Surface Water Ambient Monitoring Program (SWAMP)

Monitoring Plan for Cyanotoxins in Lakes/Reservoirs and Coastal Wetlands Region 9

FY 2012/2013

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1 Summary Sheet

Beneficial Uses

The proposed cyanotoxin monitoring plan for the Surface Water Ambient Monitoring Program (SWAMP) addresses a class of contaminants of emerging concern that may potentially impact many of the beneficial uses that have been designated for the lakes/reservoirs and coastal wetlands in the San Diego Region. These include, but are not limited to:

- Municipal and Domestic Supply (MUN)
- Agricultural Supply (AGR)
- Industrial Service Supply (IND)
- Industrial Process Supply (PROC)
- Ground Water Recharge (GWR)
- Freshwater Replenishment (FRSH)
- Contact Water Recreation (REC-1)
- Non-contact Water Recreation (REC-2)
- Warm Freshwater Habitat (WARM)
- Cold Freshwater Habitat (COLD)
- Wildlife Habitat (WILD)
- Rare, Threatened, or Endangered Species (RARE)
- Preservation of Biological Habitats of Special Significance (BIOL)
- Estuarine Habitat (EST)
- Marine Habitat (MAR)
- Migration of Aquatic Organisms (MIGR)
- Shellfish Harvesting (SHELL)

Assessment Questions

The proposed monitoring plan provides details for an initial investigation, or screening, of the presence of cyanotoxins in the lakes/reservoirs and coastal wetlands in the San Diego Region. These efforts will be used to address the following assessment questions:

a. In which lakes/reservoirs and coastal wetlands in the San Diego Region are cyanotoxins present?
b. Which toxins (e.g., microcystin variants, anatoxin-a, nodularin) are found in these water bodies?
c. Are there correlations between cyanotoxin presence and specific conditions (e.g., dissolved nutrients, temperature, etc.) at the sites?

Link to Framework for Monitoring and Assessment in the San Diego Region

The cyanotoxin screening of lakes/reservoirs and coastal wetlands in the San Diego Region, conducted under this monitoring plan, will support the Framework for Monitoring and Assessment in the San Diego Region (Busse and Posthumus, 2012) that was adopted by the Board on December 12, 2012. The new approach is systematic, logical, question-driven, and is water-body oriented rather than discharge-oriented. The Framework illuminates the need for conditions monitoring (referred to as M1) on an ongoing basis to determine if/how conditions are changing in the water bodies of the San Diego Region. The proposed screening will provide valuable input about the conditions of the lake/reservoirs and coastal wetlands in the San Diego Region, which help address the most basic questions that reflect the fundamental concerns about beneficial uses, such as:

- Is the water safe to drink?
- Are the fish and shellfish safe to eat?
- Is water quality safe for swimming and other recreational activities?
- Are habitats and ecosystems healthy?

Clean Water Act Section 305(b)

The data produced by this monitoring plan will be used in water body assessments required under Clean Water Act (CWA) section 305(b).

Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA)

The HABHRCA of 2004, implemented through the President's U.S. Ocean Action Plan, recognizes the importance of harmful algal blooms as a high priority national issue and mandates to advance scientific understanding and ability to detect, monitor, assess and predict harmful algal blooms and hypoxia events in coastal waters. The proposed monitoring plan contributes to these efforts and will provide valuable information about water bodies (i.e., inland and freshwater) that have not been studied extensively.

2 Background

2.1 Introduction

Toxic cyanobacteria have been reported in freshwater, brackish, and marine environments all over the world (World Health Organization (WHO), 1999 and Office of Environmental Health Hazard Assessment (OEHHA), 2012). Cyanobacterial blooms, often caused by anthropogenic eutrophication of surface waters, represent a major ecological and human health problem. Cyanobacteria can be found on the water surface, in benthic zones, and within the water column. When cyanobacteria die, a cell breaks, or a benthic mat detaches, cell membranes rupture and can release toxins into the water. Besides releasing toxins when blooms die, the decaying process of cyanobacteria consumes oxygen, can cause taste and odor problems for drinking water, and may destroy fishery habitats. Harmful cyanobacteria blooms can also impair boating activities by clogging channels and water filters.

Toxins released by various cyanobacteria species include neurotoxins (affect nervous system), hepatotoxins (affect liver), and dermatoxins (affect skin). Table 1 shows some of the specific cyanotoxins responsible for the effects (WHO, 1999), and Table 2 lists the cyanotoxin and taxa known to produce the toxin (WHO, 2003 and Castle and Rogers, 2009).

