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CHAPTER 4 – APPENDIX A: SAN DIEGO RIVER WATERSHED MONITORING AND ASSESSMENT PLAN

SAN DIEGO RIVER WATERSHED MONITORING AND ASSESSMENT PLAN

Prepared For:
San Diego River Watershed
Participating Agencies

Prepared By:
AMEC Environment and Infrastructure, Inc.
9177 Sky Park Court
San Diego, California 92123
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4 WATER QUALITY IMPROVEMENT PLAN MONITORING AND ASSESSMENT PROGRAM

This appendix of the Water Quality Improvement Plan (Plan) describes the Monitoring and Assessment Program for the San Diego River Watershed. The Participating Agencies in the watershed have developed an integrated Monitoring and Assessment Program to:

1) Measure the progress toward addressing the Highest Priority Water Quality Condition (HPWQC) established in Chapter 2;
2) Assess the progress toward achieving the goals, strategies, and schedules provided in Chapter 3; and
3) Evaluate each Participating Agency's overall efforts to implement the Plan.

The Permit supports an outcome-based approach through the Plan. Monitoring data collection and assessment provides the vehicle for determining whether intended outcomes are being realized or if adaptations of Participating Agencies' programs are necessary. Collection and assessment of monitoring data will guide future implementation of the Participating Agencies' management actions. Monitoring during wet and dry weather is conducted to collect observational and analytical data from storm drain outfalls and the receiving water. The data are utilized to help Participating Agencies determine whether discharges from storm drain outfalls are influencing receiving water quality, and if so, are storm drain discharges improving or degrading receiving water conditions over time. Participating Agencies assess the data in combination with their management actions to determine what actions are improving the quality of storm drain outfall discharges and receiving water conditions and where additional actions are necessary.

This appendix provides an overview of the two main components: (1) Monitoring, and (2) Assessment. As stated in Provision D of Order R9-2013-001(Permit):

> *"The purpose of this provision is for the Participating Agency to monitor and assess the impact on the conditions of receiving waters caused by discharges from the Participating Agency's MS4s under wet weather and dry weather conditions. The goal of the Monitoring and Assessment Program is to inform the Participating Agency about the nexus between the health of receiving waters and the water quality condition of the discharges from their MS4s. This goal will be accomplished through monitoring and assessing the conditions of the receiving waters, discharges from the storm drains, pollutant sources, and/or stressors, and effectiveness of the water quality improvement strategies implemented as part of the Water Quality Improvement Plans."*

Monitoring includes sampling, inspection, and data collection at beaches, creeks, lakes, estuaries, and storm drain outfalls to observe conditions, improve understanding, and inform the management within the watershed to improve water quality conditions.

The program incorporates monitoring to assess progress toward addressing the HPWQC per requirements of Permit Provision B.4. It also includes the compliance monitoring requirements of Permit Provision D, Illicit Discharge Detection and Elimination (IDDE) requirements of Permit Provision E.2, and Total Maximum Daily Load (TMDL) monitoring and assessment requirements in Permit Attachment E. Assessment under this program includes annual review of the monitoring data along with a comprehensive analysis of the data at the end of the Permit term.

4.1 Water Quality Improvement Plan Monitoring Program

The Monitoring Program includes five major components:

1) Monitoring to assess goals and schedules;
2) Receiving water monitoring program that measures the long-term health of the watershed during dry and wet weather conditions;
3) Storm drain outfall monitoring program that investigates the elimination of illicit dry weather flows from storm drain outfalls and the improvement in quality of the discharges from storm drains during wet weather;
4) Special studies that look further into the HPWQC presented in Chapter 2 of the Plan, and
5) Complementary Illicit Discharge Detection and Elimination investigations and inspections of potential pollutant sources that are implemented under the Jurisdictional Runoff Management Programs.

Wet Weather is defined as a storm event of >0.1 inch of rainfall and the following 72 hours after the end of rainfall.

Dry Weather is defined as all days where the preceding 72 hours has been without measurable precipitation (>0.1 inch).

Table 4-1 presents an overview of the planned monitoring activities for the watershed. The overview includes monitoring programs, conditions, monitoring elements, and the implementation schedule for each program during this Permit term. In Chapter 2, bacteria was identified as the HPWQC for the watershed. As reflected in **Table 4-1** monitoring is being conducted to characterize bacteria levels in the discharges from storm drain outfalls, identify potential sources of bacteria, and assess the effectiveness of strategies designed to address bacteria. Additionally, these programs will generate data to track priority water quality conditions and general health and conditions within the watershed.

Table 4-1. Elements of Water Quality Improvement Plan Monitoring

Monitoring Programs			Condition	Monitoring Element	Permit Schedule[a]				
					2013-2014[b]	2014-2015	2015-2016	2016-2017	2017-2018
Monitoring to Assess Goals and Schedules			Dry and Wet	Varies by goal and jurisdiction	–	–	●	●	●
Receiving Water Monitoring	Long-Term Receiving Water Monitoring		Dry	Conventionals, bacteria, nutrients, metals, pesticides, toxicity (chronic), possible TIE/TREs, visual observations, field measurements	●[b]	–	–	–	–
				Hydromodification (channel conditions, discharge points, habitat integrity, evidence and estimate of erosion and habitat impacts)	●[b]	–	–	–	–
				Bioassessment (BMI taxonomy, algae taxonomy, physical habitat characteristics)	●[b]	–	–	–	–
			Wet	Conventionals, bacteria, nutrients, metals, pesticides, toxicity (chronic), possible TIE/TREs, field measurements	●[b]	–	–	–	–
	Regional Monitoring Participation	Bight	Dry	Chemistry, toxicity, benthic infauna	●	●	–	–	●[c]
		SMC	Dry	Bioassessment	●	●	●	●	●
		2010 Hydromodification Monitoring Program (HMP)	Wet	Channel assessments; flow monitoring; sediment transport monitoring	●	●	●	–	–
	Sediment Quality Monitoring		Dry	Chemistry, toxicity, benthic infauna	●[c]	●[c]	–	–	–

Monitoring Programs			Condition	Monitoring Element	Permit Schedule[a]				
					2013-2014[b]	2014-2015	2015-2016	2016-2017	2017-2018
Receiving Water Monitoring	TMDL Monitoring	Bacteria TMDL for Forrester Creek, Lower San Diego River, and Dog Beach	Dry	Bacteria	●	●	●	●	●
			Wet	Bacteria	●	●	●	●	●
Storm Drain Monitoring	Storm Drain Field Screening		Dry	Visual: flow condition, presence and assessment of trash in and around the station, IC/IDs, descriptions	●	●	●	●	●
	Storm Drain Outfall		Dry	Field parameters, conventionals, bacteria, nutrients, metals	-	-	●	●	●
			Wet	Field parameters, conventionals, bacteria, nutrients, metals	●	●	●	●	●
Special Studies	San Diego Regional Reference Streams and Beaches		Dry	Field parameters, conventionals, bacteria instantaneous flow	2012-2014	●	–	–	–
				Streams only: nutrients, metals, bioassessment, including physical habitat and chlorophyll a	2012-2014	–	–	–	–
			Wet	Field parameters, conventionals, bacteria	2012-2014	●	–	–	–
				Streams only: nutrients, metals, toxicity, flow and precipitation (duration of storm)	2012-2014	●	–	–	–

Monitoring Programs		Condition	Monitoring Element	Permit Schedule[a]				
				2013-2014[b]	2014-2015	2015-2016	2016-2017	2017-2018
Special Studies	San Diego Wet Weather Epidemiology Study	Wet	Field parameters, bacteria, human genetic markers, viruses, human health data, flow and precipitation	●	●	●	–	–
IDDE Program	Illicit Discharge Detection and Elimination Program	Dry	Visual surveys, field parameter testing, analytical testing and follow-up investigations, if warranted	–	–	●	●	●

BMI=Benthic macroinvertebrates; IC/ID = illicit connection and/or illicit discharge; NA = not applicable; bacteria = fecal indicator; SMC = Southern California Stormwater Monitoring Coalition; Bight = Southern California Bight Regional Monitoring Program; TIE=Toxicity Identification Evaluation; TRE=Toxicity Reduction Evaluation

a. The Permit was adopted on May 8, 2013; the Permit became effective on June 27, 2013.
b. Completed under the Transitional Monitoring Program according to Permit Provisions D.1.a and D.2.a.
c. The 2018 Southern California Bight Regional Monitoring will occur during the summer of 2018 or 2019.

4.1.1 Monitoring to Assess Progress Toward Achieving Goals and Schedules

This section summarizes monitoring and assesses progress toward achieving goals related to the HPWQC, which is bacteria for the watershed, as described in Section 2.3. As outlined in Section 3.1, goals are based on the multiple compliance pathways set forth for the Bacteria TMDL in Attachment E.6 of the Permit. Compliance with the TMDL may be demonstrated via one of the compliance pathways identified in the Permit. The proposed compliance dates for both the TMDL's interim goals and final goals are set outside of this Permit cycle, as presented in Chapter 3. **Table 4-2** presents the interim TMDL goals and monitoring that may be used to track progress toward achieving the goals.

Each Participating Agency has established both wet and dry weather jurisdictional goals for bacteria, the HPWQC, during this Permit term to demonstrate progress towards compliance with the TMDL requirements. Generally, Participating Agencies have identified near-term goals to address potential bacteria sources and/or to reduce anthropogenic dry weather flow in storm drain outfalls. Data collection or monitoring elements that go beyond the prescribed Permit activities are tailored to measure progress towards meeting each goal. These elements, which are further detailed in the following subsections, may include visual surveys, inspections, physical sampling or measurements, and development of new outreach and source control programs related to bacteria reduction.

Table 4-2. Monitoring Related to Interim Bacteria TMDL Goals[a]

Compliance Pathway		Interim TMDL Goal	Monitoring Elements
1 OR	Receiving Water Conditions	No exceedances of the interim Receiving Water Limitations (RWLs) in the receiving water	Bacteria data collected at compliance points as described in Section 4.1.1.3 Bacteria TMDL Monitoring Program
2 OR	Storm Drain Discharges	No direct or indirect discharge from the Participating Agencies' storm drain outfalls to the receiving water	Visual observation of flow from outfalls to receiving waters as described in Section 4.1.3 Storm Drain Monitoring Program.
3 OR	Storm Drain Discharges	Pollutant load reductions for discharges from the Participating Agencies' storm drain outfalls greater than or equal to the final load reductions	Bacteria and flow data collected at outfalls as described in as described in Section 4.1.3 Storm Drain Monitoring Program.
4 OR	Receiving Water Conditions	Exceedances of the final receiving water limitations in the receiving waters due to loads from natural sources	Data from Sections 4.1.1, 4.1.2, 4.1.4, and 4.1.5.
5 OR	Receiving Water Conditions	No exceedances of the final RWLs in the receiving water	Bacteria data collected at compliance points as described in Section 4.1.1.3 Bacteria TMDL Monitoring Program
6	Water Quality Improvement Plan	Implementation of the Plan and use of adaptive management	Data from monitoring and Jurisdictional Runoff Management Programs

a. Participating Agencies may propose alternative TMDL interim milestones which differ from those included in Permit Attachment E.6.

4.1.1.1 Dry Weather Bacteria Monitoring

Participating Agencies have established dry weather goals for the 2013-2018 Permit term. **Table 4-3** summarizes the data that will be collected to assess these goals by jurisdiction.

Table 4-3. Dry Weather Monitoring Related to Jurisdictional Goals

Jurisdiction	First Permit Term Numeric Goals 2013-2018 (Chapter 3)	Assessment Metric	Monitoring Elements
City of El Cajon	Reduce controllable dry weather persistent flows by 10%	% reduction of flow volume or number of outfalls with flows mitigated from persistently flowing storm drain outfalls	Collect dry weather flow measurements
	Reduce gross pollutants that may contribute to bacteria loads by increasing the number of cubic yards of debris collected from drainage channels	Increased number of annual transient encampment removal events throughout the City's drainage channels	Quantify number of cubic yards of debris collected from drainage channels
City of La Mesa	Creek restoration – 900 linear feet of Alvarado Creek	Linear feet of creek restoration	Quantify linear feet of restoration completed in

Jurisdiction	First Permit Term Numeric Goals 2013-2018 (Chapter 3)	Assessment Metric	Monitoring Elements
			Alvarado Creek
City of Santee	Implement a dry weather inspection and investigation program. Dedicate 10 % of compliance inspection hours to dry weather inspections	Visual confirmation	Track visual inspections and investigations of dry weather flows
	'Complete Property' inspection program – Inspect 50% high priority, high-density use areas. Focused inspections on pavement, landscape, and trash enclosures	Visual and physical confirmation	Monitor targeted outfalls before and during implementation
	Eateries Inspection Program – Inspect 50% of high priority eateries. Focused inspections on grease storage, trash enclosures, and outdoor seating areas	Visual inspections on grease storage, trash enclosures, and outdoor seating areas	Monitor targeted outfalls before and during implementation
	Outdoor Water Use Efficiency and Conservation – Develop Residential Management Area program. Distribute outreach material	Pre and post surveys; reduction in water use	Perform pre- and post-surveys and quantify reduction in water use
City of San Diego	Develop green infrastructure policy, attain City Council approval, and construct green infrastructure best management practices (BMPs) to improve water quality	58 acres of drainage area treated through construction of 4 green infrastructure BMPs	Quantify total acres treated by constructed BMPs using information from final design drawings.
	Implement runoff reduction programs, including targeted education and outreach, enhanced inspections, rebates[a], and increased enforcement.	10% reduction in prohibited[b] dry weather flow from baseline measured at persistently flowing outfalls in the watershed	Collect flow measurements at persistently flowing outfalls
County of San Diego	Reduce by 20% the aggregate flow volume or the number of persistently flowing outfalls	% reduction of flow volume or number of outfalls with persistent flows	Conduct visual inspections and/or flow measurements at persistently flowing outfalls

a City of San Diego rebates include grass replacement, rainwater harvesting, downspout disconnect, and micro-irrigation.

b Does not include allowable discharges as defined in Provision A and Provision E.2.a of the Permit.

4.1.1.2 *Wet Weather Bacteria Monitoring*

Participating Agencies have established wet weather goals for the 2013-2018 Permit term. **Table** 4-4 summarizes the data that will be collected to assess these goals by jurisdiction.

Table 4-4. Wet Weather Monitoring Related to Jurisdictional Goals

Jurisdiction	First Permit Term Numeric Goals 2013-2018 (Chapter 3)	Assessment Metric	Monitoring Elements
City of El Cajon	Non-structural BMP – Coordinate 1 Creek Cleanup	Reduce bacteria loads in Forrester Creek	Quantify waste material
	Non-structural BMP – Expand Pet Waste Outreach to 1 focused management area or to large property owners	Reduce bacteria loads in Forrester Creek	Quantify waste material
	Conduct a structural BMP feasibility study to assess dry weather treatment control BMPs and draft environmental impact report for treatment control BMPs	30-40% reduction in bacteria load by developing structural BMPs to help meet wet weather TMDL allocations	Monitor bacteria and flow from BMP input and output
	Implement programmatic BMPs to achieve source reduction of bacterial loads from storm drain outfalls	% bacterial load reductions for Total coliform, fecal coliform, and *Enterococcus*	Collect bacteria and flow data at storm drain outfalls
City of La Mesa	Creek restoration – 900 linear feet of Alvarado Creek	Linear feet of structural projects	Quantify linear feet of restoration in Alvarado Creek
City of Santee	Identify candidate locations for off-site compliance. Develop Water Quality Equivalencies (credit system)	Acreage retrofitted.	Quantify acreage
	Conduct bi-monthly river encampment sweeps with follow up trash removal. Increase efforts to provide referrals to local community services.	Trash removal rates/quantities (tonnage removed; visual surveys	Conduct visual trash surveys and quantify tonnage removed
City of San Diego	Develop green infrastructure policy, attain City Council approval, and construct green infrastructure BMPs to improve water quality	58 acres of drainage area treated through construction of 4 green infrastructure BMPs	Quantify total acres treated by constructed BMPs using information from final design drawings.
County of San Diego	Reduce by 1% the baseline bacteria loads from distributed BMPs constructed between 2003 and 2009 during redevelopment	% bacterial load reduction based on quantitative model	Confirm installation of treatment control BMPs

4.1.2 Receiving Water Monitoring

The purpose of the receiving water monitoring program is to characterize trends in the chemical, physical, and biological conditions of a receiving water to determine whether beneficial uses are protected, maintained, or enhanced. Additionally, the receiving water monitoring component helps inform the Participating Agencies of the nexus between the health of receiving waters and the quality of discharges from their stormwater outfall. This program is designed to meet the requirements set forth in Provision D.1 of the Permit. Long-term monitoring occurs during both wet and dry weather conditions for water quality, along with physical and biological integrity. Sediment quality monitoring, if appropriate and participation in regional monitoring occurs as well. Attachment E of the Permit stipulates how TMDL monitoring requirements are to be incorporated into the receiving water monitoring program. Receiving water monitoring comprises the following programs:

- Long-term receiving water monitoring,
- Regional monitoring participation,
- Toxicity Identification Evaluation/Toxicity Reduction Evaluation, if appropriate,
- Sediment quality monitoring, if appropriate, and
- TMDL monitoring.

The receiving water programs are designed to answer one or more of the following questions:

- Are conditions in the receiving water protective, or likely protective, of beneficial uses?
- What are the extent and magnitude of the current or potential receiving water problems?
- Are the conditions in the receiving water getting better or worse?

4.1.2.1 Long-Term Receiving Water Monitoring

Long-term receiving water monitoring will track the overall health of the receiving waters. Dry and wet weather monitoring will continue at the historical mass loading station (SDR-MLS) located on the San Diego River. Participating Agencies have monitored SDR-MLS since 2001 to meet the requirements of previous permits and this site is co-located with the United States Geological Survey (USGS) monitoring station. The land uses in the surrounding drainage area for SDR-MLS are primarily residential with some industrial, commercial, and open space. The mass loading station location is in

Table 4-5.

Table 4-5. San Diego River Watershed Long-term Receiving Water Station

Station ID	Latitude	Longitude	Cross Street Description	Channel Type	Jurisdiction
SDR-MLS	32.765240	-117.168617	Directly south of the Fashion Valley Trolley Station at the footbridge across San Diego River	Modified Natural Channel	City of San Diego

Source: Transitional Receiving Water Monitoring Plan (Weston, 2014a)

This site will be monitored three times during dry weather and three times during wet weather per permit cycle. This monitoring program is designed to monitor the HPWQC in the receiving water, along with a comprehensive list of constituents based on the Clean Water Act Section 303(d) list (303(d) list) impairments, CLRP, non-storm water action levels (NALs) or storm water action levels (SALs), and Table D-3 of the Permit. During both dry and wet weather, water samples will be analyzed for constituents as shown in **Table 4-1** and provided in detail in Attachment 4A-1. Toxicity identification evaluations (TIEs), if necessary, will be conducted in compliance with Provisions D.1.c.(4)(f) and D.1.d.(4) of the Permit and used to determine the causative agent(s) of toxicity. Once per term during dry weather, a bioassessment will be conducted to evaluate chemical, physical, and biological data, and hydromodification monitoring will record the stream conditions, habitat integrity, and impacts. The Receiving Water Monitoring Plan describes detailed monitoring methods and procedures, as presented in Attachment 4A-1. These methods and procedures may be modified on the basis of site-specific environmental conditions and updated analytical methodologies.

The 2013 and 2014 Transitional Monitoring Programs satisfied long-term receiving water monitoring requirements including dry and wet weather water quality sampling, bioassessment, and hydromodification monitoring for this Permit term. Detailed proposed monitoring methods and procedures are presented in the Receiving Water Monitoring Plan as Attachment 4A-1. These methods and procedures may be modified on the basis of site-specific environmental conditions and updated analytical methodologies.

4.1.2.2 Regional Monitoring Participation

Regional monitoring includes separate studies that will evaluate various aspects of receiving water health on a regional scale. Participating Agencies will participate in the following regional programs to meet the requirements of Permit Provision D.1.e (1).

Bight Regional Monitoring

The Bight regional monitoring program is a multi-agency collaborative effort to assess the ecological condition of the Southern California Bight from a regional perspective. The core program consists of monitoring of sediment chemistry, sediment toxicity, and benthic infauna. The goals of past Bight programs are to answer three primary questions:

- What are the extent and magnitude of direct impact from sediment contaminants?
- How do the extent and magnitude of the environmental impact vary by habitat?
- What is the trend in extent and magnitude of direct impacts from sediment contaminants?

Sediment quality monitoring was conducted during the summer of 2013 at a total of 22 sites in nine estuaries and lagoons in the San Diego region including the San Diego River Estuary under the Southern California Bight 2013 Regional Monitoring Survey (Bight '13) (Weston, 2014c). As described in Section 4.1.1.3, sediment monitoring data from Bight '13 will be used to fulfill part or all of the sediment monitoring requirements of the Permit. During this Permit term, Participating Agencies will participate in planning Bight '18 monitoring programs.

Stormwater Monitoring Coalition (SMC) Regional Monitoring

Since 2001, Participating Agencies have partnered with regulated stormwater municipalities in southern California, the Regional Boards of Southern California and the Southern California Coastal Water Research Project (SCCWRP) to form the Southern California Stormwater Monitoring Coalition (SMC). The goals of the SMC are to standardize monitoring, improve understanding of stormwater mechanics, and identify receiving water impacts from stormwater (SCCWRP, 2002). According to its 2014 Research Agenda, the SMC has identified 21 potential projects and is in the process of prioritizing projects on the basis of need and availability of funding (SMC, 2014). The Participating Agencies have elected to participate in the projects that are relevant to the watershed. The Participating Agencies will continue participation in the SMC Regional Freshwater Stream Bioassessment Monitoring Program (SMC Regional Bioassessment Program) that began as a five year program in 2008-2013 and will be implemented for another five years (2015-2019).

The 2009-2013 SMC Regional Bioassessment program was designed to address the following monitoring questions (AMEC, 2014):

- What is the extent of impact in streams of southern California?
- What are the stressors that impact southern California streams?
- Is the extent of stream impacts changing over time?

A final monitoring report was prepared on the basis of 2009-2013 results to identify lessons learned, data gaps, and recommendations to guide the design of the 2015-2019 program. In 2015, a new five-year SMC program will extend the initial survey to answer key management questions about the impacts of stormwater on stream conditions. The program will have an added emphasis on detecting trends, including non-perennial streams and sampling sediment chemistry and toxicity.

The non-perennial stream monitoring was initiated in April 2014, with site revisits in May and June 2014. Sampling included benthic macroinvertebrates (BMI), algae, physical habitat, and California Rapid Assessment Method (CRAM). The trend site monitoring was conducted during the standard index period (i.e., from mid-May through July). Sampling for trend site monitoring included all of the parameters and constituents of the original SMC Regional Bioassessment

Program (Weston, 2014b). The bioassessment monitoring was conducted at a total of 64 bioassessment stations; 30 stations were compliance stations; 28 stations were randomly placed Stormwater Monitoring Coalition (SMC) stations; and 6 stations were San Diego County reference stations (Weston, 2014b).

Hydromodification Regional Monitoring Program

Copermittees have developed a regional Hydromodification Management Plan (HMP) to address impacts to beneficial uses and stream habitat from increased erosive force potentially caused by a rise in runoff discharge rates and volume from Priority Development Projects (County of San Diego, 2011). The HMP was initially developed to meet the requirements of the 2007 Permit. The Monitoring Plan is defined in Chapter 8 of the HMP, and was updated by the Copermittees and accepted by the Regional Board in February of 2014. The HMP requires monitoring with a final report due to the Regional Board in December of 2016. Monitoring consists of channel sediment transport assessments, and continuous flow monitoring of pre-project, post-project, and reference conditions per Permit Provisions D.1.a and D.1c(6). Additional monitoring is required per Provision D.1.a(2).

4.1.2.3 Sediment Quality Monitoring

Sediment quality monitoring is designed to assess compliance with the sediment quality receiving water limits applicable to enclosed bays and estuaries in accordance with the State Board's Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality (Sediment Control Plan) (State Board, 2009). Sediment quality monitoring will be performed in compliance with Permit Provision D.1.e.(2), which requires preparation of a Sediment Quality Monitoring Plan that satisfies the requirements of the Sediment Control Plan. The requirements of the sediment quality monitoring are:

1) The elements required under Sections VII.D and VII.E of the Sediment Control Plan,
2) A Quality Assurance Project Plan, and
3) A schedule for completion of sample collection, analysis, and reporting.

The Sediment Quality Monitoring Plan and Quality Assurance Project Plan (Attachment 4A-2) describe detailed proposed monitoring procedures and analytical methods that are illustrative and may change on the basis of site environmental conditions. As indicated in **Table 4-1**, sediment quality monitoring of the San Diego River Estuary was conducted in the summers of 2013 and 2014.

The participating agencies propose to conduct one round of sediment sampling each Permit term. The second required round of sampling will be satisfied by conducting additional follow up sampling in the vicinity of potentially impacted sites identified in the first round. Sediment quality monitoring will employ the following general approach to meet the requirements of the Permit:

a) Conduct initial monitoring within each qualifying water body per the requirements of the state's Sediment Control Plan. These data will be used to assess the degree of potential impact at each site using the California Sediment Quality Objective (SQO) multiple-line-of-

evidence approach in accordance with the assessment criteria specified in Sediment Control Plan Section V. These scores are derived using multiple metrics from three key lines of evidence: (1) sediment chemistry data, (2) toxicity data, and (3) benthic community data. Sites are then categorized as un-impacted, likely un-impacted, possibly impacted, likely impacted, or clearly impacted.

b) Confirm and characterize pollutant related impacts for any sites that are considered possibly impacted, likely impacted, or clearly impacted, following an integration of all lines of evidence. In accordance with Sediment Control Plan criteria, the data assessment in this phase is required to determine whether the score(s) indicate potential impacts due to toxic pollutants (e.g., freshwater-related contaminant sources from the stormwater conveyance system), or non-toxic pollutants (e.g., physical habitat, freshwater inundation, legacy contaminants, or other potential factors). This phase would be considered the first phase of the level stressor/source identification (SSID) based on existing data. The requirements of this phase are dependent on the site as categorized in the previous phase as follows:

(1) Stations deemed to be possibly, likely, or clearly impacted based on initial monitoring for which the impact or impairment is determined to likely not be caused or contributed to by storm drain discharges will be monitored once more in the current Permit term. Follow-up monitoring is required to verify the findings from the first round of monitoring.

i. If results from the follow-up monitoring are consistent (possibly impacted), or un-impacted, no additional follow-up will be required during the current Permit term.

If the second round of sampling reclassifies the station as likely or clearly impacted, an additional follow-up investigation may be needed or suspended pending future routine SQO monitoring. In this circumstance, results of the analytical assessments will be discussed with the Regional Board staff to determine whether/where any SSID studies should be undertaken, and to identify major elements of the approach for any identified studies. Prior to additional investigation, a site-specific Sediment Assessment Work Plan would be prepared that would outline specific steps and methodologies to be taken.

(2) Stations deemed by assessment to be likely or clearly impacted by storm drain discharges will require additional follow-up investigation and this is deemed the first phase of SSID. A site-specific Sediment Assessment Work Plan will be prepared that will outline specific steps and methodologies to be taken. Per the Sediment Control Plan, SSID comprises three steps: (1) confirmation and characterization of pollutant impacts, (2) pollutant identification, and (3) source identification and management actions.

c) In the annual Sediment Monitoring Report, describe the planned follow-up monitoring, including any planned SSID studies, and revisions the Sediment Monitoring Plan, accordingly.

