



Protocol Implementation Plan for Monitoring Stream Condition in the Mediterranean Coast Inventory and Monitoring Network of Southern California

Natural Resource Report NPS/MEDN/NRR—2019/1875





ON THIS PAGE

Biologist M. Mendelsohn in Santa Monica Mountains displaying an adult Red-legged frog.
NPS/Santa Monica Mountains NRA

ON THE COVER

Water Canyon, Santa Rosa Island in Channel Islands National Park
NPS/S. OSTERMANN-KELM

Protocol Implementation Plan for Monitoring Stream Condition in the Mediterranean Coast Inventory and Monitoring Network of Southern California

Natural Resource Report NPS/MEDN/NRR—2019/1875

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Contents

	Page
Figures.....	vi
Tables.....	vii
Standard Operating Procedures (SOPs)	viii
Executive Summary	ix
Acknowledgments.....	xi
Glossary	xii
Acronyms and Abbreviations.....	xii
1 Background and Objectives	1
1.1 Overview	1
1.1.1 The National Park Service Inventory and Monitoring Program.....	1
1.1.2 Parks Included in This Protocol Implementation Plan	2
1.1.3 Rationale for Monitoring Stream Condition using Benthic Invertebrates (Water Quality and Riverine Integrity)	2
1.1.4 Protocol Implementation Plan Development Process	2
1.2 Study Area	4
1.2.1 Geographic Setting	4
1.2.2 Geology	6
1.2.3 Climate	6
1.2.4 Major Watersheds.....	7
1.2.5 Land Use and Stream Conditions	10
1.2.6 Aquatic Species	12
1.2.7 Regulatory Status / Impaired Waterbodies.....	13
1.2.8 Summary of Current and Historic Monitoring at SAMO and CHIS	14
1.2.9 Aquatic Amphibian Monitoring at SAMO.....	16
1.2.10 Summary of Monitoring Drivers	16
1.3 Objectives	17
1.3.1 Management Questions	17
1.3.2 Measureable Objectives.....	18

Contents (continued)

	Page
1.3.3 Monitoring Approach	18
2 Sampling Design	20
2.1 Rationale for This Monitoring Approach	21
2.1.1 SAMO	21
2.1.2 CHIS	21
2.1.3 Regional Coordination.....	22
2.2 Sampling Domain.....	23
2.2.1 SAMO	23
2.2.2 CHIS	23
2.3 Sample Frame.....	24
2.3.1 SAMO	24
2.3.2 CHIS	24
2.4 Stratification	24
2.4.1 SAMO	24
2.4.2 CHIS	25
2.5 Site Selection	25
2.5.1 SAMO	25
2.5.2 CHIS	26
2.6 Revisit Design	27
2.6.1 SAMO	27
2.6.2 CHIS	28
2.7 Response Design	28
2.7.1 Water Chemistry Parameters.....	31
2.7.2 Bioassessments (Stream Benthic Macroinvertebrates with Associated Physical Habitat and Water Quality Measurements).....	33
2.7.3 Riverine Wetland Function.....	33
3 Field and Laboratory Methods	35
4 Data Handling, Analysis and Reporting	35

Contents (continued)

	Page
4.1 Data Management Overview	35
4.2 Overview of Data templates and Databases	37
4.2.1 Site Evaluation.....	38
4.2.2 Vertebrate Observations (CHIS only)	38
4.2.3 In-Situ Water Chemistry.....	38
4.2.4 SWAMP Bioassessments	38
4.2.5 CRAM (Riverine Module)	39
4.3 Data Entry, Verification and Editing.....	39
4.4 Metadata Procedures	39
4.5 Sensitive Information	40
4.6 Data Certification and Delivery.....	40
4.7 Data Archival.....	41
4.8 Reporting	41
5 Personnel and Qualifications, Schedule, and Budget	43
5.1 Personnel and Qualifications.....	43
5.2 Schedule	43
5.3 Budget	43
5.3.1 CRAM and Bioassessments	44
5.3.2 Water Chemistry.....	45
6 Literature Cited	46
Appendix A: Detailed Background Information on SAMO	50
Appendix B: Detailed Background Information on CHIS.....	66

Figures

	Page
Figure 1. Map of Mediterranean Coast Network parks.....	2
Figure 2. Maps showing land use and vegetation types at Santa Monica Mountains NRA in 1986 and 2011.....	4
Figure 3. Map of Channel Islands National Park.....	5
Figure 4. Map of Santa Monica Mountains NRA watersheds (HUC-10).....	7
Figure 5. Malibu Creek watersheds and streams within Santa Monica Mountains NRA.....	8
Figure 6. Coastal streams west and east of Malibu Creek within Santa Monica Mountains NRA.	9
Figure 7. Major streams and watersheds on Santa Rosa Island).....	10
Figure 8. Sites on Santa Rosa Island where water quality testing and benthic macroinvertebrate assessments were made in 2006, prior to the removal of non-native deer and elk from the island.....	22
Figure 9. Preliminary California Stream Condition Index percentile scores for the 69 SMC monitoring sites within the Santa Monica Mountains NRA EMZ between 2009-2013.....	23
Figure 10. Map of the four ecological regions within the Santa Monica Mountains Resource Management Zone (or Ecological Management Zone) from Delaney et al. (2011).....	24
Figure 11. Map of Santa Monica Mountains NRA aquatic amphibian monitoring sites per the Mediterranean Network Inventory and Monitoring protocol.....	26
Figure 12. Stream condition monitoring locations at SAMO will be a subset of the amphibian monitoring sites.....	27
Figure 13. Monitoring locations on Santa Rosa Island for 2017	30
Figure 14. Monitoring locations on Santa Rosa Island for 2018	31
Figure 15. Recommended flow diagram of the stages of data management from pre-season preparation to season closeout.....	37

Tables

	Page
Table 1. Amphibian species of Channel Islands National Park.	13
Table 2. Summary of major stream monitoring currently and previously conducted at SAMO.	14
Table 3. Summary of past stream monitoring at CHIS.	15
Table 4. Summary of key drivers for stream monitoring at SAMO and CHIS.	17
Table 5. Overview of the monitoring approach for stream condition monitoring at MEDN parks.	20
Table 6. Aquatic amphibian monitoring revisit design	28
Table 7. Summary of requirements for each type of sampling.	28
Table 8. Summary of sampling design for SAMO.	29
Table 9. Summary of sampling design for CHIS.	29
Table 10. Locations of where the MEDN stream condition monitoring program data and databases are stored and managed.	37
Table 11. Estimated annual costs for field data collection, laboratory analysis, data entry and summary reporting at CHIS	43
Table 12. Estimated annual costs for sampling at SAMO	44
Table 13. Estimated annual costs NPS staff to implement the Stream Condition Monitoring Protocol.	44

Standard Operating Procedures (SOPs)

Thirteen standard operating procedures are associated with the Mediterranean Coast Network stream condition protocol implementation plan. To accommodate frequent changes, the SOPs are informally published online through the National Park Service Integrated Resources Management Applications (IRMA) portal (<https://irma.nps.gov/Portal>). The SOPs can be retrieved from IRMA using the citation below. Versioning tools in IRMA will offer the most current of the document.

Federico, F., R. Mazor, L. Lee, and S. Ostermann-Kelm. 2019. Protocol implementation plan for monitoring stream condition in the Mediterranean Coast Inventory and Monitoring Network of Southern California - Standard Operating Procedures, Version 1.0. Mediterranean Coast Network, National Park Service, Thousand Oaks, California.

List of Standard Operating Procedures:

SOP 1: Field Season Planning and Coordination

SOP 2: Site Selection

SOP 3: Field Measurements of Water Chemistry (SAMO)

SOP 4: Bioassessment Monitoring

SOP 5: Riverine Wetland Functional Assessment

SOP 6: Regulatory Status Monitoring (SAMO)

SOP 7: GRTS Draw for Santa Rosa Island (CHIS)

SOP 8: Data Management

SOP 9: Annual Status Reports and Periodic Synthesis Reports

SOP 10: Safety

SOP 11: Personnel Requirements and Training

SOP 12: Equipment Disinfection

SOP 13: Monitoring Site Locations and Driving Directions

Executive Summary

The National Park Service's Mediterranean Coast Network of the Inventory and Monitoring Program Vital Signs Monitoring Plan (Cameron et al. 2005) identified freshwater monitoring as a vital sign for Channel Islands National Park (CHIS) and Santa Monica Mountains National Recreation Area (SAMO). The conceptual models presented by Cameron et al. (2005) identified water as a significant driver in these two network parks. The presence of water determines the presence and abundance of much of the native and exotic flora and fauna in Mediterranean-type ecosystems.

In this protocol implementation plan, we describe the use of peer-reviewed, published, and well-established methodology to monitor stream condition using a rapid assessment method, and where water is present, we will also use water chemistry, physical habitat and benthic macroinvertebrate sampling. The California Rapid Assessment Method (CRAM) is a cost-effective and scientifically defensible rapid assessment method for monitoring the conditions of wetlands throughout California that does not require the presence of water. It is designed for assessing ambient conditions within watersheds, regions, and throughout the state. Where conditions are suitable (i.e., the presence of a wadeable stream), we will also sample physical habitat and benthic invertebrates, which are effective ways to measure stream health (Harrison et al. 2004). Benthic invertebrates have diverse life histories that make them sensitive to a variety of stressors and can integrate responses over space and time in a way that traditional measures of stream health (e.g., water chemistry) cannot. Limited water chemistry sampling will also be conducted when feasible to help identify stressors to streams on NPS-managed lands.

The overarching programmatic goal of the MEDN I&M Stream Condition Monitoring Program is to obtain information that will aid in the assessment, conservation, and restoration of surface water resources. This monitoring program addresses the following management questions:

1. What is the regulatory status of SAMO streams under section 303(d) of the Clean Water Act?
2. What is the status of and what are the trends in the overall health of the streams in SAMO and CHIS?
3. What is the relationship between aquatic amphibian presence/abundance and stream health at SAMO and CHIS?

Riverine wetland conditions will be monitored using the CRAM for wetlands (California Wetlands Monitoring Workgroup 2013). Macroinvertebrate assemblages, physical habitat conditions and stream water chemistry will be monitored using the bioassessment protocols designed by the California Surface Water Ambient Monitoring Program (SWAMP; Ode 2007).



Photo 1. Federally threatened Red legged frog (*Rana draytonii*) in the Santa Monica Mountains. NPS Photo.

These monitoring approaches are California State standards, considered best practice, and have been used at thousands of monitoring locations throughout the state including Southern California. The aim of the sampling design is to provide statistical and scientific rigor, given safety, fiscal and logistical constraints, as well as the ability to integrate data with other NPS monitoring programs (e.g., aquatic amphibian monitoring). The alignment of water quality monitoring sites with the aquatic amphibian monitoring sites at SAMO required that the sampling design for SAMO water quality follows the amphibian monitoring design. At CHIS, given our limited resources, we focused water quality monitoring on Santa Rosa Island. Because of the emphasis on understanding the physical recovery process of the island's streams following the removal of non-native animals, a measure of riverine wetland function (CRAM) was selected as the primary metric, with the additional use of a bioassessment metric, amphibian presence/absence monitoring, and limited water chemistry at a subset of the sites.

Monitoring will alternate between CHIS and SAMO every three years. At CHIS, 30 randomly selected sites on Santa Rosa Island will be monitored over a 3-year period (2016-2018; approximately 10 sites/year). In the subsequent 3 years (2019-2021), sampling will be performed at SAMO at 24 of the already established amphibian monitoring sites (approximately 8/year; Delaney et al. 2011). Afterward, monitoring will continue to alternate between the two parks.

Reporting will consist of brief annual summary reports and synthesis reports at the end of the three-year cycle of sampling at each park. Annual summary reports will contain full descriptions of each site visited, a list of the field crew and sampling dates, a summary of the methods used, CRAM scores, California Stream Condition Index scores, and a list of all species identified along with general photos of the site. In-depth analyses that are suitable for publication in peer-reviewed journals will be encouraged after the first 9-12 years of protocol implementation (when all sites have been visited twice).

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Glossary

Ephemeral: A stream or portion of a stream which flows briefly in direct response to precipitation in the immediate vicinity, and whose channel is at all times above the groundwater reservoir.

Intermittent: A stream where portions flow continuously only at certain times of the year, for example when it receives water from a spring, ground-water source or from a surface source, such as melting snow (i.e. seasonal). At low flow there may be dry segments alternating with flowing segments.

Impaired Waters: Waters that are listed under section 303(d) of the Clean Water Act.

Perennial Stream: A stream or portion of a stream that flows year-round, is considered a permanent stream, and for which baseflow is maintained by ground-water discharge to the streambed due to the ground-water elevation adjacent to the stream typically being higher than the elevation of the streambed.

Reach: A discrete segment of a stream.

Acronyms and Abbreviations

303(d): Section of the Clean Water Act mandating that states submit a list of water bodies not meeting or not expected to meet water quality standards.

CHIS: Channel Islands National Park

EMZ: Ecological Management Zone. Synonymous with RMZ. These areas are defined as SAMO and additional areas of public lands surrounding SAMO.

HUC: Hydrologic unit code. The Watershed Boundary Dataset (WBD) maps the full areal extent of surface water drainage for the U.S. using a hierarchical system of nesting hydrologic units at various scales, each with an assigned hydrologic unit code (HUC)

MEDN: Mediterranean Coast Network of the NPS Inventory and Monitoring Program.

PIP: Protocol Implementation Plan

RCD: Resource Conservation District

RMZ: Ecological Management Zone (includes SAMO and surrounding lands). Synonymous with EMZ. These areas are defined as SAMO and additional areas of public lands surrounding SAMO.

SAMO: Santa Monica Mountains National Recreation Area

SCCWRP: Southern California Coastal Water Research Program

SMC: Stormwater Monitoring Coalition. The goal of the SMC is to develop the technical information necessary to better understand stormwater mechanisms and impacts, and then develop the tools that will effectively and efficiently improve stormwater decision-making.

TMDL: Total maximum daily limit

SWAMP: Surface Water Ambient Monitoring Program. The mission of SWAMP is to provide resource managers, decision makers and the public with timely, high-quality information to evaluate the condition of all waters throughout California.

Additional information can be found at

https://www.waterboards.ca.gov/water_issues/programs/swamp/quality_assurance.html#qapgd

BMI: Benthic macroinvertebrates

PHAB: Physical Habitat Condition

GRTS: Generalized random tessellation stratified. GRTS is a form of spatially-balanced sampling that is a true probability design.

1 Background and Objectives

1.1 Overview

1.1.1 *The National Park Service Inventory and Monitoring Program*

The purpose of the National Park Service (NPS) Inventory & Monitoring (I&M) Program is to gather and provide scientific information on the current status and long-term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. As part of the NPS effort to improve park management through greater reliance on scientific knowledge, the primary role of the I&M Program is to collect, organize, and make available natural resource data on key vital signs and to contribute to the NPS institutional knowledge by interpreting this data through analysis, synthesis, and modeling. The I&M Program defines vital signs as a subset of physical, chemical, and biological elements and processes of park ecosystems that are thought to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values (Fancy et al. 2008).

The five overall goals of the I&M Program are to (Fancy et al. 2009):

1. Inventory the natural resources and park ecosystems under NPS stewardship to determine their nature and status
2. Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments
3. Establish natural resource inventory and monitoring as a standard practice throughout the NPS system that transcends traditional program, activity, and funding boundaries
4. Integrate natural resource inventory and monitoring information into NPS planning, management, and decision-making
5. Share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives

These goals are accomplished through park-wide inventories and long-term monitoring programs. In establishing a service-wide natural resources I&M Program, the NPS created networks of parks that are linked by geography and shared natural resource characteristics. Working within and across networks improves the efficiency of inventory and monitoring because parks are able to share budgets, staffing, and other resources to plan and implement an integrated program. The Mediterranean Coast Network (MEDN) is one of 32 monitoring networks across the NPS. The MEDN is comprised of three NPS units: Cabrillo National Monument (CABR), Channel Islands National Park (CHIS), and the Santa Monica Mountains National Recreation Area (SAMO) (Figure 1). The MEDN Vital Signs Monitoring Plan (Cameron et al. 2005) provides the foundation for the long-term ecological monitoring programs of the network and describes the rationale and basis for the programs.

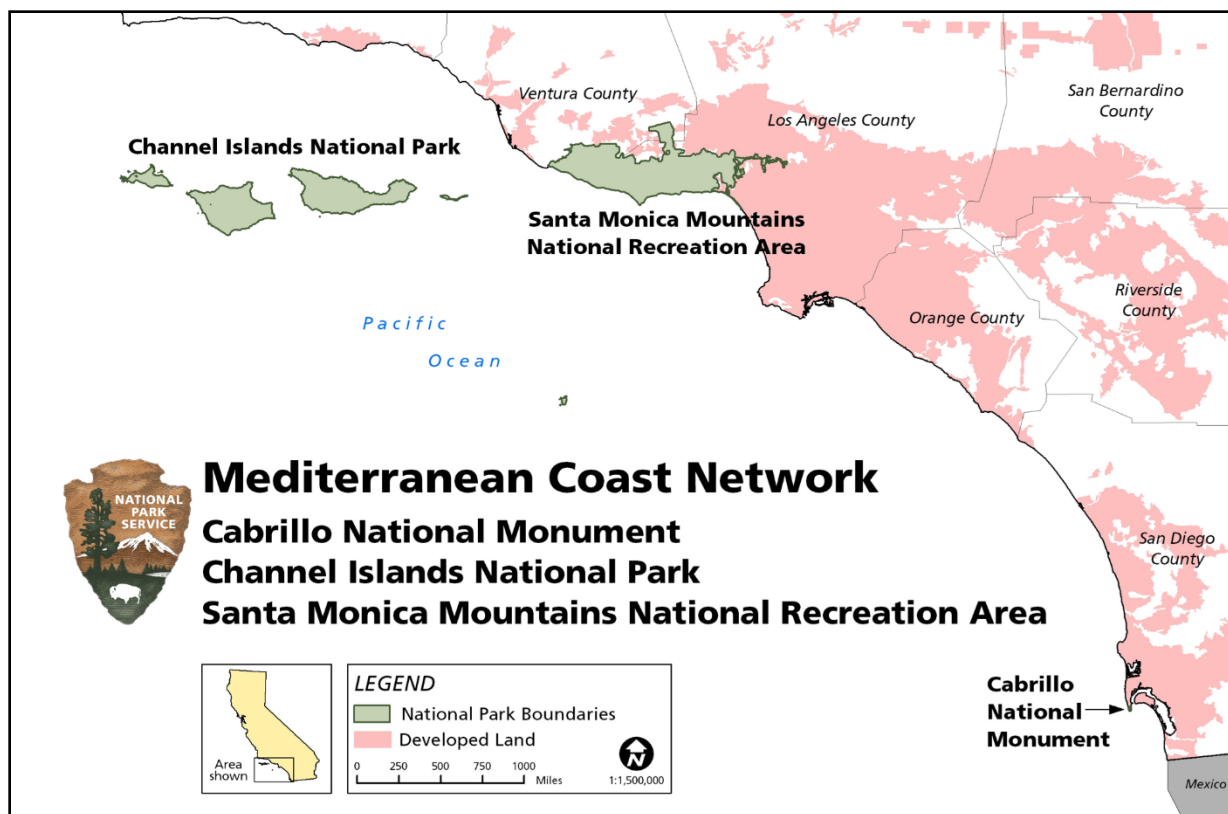


Figure 1. Map of Mediterranean Coast Network parks.

1.1.2 Parks Included in This Protocol Implementation Plan

Within SAMO and CHIS there are numerous ephemeral, intermittent and perennial streams. While CABR contains ephemeral stream channels, biological surveys at CABR have found no resident organisms that require freshwater aquatic habitat for any of their life stages. Because of its lack of freshwater habitat resources, CABR is not included in this monitoring protocol. This protocol addresses surface fresh water resources in SAMO and CHIS.

1.1.3 Rationale for Monitoring Stream Condition using Benthic Invertebrates (Water Quality and Riverine Integrity)

The MEDN Vital Signs Monitoring Plan (Cameron et al. 2005) documented a comprehensive effort to identify, prioritize, select, develop protocols for and monitor vital signs of ecosystem condition at network parks. Freshwater monitoring was identified as a vital sign for CHIS and SAMO. Biological indicators, such as benthic invertebrates, are an effective way to measure stream health (Harrison et al. 2004). They have diverse life histories that make them sensitive to a variety of stressors and can integrate responses over space and time in a way that traditional measures of stream health (e.g., water chemistry) cannot. Furthermore, they provide direct measures of the biological resources that the parks need to manage.

1.1.4 Protocol Implementation Plan Development Process

Our goal was to develop a technically sound, cost-effective monitoring protocol that complemented data collected by other agencies in southern California and therefore supported data sharing with

regional programs. Protocol development involved extensive document review, research, and stakeholder coordination. This included review of MEDN I&M documents, the previous draft freshwater quality monitoring protocol (Hibbs et al. 2011a), water resources inventories, previous studies conducted to support protocol development (Williams 2004), and recent water quality monitoring protocols developed for other networks (Rawhouser et al. 2012). Research was conducted to identify other MEDN water quality stakeholders and regulators, understand what water quality monitoring was/is being conducted by others and the results, determine the current regulatory status of MEDN streams and NPS responsibilities under those regulations, understand the trajectory of State and local monitoring approaches and emerging issues, and determine the costs associated with various monitoring activities. Stakeholder coordination involved regular meetings with MEDN I&M Program staff and park staff to understand current priorities, provide data updates, and get input and buy-in for direction. Numerous meetings were also held with other local stakeholders to discuss the potential for collaborations and data sharing. Given the substantial changes to the scope, objectives and methodology of the newly developed monitoring plan compared to the previous draft (Hibbs et al. 2011a), we developed a new approach rather than revising the existing draft protocol. We did however retain portions of the introduction and literature review from the Hibbs et al. (2011a) draft protocol.

MEDN parks are located within a well-documented, long-term monitoring program coordinated by the Southern California Coastal Water Research Program (SCCWRP). Because the SCCWRP program addresses our monitoring objectives and allows our findings to be placed in a regional context, we chose to develop a Protocol Implementation Plan (PIP) that adopts the bioassessment protocols designed by the California Surface Water Ambient Monitoring Program (SWAMP; Ode 2007). These monitoring approaches are California State standards, considered best practice, and have been used at thousands of monitoring locations throughout the state including Southern California.

To expedite protocol development, I&M networks have the option of formally adopting and implementing peer-reviewed protocols approved by other networks within NPS, or in use by other agencies. Networks may now submit a Protocol Implementation Plan (PIP) to their regional program manager for approval in lieu of a full traditional protocol. This option is not intended to reduce the scientific rigor of the monitoring methods used by the Inventory and Monitoring Division (IMD)—rather to leverage the efforts of partners internal and external to IMD and to encourage consistency of methods and data across networks and between NPS and partner agencies. A PIP is a relatively short document that describes how a published “source” protocol will be used to meet one or more monitoring objectives for an I&M Network. The purpose of the PIP and associated review process is to provide the information justifying—and make the determination—that planned deviations on the whole do not constitute a major departure from the source protocol and that the use of the protocol is appropriate for the stated monitoring objectives. A PIP is not intended to be an exhaustive scholarly document, but rather a high-level summary of how the source protocol will be implemented by the Network within the framework outlined in Oakley et al. (2003).