Table 1. Cyanotoxins listed by toxin type (WHO, 1999)

TOXIN TYPE	CYANOTOXINS
Dermatoxins	Lyngbyatoxins
Neurotoxins	Anatoxins
	Saxitoxins
	B-methylamino alanine (BMAA)
Hepatotoxins	Cylindrospermopsin
	Microcystins (approx. 80 known variants)

Table 2. Taxa known to produce specific cyanotoxin(s) (WHO, 2003 and Castle and Rogers, 2009)

Cyanotoxins	Taxa known to produce toxin(s)
Microcystins in general Microcystin-LR Microcystin-YR Microcystin-RR	*Microcystis* *Planktothrix* *Oscillatoria* *Nostoc* *Anabaena* *Anabaenopsis* *Hepalosiphon* *Nodularia* *Synechococcus* *Phormidium* *Woronichinia naegeliana*
Nodularin	*Nodularia spumigena*

Anatoxin-a (alkaloid)	*Anabaena* *Oscillatoria* *Aphanizomenon* *Cylindrospermum* *Planktothrix*
Saxitoxins	*Anabaena* *Lyngbya* *Cylindrospermopsis raciborskii* *Aphanizomenon*
Cylindrospermopsin	*Cylindrospermopsis raciborskii* *Aphanizomenon*

Humans, pets, livestock, and wildlife may be exposed to cyanotoxins in a variety of ways. Humans can inadvertently ingest contaminated water while participating in recreational water activities such as swimming, boating, and waterskiing. The toxins may also be aerosolized and inhaled or consumed when eating contaminated shellfish. Pets and wildlife may ingest cyanobacterial scum and drink contaminated water. Some animals tend to be attracted to the drying clumps of cyanobacteria (also called crusts or mats) that have washed onto the land (Office of Environmental Health hazard Assessment (OEHHA), 2012).

Presence of high levels of cyanotoxins in recreational or drinking water can cause symptoms in humans that include: fever, headaches, muscle and joint pain, blisters, stomach cramps, diarrhea, vomiting, mouth ulcers, and allergic reactions. There is evidence that some cyanotoxins, especially hepatotoxins, are potent tumor promoters (Carmichael, 2001). In the most severe cases, effects can include seizures, liver failure, respiratory arrest, and (rarely) death. Harmful cyanobacteria and their toxins are contaminants of emerging concern and were placed on the Candidate Contaminant List (CCL) by the United States Environmental Protection Agency in July 2012 (USEPA, 2012). Included on the list are microcystin-LR, anatoxin-a, and cylindrospermopsin.

Cyanobacteria blooms have been documented throughout the State of California. Table 3 provides a list of some of the water bodies where cases have been reported (California Department of Public Health, 2012).

Table 3. Water bodies with documented cyanobacteria blooms (CA Dept. of Public Health, 2012)

Water Body	County
Klamath River	Siskiyou
Big Lagoon, Eel River	Humbolt
Clear Lake	Lake
Lake Isabella	Kern
Crowley	Mono
Lake Elsinore	Riverside
San Francisco Bay Delta	multiple counties
Stockton Channel	San Joaquin
Pinto Lake	Santa Cruz

There is evidence that cyanobacteria, microcystin (the most widespread toxin produced by cyanobacteria), and other toxins occur in various water body types throughout the San Diego Region. A 2012 screening of streams and depressional wetlands in the San Diego Region, which is further described below in section 2.2.1, produced many samples that tested positive for cyanotoxins. Magrann (2011) found microcystin, anatoxin-a, and cylindrospermopsin in Buena Vista Lagoon, San Juan Creek, Lake San Marcos, and San Mateo Lagoon in samples that were collected in 2009. There is an ongoing investigation of the nutrient impairments of Lake San Marcos, which includes some cyanotoxin monitoring. Microcystin-LR and Microcystin-RR were detected using SPATT (Solid Phase Adsorption Toxin Tracking) samplers deployed in Lake San Marcos in the fall of 2012. The first sample, deployed from September 4, 2012 to September 24, 2012, had 3.6 ng/g of Microcystin-LR and 0.5 ng/g of Microcystin-RR. The second SPATT sample, deployed from September 24, 2012 to October 15, 2012, had slightly higher concentrations: 4.18 ng/g of Microcystin-LR and 1.56 ng/g of Microcystin-RR.

Many factors affect cyanobacteria bloom formation and persistence. These include light intensity, sunlight duration, nutrient availability, water temperature, pH, an increase in precipitation events, altered flow regimes, and water column stability. Many harmful cyanobacteria have the ability to fix nitrogen and can therefore thrive in nitrogen-depleted environments. Others, such as *Microcystis*, do not have nitrogen-fixing capabilities but may be favored by reduced forms of nitrogen (e.g., ammonium and urea rather than nitrate). Rising surface water temperatures, a result of the changing global climate, tend to favor cyanobacteria (O'Neil et al., 2012). At higher temperatures, cyanobacteria are able to outcompete other phytoplankton species. Warmer temperatures result in stronger vertical stratification of lakes and reduce vertical mixing. Cyanobacteria can exploit these conditions using cellular gas vesicles that create buoyancy, allowing them to rise to the top, warmer waters and cast shade over the non-buoyant phytoplankton (Paerl and Huisman, 2008).