During the transitional (pre-Water Quality Improvement Plan) monitoring phase, the Southern California Regional Bight '13 Monitoring Program (Bight '13) satisfied the initial monitoring requirements of the state's Sediment Control Plan. As presented in **Table 4-6**, up to three sites were monitored in the San Diego River Estuary in 2013 for the initial screening of sediment quality. Follow-up monitoring was conducted in summer 2014 to further characterize one site that was possibly impacted. Based on the monitoring and assessment completed, sediment conditions in San Diego River Estuary are generally protective of the beneficial uses and typical of a tidally influenced shallow lagoon (Weston, 2014). No further monitoring is planned for San Diego River Estuary during this Permit term because there was no evidence to indicate that urban runoff from the watershed had significantly impaired the estuarine beneficial use of the receiving water (Weston, 2014).

Table 4-6. Bight '13 Sample IDs, Site Locations, Dates Sampled, and Sample Depths

Lagoon/Estuary	# of Sites	Site ID	Sediment Sampling			Monitored Events	
			Latitude	Longitude	Depth (m)	Date Sampled	Date Sampled
San Diego River Estuary	3	8129	32.7568	-117.2353	1.1	7/31/2013	NA
		8134	32.7574	-117.2380	1.0	7/31/2013	NA
		8136	32.7579	-117.2274	1.0	7/31/2013	9/18/14

Source: Transitional Monitoring and Assessment Report Appendix H Sediment Monitoring Report (Weston, 2014c).
NA – Follow-up monitoring not required.

4.1.2.4 TMDL Monitoring

TMDL provisions, schedules, and monitoring requirements are provided in Attachment E of the Permit. The purpose of the monitoring program is to track progress toward achieving compliance with interim and final TMDL numeric targets. The Bacteria TMDL in Attachment E.6 is applicable to the watershed. Monitoring is designed to meet compliance with the monitoring requirements of the TMDL. Wet and dry weather sampling will be conducted each year at the compliance point located at the existing California Assembly Bill 411 (AB411) monitoring location along the Pacific Ocean shoreline (25 yards down current of where ocean currents meet river discharge in ankle to knee deep water) and four additional compliance points are located in the lower San Diego River and Forrester Creek. The data generated will be used to address the following questions:

- Are TMDL numeric targets for indicators being met at the compliance monitoring locations?
- Are levels of bacteria decreasing at the compliance monitoring locations?

The proposed Bacteria TMDL Monitoring Plan and Quality Assurance Project Plan describe detailed monitoring procedures and analytical methods that are illustrative and may be revised based on site-specific environmental conditions and updated methodology. They are presented in

Attachment 4A-3. Dry weather monitoring will be conducted weekly, for a minimum of 5 samples in a 30-day period during the recreation season (April 1 through October 31) to be consistent with AB411 monitoring frequencies, and monthly (at a minimum) during the wet season (October 1 through April 30) per the Permit requirements. Samples are to be collected on dry weather days, after an antecedent dry period of 72 hours with less than 0.1 inch of rainfall. Wet weather monitoring will be conducted at the compliance monitoring location during at least one storm event for each wet season, per the Permit Attachment E.6.

Fecal indicator bacteria are the target constituents for the Pacific Ocean Shoreline within the watershed, as indicated by the Permit. Grab samples will be collected in a manner consistent with the requirements of the AB411 program and analyzed for total coliform, fecal coliform, and *Enterococcus*. For details of the current approved TMDL monitoring program, refer to Attachment 4A-3.

Bacteria TMDL compliance monitoring has been conducted in the receiving water since the Permit became effective on June 27, 2013.

4.1.2.5 Toxicity Identification Evaluation/Toxicity Reduction Evaluation

Provision D.1.c(4)(f) of the Permit requires that the Copermittees discuss the need for conducting a Toxicity Identification Evaluation (TIE)/Toxicity Reduction Evaluation (TRE) if chronic toxicity is detected in receiving waters. A TIE is a set of procedures to identify specific chemicals or conditions responsible for toxicity; a TRE is a study designed to identify causative agents of effluent or ambient toxicity, isolate its sources, evaluate effectiveness of toxicity control options, and confirm reduction of toxicity. A work plan that outlines the process to identify chronic toxicity and prioritize the need to implement a TIE/TRE based on the magnitude and persistence of chronic toxicity is included as Attachment 4A-4.

4.1.3 Storm Drain Outfall Monitoring

The purpose of the Storm Drain Outfall Monitoring Program is to evaluate the potential impact from storm drain discharges on the beneficial uses of the waterbody. This program is designed to meet requirements set forth in Provision D.2 of the Permit and seeks to answer the following question:

- Do non-stormwater or stormwater discharges from the storm drain outfalls contribute to receiving water quality problems?

Table 4-7 provides the number of major outfalls to be monitored under each component of the Storm Drain Outfall Monitoring Program by each Participating Agency. Detailed proposed monitoring methods and procedures as presented in the Storm Drain Outfall Monitoring Plan (Attachment 4A-5). These methods and procedures may be modified on the basis of site-specific environmental conditions and updated analytical methodologies. Additionally, the number of major outfalls monitored per year as shown in **Table 4-7** are subject to change based on new information, updates to the Participating Agency's storm drain outfall inventories, changes in

transient or persistent flow classifications, and/or changes or updates to the priority water quality conditions over the life of the Plan.

Table 4-7. Number of Major Storm Drain Outfalls per Jurisdiction

Jurisdiction	Number of Outfalls Monitored Per Year		
	Field Screening (Provision D.2.b(1))	Dry Weather Monitoring (Provision D.2.b(2))	Wet Weather Monitoring (Provision D.2.c)
City of El Cajon	TBD	TBD	1
City of La Mesa	11[a]	3	1
City of San Diego	502[b]	5	1
City of Santee	46[a]	5	1
County of San Diego	40[a]	5	1

a. For Participating Agencies with fewer than 125 major storm drain outfalls in the watershed, 80% of major outfalls must be screened twice per year.
b. For Participating Agencies with more than 500 major storm drain outfalls, at least 500 major outfalls must be screened once per year (citywide).

4.1.3.1 Storm Drain Outfall Dry Weather Monitoring

The purpose of the Storm Drain Outfall Dry Weather Monitoring Program is to evaluate the potential contribution from storm drain discharges on receiving water quality during dry weather conditions and to assess the ability of programs to effectively eliminate non-storm water discharges to waterbodies or waterways. Each Participating Agency has established a number of major storm drain outfalls that are prioritized based on non-stormwater flow status and threat to receiving water quality, and will be screened once or twice annually based on this prioritization and Permit requirements. Additionally, the highest priority major storm drain outfalls have been selected for further water quality testing to facilitate source investigations of these outfalls with persistent dry weather flows.

Dry Weather Field Screening

Field screening is visual monitoring of all storm drain outfalls to identify and effectively eliminate sources of persistently flowing non-stormwater discharges as required by Provision D.2.b(1). This program assesses the effectiveness of other jurisdictional programs to effectively prohibit non-stormwater discharges. Each Participating Agency will continue to perform a field screening of a certain number of outfalls on an annual basis to maintain an up-to-date inventory of persistently flow outfalls and to initiate follow-up IC/ID investigations the identify and mitigate the source(s). The frequency of field screening will vary from once to twice per year on a jurisdictional basis and is dependent on the number of major outfalls. **Table 4-7** presents the number of outfalls subject to field screening for each jurisdiction in the watershed.

Highest Priority Storm Drain Outfall Dry Weather Monitoring

Per Permit Provision D.2.b(2), Participating Agencies have prioritized the persistently flowing outfalls on the basis of their potential to impact receiving water quality. Highest priority storm drain outfalls with persistent non-stormwater flow will be monitored during dry weather within each jurisdiction, as presented in **Table 4-7**. Using this prioritized list, Participating Agencies will focus resources on abating identified sources to mitigate flow at the five highest priority major outfalls within each of their respective jurisdictions, per Permit Provision D.2.b.(2)(b)(i). Each of the selected outfalls will be monitored twice per year during dry weather conditions. During each event, field observations will be recorded, and when measureable flow is present, *in-situ* field measurements and analytical data will be collected. Analytical constituents will include constituents contributing to the HPWQC, 303(d) List impairments, TMDLs, NALs, and Table D-7 of the Permit; a detailed analyte list is provided in Attachment 4A-5. If historical data demonstrate or justify that analysis of a constituent is not necessary for a particular waterbody or outfall, then it will be removed and noted as an update to this program in the Annual Report.

Based on the data collected at the storm drain outfalls per jurisdiction as shown in **Table 4-7**, monitoring at these outfalls may be reprioritized to eliminate monitoring entirely or to have it be reduced to field screening activities only to address higher priority non-stormwater persistent flows. Reprioritization of outfalls may occur if one of the following conditions is met:

- Non-stormwater discharges have been effectively eliminated for three consecutive monitoring events; or
- Source(s)s of the persistent flows have been identified as not an illicit or a source of pollutants; or
- Pollutants in the persistent flow do not exceed NALs; or
- The threat to water quality has been reduced by the Participating Agency.

Each jurisdiction ranked its outfalls independently on the basis of the HPWQC, pollutant generating areas (PGAs), and available resources. Participating Agencies considered the following factors to prioritize persistently flowing outfalls:

- Potential to contribute to a HPWQC or Priority Water Quality Condition,
- Historical monitoring or inspection data,
- Controllability,
- Surrounding land uses/potential sources, and
- Flow rate.

4.1.3.2 Storm Drain Outfall Wet Weather Monitoring

The purpose of this program is to identify pollutants in stormwater discharges from the stormwater conveyance system, guide pollutant source identification efforts, and track progress in achieving the goals set forth in Chapter 3. The Participating Agencies' five monitoring locations for the wet weather storm drain outfall discharge monitoring component were chosen to be representative of the residential, commercial, industrial, and mixed-use land uses within the watershed pursuant to Provision D.2.c, as presented in **Table 4-7**.

A minimum of five outfalls will be monitored once per year during a storm event with greater than 0.1 inch of rainfall. During each event, observational and hydrologic data will be recorded, including duration of the storm, rainfall estimates, and estimated or measured flow rates and volumes. Grab samples will be collected to analyze for pH, temperature, specific conductivity, dissolved oxygen, turbidity, hardness, and indicator bacteria. A composite sample must be collected and analyzed for constituents contributing to the HPWQC, 303(d) List impairments, TMDLs, and SALs; a detailed analyte list is provided in Attachment 4A-5. If historical data demonstrate or justify that analysis of a constituent is not necessary for a particular waterbody or outfall, then it will be removed and noted as an update to this program in the Annual Report.

The 2013 Transitional Monitoring Programs began implementation of the wet weather storm drain outfall monitoring requirements at the five outfalls within the watershed. Monitoring at selected wet and dry weather storm drain outfalls will be conducted on an annual basis as described above and in Attachment 4A-5.

4.1.4 Special Studies

Special studies have been selected to further investigate the HPWQC to meet requirements of Provision D.3 of the Permit. Per Provision D.3, the purpose of the special studies is to "address pollutant and/or stressor data gaps and/or develop information necessary to more effectively address the pollutants and/or stressors that cause or contribute to Highest Priority Water Quality Conditions identified in the Water Quality Improvement Plan." The special studies will include a regional special study and a special study specific to the watershed. Both special studies selected

for the San Diego River watershed will provide additional information on the HPWQC selected by the watershed's Participating Agencies.

4.1.4.1 San Diego Regional Reference Streams and Beaches Studies

Participating Agencies have elected to participate in the San Diego Regional Reference Streams and Beaches Study currently being conducted by the San Diego and Orange County Participating Agencies. These two regional studies fulfill the requirements for special studies per Provisions D.3.a(2) and D.3.a(3). The studies will develop reasonable and accurate TMDL numeric targets that account for "natural sources" to establish the concentrations or loads from streams minimally disturbed by anthropogenic activities or "reference" conditions. The Reference Stream Study also collected nutrients, metals, and toxicity data as secondary constituents. This study will provide a scientific basis for updating the reference conditions to be considered in evaluating compliance levels in the Bacteria TMDL. The results of this study will be used to support the forthcoming re-evaluation of the recently adopted Bacteria TMDL and to support numeric target development in future TMDLs or alternative regulatory approaches for nutrients and metals.

The San Diego Regional Stream Reference Study will address the following questions (SCCWRP, 2013) in streams minimally influenced by anthropogenic activities:

- How does the Water Quality Objective (WQO) exceedance frequency vary between summer dry weather, winter dry weather, and wet weather?
- How does the WQO exceedance frequency vary by hydrologic factors?
- How does the WQO exceedance frequency vary by input factors?
- How does the WQO exceedance frequency vary by biotic and abiotic factors?

The San Diego Regional Reference Beaches Study will address the following questions (SCCWRP, 2013) at beaches minimally influenced by anthropogenic activities.

- How does the WQO exceedance frequency vary between summer dry weather, winter dry weather, and wet weather?
- How does the WQO exceedance frequency vary by hydrologic factors, including:
    - Discharge flow rate (wet and dry weather), and
    - Status of estuary mouth (open/closed; dry weather only).
- What are the wet and dry weather exceedance frequencies of fecal indicator bacteria in estuaries?

For the stream study, a total of six locations were selected for wet weather monitoring and up to ten locations were selected for dry weather monitoring. Sites were selected to represent 95 percent undeveloped land uses (reference conditions), two major geologic settings, and the target catchment sizes. Wet weather sampling frequency at the six locations consists of three targeted events throughout the wet season (October 1 through April 31). Dry weather sampling frequency consists of weekly sampling for up to 40 weeks at flowing locations during winter and summer dry

weather periods. Dry weather sampling occurs if there has been no measurable rainfall for at least 72 hours.

Water samples will be analyzed for a combination of conventional constituents, nutrients, metals, fecal indicator bacteria, microbial source testing, and algae. Of these constituents, *Enterococcus*, *E. coli*, fecal coliform, total coliform, Bacteroides, and *in-situ* parameters are of primary importance; all other analytes are considered secondary. During dry weather sampling, reference stream sites will be assessed for algal percent cover, algal biomass, ash-free biomass, and factors that control the growth of algae (stream bankful dimensions, canopy cover, and pebble count). Flow discharge rates were estimated for seven reference streams using recorded continuous water level data during both wet and dry weather conditions and measured velocity and flow during sampled wet weather events.

4.1.4.2 Wet Weather Epidemiology Study and Quantitative Microbial Risk Assessment

The special study specific to the watershed will examine the correlation between bacteria levels in stormwater discharges from the San Diego River and the health effects experienced by surfers at Ocean Beach, located near the mouth of the San Diego River. SCCWRP and the University of California at Berkeley, in collaboration with the Surfrider Foundation are conducting the study. It is primarily funded equally by the County of San Diego and City of San Diego with additional funding assistance from the remaining San Diego River Participating Agencies. The Wet Weather Epidemiology Study and Microbial Risk Assessment (Surfer Health Study) began in January 2014 and will continue through March of 2015. A final report is anticipated in June of 2016.

The Surfer Health Study will be conducted using a two-phased approach. Phase 1 consists of an epidemiological study involving recruitment of surfers for self-reported illness tracking and water quality sampling at the beaches. Phase 2 consists of a quantitative microbial risk assessment (QMRA), including source tracking through composite wet weather sampling of San Diego River and Tourmaline Creek, measurements and modeling of swimmer exposure, and modeling of illness response. The overall purpose of this study is to assess wet weather impacts on the water contact recreation (REC-1) beneficial use.

Specifically, the Surfer Health Study will address the following questions (SCCWRP, 2014):

- Is water contact associated with an increased risk of illness?
- Is illness risk greater following exposure to wet weather events as compared with dry weather?
- What is the association between levels of *Enterococcus* and illness following wet weather events?
- What level of *Enterococcus* corresponds to the same risk of illness as current water quality standards?

The epidemiology study portion involves recruitment of surfers to provide 22,000 exposure-days of health information. Surfer survey parameters will include location, timing, and duration of water exposure, and estimated volume of water ingestion. Survey parameters for illness will include

symptoms of illness as well as potential confounding factors (e.g., household illness) and economic impact of illness (e.g., missed work days). During the same period, 120 days of fecal indicator bacteria measurements will be collected from the two study beaches. Roughly 200 surfers will be followed longitudinally for 16 weeks, providing information on marine water exposure and reported illness via website and smartphone application. Water quality sampling will be conducted daily at Tourmaline Surfing Park and Ocean Beach; sample locations consist of existing AB411 monitoring locations, with the addition of at least one sample site at Ocean Beach Pier. Beach water quality sampling will focus on existing protocols used in the AB411 monitoring program, with samples analyzed for *Enterococcus*, fecal coliform, and total coliform.

The QMRA study portion involves collection of 20-liter flow-weighted composite samples from at least six storm events from Tourmaline Creek and the San Diego River, which comprise the two largest watershed discharge sources at the two study beaches. Health risk assessments with uncertainty calculations will be conducted for surfers at the two study beaches.

Water samples will be analyzed for host-specific markers to facilitate source tracking. Additionally, samples will be analyzed for human pathogens such as viruses, and protozoans. The pathogen concentrations detected will be incorporated in a plume fate and transport model to estimate swimmer exposure. Physical water quality parameters, including temperature and salinity, will be measured at the stream discharge points at the study beaches; these data will also be included in the model. For details of the Surfer Health Study, refer to Attachment 4A-6.

4.1.5 Illicit Discharge Detection and Elimination Program

Each Participating Agency is required to develop an Illicit Discharge Detection and Elimination (IDDE) Program to address the potential contribution of pollutants from non-stormwater and stormwater discharges and to establish and enforce pollutant discharge prohibitions in compliance with Provision E.2 of the Permit. The outline of an IDDE Program is included in the Plan to establish a consistent framework for all Jurisdictional Runoff Management Programs (JRMP) within the watershed and to describe the data that may be generated to support assessments described in **Section 4.2**. The IDDE Program will be designed to have the following goals:

- Control the contribution of pollutants to and the discharges from the storm drains within its jurisdiction.
- Effectively prohibit non-stormwater discharges to the storm drain.
- Reduce the discharge of pollutants in stormwater to the maximum extent practicable.

4.1.5.1 Prevent and Detect Illicit Discharges and Connections

To prevent and detect ID/ICs, Participating Agencies have implemented protocols and programs in their jurisdictions to promote good housekeeping and clean practices to prevent ID/ICs. Each Participating Agency maintains a map of its stormwater conveyance system and a detailed inventory of its outfalls as critical investigative tools to better identify potential sources and impacts. Additionally, staff and contractors will be trained and a public hotline will be made

available to continue to promote reporting of potential incidents on a broader scale. The Regional Stormwater Hotline (1-888-846-0800), operated by the County of San Diego on behalf of the Copermittees, is a valuable resource for pollution reporting. The Project Clean Water website (www.projectcleanwater.org) will continue to be emphasized as a resource to disseminate water quality-related information to the public. Each Participating Agency also relies on jurisdictional public reporting methods such as websites, call centers and/or mobile smartphone reporting systems. These programs are described in more detail in Participating Agencies' Jurisdictional Runoff Management Plans. **Table 4-8** presents three key tools of prevention implemented throughout the watershed.

Table 4-8. IC/ID Prevention Tools

Storm Drain System Mapping	Outfall Monitoring Station Inventory	Identifying and Reporting ID/ICs
The map will identify: • All segments of the stormwater conveyance system owned, operated, and maintained by the Participating Agency • Locations of all known connections with other stormwater conveyance systems not owned by the Participating Agency • Locations of inlets and outfalls that collect and/or discharge runoff within the stormwater conveyance system • All waterbody segments within the Participating Agency's jurisdiction that receive discharges from Participating Agency stormwater conveyance system outfalls • Locations of the stormwater conveyance system outfalls within the Participating Agency's jurisdiction • Locations of stormwater conveyance system outfalls with known persistent flows	The inventory will include: • GPS coordinates (latitude and longitude) of the stormwater conveyance system outfall • Watershed Management Area • Hydrologic subarea • Outlet size • Accessibility (safety, co-location of critical habitat, presence of tidal influence, etc.) • Approximate drainage area • Historical dry weather flow classification (persistent, transient, no, or unknown flow)	Actions will include: • Training personnel and contractors to identify ID/ICs during their daily routine • Promoting and facilitating public reporting of IC/IDs. • Providing a Regional Stormwater Hotline (1-888-846-0800) • Emphasizing the Project Clean Water website (www.projectcleanwater.org) These programs are described in more detail in Participating Agencies' Jurisdictional Runoff Management Plans.

4.1.5.2 INVESTIGATE AND ELIMINATE ILLICIT DISCHARGES AND CONNECTIONS

The Participating Agencies may modify these procedures as necessary to ensure that they are reflective of their own internal policies and procedures. Participating Agencies will prioritize, conduct follow-up investigations, and seek to identify sources of non-stormwater discharges on the basis of the following information:

- Field screening visual observations per Permit Provision D.2.a(1),
- Non-stormwater monitoring per Permit Provision D.2.a(2), and
- Reports or notifications of illicit discharges, illicit connections, or other sources of non-stormwater from hotlines or other sources.

Obvious illicit discharges (e.g., based on color, odor, or exceedance of an action level) and any discharges that pose an immediate threat to human health or the environment will be investigated immediately. Each Participating Agency will respond in accordance with its legal authority to eliminate illicit discharges and connections to the stormwater conveyance system and its Enforcement Response Plan, as appropriate.

Incident reports will be assessed in a timely manner. The validity of a report or notification will be based on the inspector's best professional judgment given the information that has been obtained. Invalid reports will be noted and reported in the JRMP Annual Report Form; valid reports will be prioritized for further investigation.

Follow-up investigations may include review of information provided in the incident report, recent sample results, and review of inventories or land use data and may involve collection of additional analytical samples. Prioritization of follow-up investigations will, at minimum, be based on the criteria provided in Permit Provision E.2.d(1):

1) Pollutants causing or contributing to bacteria, the HPWQC.
2) Pollutants causing or contributing to, or threatening to cause or contribute to, impairments in waterbodies on the 303(d) List and/or environmentally sensitive areas (ESAs) located within its jurisdiction;
3) Pollutants from sources or land uses known to exist within the area, drainage basin, or watershed that discharges to the portion of stormwater conveyance system within its jurisdiction; or
4) Pollutants causing or contributing to an exceedance of an NAL.

A field investigation must be conducted to seek to identify the sources of non-stormwater persistent flows monitored under Permit Provision D.2.b(2). The investigation may include follow up field investigations and/or review of inventories and other land use data to identify potential sources.

4.1.5.3 *Records and Reporting*

With each Annual Report, each Participating Agency must summarize all IC/ID investigations and those eliminated within its jurisdiction using the IC/ID investigations data-sharing template per Permit Provision D.2d.(4). The Participating Agencies developed a data-sharing template during the transitional monitoring period 2013–2015 to include all the information listed below, per the Permit requirements. Each Participating Agency must maintain records and a database of the following information per Permit Provisions D.2.d(2)(d) and D.2.d(2)(e):

- Location of incident, hydrologic subarea (HSA), portion of the stormwater conveyance system affected, and point of discharge or potential discharge to the receiving water; and
- Source of information, including dates of report, initiation of investigation, and follow-up investigation, identified or suspected source, known or suspected incident, result of the investigation, and documentation of the response.

4.1.6 *Regional Clearinghouse*

Participating Agencies will use existing data-sharing templates to facilitate compilation of watershed-wide datasets for assessment and reporting purposes. To support reporting under previous Permit cycles, regional data-sharing templates were developed for receiving water monitoring, storm drain outfall monitoring, field screening, and IC/ID reporting. Participating Agencies will make the following data and documentation available to the public on the Project Clean Water website:

- San Diego River Water Quality Improvement Plan and all updated versions with date of update,
- Annual Reports for the watershed,
- Jurisdictional Runoff Management Program documents for each Participating Agency within the watershed and all updated versions with date of update,
- BMP Design Manual for each Participating Agency within the watershed and all updated versions with date of update,
- Reports from special studies conducted in the watershed,
- Monitoring data uploaded to the California Environmental Data Exchange Network (CEDEN) with links to the uploaded data, and
- Geographic information system (GIS) data, layers, and/or shape files that are available for distribution and used to develop the maps to support the Plan, Annual Reports, and Jurisdictional Runoff Management Programs.

> Project Clean Water is a web-based portal that functions as a regional clearinghouse for San Diego County watersheds. It is used as a centralized point of access to share educational materials, water quality information, and Permit-required reports with the public.
>
> www.projectcleanwater.org

4.2 WATER QUALITY IMPROVEMENT PLAN ASSESSMENT PROGRAM

The assessment portion of the Monitoring and Assessment Program will evaluate the data collected under the monitoring programs described in Section 4.1, and integrate the information collected as part of the Jurisdictional Runoff Management Programs. The data collected from these two programs will be used to assess the progress toward achieving the numeric goals and schedules identified in the Plan and to measure the progress toward addressing the HPWQC. **Figure 4-1** depicts how the watershed monitoring activities will support the assessments required by the Permit.

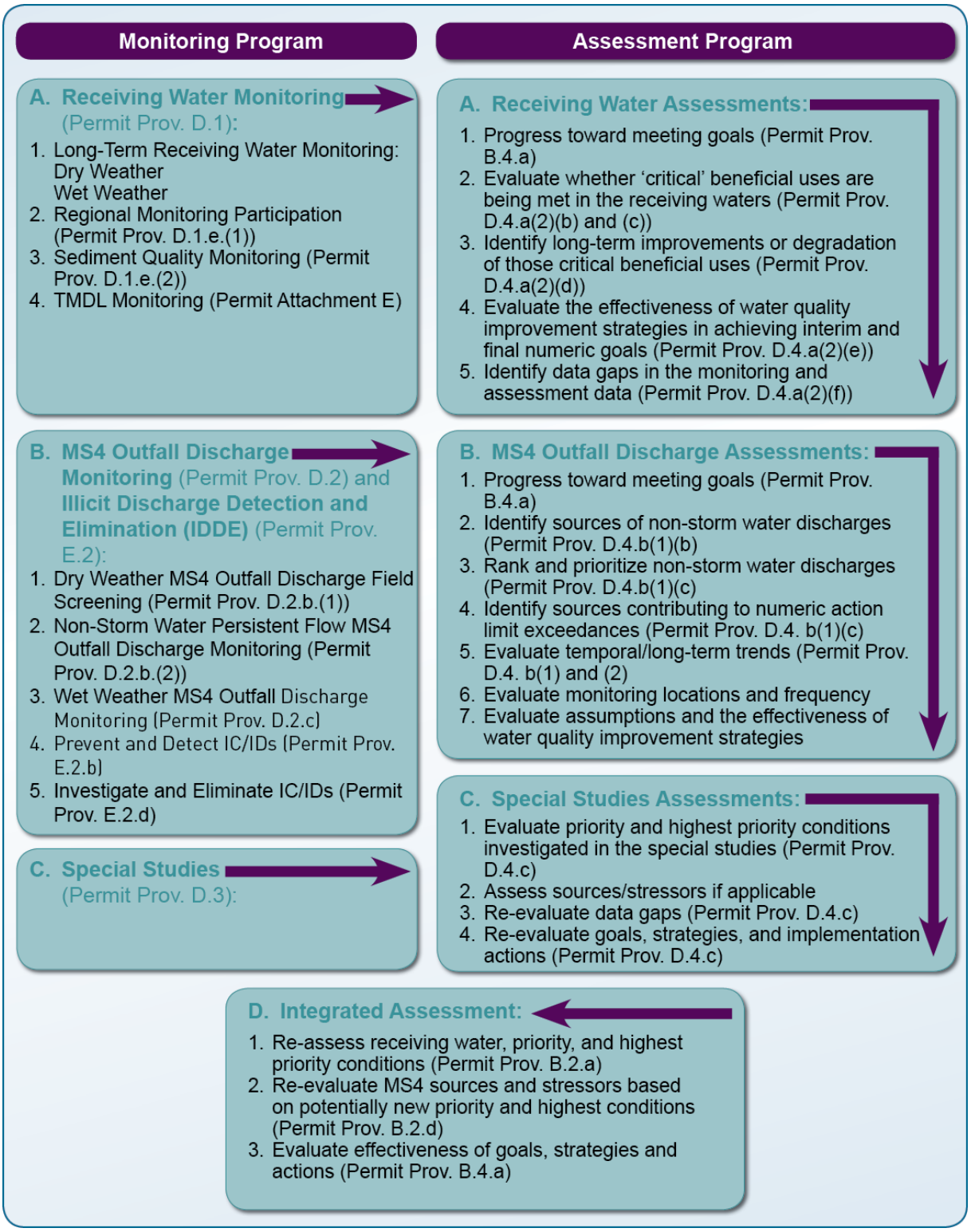

Figure 4-1. Monitoring and Assessment Program Components for the San Diego River Watershed

Table 4-9 summarizes the reporting and assessment requirements of the Permit. Some assessments will be reported annually, as part of the Annual Report, while others will be included in the Report of Waste Discharge that the Participating Agencies must submit 180 days prior to the end of this Permit.

