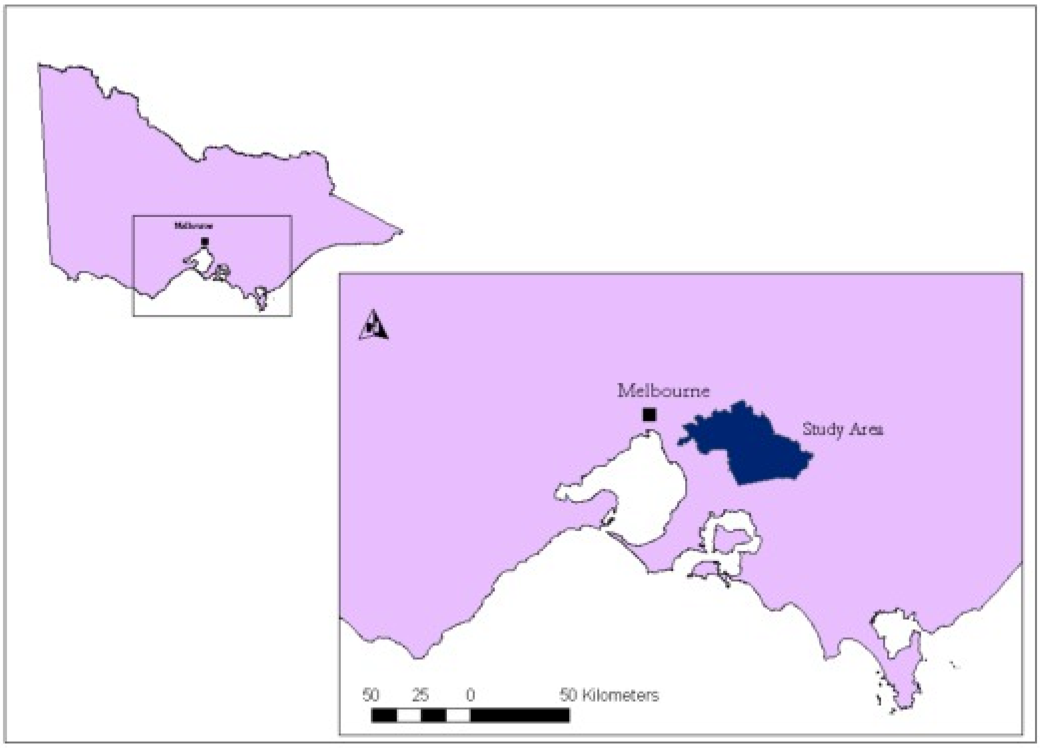


Fig. 1. Outline of the study area for CRC FE project D210.

Introduction

Catchment imperviousness (the proportion of a catchment covered by hard surfaces impervious to water) and degree of stormwater drainage connection have been identified as central elements of urban design that impact upon receiving waters (Walsh, 2000). Catchment imperviousness is a useful neutral measure of urban density, while drainage connection is an indicator of the efficiency of water and pollutant transport from impervious surfaces to receiving waters.

CRC for Freshwater Ecology Project D210, 'Urbanization and the ecological function of streams', aims to relate a variety of in-stream ecological processes and indicators to these two urban attributes in catchments of small streams draining the hills on the eastern fringe of Melbourne, Victoria, Australia (Fig. 1). This paper reports on the methods used to build the spatial database of imperviousness and drainage connection for the study area. Appendix B is a user's manual for determining these variables for any designated area using the completed MapInfo® database.

Table 1. Data supplied (√ = digital data supplied) by local government authorities in the study area

LGA	Gross building area	Stormwater drainage
Knox City	unavailable	√
Monash City	√	√
Manningham City	unavailable	unavailable
Maroondah City	not supplied	not supplied
Whitehorse City	unavailable	√
Greater Dandenong City	unavailable	√
Shire of Yarra Ranges	√	√
Shire of Cardinia	unavailable	drained areas outlined manually

Data sources

Digital aerial orthophotography (Nov 1999-Feb 2000) for the entire study area was provided by the Melbourne Water Corporation (MWC).

The State Digital Road Network (SDRN) and the National Mapping Division (NMD) 1:25,000 topographic road map data were used to delineate road areas.

Land parcel and planning zone data were derived from the Victorian statewide cadastral map data.

For connection modelling 1m contour data from the MWC were used in the metropolitan area, stream and 10m contour data from the NMD1:25,000 topographic map data was used.

Data availability and quality varied between the 8 local government authorities (LGAs) that lie within the study area. Table 1 outlines the data supplied by each of the LGAs for the study.

MWC also provided data delineating their main drains and waterways.

Deriving the impervious surface layer

A flow path for the derivation of the impervious layer is presented in Appendix B. Impervious surfaces were treated as three separate categories—buildings, roads and carparks.

Buildings Layer

The buildings layer was derived from either gross building area data (where available) or from aerial orthophotographs.

Where the LGA's valuation database included locations of building points, polygons representing each building were directly plotted. Otherwise, the building area data was geocoded using a unique key field linked to the land-parcel data set.

In the initial building of the data set, a buffer of 1.1 times the recorded area was set to allow for eaves, paved areas and non-registered buildings. A preliminary ground-truthing found this to be an underestimate for the study area, and a correction factor of 1.5 was applied to building areas. A more systematic ground-truthing is required to assess the accuracy of this correction factor for the entire study area.

Where LGA data was not available, building areas were digitized manually from the orthophotographs. Manual digitization entails the identification of each building from the orthophoto, and on-screen tracing of the building to produce a polygon. In less densely developed areas, such as Cardinia City, all visible building areas were digitized manually.

In the densely developed areas of Manningham, Maroondah, Knox, Whitehorse and Greater Dandenong cities, a sampling approach to digitizing was taken. From visual inspection of the orthophotographs, blocks of suburbs were designated as relatively homogeneous in regard to the size of residential buildings. A random sample of 150 residential houses was digitized manually in each block (determined in a pilot study to be an adequate sample size for an estimated mean area with a precision of 0.05, where precision = standard error/mean). The mean residential house area was applied to the centroid of each land parcel as derived from the cadastre to produce a polygon of the appropriate area (Fig. 2a, b).