Currently, a cyanobacteria and cyanotoxin monitoring program does not exist in the region, or in the State of California. In 2010, the Blue Green Algae Work Group, comprised of members from the State Water Resources Control Board (SWRCB), the California Department of Public health (CDPH), and Office of Environmental Health and Hazard Assessment (OEHHA), developed voluntary statewide guidance for educating and notifying the recreating public about blue-green algae blooms of non-marine water bodies in the state of California (SWRCB et al., 2010). In May 2012, OEHHA finalized a report that provides calculated health-based water concentration levels (action levels) of microcystins (LA, LR, RR, and YR), anatoxin-a, and cylindrospermopsin for people, pets, and livestock exposed to the cyanotoxins through various scenarios. Health-based concentrations in sport fish and shellfish were also calculated (OEHHA, 2012). These action levels may be applied as needed on a voluntary basis, by local, regional, state or tribal entities throughout California, to reduce exposures to cyanotoxins. On November 28, 2012, the State Water Resources Control Board and the SWAMP Bioaccumulation Oversight Group held a Cyanotoxin Workshop in Oakland, CA. The participants at the workshop felt strongly that there is a need for the State of California

to develop a statewide cyanotoxin/cyanobacteria monitoring program. It was agreed upon by the participants that the Blue Green Algae Working Group (BGA Group) would be formalized to create a network and ultimately a statewide monitoring program. This vision is moving forward at the next BGA group meeting scheduled for March 2013. Because cyanobacteria thrive under the conditions created by eutrophication and climate change and can cause detrimental ecological and economic impacts, a great need exists for the monitoring and mitigation of cyanobacteria and cyanotoxins in our region's waters.

In 2012, a SWAMP-funded cyanotoxin screening was conducted in streams and depressional wetlands in the San Diego Region. Under this monitoring plan, we will expand the screening dataset to include additional water body types. We propose to conduct cyanotoxin screening in lakes/reservoirs and coastal wetlands in the San Diego Region in 2013. Funding for this effort will be provided by SWAMP (FY 2012/2013).

2.2 Past Cyanotoxin Monitoring (SWAMP and non-SWAMP efforts)

2.2.1 Region 9 (San Diego Region)

Cyanotoxin Screenings

During FY 2011/2012, a cyanotoxin screening was conducted in streams and depressional wetlands in the San Diego Region. The stream sites were sampled as part of a larger effort by the Stormwater Monitoring Coalition (SMC) (Betty Fetscher, personal communication, February 12, 2013). The depressional wetland sampling sites were selected from a larger study on the extent and conditions of depressional wetlands conducted by the Southern California Coastal Water Research Project (SCCWRP) and the (San Diego, Santa Ana, and Los Angeles) Regional Water Boards (SCCWRP, 2011).

Samples for the screenings were obtained using discrete (i.e., grab sample) and passive, continuous (i.e., Solid Phase Adsorption Toxin Tracking (SPATT) bag) methods. SPATT bags are sampling devices constructed of resins that adsorb specific toxins, which are deployed in a water body for a fixed amount of time (Kudela, 2011). SPATT provide an integrated sample to supplement the grab samples, which are subject to variability due to spatial and temporal heterogeneity in toxin expression in water bodies. SPATT results provide insight into toxin presence, but do not yield toxin concentrations.

The cyanotoxin screening in streams included 120 samples that were collected in 2011 and 2012 throughout Southern California, using a random design. All samples were analyzed for microcystin using Enzyme-Linked Immunosorbent Assays (ELISA) by SCCWRP. A smaller subset of samples was analyzed at UC Santa Cruz by Raphael Kudela, using LC-MSMS for microcystin, anatoxin, cylindrospermopsin, saxitoxin, nodularin, and lyngbyatoxin detection. Out of the 120 samples measured by ELISA, 38% contained microcystin. In the smaller subset of samples analyzed by LC-MSMS, 21% contained lyngbyatoxin, 5% contained saxitoxin, and 3% contained anatoxin.

There was no cylindrospermopsin or nodularin found in the samples. These efforts were funded in-kind by SCCWRP and the Southern California Stormwater Monitoring Coalition (SMC).

The depressional wetlands screening was funded by SWAMP and included ten (10) sites randomly randomly-selected from the extent and conditions study. The sampling sites are located in seven (7) of the eleven (11) hydrologic units (HUs), found within the San Diego Region (Table 4). Two of the wetland sites experienced dry conditions upon the beginning of the field work and were unable to be sampled, bringing the total number sample sites down to eight (8).

Table 4. Number of depressional wetland sites sampled per hydrologic unit

HU #	Hydrologic Unit Name	# of Wetlands Sampled
902	Santa Margarita	1
903	San Luis Rey	2
904	Carlsbad	1
905	San Dieguito	1
907	San Diego	1
909	Sweetwater	1
910	Otay	1

Grab samples, taken twice at each site, were analyzed for chlorophyll-a, cyanotoxins, pigments, and nutrients. Of the lab results that are available to date, microcystins were detected at 60% of the sites in the spring and only 30% of the sites in the summer and fall of 2012. Saxitoxin was also detected in 10% of the sites in the spring, 14% in summer and none of the sites in the fall. The SPATT bags retrieved from the final two wetland sites have not yet been analyzed. However, the SPATT samplers detected microcystins at 83% of the sites. The cyanotoxins detected to date are listed in Table 5.

Table 5. Cyanotoxins detected in depressional wetlands monitored in 2012

SITE ID	City	Cyanotoxin Detected
902CRXFAL	Fallbrook	Microcystin
903CCRVAL	Valley Center	Microcystin-RR
903OLVFAL	Fallbrook	Microcystin-RR
904EMISGC	Oceanside	Microcystin-RR
904MANENC	Encinitas	Microcystin
907SL7SNT	Santee	Microcystin-LR & Microcystin-LA
909SWASPV	Spring Valley	Microcystin
910LVRJAM	Jamul	Microcystin-LR

Benthic Algae Sampling

Benthic algae were sampled throughout wadeable streams in southern California as part of the SWAMP Bioassessment study in 2008, the Stormwater Monitoring Coalition

efforts from 2009-2012, and through funding awarded to SCCWRP from a Proposition 50 grant. The benthic algae sampling efforts included diatoms and soft algae, which supported the development of an Index of Biologic Integrity (IBI) for benthic algae in Southern California. Soft algae sampling included the cyanobacteria community. In 2011 and 2012, 41% of the benthic algal mat and biofilm samples contained some form of cyanotoxin.