The Monitoring and Assessment Program will be evaluated and adapted in the context of the Annual Report and the Report of Waste Discharge. The re-evaluation will consider data gaps and the results of all monitoring program elements. Modifications may be made to the program, but the core elements required by the Permit and described in **Section 4.1** must be maintained. This limits the amount of adaptation that is possible. Potential changes could be to modify the frequency of sampling, add a new analyte of concern, or move a monitoring location.

4.2.1 Water Quality Improvement Plan Annual Report

The Annual Report must be submitted for each reporting period no later than January 31 of the following year. The Annual Report will evaluate data and information from JRMP and monitoring programs to present key findings related to water quality in the receiving waters and storm drain discharges, evaluate the effectiveness of these programs, and present any recommended modifications to the Plan. The JRMP Annual Reports will reflect program activities conducted between July 1 and June 30 of the year following acceptance of the Plan. The Monitoring and Assessment Annual Report will reflect program activities conducted between October 1 and September 30 of the year following acceptance of the Plan. **Table 4-9** presents the assessments and information that must be included in each Annual Report required by the Permit.

Table 4-9. Water Quality Improvement Plan Annual Report Requirements

Assessment and Documentation	Detailed Data and Information
Summary of data collected, findings, interpretations, and conclusions from the assessments required per Provision F.b.(3)(a), (b), and (c)	• Receiving Water Assessments per Provision D.4.a. • Sediment Quality Assessments per Provision D.1.e(2) • TMDL Assessments per Provision E.6 • Storm Drain Discharge Assessments D.4.b • IDDE relevant information and findings • Special studies: findings and progress per Provision D.4.c • Re-evaluation of the priority water quality conditions, numeric goals, strategies, schedules, and/or monitoring and assessment, as needed per Provision D.4.d.[(1)]
Progress of implementing the Plan per Provision F.b.(3)(d)	• Progress towards interim and final numeric goals for the highest priority water quality priorities for the watershed • Status of water quality improvement strategies by each Participating Agency • Proposed modifications to water quality improvement strategies and supporting rationale • Water quality improvement strategies planned for implementation during the next reporting period • Proposed modifications to the Plan and/or each Participating Agency's jurisdictional runoff management program document • Previous modifications or updates incorporated into the Plan

Assessment and Documentation	Detailed Data and Information
	and/or each Participating Agency's jurisdictional runoff management program document
A completed Jurisdictional Runoff Management Program Annual Report Form for each Copermittee in the watershed, certified by a Principal Executive Officer, Ranking Elected Official, or Duly Authorized Representative per Provision F.b.(3)(e)	• City of El Cajon • City of La Mesa • City of San Diego • City of Santee • County of San Diego
Any data or documentation utilized in developing the Annual Report for each Participating Agency, upon request by the Regional Board. Monitoring data must be uploaded to the California Environmental Data Exchange Network (CEDEN) and available for access on the Regional Clearinghouse per Provision F.b.(3)(f)	• Receiving water and data collected per Permit Provision D. 1 • Storm drain discharge monitoring data collected per Permit Provision D.2 • Special Study data • IC/ID investigation data

4.2.1.1 Receiving Water Assessment

The assessment of receiving waters involves evaluating the physical, chemical, and biological conditions of the receiving waters and sediments. The Participating Agencies must assess the status and trends of receiving water quality conditions in coastal waters, enclosed bays, estuaries, and streams in the watershed. The receiving water assessment to be presented in the Annual Report will:

- Assess whether or not the conditions of the receiving waters are meeting the numeric goals established in the Plan,
- Identify the most critical beneficial uses that must be protected to ensure the overall health of the receiving water,
- Evaluate whether or not those critical beneficial uses are being protected,
- Identify short-term and/or long-term improvements or degradation of those critical beneficial uses,
- Consider whether or not the strategies established in the Plan contribute toward progress in achieving the interim and final numeric goals of the Plan, and
- Identify data gaps in the monitoring data needed to assess the provisions above.

4.2.1.2 *Stormwater Drain Discharge Assessments*

The storm drain discharge assessments include evaluating both the dry weather monitoring data associated with the IDDE program collected as part of the Jurisdictional Runoff Management Program and the wet weather monitoring data collected by the Participating Agencies. Details of these two separate assessments are provided below. Each Participating Agency will assess its dry weather stormwater conveyance system monitoring programs individually and compile results annually as part of the Annual Report. Each Participating Agency must assess and report the progress of its IDDE program (required pursuant to Permit Provision E.2) toward effectively prohibiting non-stormwater and illicit discharges into the stormwater conveyance systems within its jurisdiction, including the elements in **Table 4-10**.

Table 4-10. Key Elements of the Storm Drain Discharge Assessments

Non-stormwater Assessment	Illicit Discharge	Wet Weather Outfall Assessment
• Identify sources of non-stormwater discharges on the basis of field screening data or IDDE activities • Rank and prioritize non-stormwater discharges • Identify sources contributing to numeric action limit exceedances • Estimate volumes and loads of non-stormwater discharges • Evaluate non-stormwater discharge monitoring locations • Evaluate the effectiveness of the water quality improvement strategies	• All IC/ID investigations • IC/IDs eliminated within the jurisdiction	• Estimate volumes and loads of stormwater discharges • Evaluate temporal trends • Evaluate stormwater discharge monitoring locations and frequency • Evaluate Plan analysis • Evaluate the effectiveness of water quality improvement strategies

4.2.1.3 *Special Studies Assessments*

As part of the Annual Report, the Participating Agencies will evaluate the results and findings from the special studies. They will use the resulting data to (1) assess their relevance to the Participating Agencies' characterization of receiving water conditions, (2) understand sources of pollutants and/or stressors, and (3) control and reduce the discharges of pollutants from the storm drain outfalls to receiving waters. As with the other monitoring programs, the results of the special studies assessment may warrant modifications of or updates to the Plan.

The special studies will attempt to answer questions concerning the natural "reference" concentrations of bacteria and other pollutants in the region, and to identify the current known sources of in the watershed. The special studies will help guide the implementation of the strategies for the HPWQC.

4.2.1.4 *Modifications or Updates to Water Quality Improvement Plan Programs*

Participating Agencies may recommend modifications or updates to priorities, goals, strategies, monitoring, or JRMP program activities in the Annual Report.

4.2.2 *Report of Waste Discharge*

Submittal of the Report of Waste Discharge serves as an application for renewal of the Permit and, therefore, must be submitted by all listed Participating Agencies 180 days prior to the expiration date of the Permit. The Report of Waste Discharge will include information required for the permit renewal process per Permit Provision F.5, an integrated assessment of Plan programs, and possibly the Regional Monitoring and Assessment Report as required under Permit Provision F.3c.

4.2.3 *Integrated Assessment*

The Participating Agencies will integrate the data collected as part of the Monitoring and Assessment Program, along with information collected during the implementation of the JRMP. The integrated assessment will evaluate the main components of the Plan and will follow the assessment process outlined in the Permit, as summarized in **Table 4-11**.

The integrated assessment builds on the receiving water assessment, storm drain discharge assessment, and special studies assessment described in Sections 4.2.2, and includes an additional evaluation of temporal/long-term trends of wet weather stormwater conveyance system outfalls. Additionally, the integrated assessment will evaluate the data collected as part of the transitional monitoring program implemented after the approval of the 2013 Permit and before the implementation of the monitoring program detailed in Section 4.1.

The integrated assessment for all three Plan components: (1) Priority Water Quality Conditions, (2) Goals and Schedules, and (3) Strategies and will be performed during the development of the Report of Waste Discharge. The priority water quality conditions will be re-evaluated using the receiving water and storm drain discharge assessments. The goals and schedules in Chapter 2 will be reviewed on the basis of the results of the receiving water and storm drain discharge assessments, along with data collected as part of the JRMP. This evaluation will highlight the progress in achieving the compliance goals. Finally, both water quality monitoring data and maintenance/observational data related to BMP effectiveness will be used to assess the strategies implemented by the Participating Agencies. Strategies will be evaluated in the Annual Report on the basis of the data collected as part of the JRMP and any new relevant BMP effectiveness data collected by the Participating Agencies.

Table 4-11. Integrated Assessment Components

Component	Permit Assessment Methodology	Evaluation Assessment
Priority Water Quality Conditions	<u>Re-assess receiving water, priority, and highest priority conditions.</u> (1) Re-evaluate the receiving water conditions per methodology and any new methodology described in Chapter 2. (2) Re-evaluate the impacts of storm drain discharges on receiving waters, including an evaluation of temporal/long-term trends of the cumulative wet weather storm drain outfall water quality data sets (Provision D.4.b.(2)(d)). (3) Identify beneficial uses in receiving waters that must be protected per Receiving Water Assessment presented in Chapter 2. <u>Re-evaluate stormwater conveyance system sources and stressors based on potentially new priority and highest priority conditions.</u> (4) Re-evaluate the identification of stormwater conveyance system sources and/or stressors performed in Chapter 2.	• Receiving Water Assessments • Storm Drain Discharge Assessments
Goals and Schedules	<u>Evaluate effectiveness of goals.</u> (1) Evaluate the progress toward achieving interim and final numeric goals for protecting impacted beneficial uses in receiving waters.	• Receiving Water Assessments • Storm Drain Discharge Assessments • JRMP Assessments
Strategies	<u>Evaluate effectiveness of strategies and actions.</u> (1) Identify the non-stormwater and stormwater pollutant loads from the storm drain outfalls on the basis of the Storm Drain Discharge Assessment (Section 4.2.1.2). (2) Identify the non-stormwater and stormwater pollutant load reductions, or other improvements that are necessary to attain the interim and final numeric goals. (3) Identify the non-stormwater and stormwater pollutant load reductions, or other improvements, that are necessary to demonstrate that non-stormwater and stormwater discharges are not causing or contributing to exceedances of receiving water limitations. (4) Evaluate the progress of the strategies toward achieving interim and final numeric goals for protecting beneficial uses in receiving waters.	• Storm Drain Discharge Assessments • Special Studies Assessments for BMP Effectiveness • JRMP Assessments

4.2.4 Regional Monitoring Report

The regional monitoring and reporting requirement from Provision F.3.c of the Permit requires integration of all data on a regional scale to recommend modifications to the implementation or assessment of the Plan and jurisdictional runoff management programs. The report must assess the following:

- The beneficial uses of the receiving waters within the San Diego Region that are supported and not adversely affected by the Participating Agency's storm drain discharges,
- The beneficial uses of the receiving waters within the San Diego Region that are adversely affected by the Participating Agency's storm drain discharges,
- The progress toward protecting beneficial uses of the receiving waters within the San Diego Region from Participating Agency's storm drain discharges, and
- Pollutants or conditions of emerging concern that may impact beneficial uses of the receiving waters within the San Diego Region.

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ATTACHMENT 4A-1: SAN DIEGO RIVER WATERSHED RECEIVING WATER MONITORING PLAN

SAN DIEGO RIVER WATERSHED RECEIVING WATER MONITORING PLAN

Prepared For:
San Diego River Watershed
Participating Agencies

Prepared By:
AMEC Environment and Infrastructure, Inc.
9177 Sky Park Court
San Diego, California 92123
January 2015

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Attachment B Stream Rating and Channel Survey Details
Attachment C Example Chain-of-Custody Form

LIST OF ACRONYMS AND ABBREVIATIONS

>	less than
<	greater than
AFDM	ash-free dry mass
APHA	American Public Health Association
AWWA	American Water Works Association
BMI	benthic macroinvertebrate
BOD	biochemical oxygen demand
BSA	bovine serum albumin
Caltrans	California Department of Transportation
CDFG	California Department of Fish and Game
CEDEN	California Environmental Data Exchange Network
COC	chain of custody
cm^2	square centimeter
CRAM	California Rapid Assessment Method
CSBP	California Stream Bioassessment
EDD	electronic data deliverable
EDTA	ethylenediaminetetraacetic acid
ELAP	Environmental Laboratory Accreditation Program
GIS	geographic information system
GPS	Global Positioning System
IBI	Index of Biological Integrity
ID	identification
m	meter
mL	milliliter
MLS	Mass Loading Station
mm	millimeter
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
PBO	piperonyl butoxide
Permit	San Diego Regional Water Quality Control Board Order Number R9-2013-0001, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds Within the San Diego Region
pH	hydrogen ion concentration
PVC	polyvinyl chloride
O/E	observed to expected

QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RWQCB	Regional Water Quality Control Board
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California's Coastal Water Research Project
SDCRC	San Diego County Regional Copermittees
SDR-MLS	San Diego River Mass Loading Station
SDWQCB	San Diego Regional Water Quality Control Board
SMC	Stormwater Monitoring Coalition
SOP	standard operating procedure
SPE	solid phase extraction
STS	sodium thiosulfate
SWAMP	Surface Water Ambient Monitoring Program
TIE	toxicity identification evaluation
TMDL	total maximum daily load
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
WEF	Water Environment Federation

1 INTRODUCTION

The purpose of this Monitoring Plan is to describe the long-term receiving water monitoring, as required by the San Diego Regional Water Quality Control Board (RWQCB) Order No. R9-2013-0001, *National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges From the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds Within the San Diego Region*, hereafter referred to as the Permit. The goal of the San Diego River Watershed Receiving Water Monitoring Program is to characterize current conditions and assess progress in the receiving waters, and effectiveness of water quality improvement strategies implemented as part of the San Diego River Watershed Water Quality Improvement Plan.

1.1 PROGRAM OVERVIEW

The Receiving Water Monitoring Plan includes the following monitoring to satisfy the requirements of Provision D of the Permit:

- Long-term dry and wet weather receiving water monitoring at one mass loading station (MLS) in accordance with the Permit (Provisions D.1.b, c, and d)
- Rapid stream bioassessment and in accordance with the Permit (Provision D.1.c.(5)) which includes Regional monitoring participation in the Stormwater Monitoring Coalition (SMC) Regional Monitoring Program and Southern California Bight Regional Monitoring Program (Provision D.1.e.(1))
- Continue dry weather hydromodification monitoring in accordance with the Permit (Provision D.1.c.(6))

1.2 MONITORING LOCATIONS

The San Diego River Watershed Participating Agencies have selected the San Diego River Mass Loading Station (MLS) (SDR-MLS) as the long-term receiving water monitoring location. SDR-MLS is co-located with the U.S. Geological Survey (USGS) gauging station in a modified natural channel, adjacent to the Fashion Valley Mall in the City of San Diego. Location details are provided in Table 1-1. A map of the location is presented in Figure 1-1.

Table 1-1. List of Receiving Water Monitoring Locations for the Permit Term

Watershed	Station ID	Latitude	Longitude	Cross Street Description	Channel Type	Jurisdiction
San Diego River	SDR-MLS	32.765240	-117.168617	Directly south of the Fashion Valley Trolley Station at the footbridge.	Modified natural channel	City of San Diego

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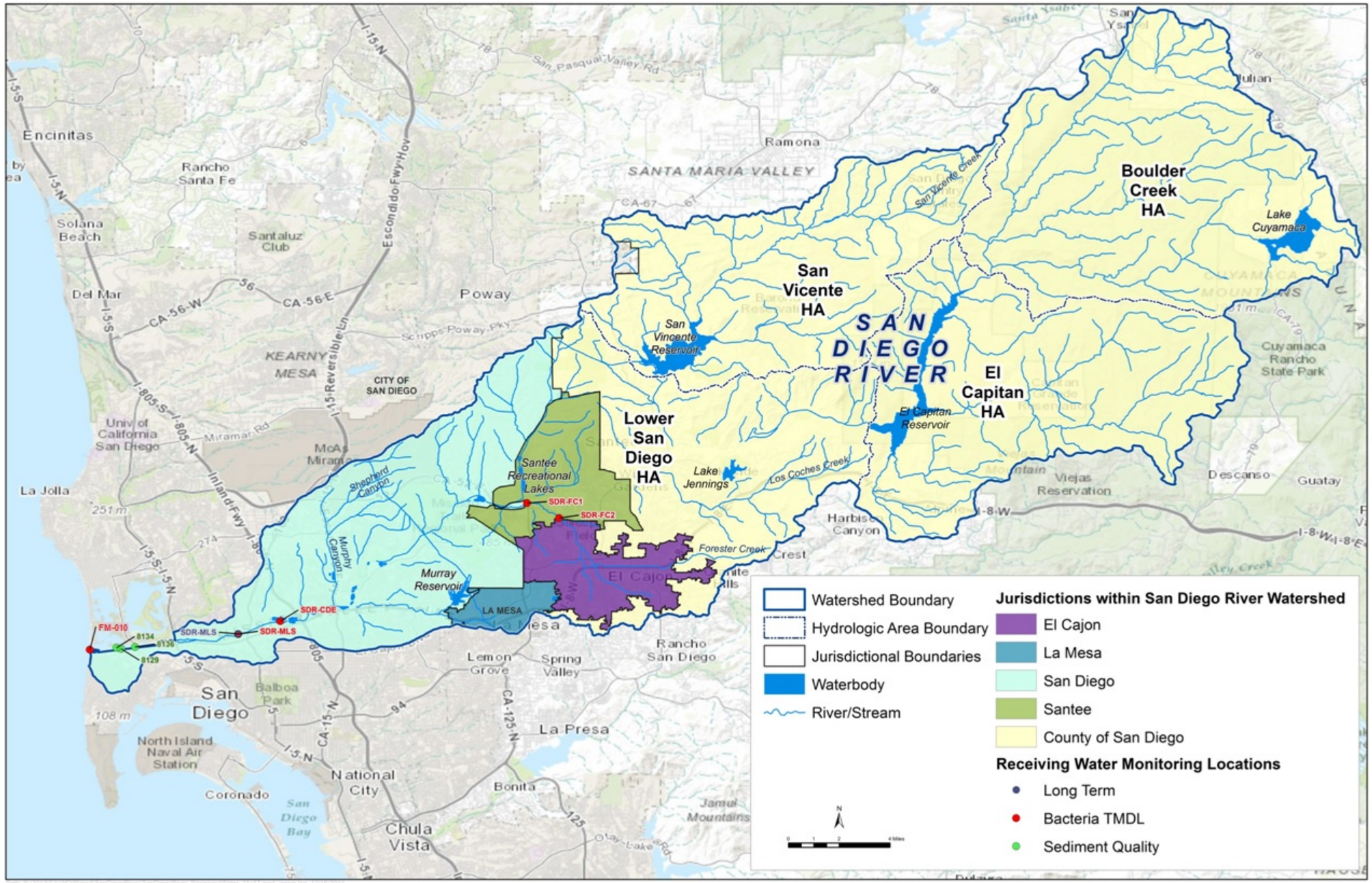

Figure 1-1. Receiving Water Monitoring Locations

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2 MONITORING METHODS

This section describes monitoring methods and procedures used to implement the long-term receiving water monitoring program. Long-term receiving water monitoring will be conducted at the MLS for the San Diego River Watershed, in accordance with the Permit (Provisions D.1.b, c, and d).

2.1 WATER QUALITY SAMPLING

This section discusses the sampling procedures and analytical methods for water quality sampling. All sampling and analyses conducted for long-term receiving water monitoring locations will be in accordance with applicable United States Environmental Protection Agency (USEPA) regulations and guidance. Attachment A provides a complete list of constituents, potential methods, sample volumes, holding times, and target reporting limits for the San Diego River Watershed Receiving Water Monitoring Program.

2.1.1 DRY WEATHER

Each long-term monitoring location will be monitored during three dry weather events: once during September prior to the start of the wet season, once during a dry period in the wet season, and once in May or June after the end of the wet season. Dry weather monitoring will be conducted in days with less than 0.1 inches of rainfall and 72 hours of antecedent dry conditions.

In the event that dry weather flow is not observed at a station during the September monitoring event prior to the start of the wet season, the first dry weather sampling event will occur during a qualifying event (e.g., at least 72 hours after a storm event) if dry weather flow is observed during the wet season.

2.1.2 WET WEATHER

Each long-term station will be monitored during three wet weather events: during the first viable rainfall event of the wet season on or after October 1, during one event at least 30 days after the first rainfall event, and during one rainfall event after February 1. A flow- or time-weighted composite will be collected.

2.1.3 FLOW MONITORING

Flow rates may be monitored using American Sigma (or comparable) flowmeters with an ultrasonic sensor, bubbler, or submerged pressure transducer as the primary measuring device. The primary sensor will continuously measure stage (i.e., stream height) and relay that information to the flowmeter. The flowmeter will continually calculate flow rates by inserting the stage information into the preprogrammed discharge equation. Using this system, the flowmeter will be able to actuate the sampler to achieve a flow-weighted composite sample, if desired. Sampling and flow equipment will be monitored remotely, and data will be transferred to a permanent data system by cellular modem or manual download.

Equipment installed and used for monitoring during dry weather will remain in place for at least the duration of the monitoring event. The monitoring year is approximately October 1 through September 30. If collected, continual flow data will be downloaded remotely from each station once every two weeks to verify equipment functionality and to reduce data gaps, ensure accuracy, and identify maintenance and calibration needs. Flow data will be entered into the data management system. Equipment will be maintained throughout this period to ensure that it is in proper working order. Additional flow monitoring details, including example methods used for stream rating and channel surveys, are provided in Attachment B.

2.1.4 Grab Samples

Grab samples will be collected for those constituents that are not amenable to composite sampling. Per the Permit, the constituents to be collected as grab samples are indicated in Attachment A and include:

- Temperature
- Hydrogen ion concentration (pH)
- Specific conductance
- Dissolved oxygen
- Turbidity
- Total coliform
- Fecal coliform
- *Enterococcus*

Samples will be collected from the horizontal and vertical center of the channel if possible and will be kept clear of uncharacteristic floating debris.

Microbiology samples will be collected using sterile techniques. Nitrile or latex-type gloves will be worn during sample handling. During the sample event, a 100-milliliter (mL) sterile bacteria bottle will be used to collect the sample directly from the receiving water. Care will be employed to not allow contact with area structures or bottom sediments. The container will be opened only for the time needed to collect the sample and will be closed immediately following sample collection. If it is suspected that the container was compromised at any time, the sample container will be discarded, and a new sample will be collected using a new sample bottle. The sample must be filled only to the 100-mL mark on the sample bottle (not over-topped or under-filled).

Field measurements will be performed for pH, specific conductance, temperature, dissolved oxygen, and turbidity using a water quality probe or similar device. Calibration of the instruments will be conducted prior to each sampling event in accordance with the manufacturer's specifications and calibrated following each sampling event. Calibration records will be kept on file.

A field observation data sheet will be completed for each sample collected to be representative of station conditions. Field observations include trash assessments, which will be performed at each station in accordance with the *Monitoring Workplan for the Assessment of Trash in San Diego County* (San Diego County Regional Copermittees [SDCRC], 2007a).

2.2 COMPOSITE SAMPLES

A flow- or time-weighted composite sample will be collected at each station during the dry weather and wet weather monitoring events. During the monitoring event, sample aliquots will be collected in proportion to the rate of flow (i.e., flow-weighted) using automated equipment and Teflon-lined tubing. Dry weather flow-weighted composite samples will be collected over a typical 24-hour period, with a minimum of three sample aliquots collected per hour. Wet weather flow-weighted composite samples will be collected by taking sample aliquots across the hydrograph of the storm event. Based on the anticipated size of the storm, a flow-proportioned pacing will be programmed into the automated sampling equipment. The first sample aliquot will be taken at or shortly after the time that stormwater runoff begins, and each subsequent aliquot of equal volume will be collected every time the pre-selected flow volume (flow-proportional pacing) discharges past the monitoring location. Some variation may occur depending on actual storm intensity and duration.

The flow-weighted composite samples will be analyzed for all the constituents not identified for grab sampling. The complete list of constituents for the San Diego River Watershed for dry weather and wet weather is provided in Attachment A.

2.3 SAMPLE ANALYSIS

Samples will be analyzed for the bacteria, chemistry, toxicity, and general field parameters provided in Attachment A. Attachment A includes the methods and target reporting limits for each constituent. Chemical, toxicity, and bacterial analysis of samples will be performed by a laboratory certified for the appropriate fields of testing by the California Environmental Laboratory Accreditation Program (ELAP). The laboratory(s) will also be a participant in the SMC Intercalibration Program.

General physical and chemical constituents will be analyzed by accredited laboratories, with the exception of field-measured constituents (i.e., pH, specific conductance, temperature, turbidity, and dissolved oxygen). Field measurements will be collected by field staff during sampling activities using an YSI 6600 series water quality probe or similar type device.

2.4 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance (QA) and quality control (QC) for sampling processes will include proper collection of the samples to minimize the possibility of contamination. All samples will be collected in laboratory-supplied, laboratory-certified, contaminant-free sample bottles. Field staff will wear powder-free nitrile or similar gloves at all times during sample collection.

QC samples will be collected to ensure that valid data are collected. Depending on the parameter, QC samples will consist of blanks and duplicate samples to remain compliant with Surface Water Ambient Monitoring Program (SWAMP) protocols. QC requirements will be reviewed and discussed with the appropriate staff to verify the proper working order of equipment, refresh monitoring personnel in monitoring techniques, and determine whether the data quality objectives are being met.

The QA objectives for analyses conducted by the participating analytical laboratories are detailed in their Laboratory QA Manuals. The objectives for accuracy and precision involve all aspects of the testing process, including the following:

- Methods and standard operating procedures (SOPs)
- Calibration methods and frequency
- Data analysis, validation, and reporting
- Internal QC
- Preventive maintenance
- Procedures to ensure data accuracy and completeness

The results of the laboratory QC analyses will be reported with the final data. Any QC samples that fail to meet the specified QC criteria in the methodology will be identified, and the corresponding data will be appropriately qualified in the final report. All QA/QC records for the various testing programs will be kept on file for review by regulatory agency personnel.

2.4.1 Training and Certification

All field personnel will have current and relevant experience in all aspects of standard field monitoring, including use of relevant field equipment such as field instruments and monitoring equipment. Field personnel will be trained and will have experience in the sample collection and handling/storage, and chain-of-custody procedures. Proper field sampling and sample-handling techniques will be reviewed prior to sampling, and only those staff with proficiency will be permitted to conduct the field work. Training will be documented in the health and safety plan for each member of the field team.

All personnel are responsible for complying with the QA/QC requirements that pertain to their organizational/technical functions. Each technical staff member must have a combination of experience and education to adequately demonstrate a specific knowledge of his or her particular function and a general knowledge of laboratory operations, test methods, QA/QC procedures, and records management.