1.2 Study Area

The following is an overview of the geography, climate and freshwater resources at SAMO and CHIS.

1.2.1 Geographic Setting

Santa Monica Mountains National Recreation Area (62,593 ha) is a complex matrix of private and public lands (Figure 2). NPS owns only 15% of the property within the recreation area, although approximately 53% of the national recreation area is protected as parkland or other publicly owned land. The remaining 47% is privately owned. Given the pattern of diffusely intermixed private and public land ownership, NPS coordinates management activities with other landowners to best meet the conservation and preservation mandates of the multiple agencies responsible for land management within the recreation area.

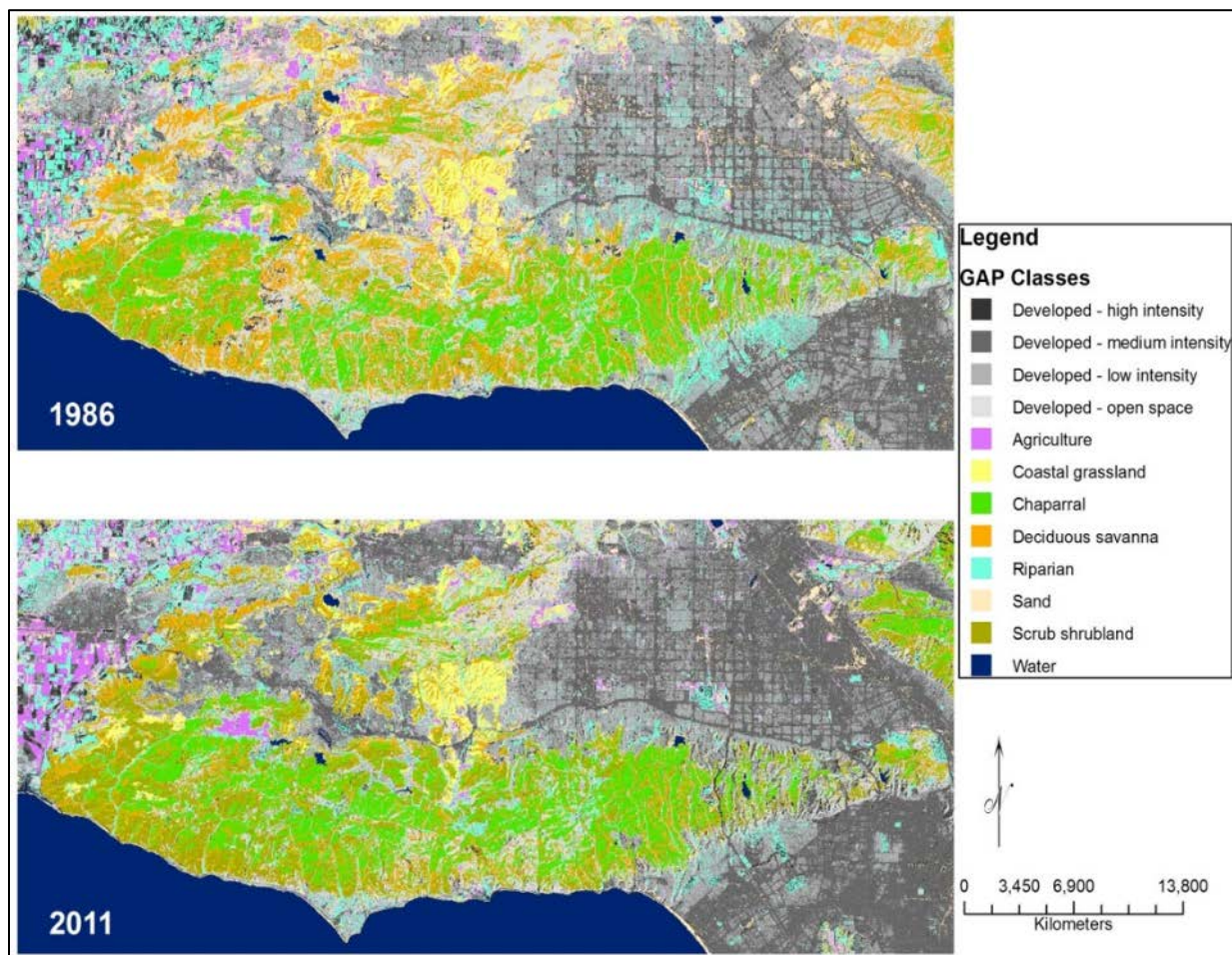


Figure 2. Maps showing land use and vegetation types at Santa Monica Mountains NRA in 1986 and 2011.

Land uses within and surrounding the Santa Monica Mountains can have significant influences on protected lands inside the boundaries of the park. With this in mind, the Santa Monica Mountains Ecological Management Zone (EMZ), which includes additional areas surrounding the NRA, has

been identified as an area of significant ecological and management interest. Within the EMZ, local, state, and national park managers operate to coordinate management activities to best meet the NPS mandate to maintain the natural resources for future generations. The larger EMZ is the study area for stream condition monitoring at SAMO. Note: in earlier SAMO documents, including the aquatic amphibian monitoring protocol (Delaney et al. 2011), this boundary was called the Resource Management Zone, abbreviated as RMZ. The two terms are synonymous.

Channel Islands National Park (CHIS) comprises five of the eight California Channel islands – Santa Barbara Island (SBI), Anacapa Island (ANI), Santa Cruz Island (SCI), Santa Rosa Island (SRI), and San Miguel Island (SMI) – off the coast of southern California (Figure 3), with a total land area of 51,012 ha. Because of its isolation, CHIS has a relatively low visitation rate. However, the islands have a long history of intensive ranching and farming that began in the 1800s. Intensive grazing of the islands by large herbivores such as thousands of cattle and sheep have caused profound changes to the islands' native plant communities and ecosystems (Barbour et al. 2007).



Figure 3. Map of Channel Islands National Park.

Given the limited I&M resources, we focused stream condition monitoring at CHIS on Santa Rosa Island for the following reasons:

- Santa Rosa Island has more abundant freshwater habitats that are owned and managed by the NPS than other islands within CHIS. While Santa Cruz has a comparable stream network to Santa Rosa, only ~25% of that island is under NPS jurisdiction. Streams on San Miguel Island are far less extensive than those on Santa Rosa. Anacapa and Santa Barbara islands are not known to harbor freshwater habitats or resident freshwater-dependent organisms.

- Focusing on a single island will serve to reduce costs associated with travel and transportation time, and maximize the number of sites that can be monitored.
- Monitoring aquatic resources on island settings comes with challenges that may require adaptation of the monitoring protocol. Focusing on a single island allows us to identify and respond to these challenges before expanding the program to all of CHIS (pending additional funding).

1.2.2 Geology

SAMO

The Santa Monica Mountains are the southern-most mountain chain in the east-west trending Transverse Ranges of southern California. Numerous faults, folds, down warps, and a complex geologic structure characterize this area. The mountains are a complex assemblage of marine and non-marine deposition. The western end of the mountains is igneous in origin shifting to a largely sedimentary base in the east. Due to a combination of steep unstable slopes and poorly cemented sedimentary bedrock, the Santa Monica Mountains are prone to landslides. The shrink-swell behavior and erosivity of soils throughout the mountains are important concerns. Soil erosion typically results from concentrated runoff on unprotected slopes or along unlined streambeds. Debris flows occur with some regularity where sufficient sediment mixes with water flow to form a thick slurry of water, soil, and rock (Cameron et al. 2005).

CHIS

The geology of the California Channel Islands is similar to that of the Santa Monica Mountains. The northern Channel Islands occur along the seaward extension of the mainland transverse mountains that have been separated from the mainland since the late- to mid-Pleistocene by the Santa Barbara Channel. The islands represent emergent portions of a complex system of submarine canyons and ridges. During the time of probable minimum sea levels about 17-18,000 years ago, the four present-day northern Channel Islands were all part of one large landmass, referred to as “Santarosae” (Porcasi et al. 1999). The Channel Islands exhibit extensive marine terracing formed as changing sea levels and rising islands caused shorelines to recede. The larger islands are topographically diverse with sea caves, rugged shorelines, sandy beaches, mountain peaks, and valleys. Eolian landforms with active dunes are also present (Cameron et al. 2005).

Santa Rosa Island is mainly composed of sedimentary rocks overlain by Pleistocene marine terrace deposits, which largely cover the island except where they have been eroded. A major fault, the Santa Rosa fault, trends eastward across the island, producing distinct difference in topography between the northern and southern parts of the island. The northern half of the island has broad, flat terraces into which streams have cut deep canyons. South of the Santa Rosa fault, the land is higher and more rugged. The highest point, Soledad Peak, at 508 m (1574 ft), lies on the ridge that follows the trend of the fault.

1.2.3 Climate

The Mediterranean climate of the southern California region is characterized by cool wet winters and warm dry summers (Gasith and Resh 1999). Surface hydrologic systems in southern California are

very flashy. Stream flows rise quickly in response to winter storms, then diminish rapidly when rainfall ceases. Between storm events, emerging groundwater and urban runoff generate relatively small base flows. Base flow discharge is typically subsurface in stream reaches with deep alluvial substrate. Stream channel processes are naturally quite dynamic due to active geologic processes associated with faulting, tectonic uplift, stream erosion, and coastal erosion.

Spring and summer coastal fog is an important climatic element, particularly in the Channel Islands, and along the south-facing coastal slopes of the Santa Monica Mountains (Fisher and Still 2007). Accumulation of moisture on vegetation results in fog drip precipitation, which is a significant source of moisture during otherwise dry periods.

1.2.4 Major Watersheds

SAMO

The primary USGS-defined HUC-10 watersheds within the EMZ (Figure 4) include: Calleguas Creek, Malibu Creek, Big Sycamore Canyon – Frontal Santa Monica Bay (consisting of numerous small separate coastal streams), Garapito Creek – Frontal Santa Monica Bay (consisting of numerous small separate coastal streams), and Ballona Creek.

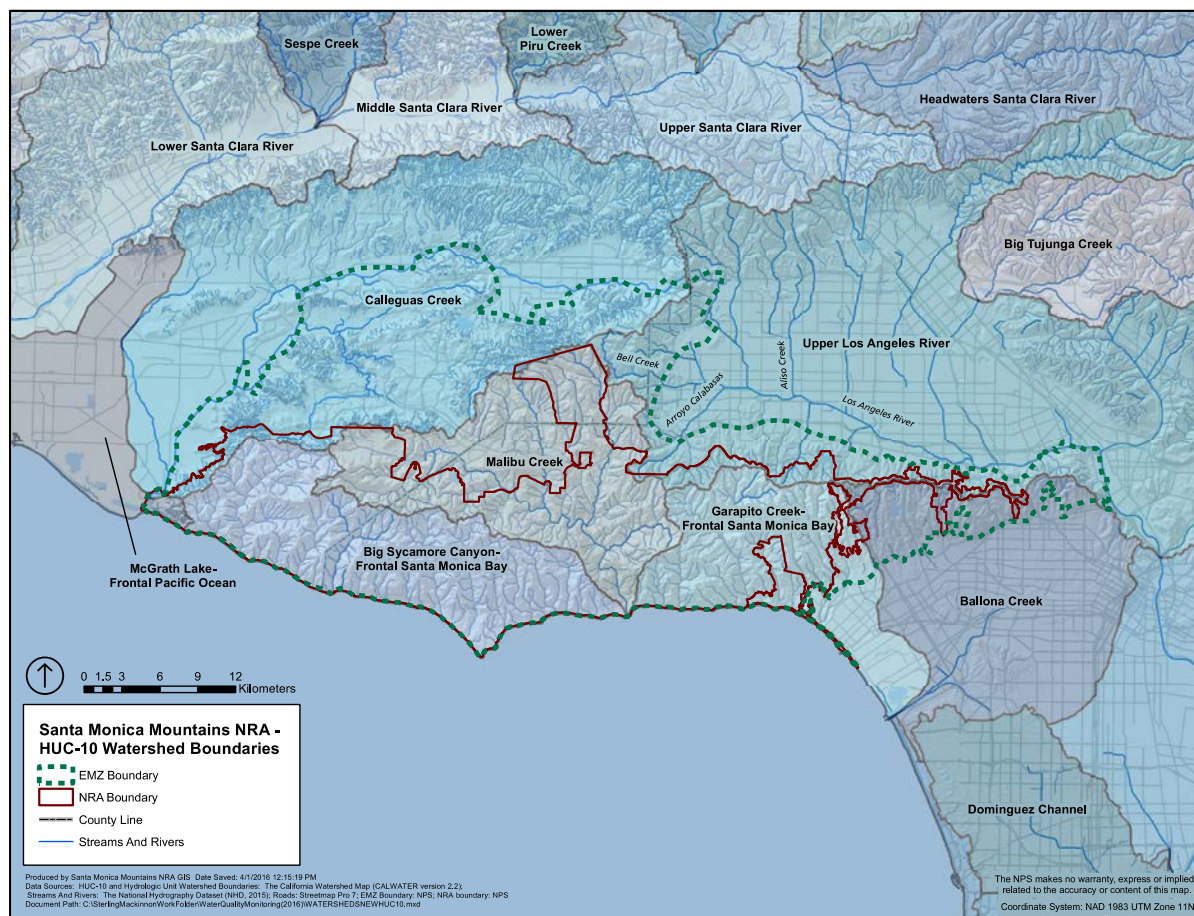


Figure 4. Map of Santa Monica Mountains NRA watersheds (HUC-10).

Aquatic resources within the SAMO EMZ are very diverse and include over 50 coastal streams with coastal outlets, upper watershed streams, and lakes and reservoirs (Williams 2004). The largest watershed within SAMO is the Malibu Creek Watershed (Figure 5), which incorporates 105 mi² and several major drainage basins (Medea Creek, Triunfo Creek, Cold Creek, Malibu Creek, and Sleeper, Las Virgenes, and Potrero valleys). Figure 6 shows the many coastal streams within SAMO.

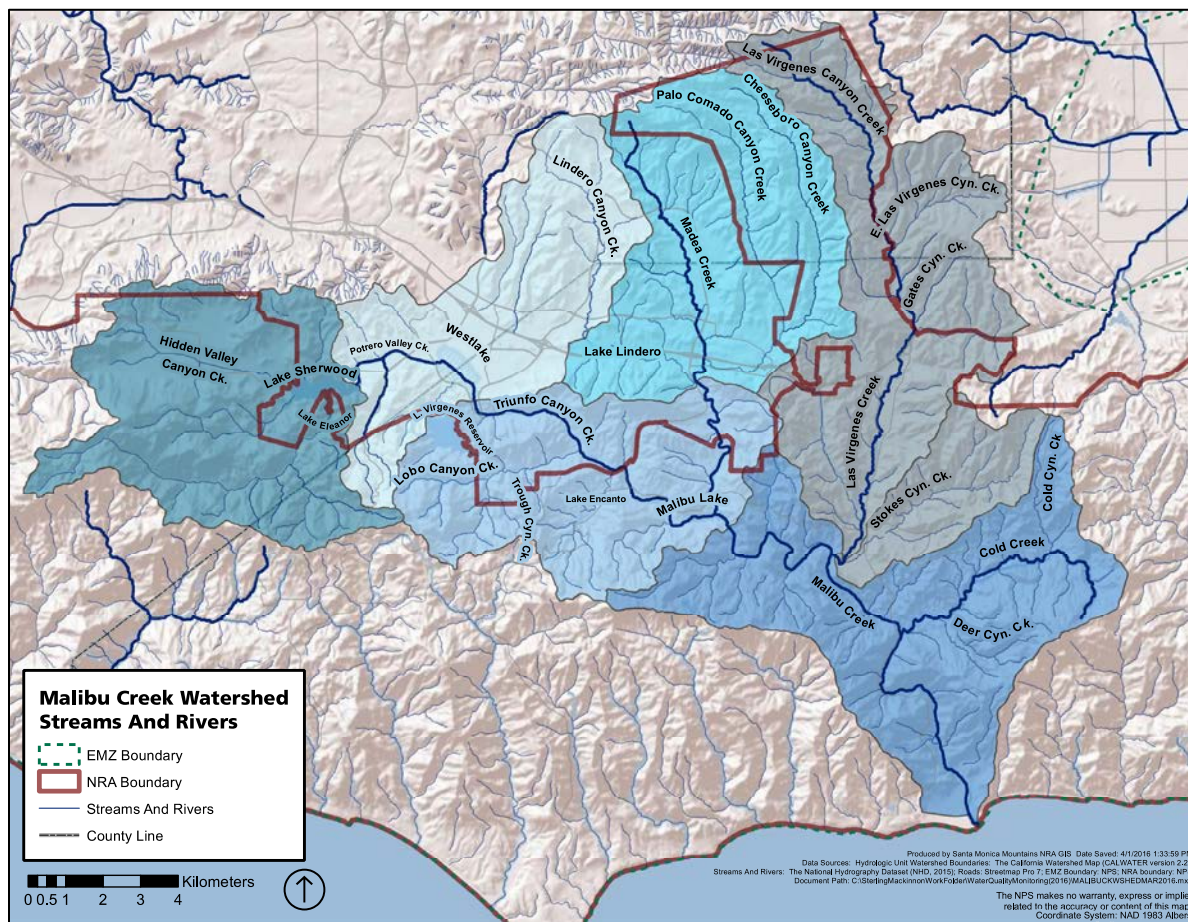


Figure 5. Malibu Creek watersheds and streams within Santa Monica Mountains NRA.

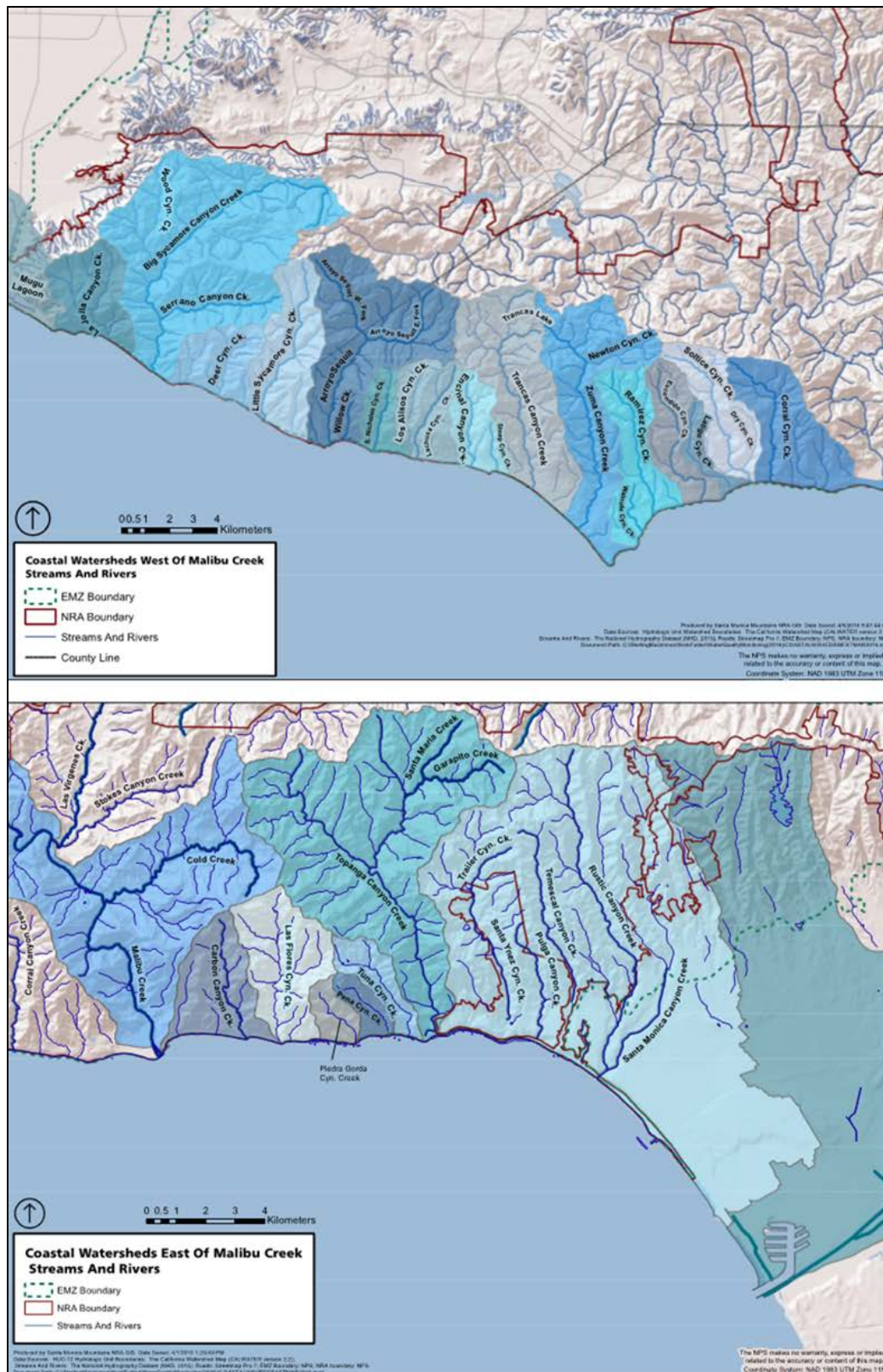


Figure 6. Coastal streams (top) west and (bottom) east of Malibu Creek within Santa Monica Mountains NRA.

CHIS

A comprehensive report by Engle (2006) contains a detailed listing of the freshwater resources on CHIS; the following excerpts provide an overview:

“Freshwater resources in the Park include seasonal and permanent streams, riparian corridors, coastal lagoons or wetlands at the mouths of several canyons, coastal seeps, and vernal pools... Santa Barbara and Anacapa have no streams or other freshwater bodies. The freshwater features of Santa Rosa Island include streams, creeks, or washes in numerous canyons on the island [...]. The major drainages originate from a single central highland, producing long stream lengths and many fourth order stream segments (Mertes et al. 1998). [...]”

Figure 7 illustrates the major streams and watershed on Santa Rosa Island. As discussed below, SRI will be the focus of this monitoring protocol at Channel Islands National Park.