Summer and fall 2001 cyanobacterial blooms in Lake Skinner (Region 9) and Silverwood Lake (Region 6) prompted the Metropolitan Water District of Southern California (MWDSC) to develop a cyanotoxin monitoring program in 2003. MWDSC found benthic algal samples from several drinking water reservoirs that tested positive for microcystin, which lead to further studies to identify the particular toxin variant(s) involved and the corresponding cyanobacteria. The lakes that were found to contain microcystin include two lakes located in Region 9, Lake Skinner and Diamond Valley Lake (Izaguirre et al., 2007).

2.2.2 Region 1 (North Coast Region)

In 2007, the USEPA provided funding through a Water Quality Cooperative Agreement (CP 96941301-2) to analyze fish tissue and water from the Klamath River, which is an impaired water body on the CWA section 303(d) list for sediment, microcystin toxin, temperature, nutrients, and dissolved oxygen (Kanz, 2008). The study provided a screening level analysis of microcystin accumulation in a range of aquatic species. Targeted species included yellow perch, yearling Chinook salmon, and freshwater mussels. The study determined that the levels of microcystin found in the fish and shellfish warranted development of advisories for tissue consumption. On December 28, 2010, the USEPA approved Total Maximum Daily Loads (TMDLs) addressing temperature, dissolved oxygen, nutrient and microcystin impairments of the Klamath River.

2.2.3 Region 2 (San Francisco Bay Region)

A bloom of *Microcystis aeruginosa* has been observed between June-November in the northern reach of the San Francisco Bay Estuary since 1999 (Lehman et al., 2005). A study on its distribution, biomass and toxicity was conducted in 2003, which determined that microcystin is widely distributed, from freshwater to brackish water environments. Samples from all stations throughout the estuary were found to contain hepatotoxic microcystins and indicated the need for long-term monitoring. Part of the monitoring, funded by a special grant from the San Francisco Bay Delta Interagency Ecological Program, has included an investigation of the impacts of the *Microcystis aeruginosa* blooms on the aquatic food webs in the San Francisco Estuary (Lehman et al., 2010). Phytoplankton, cyanobacteria, zooplankton, and fish were collected biweekly throughout the estuary and analyzed for microcystins. Total microcystins were present at all levels of the food web. Greater total concentrations in striped bass, as compared with their prey, indicated that microcystin is accumulating at higher trophic levels.

An ongoing study has also investigated a bloom of *Aphanizomenon flosaquae* in the Sacramento-San Joaquin Delta during the summer of 2011 (Mioni et al., 2012). A lower abundance of Aphanizomenon flosaquae was found during summer 2012, but the strain is still present. Other strains of interest in this region include *Anabaena sp*., which has a patchy distribution but can reach significant levels.

2.2.4 Region 3 (Central Coast Region)

The deaths of marine mammals (21 dead and dying sea otters) found along the shores of Monterey Bay, with microcystin intoxication determined to be the cause, prompted a study investigating the land-sea flow and trophic transfer of microcystin through marine invertebrates (Miller et al., 2010). During cyanobacteria bloom events, water samples and surface bloom samples were collected from Pinto Lake, just inland of Monterey Bay, and its drainage into Corralitos Creek and the Pajaro River. Time-integrative passive samplers (SPATT) were also deployed in fresh and marine systems along the central California coast. Water from Pinto Lake in fall of 2007 confirmed occurrence of an extensive *Microcystis* bloom with high toxin production. Recurrent *Microcystis* blooms, with toxin production, were also confirmed in samples from Pinto Lake and surrounding waters in 2008 and 2009. The most common congener of microcystin found in the lake and surrounding water is microcystin-LA, but others were also detected. Field deployed SPATT, placed in ocean water and the marine interfaces of coastal rivers flowing into Monterey Bay, were analyzed for microcystins and provided results that determined the main source of toxins in Monterey Bay is not of marine origin. Since that time, regular (weekly) monitoring of Pinto Lake using both grab samples and continuous toxin measurements using SPATT showed that grab samples can miss toxic events (Kudela, 2011).

2.2.5 Region 5 (Central Valley Region)

Under contract #10-058-150, monitoring was conducted to determine the distribution of harmful cyanobacteria of concern and their associated toxins in the surface waters of Clear Lake and the Sacramento-San Joaquin Delta (Mioni et al., 2012). Samples (discrete and continuous) were collected from June through October of 2011 and analyzed for toxins, nutrients, chlorophyll-a, cyanobacterial deoxyribonucleic acid (DNA), dissolved organic carbon (DOC), and taxonomy. *Lyngbya* bloom in Clear Lake was the initial focus of the study, but several strains of harmful cyanobacteria bloom in the system. Several successive blooms were found to occur over the year. *Anabaena* and *Aphanizomenon* dominate in spring; *Lyngbya* dominates during summer; and *Microcystis* usually dominates in late summer/early fall. *Woronichinia* can also reach a relatively high abundance in the summer. The data collected during this study was used to determine correlations between individual cyanobacteria taxa and environmental controls. Several environmental drivers in surface waters were found,

with the major influencing factors being temperature, and nitrogen and phosphorous concentrations.