2.4.2 Chain-of-Custody Procedures

Samples will be considered to be in custody if they are (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a container and secured with an official seal such that the sample could not be reached without breaking the seal. The principal documents used to identify samples and to document possession will be chain-of-custody (COC) records, field logbooks, and field tracking forms. COC procedures will be used for samples throughout the collection, transport, and analytical process.

COC procedures will be initiated during sample collection. A COC record will be provided with each sample or group of samples. Each person who will have custody of the samples will sign the form and ensure that the samples will not be left unattended unless properly secured. Documentation of sample handling and custody includes the following:

- Sample identifier
- Sample collection date and time
- Any special notations on sample characteristics or analysis
- Initials of the person collecting the sample
- Date the sample was sent to the analytical laboratory
- Shipping company and waybill information

Completed COC forms will be placed in a plastic envelope and kept inside the cooler containing the samples. Once delivered to the analytical laboratory, the COC form will be signed by the person receiving the samples. The condition of the samples will be noted and recorded by the receiver. COC records will be included in the final reports prepared by the analytical laboratories and are considered an integral part of the report. An example chain of custody form is provided in Attachment C

2.4.3 Field Quality Control

For all conventional water quality analyses except field measurements performed on grab samples, field blanks and field duplicates will be analyzed in accordance with SWAMP guidelines as described in Attachment B.2.i(1) of the Permit.

For toxicity testing, only field duplicates will be collected. The use of controls and reference toxicant testing are QA/QC measures that have been put in place to identify changes in test organism sensitivity due to stress or other factors.

2.4.4 Equipment Calibration

All instruments used for field and laboratory analyses will be calibrated in accordance with the manufacturer's specifications. Calibration of the flow monitoring and sampling equipment will be conducted immediately prior to deployment or use and will be field verified during each data download or sampling event. The calibrations will be conducted in accordance with the manufacturer's specifications.

Field measurements for pH, specific conductance, dissolved oxygen, turbidity, and temperature will be made using a water quality probe in accordance with the manufacturer's specifications. The water quality probe will be calibrated with calibration solutions, and it will be verified that the expiration date has not been exceeded.

2.4.5 Equipment Decontamination and Cleaning

QA/QC for sampling processes begins with proper collection of the samples to minimize the possibility of contamination. All water samples will be collected in laboratory-certified, contaminant-free bottles. Appropriate sample containers and field measurement and sampling gear

will be transported to the sampling location in clean storage containers. Field measurements will be taken and recorded using the appropriate decontaminated equipment. If sampling poles are used for collecting water samples, they will be decontaminated between sampling locations.

2.5 *Toxicity Identification Evaluations*

Toxicity identification evaluations (TIEs), if necessary, will be conducted in compliance with Provisions D.1.c.(4)(f) and D.1.d.(4) of the Permit and used to determine the causative agent(s) of toxicity. Provision D.4.a.(2) indicates the need for a TIE. As necessary, TIEs will be conducted in accordance with the guidelines for characterizing chronically toxic effluents (USEPA, 1991; USEPA, 1992; USEPA, 1993a; USEPA, 1993b).

Phase I TIE testing typically involves manipulating the sample(s) using the methods in Table 2-1.

Treatment blanks will be created for each TIE treatment to determine the effects of the manipulation on laboratory dilution water. The results of these blanks will be used to determine whether any changes in toxicity of the control (dilution water) are impacted by the chemical or physical manipulation of the sample. A baseline test, run concurrently with the TIE treatments, will be performed to assess the toxicity of the unmanipulated sample(s). Baseline tests are intended to confirm the presence of toxicity in the sample and to benchmark the toxicity for comparison to toxicity in TIE treatments.

Table 2-1. Typical Phase I TIE Manipulations

Physical and Chemical Manipulation (Test) on Water Samples	Purpose of Test
Filtration	Detects filterable compounds (e.g., total suspended solids [TSS] related)
Aeration	Detects volatile, oxidizable, sublatable, or spargeable compounds
Ethylenediaminetetraacetic acid (EDTA) addition	Detects cationic metals (e.g., cadmium)
Sodium thiosulfate (STS) addition	Detects oxidative compounds (e.g., chlorine)
Solid phase extraction (SPE) over C18 column, followed by methanol elution	Detects non-polar organics and some surfactants
Piperonyl butoxide (PBO) addition	Detects organophosphate pesticides and pyrethroids
Carboxyl esterase addition	Detects pyrethroids
Bovine serum albumin (BSA) addition	Protein BSA is used as a control for the carboxyl esterase
Temperature reduction	Increases toxicity of pyrethroid pesticides
pH reduction	Detects pH-dependent toxicants (e.g., ammonia or sulfides)

2.6 *Dry Weather Hydromodification Monitoring*

This section describes the sampling and data collection methods for the dry weather receiving water hydromodification monitoring requirements as outlined in Provision D.1.c.(6) of the Permit.

In addition to the hydromodification monitoring conducted as part of the Participating Agencies' Hydromodification Management Plans, hydromodification monitoring for SDR-MLS is required at least once during the Permit term. The Participating Agencies must collect the following hydromodification monitoring observations and measurements within an appropriate domain of analysis during at least one dry weather monitoring event for each long-term receiving water monitoring location:

- Channel conditions, including: Channel dimensions, hydrologic and geomorphic conditions, and presence and condition of vegetation and habitat
- Location of discharge points
- Habitat integrity
- Photo documentation of existing erosion and habitat impacts, with location (i.e., latitude and longitude coordinates) where photos were taken
- Measurement or estimate of dimensions of any existing channel bed or bank eroded areas, including length, width, and depth of any incisions
- Known or suspected cause(s) of existing downstream erosion or habitat impact, including flow, soil, slope, and vegetation conditions, as well as upstream land uses and contributing new and existing development

The monitoring will coincide with the spring receiving water dry weather monitoring event in May or June and the dry weather receiving water bioassessment monitoring. The domain of analysis at each long-term monitoring location for dry weather hydromodification monitoring will be within the same reach of the channel as that used for dry weather bioassessment monitoring.

Table 2-2 provides an outline of the hydromodification monitoring requirements and the methods for each assessment category. Detailed methods for each assessment category are described in the following sections.

Table 2-2. Hydromodification Monitoring Requirements

Assessment Requirement Category	Method
Channel Conditions	
Channel Dimensions	Channel survey (cross-sectional and thalweg survey)
Hydrologic and geomorphic conditions	Southern California Coastal Water Research Project (SCCWRP) channel assessment tool
Presence and condition of vegetation and habitat	California Rapid Assessment Method (CRAM)
Location of discharge points	Table of MS4 outfalls to stream segment
Habitat integrity	CRAM
Photo documentation of existing erosion and habitat impacts, with location (i.e., latitude and longitude coordinates) where photos were taken	Channel survey and photo documentation
Measurement of estimate of dimensions of any bed or bank eroded areas, including length, width, and depth of any incisions	Channel survey
Known or suspected cause(s) of existing downstream erosion or habitat impact, including flow, soil, slope, and vegetation conditions, as well as upstream land uses and contributing new and existing development	Geographic information system (GIS) desktop analysis and SCCWRP channel assessment tool

2.6.1 CHANNEL DIMENSIONS

Channel surveys will be conducted at each monitoring location to gather basic hydraulic measurements of the receiving water channels. Channel surveys will be conducted using a DeWalt self-leveling rotary laser. The cross-section survey involves placing endpoints at the highest point of the channel on each bank. A measuring tape will be stretched between the endpoints such that the zero end of the tape is attached to the endpoint on the left bank of the channel (looking downstream). Channel depth will be measured across the channel from a stadia rod that is vertical and level from the channel bottom. The channel thalweg surveys will be conducted for the reach upstream and downstream of the cross-section. The average channel slope will be calculated from the survey data.

2.6.2 HYDROLOGIC AND GEOMORPHIC CONDITIONS

The geomorphic assessment will be conducted to characterize the susceptibility of the channel and gather basic hydraulic measurements of the receiving water channels. The geomorphic assessment comprises the channel survey and the Southern California Coastal Water Research Project (SCCWRP) channel assessment tool. The SCCWRP Field Manual (Bledsoe et al., 2010) will be used to assess the vertical and lateral susceptibility of the receiving water channels. The domain of analysis for each monitoring location is derived from the desk and field components of the screening tool and will be within reach of the channel used for dry weather bioassessment monitoring. A suite of field measurements will also be made to characterize the channel bed and banks, and overall stability state. Sediment samples will be collected to characterize bed materials. Fixed-interval pebble counts will be performed for each reach where the channel bed is composed of gravel or coarser material (Bunte and Abt, 2001), and channel beds composed of fine material will be noted as sand or cohesive materials (bed gradations are not required for channels with D50 less than (<) 2 millimeters [mm]).

2.6.3 PRESENCE AND CONDITION OF VEGETATION AND HABITAT INTEGRITY

The presence and condition of vegetation and habitat integrity will be determined from the data collected during dry weather bioassessment monitoring. For dry weather bioassessment monitoring, the sampling will follow the protocols previously outlined in Section 2.5. Physical habitat quality assessments of the monitoring locations using the California Rapid Assessment Method (CRAM) will provide a numerical summary score of the physical conditions for each monitoring location. This method involves assessing the quality of the in-stream habitat features as well as the buffer zones (250 meters perpendicular to flow from each bank and 500 meters upstream and downstream of the monitoring reach), hydrologic source quality, and biotic structure quality. For each monitoring reach sampled, the physical habitat of the stream and its adjacent banks will be assessed to provide a record of the overall physical condition of the reach. Parameters such as substrate complexity, channel alteration and human influence, frequency of riffles, and width and quality of riparian zones will provide a more comprehensive understanding of the condition of the stream. Additionally, specific characteristics of the sampled riffles will be measured, including substrate size classes, stream depth, gradient, sinuosity, and flow volume. A final CRAM score will be calculated that can range from 25 to 100 points, with higher scores

indicating higher quality conditions. CRAM ratings of good, fair, and poor are defined by the score (i.e., for the CRAM score range of 25-100, <50=low, 50-75=moderate, and >75=high).

2.6.4 *Photo Documentation*

A channel survey will be conducted and photographs will be used to document the conditions in the receiving water channels, including any existing erosion and habitat impacts. Photographs will be taken using a digital camera with a built-in Global Positioning System (GPS), altimeter, and compass. Photo documentation will be conducted using the general procedures outlined in San Diego Water Board Stream Photo Documentation Procedures for 401 Water Quality Certifications Standard Operating Procedure.

The following information will be recorded for each photograph:

- Project name
- General location
- Photographer and team members
- Photo number
- Date
- Time

At a minimum, photographs will be taken of the following:

- Long view up or down the stream (from stream level) showing changes in the stream bank and vegetation
- Long view and medium view of streambed changes (e.g., thalweg, gravel, meanders)
- Long views from a bridge or other elevated position
- Medium and close views of structures and plantings
- Medium views of bars and banks, with a person (preferably holding a stadia rod) in view for scale
- Close views of streambed with a ruler or other common object in the view for scale

2.6.5 *Dimensions of Bed or Bank Eroded Areas*

Measurements or estimates of dimensions of any bed or bank eroded areas, including length, width, and depth of any incisions, will be conducted during the channel survey. Bed or bank eroded areas will be documented with photographs as described in the channel survey section above.

2.6.6 *Location of Discharge Points/Known or Suspected Causes of Erosion or Habitat Impact*

Known or suspected cause(s) of existing downstream erosion or habitat impact, including flow, soil, slope, and vegetation conditions, as well as upstream land uses and contributing new and existing development, will be assessed during a GIS desktop exercise and the SCCWRP channel assessment tool.

2.7 DRY WEATHER RECEIVING WATER BIOASSESSMENT MONITORING

Dry weather receiving water bioassessment monitoring will be conducted in accordance with the Permit (Provisions D.1.a.(1), D.1.a.(3)(a), D.1.c.(5), and D.1.e.(1)(a)). Dry weather receiving water bioassessment monitoring will include bioassessment at each long-term receiving water monitoring location and participation in the SMC Regional Monitoring Program. Bioassessment surveys will be conducted during the spring/summer dry season bioassessment index period, typically from May through July. Benthic macroinvertebrates (BMIs) and physical habitat data will be collected following the *SWAMP Bioassessment Procedures: Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California* (Ode, 2007) using the reach-wide benthos method. Benthic algae (i.e., periphyton) monitoring will be conducted in accordance with the *SWAMP Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California* (Fetscher et al., 2009). Samples will be collected and processed for ash-free dry mass (AFDM), chlorophyll-a analysis, and periphyton taxonomy. Reach-wide algal cover will be quantified as part of the SWAMP physical habitat assessment. Physical habitat quality of the monitoring locations will be quantified using CRAM for riverine wetlands (Collins et al., 2012).

The SWAMP sampling protocol includes the collection of stream BMI and also assesses the physical quality and condition of the streambed and banks in detail. (Note: A physical habitat index based on the SWAMP procedure has not been developed at the time of this report). CRAM assessments incorporate broader buffer zone and land use attributes than do SWAMP assessments, and also provide a numerical quality score for each monitoring location. BMIs reside in streams for periods ranging from a month to several years, and have varying sensitivities to the multiple stressors associated with urban runoff. Using species-specific tolerance values and community species composition, numerical biometric indices are calculated, allowing for comparison of relative habitat health among streams in a region. By assessing the invertebrate community structure of a stream, a cumulative measure of stream habitat health and ecological response is obtained.

The data include a taxonomic listing of all BMIs identified in the surveys, and calculation of the biological metrics listed in the California Stream Bioassessment Procedure (CSBP). Additionally, calculation of two indices that rate the overall BMI community quality will be performed. These include the Index of Biotic Integrity (IBI) (Ode et al., 2005) and the observed to expected (O/E) ratio of taxa (Hawkins, Western Center for Monitoring and Assessment, 2010).

2.7.1 2015 SMC REGIONAL MONITORING PROGRAM

The 2015 SMC Regional Monitoring Program is currently being developed. The SMC Bioassessment Technical Workgroup is working to determine which components of the 2009-2013 SMC Regional Monitoring Program were effective tools for achieving the program's goals and what monitoring elements may be suspended or added for future assessments. Beginning in 2015, SMC will confirm the monitoring locations under this program.

2.7.2 MONITORING REACH DELINEATION

Using SWAMP methodology, every monitoring reach is 150 meters in length and will be sampled from downstream to upstream. If a portion of a reach is inaccessible, the reach length may be reduced to as little as 100 meters. The bioassessment reaches are placed as closely as possible to the water quality and flow monitoring locations.

2.7.3 MACROINVERTEBRATE SAMPLE COLLECTION

BMI samples will be collected at evenly spaced 15-meter transects for a total of 11 transects in the 150-meter reach. The samples will be collected in an alternating margin-center-margin pattern. Collections will be made using a 1-foot-wide, 0.5-millimeter (mm)-mesh, D-frame kick-net. A 1-square-foot area upstream of the net will be sampled by disrupting the substrate and scrubbing the cobble and boulders, so that the organisms will be dislodged and swept into the net by the current. The duration of the sampling generally ranges from 1 to 3 minutes, depending on the substrate complexity. Every monitoring location will be sampled from downstream to upstream. The samples will be combined into a single composite sample for the reach, transferred to 1-quart jars, preserved with 95 percent ethanol, and returned to the laboratory for processing. Photographs will be taken of every monitoring location.

2.7.4 MULTIHABITAT PERIPHYTON SAMPLE COLLECTION

Periphyton (benthic algae) will be collected using the reach-wide procedure and within the same transects used for BMI collection, but offset 1 meter upstream to avoid disturbed substrate. Depending on the substrate type and the stream habitat, one of three sampling devices will be used to collect the substrate sample: a 12.6-square centimeter (cm^2) rubber delimiter, a 4-centimeter (cm) diameter polyvinyl chloride (PVC) delimiter, or a syringe scrubber.

After all transects are sampled, the subsamples will be composited. The macroalgae will be gathered and separated from the composited liquid. A subsample of the macroalgae will be taken for the soft-bodied taxonomic identification sample. The composite liquid volume will be recorded, and the remaining macroalgae will be finely cut up and thoroughly mixed with the composite liquid. The homogenized sample will be used for the diatom taxonomic identification sample, as well as the two filtered biomass samples. The diatom and soft-bodied algae samples will be fixed accordingly before being delivered to the laboratory for taxonomic identification. Taxonomic identification will be performed by a qualified taxonomist. The remaining homogenized portion of the composite will be filtered in the field, and the filters will be placed on ice and/or frozen until delivery to the chemistry laboratory for chlorophyll-a and ash-free dry mass analysis.

A separate soft-bodied algae sample will be collected for qualitative taxonomic identification. The qualitative sample consists of a composite of all soft-bodied algae found within the reach. The sample will be left unpreserved and put on ice or refrigerated until delivery to the laboratory for taxonomic identification. Qualitative taxonomic identifications will be performed by a qualified taxonomist for the receiving water and SMC monitoring locations.

2.7.5 *Physical Habitat Quality Assessment*

For each monitoring reach sampled, the physical habitat of the stream and its adjacent banks will be assessed to provide a record of the overall physical condition of the reach. Parameters such as substrate complexity, channel alteration and human influence, frequency of riffles, and width and quality of riparian zones will provide a more comprehensive understanding of the condition of the stream. Additionally, specific characteristics of the sampled riffles will be measured, including substrate size classes, stream depth, gradient, sinuosity, and flow volume.

CRAM assessments of each monitoring location also will be performed. This method assesses the quality of the in-stream habitat features as well as the buffer zones (250 meters perpendicular to flow from each bank and 500 meters upstream and downstream of the monitoring reach), hydrologic source quality, and biotic structure quality. A final CRAM score will be calculated that can range from 25 to 100 points, with the higher scores indicating higher quality conditions.

Water quality measurements will be taken at each of the monitoring locations using a YSI Model 6600 (or comparable) data sonde. Measurements will include water temperature, specific conductance, pH, and dissolved oxygen. Samples will be collected for laboratory analysis following the protocols outlined in the SMC Regional Monitoring Program Workplan. Stream flow velocity will be measured with a Marsh-McBirney Model 2000 (or comparable) portable flowmeter, or will be visually estimated when the water is too shallow for the flowmeter.

2.7.6 *Laboratory Processing and Analysis*

Laboratory processing of BMI samples will follow the SWAMP Bioassessment Procedures: *Standard Operating Procedures for Laboratory Processing and Identification of Benthic Macroinvertebrates in California* (Woodward et al., 2012). At the laboratory, samples are poured over a No. 35 standard testing sieve (0.5-mm stainless-steel mesh), and the ethanol is retained for reuse. The sample is gently rinsed with fresh water, and large debris such as wood, leaves, or rocks are removed. The sample is transferred to a tray marked with grids approximately 50 cm^2 in size. One grid is randomly selected, and the sample material contained within that grid is removed and processed. In cases where the test organisms appear extremely abundant, a fraction of the grid may be removed.

The material from the grid is examined under a stereomicroscope, and all the invertebrates are removed, sorted into major taxonomic groups, and placed in vials containing 70 percent ethanol. If there are less than 600 test organisms in the grid, another grid is selected and processed. This process is repeated until 600 organisms are removed from the sample, or until the entire sample is sorted. Organisms from a grid in excess of 600 are also removed, counted, and recorded as "remaining test organisms," so that estimated total organism abundance and density for the sample can be calculated. Terrestrial organisms, vertebrates, water-column associated organisms (e.g., copepods), and nematodes are not removed from the samples. Processed material from the sample is placed in a separate jar and labeled "sorted," and the unprocessed material is returned to the original sample container and archived. Sorted material is retained for QA purposes. All organisms are identified to Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) standard taxonomic effort Level II (SAFIT, 2006).

2.7.7 Quality Assurance/Quality Control

QA/QC procedures for the Bioassessment Monitoring and SMC Program will be consistent with those outlined in Section 2.2.4. In addition, QA of the benthic infauna sample sorting will be performed on all of the samples to ensure at least a 90 percent removal rate of organisms. Organisms removed during sorting QA also will be identified. Taxonomic QA will be performed on 10 percent of the samples.

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3 DATA MANAGEMENT, ASSESSMENT, AND REPORTING

The Monitoring and Assessment Annual Report, which will be submitted to the RWQCB on January 31 annually, will include descriptions of monitoring conducted during the applicable monitoring year.

3.1 DATA MANAGEMENT

Field Data Records and Analytical Data Reports will be sent to and kept by the Program Manager or specified contracted agency. Data will be submitted in a standardized California Environmental Data Exchange Network (CEDEN)-compatible format to the County of San Diego for their records.

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ATTACHMENT A
DRY WEATHER AND WET WEATHER CONSTITUENTS, POTENTIAL METHODS, VOLUMES, HOLDING TIMES, AND TARGET REPORTING LIMIT

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Table A-1. Analyte List for Long-Term Receiving Water Monitoring

Analyte	Volume Required	Potential Analytical Method*	Target Reporting Limit	Units	Max Holding Time	Dry Weather Receiving Water Monitoring	Wet Weather Receiving Water Monitoring
Conventional Parameters							
Chloride	250 mL	USEPA 300.0	0.5	mg/L	28D	X[4]	X[4]
Color	500 mL	SM 2120B	3	Color Units	48H	X[4]	X[4]
Dissolved Organic Carbon	250 mL	SM 5310 C	0.50	mg/L	28D	X[7]	X[7]
Dissolved Oxygen	In field	Meter	0.01	mg/L	NA	X[1,2,4,6C,9]	X[1,2,4,9]
pH	In field	Meter	0.01	pH	NA	X[1,2,4,6B,6C,9]	X[1,2,4,9]
Specific Conductivity	In field	Meter	1	µS/cm	NA	X[1,2,9]	X[1,2,9]
Sulfates	250 mL	USEPA 300.0	0.5	mg/L	28D	X[4,7]	X[4,7]
Temperature	In field	Meter	0.1	◦C	NA	X[1,2,9]	X[1,2,9]
Total Hardness	Calculation from Calcium and Manganese	SM 2340B	0.662	mg/L	NA	X[7,9]	X[7,9]
Total Organic Carbon	250 mL	SM 5310 C	0.30	mg/L	28D	X[7]	X[7]
Turbidity	In field or lab: 250 mL	Meter	0.1	NTU	NA or 48H	X[1,2,6B,6C,7,9]	X[1,2,7,8,9]
Indicator Bacteria							
Enterococcus	100 mL	SM 9230C	20	MPN/100mL	8H	X[3,4,5,6A,6B,6C,7,9]	X[3,4,5,7,9]
Fecal Coliform	100 mL	SM 9221E	20	MPN/100mL	8H	X[3,4,5,6A,6B,6C,7,9]	X[3,4,5,7,9]
Total Coliform	100 mL	SM 9221B	20	MPN/100mL	8H	X[3,4,5,6A,7,9]	X[3,4,5,7,9]

Table A-1. Analyte List for Long-Term Receiving Water Monitoring (Continued)

Table A-1. Analyte List for Long-Term Receiving Water Monitoring (Continued)

Analyte	Volume Required	Potential Analytical Method*	Target Reporting Limit	Units	Max Holding Time	Dry Weather Receiving Water Monitoring	Wet Weather Receiving Water Monitoring
Inorganic Analytes							
Arsenic (Dissolved)	250 mL	USEPA 200.8	0.0004	mg/L	6M	X[7]	X[7]
Arsenic (Total)	250 mL	USEPA 200.8	0.0004	mg/L	6M	X[7]	X[7]
Cadmium (Dissolved)	250 mL	USEPA 200.8	0.0001	mg/L	6M	X[6B,6C,7]	X[7]
Cadmium (Total)	250 mL	USEPA 200.8	0.0001	mg/L	6M	X[6B,6C,7]	X[7,8]
Chromium (Dissolved)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[6B,6C,7,12]	X[7]
Chromium (Total)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[6B,6C,7,12]	X[7]
Chromium III (Dissolved)	NA	Calculated from Chromium and Chromium VI	NA	NA	NA	X[6B,6C]	-
Chromium III (Total)	NA	Calculated from Chromium and Chromium VI	NA	NA	NA	X[6B,6C]	-
Chromium VI (Dissolved)	250 mL	USEPA 218.6	0.0003	mg/L	28D	X[6B,6C]	-
Chromium VI (Total)	250 mL	USEPA 218.6	0.0003	mg/L	28D	X[6B,6C]	-
Copper (Dissolved)	250 mL	USEPA 200.8	0.0005	mg/L	6M	X[6B,6C,7]	X[7]
Copper (Total)	250 mL	USEPA 200.8	0.0005	mg/L	6M	X[6B,6C,7]	X[7,8]
Iron (Dissolved)	250 mL	USEPA 200.7	0.01	mg/L	6M	X[6C,7]	X[7]
Iron (Total)	250 mL	USEPA 200.7	0.01	mg/L	6M	X[6C,7]	X[7]

Table A-1. Analyte List for Long-Term Receiving Water Monitoring (Continued)

Analyte	Volume Required	Potential Analytical Method*	Target Reporting Limit	Units	Max Holding Time	Dry Weather Receiving Water Monitoring	Wet Weather Receiving Water Monitoring
Lead (Dissolved)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[6B,6C,7]	X[7]
Lead (Total)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[6B,6C,7]	X[7,8]
Manganese (Dissolved)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[4,6C]	X[4]
Manganese (Total)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[4,6C]	X[4]
Mercury (Dissolved)	250 mL	USEPA 245.1	0.00005	mg/L	28D	X[7]	X[7]
Mercury (Total)	250 mL	USEPA 245.1	0.00005	mg/L	28D	X[7]	X[7]
Nickel (Dissolved)	250 mL	USEPA 200.8	0.0008	mg/L	6M	X[6B,6C,7]	X[7]
Nickel (Total)	250 mL	USEPA 200.8	0.0008	mg/L	6M	X[6B,6C,7]	X[7]
Selenium (Dissolved)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[4,7]	X[4,7]
Selenium (Total)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[4,7]	X[4,7]
Silver (Dissolved)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[6B,6C]	-
Silver (Total)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[6B,6C]	-
Thallium (Dissolved)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[7]	X[7]
Thallium (Total)	250 mL	USEPA 200.8	0.0002	mg/L	6M	X[7]	X[7]
Zinc (Dissolved)	250 mL	USEPA 200.8	0.005	mg/L	6M	X[6B,6C,7]	X[7]
Zinc (Total)	250 mL	USEPA 200.8	0.005	mg/L	6M	X[6B,6C,7]	X[7,8]
Nutrients							
Ammonia	250 mL	USEPA 350.1	0.1	mg/L	28D	X[4,7]	X[4,7]
Dissolved Phosphorus	250 mL	USEPA 365.1	0.01	mg/L	48H	X[4]	X[4]

Table A-1. Analyte List for Long-Term Receiving Water Monitoring (Continued)

Analyte	Volume Required	Potential Analytical Method*	Target Reporting Limit	Units	Max Holding Time	Dry Weather Receiving Water Monitoring	Wet Weather Receiving Water Monitoring
Nitrate	250 mL	USEPA 353.2	0.1	mg/L	48H	X[4,7,10]	X[4,7,8,11]
Nitrite	250 mL	USEPA 353.2	0.1	mg/L	48H	X[4,7,10]	X[4,7,8,11]
Orthophosphate	250 mL	USEPA 365.1	0.002	mg/L	48H	X[4,7]	X[4,7]
TKN	250 mL	USEPA 351.2	0.1	mg/L	28D	X[4,7]	X[4,7]
Total Nitrogen	Calculation	Calculated from TKN, Nitrate, and Nitrite	NA	NA	NA	X[4,5,6C]	X[4,5]
Total Phosphorus	250 mL	USEPA 365.1	0.01	mg/L	28D	X[4,5,6C,7]	X[4,5,7,8]
Solid Parameters							
TDS	500 mL	SM 2540C	10	mg/L	7D	X[4,7]	X[4,7]
TSS	1000 mL	SM 2540D	5	mg/L	7D	X[7]	X[7]
Synthetic Organic Compounds							
MBAS	500 mL	SM 5540C	0.05	mg/L	48H	X[6C,7]	X[7]
Organophosphate Pesticides	2 L	USEPA 625M	0.01	µg/L	7/40D	X[7]	X[7]
Synthetic Pyrethroids	2 L	GC/MS NCI-SIM	2-10	ng/L	7/40D	X[7]	X[7]

Table A-1. Analyte List for Long-Term Receiving Water Monitoring (Continued)

Analyte	Volume Required	Potential Analytical Method*	Target Reporting Limit	Units	Max Holding Time	Dry Weather Receiving Water Monitoring	Wet Weather Receiving Water Monitoring
Toxicity							
Larval Survival and Growth with *Pimephales promelas*	15 L	EPA-821-R-02-013	NA	Pass/Fail	36H	X[4,13]	X[4,13]
Survival and Reproduction with *Ceriodaphnia dubia*	4 L	EPA-821-R-02-013	NA	Pass/Fail	36H	X[4,13]	X[4,13]
Growth with *Selenastrum capricornutum*	4 L	EPA-821-R-02-013	NA	Pass/Fail	36H	X[4,13]	X[4,13]

NA = Not applicable; mL = milliliter; L = liter; D = day; H = hour; M = month

* The methods presented in the table are potential methods. Other equicalent EPA-approved methods may be substituted as long as the target reporting limits are met for the corresponding constituents.