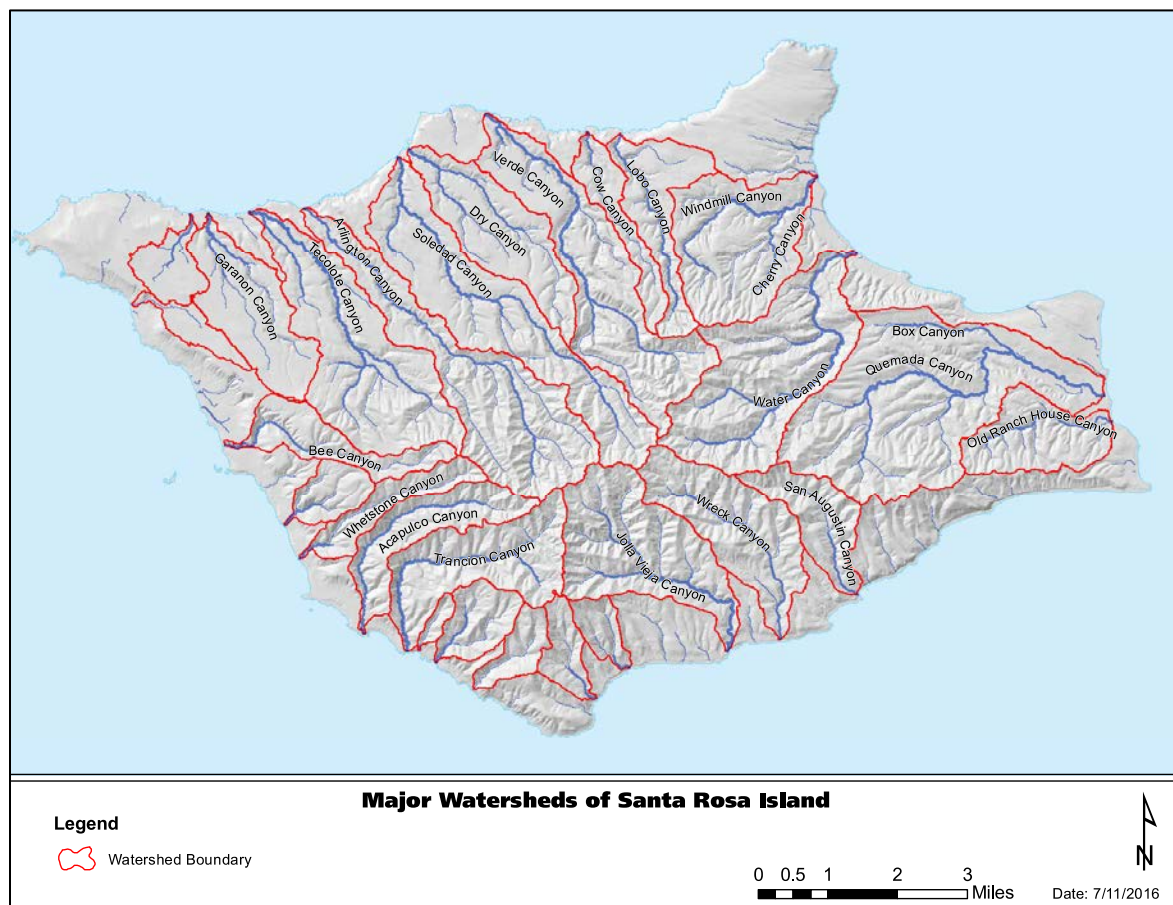


Figure 7. Major streams and watersheds on Santa Rosa Island (SRI).

1.2.5 Land Use and Stream Conditions

SAMO

Terrain throughout SAMO includes coastal plains, coastal mountains, deeply-incised canyons, and inland valleys. Watershed conditions vary from relatively undisturbed to those with significant urban

development. Large areas of wildland are protected as State Park and National Park open space. The communities of Calabasas, Agoura Hills, Newbury Park, Malibu, and Thousand Oaks are largely or completely within the boundary of the Santa Monica Mountains NRA. Land use within SAMO and the larger EMZ includes agricultural, commercial, residential, natural open space (in public and private ownership), and state designated wilderness areas (Figure 2); these areas are connected through an extensive network of roads, highways and freeways.

Inputs to watersheds include local precipitation, groundwater base flow, runoff of imported water, and treated municipal wastewater derived from imported water. It is important to note that Tapia Water Reclamation Facility is permitted to discharge tertiary treated effluent into the Malibu Creek watershed between November 16th and April 14th of each year. There are also discharge prohibition exemptions for treatment plant upset or operational emergencies, qualifying storm events, and maintaining minimal streamflow for endangered steelhead trout. In order to achieve compliance with the permit's new winter waste load allocations, the Las Virgenes – Triunfo Joint Powers Authority will be constructing an advanced water treatment facility for indirect potable reuse. The Las Virgenes – Triunfo Pure Water Project will take surplus recycled water and process it through an advanced treatment facility and then store it in Las Virgenes Reservoir for later use as drinking water. The National Pollutant Discharge Elimination System permit compliance schedule includes facility start-up in 2030 (Personal Communication, Jan Dougall, Las Virgenes Municipal Water District).

In recent years, some of the historically intermittent streams have become perennial (National Parks Conservation Association 2008). Although this uncharacteristic continuous flow has at times been attributed to urban runoff, Hibbs et al. (2011b) used stable isotope analysis to determine that a combination of channelization, removal of riparian vegetation and recharge of imported water more likely account for the transition from intermittent to perennial flows.

Recent and continuing anthropogenic watershed alterations increase the complexity of the natural hydrologic systems. Impervious surfaces such as pavement and rooftops significantly reduce infiltration and increase storm runoff, accelerate the delivery of pollutants (e.g., VOCs, metals, pesticides, nutrients, fine sediments) to waterways, alter natural stream-flow patterns, and increase channel bed and bank erosion (Stein et al. 2012). Streambeds and stream banks have also been directly altered by channelization and dam construction (Cameron et al. 2005).

CHIS

The history of humans on Santa Rosa Island dates back thousands of years, but the ranching era that occurred in the most recent ~150 years has had the most impact on freshwater resources. Human use of the Channel Islands is detailed by Engle (2006). Non-native species introduced for these purposes include cattle, sheep, elk, mule deer, and feral pigs. These species were gradually removed from the islands starting in the 1990s and as of 2015 all known feral animals had been removed from the islands. Engle (2006) described the impacts from non-native species:

Riparian corridors in the Park were substantially altered... On Santa Rosa, cattle grazing on uplands and extensive use of streams by cattle, elk and deer transformed streams into sediment-

choked, braided channels with unvegetated banks (Wagner et al. 2004). The native woody species and perennial herbaceous riparian wetland species - that would ordinarily stabilize the banks, shade the streams, trap the sediment accompanying winter runoff, and dissipate the energy of storm flows - were practically eliminated. Natural riparian vegetation was relegated to portions of canyons too steep for livestock, elk or deer.

In contrast to SAMO, water imports, wastewater discharges, and artificial impervious surfaces are negligible on SRI.

1.2.6 Aquatic Species

SAMO

Streams in the Santa Monica Mountains support three of the four southern-most existing populations of steelhead trout (*Oncorhynchus mykiss*) on the Pacific coast (Cameron et al. 2005). Native aquatic amphibian species in the Santa Monica Mountains include California newts (*Taricha torosa*, TATO), Baja California treefrogs (*Pseudacris hypochondriaca hypochondriaca*, formerly *Hyla regilla*, HYRE), California treefrogs (*P. cadaverina*, formerly *H. cadaverina*, HYCA), western toads (*Bufo boreas*, BUBO), and red-legged frogs (*Rana draytonii*; Appendix A). Red-legged frogs, formerly common in a number of streams in the region (De Lisle et al. 1987), were extirpated from the Santa Monica Mountains in the mid-20th century. In 1999, an extant population was discovered and park staff initiated a translocation program to establish new populations throughout the park.

Exotic aquatic species within the Santa Monica Mountains include red swamp crayfish (*Procambarus clarkii*) from the southeastern United States, bullfrogs (*Lithobates catesbeiana*), and a number of fish species including bass (*Micropterus* spp.), bluegill (*Lepomis macrochirus*), and mosquitofish (*Gambusia affinis*). In addition, invasive New Zealand mudsnails (*Potamopyrgus antipodarum*) have recently been found in many streams of the Santa Monica Mountains and surrounding areas (Cameron et al. 2005). All of these species depend on access to perennial water to complete their life cycle, and are generally not found in intermittent streams.

Water quality, in particular the amount of contaminants and pesticides, has been suggested as a possible cause of world-wide amphibian decline (Blaustein and Wake 1990, Cameron et al. 2005, Westman et al. 2010). Given the importance of aquatic amphibians at SAMO and their threatened status locally and worldwide, stream condition monitoring sites will be co-located with the MEDN I&M Aquatic Amphibian and Invasive Species Protocol monitoring sites (Delaney et al. 2011). A summary of the amphibian and invasive species monitoring protocol is provided in Section 1.2.8, below. Stream condition monitoring will be conducted (nearly simultaneously) at a subset of the Amphibian monitoring sites as explained in more detail below.

CHIS

Table 1 displays the native amphibians at CHIS, which include the black-bellied slender salamander (*Batrachoseps nigriventris*), Channel Islands slender salamander (*B. pacificus pacificus*), and Baja California treefrog (*Pseudacris hypochondriaca hypochondriaca*). The Channel Islands slender salamander is endemic to the Channel Islands and is a Federal Species of Special Concern. Aquatic

invasive fauna are not known on Santa Rosa Island. Amphibians on SRI include the Channel Islands slender salamander and the Baja California tree frog.

Table 1. Amphibian species of Channel Islands National Park.*

Common Name	Scientific Name	SB	AN	SC	SR	SM
Blackbelly slender salamander	<i>Batrachoseps nigriventris</i>	–	–	X	–	–
Channel Islands slender salamander	<i>B. pacificus</i>	–	X	X	X	X
Baja California tree frog	<i>Pseudacris hypochondriaca</i>	–	–	X	X	–

* Island codes are SB = Santa Barbara Island, AN = Anacapa Island, SC = Santa Cruz Island, SR = Santa Rosa Island, SM = San Miguel Island

1.2.7 Regulatory Status / Impaired Waterbodies

SAMO

Regulatory considerations for this protocol were assessed using two evaluation methods:

- First, a review was conducted of Total Maximum Daily Loads (TMDLs) that are either in effect, in progress or draft, to determine if NPS is named as a responsible party and if so, what expected actions were identified. Note that most TMDLs are adopted as amendments to the Basin Plan (LARWQCB 1994) and implemented by the Regional Water Quality Control Board (Regional Board) through permits. The Regional Board issues National Pollutant Discharge Elimination System (NPDES) permits to point sources, and Waste Discharge Permits to non-point sources. However, NPS is not a point source and has not been issued a Waste Discharge Permit.
- Second, data was obtained from the State and Regional Water Resources Control Boards on impaired streams. These are streams that do not meet the water quality objectives established for their beneficial uses. A GIS layer was downloaded from the Regional Board website (http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/303d_list.shtml) of the impaired waterbodies as of the 2016 listing (the most current version available as of the analysis). This layer was then evaluated against the location of all NPS-owned properties within the NRA. Areas were identified where significant NPS-owned properties were within watersheds immediately tributary to the impaired waterbody. Using this second method, potential NPS involvement in TMDLs that have not yet been developed was evaluated.

The assessment found no monitoring requirements for SAMO that need to be addressed as part of this water quality monitoring protocol (see Appendix A for maps and additional details). NPS was named in only two adopted TMDLs, both related to trash monitoring, which SAMO is addressing through a park-funded maintenance effort. Based on the assessment, it appears unlikely that NPS would be named in future TMDLs related to other impairments; however, because of the continuously evolving nature of the 303(d) listing and TMDL development process, this protocol will include an annual status review and evaluation of SAMO responsibilities.

CHIS

There are no CHIS streams on the 303(d) list of impaired waterbodies. Future listings are not anticipated, since the removal of non-native fauna has been completed and there are very limited human activities on the islands.

A Cleanup or Abatement Order (No. 95-064) (CAO) was issued by the Central Coast Regional Water Quality Control Board in August 1995 for activities associated with grazing and road management practices on Santa Rosa Island. The CAO required improved management actions, monitoring, and reporting. A water quality assessment was conducted from 1993-1998 on the Island. A follow-up study was conducted in 2002 after cattle were removed from the island. In December 2015, the CAO was lifted (personal comm. w/K. Faulkner, Dec 2015).

1.2.8 Summary of Current and Historic Monitoring at SAMO and CHIS

SAMO

Table 2 summarizes the major stream monitoring activities currently and previously conducted at SAMO (or within the EMZ). Further details are provided in Section 2 of Appendix A.

Table 2. Summary of major stream monitoring currently and previously conducted at SAMO.

Study / Report Name	Data Collected	Years
1. NPS Baseline Water Quality Data Inventory & Analysis Report (1996)	Historic water chemistry (summary only, no new data)	1951 - 1991
2. MEDN Water Quality Monitoring Protocol (unpublished draft)	Water chemistry. Results summarized in UCLA report (Chan et al. 2013).	2006-2011
3. MEDN Aquatic Amphibian Monitoring Protocol (Delaney, et al. 2011)	Presence and relative abundance of native aquatic amphibians and presence of non-native species (e.g. fish, crayfish, New Zealand mudsnails)	Ongoing since 2006 under this protocol. Also, a 5-yr inventory was conducted from 2000-2004 at targeted locations in coordination with Pepperdine and RCD SMM.
4. Las Virgenes Municipal Water District Monitoring Program. Results from this program and others summarized by LCMWD in the Malibu Creek Comprehensive Report (LVMWD 2011).	Water chemistry.	Ongoing monitoring. Report includes data through 2010.
5. Southern California Stormwater Monitoring Coalition (SMC), led by Southern California Coastal Water Research Project (SCCWRP).	BMI, PHAB, CRAM, water chemistry and toxicity testing. Throughout southern CA. Uses a probabilistic sampling design.	Ongoing since 2009.
6. Other SCCWRP studies, including TR500-Natural Loadings (Stein et al. 2007) and TR510 – Sources, Patterns and Mechanisms of Storm Water Pollutant Loading from Watersheds and Land Uses of the Greater Los Angeles Area (Stein and Yoon 2007)	Stormwater and in-stream chemistry	Approx. 2004-2006.

Table 2 (continued). Summary of major stream monitoring currently and previously conducted at SAMO.

Study / Report Name	Data Collected	Years
7. County and City Regulatory Monitoring	Water chemistry and bacteria, per MS4 permit requirements.	Ongoing. Locations may change as part of Enhanced Watershed Monitoring coordinated stakeholder efforts.
8. Heal the Bay Monitoring Program. Results from this program are summarized in the report Malibu Creek Watershed, Ecosystem on the Brink (2013)	Water chemistry and bioassessment	Ongoing. Report summarizes data from 2000-2012.
9. USGS monitoring – historical, project specific.	Water quality data and aquatic amphibians.	Various.
10. Red-legged frog water chemistry monitoring	Total trace metals in freshwater samples and pyrethroids in sediment samples.	May, 2013
11. Resource Conservation District of the Santa Monica Mountains (Rosie Dagit)	Aquatic amphibian monitoring, water chemistry, some BMI; primarily in Topanga Canyon	2010-present
12. Pepperdine University (Lee Kats)	Aquatic amphibian monitoring and water chemistry (field parameters only), in Arroyo Sequit, Trancas and Zuma Canyons, Cold Creek, Triunfo and Tuna Canon.	Ongoing since 1994
13. Los Angeles Regional Water Quality Control Board ambient assessments.	BMI, PHAB, CRAM, and water chemistry. Throughout southern CA. Uses a probabilistic sampling design.	2008, conducted in anticipation of the SMC program (#5 above)

CHIS

There are no current monitoring programs related to water quality at CHIS other than the monitoring described in this document. Table 3 summarizes previous stream monitoring activities conducted on the islands. Further details are provided in Section 3 of Appendix B.

Table 3. Summary of past stream monitoring at CHIS.

Study / Report Name	Islands	Data Collected	Years
1. NPS Baseline Water Quality Data Inventory & Analysis Report	Santa Rosa and Santa Cruz	Historic water chemistry (summary only, no new data)	Up to 1994
2. Federal Interagency Riparian Assessments – Proper Functioning Condition	Santa Rosa	Riparian condition assessments	1995 and 2004
3. Melack and Cooper Report, 2008	Santa Rosa	Water chemistry and BMI	2005-2007
4. Quemada Creek Morphology Monitoring	Santa Rosa	Channel x-section surveys	1999 and 2002
5. Quemada Creek Stream Condition Inventory	Santa Rosa	Stream Condition Inventory (SCI)	1998

Table 3 (continued). Summary of past stream monitoring at CHIS.

Study / Report Name	Islands	Data Collected	Years
6. Vegetation Monitoring – Quemada Creek	Santa Rosa	In-stream and riparian veg	1998 and 2002
7. Survey to map the presence/absence of water	Santa Rosa	Presence and absence of water	2014
8. Geomorphology - Quemada Creek	Santa Rosa	Channel x-section surveys	2014-2015

1.2.9 Aquatic Amphibian Monitoring at SAMO

As discussed further in the Objectives Section 1.3 below, the stream condition monitoring program at SAMO is designed to support (and be closely coordinated with) the aquatic amphibian monitoring. The following is a brief overview of the amphibian monitoring program at SAMO from Delaney et al. (2011); further details are provided below in Section 2.0 Sampling Design.

A five year inventory of aquatic amphibians was conducted at SAMO from 2000-2004 using a targeted sampling design. Since 2006, monitoring has been conducted under the current MEDN I&M protocol (Delaney et al. 2011) which retained 10 of the sites used in the 5-year inventory (now referred to as sentinel sites and visited annually), and added 36 randomly-selected sites of which 12 are visited each year over a 3-year rotation. Other sites from the 5-year inventory continue to be monitored by other organizations within the Santa Monica Mountains, namely Pepperdine University and the Resource Conservation District of the Santa Monica Mountains (RCD).

*The 36 random sites in the current protocol were selected using a generalized random tessellated stratified (GRTS) method (Stevens and Olsen 1999, 2003, 2004). The aquatic amphibian monitoring protocol collects data on native amphibians and invasive species. Native species include: California newts (*Taricha torosa*), Pacific treefrogs (*Pseudacris regilla*, formerly *Hyla regilla*), California treefrogs (*P. cadaverina*, formerly *H. cadaverina*), western toads (*Bufo boreas*), and red-legged frogs (*Rana draytonii*). Exotic aquatic species include red swamp crayfish (*Procambarus clarkia*), bullfrogs (*Rana catesbeiana*), invasive New Zealand mudsnails (*Potamopyrgus antipodarum*), and a number of fish species including bass (*Micropterus* spp.), bluegill (*Lepomis macrochirus*), and mosquitofish (*Gambusia affinis*).*

1.2.10 Summary of Monitoring Drivers

Table 4 summarizes the park context, stream regulatory status, and management concerns that drive the management questions and objectives for this monitoring protocol.

Table 4. Summary of key drivers for stream monitoring at SAMO and CHIS.

Element	Santa Monica Mountains National Recreation Area (SAMO)	Channel Islands National Park (CHIS)
Park context	• Matrix of NPS, State Parks and other conserved lands, and private property within major municipal centers • Intersected by an extensive system of roads and major highways • Extensive anthropogenic influences	• Remote; very little human occupancy • Few anthropogenic influences now that non-native animals have been removed
Regulatory status	• Over 35 stream segments within the park are on the 303d list of impaired waterways for multiple pollutants and/or conditions.	• No streams on 303d list of impaired waterways.
Management concerns	• Link to existing long-term aquatic amphibian monitoring • Multi-metric approach to characterize range of stressors, conditions, responses • Leveraging work by other stakeholders to maximize cost effectiveness	• Hydrologic, structural, and biotic recovery of the island's streams
Complementary monitoring	• Amphibian monitoring at 36 randomly-selected sites within SAMO, along with in-situ water quality measurements. • Regional stakeholders conduct targeted monitoring throughout the SMMs, and a broad coalition of municipalities belong to the Stormwater Monitoring Coalition, which has just finished 5 years of bioassessment, water chemistry and wetland function monitoring at randomly selected sites in SoCA, including many within SAMO.	• Targeted monitoring only; no broad assessment of stream condition has been conducted

1.3 Objectives

1.3.1 Management Questions

This protocol implementation plan outlines a monitoring program that will address four primary management questions faced by park managers. These questions fall into two categories: the regulatory status of surface waters at SAMO, and assessment of ecosystem condition and trend in streams at SAMO and CHIS. Regulatory status is defined as the listing status of each waterbody as impaired or unimpaired, as assessed under section 303(d) of the CWA.

The overarching programmatic goal of the MEDN I&M Program is to obtain information that will aid in the assessment, conservation, and restoration of surface water resources. The management questions below are the overarching questions faced by park managers. The measurable objectives are the information that the monitoring program can provide to help address these issues.

1. What is the regulatory status of SAMO streams under section 303(d) of the Clean Water Act? Do changes in listing status indicate improving or declining water quality?
2. What is the status of and what are the trends in the overall health of the streams in SAMO and CHIS?

3. What is the relationship between aquatic amphibian presence/abundance and stream health at SAMO and CHIS?
4. How is stream health at CHIS changing over time from the point of eradication of non-native fauna and how does it compare to pre-eradication conditions?

1.3.2 Measureable Objectives

In light of the above management questions, this protocol will address the following specific measurable objectives:

1. What is the regulatory status of 303(d)-assessed waters within SAMO? Is the number of listed water bodies or listed water quality parameters changing over time?

The measurable objectives for regulatory issues will be achieved by monitoring the 303(d) listing status and TMDL promulgation related to streams within the SAMO EMZ.

2. What is the status of, and what are the trends in, riverine wetland conditions, macroinvertebrate assemblages, physical habitat conditions and stream water chemistry?

These metrics will be evaluated using thresholds used in Mazor (2015a) to indicate “reference condition” or “degraded conditions” for relevant indicators.

1.3.3 Monitoring Approach

Riverine wetland conditions will be monitored using the California Rapid Assessment Method (CRAM) for wetlands, using the riverine module (California Wetlands Monitoring Workgroup 2013). A riverine wetland consists of the riverine channel and its active floodplain, plus any portions of the adjacent riparian areas that are likely to be strongly linked to the channel and immediate floodplain through bank stabilization and allochthonous organic material (productivity) inputs. Macroinvertebrate assemblages, physical habitat conditions and stream water chemistry will be monitored using the bioassessment protocols designed by the California Surface Water Ambient Monitoring Program (SWAMP) (Ode 2007).

These monitoring approaches are California State standards, considered best practice, and have been used at thousands of monitoring locations throughout the state including Southern California. Further details on each approach are provided later in the narrative and also in the SOPs. Although there may be a few components that we cannot include due to budget limitations (such as algae taxonomy and some water chemistry parameters), for all components that we do include, we will maintain consistency with the established standards, thereby providing for a Statewide and regional context and basis of comparison for MEDN results, as well as ensuring that MEDN results can contribute to this larger data set.

Additional stream chemistry monitoring at SAMO will be conducted through in-situ measurements of the Water Resources Division “core” parameters using a hand-held multi-meter concurrent with the amphibian monitoring protocol.

Monitoring of the listing status and TMDL promulgation for streams within the SAMO EMZ is a desktop activity that will be conducted annually. Details are provided in SOP 6.

2 Sampling Design

The aim of the sampling design is to provide optimal statistical robustness and scientific rigor, given safety, fiscal and logistical constraints, as well as to integrate data with other NPS monitoring programs (e.g., aquatic amphibian monitoring). Below we describe the overall rationale leading to our decisions regarding the sampling domain, sample frame, stratification, site selection procedures and the revisit designs for long-term monitoring. An overview of the monitoring approach is provided in Table 5.