2.2.6 Region 8 (Santa Ana Region)

The MWDSC monitoring studies mentioned above in Section 2.2.1, include two lakes that are located in Region 8. Benthic algal samples from Lake Mathews and Lake Perris tested positive for microcystins and were further analyzed to determine which variants were present and which cyanobacteria produced the toxins (Izaguirre et al., 2007).

2.3 Proposed SWAMP Cyanotoxin Monitoring in Region 9 for 2013

Data from California and southern California clearly show that cyanobacteria and cyanotoxins occur throughout different water bodies. Because a monitoring program does not currently exist for cyanobacteria and cyanotoxins, we are proposing a plan for an initial screening lakes/reservoirs and coastal wetlands in the San Diego Region for these contaminants of emerging concern. The proposed efforts will complement the cyanotoxin screening that was completed in 2012 on streams and depressional wetlands. Information from the screenings will be combined and used to determine the presence and estimated extent of cyanotoxins found in the various water bodies in the San Diego Region.

Specifically, the proposed screening efforts detailed in the monitoring plan will be used to address the following assessment questions:

a. In which lakes/reservoirs and coastal wetlands in the San Diego Region are cyanotoxins present?
b. Which toxins (e.g., microcystin variants, anatoxin-a, nodularin) are found in these water bodies?
c. Are there correlations between cyanotoxin presence and specific conditions (e.g., dissolved nutrients, temperature, etc.) at the sites?

Results of the assessment will be used to determine future needs for properly monitoring the water bodies for cyanobacteria and cyanotoxins in the San Diego Region. It will be done in accordance with the Framework for Monitoring and Assessment in the San Diego Region, recently adopted by the Board, considering the following beneficial use questions:

- Is the water safe to drink?
- Are the fish and shellfish safe to eat?
- Is water quality safe for swimming and other recreational activities?
- Are habitats and ecosystems healthy?

3 Study Methods

3.1 Monitoring Design

3.1.1 Site Selection

The SWAMP funding that is available for the proposed cyanotoxin screening will allow for ten (10) samples collected from lakes/reservoirs and ten (10) samples collected from coastal wetlands. It is anticipated that sampling will occur at the following lakes/reservoirs and coastal wetlands shown in Table 6. Several (2-3) samples shall be taken at different locations in the San Diego Bay. Location maps are provided below in Figures 1 and 2.

Table 6. Lists of potential lakes/reservoirs and coastal wetlands for cyanotoxin sampling

	LAKES / RESERVOIRS
1	O'Neill Lake
2	Diamond Valley Lake
3	Lake Hodges
4	Sutherland Lake
5	Miramar Reservoir
6	Lake Murray
7	El Capitan Reservoir
8	Cuyamaca Reservoir
9	Lower Otay Reservoir
10	Morena Reservoir

	COASTAL WETLANDS
1	Tijuana River Estuary
2	San Diego Bay – Full/Muted/Marina
3	Mission Bay
4	Los Peñasquitos Lagoon
5	San Elijo Lagoon
6	Buena Vista Lagoon
7	Santa Margarita Estuary
8	San Mateo Lagoon

The water bodies chosen for sampling in this targeted design include those that are listed as impaired for nutrients, provide a variety of uses, and are most likely accessible for sample collection. The lakes/reservoirs chosen for sampling have (1) drinking water use, (2) fish use, and (3) recreational use. The coastal wetlands chosen for sampling include those in the region which are more heavily used for recreational purposes. Water bodies with known limited or prohibited access for sampling, such as those with threatened and endangered species and/or critical or sensitive habitats, were avoided for this initial screening effort.