1. Parameter listed in Table D-2 of the Permit.
2. Analytes that are field measured are not required to be analyzed by a laboratory.
3. Parameter contributes to a highest priority water quality condition identified in the San Diego River Watershed Water Quality Improvement Plan.
4. Parameter listed as a cause for impairment of receiving waters in the San Diego River Watershed on the 303(d) list.
5. Parameter for CLRP developed for a TMDL in the San Diego River Watershed.

6A. Parameter listed in NALs for discharges from MS4s to Ocean Surf Zone (Permit Provision C.1.a(1))

6B. Parameter listed in NALs for discharges from MS4s to Bays, Harbors, and Lagoons/Estuaries (Permit Provision C.1.a(2))

6C. Parameter listed in NALs for discharges from MS4s to Inland Surface Waters (Permit Provision C.1.a(3))

7. Parameter listed in Table D-3 of the Permit.
8. Parameter listed in SALs for discharges from MS4s to receiving waters (Table C-5 of the Permit).
9. Grab samples may be collected for pH, temperature, specific conductivity, dissolved oxygen, turbidity, hardness, and indicator bacteria.
10. Nitrite and nitrate may be combined and reported as nitrite+nitrate.
11. Nitrite and nitrite will be reported as nitrite+nitrate.
12. Analysis of Chromium in MS4 discharges is not explicitly required in the Permit. Chromium is analyzed to calculate Chromium III.
13. Parameter listed in Table D-4 of the Permit. SDR-MLS is located in freshwater so only freshwater constituents are represented.

Table A-1. Analyte List for Long-Term Receiving Water Monitoring (Continued)

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ATTACHMENT B
STREAM RATING AND CHANNEL SURVEY DETAILS

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STREAM RATINGS

The flow rate at each of the monitoring locations will be determined by stream stage (water level) sensors that are typically secured to the bottom of the channel. To quantify flow rates on the basis of stream stage, a relationship between flow and stage will be derived using the standardized stream rating protocols developed by the U.S. Geological Survey (USGS) (Rantz, 1982; Oberg et al., 2005). Instantaneous flow measurements will be taken at various stages at each of the monitoring locations. The measurements will be combined to produce and calibrate the rating curve for each monitoring location.

To accurately measure flow in streams, the following elements are needed to develop the rating curves:

- An accurate survey of the stream channel cross-section and longitudinal slope
- Accurate level measurements based on a fixed point
- Measurements of velocity and flows at several points throughout the rating curve, including low flow, mid flow, and peak flow conditions

To measure instantaneous flows during low flow and base flow conditions, two velocity measurement instruments are typically used—a Marsh-McBirney Model 2000 Portable Flowmeter connected by a cable to an electromagnetic open channel velocity sensor and the SonTek (YSI) FlowTracker Acoustic Doppler Velocimeter. The FlowTracker is a high-precision, shallow-water flowmeter that measures velocity in three dimensions and features an automatic discharge computation.

To make an instantaneous flow measurement, a tape measure is stretched across the stream, perpendicular to flow and secured on both banks of the stream. The tape is positioned so that it is suspended approximately 1 foot above the surface of the water. The distance on the tape directly above the waterline (i.e., where the water meets the bank) is recorded as the initial point. The first measurement is made at the first point where there is adequate water depth (i.e., at least 0.2 foot) and measurable velocity. At this point, three measurements are made, including water depth, velocity, and distance from the bank (the initial point). Subsequent depth, velocity, and distance measurements are made incrementally across the entire width of the channel. Data from the field measurements are entered into a computer model that calculates the stream's cross-sectional profile from the depth and distance from bank measurements. Total flow across the channel is determined by integrating the velocity measurements over the cross-sectional surface area of the stream channel. The result is an instantaneous flow measurement in cubic feet per second.

A StreamPro Acoustic Doppler Current Profiler (ADCP) is used to measure mid- and high-stage flow conditions. The StreamPro ADCP is the USGS instrument of choice for measuring flows nationwide (Oberg et al., 2005). The instrument is pulled across the stream either by walking across a bridge or attaching the unit to a tagline. Data are collected in real time and transmitted by a wireless data link to a PC. Data can be viewed in real time and are typically post-processed following the field event in the office.

Rating curves are extended to high stream stages not measured using site-specific survey information and the Chézy–Manning formula (Linsley et al., 1982). The Chézy–Manning formula is an empirical formula for open channel flow, or flow driven by gravity, as follows:

$$Q = (1.486 / n) A R^{2/3} S^{1/2}$$

where:

Q = flow
n = Manning Roughness coefficient
A = cross-sectional area
R = hydraulic radius
S = hydraulic slope

The hydraulic radius is derived as follows:

$$R = A/P$$

where:

A = cross-sectional area of flow (ft2)
P = wetted perimeter (ft)

The Chézy–Manning formula was developed for conditions of uniform flow in which the water surface profile and energy gradient are parallel to the streambed and the area, hydraulic radius, and depth remain constant throughout the reach. Field surveys of the channel geometry of each MLS will be conducted to compute the channel characteristics for each station.

CHANNEL SURVEYS

Channel surveys will be conducted at each monitoring location to gather basic hydraulic measurements of the receiving water channels and to derive stream discharge using the Chézy–Manning formula. Channel surveys will be conducted using a DeWalt self-leveling rotary laser. The cross-section survey involves placing endpoints at the highest point of the channel on each bank. A measuring tape is stretched between the endpoints such that the zero end of the tape is attached to the endpoint on the left bank of the channel (looking downstream). Channel depth is measured across the channel from a stadia rod that is vertical and level from the channel bottom. The channel thalweg surveys are conducted for the reach upstream and downstream of the cross-section. The average channel slope is calculated from the survey data.

Channel survey data are used with the Chézy–Manning formula to produce a rating curve for each sampling location. Each rating curve is calibrated using instantaneous flow measurements by adjusting the formula roughness coefficient.

UNITED STATES GEOLOGICAL SURVEY WATERSHEDS

USGS flow monitoring gauges are located in the larger watersheds, specifically Santa Margarita, San Luis Rey, Los Peñasquitos Creek, San Diego River, and Tijuana River. The USGS gauging stations are used to estimate the annual flow volumes for the watersheds. The SDR-MLS is within relative proximity to the USGS San Diego River flow monitoring station. The SDR-MLS flow data will be compared with USGS data, as it will also be used to validate flow monitoring data collected at SDR-MLS.

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ATTACHMENT C
EXAMPLE CHAIN-OF-CUSTODY FORM

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EXAMPLE - CHAIN-OF-CUSTODY FORM

Date: _____ ***Page*** ____ ***of*** ____

Analyzing Laboratory: _____

Project Name / Project Number

Project Manager / Contact

Client

Address

Phone / Fax / Email

Site ID (Location)	Sample ID	Date	Time	Matrix	Container Type / Volume	Total Number of Containers	Analysis / Test Requested								Preservation	Laboratory Use Only: Temp (C) Upon Receipt	Laboratory Use Only: Laboratory ID

Sample Matrix Code: FW = Freshwater; SW = Storm Water; SLT = Saltwater; SED = Sediment; BIO = Biologic; O = Other (Specify) _____

Container Code: G = Glass; P = Plastic; B = Bags; O = Other (Specify) _____

Shipped By: ☐ Courier ☐ FedEx ☐ UPS ☐ USPS ☐ Client Drop-Off ☐ Other _____

Turnaround Time: ☐ 2-day ☐ 5-day ☐ 7-day ☐ 10-day ☐ 14-day ☐ Standard ☐ Other _____

Reporting Requirements: ☐ PDF ☐ EDD ☐ Hard Copy ☐ Email ☐ Other _____

Sampled By:

Name (Print): _____

Signature: _____

Comments/Special Instructions:

Relinquished By				Received By			
Print Name	Signature	Firm	Date/Time	Print Name	Signature	Firm	Date/Time
1				1			
2				2			
3				3			
4				4			
5				5			

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ATTACHMENT 4A-2: SAN DIEGO RIVER WATERSHED SEDIMENT QUALITY MONITORING PLAN

San Diego River Watershed Sediment Monitoring Plan

Prepared For:
San Diego River Watershed
Participating Agencies

Prepared By: Weston
Solutions, Inc.
5817 Dryden Place, Suite 101
Carlsbad, California 92008
September 2, 2014

Revised By:
AMEC Environment and Infrastructure, Inc.
9177 Sky Park Court
San Diego, California 92123
January 2015

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ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
AVS:SEM	acid-volatile sulfides and simultaneously extracted metals
Bight	Southern California Bight Regional Monitoring Program
BRI	Benthic Response Index
CA EPA	California Environmental Protection Agency
CA LRM	California Logistic Regression Model
CEDEN	California Environmental Data Exchange Network
COC	chain-of-custody
Copermittees	San Diego Regional Copermittees
CSI	Chemical Score Index
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System
DO	dissolved oxygen
DTCS	Department of Toxic Substances Control
EC_{50}	median effective concentration
IBI	Index of Biotic Integrity
ID	inner diameter
LC_{50}	median lethal concentration
LOE	line of evidence
$MgSO_4$	magnesium sulfate
MLOE	multiple lines of evidence
MS4	Municipal Separate Storm Sewer System
MW	molecular weight
NPDES	National Pollutant Discharge Elimination System
OEHHA	Office of Environmental Health Hazard Assessment
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls pH hydrogen ion concentration
P_{MAX}	maximum probability model
QA	quality assurance
QA/QC	quality assurance/quality control
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan
QC	quality control

ACRONYMS AND ABBREVIATIONS (Continued)

RBI	Relative Benthic Index
RIVPACS	River Invertebrate Prediction and Classification System
RL	Reporting Limit
RWQCB	Regional Water Quality Control Board
SCAMIT	Southern California Association of Marine Invertebrate Taxonomists
SDRWQCB	San Diego Regional Water Quality Control Board
SOPs	Standard Operating Procedures
SPME	solid phase microextraction
SQOs	Sediment Quality Objectives
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TIE	toxicity identification evaluation
TMDL	Total Maximum Daily Load
TOC	total organic carbon
USEPA	United States Environmental Protection Agency
WQIP	Water Quality Improvement Plan

UNITS OF MEASURE

cm	centimeter
°C	degrees Celsius
ft	feet or foot
L	liter
m^2	square meters
µg/kg	microgram per kilogram
mg	milligram
mg/kg	milligram per kilogram mg/L milligram per liter
mL	milliliter
mm	millimeter
ppt	parts per thousand
%	percent

INTRODUCTION

The San Diego County Regional Copermittees (Copermittees) are required to conduct sediment quality monitoring in accordance with the requirements of the San Diego Regional Water Quality Control Board (RWQCB) Order No. R9-2013-0001 (Permit), effective June 27, 2013. The Copermittees are required, either individually, in association with multiple Copermittees, or through participation in a water body monitoring coalition to perform sediment quality monitoring to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries. Provision D.1.e.(2) of the Permit requires the Copermittees to develop a Sediment Monitoring Plan for incorporation into the Water Quality Improvement Plan (WQIP) which satisfies the requirements of the Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality (Sediment Control Plan; State Water Quality Control Board [SWRCB] and California Environmental Protection Agency [CA EPA], 2009; see Appendix A).

Provision D.1.e.(1)(b) of the Permit also requires the Copermittees to participate in the Southern California Bight Regional Monitoring Program (Bight). The Bight Program can be used to simultaneously fulfill all or part of the sediment quality monitoring requirement (Provision D.1.e(2)) as long as the Bight Program utilizes the Sediment Control Plan to assess the health of San Diego County lagoons. Depending on the outcome of the sediment quality objectives (SQOs) assessments at Bight stations located in San Diego County lagoons, follow-up monitoring may be necessary to meet all of the Permit requirements.

The following Sediment Monitoring Plan describes the sediment quality sample collection and analysis activities that will be implemented by the Copermittees during the Permit term. As required by the Permit, this Sediment Monitoring Plan includes the elements listed in Sections VII.D and VII.E of the Sediment Control Plan (Receiving Water Limits Monitoring Frequency and Sediment Monitoring, respectively), a Sediment Monitoring Quality Assurance Project Plan (QAPP) (Appendix B), and a schedule for completion of monitoring and submission of the Sediment Monitoring Report. Once the sediment quality monitoring is complete, the Copermittees will incorporate a Sediment Monitoring Report into the WQIP Annual Report.

1.1 BACKGROUND

In 2003, the SWRCB initiated a program to develop SQOs for enclosed bays and estuaries. The primary objective is to protect benthic communities and aquatic life from exposure to contaminants in sediment that have been directly discharged into the water body or indirectly discharged into waters draining into the water body. The SQOs, which are outlined in the Sediment Control Plan, are based on a multiple lines of evidence (MLOE) approach in which the lines of evidence (LOE) are sediment toxicity, sediment chemistry, and benthic community condition, as described in the Sediment Control Plan (see Appendix A) and in Section 3.2. The MLOE approach evaluates the severity of biological effects and the potential for chemically mediated effects to provide a final station level assessment. The Sediment Control Plan was approved by the SWRCB and the Office of Administrative Law on September 16, 2008, and on January 5, 2009, respectively, and was subsequently approved by the United States Environmental Protection Agency (USEPA) on August 25, 2009.

1.2 MONITORING OBJECTIVE

The primary objective of the sediment monitoring program is to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries of San Diego County. Sediment toxicity, chemistry, and benthic community condition will be assessed using SQOs as described in the Sediment Control Plan (Appendix A). The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful.

The goal of the Sediment Monitoring Plan is to provide the key elements that are required to successfully conduct field sediment sampling, processing, testing, and analysis of the results. Analyses of chemistry, toxicity, and benthic community condition require that samples be collected, preserved, processed, and analyzed using proper field and laboratory equipment, methods, and techniques. Additionally, representative station locations ensure the proper characterization of benthic conditions. The Sediment Monitoring Plan and Sediment Monitoring QAPP (Appendix B) describe the collection and analysis of surface sediment samples necessary to provide representative assessments of in situ conditions for the enclosed bays and estuaries of San Diego County.

MATERIALS AND METHODS

The materials and methods described in this section are designed to meet the requirements of the Sediment Control Plan, Sections VII.D and VII.E, as required by Permit Provision D.1.e.(2)(a). The methodology is outlined in Section V of the Sediment Control Plan. If sediment quality monitoring is conducted as part of the Bight Program, the work plans and associated QA/QC documents pertaining to the Bight Program should be followed.

Quality assurance methods and procedures needed to maintain consistency in sample collection, processing, and analysis to produce scientifically defensible data are provided in the Sediment Monitoring Quality Assurance Project Plan (QAPP) (Appendix B). The QAPP provides acceptability criteria for the collection and analysis of duplicate field samples, field or equipment rinse blanks, laboratory methods, and laboratory spikes. The QAPP should be used as a reference to ensure proper methods are used consistently throughout the monitoring program.

1.3 FIELD COLLECTION PROGRAM

1.3.1 Station Selection

The Sediment Control Plan applies to subtidal surficial sediments located seaward of the intertidal zone in enclosed bays and estuaries. It does not apply to ocean waters, inland surface waters, sediments consisting of less than 5 percent (%) fines or substrates composed of gravel, cobble, or consolidated rock, or to sediment classified as a pollutant due to physical processes such as burial or sedimentation. SQOs have been fully developed for only two of California's six enclosed bay habitats: euhaline (salinity = 25 to 32 parts per thousand [ppt]) bays and coastal lagoons south of Point Conception and polyhaline (18 to 25 ppt) central San Francisco Bay. In addition, the benthic species assemblage used to calculate the benthic LOE for southern California marine bays is Habitat C (Bay et al., 2014), and one of the criteria for Habitat C is a salinity greater than 27 ppt. In order to select a sampling station applicable to the SQQ assessment using Habitat C for the benthic LOE, it is recommended to verify that a proposed sampling station is both subtidal and has salinity greater than 27 ppt. Salinity measurements should be taken at a spring high and low tide to get an estimate of the salinity range for a proposed station. If feasible, it is recommended that salinity should be monitored throughout an entire spring tidal cycle to ensure it meets the salinity criteria prior to sampling. This monitoring can be accomplished by deploying a continuous monitoring device such as an YSI water quality data sonde. Water depth should also be measured when visiting the station at a spring low tide or deploying a continuous monitoring device over a spring tidal cycle to ensure the station is subtidal.

The Sediment Control Plan does not give guidance as to how many stations should be sampled in each lagoon. The number of sampling stations may vary within based on the spatial extent of the area likely to be impacted. If the Bight Program is utilized to fulfill the Sediment Quality Monitoring requirement of the Permit, then the number of stations will be dictated by the Bight Program. For example, in the 2008 Bight Program, five stations were analyzed per lagoon; however, in the 2013 Bight Program the number of stations per lagoon varied from one to three stations. If a stressor identification study becomes necessary following the original SQO assessment of a lagoon (see Section 4.0), then the number of stations will be based on what

suspected pollutants are driving the impacted scores (e.g. algae, physical factors, or chemical factors) and to have enough samples to statistically support meaningful findings.

1.3.1.1 San Diego River Monitoring Stations

Although the number of stations selected may vary, three monitoring stations were selected in the San Diego River Estuary in accordance with station selection methods described in Section 2.1.1. The selected stations are presented in Table 2-1.

Table 2-1. San Diego River Estuary Selected Monitoring Stations*

Site ID	Latitude	Longitude
8129	32.7568	-117.2353
8134	32.7574	-117.2380
8136	32.7579	-117.2274

*Specific station locations and number of stations selected are subject to change based on the spatial extent of the study area, study requirements, and safety and access considerations

1.3.2 Permitting

Scientific collecting permits from the California Department of Fish and Wildlife are required to collect benthic infaunal samples containing invertebrate specimens. A minimum of 24 hours (business days only) prior to collecting benthic infaunal samples in the field, a copy of the Notification of Intent to Collect for Scientific Purposes form should be faxed or emailed to the Marine Region (Monterey, CA) office of the CDFW. Additionally, written authorization may be required from state agencies or private landowners in order to gain access to water bodies that are surrounded by private land, have locked fences or gates, contain threatened or endangered species, or require the use of a private boat launch. Nesting seasons of threatened and endangered bird species may prevent sampling from being conducted or may restrict access around nesting areas during certain times of year, typically mid to late summer months.

1.3.3 Monitoring Season and Frequency

Section VII.E.6 of the Sediment Control Plan requires that samples for SQO programs be collected between June and September. Physical environments and benthic community composition and abundance within enclosed bays and estuaries are generally stable and most similar from year to year during this time (Bay et al., 2014).

According to Section VII.D of the Sediment Control Plan, sediment monitoring associated with Phase I stormwater discharges and major discharges will be conducted at least twice during the Permit cycle except at stations that have consistently been classified as unimpacted or likely unimpacted using the MLOE approach described in Section 3.2. At the unimpacted or likely unimpacted stations, monitoring may be reduced to a frequency of once during the Permit cycle. The participating agencies propose to conduct one round of sediment sampling each permit term. The second required round of sampling will be satisfied by conducting additional follow up sampling in the vicinity of potentially impacted sites identified in the first round. For the San Diego River Estuary, this requirement is met for the 2013-2018 MS4 Permit term based on

sampling and assessments conducted through the participation in the Bight'13 monitoring program and the subsequent follow up sediment sampling carried out in 2014.

1.3.4 Sampling Vessels

Vessels used to collect sediment samples should be both stable and maneuverable and should have a sufficiently shallow draft to navigate into shallow waters (e.g. large inflatable boat). The vessels should be equipped with a side or rear davit from which to deploy and retrieve surface sampling equipment, and should accommodate a minimum of two persons in addition to all appropriate sampling and safety equipment.

1.3.5 Navigation

All station locations will be pre-plotted prior to sampling activities. Stations will be identified using a Differential Global Positioning System (DGPS). The system uses U.S. Coast Guard differential correction data, and is accurate within 10 feet (ft). All final station locations will be recorded in the field using positions from the DGPS.

1.3.6 Sediment Sampling and Handling

Benthic sediments will be collected as surface grabs using an appropriate sampler, such as a stainless steel Van Veen grab sampler. The size of the grab sampler to be used for sediment programs in Southern California should be 0.1 square meter (m^2) across the top of the sampler. An appropriate sampler for the collection of benthic sediments will have the following characteristics:

- Constructed of a material that does not introduce contaminants.
- Causes minimal surface sediment disturbance.
- Does not leak or mix during sample retrieval.
- Has a design that enables safe/easy sample verification that samples meet all applicable sampling criteria (e.g., collects sediments to at least 5 centimeters (cm) below the sediment surface, has access doors allowing visual inspection and removal of undisturbed surface sediment).

A sample will be determined to be acceptable if the surface of the grab is even, there is minimal surface disturbance, and there is a penetration depth of at least 5 cm. Rejected grabs will be discarded, and the station will be re-sampled. Upon retrieval, if the grab is acceptable, the overlying water will be carefully drained, and the sediment will be processed depending on analysis and use. Sediment grabs will be collected for the following analyses: benthic infauna, chemistry, grain size, and toxicity. Station location and grab event data should be written on preformatted field data sheets (hard copies or via computer). At a minimum, field data should include station identification, station location, date, time of sample collection, depth of water, depth of penetration of grab in sediment (e.g. 5 cm), sediment composition, sediment odor and color, and sample type (e.g. sediment chemistry).

In the event that a pre-plotted sample station is found to be unsuitable for collecting sediment, because of factors such as inaccessibility, the salinity does not meet the SQO criteria, disturbance to wildlife, or safety considerations, the station may be abandoned and an alternate station may be selected. Reasons for abandonment should be recorded on field data sheets.

The entire contents of a grab sample will be collected for benthic community analyses. Samples collected for benthic infaunal analysis will be rinsed through a 1.0-millimeter (mm) mesh screen. The material retained on the screen will be transferred to a labeled glass or plastic sample container. A 7% magnesium sulfate ($MgSO_4$) seawater solution will be added to the sample container to 85-90% of its volume to relax the collected specimens. The sample container will be inverted several times to distribute the relaxant solution. After 30 minutes, add enough sodium borate buffered formaldehyde to top off the sample container and gently invert the container several times to ensure the sample is mixed. This will make a 10% formalin solution.

Sediment samples for toxicity testing and chemistry will be collected from the top 5 cm of a grab sample using a pre-cleaned stainless steel scoop. Sediment within 1 cm of the sides of the grab will be avoided to prevent interaction of any contaminants and the steel sampling device. According to the Sediment Control Plan, the preferred method of collection for sediment-water interface toxicity tests (see Section 2.2.2.2) is to collect intact cores directly from the sediment sampler by pressing polycarbonate core tubes (7.3-cm inner diameter [ID] and 16 cm in length) into the top 5 cm of sediment. However, homogenizing sediment for sediment-water interface testing is also acceptable according to the Sediment Control Plan. This method is more practical to implement in the field and is consistent with previous sediment quality objective methodology (e.g., Bight protocols and previous lagoon monitoring implemented by the Copermittees). Minimum sample volumes and types of sample containers to be used in the sediment collection is provided in the Sediment Monitoring QAPP (see Appendix B)

All sampling equipment will be cleaned prior to sampling. Between sampling stations, the grab sampler will be rinsed with station water. Stainless steel scoops will be rinsed with seawater and rinsed with de-ionized water between stations. All sediment samples will be logged on a chain-of-custody (COC) form (see Section 2.1.7). Sediment chemistry and toxicity samples will be placed in a cooler on ice until delivered or shipped to the appropriate laboratories. Prior to shipping, sample containers will be placed in sealable plastic bags and securely packed inside the cooler with ice. The original signed COC forms will remain with the samples during shipment. Sediment samples will be shipped or delivered to the analytical laboratory within appropriate holding times (refer to Sediment Monitoring QAPP in Appendix B).

1.3.7 Documentation of Chain-of-Custody

This section describes the program requirements for sample handling and COC procedures. Samples are considered to be in custody if they are: (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a secured container. The principal documents used to identify samples and to document possession are COC records, field log books, and field tracking forms. COC procedures will be used for all samples throughout the collection, transport, and analytical process, and for all data and data documentation, whether in hard copy or electronic format.

COC procedures will be initiated during sample collection. A COC record will be provided with each sample or sample group. Each person who has custody of the samples will sign the form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include the following:

- Sample identification.
- Sample collection date and time.
- Any special notations on sample characteristics.
- Initials of the person collecting the sample.
- Date the sample was sent to the laboratory.
- Shipping company and waybill information.

The completed COC form will be placed in a sealable plastic envelope that will travel inside the ice chest containing the listed samples. The COC form will be signed by the person transferring custody of the samples. The condition of the samples will be recorded by the receiver. COC records will be included in the final analytical report prepared by the laboratory and will be considered an integral part of the report.

1.4 LABORATORY TESTING

All samples will be tested in accordance with USEPA or American Society for Testing and Materials (ASTM) protocols. If appropriate protocols do not exist, the Copermittees should use other methods approved by the SWRCB or San Diego RWQCB. Analytical laboratories will be certified by the California Department of Health Services in accordance with Water Code 13176. Additional information pertaining to laboratory testing is presented in the Sediment Monitoring QAPP (see Appendix B).

1.4.1 Physical and Chemical Analysis

Physical and chemical measurements of sediment were selected to comply with the Sediment Control Plan and to provide data on chemicals of potential concern in bays and estuaries located in San Diego County. The physical and chemical analyses of sediments will include, at a minimum, the constituents outlined in Table 2-2. Reporting limits (RLs) must be equal to or less than those listed in Table 2-2 in order to generate the chemistry LOE outlined in Section 2.3.3.1. Concentrations associated with the RLs in Table 2-2 are expressed in dry-weight. Physical analyses of sediment will include grain size and percent solids. Grain size will be analyzed to determine the general size classes that make up the sediment (e.g., gravel, sand, silt, and clay), whereas percent solids will be measured to convert chemical concentrations from a wet-weight to a dry-weight basis. Chemical analyses of sediment will include total organic carbon (TOC), and the select trace metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) shown in Table 2-2.