Each land parcel was visually checked for a match between the generated polygon and a building. Where no building was present in the land parcel, the polygon was deleted. Where the land parcel contained a non-residential building, the generated polygon was replaced by manually generated polygons (Fig. 2c).

a) centroids from land-parcel data

b) buffers applied to produce polygons

c) automatic generation of polygons checked, manual digitization

Fig. 2. Process of building area estimation in densely developed areas without existing data

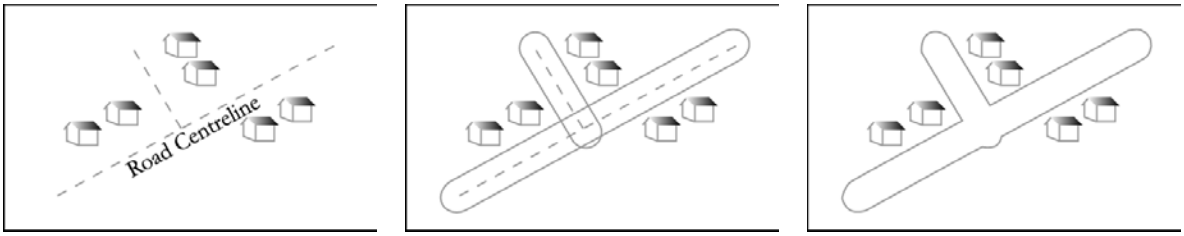
Roads Layers

This layer was derived from both the SDRN and 1:25,000 scale topographic road layer. Both datasets were necessary because the SDRN data does not categorize roads as sealed or unsealed, while the 1:25,000 scale road layer is not current. Therefore, current data from SDRN was combined with sealed and unsealed information from topographic road layer. Road lines were used to produce buffers that represent the total area of the road surface. Final categorization of road surface was assessed by ground truthing.

Mean road widths were estimated for each SDRN category (e.g. highway, freeway, street, road, avenue, etc.) by on-screen sampling using the orthophotographs. Road centrelines were buffered by a radius of half the estimated road width (Fig. 3).

Ground truthing found road widths outside in the Metropolitan area were consistently overestimated in the initial buffering process, and a correction factor of 03-0.6 was applied depending on the road category.

Sealed and unsealed roads were kept as separate layers to permit the calculation of imperviousness with and without unsealed roads. It could be argued that unsealed roads do not have the same hydrological (and water quality) effect of sealed roads.



INPUT road centreline DURING buffer AFTER buffer

Fig. 3. Road buffer processing.

Carpark Layer

Finally, carparks and other paved surfaces were manually digitised.

Estimation of drainage connection

Defining connection

Leopold (1968) attempted to quantify the degree of drainage connection by estimating 'the proportion of basin [catchment] with storm sewers [stormwater drainage pipes] and improved channels'. In this study, we reduced the correlation between catchment imperviousness and drainage connection by considering only the impervious areas (as opposed to all land surfaces) that are directly connected to stormwater pipes draining directly to receiving streams. From such data, a calculation of the proportion of impervious areas that are directly connected to receiving waters (connection) can be calculated for any catchment.

In many areas of Melbourne, directly connected suburbs are easily identifiable from drainage maps. In other areas, particularly in the urban fringe and beyond, some impervious areas are drained by stormwater pipes, but these in turn drain to dry earthen or grassed channels or to unchannelized dry land. In such areas, a binary classification (connected or unconnected) is obviously an oversimplification. The methods developed here attempted a binary classification of such areas by assessing the runoff ratio of the land below the stormwater pipe outlet. Where the runoff ratio was classified as low, the impervious areas upstream were considered unconnected.

This classification system is being developed further using hydrological models (e.g. (Fletcher et al., 2001) to estimate a degree of effective connection for different drainage systems (rather than a binary classification). Degree of connection could also be divided into several categories: e.g. hydrological connection and connection for several size fractions of pollutants. However, for the purposes of study design in project D210, a binary categorization of connection was employed.

Data integration and validation

1) A cohesive hydrology network was established using LGA drainage data, MWC underground pipes and channel data and NMD stream data.
2) Planning zone data was used to make an initial division based on the assumption that areas zoned as Environmental Rural Zone (ERZ) will not be connected.
3) Further classification of non-ERZ areas was made based on the availability and quality of drainage pipe data.
    a) Areas with full pipe data coverage showing drainage directly to streams on trunk drains were classified as connected.
    b) Areas where the pipe network was connected to other pipes or streams, but the pipe data was incomplete, so that some enclaves appeared unconnected were classified preliminarily as ambiguous.
    c) Areas with a pipe network designed to solve local drainage problems such that pipes are not directly connected to streams were classified as unconnected.
    d) Areas for which inadequate pipe data were available were preliminarily classified using the advice of LGA engineers, but these classifications were re-assessed (below)

4) Ambiguous areas (b and d, above) were re-assessed using slope and aspect information from topographic data. A two-class map was produced, separating slopes into high (≥4%) and low. High slopes were sub-divided into eight aspect categories. Where overland flow distance to stream was all along a high-slope path, the drained area was classified as connected.
5) Classifications of ambiguous areas were ground-truthed and re-classified where necessary.

The output of this process was a single layer of polygons classified as connected or unconnected. Combining this layer with the imperviousness layers, permitted classification of each impervious polygon. (see Appendix B for explanation of this process)