Figure 1. Map of proposed lake/reservoir sampling locations

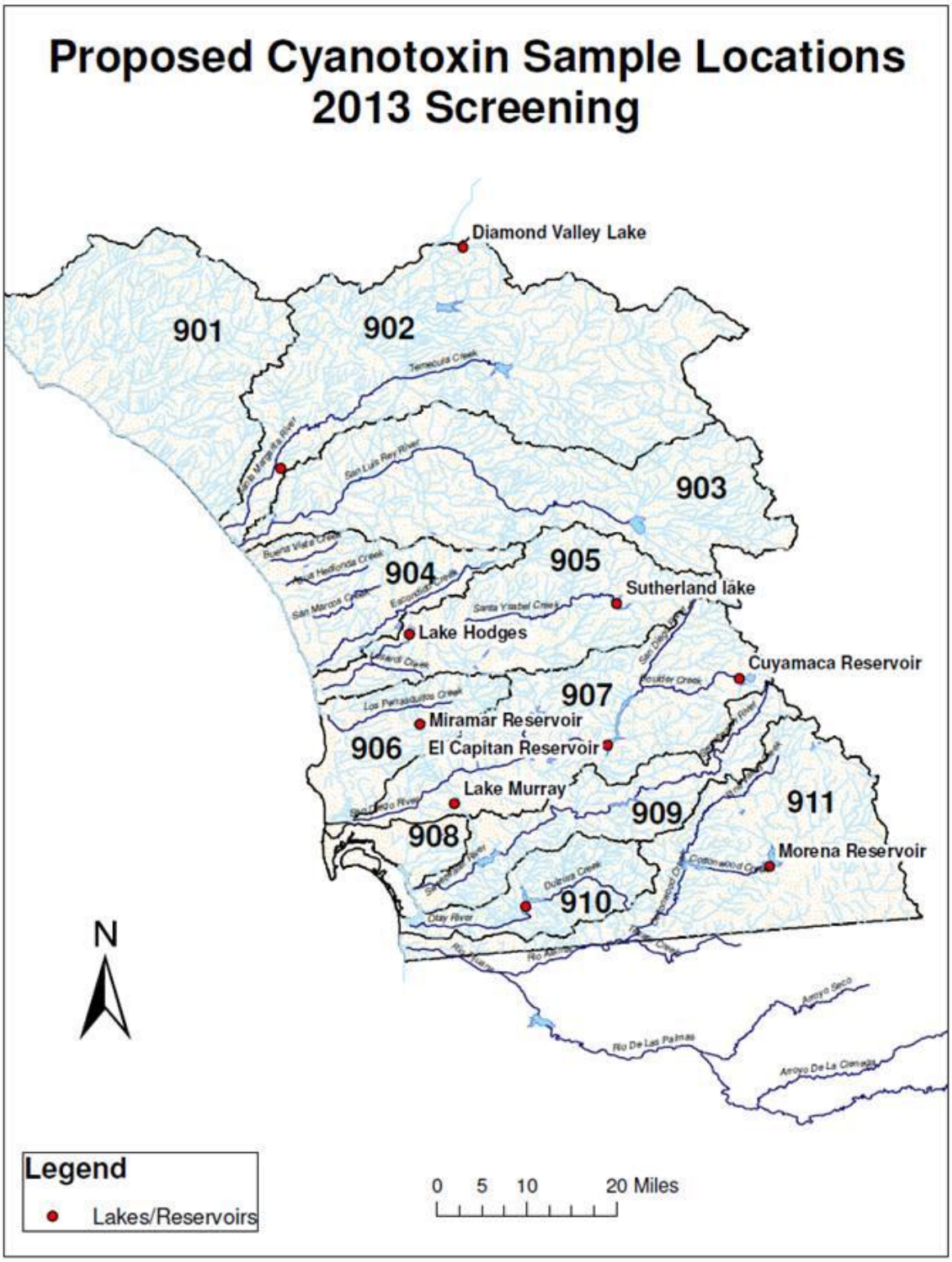
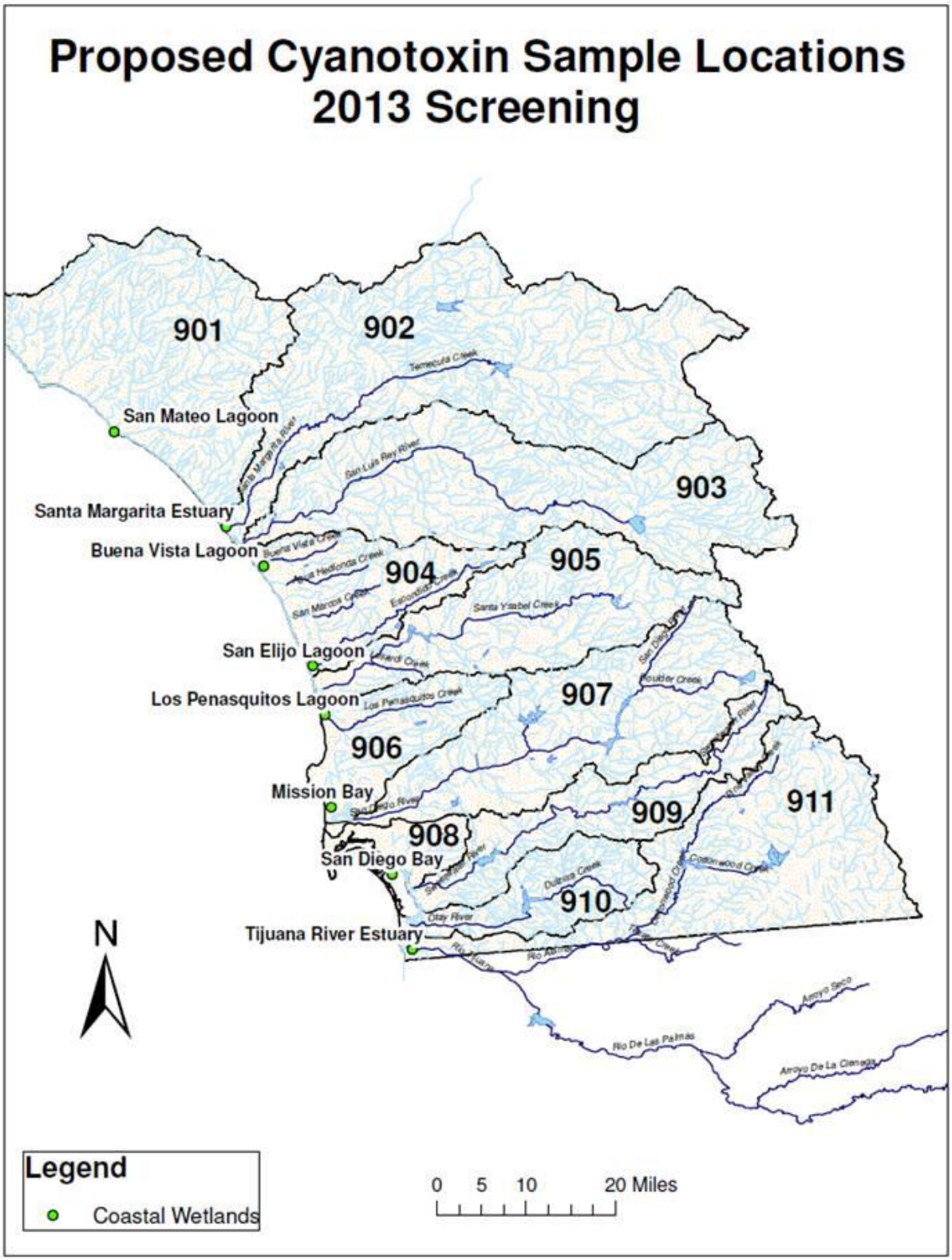