Table 2-2. Chemical and Physical Parameters for Sediment Samples

Parameter	Reporting Limit
Physical/Conventional Tests	
Grain Size	1.00 %
Percent Solids	0.10 %
Total Organic Carbon (TOC)	0.01 %
Metals	
Cadmium (Cd)	0.09 mg/kg
Copper (Cu)	52.8 mg/kg
Lead (Pb)	25.0 mg/kg
Mercury (Hg)	0.09 mg/kg
Zinc (Zn)	60.0 mg/kg
Organochlorine Pesticides	
2,4′-DDD	0.50 µ g/kg
2,4′-DDE	0.50 µ g/kg
2,4′-DDT	0.50 µ g/kg
4,4′-DDD	0.50 µ g/kg
4,4′-DDE	0.50 µ g/kg
4,4′-DDT	0.50 µ g/kg
Chlordane-alpha	0.50 µ g/kg
Chlordane-gamma	0.54 µ g/kg
Dieldrin	2.5 µ g/kg
trans-Nonachlor	4.6 µ g/kg
PCB Congeners	
2,4'-Dichlorobiphenyl	3.0 µ g/kg
2,2',5-Trichlorobiphenyl	3.0 µ g/kg
2,4,4'-Trichlorobiphenyl	3.0 µ g/kg
2,2',3,5'-Tetrachlorobiphenyl	3.0 µ g/kg
2,2',5,5'-Tetrachlorobiphenyl	3.0 µ g/kg
2,3',4,4'-Tetrachlorobiphenyl	3.0 µ g/kg
2,2',4,5,5'-Pentachlorobiphenyl	3.0 µ g/kg
2,3,3',4,4'-Pentachlorobiphenyl	3.0 µ g/kg
2,3',4,4',5-Pentachlorobiphenyl	3.0 µ g/kg
2,2',3,3',4,4'-Hexachlorobiphenyl	3.0 µ g/kg
2,2',3,4,4',5'-Hexachlorobiphenyl	3.0 µ g/kg
2,2',4,4',5,5'-Hexachlorobiphenyl	3.0 µ g/kg
2,2',3,3',4,4',5-Heptachlorobiphenyl	3.0 µ g/kg
2,2',3,4,4',5,5'-Heptachlorobiphenyl	3.0 µ g/kg
2,2',3,4',5,5',6-Heptachlorobiphenyl	3.0 µ g/kg
2,2',3,3',4,4',5,6-Octachlorobiphenyl	3.0 µ g/kg
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	3.0 µ g/kg
Decachlorobiphenyl	3.0 µ g/kg
PAHs (low molecular weight)	
Acenaphthene	20.0 µ g/kg
Anthracene	20.0 µ g/kg
Phenanthrene	20.0 µ g/kg
Biphenyl	20.0 µ g/kg

Table 2-2. Chemical and Physical Parameters for Sediment Samples (Continued

Parameter	Reporting Limit
Naphthalene	20.0 µ g/kg
2,6-Dimethylnaphthalene	20.0 µ g/kg
Fluorene	20.0 µ g/kg
1-Methylnaphthalene	20.0 µ g/kg
2-Methylnaphthalene	20.0 µ g/kg
1-Methylphenanthrene	20.0 µ g/kg
PAHs (high molecular weight)	
Benzo(a)anthracene	80.0 µ g/kg
Benzo(a)pyrene	80.0 µ g/kg
Benzo(e)pyrene	80.0 µ g/kg
Chrysene	80.0 µ g/kg
Dibenzo(a,h)anthracene	80.0 µ g/kg
Fluoranthene	80.0 µ g/kg
Perylene	80.0 µ g/kg
Pyrene	80.0 µ g/kg

DDD Dichlorodiphenyldichloroethane
DDE dichlorodiphenyldichloroethylene
DDT dichlorodiphenyltrichloroethane
mg/kg milligrams per kilogram
µ g/kg micrograms per kilogram

1.4.2 Toxicity Testing

To evaluate the benthic condition of San Diego County's bays and lagoons, sediment toxicity testing will be conducted in accordance with ASTM and USEPA methods. Toxicity testing involves a short-term survival test, a sublethal endpoint test, and an assessment of sediment toxicity. For each test type, more than one specific test is acceptable. The appropriate species tested for a sample will depend on the characteristics of the sample such as grain size, salinity, and suspected toxic constituents, if any. When historical data are available for a sample location, it is recommended that the same species be used in order to make comparisons and to conduct trend analysis. In addition, when testing is conducted as part of a regional monitoring program such as the Bight program, the species selection will be dictated by the program.

If significant toxicity is observed in the solid phase or sediment-water interface test, a toxicity identification evaluation (TIE) may be conducted as part of stressor identification studies described in Section 4.0.

1.4.2.1 Short-Term Survival Testing

SQO analysis requires that at least one short-term survival test be conducted. There are three acceptable short-term survival tests, each of which is a 10-day test exposing amphipods to whole sediment. The three acceptable test organisms are Eohaustorius estuarius, Leptocheirus plumulosus, and Rhepoxynius abronius. The E. estuarius short-term survival test has been the 10-day test method used in previous San Diego County lagoon monitoring programs where the SQO analytical tool was used to assess lagoon health. These amphipod bioassays will be conducted in accordance with procedures outlined in Methods for Assessing Toxicity of

Sediment-Associated Contaminants with Estuarine and Marine Amphipods (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006) or an equivalent method. Test conditions are summarized in Table 2-3.

A water-only reference toxicity test should be conducted concurrently with the whole sediment amphipod test to assess the relative sensitivity of test organisms used in the evaluation of project sediments. Amphipod reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing.

Table 2-3. Summary of Conditions for 10-Day Whole Sediment Amphipod Bioassay

Test Conditions 10-Day Whole Sediment Bioassay				
	Test Species	E. estuarius	L. plumulosus	R. abronius
	Test Procedures	USEPA (1994); ASTM E1367-03 (2006)		
	Test Type/Duration	Static - Acute Whole Sediment/10 days		
	Sample Storage Conditions	4 °C, dark, minimal head space		
	Age/Size Class	3-5 mm	2-4 mm; immature	3-5 mm
	Grain Size Tolerance	0.6-100% sand	0-100% sand	10-100% sand
Recommended Water Quality Parameters	Temperature	15 ± 1 °C	25 ± 1 °C	15 ± 1 °C
	Salinity	20 ± 2 ppt	20 ± 2 ppt	28 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation		
	Total Ammonia	< 60 mg/L	< 60 mg/L	< 30 mg/L
	Test Chamber	1 L glass		
	Exposure Volume	2 cm sediment, 800 mL seawater		
	Replicates/Sample	5		
	No. of Organisms/Replicate	20		
	Photoperiod	Continuous light		
	Feeding	None		
	Water Renewal	None		
	Aeration	Constant gentle aeration		
	Acceptability Criteria	Mean control survival > 90%; >80% survival in each replicate		

mg/L milligram per liter

1.4.2.2 Sublethal Testing

The second type of testing required for SQO analysis is a sublethal test. Either a 48-hour development test exposing embryos of the bivalve *Mytilus galloprovincialis* to the sediment-water interface may be conducted or a 28-day survival and growth test exposing the polychaete worm *Neanthes arenaceodentata* to whole sediment. Test condition summaries for the bivalve and polychaete tests are presented in Table 2-4 and Table 2-5, respectively. The *M. galloprovincialis* sediment-water interface test has been the sublethal test method used in previous San Diego County lagoon monitoring programs where the SQO analytical tool was used to assess lagoon health.

Mytilus galloprovincialis Sediment-Water Interface Development Sublethal Test

Sediment-water interface bioassays are performed to estimate the potential toxicity of contaminants fluxing from test sediments into the overlying water. The sediments will be tested in a 48-hour sediment-water interface test using the bivalve M. galloprovincialis in accordance with procedures outlined in Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms (USEPA, 1995) and Assessment of Sediment Toxicity at the Sediment-Water Interface (Anderson et al., 1996). Sediment-water interface bioassays will be tested on intact cores collected in the field or on homogenized sediment samples as described in Section 2.1.6.

A water-only reference toxicity test should be conducted concurrently with the sediment-water interface bivalve test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing.

Table 2-4. Test Conditions for the 48-Hour M. galloprovincialis Sediment-Water Interface Bioassay

Test Conditions 10-Day Whole Sediment Bioassay		
	Test Species	M. galloprovincialis
	Test Procedures	USEPA (1995), Anderson et al. (1996)
	Test Type/Duration	Static - Acute sediment-water interface/48 hours
	Sample Storage Conditions	4 °C, dark, minimal head space
	Age/Size Class	< 4 hour old larvae
Recommended Water Quality Parameters	Temperature	15 ± 1 °C
	Salinity	32 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation
	Total Ammonia	< 4 mg/L
	Test Chamber	Polycarbonate core tube 7.3-cm inner diameter, 16 cm high
	Exposure Volume	5 cm sediment, 300 mL water
	Replicates/Sample	4
No. of Organisms/Replicate		Approximately 250 larvae
Photoperiod		16 hours light: 8 hours dark
Feeding		None
Water Renewal		None
Aeration		Constant gentle aeration
Acceptability Criteria		Mean control normal-alive > 80%

Neanthes arenaceodentata Whole Sediment Survival and Growth Sublethal Test

The N. arenaceodentata test will be conducted in accordance with ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure. A water-only reference toxicity test should be conducted concurrently with the whole sediment polychaete test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Polychaete reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing.

Table 2-5. Test Conditions for the 28-Day Whole Sediment N. arenaceodentata Bioassay

Test Conditions 10-Day Whole Sediment Bioassay		
Test Species		N. arenaceodentata
Test Procedures		ASTM E1562 (2002), Farrar and Bridges (2011)
Test Type/Duration		Static - Acute Whole Sediment/28 days
Sample Storage Conditions		4 °C, dark, minimal head space
Age/Size Class		≤ 7 days post-emergence
Grain Size Tolerance		5-100% sand
Recommended Water Quality Parameters	Temperature	20 ± 1 °C
	Salinity	30 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation
	Total Ammonia	< 20 mg/L
Test Chamber		300 mL glass
Exposure Volume		2 cm sediment, 125 mL seawater
Replicates/Sample		10
No. of Organisms/Replicate		1
Photoperiod		12 hours light: 12 hours dark
Feeding		Twice per week
Water Renewal		Weekly
Aeration		Constant gentle aeration
Acceptability Criteria		Mean control survival ≥ 80%; positive growth in

1.4.3 Benthic Infauna Analysis

The benthic infauna samples will be transported from the field to the laboratory and stored in a formalin solution for a minimum of 48 hours and no longer than 5 days. The samples will then be transferred from formalin to 70% ethanol for laboratory processing. The organisms will initially be sorted using a dissecting microscope into five major phyletic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla. While sorting, technicians will keep a count for quality control purposes, as described in the following paragraph. After initial sorting, samples will be distributed to qualified taxonomists who will identify each organism to species or

to the lowest possible taxon. Taxonomists will use the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing for nomenclature and orthography.

A QA/QC procedure will be performed on each of the sorted samples to ensure a 95% sorting efficiency. A 10% aliquot of a sample will be re-sorted by a senior technician trained in the QA/QC procedure. The number of organisms found in the aliquot will be divided by 10% and added to the total number found in the sample. The original total will be divided by the new total to calculate the percent sorting efficiency. When the sorting efficiency of the sample is below 95%, the remainder of the sample (90%) will be re-sorted.

1.4.3.1 Quality Assurance/Quality Control

All quality assurance/quality control (QA/QC) samples must be conducted in accordance with the Quality Assurance Management Plan (QAMP) for the State of California's Surface Water Ambient Monitoring Program (SWAMP). The data quality objectives for all analyses conducted by the participating analytical laboratories will be detailed in the Sediment Monitoring QAPP (see Appendix B). The results of the laboratory quality control (QC) analyses will be reported with the final data. Any QC samples that fail to meet the specified QC criteria in the methodology or the Sediment Monitoring QAPP will be identified, and the corresponding data will be appropriately qualified in the final report. All QA/QC records for the various testing programs will be kept on file for review by regulatory agency personnel.

DATA REVIEW, MANAGEMENT, AND ANALYSIS

1.5 DATA REVIEW AND MANAGEMENT

All quality assurance/quality control (QA/QC) data must be conducted in accordance with the Quality Assurance Management Plan (QAMP) for the State of California's SWAMP and the data quality objectives as outlined in the Sediment Monitoring QAPP (see Appendix B). Data will be reviewed to determine that appropriate corrective actions have been taken, when necessary. The laboratories will supply analytical results in both hard copy and electronic formats. Laboratories will have the responsibility of ensuring that both formats are accurate. Monitoring data and analytical results will be uploaded into California Environmental Data Exchange Network (CEDEN).

1.6 DATA ANALYSIS

Sediment toxicity, chemistry, and benthic community condition will be assessed using California's SQOs as described in the Sediment Control Plan (Appendix A). The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful to humans. SQOs have been fully developed for only one of Southern California's enclosed bay habitats: euhaline (salinity = 25 to 32 ppt) bays and coastal lagoons south of Point Conception. In addition, the benthic species assemblage used to calculate the benthic LOE for southern California marine bays is Habitat C (Bay et al., 2014), and one of the criteria for Habitat C is a salinity greater than 27 ppt. The data analysis methods described below should be limited to those subtidal areas of the coastal lagoons/estuaries where the for the SQO salinity criteria can be met.

The SQOs are based on a MLOE approach in which sediment toxicity, sediment chemistry, and benthic community condition are the LOE. The MLOE approach evaluates the severity of biological effects and the potential for chemically mediated effects to provide a final station level assessment. Brief descriptions of the specific methods associated with each LOE are described below. Detailed calculations and descriptions of each LOE are provided in the Sediment Control Plan (SWRCB and CA EPA, 2009) (see Appendix A).

1.6.1 Sediment Toxicity

Sediment toxicity will be assessed using two tests: a short-term survival test using one of three species of marine amphipods (E. estuarius, L. plumulosus, or R. abronius) and a sublethal test using either N. arenaceodentata (a species of polychaete worm) or M. galloprovincialis (a species of marine bivalve). Sediment toxicity test results from each station will be statistically compared to control test results; normalized to the control survival; and categorized as nontoxic, low, moderate, or high toxicity according to Table 3-1. The average of the two test response categories (nontoxic, low toxicity, moderate toxicity, and high toxicity) will be calculated to determine the final toxicity LOE category. If the average falls midway between the two categories, it will be rounded up to the higher of the two. For example, if the test response category for the short-term survival test is low toxicity, and the test response category for the sublethal test is moderate toxicity, the final category for sediment toxicity would be moderate toxicity.

Table 3-1. Sediment Toxicity Categorization Values

Test Type	Endpoint	Statistical Significance	Nontoxic[1]	Low Toxicity2	Moderate Toxicity[2]	High Toxicity[2]
Short-Term Survival Tests	E. estuaries Survival	Significant	90 to 100	82 to 89	59 to 81	<59
		Not significant	82 to 100	59 to 81	-	<59
	L. plumulosus Survival	Significant	90 to 100	78 to 89	56 to 77	<56
		Not significant	78 to 100	56 to 77	-	<56
	R. abronius Survival	Significant	90 to 100	83 to 89	70 to 82	<70
		Not significant	83 to 100	70 to 82	-	<70
Sublethal Tests	N. arenaceodentata Growth	Significant	90 to 1002	68 to 90	46 to 67	<46
		Not significant	68 to 100	46 to 67	-	<46
	M. galloprovincialis Normal-Alive	Significant	80 to 100	77 to 79	42 to 76	<42
		Not significant	77 to 79	72 to 76	-	<42

[1] Expressed as percent.
[2] Expressed as percent of control.

1.6.2 Sediment Chemistry

Sediment chemistry will be assessed using the analyte list presented in Table 3-2. Concentrations of chemicals detected in sediments will be compared to the California Logistic Regression Model (CA LRM) and the Chemical Score Index (CSI). The CA LRM is a maximum probability model (P_{max}) that uses logistic regression to predict the probability of sediment toxicity. The CSI is calculated independently of the CA LRM and is a predictive index that relates sediment chemical concentration to benthic community disturbance. Sediment chemistry results according to CA LRM and CSI are categorized as having minimal, low, moderate, and high exposure to pollutants (Table 3-2). The final sediment LOE category is the average of the two chemistry exposure categories. If the average falls midway between the two categories, it is rounded up to the higher of the two. For example, if the CA LRM is low exposure and the CSI is moderate exposure, then the final sediment LOE category is moderate exposure.

Table 3-2. Sediment Chemistry Guideline Categorization

Sediment Chemistry Guideline		Sediment LOE Category
CA LRM	CSI	
<0.33	<1.69	Minimal Exposure
0.33 - 0.49	1.69 - 2.33	Low Exposure
0.50 - 0.66	2.34 - 2.99	Moderate Exposure
>0.66	>2.99	High Exposure

1.6.3 Benthic Community Condition

Benthic community condition will be assessed using a combination of four benthic indices: the Benthic Response Index (BRI; abundance-weighted average pollution tolerance of sample organisms), the Relative Benthic Index (RBI; the weighted sum of community parameters and abundance of indicator species), the Index of Biotic Integrity (IBI; a measure that identifies benthic

community characteristics outside of reference ranges), and a predictive model based on the River Invertebrate Prediction and Classification System (RIVPACS; a comparison of assemblages in a sample to expected species composition). The four indices will be calculated following the January 21, 2008, guidance provided by Southern California Coastal Water Research Project (SCCWRP) entitled Determining Benthic Invertebrate Community Condition in Embayments for Southern California marine bays. Each benthic index result is categorized according to four levels of disturbance, including reference, low, moderate, and high disturbance.

- Reference: Equivalent to a least affected or unaffected station.
- Low Disturbance: Some indication of stress is present, but is within measurement error of unaffected condition.
- Moderate Disturbance: Clear evidence of physical, chemical, natural, or anthropogenic stress.
- High Disturbance: High magnitude of stress.

Specific categorization values, which are tailored to southern California marine bays, are assigned for each index (Table 3-3), and are based on the specific taxa found within a given sample. To determine the benthic community condition, the four indices will be integrated into a single category. The median of the four benthic index response categories are computed to determine the benthic condition. If the median falls between two categories, the value is rounded to the next higher category to provide the most conservative estimate of benthic community condition.

Table 3-3. Benthic Index Categorization Values for Southern California Marine Bays

Benthic Community Guideline				Index
BRI	**IBI**	**RBI**	**RIVPACS**	
<39.96	0	>0.27	>0.90 to <1.10	Reference
39.96 - 49.14	1	0.17 - 0.27	0.75 - 0.90 or 1.10 - 1.25	Low Disturbance
49.15 - 73.26	2	0.09 - 0.16	0.33 - 0.74 or >1.25	Moderate Disturbance
>73.26	3 or 4	<0.09	<0.33	High Disturbance

1.6.4 Integration of Multiple Lines of Evidence

The station level assessment that indicates whether the aquatic life SQO at a station has been met will be determined by the combination of the three LOE categories to assess the severity of biological effects and the potential for chemically mediated effects. The severity of biological effects will be determined by combining the toxicity and benthic community condition LOEs (Table 3-4). The potential for chemically mediated effects will be determined by combining the toxicity and chemistry LOEs (Table 3-5).

Table 3-4. Determination of Severity of Biological Effects

Combination of Toxicity LOE and Benthic Condition LOE		Toxicity LOE			
		Non-toxic	**Low Toxicity**	**Moderate Toxicity**	**High Toxicity**
Benthic Community Condition LOE	Reference	Unaffected	Unaffected	Unaffected	Low Effect
	Low Disturbance	Unaffected	Low Effect	Low Effect	Low Effect
	Moderate Disturbance	Moderate Effect	Moderate Effect	Moderate Effect	Moderate Effect
	High Disturbance	Moderate Effect	High Effect	High Effect	High Effect

Table 3-5. Determination of Potential for Chemically Mediated Effects

Combination of Toxicity LOE and Sediment Chemistry LOE		Toxicity LOE			
		Non-toxic	**Low Toxicity**	**Moderate Toxicity**	**High Toxicity**
Sediment Chemistry LOE	Minimal Exposure	Minimum Potential	Minimum Potential	Low Potential	Moderate Potential
	Low Exposure	Minimum Potential	Low Potential	Moderate Potential	Moderate Potential
	Moderate Exposure	Low Potential	Moderate Potential	Moderate Potential	Moderate Potential
	High Exposure	Moderate Potential	Moderate Potential	High Potential	High Potential

Based on the determinations of the severity of biological effects and the potential for chemically mediated effects, a station level assessment (Table 3-6) will be made that categorizes the station as one of the following:

- Unimpacted: Confident that sediment contamination is not causing significant adverse impacts to aquatic life living in station sediments.
- Likely unimpacted: Sediment contamination at the station is not expected to cause adverse impacts to aquatic life, but some disagreement among the LOE reduces the certainty that the station is unimpacted.
- Possibly impacted: Sediment contamination at the station may be causing adverse impacts to aquatic life, but the impacts are either small or uncertain due to disagreement among the LOE.
- Likely impacted: Evidence for a contaminant-related impact to aquatic life at the station is persuasive, even if there is some disagreement among the LOE.
- Clearly impacted: Sediment contamination at the station is causing clear and severe adverse impacts to aquatic life.

- Inconclusive: Disagreement among the LOE suggests that either the data are suspect or additional information is needed before a determination can be made.

Table 3-6. Determination of Final Station Assessment

Combination of Severity of Biological Effects and Potential for Chemically-Mediated Effects		**Severity of Biological Effects**			
		Unaffected	**Low Effect**	**Moderate Effect**	**High Effect**
Potential for Chemically-Mediated Effects	Minimal Potential	Unimpacted	Likely Unimpacted	Likely Unimpacted	Inconclusive
	Low Potential	Unimpacted	Likely Unimpacted	Possibly Impacted	Possibly Impacted
	Moderate Potential	Likely Unimpacted	Possibly Impacted or Inconclusive[1]	Likely Impacted	Likely Impacted
	High Potential	Inconclusive	Likely Impacted	Clearly Impacted	Clearly Impacted

[1] When chemistry classification is minimal exposure, benthic response is reference, and toxicity is high.

All 64 possible combinations are presented in Attachment B of the Sediment Control Plan.

If a station is consistently classified as Unimpacted or Likely Unimpacted according to the SQO assessments, then the protective condition has been achieved. In cases where segments contain stations categorized as Possibly Impacted but not Clearly Impacted or Likely Impacted, confirmation monitoring will be conducted prior to requiring stressor identification studies. If a follow-up assessment result is Unimpacted or Likely Unimpacted, the protective condition has been achieved at that location. If the final station assessment result is Possibly Impacted, Likely Impacted or Clearly Impacted, the station is considered degraded and the Copermittees may need to conduct a stressor identification study. Stations categorized as Inconclusive should not be used to evaluate whether the protective condition at a station has been met. Additional information should be gathered at stations classified as Inconclusive in order to understand why the LOE results show a level of disagreement.

If stations are categorized as Possibly Impacted within a monitored segment, reach, or water body that also contain stations that are not categorized as Clearly or Likely Impacted, then confirmation monitoring should be conducted in order to confirm the level of impact at these stations prior to initiating a stressor identification study. As stated in the Sediment Quality Assessment Technical Support Manual (Bay et al., 2014), "the Possibly Impacted station assessment is the least certain of all categorizations, and therefore requires the most caution during interpretation. Stations may be classified as Possibly Impacted due to low levels of effect for each LOE, indicating a low magnitude of impacts. Alternatively, a Possibly Impacted classification may be the result of a large disagreement between LOEs, potentially due to confounding factors or noncontaminant stressors." Following the confirmation monitoring, if the station assessment is categorized as Possibly Impacted, Likely Impacted, or Clearly Impacted then the Copermittees may need to conduct a stressor identification study. If additional monitoring or specialized studies at Possibly Impacted stations indicate that factors other than toxic pollutants in sediments are causing observed negative responses then it may be possible to designate the station as meeting the protective condition.

STRESSOR IDENTIFICATION

The highest priority for stressor identification will be assigned to those water body segments with the highest percentage of Clearly Impacted or Likely Impacted stations. In cases where segments contain sediments categorized as Possibly Impacted but not Clearly Impacted or Likely Impacted, confirmation monitoring will be conducted prior to requiring stressor identification studies. By reviewing the available data sets, deductive reasoning can be used to narrow the focus of future actions. Based on the outcome of the additional data analysis, steps forward for stressor identification should be coordinated with the San Diego RWQCB. If a stressor identification study is required, the Copermittees should develop a clearly defined work plan prior to beginning work. No formal guidance is given in the Sediment Control Plan on how to conduct a stressor identification study; however, the Sediment Control Plan does give some general guidance on types of stressor identification studies that can be implemented. These studies include confirmation and characterization of pollutant-related impacts, pollutant identification, and source identification and management actions. These types of studies are summarized in the following sections.

1.6.5 Pollutant Confirmation and Characterization

When the analyses described in Section 3.2 indicate that pollutants are a likely cause of an SQO exceedance at a station, a variety of tools can be used to determine whether the reason for the narrative objective not being met is due to generic stressors other than toxic pollutants, such as physical alterations or other pollutant-related stressors. Physical disturbances, such as decreased salinity, dredging impacts, and grain size, are confounding factors that may produce conditions mimicking the effects of pollutants. In these cases, the benthic community LOE will indicate degradation, but the toxicity and chemistry LOEs may not. Pollutant-related stressors, such as ammonia, TOC, nutrients, and pathogens, may also be confounding factors. In these cases, the benthic community LOE will indicate degradation, toxicity may be indicated, and chemical concentrations will be low. To determine whether a station is impacted from toxic pollutants, one or more of the following tools may be included in the stressor identification analysis as part of the confirmation:

- Evaluate the spatial extent of the area of concern in relation to anthropogenic sources.
- Evaluate the body burden of the pollutants accumulated in the animals used for exposure testing.
- Evaluate the chemical constituent results in relation to the mechanistic benchmarks.
- Compare chemistry and biology LOE to determine whether correlations exist.
- Alternative biological assessment, such as bioaccumulation experiments, pore water toxicity, or pore water chemistry analyses, may be conducted.
- Phase I TIEs, which are often useful in determining the causative agent or class of compounds causing toxicity may be conducted.

According to the SQO guidelines, “If there is compelling evidence that the SQO exceedances contributing to a receiving water limit exceedance are not due to toxic pollutants, then the assessment area shall be designated as having achieved the receiving water limit.”

1.6.6 Pollutant Identification

Pollutant identification investigations may be conducted using one or more of the following types of data: statistical, biological, or chemical investigation data. These investigations should be station-specific and should be based on:

- Correlations between individual chemicals and biological endpoints.
- Gradient analysis of chemical concentrations and the biological responses in comparison to distance from a chemical hotspot.
- Additional TIE procedures.
- Sediment pore water investigations into the bioavailability of pollutants (e.g., acid-volatile sulfides and simultaneously extracted metals [AVS:SEM] analysis, solid phase microextraction [SPME], and/or laboratory desorption studies.
- Verification studies such as spiking or in situ toxicity and bioaccumulation studies.

In cases where stressor identification studies conducted on stations categorized as Possibly Impacted are inconclusive, the Copermittees may iplement a one-time augmentation to the study or suspend stressor identification studies in favor of additional routine SQO monitoring.

1.6.7 Pollutant Source Identification and Management

Stressor identification studies should include determinations of whether sources are ongoing or legacy and determinations of the number and nature of ongoing sources. If a single or multiple dischargers are responsible for stressor pollutant discharges, the discharger(s) may need to address the SQO exceedance and to reduce the pollutant loading.

According to Section VII.H of the Sediment Control Plan, the San Diego RWQCB may develop station-specific sediment management guidelines to estimate the level of the stressor pollutant in order to meet the SQOs. Guideline development should be initiated only following identification of the stressor, and should have an overall goal of establishing a relationship between the organism's exposure and the biological effect. Upon establishing this relationship, a pollutant-specific guideline may be designated that corresponds with minimum biological effects. Approaches that can be used to establish relationships between exposure and biological effect include the following: correspondence with sediment chemistry, correspondence with bioavailable pollutant concentration, correspondence with tissue residue, and literature review. Additionally, the Sediment Control Plan states that the chemistry LOE, "including the threshold values (e.g. CSI and CALRM) shall not be used for setting cleanup levels or numeric values for technical TMDLs."