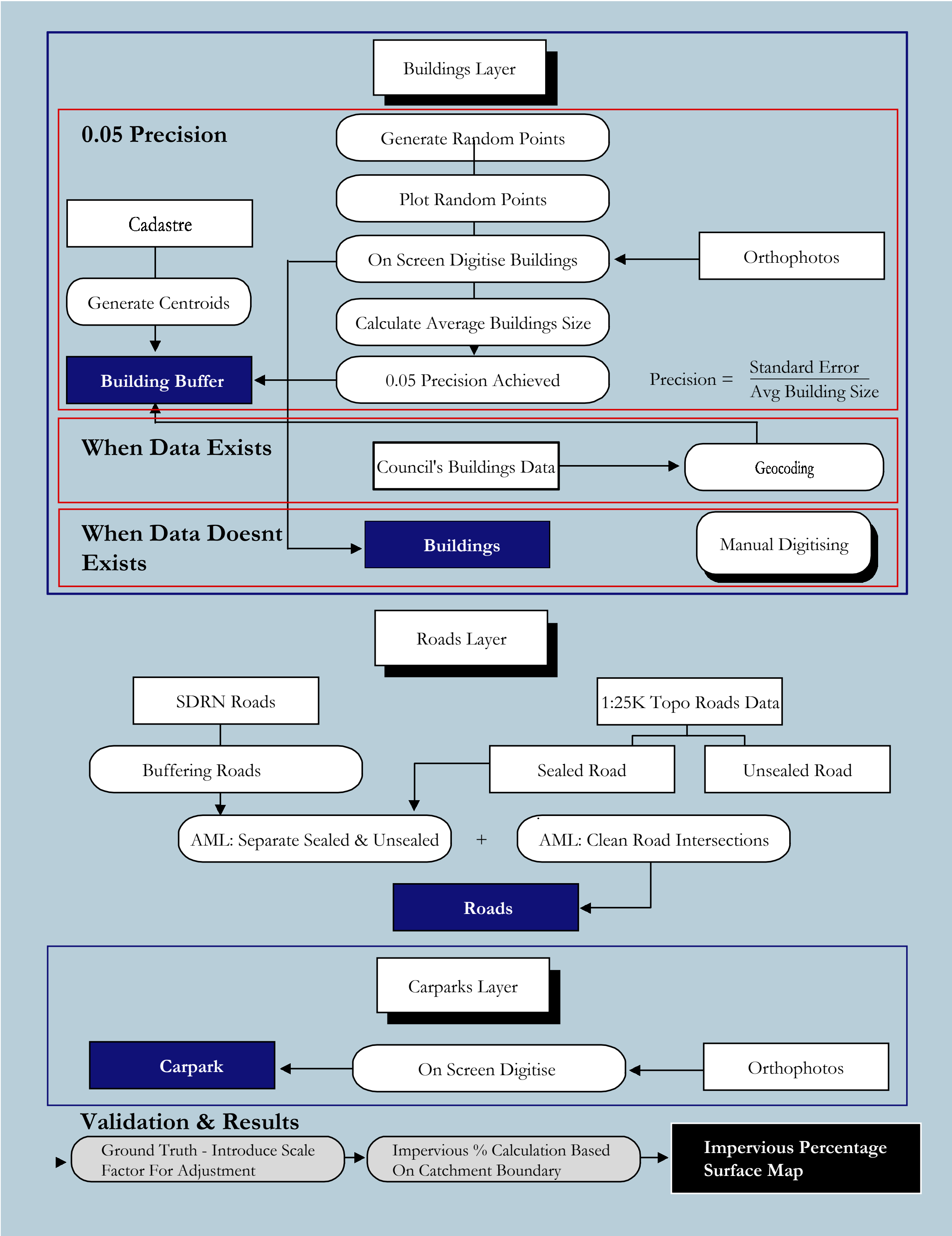
References

Fletcher, T. D., Wong, T. H. F., Duncan, H., Jenkins, G. A., & Coleman, J. (2001) Managing impacts of urbanisation on receiving waters: a decision-maiking framework. In *Proceedings of Third Australian Stream Management Conference.* (ed I. Rutherfurd), Cooperative Research Centre for Catchment Hydrology, Brisbane, Qld.

Leopold, L. B. (1968) *Hydrology for Urban Land Planning: a Guidebook on the Hydrological Effects of Urban Land Use.* Circular 554. U.S. Geological Survey, Washington D.C.

Walsh, C. J. (2000) Urban impacts on the ecology of receiving waters: a framework for assessment, conservation and restoration. *Hydrobiologia*, **431,** 107-114.

Appendix A. Workflow path for determination of imperviousness



Appendix B. D210 spatial database. User's manual

Accessing the data

The D210 spatial database resides on the shared drive accessible to all Monash team members (directory '*D210\Spatial data'*). Team members without access to that drive should contact Chris Walsh. The database consists of four primary MapInfo layers that should be opened from MapInfo.

1. *\catchment data\Buildings*
2. *\catchment data\Sealroads*
3. *\catchment data\Unsealed roads*
4. *\catchment data\Connected area Aug 01*

Additional layers that may prove useful include

d210 subcatchments (180 sub-catchments delineated in the process of site selection)
d210 final subcatchments (sub-catchments of the 16 study sites)
\catchment data\MWC Waterways (drainage lines for streams in the study area)
\catchment data\YVW STPs (locations of STPs in the study area)
\contours\79222_contours and *\contours\79223_contours* (10 m contours for the study area)

Calculation of catchment imperviousness

1) Delineate the catchment(s) of interest. d210 subcatchments will be a useful template for this purpose. These subcatchments have been derived using 10m contours, MWC and LGA drainage lines. Alterations to the already delineated catchments are best made using the contours and waterways layers listed above. One of several ways to do this is to
<Map – layer control>
Select cosmetic layer and make it editable by checking the 'editable' box (pencil icon).
Close the layer control dialogue box and select the 'polygon tool'.
Use the waterways and contours as guides to produce a new polygon.
If you wish to trace an existing subcatchment, press the S key, which will turn on snap mode (S again to turn it off). Snap mode, snaps the cursor to existing nodes.
Click on one node of the target subcatchment (ensure it is snapped first, the cursor should turn into large dashed cross).
Pointing to another node on the same polygon and pressing the shift key will trace the shortest path around the polygon.
Pressing the Control key will trace the longest path.
Using this method, a complex polygon can be traced with 3 mouse clicks.

Once the desired polygon(s) have been produced, save them by
<Map – save cosmetic objects>

2) Make the catchment polygon editable
<Map – layer control. Select the new catchment polygon layer and check the 'editable' box (pencil icon)>
and convert it into polylines
<Query-Select-Records from table-(the catchment polygon table)>
<Objects – convert to polylines>

(save this object as a new file with a new name <*File – save copy as- ‘catchment polylines’- save table*>).
If necessary (if some polygons have been deleted), <*Table-maintenance-pack table-‘catchment polygons’*>
<*File close ‘catchment polygons table’*>
<*File open table ‘catchment polygons’*>

3) Make the buildings layer editable. Run an SQL query to select the buildings that intersect with the newly created polyline.
<*Query – SQL select, select Tables Buildings and ‘catchment polylines’, where condition Buildings intersects catchment polylines*>
(This selects just those buildings that are on the boundaries of polygons and therefore drastically improves calculation time for the next bit)
<*Objects-set target*>
Select the polygon object(s). <*Query select table ‘catchment polygons’*>.
<*Objects-split*> *set all fields to method = VALUE, except IMPAREA_M2, which = Area proportion*
(This makes sure that any polygons spanning two catchments are only proportionately counted in each catchment).

4) Do the same for sealroads (and for unsealed roads if this layer is to be included in imperviousness estimate).

5) Modify the structure of the ‘catchment polygons’ table (if this has not already been done)
<*Table-maintenance-Table Structure*>
and add the following columns (as type = float):
carea,
buildings,
sealedroads,
unsealedroads (if including)
imp.