Table 5. Overview of the monitoring approach for stream condition monitoring at MEDN parks.*

Year	CHIS Water Quality Protocol	SAMO Water Quality Protocol	SAMO Aquatic Amphibian Protocol (Delaney et al. 2011)
2016	One time sampling of Melack & Cooper sites	–	In-situ core parameters (all R3 and Sentinel sites)
2017	CRAM & bioassessments (sites 1-15)	–	In-situ core parameters (all R1 and Sentinel sites)
2018	CRAM & bioassessments (sites 16-30)	–	In-situ core parameters (all R2 and Sentinel sites)
2019	–	CRAM and Bioassessments (at 8 R1 sites*)	In-situ core parameters (all R3 and Sentinel sites)
2020	–	CRAM and Bioassessments (at 8 R2 sites*)	In-situ core parameters (all R1 and Sentinel sites)
2021	–	CRAM and Bioassessments (at 8 R3 sites*)	In-situ core parameters (all R2 and Sentinel sites)
2022	CRAM & bioassessments (sites 1-10)	–	In-situ core parameters (all R3 and Sentinel sites)
2023	CRAM & bioassessments (sites 11-20)	–	In-situ core parameters (all R1 and Sentinel sites)
2024	CRAM & bioassessments (sites 21-30)	–	In-situ core parameters (all R2 and Sentinel sites)
2025	–	CRAM and Bioassessments (at 8 R1 sites)	In-situ core parameters (all R3 and Sentinel sites)
2026	–	CRAM and Bioassessments (at 8 R2 sites)	In-situ core parameters (all R1 and Sentinel sites)
2027	–	CRAM and Bioassessments (at 8 R3 sites)	In-situ core parameters (all R2 and Sentinel sites)

*R1, R2, and R3 sites refer to the rotating panel of randomly selected sites at which amphibian monitoring is conducted at SAMO. Each consists of 12 sites, for a total of 36 sites monitored over 3 years. CRAM and Bioassessments will be conducted at 7 of those 12 sites each year. The 3 panels of 7 sites will be determined in the first 3 years of monitoring at SAMO, and will be revisited in subsequent 3 year cycles. Further details are provided in Section 2.0 below.

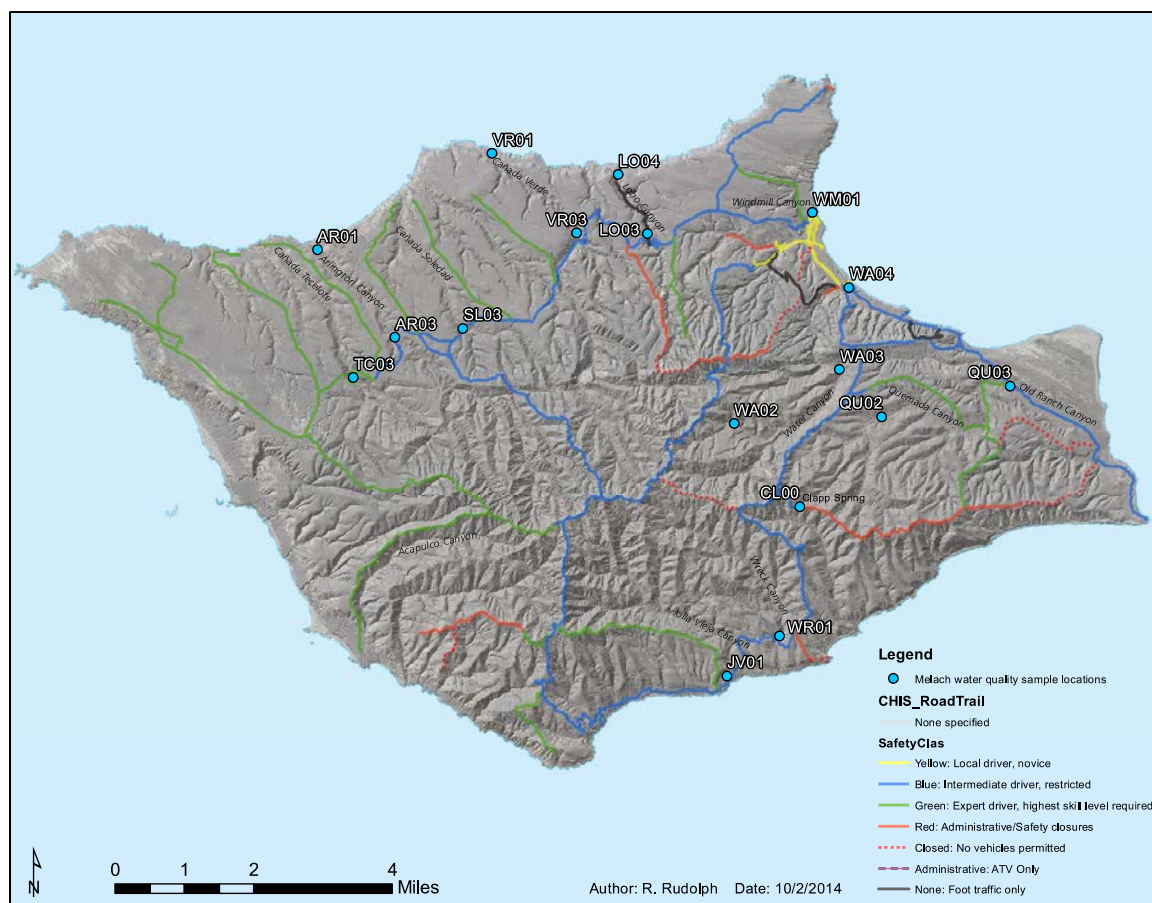
2.1 Rationale for This Monitoring Approach

2.1.1 SAMO

NPS is the only stakeholder that has a program of monitoring aquatic amphibian health across the Santa Monica Mountains. Other stakeholders conducting aquatic amphibian monitoring in the SMM are the Resource Conservation District and Pepperdine University; however, these programs are geographically limited and the sampling locations were not randomly selected. We prioritized stream condition monitoring at a subset of locations coincident with amphibian monitoring in order to understand the relationships between these datasets.

2.1.2 CHIS

As described in Section 1.2.1 above, we focused water quality monitoring on Santa Rosa Island within CHIS. Given the emphasis on understanding the physical recovery process of the island's streams following the removal of non-native animals, a measure of riverine wetland function (CRAM) was selected as the primary metric, with the additional use of a bioassessment metric, amphibian presence/absence monitoring, and limited water chemistry. CRAM is more widely applicable on the islands because water is not necessary at the site. In contrast, the SWAMP bioassessment protocol (which includes sampling benthic macroinvertebrates), cannot be used to assess non-perennial streams during their dry phase. However, there was still a strong interest in understanding benthic community condition. Therefore, CRAM will be conducted during two of the three monitoring years, using a GRTS design to allow inference to the entire island. Bioassessments were conducted at targeted locations in 2015, in order to compare current conditions to those of 2006 (Melack and Cooper 2008), prior to deer and elk eradication from the island (Figure 8). Bioassessments will be conducted at other, probabilistically selected locations once initial information is obtained from the targeted sampling locations.



2.1.3 Regional Coordination

As identified in Table 2, item 5, and further discussed in Appendix A, the Stormwater Monitoring Coalition (SMC), led by Southern California Coastal Water Research Project (SCCWRP), is a group of municipal stakeholders who coordinate their stormwater permit monitoring requirements. The SMC has conducted bioassessment, wetland function and water chemistry monitoring at randomly selected sites (using a GRTS design) across southern California for the past eight years, using the same protocols (CRAM and SWAMP) that we will use through this protocol implementation plan. Sixty-nine of the SMC monitoring sites are located within the SAMO EMZ and these were preliminarily scored in May 2014 by SCCWRP scientists (Figure 9). Scores were based on the California Stream Condition Index (CSCI) (Mazor et al. 2016). The CSCI is based upon comparison to reference site conditions. Figure 8 is a summary graphic of the results, using 5 condition classes based on the probability that that a score represents reference condition (>50%, 30 to 50, 10 to 30, 1 to 10, and <1%). SMC began a second survey (2015-2019), with an emphasis on revisits previously sampled sites to understand trends, as well as a focus on intermittent stream condition.

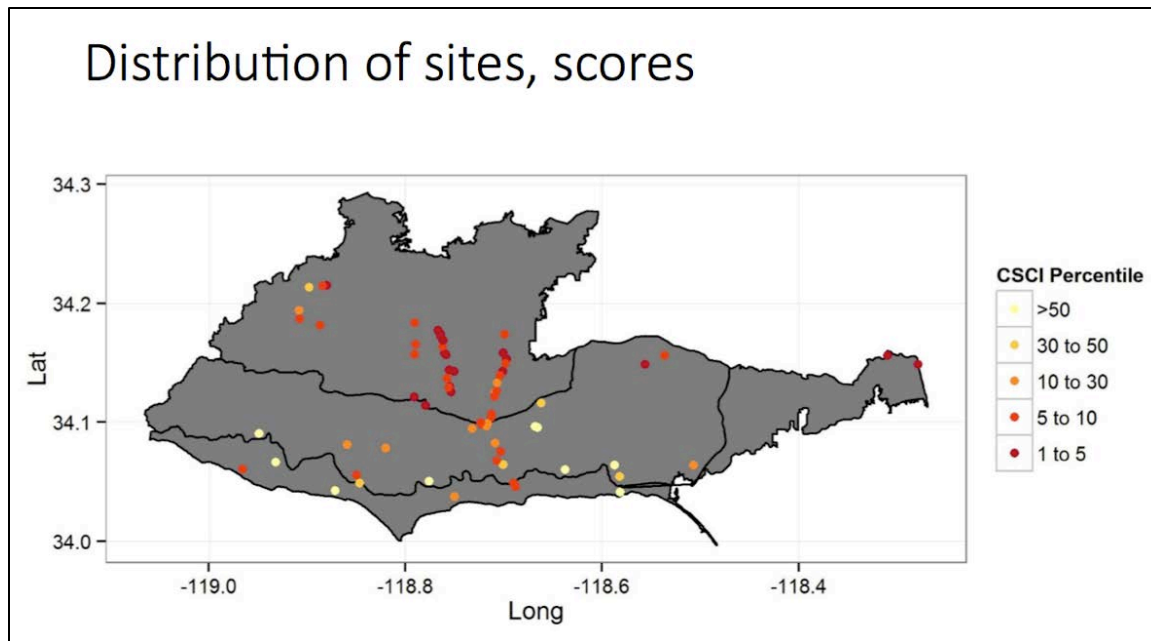


Figure 9. Preliminary California Stream Condition Index (CSCI) percentile scores for the 69 SMC monitoring sites within the Santa Monica Mountains NRA EMZ between 2009-2013.

As part of the water quality monitoring protocol development process, MEDN coordinated closely with SCCWRP to evaluate potential synergies between the SMC program and NPS management objectives. Although there were too many differences in scope, objectives, and planning horizon to realize significant overlap between the two programs, SMC results provide important complementary data that will be tracked and communicated to NPS management as reports become available.

2.2 Sampling Domain

2.2.1 SAMO

While SAMO has a distinct and permanent administrative boundary, approximately 50% of the land within the park is privately owned. Some of this private land within the park boundary is developed, and the park is surrounded by intensive urban development. In addition, many SAMO parklands are adjacent to state and local park lands. The sampling domain for the SAMO aquatic amphibian protocol was therefore selected to be the Santa Monica Mountains Ecological (or Resource) Management Zone, excluding the Eastern Urban section (see next section for further explanation of this exclusion). Similarly, the EMZ (excluding the Eastern Urban Section) will be the target population for this water quality monitoring protocol.

2.2.2 CHIS

The sampling domain is defined as Santa Rosa Island. The rationale for limiting monitoring to this island was described in Section 1.2.1 above.

2.3 Sample Frame

2.3.1 SAMO

To facilitate the co-location of stream condition sampling sites with the ongoing amphibian monitoring at SAMO, we will use the sampling frame described by Delaney et al. (2011) for the aquatic amphibian monitoring program. Briefly, the sampling frame is based on a GIS layer of the stream network within the EMZ, excluding the eastern urban section of SAMO (Figure 10) and cells containing <50% protected parklands, no intermittent or perennially flowing streams, or no safe access. The eastern urban region of the EMZ was eliminated from the sample frame because of access and ownership limitations, small overall size, and its high proportion of development.

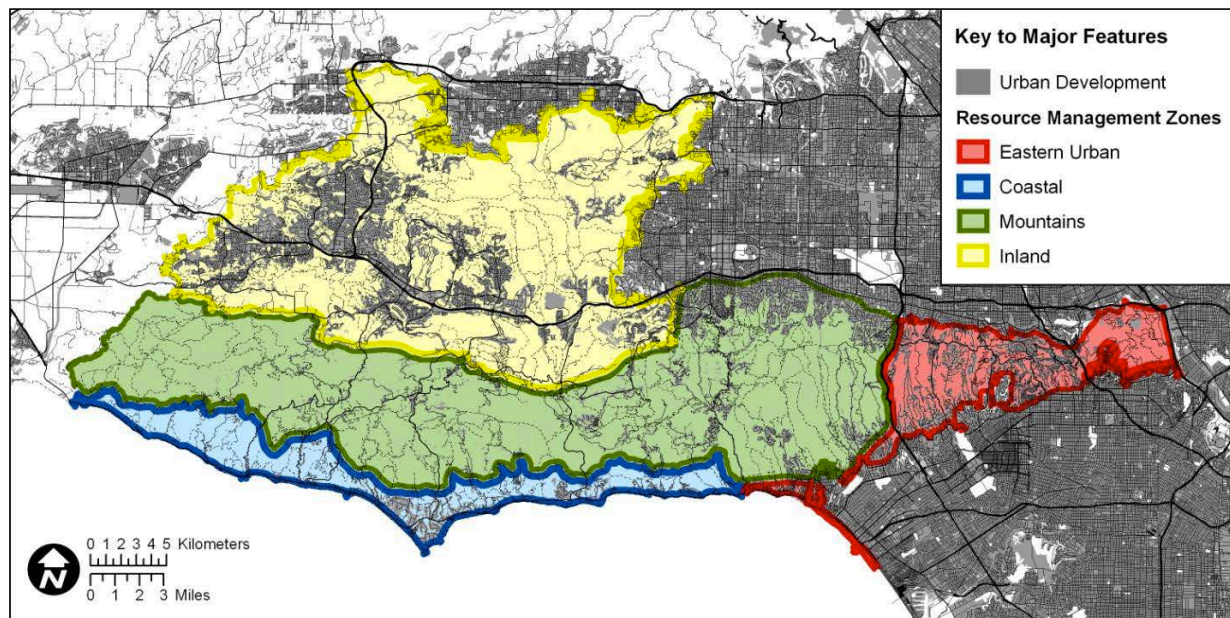


Figure 10. Map of the four ecological regions within the Santa Monica Mountains Resource Management Zone (or Ecological Management Zone) from Delaney et al. (2011). The eastern urban region was excluded from the sample frame for this program.

2.3.2 CHIS

The sampling frame is defined by a custom GIS layer (R. Rudolph, pers. comm) of the stream network on Santa Rosa Island.

2.4 Stratification

2.4.1 SAMO

The aquatic amphibian sampling design stratified the EMZ into four ecological regions (Figure 10) based on physical features, vegetation, coastal influence, elevation, and development: 1) Lower elevation inland Santa Monica Mountains and Simi Hills (Inland, primarily chaparral vegetation); 2) Upper elevation Santa Monica Mountains (Mountains, primarily chaparral vegetation), 3) Immediate coast (Coastal, primarily coastal sage scrub), and 4) Eastern Urban (very fragmented habitat). As described above, the eastern urban region was eliminated from the sample frame.

During the site selection process, the number of cells (or sites) selected from each eco-region was proportionate to the total number of cells meeting the sampling criteria within each eco-region. A total of 12 cells were identified from the Inland region, 18 from the Mountains region, and six from the Coastal region.

2.4.2 CHIS

The sampling design for CHIS will not be stratified, but will be a multi-density (unequal probability) selection in order to increase the chances of selecting perennial stream sites. This is necessary because streams with adequate flow during the index period are estimated to comprise only ~10% of stream miles on SRI, yet are the most suitable for bioassessment monitoring. Furthermore, it is likely that non-native fauna preferentially inhabited areas near perennial streams; these reaches are therefore priorities for monitoring stream recovery after non-native fauna removal.

2.5 Site Selection

2.5.1 SAMO

Stream condition monitoring sites will be located at a subset of aquatic amphibian monitoring sites (Figure 11). Sites will be evaluated in the order of their GRTS number and only sites having wadable streams appropriate for bioassessments will be selected. Amphibian monitoring sites were selected as described below and in more detail by Delaney et al. (2011):

- A map of cells that included stream segments was created by overlaying a grid of 2.25 km² cells (1.5 km on a side) over the EMZ. Cells that had less than 50% protected park lands, contained no intermittent or perennially flowing streams, or already had sentinel monitoring sites located within them were eliminated.
- A spatially random selection of 36 cells was made from the final sampling frame of cells stratified within the EMZ eco-regions by GRTS methods running on the open source statistical software package R (see the U.S. E.P.A. Aquatic Resources Monitoring web page, <http://www.epa.gov/nheerl/arm/>, accessed July 13, 2006). If the majority of a cell (>50%) contained land within a particular stratum, it was named to that stratum (mountain, inland, or coastal). The number of cells selected from each eco-region was proportionate to the total number of cells meeting the sampling criteria within each ecoregion.
- After cells were selected, sites were visited and accessibility was assessed. If a site contained geophysical characteristics such as extremely steep banks so that access to the stream was unsafe, it was eliminated after the site visit. Such constraints on the sampling frame composed of stream segment cells was thought necessary because a blind and fully random selection of monitoring sites along streams would result in the majority of sites not meeting the safety, access, and presence of perennial water criteria or because of vegetation and topography would be unreachable or they would be located on private lands. The safety and access restrictions made on the sampling frame reduce the sampled population to a subset of the desired target population, but this is a common and necessary trade-off for long-term monitoring programs, and only reduces our scope of inference based on the probabilistic sites.

- The bioassessment and wetland function assessment components of stream condition monitoring will be conducted at a subset of the randomly selected (rotating) NPS amphibian monitoring sites only, not the sentinel sites (Figure 10). There are 12 rotating amphibian sites visited each year, but only 8 of these will have bioassessment and wetland function assessed. This is due to both budgetary constraints and the fact that not all amphibian sites are suitable for the SWAMP bioassessment protocol, which applies to perennial, wadable streams. In the first three years of monitoring at SAMO, the rotating sites will be visited in order of the original GRTS draw; the first 8 sites visited that are suitable will be monitored. These will become the final sites for long-term monitoring.

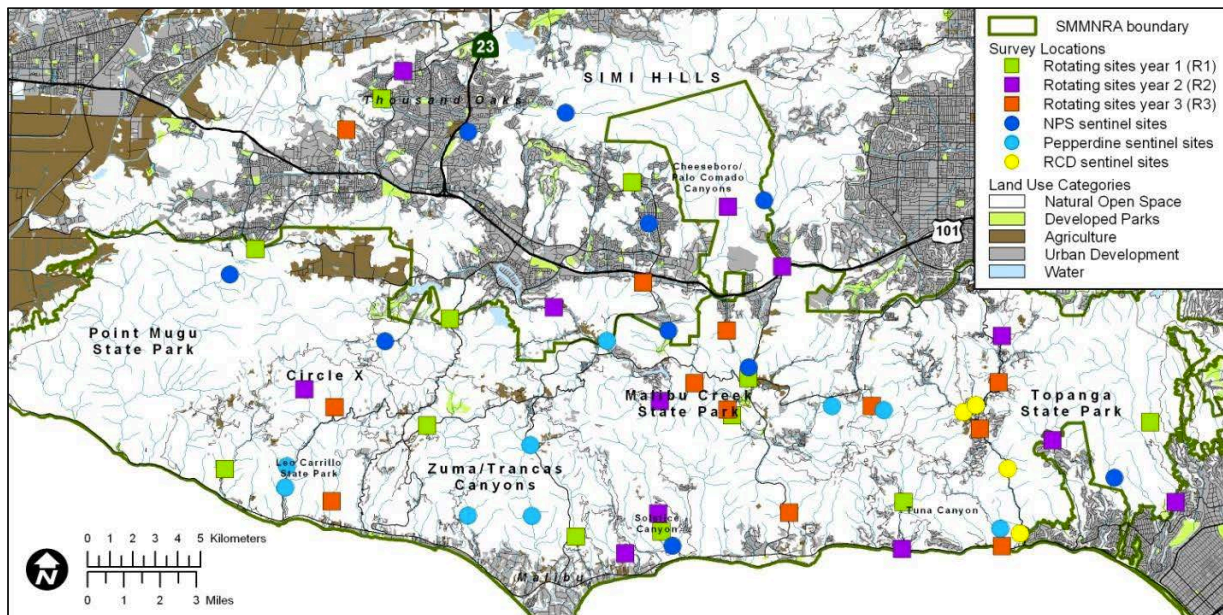


Figure 11. Map of Santa Monica Mountains NRA aquatic amphibian monitoring sites per the Mediterranean Network Inventory and Monitoring protocol (Delaney et al. 2011). Stream conditioning monitoring will occur at a subset of the amphibian monitoring sites.

2.5.2 CHIS

A set of 30 probabilistically-selected sites will be assessed for wetland function using CRAM during each 3-year monitoring cycle (roughly 10 sites each year). A draw of 90 sites (see SOP 7) was made using Generalized Random Tessellation Sampling (GRTS) (Stevens and Olsen 2004) from the sampling frame described above. This extensive oversample allows for replacement of unsuitable sites, of which many are expected on CHIS due to challenging topography or nesting birds. The sample draw also included a multi-density intensification, in which perennial streams were weighted to improve representation of these scarce stream types, as discussed above. The final selection of 30 sites will be made in the first three years of monitoring, and sites will be used in the order of the GRTS draw. Locations which cannot be accessed or which pose safety hazards will be eliminated. In all cases, the reason for rejecting a site will be recorded. A record will also be kept of those sites visited for CRAM assessments that are also suitable for bioassessment monitoring (see further discussion below).

2.6 Revisit Design

Monitoring will alternate between CHIS and SAMO every three years. At CHIS, 30 randomly selected sites on Santa Rosa Island will be monitored over a 3-year period (approximately 10/year). In the subsequent 3 years, sampling will be performed at SAMO at approximately 24 amphibian monitoring sites (approximately 8/year). Afterward, monitoring will once again return to CHIS.

2.6.1 SAMO

As noted above, stream condition monitoring will occur at a subset of the amphibian monitoring sites (Figure 12) and therefore follows the revisit design of the amphibian monitoring program (Delaney et al. 2011).

The temporal revisit design used is summarized in [Figure 12 and Table 6]. The GRTS monitoring stations are visited following a rotating panel design (Fuller 1999). Each panel includes four cells from the lower elevation region, six from the upper elevation region and two from the immediate coast region. Using the notation introduced by McDonald (2003) we use a [1-2] revisit design as in [Table 6]. A panel is visited in one year, rests for two years, and then is revisited in the third year. The sentinel sites are visited every year (always revisit design; [1-0] design).