Figure 2. Map of proposed coastal wetland sampling locations



If it is not feasible (e.g., access is not granted) to conduct sampling at any of the water bodies listed above, alternative sampling sites will be chosen from the lists shown in Table 7.

Table 7. Lists of alternate lakes/reservoirs and coastal wetlands for cyanotoxin sampling

LAKES / RESERVOIRS	COASTAL WETLANDS
Vail Lake	Sweetwater Channel
Lake Skinner	Famosa Slough
Turner Lake	San Diego River Estuary
Lake Henshaw	San Dieguito Lagoon
Olivenhain Reservoir	Batiquitos Lagoon
Lake Dixon	Agua Hedionda
Lake Wohlford	Loma Alta Slough
Lake Poway	Las Pulgas Creek
Lake Jennings	San Juan Creek
Sweetwater Reservoir	
Loveland Reservoir	
Upper Otay Reservoir	
Lake Barrett	

3.1.2 Site Reconnaissance and Sample Collection Site Determination

Site reconnaissance will be used to determine the final site selection and sampling locations. Data will be collected about the site conditions, which will include photo documentation, GPS waypoints, location of sampling access points, and appropriate conditions for SPATT bag deployments. Consideration will be given to areas where the formation of cyanobacteria scum is most likely and where recreation and exposure to cyanobacteria could occur.

3.2 Selected Parameters

Two to three field sampling events will occur at each lake/reservoir and coastal wetland site between the months of July through October, 2013. Grab samples will be collected during each site visit to obtain data on the following parameters:

1. Water Column Chlorophyll-a
2. Cyanotoxins (particulates – see description below)

3. Nutrients
   Particulate Nitrogen, Particulate Phosphorous, Total Nitrogen, Total Phosphate, Dissolved Inorganic Nutrients (Nitrate+Nitrite, Ammonium, Phosphate, Silicate)
4. Pigments

A portion of the grab sample will also be used to run an alkalinity titration in the field.

In addition, the following parameters will be measured in-situ in the field at each site:

1. Dissolved oxygen
2. Temperature
3. Conductivity
4. pH
5. Salinity (for coastal wetlands)
6. Secchi depth (for lakes/reservoirs)

During the first visit to each site, a SPATT bag will be deployed. The SPATT will remain in the water body for 4 weeks. During the second site visit, the first SPATT bag will be retrieved, and a second SPATT bag will be deployed. After 4 weeks, the second SPATT bag will be retrieved. SPATT will be analyzed for dissolved microcystins.

Due to limited funding, this monitoring plan describes a cursory investigation of lakes/reservoirs and coastal wetlands in the San Diego Region. SPATT bags were chosen for these efforts, as they are useful, inexpensive screening tools. Results from the proposed analyses could be used to develop a more extensive study in the future, including a focus on higher risk areas for human or animal exposure.

3.3 Sampling and Lab Analyses

Staff from the Regional Water Quality Control Board (RWQCB) will collect and field process all of the samples. The SPATT bags will be shipped to UC Santa Cruz for microcystin analysis. All chlorophyll-a, nutrient, and pigment samples will be shipped to SCCWRP for analysis. Particulate cyanotoxin samples filtered from water-column grabs will be collected during each sampling event. When the SPATT analyses result in a positive hit for microcystin at a site, the particulate grab samples collected during the deployment and recovery of the SPATT will be sent to the California Department of Fish and Wildlife, Water Pollution Control Lab (WPCL) for cyanotoxin analysis. WPCL will analyze the samples for microcystin, anatoxin-a, nodularin (and possibly cylindrospermopsin and lyngbyatoxin) using liquid chromatography-mass spectrometry (LC-MS). A separate Quality Assurance Project Plan (QAPP) is being be developed and will provide more detail on the methods used for sample collection, handling, analyses, and data management to ensure the project objectives are met with high quality data.

Nutrient samples will be analyzed through other funding.