6) Open up the catchment table again and
<tables-update column>
Table to update-‘catchment polygons’
Column to update This step will need to be repeated for each of a) to e) below. For each column, make sure that the column to update entry is correct before pressing OK. Mapinfo will default to adding a temporary column when values are being calculated from a second table.*

   a) carea: value = Area(obj, "sq m")

   b) buildings: (get value from Table Buildings, where object from table buildings is within obect from table catchments)
   sum of expression = ImpArea_m2*Correction_factor

   c) sealedroads: same as for buildings, but from Table Sealroads and expression = ImpArea_m2/Correction_factor

   d) unsealedroads: same as for sealedroads

   e) imp: value = (buildings + sealedroads)/carea or
   (buildings + sealedroads + unsealedroads)/carea

7) The completed table can be exported by saving as an access database.

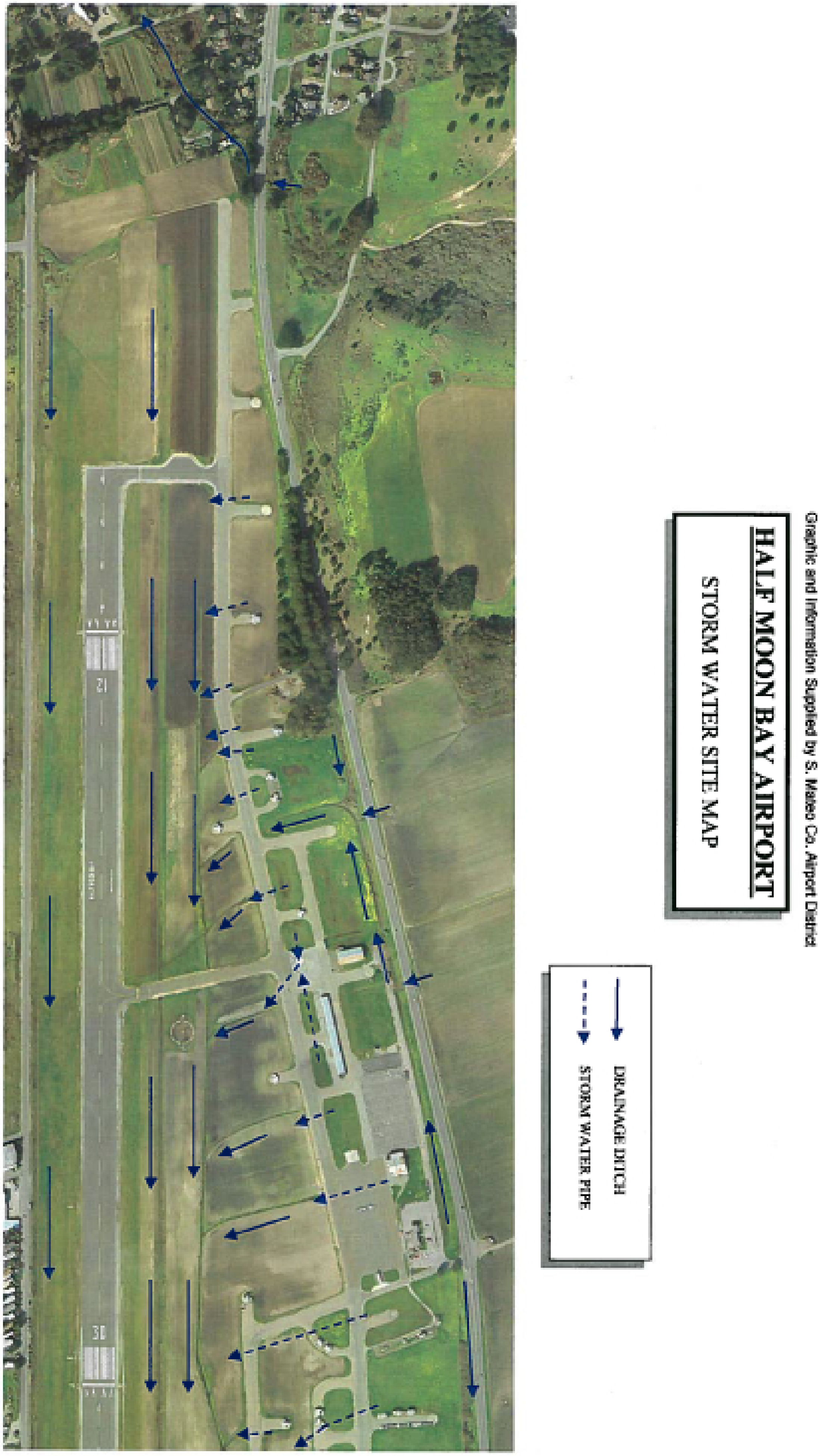
Calculation of connection

Each polygon in the buildings, sealroads, and unsealed roads tables has been classified as connected (1) or not (0) using the connected layer. These values are recorded in each table under the field ‘connected’.