REPORTING

Provision D.1.e.(2)(c) of the Permit requires incorporation of Sediment Monitoring Report into the WQIP Annual Report. The Sediment Monitoring Report will contain an evaluation, interpretation, and tabulation of monitoring data, including an assessment of whether receiving water limits outlined in the Permit were attained; a sample location map; and a statement of certification that monitoring data and results have been uploaded into CEDEN.

Based on the conclusions of the Sediment Monitoring Report, a human health risk assessment may be necessary to determine whether human health objectives have been obtained at each sample location. Provision A.2.a.(3)(b)(ii) states that "pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health." The potential risk assessments must consider any relevant information, such as guidelines set forth in the CA EPA's Office of Environmental Health Hazard Assessment (OEHHA) fish consumption policies, CA EPA's Department of Toxic Substances Control (DTSC) risk assessment, and the USEPA human health risk assessment policies.

Based on the monitoring and assessment completed as part or Bight'13 study and follow-up monitoring conducted in 2014, sediment conditions in San Diego River Estuary are generally protective of the beneficial uses and typical of a tidally influenced shallow lagoon (Weston, 2014). [*]

[*] No further monitoring is planned for San Diego River Estuary during this permit term because there was no evidence, from the follow-up investigation conducted in 2014, to indicate that urban runoff from the watershed had significantly impaired the receiving water (Weston, 2015)

* ".. benthic community in the three samples collected at SDR14 [potentially impacted location] showed low diversity and high abundances of a few dominant species. …. Since a current valid benthic assemblage cannot be used to calculate the benthic LOE for the three SDR14 samples, final SQO site assessments could not be determined using the SQOs. However, … because …results indicate low chemistry exposure and no toxicity, even if the benthic LOE results indicated a high disturbance, the mean final SQO site assessment would still be categorized as Likely Unimpacted. The current composition of the benthic community appears to be a result of natural biological variation or physical disturbances such as the influence of tidal exchanges on the landscape of the estuary or freshwater inputs rather than related to chemically mediated effects from organochlorine pesticides, PCBs or metals. Overall, the water quality at SDR14 (Site 8136) was typical of a tidally-influenced shallow lagoon and there was no evidence from the chemistry data that urban runoff from the watershed had significantly impaired the lagoon's receiving waters." (Weston, 2015)

SCHEDULE

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the Sediment Monitoring Report is shown in Table 6-1:

Table 6-1. Sediment Monitoring Plan Schedule

Activity/Deliverable	Dates(s)
San Diego RWQCB Order No. R9-2013-0001	Adopted May 8, 2013 and effective June 27, 2013
Southern California Bight Regional Monitoring Program	July 2013
Draft Sediment Monitoring Plan	September 2014
Draft Sediment Monitoring QAPP	September 2014
Final Sediment Monitoring Plan	November 2014
Final Sediment Monitoring QAPP	November 2014
Follow-up confirmation monitoring	September 2014
Final Sediment Monitoring Plan incorporated into WQIPs	January 2014
Draft Sediment Monitoring Report	December 2014
Final Sediment Monitoring Report incorporated into Transitional Monitoring and Assessment Report	January 31, 2015
Potential Stressor ID Studies	Not required
Potential Human health risk assessment	Not required

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SDRWQCB (San Diego Regional Water Quality Control Board). 2013. Order No. R9-2013-0001. NPDES No. CAS0109266. National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds Within the San Diego Region. June 27, 2013.

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Appendix A

Water Quality Control Plan for Enclosed Bays and Estuaries - Part 1 Sediment Quality

WATER QUALITY CONTROL PLAN FOR ENCLOSED BAYS AND ESTUARIES - PART 1 SEDIMENT QUALITY

Effective August 25, 2009

STATE WATER RESOURCES CONTROL BOARD

California Environmental Protection Agency

State of California
Arnold Schwarzenegger, Governor

California Environmental Protection Agency
Linda S. Adams, Secretary

State Water Resources Control Board
http://www.waterboards.ca.gov

Charles R. Hoppin, Chair

Francis Spivy-Weber, Vice Chair

Tam M. Doduc, Member

Arthur G. Baggett, Jr., Member

Dorothy Rice, Executive Director

Jonathan Bishop, Chief Deputy Director

Thomas Howard, Chief Deputy Director

History of Plan
Adopted by the State Water Resources Control Board on September 16, 2008
Approved by the Office of Administrative Law on January 5, 2009
Approved by the U. S. Environmental Protection Agency on August 25, 2009

Prepared by
Chris Beegan, Ocean Unit, Division of Water Quality

STATE WATER RESOURCES CONTROL BOARD
RESOLUTION NO. 2008-0070

ADOPTION OF A WATER QUALITY CONTROL PLAN FOR
ENCLOSED BAYS AND ESTUARIES – PART 1 SEDIMENT QUALITY

WHEREAS:

1. California Water Code section 13393 requires the State Water Resources Control Board (State Water Board) to develop sediment quality objectives for toxic pollutants for California's enclosed bays and estuaries.

2. In 1991, the State Water Board adopted a workplan for the development of sediment quality objectives for California's enclosed bays and estuaries (1991 Workplan).

3. Due to funding constraints, the State Water Board did not implement the 1991 Workplan; consequently, litigation by environmental interests against the State Water Board ensued.

4. In August 2001, the Sacramento County Superior Court ruled against the state and ordered the State Water Board to initiate development of sediment quality objectives. On May 21, 2003, the State Water Board adopted a revised workplan.

5. Based upon the scope of work in the revised workplan, staff developed narrative sediment quality objectives to protect benthic communities, which utilize an approach based upon multiple lines of evidence.

6. Narrative sediment quality objectives have also been developed to protect human health from exposure to contaminants in fish tissue.

7. Staff also developed an implementation program for the narrative sediment quality objectives based upon input from the Scientific Steering Committee, Sediment Quality Advisory Committee, and staff of the State Water Board and the Regional Water Quality Control Boards (Regional Water Boards), and staff from other state and federal agencies. The work that has been completed, to date, is Phase 1 of the sediment quality objectives program.

8. The State Water Board recognizes this effort is an iterative process. Staff additionally have initiated a second phase of the sediment quality objectives program (Phase 2), which includes extensive sediment sampling in the Delta; further development of the estuarine chemistry, sediment toxicity, and benthic community indicators; and completion of a more prescriptive framework to address human health and exposure to contaminants in fish tissue. The tools, indicators, and framework developed under Phase 2 will be adopted into the draft plan in 2010. Phase 3 is proposed as the development, within available resources, of a

framework to protect fish and/or wildlife from the effects of pollutants in sediment. During Phases 2 and 3, staff would continue to evaluate the tools developed during the initial phase and the implementation language. As the Water Boards experience grows, the draft plan would be updated and amended as necessary to more effectively interpret and implement the narrative objectives.

9. In the process of developing SQOs, the State Water Board has identified the need to address statewide consistency in the regulation of dredging activities under the water quality certification program. While this issue is outside the scope of this plan, the State Water Board will consider initiating policy development in the future to address regulation of dredging activities under the water quality certification program.

10. The State Water Board's Clean Water Act section 303(d) listing policy was adopted prior to the development of SQOs and without the benefit of the scientific evidence supporting their development. The State Water Board recognizes the need to ensure that the listing policy and this plan are consistent. The State Water Board will, therefore, consider amending the 303(d) listing policy in the future to ensure consistency with this plan.

11. Staff has responded to significant verbal and written comments received from the public and made minor revisions to the draft plan in response to the comments.

12. In adopting this draft plan, the State Water Board has considered the requirements in Water Code section 13393. In particular, the sediment quality objectives are based on scientific information, including chemical monitoring, bioassays, and established modeling procedures; and the objectives provide adequate protection for the most sensitive aquatic organisms. In addition, sediment quality objectives for the protection of human health from contaminants in fish tissue are based on a health risk assessment.

13. As required by Water Code section 13393, the State Water Board has followed the procedures for adoption of water quality control plans in Water Code sections 13240 through 13247, in adopting this draft plan. In addition to the procedural requirements, the State Water Board has considered the substantive requirements in Water Code sections 13241 and 13242. The State Water Board has considered the past, present, and probable future beneficial uses of estuarine and bay waters that can be impacted by toxic pollutants in sediments; environmental characteristics of these waters; water quality conditions that can reasonably be achieved through the control of all factors affecting sediment quality; and economic considerations. Adoption of this draft plan is unlikely to affect housing needs or the development or use of recycled water. Further, the State Water Board has developed an implementation program to achieve the sediment quality objectives, which describes actions to be taken to achieve the objectives and monitoring to determine compliance with the objectives. Time schedules to achieve the objectives will be developed on a case-by-case basis by the appropriate Regional Water Board.

14. This draft plan is consistent with the state and federal antidegradation policies (State Water Board Resolution No. 68-16 and 40 C.F.R. Section 131.12, respectively). No lowering of water quality is anticipated to result from adoption of the draft plan. The draft plan contains scientifically-defensible sediment quality objectives for bays and estuaries, which can be consistently applied statewide to assess sediment quality, regulate waste discharges that can impact sediment quality, and provide the basis for appropriate remediation activities, where necessary. Adoption of the draft plan should result in improved sediment quality.

15. The Resources Agency has approved the State and Regional Water Boards' planning process as a "certified regulatory program" that adequately satisfies the California Environmental Quality Act (CEQA) requirements for preparing environmental documents. State Water Board staff has prepared a "substitute environmental document" for this project that contains the required environmental documentation under the State Water Board's CEQA regulations. (California Code of Regulations, title 23, section 3777.) The substitute environmental documents include the "Draft Staff Report – Water Quality Control Plan for Enclosed Bays and Estuaries, Part 1. Sediment Quality," the environmental checklist, the comments and responses to comments, the plan itself, and this resolution. The project is the adoption of sediment quality objectives and an implementation program, as Part 1 of the Water Quality Control Plan for Enclosed Bays and Estuaries.

16. CEQA scoping hearings were conducted on October 23, 2006 in San Diego, California, on November 8, 2006 in Oakland, California, and on November 28, 2006 in Rancho Cordova, California.

17. On September 26, 2007, staff circulated the draft plan – Part 1 Sediment Quality for public comment.

18. On November 19, 2007, the State Water Board conducted a public hearing on the draft plan and supporting Draft Staff Report and Substitute Environmental Document. Written comments were received through November 30, 2007.

19. The State Water Board adopted the Plan on February 19, 2008, and submitted it to the Office of Administrative Law (OAL) on February 29, 2008. Review by OAL revealed that the statutorily-required newspaper notification of the November 2007 hearing had not occurred. The State Water Board has, therefore, noticed and conducted a new public hearing for the draft plan on September 16, 2008.

20. In preparing the substitute environmental documents, the State Water Board has considered the requirements of Public Resources Code section 21159 and California Code of Regulations, title 14, section 15187, and intends these documents to serve as a Tier 1 environmental review. The State Water Board has considered the reasonably foreseeable consequences of adoption of the draft plan; however, project level impacts may need to be considered in any subsequent environmental analysis performed by lead agencies, pursuant to Public Resources Code section 21159.1.

21. Consistent with CEQA, the substitute environmental documents do not engage in speculation or conjecture but, rather, analyze the reasonably foreseeable environmental impacts related to methods of compliance with the draft plan, reasonably foreseeable mitigation measures to reduce those impacts, and reasonably feasible alternatives means of compliance that would avoid or reduce the identified impacts.

22. The draft plan could have a potentially significant adverse effect on the environment. However, there are feasible alternatives or feasible mitigation measures that, if employed, would reduce the potentially significant adverse impacts identified in the substitute environmental documents to less than significant levels. These alternatives or mitigation measures are within the responsibility and jurisdiction of other public agencies. When the sediment quality objectives are implemented on a project-specific basis, the agencies responsible for the project can and should incorporate the alternatives or mitigation measures into any subsequent project or project approvals.

23. From a program-level perspective, incorporation of the mitigation measures described in the substitute environmental documents will foreseeably reduce impacts to less than significant levels.

24. The substitute environmental documents for this draft plan identify broad mitigation approaches that should be considered at the project level.

25. Pursuant to Health and Safety Code section 57400, the draft Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality has undergone external peer review through an interagency agreement with the University of California.

26. This draft plan must be submitted for review and approval to the State Office of Administrative Law (OAL) and the United States Environmental Protection Agency (USEPA). The draft plan will become effective upon approval by OAL and USEPA.

27. If, during the OAL approval process, OAL determines that minor, non-substantive modifications to the language of the draft plan are needed for clarity or consistency, the Executive Director or designee may make such changes consistent with the State Water Board's intent in adopting this draft plan, and shall inform the State Water Board of any such changes.

THEREFORE BE IT RESOLVED THAT:

The State Water Board:

1. Approves and adopts the CEQA substitute environmental documentation, including all findings contained in the documentation, which was prepared in accordance with Public Resources Code section 21159 and California Code of

Regulations, Title 14, section 15187, and directs the Executive Director or designee to sign the environmental checklist;

2. After considering the entire record, including oral testimony at the public hearing, hereby adopts the proposed Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality;

3. Directs staff to submit the administrative record to OAL for review and approval; and

4. If, during the OAL approval process, OAL determines that minor, non-substantive modifications to the language of the draft plan are needed for clarity or consistency, directs the Executive Director or designee to make such changes and inform the State Water Board of any such changes.

5. Directs staff to initiate appropriate proceedings to amend the section 303(d) listing policy by February 2009.

CERTIFICATION

The undersigned Acting Clerk to the Board does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on September 16, 2008.

AYE:	Chair Tam M. Doduc Arthur G. Baggett, Jr. Charles R. Hoppin Frances Spivy-Weber
NAY:	None
ABSENT:	Vice Chair Gary Wolff, P.E., Ph.D
ABSTAIN:	None

Jeanine Townsend

Jeanine Townsend
Clerk to the Board

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I. INTENT AND SUMMARY

A. INTENT OF PART 1 OF THE WATER QUALITY CONTROL PLAN FOR ENCLOSED BAYS AND ESTUARIES (PART 1)

It is the goal of the State Water Resources Control Board (State Water Board) to comply with the legislative directive in Water Code §13393 to adopt sediment quality objectives (SQOs). Part 1 integrates chemical and biological measures to determine if the sediment dependent biota are protected or degraded as a result of exposure to toxic pollutants* in sediment and to protect human health. Part 1 is not intended to address low dissolved oxygen, pathogens or nutrients including ammonia. Part 1 represents the first phase of the State Water Board's SQO development effort and focuses primarily on the protection of benthic* communities in enclosed bays* and estuaries*. The State Water Board has committed in the second phase to the refinement of benthic community protection indicators for estuarine waters and the development of an improved approach to address sediment quality related human health risk associated with consumption of fish tissue.

B. SUMMARY OF PART 1

Part 1 includes**:**

1. Narrative SQOs for the protection of aquatic life and human health;
2. Identification of the beneficial uses that these objectives are intended to protect;
3. A program of implementation that contains:
   a. Specific indicators, tools and implementation provisions to determine if the sediment quality at a station or multiple stations meets the narrative objectives;
   b. A description of appropriate monitoring programs; and
   c. A sequential series of actions that shall be initiated when a sediment quality objective is not met including stressor identification and evaluation of appropriate targets.
4. A glossary that defines all terms denoted by an asterisk

II. USE AND APPLICABILITY OF SQOS

A. AMBIENT SEDIMENT QUALITY

The SQOs and supporting tools shall be utilized to assess ambient sediment quality.

B. RELATIONSHIP TO OTHER NARRATIVE OBJECTIVES

1. Except as provided in 2 below, Part 1 supersedes all applicable narrative water quality objectives and related implementation provisions in water quality control plans (basin plans) to the extent that the objectives and provisions are applied to protect bay or estuarine benthic communities from toxic pollutants in sediments.
2. The supersession provision in 1. above does not apply to existing sediment cleanup activities where a site assessment was completed and submitted to the Regional Water Board by February 19, 2008.

C. APPLICABLE WATERS

Part 1 applies to enclosed bays[1] and estuaries[2] only. Part 1 does not apply to ocean waters* including Monterey Bay and Santa Monica Bay, or inland surface waters*.

D. APPLICABLE SEDIMENTS

Part 1 applies to subtidal surficial sediments* that have been deposited or emplaced seaward of the intertidal zone. Part 1 does not apply to:

1. Sediments characterized by less than five percent of fines or substrates composed of gravels, cobbles, or consolidated rock.
2. Sediment as the physical pollutant that causes adverse biological response or community degradation related to burial, deposition, or sedimentation.

E. APPLICABLE DISCHARGES

Part 1 is applicable in its entirety to point source* discharges. Nonpoint sources* of toxic pollutants are subject to Sections II, III, IV, V, and VI of Part 1.

III. BENEFICIAL USES

Beneficial uses protected by Part 1 and corresponding target receptors are identified in Table 1.

Table 1. Beneficial Uses and Target Receptors

Beneficial Uses	Target Receptors
Estuarine Habitat	Benthic Community
Marine Habitat	Benthic Community
Commercial and Sport Fishing	Human Health
Aquaculture	Human Health
Shellfish Harvesting	Human Health

[1] ENCLOSED BAYS are indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes, but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

[2] ESTUARIES AND COASTAL LAGOONS are waters at the mouths of streams that serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include, but are not limited to, the Sacramento-San Joaquin Delta as defined by Section 12220 of CWC, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

IV. SEDIMENT QUALITY OBJECTIVES

A. AQUATIC LIFE – BENTHIC COMMUNITY PROTECTION

Pollutants in sediments shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California. This narrative objective shall be implemented using the integration of multiple lines of evidence (MLOE) as described in Section V of Part 1.

B. HUMAN HEALTH

Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health. This narrative objective shall be implemented as described in Section VI of Part 1.

V. BENTHIC COMMUNITY PROTECTION

A. MLOE APPROACH TO INTERPRET THE NARRATIVE OBJECTIVE

The methods and procedures described below shall be used to interpret the Narrative Objective described in Section IV.A. These tools are intended to assess the condition of benthic communities relative to potential for exposure to toxic pollutants in sediments. Exposure to toxic pollutants at harmful levels will result in some combination of a degraded benthic community, presence of toxicity, and elevated concentrations of pollutants in sediment. The assessment of sediment quality shall consist of the measurement and integration of three lines of evidence (LOE). The LOE are:

- ***Sediment Toxicity***—Sediment toxicity is a measure of the response of invertebrates exposed to surficial sediments under controlled laboratory conditions. The sediment toxicity LOE is used to assess both pollutant related biological effects and exposure. Sediment toxicity tests are of short durations and may not duplicate exposure conditions in natural systems. This LOE provides a measure of exposure to all pollutants present, including non-traditional or unmeasured chemicals.
- ***Benthic Community Condition***—Benthic community condition is a measure of the species composition, abundance and diversity of the sediment-dwelling invertebrates inhabiting surficial sediments*. The benthic community LOE is used to assess impacts to the primary receptors targeted for protection under Section IV.A. Benthic community composition is a measure of the biological effects of both natural and anthropogenic stressors.
- ***Sediment Chemistry***—Sediment chemistry is the measurement of the concentration of chemicals of concern* in surficial sediments. The chemistry LOE is used to assess the potential risk to benthic organisms from toxic pollutants in surficial sediments. The sediment chemistry LOE is intended only to evaluate overall exposure risk from chemical pollutants. This LOE does not establish causality associated with specific chemicals.

B. LIMITATIONS

None of the individual LOE is sufficiently reliable when used alone to assess sediment quality impacts due to toxic pollutants. Within a given site, the LOEs applied to assess exposure as described in Section V.A. may underestimate or overestimate the risk to benthic

communities and do not indicate causality of specific chemicals. The LOEs applied to assess biological effects can respond to stresses associated with natural or physical factors, such as sediment grain size, physical disturbance, or organic enrichment.

Each LOE produces specific information that, when integrated with the other LOEs, provides a more confident assessment of sediment quality relative to the narrative objective. When the exposure and effects tools are integrated, the approach can quantify protection through effects measures and also provide predictive capability through the exposure assessment.

C. WATER BODIES

1. The tools described in the Sections V.D. through V.I. are applicable to Euhaline* Bays and Coastal Lagoons* south of Point Conception and Polyhaline* San Francisco Bay that includes the Central and South Bay Areas defined in general by waters south and west of the San Rafael Bridge and north of the Dumbarton Bridge.
2. For all other bays and estuaries where LOE measurement tools are unavailable, station assessment will follow the procedure described in Section V.J.

D. FIELD PROCEDURES

1. All samples shall be collected using a grab sampler.
2. Benthic samples shall be screened through:
   a. A 0.5 millimeter (mm)-mesh screen in San Francisco Bay and the Sacramento-San Joaquin Delta;
   b. A 1.0 mm-mesh screen in all other locations.
3. Surface sediment from within the upper 5 cm shall be collected for chemistry and toxicity analyses.
4. The entire contents of the grab sample, with a minimum penetration depth of 5 cm, shall be collected for benthic community analysis.
5. Bulk sediment chemical analysis will include at a minimum the pollutants identified in Attachment A.

E. LABORATORY TESTING

All samples will be tested in accordance with U.S. Environmental Protection Agency (USEPA) or American Society for Testing and Materials (ASTM) methodologies where such methods exist. Where no EPA or ASTM methods exist, the State Water Board or Regional Water Quality Control Boards (Regional Water Boards) (collectively Water Boards) shall approve the use of other methods. Analytical tests shall be conducted by laboratories certified by the California Department of Health Services in accordance with Water Code Section 13176.

F. SEDIMENT TOXICITY

1. Short Term Survival Tests—A minimum of one short-term survival test shall be performed on sediment collected from each station. Acceptable test organisms and methods are summarized in Table 2.

Table 2. Acceptable Short Term Survival Sediment Toxicity Test Methods

Test Organism	Exposure Type	Duration	Endpoint*
Eohaustorius estuarius	Whole Sediment	10 days	Survival
Leptocheirus plumulosus	Whole Sediment	10 days	Survival
Rhepoxynius abronius	Whole Sediment	10 days	Survival

2. Sublethal Tests—A minimum of one sublethal test shall be performed on sediment collected from each station. Acceptable test organisms and methods are summarized in Table 3.

Table 3. Acceptable Sublethal Sediment Toxicity Test Methods

Test Organism	Exposure Type	Duration	Endpoint
Neanthes arenaceodentata	Whole Sediment	28 days	Growth
Mytilus galloprovincialis	Sediment-water Interface	48 hour	Embryo Development

3. Assessment of Sediment Toxicity—Each sediment toxicity test result shall be compared and categorized according to responses in Table 4. The response categories are:
   a. Nontoxic—Response not substantially different from that expected in sediments that are uncontaminated and have optimum characteristics for the test species (e.g., control sediments).
   b. Low toxicity—A response that is of relatively low magnitude; the response may not be greater than test variability.
   c. Moderate toxicity—High confidence that a statistically significant toxic effect is present.
   d. High toxicity—High confidence that a toxic effect is present and the magnitude of response includes the strongest effects observed for the test.

Table 4. Sediment Toxicity Categorization Values

Test Species/ Endpoint	Statistical Significance	Nontoxic (Percent)	Low Toxicity (Percent of Control)	Moderate Toxicity (Percent of Control)	High Toxicity (Percent of Control)
Eohaustorius Survival	Significant	90 to 100	82 to 89	59 to 81	< 59
Eohaustorius Survival	Not Significant	82 to 100	59 to 81		<59
Leptocheirus Survival	Significant	90 to 100	78 to 89	56 to 77	<56
Leptocheirus Survival	Not Significant	78 to 100	56 to 77		<56
Rhepoxynius Survival	Significant	90 to 100	83 to 89	70 to 82	< 70
Rhepoxynius Survival	Not Significant	83 to 100	70 to 82		< 70
Neanthes Growth	Significant	90 to 100*	68 to 90	46 to 67	<46
Neanthes Growth	Not Significant	68 to 100	46 to 67		<46
Mytilus Normal	Significant	80 to 100	77 to 79	42 to 76	< 42
Mytilus Normal	Not Significant	77 to 79	42 to 76		< 42

* Expressed as a percentage of the control.

4. Integration of Sediment Toxicity Categories—The average of all test response categories shall determine the final toxicity LOE category. If the average falls midway between categories it shall be rounded up to the next higher response category.

G. BENTHIC COMMUNITY CONDITION

1. General Requirements.
   a. All benthic invertebrates in the screened sample shall be identified to the lowest possible taxon and counted.
   b. Taxonomic nomenclature shall follow current conventions established by local monitoring programs and professional organizations (e.g., master species list).
2. Benthic Indices—The benthic condition shall be assessed using the following methods:
   a. Benthic Response Index (BRI), which was originally developed for the southern California mainland shelf and extended into California's bays and estuaries. The BRI is the abundance-weighted average pollution* tolerance score of organisms occurring in a sample.
   b. Index of Biotic Integrity (IBI), which was developed for freshwater streams and adapted for California's bays and estuaries. The IBI identifies community measures that have values outside a reference range.
   c. Relative Benthic Index (RBI), which was developed for embayments in California's Bay Protection and Toxic Cleanup Program. The RBI is the weighted sum of: (a) several community parameters (total number of species, number of crustacean species, number of crustacean individuals, and number of mollusc species), and abundances of (b) three positive, and (c) two negative indicator species.
   d. River Invertebrate Prediction and Classification System (RIVPACS), which was originally developed for British freshwater streams and adapted for California's bays and estuaries. The approach compares the assemblage at a site with an expected species composition determined by a multivariate predictive model that is based on species relationships to habitat gradients.
3. Assessment of Benthic Community Condition—Each benthic index result shall be categorized according to disturbance as described in Table 5. The disturbance categories are:
   a. Reference—A community composition equivalent to a least affected or unaffected site.
   b. Low disturbance— A community that shows some indication of stress, but could be within measurement error of unaffected condition.
   c. Moderate disturbance—Confident that the community shows evidence of physical, chemical, natural, or anthropogenic stress.
   d. High disturbance—The magnitude of stress is high.
4. Integration of Benthic Community Categories—The median of all benthic index response categories shall determine the benthic condition LOE category. If the median falls between categories it shall be rounded up to the next higher effect category.

Table 5. Benthic Index Categorization Values

Index	Reference	Low Disturbance	Moderate Disturbance	High Disturbance
Southern California Marine Bays				
BRI	< 39.96	39.96 to 49.14	49.15 to 73.26	> 73.26
IBI	0	1	2	3 or 4
RBI	> 0.27	0.17 to 0.27	0.09 to 0.16	< 0.09
RIVPACS	> 0.90 to < 1.10	0.75 to 0.90 or 1.10 to 1.25	0.33 to 0.74 or > 1.25	< 0.33
Polyhaline Central San Francisco Bay				
BRI	< 22.28	22.28 to 33.37	33.38 to 82.08	> 82.08
IBI	0 or 1	2	3	4
RBI	> 0.43	0.30 to 0.43	0.20 to 0.29	< 0.20
RIVPACS	> 0.68 to < 1.32	0.33 to 0.68 or 1.32 to 1.67	0.16 to 0.32 or > 1.67	< 0.16

H. SEDIMENT CHEMISTRY

1. All samples shall be tested for the analytes identified in Attachment A—This list represents the minimum analytes required to assess exposure. In water bodies where other toxic pollutants are believed to pose risk to benthic communities, those toxic pollutants shall be included in the analysis. Inclusion of additional analytes cannot be used in the exposure assessment described below. However, the data can be used to conduct more effective stressor identification studies as described in Section VII. F.
2. Sediment Chemistry Guidelines—The sediment chemistry exposure shall be assessed using the following two methods:
   a. Chemical Score Index (CSI), that uses a series of empirical thresholds to predict the benthic community disturbance category (score) associated with the concentration of various chemicals (Table 6). The CSI is the weighted sum of the individual scores (Equation 1).