3.4 Data

3.4.1 Data Quality Evaluation and Data Reporting

Data quality evaluation and data reporting will follow the specifications in the SWAMP Quality Assurance Project Plan (QAPP). Quality control will include a 5% field duplicate level for all parameters. We do not anticipate needing additional special data quality evaluation or data reporting procedures.

3.4.2 Data Management

Data generated from the proposed monitoring plan will be stored in the SWAMP database. RWQCB staff will be responsible for entering all field generated data into the database. Results from the laboratory analyses will be uploaded into the SWAMP database by SCCWRP and WPCL with the help of the SWAMP database management team. It is expected that the data will also be uploaded to the California Environmental Data Exchange Network (CEDEN).

4 Collaborations

SCCWRP scientists, Meredith Howard and Betty Fetscher, have provided technical assistance for the development of the monitoring plan and QAPP for the proposed lakes/reservoirs and coastal wetlands cyanotoxin screening. Further collaboration with SCCWRP will be utilized to coordinate field collection and laboratory analysis activities, data management, and report preparation.

The Kudela Laboratory of Biological Oceanography at the University of California, Santa Cruz, will be responsible for all laboratory activities involved in the microcystin analyses of the SPATT bags used in this screening study.

The San Diego Regional Water Quality Control Board has contacted the City of San Diego in anticipation of the proposed cyanotoxin screening discussed in this monitoring plan. The City of San Diego is willing to collaborate with the RWQCB and will allow access for sampling all of the City-owned reservoirs upon coordination. Access to the non-City-owned reservoirs proposed for sampling will require coordination with Rancho California Water District and Helix Water District.

To facilitate sampling of the proposed coastal wetlands, collaboration will be required with the following: Tijuana River National Estuarine research Reserve (Jeff Crooks), City of San Diego (Lori Charett Gerbac), San Elijo Lagoon Conservancy (Doug Gibson), Buena Vista Lagoon Foundation, California Department of Fish and Wildlife (Tim Dillingham and Warren Wong), and Marine Corps Base Camp Pendleton (Mo Lahsaie).

5 Deliverable Products

A technical report will be produced to present the findings of the screening effort outlined in this monitoring report. The report will also include data from the streams and depressional wetlands screenings that were completed in 2012. The technical report will be finalized by December 31, 2014 and made available to the public on the San Diego Water Board website by January 31, 2015.

6 Project Schedule

Task 1 – Conduct reconnaissance and determine a list of sampling sites for the cyanotoxin screening, with GPS locations. Deliverable date: 06/30/2013.

Task 2 – Conduct sampling at the lakes/reservoirs and coastal wetland sites. Samples will be sent to the laboratories on weekly or bi-weekly bases. Dates: 07/01/2013 – 10/31/2013.

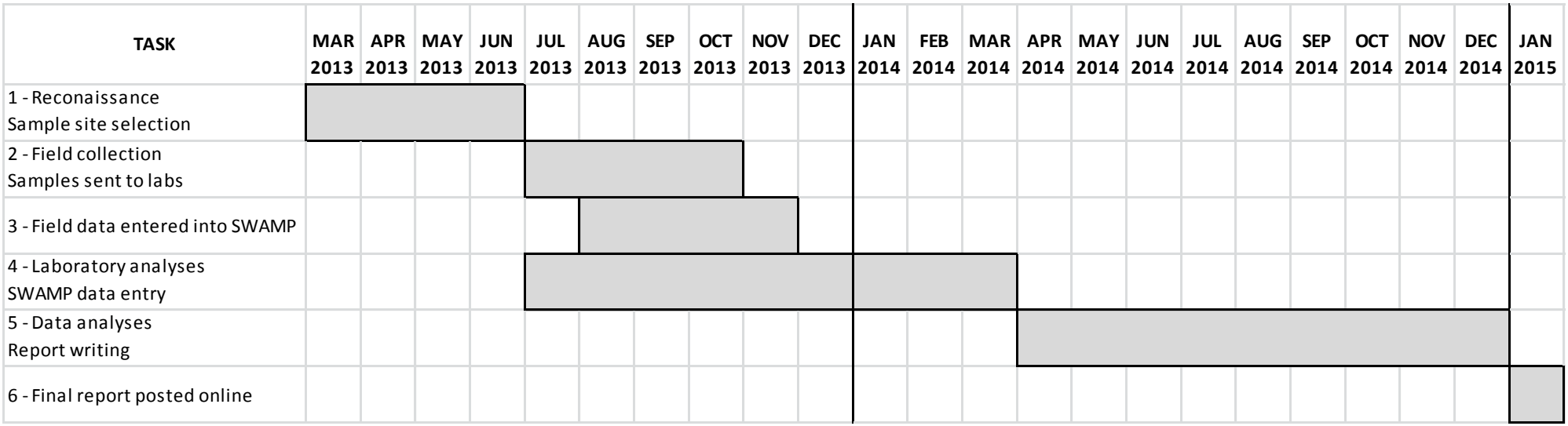
Task 3 – Enter field data into SWAMP database. Deliverable date: 11/30/2013.

Task 4 – Laboratory analyses of samples and enter data into SWAMP database. Deliverable date: 03/13/2014.

Task 5 – Analyses of all data produced in the cyanotoxin screening studies and write final report. Deliverable date: 12/31/2014.

Task 6 – Final report posted online. Deliverable date: 01/31/2015.

Project Schedule



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