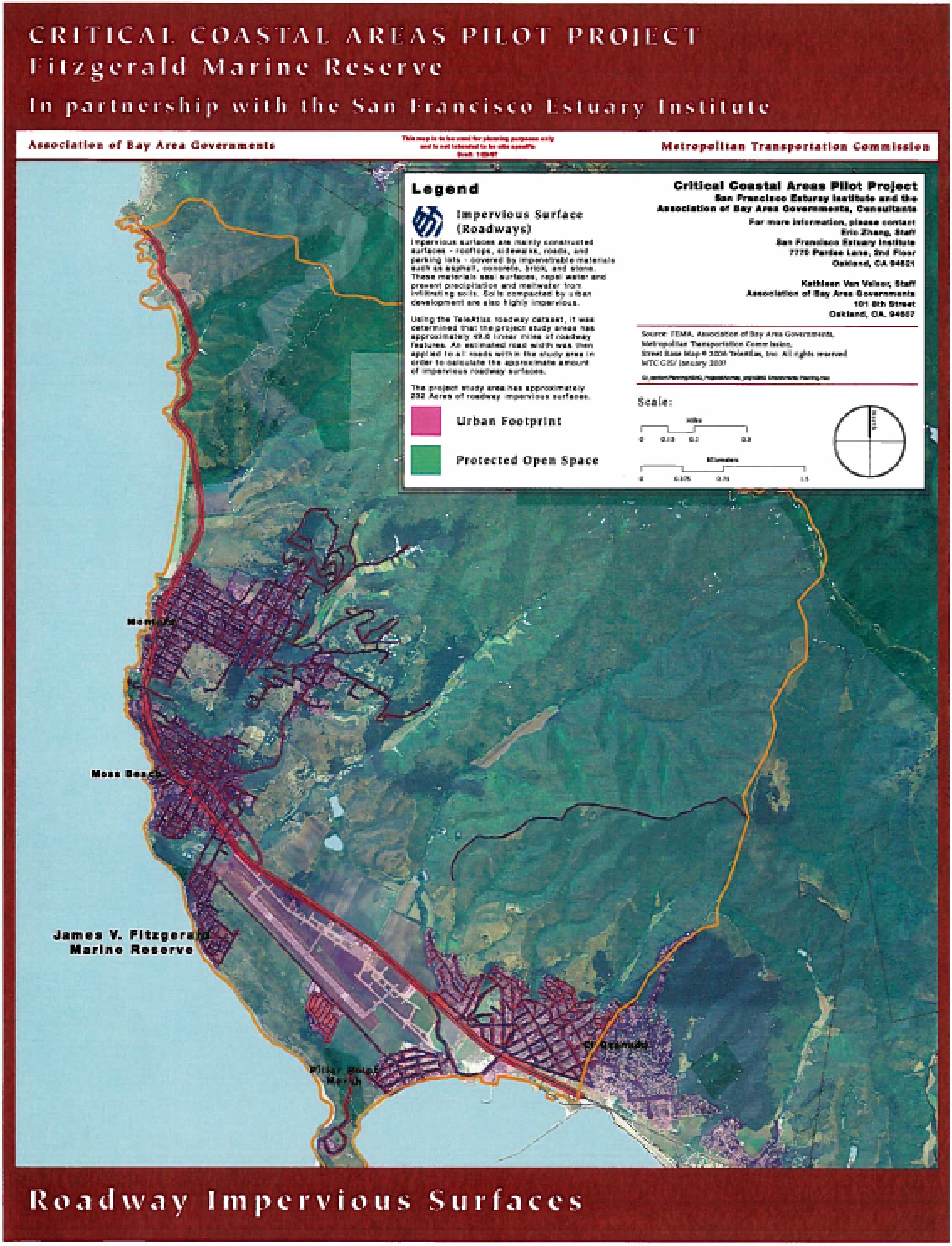
1) Modify the structure of the catchment table
   <Table-maintenance-Table Structure>
   and add the following columns (as type = float):
   connbuildings,
   connsealedroads,
   connection
   (no unsealed roads are classed as connected)
2) Open up the catchment table again and
   <tables-update column>
   a) connbuildings: (get value from Table Buildings, where object from table buildings is within obect from table catchments)
      sum of expression = ImpArea_m2*Correction_factor*connected
   b) sealedroads: same as for buildings, but from Table Sealroads and expression = ImpArea_m2*connected/Correction_factor
   c) conn: value = (connbuildings + connsealedroads)/(buildings + sealedroads) or (connbuildings + connsealedroads)/(buildings + sealedroads + unsealedroads)
3) The completed table can be exported by saving as an access database.

Note that all these calculations have been conducted and saved in the d210 subcatchments table.