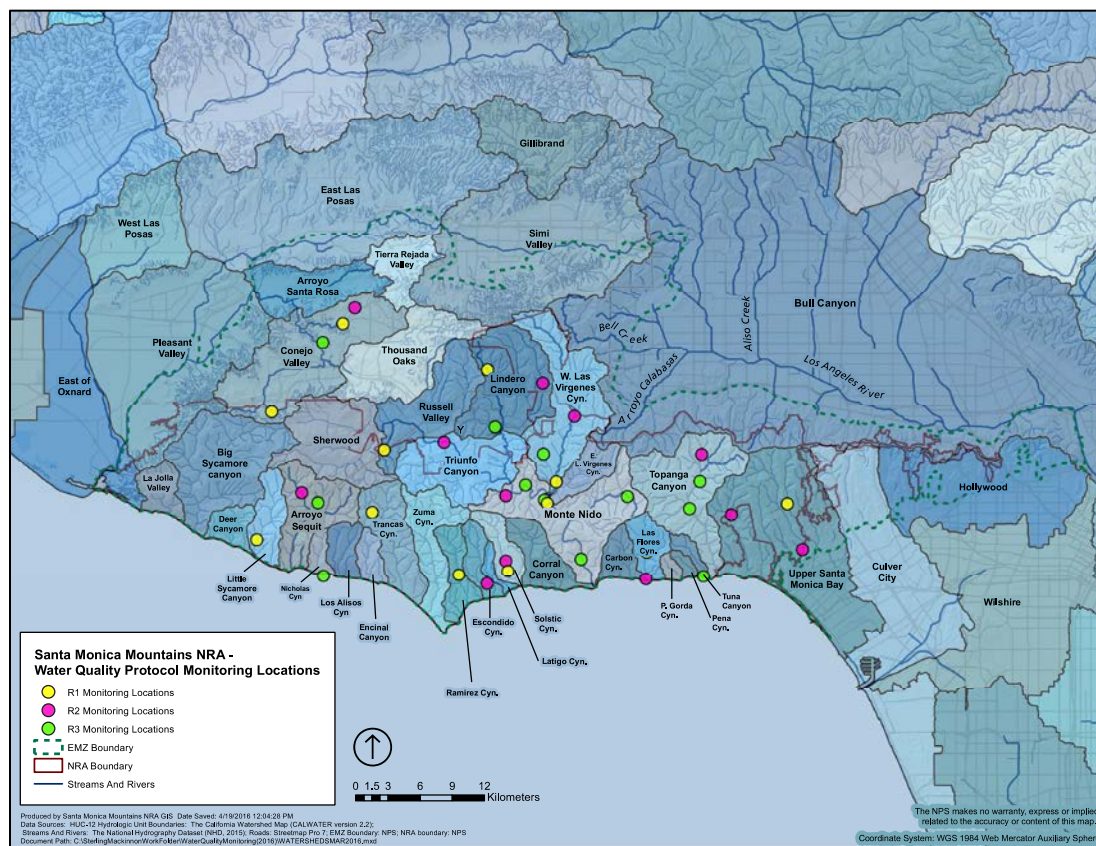


Figure 12. Stream condition monitoring locations at SAMO will be a subset of the amphibian monitoring sites. R1 = rotating panel 1, R2 = rotating panel 2, R3 = rotating panel 3. EMZ = Ecological management zone. NRA = National Recreation Area boundary.

Table 6. Aquatic amphibian monitoring revisit design (adapted from Delaney et al. 2011). The Stream Condition Monitoring Program at SAMO will follow this revisit design and sample at approximately 8 rotating sites in each of the 3 years of sampling.

Site Type	Site Location	Year 1	Year 2	Year 3
Sentinel sites—all years	NPS Sites	10	10	10
	Pepperdine Sites	9	9	9
	RCD Sites	3	3	3
Rotating sites	Coastal Zone	2	2	2
	Mountains	6	6	6
	Inland	4	4	4

2.6.2 CHIS

During every three-year cycle during which monitoring is conducted at CHIS, 10 sites will be visited each year. Overall, this means that each site will be evaluated for CRAM every 6 years. Similarly, bioassessments and water chemistry testing will be conducted at the same targeted locations every Year 3 of the cycle, such that these sites are monitored every 6 years. Note that the number of CRAM and bioassessments performed per year may be altered due to weather and road conditions, although the total number of CRAM and bioassessments will remain at 30 and 10 respectively, at the end of each 3 year rotation.

2.7 Response Design

The following suite of parameters were selected on-the-basis of scientific, logistical, and monetary considerations. A summary of the physical requirements at the site for each sampling method is described in Table 7. The sampling plan for SAMO and CHIS is shown in Tables 8 and 9, and the monitoring locations are shown on the maps in Figures 12, 13 and 14. Below we provide brief descriptions of why specific parameters were chosen and how they will be monitored.

Table 7. Summary of requirements for each type of sampling.

Data type	Requirements for sampling
CRAM	Distinct channel-forming processes are evident.
Water chemistry	Aquatic habitat currently present
BMI + PHAB	Aquatic habitat currently present and probably present for at least 2 weeks before sampling (preferably 4); At least 100 m (preferably 150 m) aquatic habitat; Wetted width >1 m for >50% of reach-length Depth <1 m for >50% of reach-length
Amphibians	Presence/absence of amphibians

Table 8. Summary of sampling design for SAMO.

Data Type	Sampling Location	Measured Parameters	Sampling Frequency
Benthic macro-invertebrates (BMI)	Co-located with aquatic amphibian sites at GRTS selected sites, when and where possible.	Collected macro-invertebrates are taxonomically identified and enumerated. Metrics are calculated from these data.	Panel design rotating between SAMO and CHIS, with BMI monitoring conducted annually for 3 years on, 3 years off.
Physical habitat condition (PHAB)	Co-located with aquatic amphibian sites at GRTS selected sites, when and where possible.	See details on PHAB data collected in SOP 4.	Panel design rotating between SAMO and CHIS, with PHAB monitoring conducted annually for 3 years on, 3 years off.
Riverine wetland function (CRAM)	Co-located with aquatic amphibian sites at GRTS selected sites	See details on wetland function data collected in SOP 5.	Panel design rotating between SAMO and CHIS, with CRAM conducted annually for 3 years on, 3 years off.
Water chemistry	Co-located with aquatic amphibian sites at GRTS selected sites, when and where possible	In situ: temperature, pH, specific conductance, dissolved oxygen, turbidity. Lab analysis: total phosphorous, total nitrogen, chloride, sulfate, and selenium.	In-situ parameters to be monitored as part of the amphibian protocol. Samples requiring lab analysis will be done concurrently with BMI and PHAB monitoring.

Table 9. Summary of sampling design for CHIS.

Data Type	Sampling Location	Measured Parameters	Sampling Frequency
Riverine wetland function (CRAM)	Randomly selected through a GRTS draw.	See details on wetland function data collected in SOP 5.	Panel design rotating between SAMO and CHIS, with CRAM monitoring conducted in Years 1 and 2 of the 3-year cycle.
Benthic macro-invertebrates (BMI) and aquatic amphibian monitoring (presence / absence)	Targeted sites previously monitored for BMI	Collected macro-invertebrates are taxonomically identified and enumerated. Metrics are calculated from these data.	Panel design rotating between SAMO and CHIS, with BMI monitoring conducted in Year 3 of the 3-year cycle.
Physical habitat condition (PHAB)	Targeted sites previously monitored for BMI	See details on PHAB data collected in SOP 4.	Panel design rotating between SAMO and CHIS, with PHAB monitoring conducted in Year 3 of the 3-year cycle.
Water chemistry	Targeted sites previously monitored for BMI	In situ: temperature, pH, specific conductance, dissolved oxygen, and turbidity. Lab analysis: total phosphorous, total nitrogen, chloride, sulfate and selenium.	Will be done concurrently with BMI and PHAB monitoring

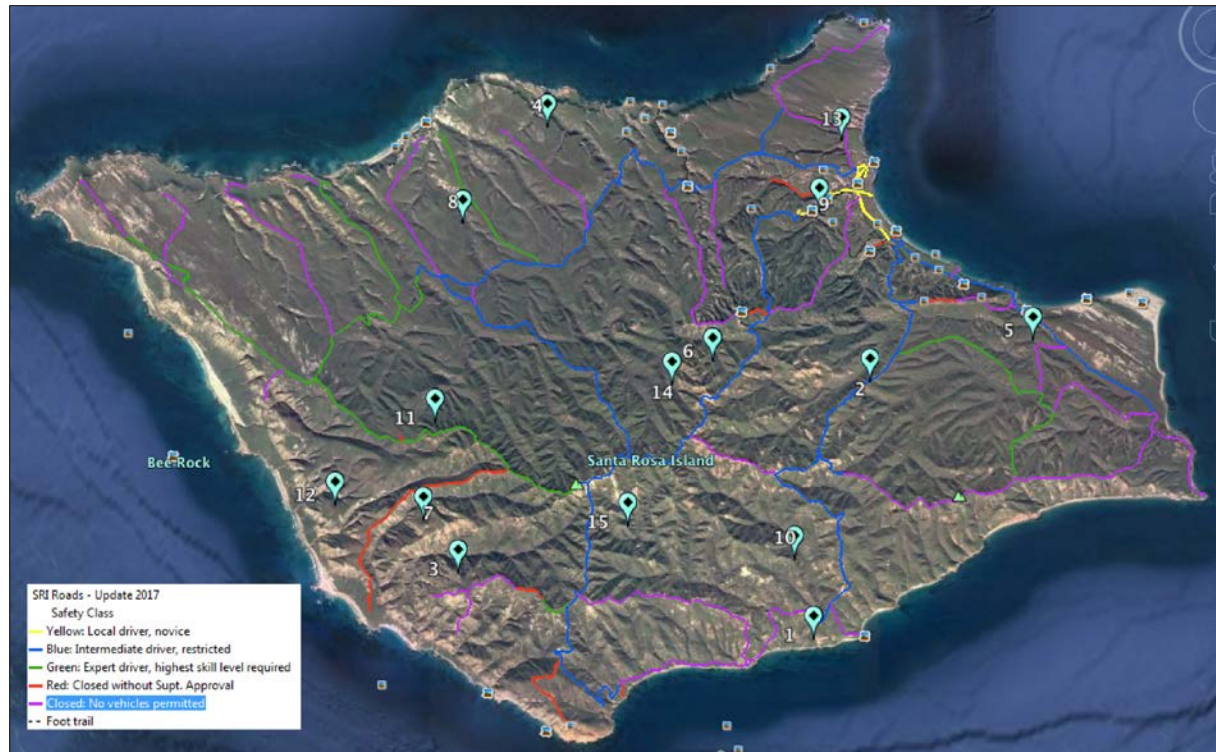


Figure 13. Monitoring locations on Santa Rosa Island for 2017. Sites will be allocated to panels once the 30 sites have been established. Aqua-colored balloons represent the sampling sites. Although there are many roads on the island, several are now closed (purple) or require special permission to use (red). Blue roads are open to intermediate drivers who have been drive-tested by park staff. Drivers must be drive tested a second time to be approved to drive on green roads.



Figure 14. Monitoring locations on Santa Rosa Island for 2018. Sites will be allocated to panels once the 30 sites have been established. Although there are many roads on the island, several are now closed (purple) or require special permission to use (red). Blue roads are open to intermediate drivers who have been drive-tested by park staff. Drivers must be drive tested a second time to be approved to drive on green roads.

2.7.1 Water Chemistry Parameters

Discussion of water chemistry monitoring is divided by the location of the analysis: in the field or laboratory.

The NPS WRD has identified four parameters (temperature, pH, specific conductance and dissolved oxygen) as critical “core parameters” to be monitored in aquatic habitats. These parameters, as well as turbidity, will be monitored in-situ annually at SAMO as part of the aquatic amphibian protocol, at all amphibian sites, both sentinel and rotating, according to the amphibian monitoring program revisit design. (Note this only applies to NPS-monitored amphibian sites; the amphibian protocol and Table 6 above, refers to 2 other stakeholder groups doing limited, targeted amphibian monitoring.) The same five parameters will be monitored at CHIS concurrently with bioassessment and CRAM data collection per the schedule shown in Table 5. Additional details on field sampling are provided in SOP 3.

Laboratory-analyzed parameters were chosen to augment core parameters taken in-situ to provide basic information on potential stressors, while at the same time balancing the cost allocation between biological monitoring and water chemistry, recognizing the more limited value of annual grab samples compared to the integrative nature of biological monitoring. It is expected that a more detailed source identification effort would be undertaken by either the park and/or MEDN I&M for

stream reaches with poor bioassessment results that could not be explained based on physical conditions.

Parameters analyzed as part of the SMC stream monitoring program were used as the starting point for selecting parameters for MEDN parks. Specifically, water chemistry stressors identified as priority stressors in the SMC five-year report (Mazor 2015a) were evaluated in combination with data from additional park-specific monitoring. SMC-identified priority water chemistry stressors (categorized as “very high,” “high,” or “medium”) were those with a significant correlation to biological measures of stream health as follows:

- Very high priority: total phosphorous and total nitrogen
- High priority: Chloride, pH, TSS, Specific Conductance

We selected the following five parameters for laboratory analysis for SAMO and CHIS: **total nitrogen, total phosphorous, sulfate, chloride, and total selenium**. The reasoning is as follows:

Total nitrogen and total phosphorous

Exceeded reference-based thresholds in extensive portions of the region monitored by the SMC. Malibu Creek-specific monitoring found “naturally high background levels of phosphate and nitrate, higher than current water quality standards and well above those necessary to sustain high algal growth” (LVMWD, 2011). Although the SMC monitoring program did not include any sites on CHIS, nearly 30% of “open space” sites monitored by the SMC were above the reference-based threshold for total nitrogen and total phosphorous.

Sulfate

Sulfate (SO₄) exceeded regulatory-based thresholds extensively in SMC-monitored areas, and was also classified as “very high” priority. Malibu Creek-specific monitoring found that “sulfate levels in Malibu Creek’s northern tributaries are very high (~3 times the 500 mg/L Basin Plan objective)” (LVMWD, 2011). Data from Melak and Cooper (2008) show sulfate levels on CHIS consistently exceeded regulatory thresholds. Measured results were almost always above the secondary maximum contaminant level (MCL) for drinking water and was often above the primary MCL. (There are no sulfate regulatory thresholds established for freshwater aquatic life protection.)

Chloride

Chloride was classified in the SMC report as a “high” priority stressor; it was found to exceed the secondary MCL (and the chronic freshwater aquatic life water quality criteria) in 14% of the Santa Monica Bay and Calleguas watersheds. Data from water chemistry monitoring conducted by Melak and Cooper (2008) on CHIS, show streams are, on average, enriched in chloride relative to seawater. Measured chloride levels on CHIS were commonly higher than the chronic water quality criteria for freshwater aquatic life protection and sometimes exceeded the acute criteria.

Selenium

Selenium was classified as a “moderate” priority stressor; however, geographic clustering of exceedances was found for both selenium and chloride, “suggesting a localized (perhaps geological)

source for these constituents” (Mazor, 2015a). Selenium exceeded its regulatory threshold in 40% of the Calleguas and 55% of the Santa Monica Bay watersheds. The geology of CHIS includes areas of marine sedimentary deposits classified as Monterey shales (Vedder et al. 1969), like that found in parts of SAMO. This geological formation is a source of selenium (Piper and Isaacs 1995) as well as sodium and chloride (Melack and Cooper 2008).

In summary, the following water chemistry parameters will be measured in-situ using handheld multi-sensor instruments: temperature, pH, specific conductance, dissolved oxygen, and turbidity. The remaining 5 parameters (total nitrogen, total phosphorous, sulfate, chloride, and total selenium) will be analyzed in the laboratory based on water quality samples collected on site. Bottle samples will be collected using the hand-dipping method described in the USGS National Field Manual (USGS 2006). Sampling will be conducted concurrently with CRAM or Bioassessment monitoring. Water chemistry monitored as part of the annual aquatic amphibian monitoring will take place at the sites visited each year per the amphibian monitoring protocol (sentinel sites and random sites per the rotating design; see Table 5 above).

2.7.2 Bioassessments (Stream Benthic Macroinvertebrates with Associated Physical Habitat and Water Quality Measurements)

Stream benthic macroinvertebrates (BMI) are an abundant, diverse, and ecologically important component of stream biological communities. BMI are also widely used to infer water quality because macroinvertebrate assemblages are sensitive to changing physical, chemical, and biological conditions over multiple spatial and temporal scales (Barbour et al. 1999). Data on physical habitat and water chemistry is routinely collected along with BMI monitoring to help analyze stream stressors and conditions related to BMI community response.

California SWAMP (bioassessment) protocols will be used to conduct benthic macro-invertebrate (BMI) sampling, physical habitat (PHAB) monitoring, water chemistry sampling and analysis, and (on CHIS only) aquatic amphibian presence/absence. The timing of sampling will be consistent with guidance provided in the Stormwater Monitoring Coalition Workplan (Mazor 2015b), which advises an ideal waiting period of 4 weeks after storm events to avoid the effects of scour. This timing roughly corresponds with the recommended seasonal window for sampling aquatic amphibians (Delaney et al. 2011) which is from April to July to capture the breeding seasons of target amphibians.

This monitoring approach will allow us to report the following metrics calculated from the BMI data: the California Stream Condition Index (CSCI) and its two component measures, the Multi-Metric Index and the Observed/Expected value. We will evaluate the scores using thresholds reported in Mazor (2015a). PHAB scores and water chemistry analysis results will also be reported.

Detailed information on Bioassessment monitoring is provided in SOP 4.

2.7.3 Riverine Wetland Function

A riverine wetland assessment provides information on the processes and functions that provide services to society (e.g., flood control, wildlife habitat). Particularly on CHIS, where riverine function has been significantly altered by non-native wildlife (now eradicated), such an assessment is

critical to understanding conditions and trends as streams recover, as well as to identify differences in recovery rates and patterns among streams. Such information will be used to inform management actions related to restoration.

Riverine wetland conditions will be monitored using the California Rapid Assessment Method (CRAM) for wetlands, using the riverine module (CWMW, 2013). CRAM was developed specifically for the wetland types of California as a tool to assess the status of and trends in the condition of wetlands throughout the state. MEDN will report the following metrics from CRAM assessments: the overall score for the wetland and the scores for the four component attributes (landscape context, hydrology, physical structure, and biotic structure). We will evaluate the scores using thresholds reported in Mazor (2015a).

Detailed information on CRAM monitoring is provided in SOP 5.

3 Field and Laboratory Methods

Macroinvertebrate assemblages, physical habitat conditions and stream water chemistry will be monitored using the bioassessment protocols designed by the California Surface Water Ambient Monitoring Program (SWAMP) (Ode 2007). Riverine wetland conditions will be monitored using the California Rapid Assessment Method (CRAM) for wetlands, using the riverine module (CWMW, 2013). Water chemistry samples for laboratory analysis will be collected using the hand-dipping method described in the USGS National Field Manual (USGS 2006). The following SOPs provide details related to field and laboratory methods:

SOP 3: Field Measurements of Water Chemistry (SAMO only)

SOP 4: Field and Laboratory Methods: Bioassessment Monitoring

SOP 5: Field and Laboratory Methods: CRAM Wetlands Assessment

4 Data Handling, Analysis and Reporting

The following section outlines general procedures for data entry, checking, analysis, and report development. **This section is required reading for anyone involved in the collection or processing of data for this program, including field crews.** Proper data management ensures that data will be reliable, relatively free of errors, and ready for analysis.

Specific data management procedures are described in the MEDN data management plan (Lee 2005) and SOP 8. The MEDN vital signs monitoring plan (Cameron et al. 2005) provides an overview of the network's information management and reporting plan. **Furthermore, the Quality Assurance and Data Management sections of the SWAMP website (https://www.waterboards.ca.gov/water_issues/programs/swamp/quality_assurance.html) will be regularly consulted for templates, file naming conventions, and other quality assurance measures.** All project personnel must know and understand their responsibilities in data management.

4.1 Data Management Overview

The stages of the data management life cycle are summarized below and in Figure 15. Quality assurance and documentation are not limited to any particular stage, but rather occur throughout the life cycle.

- *Preparation* – Training, logistics planning, print forms and maps.
- *Data acquisition* – Field data collection.
- *Data entry and processing* – Data entry on a daily or seasonal basis, database uploads, GPS processing, etc.

- *Quality review* – Program Lead(s) oversee data verification (paper datasheet checked against electronic record) and validation (reviewed for completeness and logical consistency using queries within the database). Data verification and validation constitute the quality review.
- *Metadata* – Documentation of the year’s data collection (e.g., version of protocol followed) and results of the quality review. The required list of metadata information is provided in SOP 8.
- *Data certification* – Program Lead(s) in consultation with the Data Manager certifies the data in the database after it has been verified and validated. The data are certified as complete for the period of record.
- *Data delivery/archiving* – Certified data and metadata are delivered to the MEDN Data Manager for archiving.
- *Data analysis* – Data are summarized and analyzed.
- *Product development* – Reports, maps, and other products are developed.
- *Product delivery* – Deliver reports and other products for posting and archiving.
- *Posting and distribution* – Distribute products as planned and/or post to NPS websites.
- *Archiving and records management* – Review analog and digital files for retention (or destruction) according to NPS Director’s Order 19. Retained files are renamed and stored as needed.
- *Season closeout* – Review and document improvements needed to the database, procedures or infrastructure.

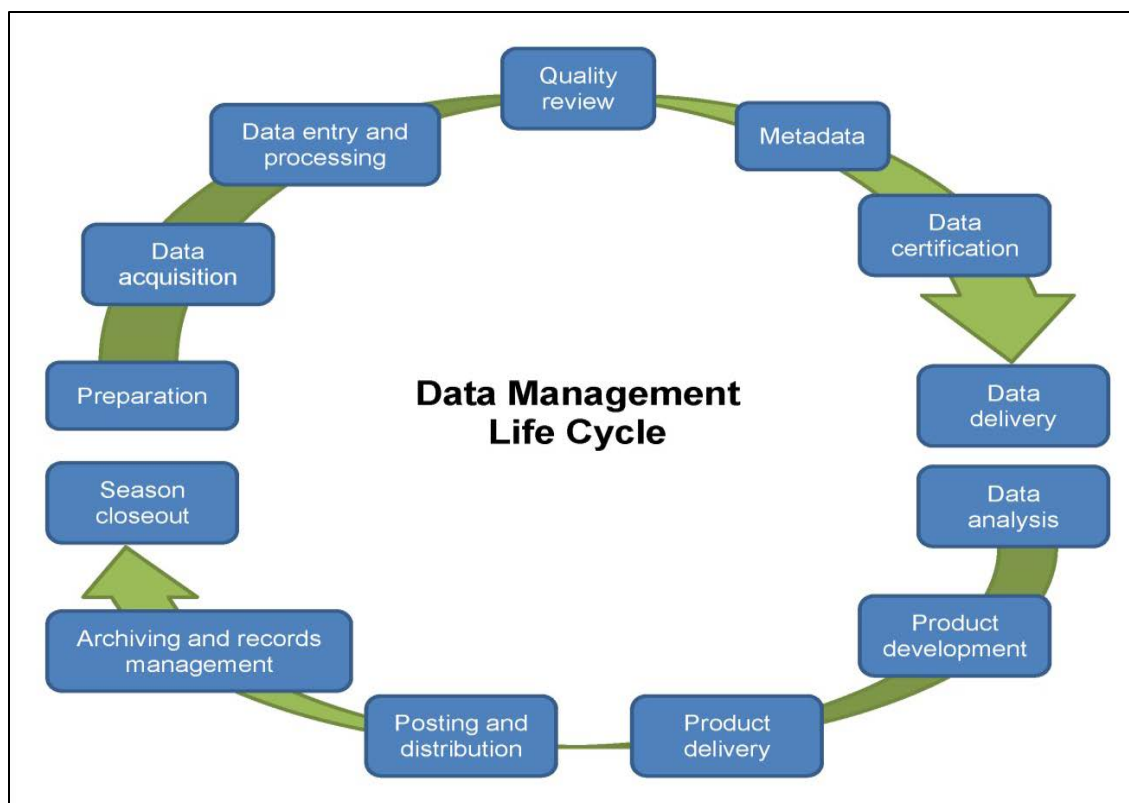


Figure 15. Recommended flow diagram of the stages of data management from pre-season preparation to season closeout. Quality review includes data verification (checking paper datasheets against the electronic data) and validation (queries for logical consistency and completeness) that require input from the Program Leads.