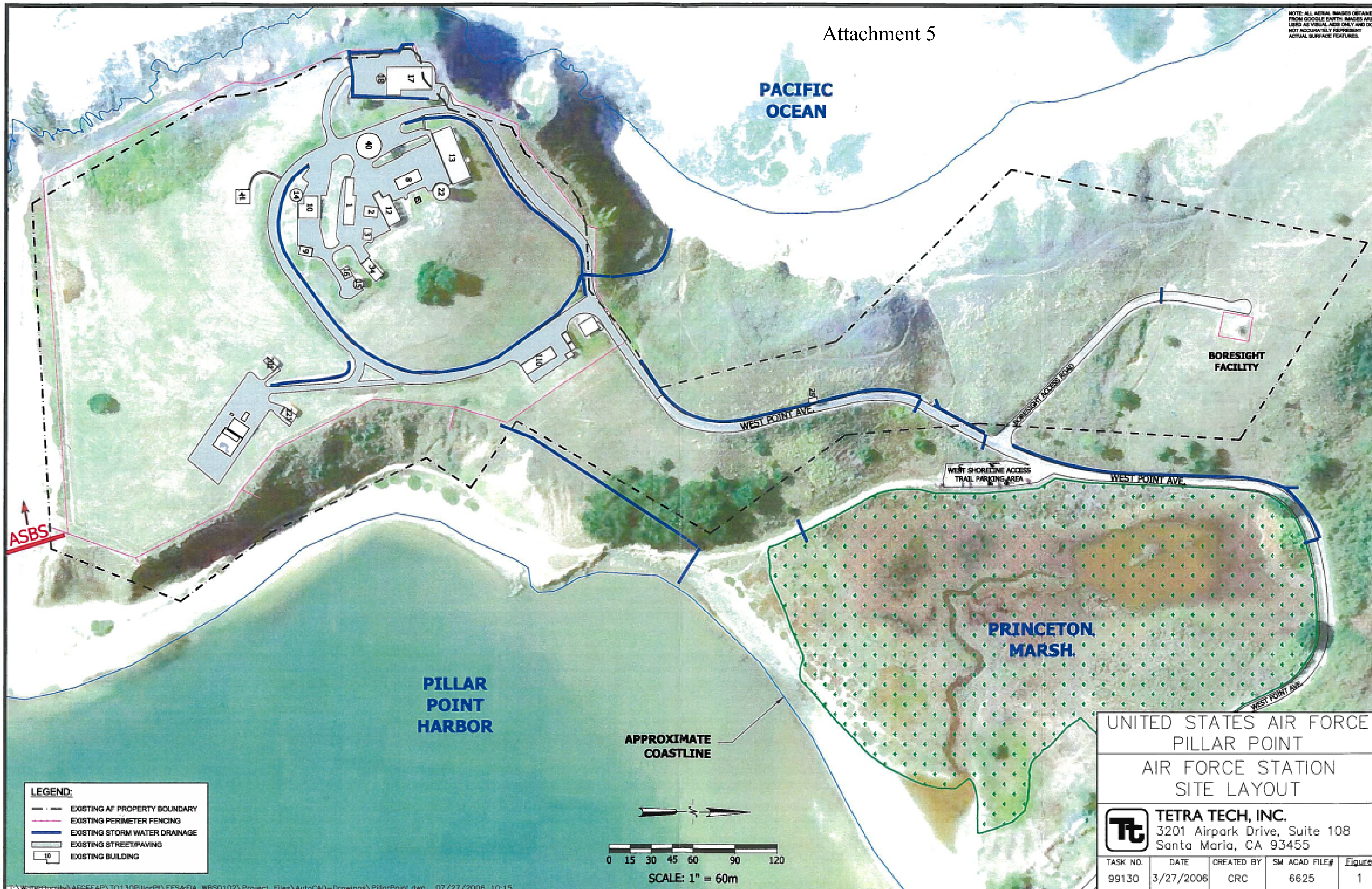
Attachment 3



Attachment 4



Attachment 5



Attachment 6

Interview Summaries: Management Measures/Best Management Practices -- FMR CCA Pilot Project	Best Management Practice	Other Management Programs	Notes
Caltrans, District 04			
David Yam, Storm water Management program contact	None employed to his knowledge along this stretch of Highway One.		
	There is nothing in the regional work plan for this segment.		BMPs only come into play with roadway construction
Department of the Air Force			
Tim Tringali, Tetra Tech		They envision a "local implementation plan."	
Garry Sanchez, Vandenburg AIRF base	He'll inquire about an on-site spill prevention plan, and any wash down and clean out protocols.	Tim reports that a "wet weather preparedness plan" will be produced.	
Meeting materials	They are looking for models for a septic evaluation. They will get back to us in short order.		
	Alternative programs for managing their storm water have been proposed to the State Water Resources		
	Control Board to gain compliance with the State Ocean Plan.		
Pillar Point Harbor			
Dan Temko, Harbormaster			
Pillar Point Harbor web site			
The Harbor is in the process of getting certification under the state's Clean Marina Program. They are mostly in	Education, policies and procedures, enforcement.	2004 Save Our Shores Harbor Storm water Task Force	
compliance, but wish to score high. Completion is expected some six months from now.	Restaurants are well trained re. oil and grease management.	report graded the harbor's activities. This was funded	
	There is a trench drain with oil/water separator across six lanes of boat ramps.	by the Integrated Waste Management Board.	
They have little relationship to the STOPP program.	Education: Informational signage -- recycling/trash depositing; do not dump stenciling; pamphlets		
	from S. Mateo Co. Env. Health Div. re. hazardous waste management and used oil; Coastal Commission	They have a plan (under review now) to add 71 more berths and related	
Imperviousness has not been an issue for them. Note: parking lots were resealed in 2006.	Clean Boater kits to existing and new tenants; harbor school tours (littering, dumping); lots of education	facilities.	
The County regularly tests the harbor's water quality. They have consistently been rated with good water quality.	re. boat maintenance and waste control techniques.		
Stagnant areas of the harbor (at the perimeter) are getting high bacteria counts. There are large collections of	SOS-initiated "dock walker" program was retired.	There is some private property in Princeton. Rip rap placement at	
shore birds there, which helps to account for the contamination.		these locations is an issue with the Coastal Comm.	
The harbor has a trail along entire waterfront, ending in RV park.	365 day/year, 24 hour Harbor District staff for ordinance enforcement to control dumping, painting, or		
Dredging of the harbor was last done in 1994, along with sediment testing. They are also testing sediments now as	to notify appropriate agency for action	There has been construction across the street -- dust, litter, parking	
part of the harbor expansion program.	The Coast Guard has "heart to hearts" with boaters who spill fuel; the harbor works with Coast Guard.	lots.	
	Used oil recycling facility is free		
	Sewage pump out facility is free.	El Granada storm drains are a big area of concern for the harbor.	
	Harbor manages an oily bilge water separator (first on the Cal. Coast). Cleaned water is routed to sewer.		
	A harbor ordinance requires the use of pump out stations. This also applies to live aboards.		
	There are doggie litter bags dispensers and beach signage at points of shoreline entry, but little		
	money for monitoring. They don't have a lot of jurisdiction over these activities.		
	These activities include kayaking, wading, picnicking, site seeing.		
	Thee are trash cans near the launch ramps for fish waste.		
	There is a prohibition against dumping fish waste (three commercial fish buyers operate there), but some		
	gets into harbor waters.		
	A dump truck routinely picks up the bulk of the fish waste. There may be some wash down. This is		
	an economic issue that is decades old. It can be looked at again.		
Golden Gate National Recreation Area			
Nancy Hornor, Chief of Planning and Compliance		A new General Management Plan is due for release	
		in Winter 2010 and they are on schedule.	
GGNRA isn't a land manager yet in these areas. GGNRA may soon manage lands within Corral de Tierra		They are in the alternatives development phase.	
but it will be next year at the earliest.		One concept they are exploring is describing the	
		park's role vis a vis the visitor serving side, and the	
They have not yet looked at stream management protection strategies, including equestrian centers.		resource side of park management.	
		There has not been much data collection in San	
		its perimeter that store boats.	

Attachment 6

Interview Summaries: Management Measures/Best Management Practices -- FMR CCA Pilot Project	**Best Management Practice**	**Other Management Programs**	**Notes**
San Mateo County Resource Conservation District (RCD)	The SMC RCD coordinates or collaborates to provide various adult and youth educational opportunities for the goal of		
Kellyx Nelson, Executive Director	natural resources management and stewardship.		
RCD web site	San Mateo County has given authority to the SMC RCD to approve grading permit exemptions to landowners for		
	The SMC RCD plays a key role in conservation planning in the region, including the development of watershed		
	Landowners also receive technical assistance provided through the Natural Resources Conservation Service		
	The SMC RCD's role is to bring the various stakeholders to the table, coordinate the design and implementation of the		
	Work with agricultural producers to reduce water consumption and nonpoint source pollution.		
	Provide a quarterly forum for sharing ideas, information and resources for the goal of natural resource management, education, and stewardship.		
	Technical workshops: provide on-the-ground skills to protect, conserve and restore natural resources.		
San Mateo County Agricultural Commission			
FMR Critical Coastal Area Steering Committee notes			
San Mateo County Department of Public Works			
Ann Stillman, Principle Civil Engineer			
[unable to reach]			
Dept. of Public Works web site			
San Mateo County Planning and Building Division	Local Coastal Program proposed update: new 10% imperviousness rule, proposed new winter grading ordinance		
Camille Leung, Planner			
Planning and Building Division web site			
Local Coastal Program Update			
San Mateo County Division of Environmental Health			
Greg Smith, P.G. Supervisor Water Protection Programs			
STOPP Program (new name: San Mateo Countywide Water Pollution Prevention Program), C/CAG, San Mateo County	Imperviousness study: several mid-coastside watersheds were studied.		
Matt Fabry, City of Brisbane	On-line educational materials: hazardous waste, storm drains, ___________________		
EOA consultants, Oakland	Reports of culvert and street cleaning in unincorporated areas.		
C/CAG and STOPP program web sites			
STOPP program annual reports			
San Mateo Co. Dept. of Public Works web site			
Monterey Bay National Marine Sanctuary	First Flush shoreline monitoring program.		
Bridget Hoover: Sanctuary Citizen Watershed Monitoring Network Coordinator (unabke to reach)	Snapshot Day shoreline water quality monitoring program.		
Rachel Saunders	On-line educational materials.		
Sanctuary web site	Water quality protection program action plans -- urban runoff action plan, ag/rural lands action plan (current), beach closure action plan		
	Agricultural Water Quality Alliance - Sanctuary ag water quality specialist - oversight of implementation of partnership BMPs (water quality management programs, pesticide management, irrigation techniques)		
	Oil spill response and planning collaboration with Fish and Game		
	Walk and Talk - Focus on sub-watershed (water quality) - Summer 2007		
	Half Moon Bay Office -- See Gulf of the Farallones National Marine Sanctuary		
Half Moon Bay Airport	General categories of BMPs outlined in the Storm water Management Plan for HMB Airport: fuel spill response, general maintenance, ditch clean outs, materials storage control	The airport has prepared a storm water management plan.	
James Wadleigh, Airport Operations Specialist II			
Airport Storm water Management Plan			
No imperviousness studies; estimate of impervious area provided with map of drainages.			
	Stormwater discharges from the airport to the marina are monitored every several years by the airport.		
Gulf of the Farallones National Marine Sanctuary			
Irina Cogan			
	The biggest helpers are the compliant boaters. They are often self-policing and help bring others along.		

Attachment 7

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Critical Coastal Areas

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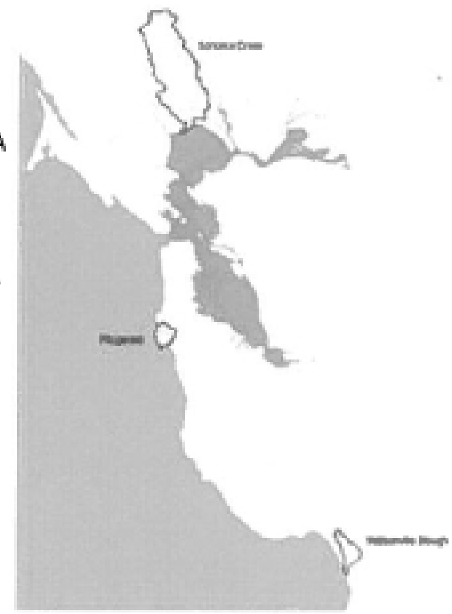
Steering Committee Documents

The Critical Coastal Areas (CCA) Program is an innovative program to foster collaboration among local stakeholders and government agencies, to better coordinate resources and focus efforts on coastal watersheds in critical need of protection from polluted runoff. A multi-agency statewide CCA Committee has identified an initial list of 101 CCAs along the coast and in San Francisco Bay. SFEI received a 319(h) grant to provide technical guidance in three CCA Pilot Areas: Sonoma Creek, Fitzgerald Marine Reserve, and Watsonville Slough. For more information on the CCA program, please visit the official website or the ASsociation of Bay Area Government's site at http://www.abag.ca.gov/cca.html.



view larger map

or contact

Kat Ridolfi
San Francisco Estuary Institute
7770 Pardee Lane, 2nd Floor
Oakland, CA 94621
Phone: (510) 746-7392
Fax: (510) 746-7300
Email: kat@sfei.org

GIS Survey
Please take the GIS survey here: http://www.surveymonkey.com/s.asp?u=160252864344

San Francisco Estuary Institute
7770 Pardee Lane
Oakland, CA 94621-1424
(510) 746-SFEI (7334)
Fax (510) 746-7300
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Steering Committee Documents

Sonoma Creek

- Boundary - SonomaCreekBoundary.zip
- County Data - SonomaCounty.zip SonomaParcels.zip
- Elevation - Elevation.zip
- Imagery
  - NAIP2005 - naip_1-1_1n_s_ca097_2005_1.sid Outline naip_1-1_1n_ca097_2005_1.shp

Fitzgerald

- Boundary - FitzgeraldBoundary.zip
- County Data - SanMateoCounty.zip Storm Drains - StormDrains.zip
- Elevation - Elevation.zip
- Imagery
  - NAIP2005 - naip_1-1_1n_s_ca081_2005_1.sid Outline naip_1-1_1n_ca081_2005_1.shp

Watsonville Slough

- Boundary - WatsonvilleBoundary.zip
- County Data - SantaCruzCountyGIS.zip
- Elevation - Elevation.zip
- Imagery
  - NAIP2005 - naip_1-1_1n_s_ca087_2005_2.sid Outline naip_1-1_1n_ca087_2005_2.shp

California

- NHD - Medium Resolution NHDM1805.zip NHDM1806.zip High Resolution NHDH1805.zip NHDH1806.zip
- Waterboard 303(d) Listings (Region 2 and 3) - Waterboard.zip
- Land Use - CaSil_Data.zip NLCD1999.zip
- Urban Areas - UrbanAreas.zip
- CalWater - CalWater2.2.zip
- ASBS - SWQPA_ASBS_April2005.shp.zip
- Bathymetry - 10mBathymetry.zip 50ftBathymetry.zip
- Elevation - 25ft_contour.zip 50ft_contour.zip 100ft_contour.zip
- Precipitation - CA_Precipitation.zip
- CNDDB (requires subscription) - CNDDB.zip
- CWHR - CWHR.zip
- Dams - Dams.zip

- Kelp Survey - Kelp.zip
- Landslides - Landslides.zip
- Liquefaction - Liquefaction.zip
- Ocean Outfalls - OceanOutfalls.zip
- Water Management Agencies - WaterManagementAgencies.zip

San Francisco Estuary Institute
7770 Pardee Lane
Oakland, CA 94621-1424
(510) 746-SFEI (7334)
Fax (510) 746-7300
www.sfei.org

Critical Coastal Areas

Watsonville Slough

Presentations

- Critical Coastal Areas Program Workshops v.3.ppt

Handouts

- Agenda.doc
- Background on the CCA Program.doc
- Watsonville Sloughs Watershed Resource Conservation & Enhancement Plan (69 mb)
- Watsonville Sloughs Watershed Resource Conservation & Enhancement Plan Technical Appendices (40 mb)
- Staff bios and contact.doc
- Evaluation 1
- Evaluation 2
- CCA Models
- Load Reduction Scenarios - Draft
- Review of Technology Options for Online Access to Coastal Areas Information
- Final Notes Workshop 01-19-07

Sonoma Creek

Presentations

- SEC intro to Sonoma Valley.ppt
- Critical Coastal Areas Program Workshops intro presentation.ppt
- Historical Ecology of Sonoma Valley.ppt
- Modeling Options for Sonoma CCA.ppt