4.2 Overview of Data templates and Databases

Data for this protocol will be entered into a number of different databases (Table 10), including the use of databases used for the SWAMP programs, which are managed and checked by State of California Water Boards staff.

Table 10. Locations of where the MEDN stream condition monitoring program data and databases are stored and managed.

Data type	Repository	Managing agency
Site evaluation data	Stormwater Monitoring Coalition database	Southern California Coastal Water Research Project
Vertebrate observations (CHIS only)	Stormwater Monitoring Coalition database	Southern California Coastal Water Research Project
In-situ water chemistry data (CHIS)	SWAMP database	California State Water Resources Control Board
In-situ water chemistry data (SAMO)	MEDN Aquatic Amphibian Monitoring Program database and SWAMP database	National Park Service and California State Water Resources Control Board

Table 10 (continued). Locations of where the MEDN stream condition monitoring program data and databases are stored and managed.

Data type	Repository	Managing agency
SWAMP Bioassessments [Benthic Macro-invertebrate (BMI) and Physical Habitat Conditions (PHAB) data]	SWAMP database	California State Water Resources Control Board
CRAM (Riverine Module)	eCRAM database	San Francisco Estuary Institute

4.2.1 Site Evaluation

Site evaluation information will be entered into an Excel spreadsheet provided by SCCWRP. Site evaluation data is used to evaluate the sampleability of a site in a probabilistic survey.

4.2.2 Vertebrate Observations (CHIS only)

Vertebrate observations include data on native as well as large invasive invertebrates that are encountered during bioassessment sampling. Information on these observations will be entered into an Excel spreadsheet provided by SCCWRP.

4.2.3 In-Situ Water Chemistry

SWAMP will be the designated repository for all in-situ water chemistry measurements (temperature, pH, specific conductance, dissolved oxygen, turbidity) collected at the parks. At CHIS, in-situ water chemistry measurements (temperature, pH, specific conductance, dissolved oxygen, turbidity) collected by contractors will be directly entered into a local copy of the SWAMP database and uploaded to the master SWAMP database.

At SAMO, measurements collected by NPS staff during intensive amphibian monitoring will be directly entered into the MEDN Aquatic Amphibian program database. The Aquatic Amphibian database is a customized relational database developed in MS Access 2007 and is used to store and manipulate the data associated with this program. The MEDN Data Manager is responsible for the development and maintenance of the database. The design of this database follows the Natural Resource Database Template (NRDT) and is consistent with NPS Inventory and Monitoring Program guidance for the management of natural resource data (Lee 2005, see SOP 8). Details of the database, including a description of the structure and relationship links among data tables are presented in the MEDN Aquatic Amphibian Monitoring protocol (Delaney et al. 2011). Database functions will be built to export the data as necessary to respective parties for inclusion into the SWAMP database.

4.2.4 SWAMP Bioassessments

Benthic macroinvertebrate (BMI), physical habitat conditions (PHAB) and lab-based water chemistry will be entered into a local copy of the SWAMP bioassessment database, a customized relational database developed in MS Access 2000 and managed by SCCWRP. The database stores data associated with this the status of the physical, chemical, and biological characteristics of the environment collected under SWAMP protocols. Detailed information on database structure and use can be found at:

http://www.waterboards.ca.gov/water_issues/programs/swamp/data_management_resources/index.shtml.

SWAMP bioassessment data collected in Southern California are housed under the Southern California Regional Data Center (SCRDC), one of four regional data centers for the California Environmental Data Exchange Network (CEDEN) and managed by SCCWRP. CEDEN consolidates information about California's water bodies, including streams, lakes, rivers, and the coastal ocean in a central location where it can be easily accessed and used for statewide management efforts. Data from this protocol will be incorporated into CEDEN through the SCRDC. Tools at CEDEN are currently being tested that will allow the submission of data to EPA Storet through the Federal WQX (water quality exchange) system on a weekly basis.

4.2.5 CRAM (Riverine Module)

Data on riverine wetland function will be entered into the CRAM on-line database (eCRAM), an external database managed by SCCWRP. The database stores information on the condition of wetlands and riparian habitats throughout California. Detailed information on database structure and use can be found at: <http://www.cramwetlands.org/>.

4.3 Data Entry, Verification and Editing

The Program Lead is responsible for ensuring that all data collected are accurate and complete, and that data are entered properly into their respective database on a daily basis. Data should be uploaded/entered after each survey in order to keep current with data entry tasks, and to identify any errors or problems as close to the time of data collection as possible.

As soon as possible after data are entered, records should be checked in the database and/or against the paper datasheet by generating a data verification report that displays the data from the database in a format similar to that of the original datasheet (NPS Aquatic Amphibian program database only). Data verification is the process of ensuring the electronic data match what was recorded on the hardcopy field forms.

Once the data have been entered and saved, the Program Lead or collaborator will run validation queries and evaluate the data for completeness and logical consistency. The creation of data validation queries requires a reviewer to have extensive knowledge of what the data mean and how they were collected. Queries and/or reports have been built in the SWAMP and CRAM database to look for apparent outliers, inconsistencies in entry, null values, or any other anomalous data points. Anomalies are reported to the Program Lead for discussion and resolution. Unresolved anomalies will be documented and included in the metadata and certification report. Any questions about the data, data entry procedures, or difficulties with the database are to be resolved by the Program Lead and program advisors/collaborators in consultation with the MEDN Data Manager.

Data will be subjected to an automated data quality process that will flag potential missing sites and invalid or improperly formatted data. Once the data have been certified, both the SWAMP and CRAM databases will be available for the public to download.

4.4 Metadata Procedures

Data documentation or the creation of metadata is a critical step toward ensuring that datasets are usable for their intended purposes well into the future. The development of metadata is defined as

structured information about the content, quality, and condition of data. Additionally, metadata provide the means to catalog datasets within intranet and internet systems, making data more accessible to a broad range of potential users. Metadata for all MEDN monitoring data will conform to Federal Geographic Data Committee guidelines (http://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/base-metadata/v2_0698.pdf) and NPS guidelines (

http://science.nature.nps.gov/NRGIS/applications/gisapps/gis_tools/mte.aspx) and will contain all components of supporting information such that the data may be confidently analyzed and synthesized. For long-term projects such as this one, metadata creation is most time consuming the first time it is developed – after which most information remains static from one year to the next (see SOP 8 for a list of metadata requirements). Metadata records in subsequent years then only need to be updated to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and to describe any changes in collection methods, analysis approaches, or quality assurance for the project.

Specific procedures for metadata development and posting are outlined in the MEDN data management plan (Lee 2005). In general, the Project Lead and MEDN Data Manager will work together to create and update an FGDC- and NPS-compliant metadata record in XML format. The Program Lead(s) should update the metadata content as changes to the protocol are made, and each year as additional data are accumulated. Edits within the document should be tracked so that any changes are obvious to those who will use it to update the XML metadata file. The MEDN Data Manager will post edited metadata records to the NPS IRMA (Integrated Resource Management Applications) data system, where they will be available to the public.

4.5 Sensitive Information

Metadata development includes determining whether or not the data include any sensitive information. For example, the location of an endangered species population could be considered sensitive data. Prior to completing metadata, the Program Lead should identify any sensitive information in the data. Any concerns should be documented and communicated to the MEDN Data Manager. At this time, we do not anticipate that sensitive information will be collected in the Stream Condition monitoring program.

4.6 Data Certification and Delivery

Data certification is a benchmark in the project information management process indicating that (1) the data are complete for the period of record, (2) they have undergone and passed the quality assurance checks, and (3) they are appropriately documented and in a condition for archiving, posting, and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies that may not have been detected during quality assurance reviews.

To ensure that only data of the highest quality are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. Results sections of annual and trend reports will include a summary of the data verification and validation steps, the number and nature of the errors found, and how they were corrected. The Program Lead is primarily responsible for completing certification, in consultation with the MEDN Data Manager. The certified

data and updated metadata should be delivered to the MEDN Data Manager according to the specified timeline. Additional details of the certification and delivery processes are included in SOP 8. Data certification will be completed by November 1st, each year.

4.7 Data Archival

File structure, version control, and regular backups are carefully controlled to preserve the integrity of MEDN datasets. The original field datasheets will be stored at the Aquatic Bioassessment Laboratory (California Department of Fish and Wildlife) and copies of the datasheets will be stored in the office of the MEDN I&M program manager. Datasheets will also be scanned into PDF documents and stored in the project directory on the server. After all data for a field season have been entered, verified, validated, and certified by the Program Lead, the database will be sent to the MEDN Data Manager for archiving and distribution on the NPS IRMA (Integrated Resource Management Applications) data system. The archived database will be stored on a secure server with regularly scheduled back-ups and will be read-only accessible to the network parks. A complete copy of the database also will be archived and stored on the MEDN network server prior to any database version changes.

Once the data have been archived, any changes made to data values must be documented in the edit log database table. Paper field data sheets will not be altered; field data will be reconciled to the database through the use of the edit log. Any editing of archived datasets will be accomplished jointly by the Program Lead and MEDN Data Manager.

Certified and archived non-sensitive data, along with any associated metadata, will be made available through the NPS IRMA (Integrated Resource Management Applications) data system. The MEDN Data Manager will post certified datasets to IRMA, where they may be downloaded for research and management applications. Other datasets, including those containing sensitive data, may be requested in writing from the Program Lead and MEDN Program Manager. Sensitive data will be released only with a signed confidentiality agreement.

All data not managed under the NPS will also be accessible to the public, upon request from the Project Lead, through various web portals. Data stored in the SWAMP database will be made publically available through the California Data Exchange Network (CEDEN). Program data in eCRAM is directly accessible to the public once the Project Lead has designated the data as “public”.

4.8 Reporting

Reporting will consist of brief annual summary reports and synthesis reports at the end of the three-year cycle of sampling at each park. Annual summary reports will contain full descriptions of each site visited, a list of the field crew and sampling dates, a summary of the methods used, CRAM scores, CSCI bioassessment scores, and a list of all species identified along with general photos of the site.

At the end of each three year cycle of monitoring, a synthesis report will be prepared that summarizes the annual reports. The synthesis reports will contain interpretation of the CRAM and

CSCI scores, along with recommendations for future implementation of the protocol and management recommendations.

Results of both annual and synthesis reports will be published in the NPS Natural Resources Report series. After the second round of sampling at each park, a more in-depth analysis of findings will be undertaken with the goal of producing a peer reviewed publication.

5 Personnel and Qualifications, Schedule, and Budget

5.1 Personnel and Qualifications

All fieldwork will be conducted by collaborators or contractors, except for in-situ chemistry measurements taken in conjunction with the amphibian monitoring at SAMO. Collaborator costs include calculation of CSCI scores, upload of data to CEDEN, and preparation of basic annual summary reports. Contractors must be trained and experienced in conducting SWAMP Bioassessment and CRAM protocols. Currently, the California Department of Fish and Wildlife (CDFW) Aquatic Bioassessment Laboratory (ABL) is the collaborator for this work. Other contractors that may be considered in the future would need experience and training equal to staff from CDFW's ABL.

SOP 11 contains information on training requirements, should resources become available in the future to support park staff to conduct the fieldwork. Field training courses are offered on a regular basis through the California Water Board's College of Bioassessment.

5.2 Schedule

The MEDN I&M Program Manager will coordinate between stream condition monitoring contractors and park staff to schedule field data collection. Coordination at SAMO will synchronize stream condition monitoring with aquatic amphibian monitoring to ensure that both programs are visiting the same set of rotating panel sites each year, in order to achieve the goal of obtaining concurrent and co-located measurements. Coordination for field data collection begins in January and requires regular communication leading up to the field season. Information on planning and coordination is provided in SOP 1.

5.3 Budget

The estimated annual cost to support this long-term monitoring program is \$27,000-\$36,305 (FY18), plus the cost of NPS staff (\$20, 713-\$22,891; Tables 11-13) for a maximum total of \$59,396 per year, excluding periodic replacement of equipment (approximately \$3,000 every 3 years). The more expensive years of sampling (at SAMO) will detract from the network funds usually available to support data analysis with collaborators. If funds become more restricted, the number of bioassessments conducted at SAMO may be reduced to decrease costs.

Table 11. Estimated annual costs for field data collection, laboratory analysis, data entry and summary reporting at CHIS. These costs are in addition to staffing costs estimates in Table 13.

Time Period	Cost Item	Annual Number of Sites	Cost per Site	Annual Cost
First two years of panel	CRAM personnel and supplies	10	\$1,530	\$15,300
	Transportation, housing, equipment storage and driver on SRI	—	—	\$3,200
	Bioassessments	3	\$2,780	\$8340
	Water chemistry	3	\$200	\$600
	Calibration standards	—	—	\$225

Table 11 (continued). Estimated annual costs for field data collection, laboratory analysis, data entry and summary reporting at CHIS. These costs are in addition to staffing costs estimates in Table 13.

Time Period	Cost Item	Annual Number of Sites	Cost per Site	Annual Cost
Annual total (years 1 & 2)	–	–	–	\$27,665
Third year in panel	CRAM	10	\$1,530	\$15,300
	Transportation, housing, equipment storage and driver on SRI	–	–	\$3,200
	Bioassessments	4	\$2,780	\$11,120
	Water chemistry	4	\$200	\$800
	Calibration standards	–	–	\$225
Annual total (year 3)	–	–	–	\$29,845

Table 12. Estimated annual costs for sampling at SAMO. Travel/transportation costs are lower because field crews can drive themselves to the sites.

Cost Item	Annual Number of Sites	Cost per Site	Annual Cost
Bioassessments + CRAM + water chemistry	8	\$4,510	\$36,080
Calibration standards for field equipment	–	–	\$225
Equipment replacement for water quality testing	–	–	\$200
TOTAL			\$36,505

Table 13. Estimated annual costs NPS staff to implement the Stream Condition Monitoring Protocol. The SAMO biologist would not be involved in sampling at CHIS, so NPS staff costs for monitoring at CHIS is \$20,713.

Staff Position	Annual Number of Pay Periods	Cost per Pay Period (FY18)	Annual Cost
MEDN Program Manager (GS-12)	3	\$5,452.43	\$16,357
MEDN Data Manager (GS-11)	1	\$4,356.24	\$4,356
SAMO Biologist (GS-11)	0.5	\$2,178.12	\$2,178
TOTAL			\$22,891

5.3.1 CRAM and Bioassessments

The following are budget estimates for the CRAM and bioassessment monitoring conducted by CDFW ABL and are applicable through 2020:

- CRAM - \$1,530 per site flat rate – includes all electronic data entry/reporting and all overhead charges.

- Bioassessments - \$2,780 per site – includes BMI sampling and BMI taxonomic identifications, full SWAMP PHAB measurements, electronic data entry/reporting and all overhead costs.

5.3.2 Water Chemistry

Estimated costs for annual laboratory analyses are:

- TN, TP, Chloride, Sulfate: 4 x \$30 = \$120
- Selenium: \$80
- Total per site = \$200

Field equipment is required for measuring in-stream temperature, conductivity, dissolved oxygen, pH and turbidity. The recommended equipment for the first 4 of those parameters is the YSI Professional Plus Handheld with cable and sensors. See: (<http://www.ysi.com/productsdetail.php?Professional-Plus-18> and <https://www.ysi.com/search?k=W4-ProPlus-Quatro-Cable>. Initial cost estimates for the YSI instruments are:

- Handheld Unit \$ 1,175
- Quatro Cable (4-meters) \$ 1325 (cable comes with Conductivity and Temperature sensor)
- D.O. Sensor \$ 180
- pH Sensor \$ 170
- Calibration standards for conductivity and pH \$225
- Total: \$ 3,075

This protocol budgets for replacement probes every 3 years and a new meter every 6 years. Cost assumptions are \$200 per replacement probe, including shipping, and \$3,000 for a new unit with cables and all required probes. New calibration standards will be required annually. The recommended equipment for turbidity measurements is the LaMotte Model 2020we portable turbidity meter kit, including the handheld unit, case, USB cable and USB computer / wall adapter, calibration standards, sample bottle and sample tubes. An initial cost estimate is \$825 for the kit.

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Appendix A: Detailed Background Information on SAMO

A1 – Regulatory Assessment

Regulatory considerations for SAMO streams were assessed using two evaluation methods:

- First, a review was conducted of Total Maximum Daily Loads (TMDLs) that are either in effect, in progress or draft, to determine if NPS is named and if so, what expected actions were identified.
- Second, data was obtained from the State Water Resources Control Board on impaired streams. These are streams which do not meet the water quality objectives established for their beneficial uses. A GIS layer was downloaded from the [California Water Boards](#) website of the impaired waterbodies as of the 2010 listing. (Note: the 2012 303(d) list came out subsequent to this analysis; a review conducted in Aug 2015 showed that there were no changes to any waterbodies assessed with the exception of Cold Creek, and this one change does not alter the conclusions of the analysis.) This layer was then evaluated against the location of all NPS-owned properties within the NRA, using a GIS layer obtained from SAMO. Areas were identified where significant NPS-owned properties were within watersheds immediately tributary to the impaired waterbody.

Below is a summary of the assessment results. NPS is named only in the TMDLs for trash and debris, which will be handled by SAMO through a maintenance contract and does not need to be addressed through the water quality monitoring protocol.

A1.1 Trash and Debris TMDLs

NPS is named as a non-point source in both the **Malibu Creek Trash TMDL** (2009) and the **Santa Monica Bay Nearshore Debris TMDL** (2012). In both cases, expected activities include monitoring and reporting of trash volumes. A GIS-based review of NPS properties in the vicinity of trash-impaired stream reaches was conducted. Results are shown in the following table and map:

Table A1. National Park Service properties in the vicinity of reaches impaired by trash and debris.

Reaches Impaired for Trash and Debris	NPS Properties in the Vicinity
Malibu Creek	None
Malibu Lagoon	None
Malibu Lake	Paramount Ranch
Medea Creek Reach 1	Paramount Ranch
Medea Creek Reach 2	Palo Comado Canyon (northwest area)
Lindero Creek Reach 1	None
Lindero Creek Reach 2	None
Lake Lindero	None
Las Virgenes Creek	Cheeseboro Canyon (southeast area, including Morrison Ranch Trail)
Santa Monica Bay	Solstice Canyon

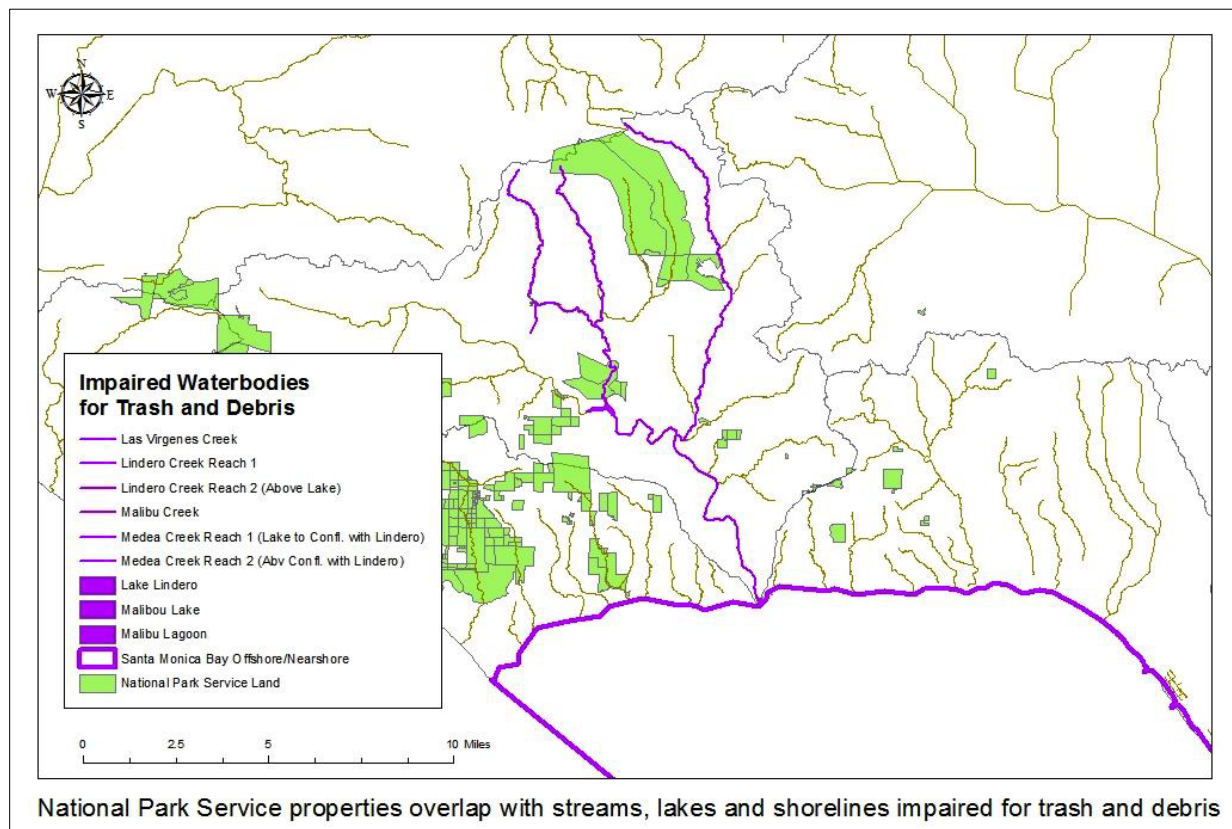


Figure A1. Map of National Park Service properties in the vicinity of waterbodies impaired by trash and debris.

A1.2 Bacteria and Nutrients TMDLs

The **Malibu Creek Bacteria TMDL** (2006) does not list NPS as a responsible jurisdiction or agency; however, the TMDL states that: "The Santa Monica Mountains Conservancy and the National Park Service as the owner of natural parkland also are responsible for water quality monitoring and compliance with load allocations resulting from anthropogenic sources (e.g., onsite wastewater treatment systems) from lands under their jurisdiction."

There are two TMDLs that address nutrients in Malibu Creek. Both TMDLs establish loading capacities for Total Nitrogen and Total Phosphorous, with more stringent levels set in 2013 compared to 2003.

- The **Nutrients TMDL** was established by the EPA in 2003. It is not yet adopted and does not list responsible jurisdictions. However, it discusses reductions in nutrients from non-point sources and open spaces. Two recommended focus areas with potential applicability to park properties are septic systems and horse stables/pastures.
- The TMDL for **Sedimentation and Nutrients to Address BMI Impairments** was established by EPA in July 2013. It is also not yet adopted. However, it discusses reductions in nutrients from non-point sources and open spaces. Under the Load Allocations for TN/TP

(page 229, Table 10-4), there are values established for “other non-point sources (including parks and forested lands).” There are also values specified for on-site waste disposal systems (septic systems). [Note that this TMDL includes Cold Creek as one of the tributaries to which TN and TP load allocation apply – see table footnote on page 10-19; however, Cold Creek is not on the 303(d) list of impaired waterbodies.]

The Nitrogen TMDL for Calleguas Creek (2009) identifies agricultural land as the primary non-point source of the ammonia impairment and does not mention NPS.

A1.2.1 Septic Systems

The Malibu Creek bacteria and nutrient TMDLs all mention reducing loads from septic systems. The 2003 TMDL refers to Regional Board Resolution 98-023 which required Reports of Waste Discharge for all multi-family and commercial septic systems in the watershed. This resolution was anticipated to lead to Waste Discharge Requirements which would either prohibit systems within 10 feet of the highest historical groundwater levels or require actions such as pretreatment via nitrogen reduction prior to leachfield discharge. The 2013 TMDL states that implementation of load allocations for onsite wastewater disposal will probably require aggressive actions to identify and repair all septic systems that do not function properly, with particular concern for the Malibu Lagoon area. A list of NPS properties with septic systems is included in Appendix B.

A1.2.2 Horse Stables/Pastures

Only the 2003 TMDL includes discussion of horse stables/pastures. It establishes a goal to “effectively eliminate runoff of manure from stables and to minimize nutrient contaminated runoff both from stables and manure piles.”

The Nitrogen TMDL for Calleguas Creek (2009) identifies agricultural land as the primary non-point source of the ammonia impairment and does not mention NPS.

A GIS-based review of NPS properties in the vicinity of bacteria- and/or nutrient-impaired stream reaches was conducted. Results are shown in the following table and map:

Table A2. National Park Service properties in the vicinity of reaches impaired by bacteria or nutrients.

Reach Category	Reach	NPS Properties in the Vicinity
Reaches Impaired for Bacteria and/or Nutrients (includes Algae, Eutrophic, Organic Enrichment/Low DO)	Lake Sherwood	None
	Westlake Lake	None
	Lindero Creek Reach 1 (below lake)	None
	Lindero Creek Reach 2 (above lake)	None
	Lake Lindero	None
	Palo Comado Creek	Palo Comado Canyon
	Medea Creek Reach 2	Palo Comado Canyon (NE corner)
	Medea Creek Reach 1	Paramount Ranch

Table A2 (continued). National Park Service properties in the vicinity of reaches impaired by bacteria or nutrients.

Reach Category	Reach	NPS Properties in the Vicinity
Reaches Impaired for Bacteria and/or Nutrients (includes Algae, Eutrophic, Organic Enrichment/Low DO) (continued)	Malibu Creek	None
	Malibou Lake	Paramount Ranch
	Las Virgenes Creek	SHEA Open Space (SE corner of Cheeseboro Canyon)
	Stokes Creek	King Gillette Ranch
	Cold Creek [listed as a tributary to which TN/TP load allocations apply but the creek is not on 303(d) list]	None
Other reaches outside of MCW	Santa Monica Canyon	None
	N. Fork Arroyo Conejo (now Calleguas Creek Reach 12)	None
	S. Branch Arroyo Conejo (now Calleguas Creek Reach 13)	Rancho Sierra Vista (but NPS not listed in Calleguas Nitrogen TMDL)

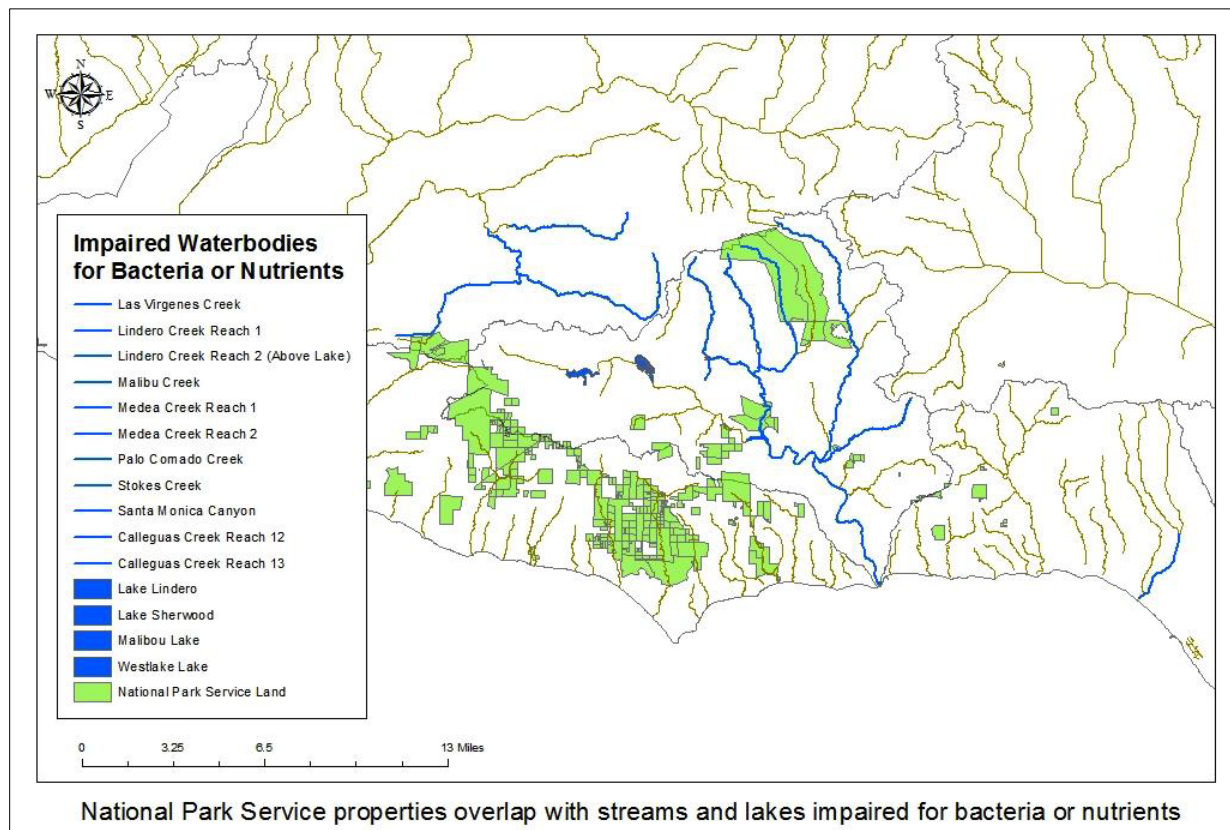


Figure A2. Map of National Park Service properties in the vicinity of waterbodies impaired by bacteria or nutrients.

A1.3 Sedimentation TMDL

The TMDL for Sedimentation and Nutrients to Address BMI Impairments makes the connection between impervious surfaces in the watershed and excess sediment transport capacity of overland and instream flows. It establishes Wasteload Allocations for point sources based on the fraction of total impervious area within the jurisdiction of each point-source permittee (Los Angeles County, Ventura County and Caltrans). The TMDL states that there is insignificant contribution from impervious areas that don't drain through point source stormwater conveyances. However, opportunities may exist on NPS properties to reduce or re-route runoff from impervious or highly compacted areas.

A GIS-based review of NPS properties in the vicinity of sediment-impaired stream reaches was conducted. Results are shown in the following table and map:

Table A3. National park Service properties in the vicinity of reaches impaired by sediment.

Reaches Impaired for Sediments	NPS Properties in the Vicinity
Triunfo Creek Reach 2	None
Triunfo Creek Reach 1	Peter Strauss Ranch
Medea Creek Reach 2	Palo Comado Canyon (NE corner)
Medea Creek Reach 1	Paramount Ranch
Malibu Creek	None
Las Virgenes Creek	SHEA Open Space (SE corner of Cheeseboro Canyon)

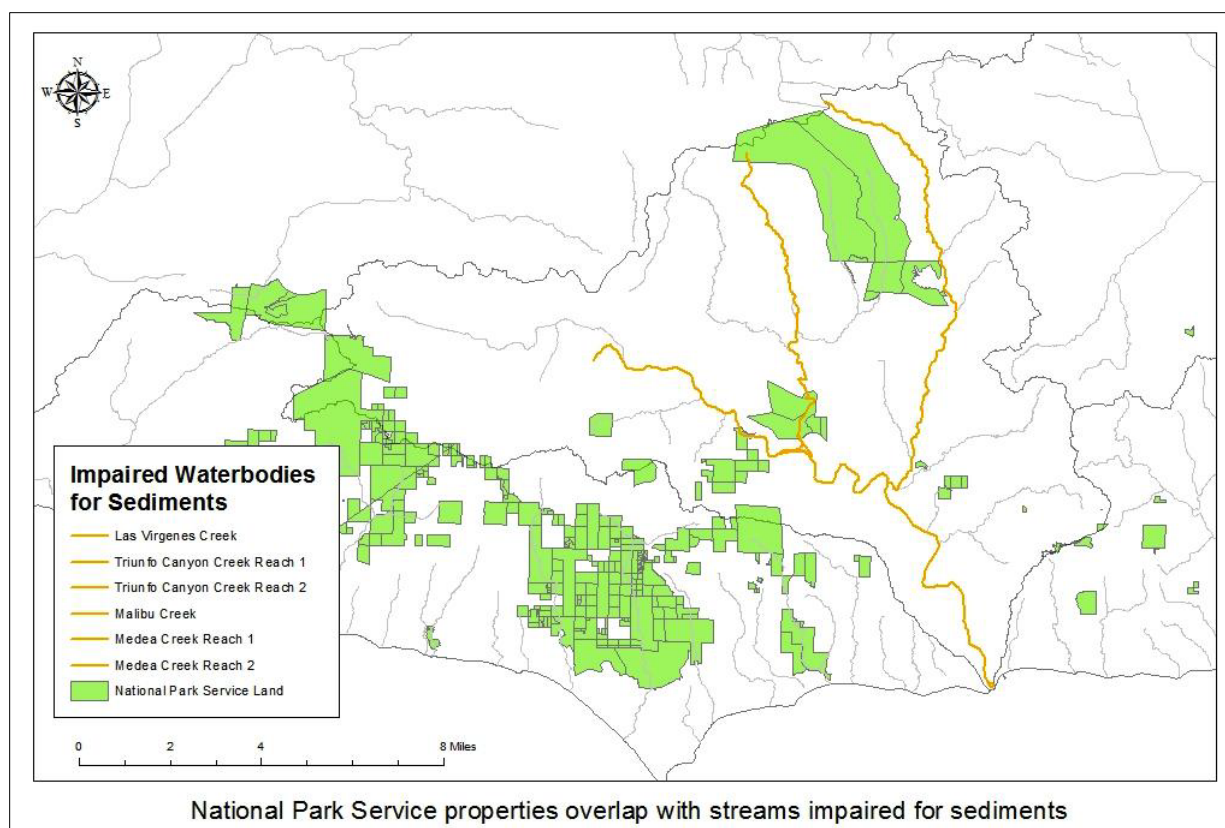


Figure A3. Map of National Park Service properties in the vicinity of waterbodies impaired by sediment.

A1.4 Benthic Macroinvertebrates

The Malibu Creek TMDL for Sedimentation and Nutrients to Address BMI Impairments establishes targets for benthic macroinvertebrate health in terms of scores for the Southern California Index of Biotic Integrity and for a related metric called “Observed over Expected.”

A GIS-based review of NPS properties in the vicinity BMI-impaired stream reaches was conducted. Results are shown in the following table and map:

Table A4. National park Service properties in the vicinity of reaches impaired for benthic macroinvertebrates.

Reaches Impaired for BMI	NPS Properties in the Vicinity
Triunfo Creek Reach 2	None
Lindero Creek Reach 1	None
Medea Creek Reach 2	Palo Comado Canyon (NE corner)
Malibu Creek	None
Las Virgenes Creek	SHEA Open Space (SE corner of Cheeseboro Canyon)

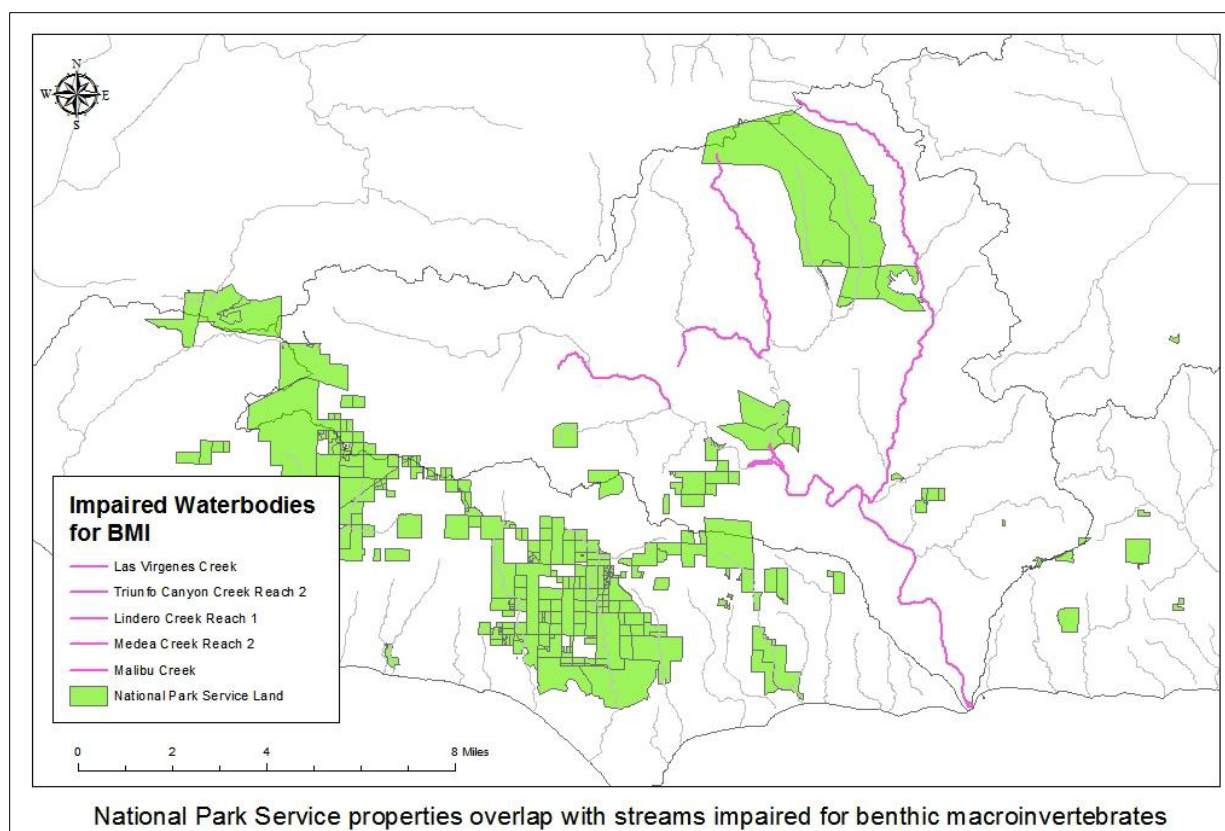


Figure A4. Map of National Park Service properties in the vicinity of waterbodies impaired for benthic macroinvertebrates.

A1.5 Other Impairments

Impairments for other pollutants exist in a number of stream reaches throughout the NRA, including:

- Lead (Grapito Creek and Santa Monica Canyon)
- Lead, mercury and selenium (Malibu Creek Watershed)
- DDT, PCBs, and pesticides (Calleguas Creek Watershed)

Although TMDLs have not yet been developed for these impairments, it is unlikely that NPS would be named as a non-point source contributor due to the location of the impaired reaches with respect to NPS properties, and because protected park lands are not expected to be significant sources of these pollutants.

Invasive species are identified as an impairment within Solstice Canyon Creek, Lindero Creek Reach 1, Medea Creek Reach 2, Malibu Creek and Las Virgenes Creek. There is some indication that while “invasive species” was at one time considered as a possible impairment listing, the State Board may have decided not to make it an official listing (pers. communication with Dr. Cindy Lin, EPA Region 9). Although it’s not clear what the future direction will be for these listings, SAMO’s aquatic amphibian monitoring protocol already gathers information on invasive species.

A1.6 TMDL Status Summary

The following table summarizes the Total Maximum Daily Loads (TMDLs) in effect, in progress, or draft for waterbodies within the SMMs.

Table A5. National park Service properties in the vicinity of reaches impaired for benthic macroinvertebrates.

Waterbody	Pollutant	No.	In Effect	Applicability to NPS	Notes
Malibu Creek	Trash	2008-007	2009	NPS is named as a non-point source in this TMDL. The Load Allocation is zero trash. Expected activities include monitoring, reporting and implementing BMPs.	—
Santa Monica Bay	Nearshore Debris	R10-010	2012	NPS is named as a non-point source in this TMDL. The Load Allocation is zero trash. Expected activities include monitoring, reporting and implementing BMPs.	—
Malibu Creek	Bacteria	2004-019R	2006	NPS is not listed as a responsible jurisdiction or agency; however, TMDL states: "The Santa Monica Mountains Conservancy and the National Park Service as the owner of natural parkland also are responsible for water quality monitoring and compliance with load allocations resulting from anthropogenic sources (e.g., onsite wastewater treatment systems) from lands under their jurisdiction."	There is a proposed "reconsideration" document, approved by State Board May 2013, but not yet approved by OAL or the EPA. Revision would change compliance calculations, but NPS still referenced in same way as in the 2006 TMDL.
Malibu Creek	Nutrients	N/A	TBD	NPS is not specifically named in this TMDL. However, page 43 states that load allocations provide for 90% reduction in nutrient loading from undeveloped land area, and includes recommendations for load reductions from open spaces, but implementation recommendations only include two items of potential applicability to NPS: septic systems and horses/livestock areas.	EPA established this TMDL in 2003, but no Regional Board action has been taken yet.
Malibu Creek	Sedimentation and Nutrients to address BMI impairments	N/A	TBD	Under the Sediment Load Allocations (page 218, Table 10-2), NPS is identified as one of the owners of protected land below Malibou Lake (although there is just a very small amount of NPS-owned property within the tributary area). Although not named explicitly, NPS may also be included as an owner of some open space that drains to Las Virgenes Creek. Under the Load Allocations for TN/TP (page 229, Table 10-4), there are values established for "other non-point sources (including parks and forested lands)." There are also values specified for on-site waste disposal systems. The process for achieving / monitoring for compliance is not clear.	EPA established this TMDL on July 2, 2013, but the Regional Board has not yet taken action.

Table A5 (continued). National park Service properties in the vicinity of reaches impaired for benthic macroinvertebrates.

Waterbody	Pollutant	No.	In Effect	Applicability to NPS	Notes
Santa Monica Bay	DDTs and PCBs	–	2012	NPS is not named in this TMDL.	It specifically states that "load allocations were not given to National Parks, State Parks or conservation areas."
Santa Monica Bay	Beaches Wet Weather Bacteria	2002-022	2003	NPS is not named in this TMDL	–
Santa Monica Bay	Beaches Dry Weather Bacteria	2002-004	2003	NPS is not named in this TMDL	–
Calleguas Creek	Nitrogen	2002-017	2003	NPS is not named in this TMDL	Revised in 2009 and No. changed to: 2008-009
Calleguas Creek	Toxicity	2005-009	2006	NPS is not named in this TMDL	–
Calleguas Creek	OC Pesticides, PCBs and Siltation	2005-010	2006	NPS is not named in this TMDL	–
Calleguas Creek	Metals	2006-012	2007	NPS is not named in this TMDL	–
Calleguas Creek	Trash	2007-007	2008	NPS is not named in this TMDL	–
Calleguas Creek	Salts	2007-016	2008	NPS is not named in this TMDL	–

A1.7 SMM Waterbodies and Impairments

The following table lists all Santa Monica Mountains freshwater bodies and shows impairment status as of 2010. See discussion below the table for further explanation.

Although there is an updated 303(d) list within the 2012 Integrated Report (approved by the EPA on July 30, 2015 and posted at:

http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2012.shtml), according to the Staff Report dated April 8, 2015 and posted on that same webpage, this only includes changes to Regions 1, 6, and 7 (SMM NRA is in Region 4). This is in keeping with the new State Water Board Policy of “rolling” updates to the Integrated Report, which is scheduled to incorporate Region 4 updates sometime in 2016. However, for unknown reasons, there was a change to the status of Cold Creek between the 2010 Integrated Report and the updated 2012 list – it moved from Category 2 to Category 3. This is noted in the table below.

Table A6. Santa Monica Mountains freshwater bodies and their impairment status as of 2010.

Hydrologic Unit(s)	Stream Name	Notes	Impairment Pollutant Categories
Calleguas Creek (HU10): Upper Conejo Arroyo (HU12)	Arroyo Conejo	<i>Part of Reach 13 (everything upstream of N. Fork is Reach 13)</i>	–
	North Fork A. Conejo	<i>Now called Calleguas Creek Reach 12</i>	Ammonia, Chlordane (tissue), DDT (tissue), Dieldrin, PCBs, Sulfates, TDS, Toxaphene (Category 4a)
	Skeleton Canyon	<i>Seems to be part of Reach 13</i>	–
	S. Branch A. Conejo	<i>Now called Calleguas Creek Reach 13 or Conejo Creek South Fork</i>	Ammonia, Chema (tissue), Chlordane, Chloride, DDT (tissue), Dieldrin, Endosulfan (tissue), PCBs, Sulfates, TDS, Toxaphene, Toxicity (Category 4a)
Big Sycamore Canyon - Frontal SM Bay (HU10): Big Sycamore Canyon (HU12), Arroyo Sequit-Frontal Pacific Ocean (HU12), Zuma Canyon-Frontal Pacific Ocean (HU12), Solstice Canyon-Frontal Santa Monica Bay (HU12)	Big Sycamore Cyn	–	–
	Wood Canyon	–	–
	Serrano Canyon	–	–
	La Jolla Canyon	–	–
	Deer Canyon	–	–
	Little Sycamore Cyn	–	–
	Arroyo Sequit	W. Fork Arroyo Sequit	–
	–	E. Fork Arroyo Sequit	–
	–	Mainstem A. Sequit	–
	Willow Creek	–	–
	San Nicholas Canyon	–	(Category 3 – Sulfates)
	Los Alisos Canyon	–	(Category 3 – Sulfates)
	Lachusa Canyon	–	(Category 3 – Sulfates)
	Encinal Canyon	–	(Category 3 – Sulfates)
	Steep Hill Canyon	–	–
	Trancas Canyon	–	(Category 3 – Chloride, Sulfates)
	Zuma Canyon	Zuma Canyon	–
	–	Newton Canyon	–
	–	–	–
	Walnut Canyon	–	–
	Ramirez Canyon	–	(Category 3 – Sulfates)
	Escondido Canyon	–	(Category 3 – Sulfates)
	Latigo Canyon	–	(Category 3 – Sulfates)
	Solstice Canyon Creek	Solstice Canyon Creek	Invasive Species (Category 5)
	–	Dry Canyon	–
	Corral Canyon	–	(Category 3 – Sulfates)
	Puerco Canyon	–	(Category 3 – Sulfates)
	Marie Canyon	–	(Category 3 – Sulfates)
	Winter Canyon	–	–

Table A6 (continued). Santa Monica Mountains freshwater bodies and their impairment status as of 2010.