Handouts

- Agenda.doc
- Background on the CCA Program.doc
- Staff bios and contact.doc
- Evaluation 1.doc
- Evaluation 2.doc
- CCA Models
- Review of Technology Options for Online Access to Coastal Areas Information
- Final Meeting Notes 02-21-07 Workshop

Fitzgerald Marine Reserve

Presentations

- Fitzgerald Marine Reserve park history.ppt
- SURFRIDER SAN VICENTE history.ppt
- Intro to the CCA Program and Subcommittee Progress.ppt
- CCA Phase I Update and mapping credits.ppt
- Monitoring Opportunities.ppt
- Coastal circulation.ppt
- Greeninfo mapping tool.ppt

Handouts

- Agenda.doc
- Background on the CCA Program.doc
- Description of Fitzgerald Pilot
- NPS issues.doc
- Impervious surfaces Calculation.pdf
- Staff bios and contact.doc
- Evaluation 1.doc
- Evaluation 2.doc
- CCA Models
- Maps and posters bibliography
- Review of Technology Options for Online Access to Coastal Areas Information
- Final Meeting Notes 03-09-07 Workshop
- FMR Map and Poster Annotations.doc

External Links

- Santa Barbara Watershed Publication

San Francisco Estuary Institute
7770 Pardee Lane
Oakland, CA 94621-1424
(510) 746-SFEI (7334)
Fax (510) 746-7300
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Sonoma Creek

- Map 36 x 36 in. pdf map (26 megs)
- Apparent Watershed Changes 1823 - 2003 22 x 33 in. pdf map (2 megs)
- Land Cover Map 24 x 36 in. pdf map (< 1 meg)
- Open Space Map.pdf 24 x 36 in. pdf map (< 1 meg)
- Tributary Subbasins 11 x 17 in. pdf map (< 1 meg)

Fitzgerald

- Map 36 x 36 in. pdf map (60 megs)
- Average Annual Precipitation 8.5 x 11 in. pdf map (2 megs)
- Soils 8.5 x 11 in. pdf map (2 megs)
- Half Moon Bay Airport Drainage and Imperviousness 36 x 24 in. pdf map (10 megs)
- Imperviousness, Population/Household Size and Population Projection at Buildout 56 x 36 in. pdf (< 1 meg)
- Discharges and Outlet Map 16 x 21 in. pdf (< 1 meg)
- Map Legend Geology of the Onshore Part of San Mateo County. 36 x 34 in. pdf (7 megs combined)
- Current Best Management Practices for Control of Land-Based Sources of Marine Pollutants 30 x 28 in. pdf (26 megs)
- Fire Planning 8.5 x 11 - 4 megs 42 x 55 - 128 megs
- Tsunami Planning 8.5 x 11 - 4 megs 42 x 55 - 124 megs
- Environmental Planning Flood Hazards 8.5 x 11 - 8 megs 42 x 55 - 137 megs
- Environmental Planning Post Fire Soil Erosion Hazards 8.5 x 11 - 8 megs 42 x 55 - 138 megs
- Environmental Planning Impervious Surface (Roadways) 8.5 x 11 - 4 megs

Watsonville Slough

- Map Overview - 36 x 36 in. pdf map (22 megs)
- Map Agricultural Lands - 36 x 36 in. pdf map (21 megs)
- Map Land Use - 36 x 36 in. pdf map (13 megs)
- Map Endangered Species and Important Natural Areas - 36 x 36 in. pdf map (22 megs)

San Francisco Estuary Institute
7770 Pardee Lane
Oakland, CA 94621-1424
(510) 746-SFEI (7334)
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Steering Committee Documents

Below are pdf's which contain all of the deliverables submitted thus far for SFEI's 319(h) grant, Phase I of CCA. These large documents start with the draft report and are followed by each deliverable, which function as "technical appendices" to the report. Many of these deliverables are referred to directly in the report by their corresponding task number, and so they are in order of task number for easy locating. All of these packages have been edited to focus on the particular CCA listed in the following headings (e.g. sections on Sonoma and Watsonville are omitted from the FMR pdf) however most of our analysis applies to all three CCAs. Of particular concern to the steering committees are the following pieces; however feel free to review all the deliverables and view the maps and other documents provided at the winter workshops on other links of this webpage. Please note that we are only able to submit substantial revisions for the draft report and the Task 2.4 deliverable.

1) The draft report

2) Task 2.4 and 3.1 deliverables which summarize the existing impairment status of the watersheds.

This letter explains a bit more about the document, the review process and provides a list of guiding questions that we suggest you use in order to form comments. As mentioned at meetings, ***please pick one person to deliver comments to Kat, Rainer and Kathleen by September 28.*** Thanks so much for your effort and comments.

Fitzgerald Marine Reserve

- FMR draft reports and deliverables package (PDF, 49.4MB)

Watsonville Sloughs

- Watsonville draft report and deliverables package (PDF, 20.2MB)

Sonoma Creek

- Sonoma deliverables package (PDF, 20.1MB)

San Francisco Estuary Institute
7770 Pardee Lane
Oakland, CA 94621-1424
(510) 746-SFEI (7334)
Fax (510) 746-7300
www.sfei.org

Basecamp Basics

Basecamp is an online project management tool that will hopefully make the organization of CCA a bit easier for all the people involved. This would supplement the documents, maps and other data that are already stored on SFEI's website and accessible to the public. For now, I'd like to use this site for Coastal Commission/BCDC, SFEI, and ABAG staff and our subcontractors. Eventually we could consider opening it up to steering committees, etc. but I'm not sure at this time.

Basecamp has two main functions that I will regularly update/manage:

1) Milestones: a calendar of deliverable due dates, meetings, and other important dates
2) Files: where we can store up to 500 MB of files including drafts of deliverables, timelines, agendas, etc. This function also lets you see multiple drafts of a single document and would help reduce email inbox clutter and facilitate the sharing of large files

Other options for the future:

1) To do lists: could be used for updating/filling in pieces of documents e.g. "Check out data available on CCAMP's site to see if it is updated, and if so, fill in and comment"
2) Whiteboard: could be used for editing a small document (around a paragraph or two). At SFEI we have used it for mission statements, but for CCA it could be an intro paragraph or some material for a website or something.
3) Messages: could be used for leaving notes and commenting; can also include attached documents e.g. setting up a meeting time or compiling meeting minutes

Basic Directions:

1) Go to http://sfei.grouphub.com/projects/1172997
2) You will be prompted to sign in. I have set up accounts for everyone with your
   User name: your first name
   Password: cca
   (if you already have a basecamp ID let me know)
3) You end up in the "dashboard which is an overview and you can see all the milestones and documents I've already uploaded. You can click directly from here or go through the tabs.
4) That's it!