Hydrologic Unit(s)	Stream Name	Notes	Impairment Pollutant Categories
Malibu Creek (HU10): Potrero Valley Creek (HU12), Medea Creek (HU12), Cold Creek - Malibu Creek (HU12), Las Virgenes Creek (HU12)	Lindero Creek Reach 1	—	Algae, BMI, Coliform Bacteria, Invasive Species, Scum/Foam-unnatural, Selenium, Trash (<i>Category 5</i>)
	Lindero Creek Reach 2 (Above Lake)	—	Algae, Coliform Bacteria, Scum/Foam-unnatural, Selenium, Trash (<i>Category 5</i>)
	Lake Lindero	—	Algae, Chloride, Eutrophic, Odor, Selenium, SC, Trash (<i>Category 5</i>)
	Palo Comado Creek	—	Coliform Bacteria (<i>Category 4a</i>)
	Cheeseboro Canyon	—	—
	Medea Creek Reach 2	—	Algae, BMI, Coliform Bacteria, Invasive Species, Sedimentation/Siltation, Selenium, Trash (<i>Category 5</i>)
	Medea Creek Reach 1	—	Algae, Coliform Bacteria, Sedimentation/Siltation, Selenium, Trash (<i>Category 5</i>)
	Cold Creek	Cold Creek	(Category 3 – Sulfates and Invasive Species) – Note that this stream was listed as Category 2 in the 2010 303(d) list.
	—	Dark Canyon	—
	—	Sleeper Canyon	—
	Malibu Creek	—	BMI, Coliform Bacteria, Fish Barriers (fish passage), Invasive Species, Nutrients (Algae), Scum/Foam-unnatural, Sedimentation / Siltation, Selenium, Sulfates, Trash (<i>Category 5</i>)
	Triunfo Creek Reach 1	—	Lead, Mercury, Sedimentation /Siltation (<i>Category 5</i>)
	Malibou Lake	—	Algae, Eutrophic, Organic Enrichment/Low DO (<i>Category 4a</i>)
	Las Virgenes Creek	—	BMI, Coliform Bacteria, Invasive Species, Nutrients (Algae), Organic Enrichment/Low DO, Scum/Foam-unnatural, Sedimentation /Siltation, Selenium, Trash (<i>Category 5</i>)
	East Las Virgenes Cyn	—	—
	Gates Canyon	—	—
	Liberty Canyon	—	—
	Stokes Creek	—	Coliform Bacteria (<i>Category 4a</i>)

Table A6 (continued). Santa Monica Mountains freshwater bodies and their impairment status as of 2010.

Hydrologic Unit(s)	Stream Name	Notes	Impairment Pollutant Categories
Garapito Creek - Frontal SM Bay (HU10): Santa Monica Beach - Frontal Santa Monica Bay (HU12), Garapito Creek (HU12), Santa Monica Canyon (HU12)	Sweetwater Cyn Crk	–	(Category 3 – Chloride, Sulfates)
	Carbon Cyn Creek	–	(Category 3 – Chloride, Sulfates)
	Las Flores Cyn Crk	Las Flores Cyn Creek	(Category 3 – Sulfates)
	–	Little Las Flores Cyn	–
	Piedra Gorda Cyn Crk	–	–
	Pena Canyon Creek	–	(Category 3 – Sulfates)
	Tuna Canyon Creek	–	(Category 2 – Meets beneficial use for WARM FRESHWATER HABITAT)
	Santa Ynez Canyon	Santa Ynez Canyon	(Category 3 – Sulfates)
	–	Quarry Canyon	–
	–	Trailer Canyon	–
	La Pulga Canyon	–	–
	Temescal Canyon	–	–
	Topanga Canyon	Topanga Canyon	Lead (Category 5)
	–	Brookside Canyon	–
	–	Dix Canyon	–
	–	Greenleaf Canyon	–
	–	Garapito Creek	–
	–	Santa Maria Creek	–
	Old Topanga Canyon	Old Topanga Canyon	–
	–	Hondo Canyon	–
	–	Red Rock Canyon	–

[The State Water Resources Control Board](#) website contains details of the 303(d) “integrated report” which assigns every assessed water segment into one of the following categories:

- **Category 5** – 1) A water segment where standards are not met and a TMDL is required, but not yet completed, for at least one of the pollutants being listed for this segment.
- **Category 4a** – 1) A water segment where ALL its 303(d) listings are being addressed; and 2) at least one of those listings is being addressed by a US EPA approved TMDL.
- **Category 4b** – A water segment where ALL its 303(d) listings are being addressed by action(s) other than TMDL.
- **Category 4d** - A water that is impacted by non-pollutant related cause(s).
- **Category 3** – A water with water quality information that could not be used for an assessment, for reasons such as: monitoring data have poor quality assurance, not enough samples in a dataset, no existing numerical objective or evaluation guideline, the information alone cannot support an assessment, etc.

- **Category 2** – 1) A water that supports some, but not all, of its California beneficial uses; and 2) has other uses that are not assessed or lack sufficient information to be assessed.
- **Category 1** – 1) A water that supports a minimum of one California Beneficial Use for each Core Beneficial Use that is applicable to the water; and 2) has no other uses impaired.

For reaches designated as impaired (Categories 5, 4a or 4b) Table A6 above contains the list of pollutants for which the reach is impaired. For reaches designated as Category 3, the last column in Table A6 indicates the pollutant for which there is insufficient information. For reaches designated as Category 2, the last column indicates the beneficial use which lacks sufficient information to be assessed. There are currently no streams listed in Categories 1 or 4c. Any reaches in Table A6 that do not fall into one of these categories have not been assessed by the Water Board.

A2 – Current and Previous Monitoring

The following data sets from various stakeholders in the SMMs, representing legacy programs as well as ongoing monitoring, were reviewed as part of this Protocol development.

2.1 NPS Baseline Water Quality Data Inventory and Analysis Report for SAMO

This report (NPS, 1996) was developed by the NPS Water Resources Division and presents a compilation of water quality data from six EPA data bases, including the Storage and Retrieval (STORET) water quality database management system, from as early as 1951 through December 1991. Compiled data includes monitoring conducted within a large region beyond the borders of the SMM NRA.

2.2 NPS Water Quality Monitoring Protocol

Data collected under the current monitoring protocol from 2006-2011 was analyzed by a UCLA student team with review and oversight by Dr. Felicia Federico (Chan et al. 2013).

2.3 MEDN Aquatic Amphibian Monitoring Protocol

Aquatic amphibian monitoring under this protocol (Delaney et al. 2011) is described in the main section of the Water Quality Protocol Narrative.

2.4 Las Virgenes Municipal Water District Monitoring Program

The LVMWD conducts ongoing monitoring required by its NPDES permit for discharge from the Tapia Water Reclamation Facility. LVMWD has compiled data collected through its own monitoring, as well as data from other sources to develop a Malibu Creek Comprehensive Report, issued March 30, 2011. LVMWD subsequently developed the Malibu Creek Watershed Monitoring Plan, issued March 28, 2012, as a submission to the Los Angeles Regional Board. This Plan identifies overlaps among entities monitoring within the watershed, recommends changes from grab sampling to continuous monitoring for some parameters, and proposes a revised program of monitoring for LVMWD. The Plan is still under review by the Regional Board.

2.5 Southern California Stormwater Monitoring Coalition (SMC)

This bioassessment monitoring program is implemented by SCCWRP (Southern California Coastal Water Research Project, a joint-powers authority) on behalf of major municipalities and counties, and

their state/federal regulatory counterparts. The program began in 2009 and is currently in the fifth year of a five-year program. The program was designed to answer the questions:

- What is the condition of southern California streams?
- What stressors affect stream condition?
- Is stream condition changing over time?

Bioassessments are conducted using California State protocols developed through the Surface Water Ambient Monitoring Program (SWAMP) protocols. SCCWRP issued Technical Report 639 (Mazor et al. 2011) describing findings from the first year (2009) of monitoring. A final report on all five years of the program is currently in draft, and priorities for the next five years of the program (starting in 2015) are currently under development.

2.6 Other SCCWRP Studies

SCCWRP has also issued other relevant reports based on regional monitoring that can provide specific data for SMM streams as well as provide a regional context against which to compare. These include: Technical Report 500 – Natural Loadings (Stein and Yoon, 2007), and Technical Report 510 - Sources, Patterns and Mechanisms of Storm Water Pollutant Loading from Watersheds and Land Uses of the Greater Los Angeles Area (Stein et al. 2007).

2.7 County and Municipal Regulatory Monitoring

Los Angeles and Ventura County, as well as cities including Malibu, have additional monitoring requirements under the Municipal Separate Storm Sewer System (MS4) Permit beyond what is addressed through the SMC. This includes data collected at mass-emissions stations and bacteria monitoring at beaches. LA County mass emissions stations currently within the SMM include Malibu Creek at Piuma. Ventura County stations include lower Calleguas Creek at University Drive and Hill Canyon WWTP within the Upper Conejo Arroyo subwatershed. LA County Tributary Monitoring Stations T25-T30 included Upper Las Virgenes Creek, Cheseboro Canyon, Lower Lindero Creek, Medea Creek, Liberty Canyon Channel, and a tributary to Triunfo Creek.

Such regulatory data is used by the State Water Board to make decisions on impairment listings (303d list) is generally available through the State Board website, although it is not compiled into a readily usable form or GIS layer. All new data should also be uploaded to the California Environmental Data Exchange Network (CEDEN), a joint program of the US EPA and the State Water Board.

2.8 Heal the Bay Monitoring Program

Heal the Bay has been conducting monitoring for many years in the Malibu Creek Watershed, through a very strong citizen science program. Based on water chemistry and bioassessment data collected from 2000-2012, they issued a report in 2013 entitled: Malibu Creek Watershed, Ecosystem on the Brink: A Scientific Roadmap for Protecting a Critical Natural Resource. Heal the Bay is currently reassessing the future of their monitoring program and are considering reductions in the

number of sites within Malibu Creek Watershed and potential expansion to other SMMs coastal watersheds.

2.9 USGS Monitoring

USGS does not have a specific monitoring program for the SMMs, but periodically collects water quality data along with aquatic amphibian monitoring in the area. Historical monitoring data from USGS can be searched using their water quality data portal at [USGS Water-Quality Information](#). The comprehensive report for Malibu Creek Watershed developed by LVMWD includes historical USGS data.

2.10 Red legged frog water chemistry monitoring

In collaboration with SAMO staff, single-event water chemistry sampling was conducted by the Regional Board on May 22-23, 2013 at six sites in the SMMs that were being considered for red-legged frog reintroduction. Samples were analyzed for total trace metals in freshwater samples and for pyrethroids (a common class of insecticides) in sediment samples. All sediment samples were non-detect for pyrethroids and most trace metals results in freshwater were either non-detect or below water quality objectives.

2.11 Resource Conservation District SMM Monitoring

The RCD has conducted monitoring in both the Malibu Creek and Topanga Canyon Watersheds. They issued a report entitled: 2010 Water Quality Monitoring Final Progress Report, containing results from three continuous data multi-meters installed in lower Malibu Creek and one in Topanga creek from April to October 2010. Data were collected for temperature, DO, chlorophyll, pH, turbidity, conductivity and salinity. RCD also conducts annual aquatic amphibian monitoring, as well as bioassessments at 4 reaches in Topanga Creek Watershed (however, SWAMP bioassessment protocols are only used at two of these sites). Rosi Dagit is the primary contact at the RCD SMM for this work.

2.12 Pepperdine University

Pepperdine conducts aquatic amphibian monitoring at nine sites including in Arroyo Sequit, Trancas and Zuma Canyons, Cold Creek, Triunfo and Tuna Canyon. However, only field water chemistry parameters are recorded, no additional water quality analysis is conducted. Professor Lee Kats is the primary contact at Pepperdine for this work.

Summary of Water Chemistry Monitoring Results 2006-2011

The following tables and figures summarize the water chemistry data collected from 2006-2011 under the draft I&M water quality monitoring protocol (Hibbs et al. 2011a). More details can be found in the UCLA report provided to SAMO on August 14, 2013 (Chan et al. 2013). The UCLA study aimed to understand the relationships between native amphibian presence/abundance and water chemistry metrics. However, due to mis-timing of water chemistry measurements with respect to the amphibian monitoring program, there was insufficient data to assess these relationships. However, the water chemistry data was summarized and compared to water quality objectives / benchmarks (Table A7).

Table A7. Summary of water chemistry results from SAMO monitoring 2006-2011 (Hibbs et al. 2011a data).

Parameter	Units	Mean	Min	Max	SD	Compared to WQ Objectives / Criteria / Benchmarks
Dissolved oxygen	mg/L	8.15	0.10	15.9	2.71	24 of 38 sites with measurements <7mg/L WQO
Specific conductance	NTU	1,985	349	5,110	987	ALL sites > 500 NTU benchmark
Phosphate-P	mg/L	0.13	ND	2.13	0.26	Three sites have levels significantly higher than EPA WQC of 0.1mg/L
Temperature	°C	16.6	8.0	33.2	4.0	Two measurements > 26.5 °C WQO for warm water streams
Ammonia-N	mg/L	0.09	0.01	7.50	0.46	Two measurements > WQO of 3mg/L but most <1mg/L
pH	pH	7.95	6.95	8.70	0.34	No sites <6.5 (lower WQO); a few measurements >8.5 (upper WQO)
Nitrate-N	mg/L	0.63	ND	6.86	1.16	All sites meet WQO of 10 mg/L

Appendix B: Detailed Background Information on CHIS

Table B1. Major streams on Santa Rosa Island.

Orientation	Stream Name
Discharges to north	Garanon Canyon
	Tecelote Canyon
	Tecelotito Canyon
	Arlington Canyon
	Soledad Canyon
	Dry Canyon
	Verde Canyon
	Trap Canyon
	Cow Canyon
	Lobo Canyon
Discharge to east	Windmill Canyon
	Cherry Canyon
	Water Canyon
	Quemada Canyon
	Old Ranch Canyon
	Box Canyon
Discharge to south	Old Ranch House Cyn
	[Unnamed]
	San Augustine Canyon
	Wreck Canyon
	Jolla Vieja Canyon
Discharge to west	[Unnamed]
	[Unnamed]
	Trancion Canyon
	Alcapulco Canyon
	Whetstone Canyon
	[Unnamed]
	Bee Canyon



Figure B1. Maps of streams on Santa Cruz (top) and San Miguel (bottom) islands at Channel Islands National Park.

Previous Monitoring

The following reports of previous monitoring at CHIS were reviewed as part of this Protocol development.

2.1 NPS Baseline Water Quality Data Inventory and Analysis Report for CHIS (1983 to 1994)

This report (NPS 1999) was developed by the NPS Water Resources Division and presents a compilation of water quality data through December 1994 from six EPA databases, including the Storage and Retrieval (STORET) water quality database management system.

The following sections from the report abstract provide an overview of findings:

The results of the STORET retrieval for the study area yielded 2,055 observations for 14 separate parameters collected by the NPS at 15 monitoring stations from 1983 through 1994. All 15 monitoring stations were located within the park boundaries. Eleven stations were located on Santa Rosa Island and four stations were located on Santa Cruz Island. Eight of the monitoring stations represent either one-time or intensive single-year sampling efforts by the collecting agencies. The seven monitoring stations (all on Santa Rosa Island) sampled during more than one year were: (1) Quemada Canyon near the Old Ranch Canyon Corral (CHIS 0006); (2) Quemada Canyon near the Las Cruces Corral (CHIS 0007); (3) Water Canyon below NPS campground (CHIS 0008); (4) Water Canyon adjacent to the corral (CHIS 0009); (5) Clapp Spring at head of San Augustine Canyon (CHIS 0012); (6) Lobo Canyon below Smith Highway (CHIS 0014); (7) Lobo Canyon near lower end of cattle enclosure (CHIS 0015).

The results of the CHIS water quality criteria screen found four groups of parameters that exceeded screening criteria at least once within the study area. Dissolved oxygen exceeded the EPA criterion for the protection of freshwater aquatic life. Fecal-indicator bacteria concentrations (total coliform and fecal coliform) and turbidity exceeded the WRD screening limits for freshwater bathing and aquatic life, respectively.

2.2 Federal Interagency Riparian Assessments – Proper Functioning Condition – Santa Rosa Island (1995/2004)

In conjunction with staff from the NPS WRD, US Forest Service and Bureau of Land Management, CHIS staff performed assessments of riparian condition on ten reaches throughout Santa Rosa Island watersheds using the BLM Proper Functioning Condition (PFC) protocol (USDI 1993, 1998). This work was done as a response to the Cleanup or Abatement Order issued by the Regional Board in 1995. The initial assessments were conducted in 1995 (Rosenlieb et al. 1995a, b). Cattle were removed from the island in 1998 and follow-up assessments were conducted in 2004 (Wagner et al. 2004). Deer and elk were still present on the island at the time of the follow-up assessments. The following table from Wagner et al. (2004) summarizes the results:

Table B2. Proper Functioning Condition assessment results of ten reaches throughout Santa Rosa Island.

Stream Reach (Name and ID# from Table B1)	1995 PFC Rating	2004 PFC Rating
Windmill Canyon (1) ¹	Functional – At Risk (High)	Functional – At Risk (High)
Lobo Canyon (2) ¹	Proper Functioning Condition	Proper Functioning Condition
Lobo Canyon (3) ¹	Proper Functioning Condition	Proper Functioning Condition
Arlington Canyon (4)	Nonfunctional	Proper Functioning Condition
Arlington Canyon (5)	Nonfunctional	Proper Functioning Condition
Arlington Canyon (6)	Nonfunctional	Proper Functioning Condition
Acapulco Canyon (7)	Functional – At Risk	Functional – At Risk
Quemada Canyon (8)	Nonfunctional	Proper Functioning Condition
Old Ranch Canyon (9)	Nonfunctional	Proper Functioning Condition
Jolla Vieja Canyon (10)	Nonfunctional	Proper Functioning Condition

1 Reference Reach

Proper Functioning Condition (PFC) is an assessment method developed by the Bureau of Land Management (USDI 1993, 1998). The following description of this method is excerpted from Wagner et al. (2004):

The PFC technique uses an interdisciplinary team to assess the “functional condition” of riparian systems according to 17 hydrology, vegetation, and stream geomorphology factors. The “Proper Functioning Condition” of a riparian area refers to the stability of the physical system, which in turn is dictated by the interaction of geology, soil, water, and vegetation. A properly functioning riparian area is in dynamic equilibrium with its streamflow forces and channel processes. Based on assessments of the 17 hydrologic, vegetative, and geomorphology elements of the riparian area, the interdisciplinary team assigns one of the following three functionality ratings to a site:

- **Proper Functioning Condition (PFC)**—Streams and associated riparian areas are functioning properly.
- **Functional-At Risk**—These riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation.
- **Nonfunctional**—These are riparian areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, sustaining desirable channel and riparian habitat characteristics, and so on as described in the PFC definition.

2.3 UC Santa Barbara Monitoring – Santa Rosa Island (2005-2007)

Researchers from UC Santa Barbara conducted monitoring on Santa Rosa Island during the period from 2005-2007 (Melack and Cooper, 2008) at 18 locations throughout 11 watersheds, selected as most likely to demonstrate residual impairment due to previous cattle grazing and to represent the island's range of variability in stream hydrochemistry. Monitoring included water chemistry and bacteria samples conducted 5 times between August 2005 and July 2007, and a benthic macroinvertebrate survey conducted in June 2006.

The following table was created as part of the research for this Protocol to summarize the monitoring program conducted under this project, based on the reported results in Melack and Cooper (2008). The following table lists the water quality monitoring dates for 2005 to 2007.

Table B3. Water quality monitoring conducted at Santa Rosa Island by Melack and Cooper (2008). A check mark (✓) indicates that water quality monitoring took place at that site and date combination.

Site	Watershed	Aug 2005	Dec 2005	Jun 2006	Apr 2007	July 2007	BMI Survey June 2006
AR01	Arlington Canyon	✓	✓	✓	✓	✓	✓
AR03	Arlington Canyon	✓	✓	✓	✓	–	✓
CL00	Clapp Spring	✓	✓	✓	✓	✓	–
JV01	Jolla Vieja Canyon	✓	✓	✓	✓	✓	✓
LO03	Lobo Canyon	✓	✓	✓	–	–	–
LO04	Lobo Canyon	✓	✓	✓	✓	✓	✓
QU02	Quemada Canyon	✓	✓	✓	✓	✓	✓
QU03	Quemada Canyon	✓	✓	✓	✓	✓	–
QU04	Quemada Canyon	✓	✓	✓	✓	–	✓
SL03	Soledad Canyon	✓	✓	✓	✓	✓	–
TC03	Tecelote Canyon	✓	✓	✓	✓	✓	–
VR01	Verde Canyon	✓	✓	✓	✓	–	✓
VR03	Verde Canyon	✓	✓	✓	✓	✓	–
WA02	Water Canyon	✓	✓	✓	✓	–	–
WA03	Water Canyon	✓	✓	✓	✓	✓	✓
WA04	Water Canyon	✓	✓	✓	✓	✓	✓
WM01	Windmill Canyon	✓	✓	✓	–	–	–
WR01	Wreck Canyon	✓	✓	✓	✓	✓	–

2.4 NPS Morphology Monitoring of Quemada Restoration Project (1999/2002)

A riparian restoration project was initiated on Quemada Canyon in 1998. In June 1999, stream channel surveys were conducted along 10 reaches of Quemada, and these same locations were resurveyed in August 2002. Results are documented in Section 4 “Geomorphic Cross-Sections of

Quemada Creek” of Wagner et al. (2004). This report includes the UTM coordinates for the 10 surveyed segments, as well as cross-sectional graphs comparing 1999 to 2002.

2.5 NPS / US Forest Service Stream Condition Inventory on Quemada Creek

NPS staff from the Water Resources Division conducted stream channel surveys on Santa Rosa Island 1998. Stream Condition Inventory (SCI) is an assessment approach developed by the USDA Forest Service (Frazier et al. 2005) that measures 18 stream condition attributes. These attributes are primarily physical (temperature, cross-section, width-to-depth ratio, streambank stability) but also includes some biological components such as macroinvertebrate sampling.

2.6 Vegetation Monitoring – Quemada Creek (2002)

Active vegetation restoration was undertaken along Quemada Creek in 1998. A series of 51 locations along the creek were identified, and vegetation restoration was conducted at half of these sites, alternating with non-planted control areas. Photographs were taken and other data recorded for each site. These sites were re-visited in 2002 and the same data and photographs were collected at 48 of the sites that could be identified (K. Faulkner, personal communication).

2.7 Santa Cruz Island – Stream Fauna (1990-1997)

Aquatic insect sampling was conducted by Dr. Laura Furlong and Dr. Adrian Wenner across seven streams on Santa Cruz Island (Furlong and Wenner 2000). However, only one of these streams (Coche) appears to be within the NPS-owned portion of the island. See also: Furlong, L. J. 1999. Biogeography and ecology of Santa Cruz Island Streams. Ph.D. Dissertation, University of California, Santa Barbara, California.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 963/150624, February 2019

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