      Equation 1. $CSI = \Sigma(w_i \times cat_i)/\Sigma w$

      Where: cat_i = predicted benthic disturbance category for chemical I;
      w_i = weight factor for chemical I;
      Σw = sum of all weights.

   b. California Logistic Regression Model (CA LRM), that uses logistic regression models to predict the probability of sediment toxicity associated with the concentration of various chemicals (Table 7 and Equation 2). The CA LRM exposure value is the maximum probability of toxicity from the individual models (P_{max})

      Equation 2. $p = e^{B0+B1\,(x)} / (1 + e^{B0+B1\,(x)})$

      Where: p = probability of observing a toxic effect;
      B0 = intercept parameter;
      B1 = slope parameter; and
      x = concentration the chemical.

Table 6. Category Score Concentration Ranges and Weighting Factors for the CSI

Chemical	Units	Weight	Score (Disturbance Category)			
			1 Reference	2 Low	3 Moderate	4 High
Copper	mg/kg	100	≤52.8	> 52.8 to 96.5	> 96.5 to 406	> 406
Lead	mg/kg	88	≤ 26.4	> 26.4 to 60.8	> 60.8 to 154	> 154
Mercury	mg/kg	30	≤ 0.09	> 0.09 to 0.45	> 0.45 to 2.18	> 2.18
Zinc	mg/kg	98	≤ 112	> 112 to 200	> 200 to 629	> 629
PAHs, total high MW	µg/kg	16	≤ 312	> 312 to 1325	> 1325 to 9320	>9320
PAHs, total low MW	µg/kg	5	≤ 85.4	> 85.4 to 312	> 312 to 2471	> 2471
Chlordane, alpha-	µg/kg	55	≤ 0.50	> 0.50 to 1.23	> 1.23 to 11.1	>11.1
Chlordane, gamma-	µg/kg	58	≤ 0.54	> 0.54 to 1.45	> 1.45 to 14.5	> 14.5
DDDs, total	µg/kg	46	≤ 0.50	> 0.50 to 2.69	> 2.69 to 117	> 117
DDEs, total	µg/kg	31	≤ 0.50	> 0.50 to 4.15	> 4.15 to 154	> 154
DDTs, total	µg/kg	16	≤ 0.50	> 0.50 to 1.52	> 1.52 to 89.3	> 89.3
PCBs, total	µg/kg	55	≤11.9	> 11.9 to 24.7	> 24.7 to 288	> 288

Table 7. CA LRM Regression Parameters

Chemical	Units	B0	B1
Cadmium	mg/kg	0.29	3.18
Copper	mg/kg	-5.59	2.59
Lead	mg/kg	-4.72	2.84
Mercury	mg/kg	-0.06	2.68
Zinc	mg/kg	-5.13	2.42
PAHs, total high MW	µg/kg	-8.19	2.00
PAHs, total low MW	µg/kg	-6.81	1.88
Chlordane, alpha	µg/kg	-3.41	4.46
Dieldrin	µg/kg	-1.83	2.59
Trans nonachlor	µg/kg	-4.26	5.31
PCBs, total	µg/kg	-4.41	1.48
p,p' DDT	µg/kg	-3.55	3.26

3. Assessment of Sediment Chemistry Exposure—Each sediment chemistry guideline result shall be categorized according to exposure as described in Table 8. The exposure categories are:
   a. Minimal exposure—Sediment-associated contamination* may be present, but exposure is unlikely to result in effects.
   b. Low exposure—Small increase in pollutant exposure that may be associated with increased effects, but magnitude or frequency of occurrence of biological impacts is low.
   c. Moderate exposure—Clear evidence of sediment pollutant exposure that is likely to result in biological effects; an intermediate category.
   d. High exposure—Pollutant exposure highly likely to result in possibly severe biological effects; generally present in a small percentage of the samples.

Table 8. Sediment Chemistry Guideline Categorization Values

Guideline	Minimal Exposure	Low Exposure	Moderate Exposure	High Exposure
CSI	< 1.69	1.69 to 2.33	2.34 to 2.99	>2.99
CA LRM	< 0.33	0.33 to 0.49	0.50 to 0.66	> 0.66

4. Integration of Sediment Chemistry Categories—The average of all chemistry exposure categories shall determine the final sediment chemistry LOE category. If the average falls midway between categories it shall be rounded up to the next higher exposure category.

I. INTERPRETATION AND INTEGRATION OF MLOE

Assessment as to whether the aquatic life sediment quality objective has been attained at a station is accomplished by the interpretation and integration of MLOE. The categories assigned to the three LOE, sediment toxicity, benthic community condition and sediment chemistry are evaluated to determine the station level assessment. The assessment category represented by each of the possible MLOE combinations reflects the presence and severity of two characteristics of the sample: severity of biological effects, and potential for chemically-mediated effects.

1. Severity of Biological Effects—The severity of biological effects present at a site shall be determined by the integration of the toxicity LOE and benthic condition LOE categories using the decision matrix presented in Table 9.
2. Potential for Chemically-Mediated Effects—The potential for effects to be chemically-mediated shall be determined by the integration of the toxicity LOE and chemistry LOE categories using the decision matrix presented in Table 10.

Table 9. Severity of Biological Effects Matrix

		Toxicity LOE Category			
		Nontoxic	Low Toxicity	Moderate Toxicity	High Toxicity
Benthic Condition LOE Category	Reference	Unaffected	Unaffected	Unaffected	Low Effect
	Low Disturbance	Unaffected	Low Effect	Low Effect	Low Effect
	Moderate Disturbance	Moderate Effect	Moderate Effect	Moderate Effect	Moderate Effect
	High Disturbance	Moderate Effect	High Effect	High Effect	High Effect

Table 10. Potential for Chemically Mediated Effects Matrix

		Toxicity LOE Category			
		Nontoxic	**Low Toxicity**	**Moderate Toxicity**	**High Toxicity**
Sediment Chemistry LOE Category	Minimal Exposure	Minimal Potential	Minimal Potential	Low Potential	Moderate Potential
	Low Exposure	Minimal Potential	Low Potential	Moderate Potential	Moderate Potential
	Moderate Exposure	Low Potential	Moderate Potential	Moderate Potential	Moderate Potential
	High Exposure	Moderate Potential	Moderate Potential	High Potential	High Potential

3. Station Level Assessment—The station level assessment shall be determined using the decision matrix presented in Table 11. This assessment combines the intermediate classifications for severity of biological effect and potential for chemically-mediated effect to result in six categories of impact at the station level:
   a. Unimpacted—Confident that sediment contamination is not causing significant adverse impacts to aquatic life living in the sediment at the site.
   b. Likely Unimpacted—Sediment contamination at the site is not expected to cause adverse impacts to aquatic life, but some disagreement among the LOE reduces certainty in classifying the site as unimpacted.
   c. Possibly Impacted—Sediment contamination at the site may be causing adverse impacts to aquatic life, but these impacts are either small or uncertain because of disagreement among LOE.
   d. Likely Impacted—Evidence for a contaminant-related impact to aquatic life at the site is persuasive, even if there is some disagreement among LOE.
   e. Clearly Impacted—Sediment contamination at the site is causing clear and severe adverse impacts to aquatic life.
   f. Inconclusive—Disagreement among the LOE suggests that either the data are suspect or that additional information is needed before a classification can be made.

Table 11. Station Assessment Matrix

		Severity of Effect			
		Unaffected	**Low Effect**	**Moderate Effect**	**High Effect**
Potential For Chemically-Mediated Effects	Minimal Potential	Unimpacted	Likely Unimpacted	Likely Unimpacted	Inconclusive
	Low Potential	Unimpacted	Likely Unimpacted	Possibly Impacted	Possibly Impacted
	Moderate Potential	Likely Unimpacted	Possibly Impacted or Inconclusive[1]	Likely Impacted	Likely Impacted
	High Potential	Inconclusive	Likely Impacted	Clearly Impacted	Clearly Impacted

[1] Inconclusive category when chemistry is classified as minimal exposure, benthic response is classified as reference, and toxicity response is classified as high.

The station assessment resulting from each possible combination of the three LOEs is shown in Attachment B. As an alternative to Tables 9, 10 and 11, each LOE

category can be applied to Attachment B to determine the overall condition of the station. The results will be the same regardless of the tables used.

4. Relationship to the Aquatic Life – Benthic Community Protection Narrative Objective.
   a. The categories designated as **Unimpacted** and **Likely Unimpacted** shall be considered as achieving the protective condition at the station. All other categories shall be considered as degraded except as provided in b. below.
   b. The Water Board shall designate the category **Possibly Impacted** as meeting the protective condition if the studies identified in Section VII.F demonstrate that the combination of effects and exposure measures are not responding to toxic pollutants in sediments and that other factors are causing these responses within a specific reach segment or waterbody. In this situation, the Water Board will consider only the Categories **Likely Impacted** and **Clearly Impacted** as degraded when making a determination on receiving water limits and impaired water bodies described in Section VII.

J. MLOE Approach to Interpret the Narrative Objective in Other Bays and Estuaries

Station assessments for waterbodies identified in Section V.C.2. will be conducted using the same conceptual approach and similar tools to those described in Sections V.D-H. Each LOE will be evaluated by measuring a set of readily available indicators in accordance with Tables 12 and 13.

1. Station assessment shall be consistent with the following key principles of the assessment approach described in Sections V.D. through V.I:
   a. Results for a single LOE shall not be used as the basis for an assessment.
   b. Evidence of both elevated chemical exposure and biological effects must be present to indicate pollutant-associated impacts.
   c. The categorization of each LOE shall be based on numeric values or a statistical comparison.
2. Lines of Evidence and Measurement Tools—Sediment chemistry, toxicity, and benthic community condition shall be measured at each station. Table 12 lists the required tools for evaluation of each LOE. Each measurement shall be conducted using standardized methods (e.g., EPA or ASTM guidance) where available.
3. Categorization of LOEs—Determination of the presence of an LOE effect (i.e., biologically significant chemical exposure, toxicity, or benthic community disturbance) shall be based on a comparison to a numeric response value or a statistical comparison to reference stations. The numeric values or statistical comparisons (e.g., confidence interval) used to classify a LOE as Effected shall be comparable to those specified in Sections V.F-H. to indicate High Chemical Exposure, High Toxicity, or High Disturbance. Reference stations shall be located in an area expected to be uninfluenced by the discharge or pollutants of concern in the assessment area and shall be representative of other habitat characteristics of the assessment area (e.g., salinity, grain size). Comparison to reference shall be accomplished by compiling data for appropriate regional reference sites and determining the reference envelope using statistical methods (e.g., tolerance interval).

Table 12. Tools for Use in Evaluation of LOEs

LOE	Tools	Metrics
Chemistry	Bulk sediment chemistry to include existing list (Attachment A) plus other chemicals of concern	CA LRM P_{max} Concentration on a dry weight basis
Sediment Toxicity	10-Day amphipod survival using a species tolerant of the sample salinity and grain size characteristics. e.g., *Hyalella azteca* or *Eohaustorius estuarius*	Percent of control survival
Benthic Community Condition	Invertebrate species identification and abundance	Species richness* Presence of sensitive indicator taxa Dominance by tolerant indicator taxa Presence of diverse functional and feeding groups Total abundance

Table 13. Numeric Values and Comparison Methods for LOE Categorization

Metric	Threshold value or Comparison
CA LRM	Pmax > 0.66
Chemical Concentration	Greater than reference range or interval
Percent of Control Survival	*E. estuarius*: < 59 *H. azteca*: < 62 or SWAMP criterion
Species Richness	Less than reference range or interval
Abundance of Sensitive Indicator Taxa	Less than reference range or interval
Abundance of Tolerant Indicator Taxa	Greater than reference range or interval
Total Abundance	Outside of reference range or interval

4. Station Level Assessment—The station level assessment shall be determined using the decision matrix presented in Table 14. This assessment combines the classifications for each LOE to result in two categories of impact at the station level:
   a. Unimpacted—No conclusive evidence of both high pollutant exposure and high biological effects present at the site. Evidence of chemical exposure and biological effects may be within natural variability or measurement error.
   b. Impacted—Confident that sediment contamination present at the site is causing adverse direct impacts to aquatic life.

Table 14. Station Assessment Matrix for Other Bays and Estuaries

Chemistry LOE Category	Toxicity LOE Category	Benthic Condition LOE Category	Station Assessment
No effect	No effect	No effect	Unimpacted
No effect	No effect	Effect	Unimpacted
No effect	Effect	No effect	Unimpacted
No effect	Effect	Effect	Impacted
Effect	No effect	No effect	Unimpacted
Effect	No effect	Effect	Impacted
Effect	Effect	No effect	Impacted
Effect	Effect	Effect	Impacted

5. Relationship to the Aquatic Life – Benthic Community Protection Narrative Objective— The category designated as **Unimpacted** shall be considered as achieving the protective condition at the station.

VI. HUMAN HEALTH

The narrative human health objective in Section IV. B. of this Part 1 shall be implemented on a case-by-case basis, based upon a human health risk assessment. In conducting a risk assessment, the Water Boards shall consider any applicable and relevant information, including California Environmental Protection Agency's (Cal/EPA) Office of Environmental Health Hazard Assessment (OEHHA) policies for fish consumption and risk assessment, Cal/EPA's Department of Toxic Substances Control (DTSC) Risk Assessment, and USEPA Human Health Risk Assessment policies.

VII. PROGRAM OF IMPLEMENTATION

Implementation of Part 1 shall be conducted in accordance with the following provisions and consistent with the process shown in Figures 1 and 2.

A. DREDGE MATERIALS

1. Part 1 shall not apply to dredge material suitability determinations.
2. The Water Boards shall not approve a dredging project that involves the dredging of sediment that exceeds the objectives in Part 1, unless the Water Boards determine that:
   a. The polluted sediment is removed in a manner that prevents or minimizes water quality degradation.
   b. The polluted sediment is not deposited in a location that may cause significant adverse effects to aquatic life, fish, shellfish, or wildlife or may harm the beneficial uses of the receiving waters, or does not create maximum benefit to the people of the State.
   c. The activity will not cause significant adverse impacts upon a federal sanctuary, recreational area, or other waters of significant national importance.

B. NPDES RECEIVING WATER AND EFFLUENT LIMITS

1. If a Water Board determines that discharge of a toxic pollutant to bay or estuarine waters has the reasonable potential to cause or contribute to an exceedance of the SQOs, the Water Board shall apply the objectives as receiving water limits.
2. The Permittee shall be in violation of such limits if it is demonstrated that the discharge is causing or contributing to the SQO exceedance as defined in Section VII.C.
3. Receiving water monitoring required by an NPDES permit may be satisfied by a Permitee's participation in a regional SQO monitoring program described in Section VII.E.
4. The sediment chemistry guidelines shall not be translated into or applied as effluent limits. Effluent limits established to protect or restore sediment quality shall be developed only after:
   a. A clear relationship has been established linking the discharge to the degradation,

b. The pollutants causing or contributing to the degradation have been identified, and

c. Appropriate loading studies have been completed to estimate the reductions in pollutant loading that will restore sediment quality.

These actions are described further in Sections VII.F and VII.G. Nothing in this section shall limit a Water Board's authority to develop and implement waste* load allocations* for Total Maximum Daily Loads. However, it is recommended that the Water Boards develop TMDL allocations using the methodology described herein, wherever possible.

C. EXCEEDANCE OF RECEIVING WATER LIMIT

Exceedance of a receiving water limit is demonstrated when:

1. Using a binomial distribution*, the total number of stations designated as not meeting the protective condition as defined in Sections V.I.4. or V.J.4. supports rejection of the null hypothesis* as presented in Table 15. The stations included in this analysis will be those located in the vicinity of the discharge and identified in the permit, and
2. It is demonstrated that the discharge is causing or contributing to the SQO exceedance, following the completion of the stressor identification studies described in Section VII.F.
3. If studies by the Permittee demonstrate that other sources may also be contributing to the degradation of sediment quality, the Regional Water Board shall, as appropriate, require the other sources to initiate studies to assess the extent to which these sources are a contributing factor.

Table 15. Minimum Number of Measured Exceedances Needed to Exceed the Direct Effects SQO as a Receiving Water Limit

Sample Size	List If the Number of Exceedances Equals or Is Greater Than
2 – 24	2*
25 – 36	3
37 – 47	4
48 – 59	5
60 – 71	6
72 – 82	7
83 – 94	8
95 – 106	9
107 – 117	10
118 – 129	11

Note: Null Hypothesis: Actual exceedance proportion $\leq$ 3 percent. Alternate Hypothesis: Actual exceedance proportion > 18 percent. The minimum effect size* is 15 percent.

*Application of the binomial test requires a minimum sample size of 16. The number of exceedances required using the binomial test at a sample size of 16 is extended to smaller sample sizes.

Exceedance will require the Permittee to perform additional studies as described in Sections VII.F and VII.G.

D. RECEIVING WATER LIMITS MONITORING FREQUENCY

1. Phase I Stormwater Discharges and Major Discharges—Sediment Monitoring shall not be required less frequently than twice per permit cycle. For Stations that are consistently classified as unimpacted or likely unimpacted the frequency may be reduced to once per permit cycle. The Water Board may limit receiving water monitoring to a subset of outfalls for Phase I Stormwater Permitees.
2. Phase II Stormwater and Minor Discharges—Sediment Monitoring shall not be required more often then twice per permit cycle or less then once per permit cycle. For stations that are consistently classified as unimpacted or likely unimpacted, the number of stations monitored may be reduced at the discretion of the Water Board. The Water Board may limit receiving water monitoring to a subset of outfalls for Phase II Stormwater Permitees.
3. Other Regulated Discharges and Waivers—The frequency of the monitoring for receiving water limits for other regulated discharges and waivers will be determined by the Water Board.

E. SEDIMENT MONITORING

1. Objective—Bedded sediments in bays contain an accumulation of pollutants from a wide variety of past and present sources discharged either directly into the bay or indirectly into waters draining into the bay. Embayments also represent highly disturbed or altered habitats as a result of dredging and physical disturbance caused by construction and maintenance of harbor works, boat and ship traffic, and development of adjacent lands. Due to the multitude of stressors and the complexity of the environment, a well-designed monitoring program is necessary to ensure that the data collected adequately characterizes the condition of sediment in these water bodies.
2. Permitted Discharges—Monitoring may be performed by individual Permitees to assess compliance with receiving water limits, or through participation in a regional or water body monitoring coalition as described under VII.E.3, or both as determined by the Water Board.
3. Monitoring Coalitions—To achieve maximum efficiency and economy of resources, the State Water Board encourages the regulated community in coordination with the Regional Water Boards to establish water body-monitoring coalitions. Monitoring coalitions enable the sharing of technical resources, trained personnel, and associated costs and create an integrated sediment-monitoring program within each major water body. Focusing resources on regional issues and developing a broader understanding of pollutants effects in these water bodies enables the development of more rapid and efficient response strategies and facilitates better management of sediment quality.
    a. If a regional monitoring coalition is established, the coalition shall be responsible for sediment quality assessment within the designated water body and for ensuring that appropriate studies are completed in a timely manner.
    b. The Water Board shall provide oversight to ensure that coalition participants are proactive and responsive to potential sediment quality related issues as they arise during monitoring and assessment.
    c. Each regional monitoring coalition shall prepare a workplan that describes the monitoring, a map of the stations, participants and a schedule that shall be submitted to the Water Board for approval.

4. Methods—Sediments collected from each station shall be tested or assessed using the methods and metrics described in Section V.
5. Design.
   a. The design of sediment monitoring programs, whether site-specific or region wide, shall be based upon a conceptual model. A conceptual model is useful for identifying the physical and chemical factors that control the fate and transport of pollutants and receptors that could be exposed to pollutants in the sediment. The conceptual model serves as the basis for assessing the appropriateness of a study design. The detail and complexity of the conceptual model is dependent upon the scope and scale of the monitoring program. A conceptual model shall consider:
      - Points of discharge into the segment of the waterbody or region of interest
      - Tidal flow and/or direction of predominant currents
      - Historic and or legacy conditions in the vicinity
      - Nearby land and marine uses or actions
      - Beneficial uses
      - Potential receptors of concern
      - Changes in grain size salinity water depth and organic matter
      - Other sources or discharges in the immediate vicinity.
   b. Sediment monitoring programs shall be designed to ensure that the aggregate stations are spatially representative of the sediment within the water body.
   c. The design shall take into consideration existing data and information of appropriate quality.
   d. Stratified random design shall be used where resources permit to assess conditions throughout a water body.
   3. Identification of appropriate strata shall consider characteristics of the water body including sediment transport, hydrodynamics, depth, salinity, land uses, inputs (both natural and anthropogenic) and other factors that could affect the physical, chemical, or biological condition of the sediment.
   f. Targeted designs shall be applied to those Permitees that are required to meet receiving water limits as described in Section VII. B.
6. Index Period—All stations shall be sampled between the months of June through September to be consistent with the benthic community condition index period.
7. Regional Monitoring Schedule and Frequency.
   a. Regional sediment quality monitoring will occur at a minimum of once every three years.
   b. Sediments identified as exceeding the narrative objective will be evaluated more frequently.
8. Evaluating Waters for placement on the Section 303(d) list —In California, water segments are placed on the section 303(d) list for sediment toxicity based either on toxicity alone or toxicity that is associated with a pollutant. The listing criteria are contained in the State Water Board's Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (2004)(Listing Policy). Part 1 adds an additional listing criterion that applies only to listings for exceedances of the narrative sediment quality objective for aquatic life protection in Section IV.A. The criterion under Part 1 is described in subsection a. below and the relationship

between the sediment toxicity listing criteria under the Listing Policy and the criterion under Part 1 is described in subsections b. and c., below.

1. Water segments shall be placed on the section 303(d) list for exceedance of the narrative sediment quality objective for aquatic life protection in Section IV.A. of Part 1 only if the number of stations designated as not achieving the protective condition as defined in Sections V.I. and V.J. supports rejection of the null hypothesis, as provided in Table 3.1 of the State Water Board's Listing Policy.
2. Water segments that exhibit sediment toxicity but that are not listed for an exceedance of the narrative sediment quality objective for aquatic life protection in Section IV.A. shall continue to be listed in accordance with Section 3.6 of the Listing Policy.
3. If a water segment is listed under Section 3.6 of the Listing Policy and the Regional Water Board later determines that the applicable water quality standard that is impaired consists of the sediment quality objective in Section IV.A. of Part 1 and a bay or estuarine habitat beneficial use, the Regional Water Board shall reevaluate the listing in accordance with Sections V.I and V.J. If the Regional Water Board reevaluates the listing and determines that the water segment does not meet the criteria in subsection a. above, the Regional Water Board shall delist the water segment.

F. STRESSOR IDENTIFICATION

If sediments fail to meet the narrative SQOs in accordance with Sections V. and VI. the Water Boards shall direct the regional monitoring coalitions or Permittees to conduct stressor identification.

The Water Boards shall assign the highest priority for stressor identification to those segments or reaches with the highest percentage of sites designated as Clearly Impacted and Likely Impacted.

Where segments or reaches contain Possibly Impacted but no Clearly or Likely Impacted sites, confirmation monitoring shall be conducted prior to initiating stressor identification.

The stressor identification approach consists of development and implementation of a work plan to seek confirmation and characterization of pollutant-related impacts, pollutant identification and source identification. The workplan shall be submitted to the Water Board for approval. Stressor identification consists of the following studies:

1. Confirmation and Characterization of Pollutant Related Impacts—Exceedance of the direct effects SQO at a site indicates that pollutants in the sediment are the likely cause but does not identify the specific pollutant responsible. The MLOE assessment establishes a linkage to sediment pollutants; however, the lack of confounding factors (e.g., physical disturbance, non-pollutant constituents) must be confirmed. There are two generic stressors that are not related to toxic pollutants that may cause the narrative to be exceeded:
   a. Physical Alteration—Examples of physical stressors include reduced salinity, impacts from dredging, very fine or coarse grain size, and prop wash from passing ships. These types of stressors may produce a non-reference condition* in the benthic community that is similar to that caused by pollutants. If impacts to a site are purely due to physical disturbance, the LOE characteristics will likely show a degraded benthic community with little or no toxicity and low chemical concentrations.

b. Other Pollutant Related Stressors—These constituents, which include elevated total organic carbon, ammonia, nutrients and pathogens, may have sources similar to chemical pollutants. Chemical and microbiological analysis will be necessary to determine if these constituents are present. The LOE characteristics for this type of stressor would likely be a degraded benthic community with possibly an indication of toxicity, and low chemical concentrations.

To further assess a site that is impacted by toxic pollutants, there are several lines of investigation that may be pursued, depending on site-specific conditions. These studies may be considered and evaluated in the work plan for the confirmation effort:

a. Evaluate the spatial extent of the Area of Concern. This information can be used to evaluate the potential risk associated with the sediment, distinguish areas of known physical disturbance or pollution and evaluate the proximity to anthropogenic source gradient from such inputs as outfalls, storm drains, and industrial and agricultural activities.

b. Body burden data may be examined from animals exposed to the site's sediment to indicate if pollutants are being accumulated and to what degree.

c. Chemical specific mechanistic benchmarks* may be applied to interpret sediment chemistry concentrations.

d. Chemistry and biology data from the site should be examined to determine if there is a correlation between the two LOE.

e. Alternate biological effects data may be pursued, such as bioaccumulation* experiments and pore water toxicity or chemical analysis.

f. Other investigations that may commonly be performed as part of a Phase 1 Toxicity Identification Evaluation* (TIE).

If there is compelling evidence that the SQO exceedances contributing to a receiving water limit exceedance are not due to toxic pollutants, then the assessment area shall be designated as having achieved the receiving water limit.

2. Pollutant Identification—Methods to help determine cause may be statistical, biological, chemical or a combination. Pollutant identification studies should be structured to address site-specific conditions, and may be based upon the following:

a. Statistical methods—Correlations between individual chemicals and biological endpoints (toxicity and benthic community).

b. Gradient analysis—Comparisons are made between different samples taken at various distances from a chemical hotspot to examine patterns in chemical concentrations and biological responses. The concentrations of causative agents should decrease as biological effects decrease.

c. Additional Toxicity Identification Evaluation efforts—A toxicological method for determining the cause of impairments is the use of toxicity identification evaluations (TIE). Sediment samples are manipulated chemically or physically to remove classes of chemicals or render them biologically unavailable. Following the manipulations, biological tests are performed to determine if toxicity has been removed. TIEs should be conducted at a limited number of stations, preferably those with strong biological or toxicological effects.

d. Bioavailability*—Chemical pollutants may be present in the sediment but not biologically available to cause toxicity or degradation of the benthic community. There are several measures of bioavailability that can be made. Chemical and

toxicological measurements can be made on pore water to determine the availability of sediment pollutants. Metal compounds may be naturally bound up in the sediment and rendered unavailable by the presence of sulfides. Measurement of acid volatile sulfides and simultaneously extracted metals analysis can be conducted to determine if sufficient sulfides are present to bind the observed metals. Similarly, organic compounds can be tightly bound to sediments. Measurements of sediment organic carbon and other binding phases can be conducted to determine the bioavailable fraction of organic compounds. Solid phase microextraction (SPME) or laboratory desorption experiments can also be used to identify which organics are bioavailable to benthic organisms.

e. Verification—After specific chemicals are identified as likely causes of impairment, analysis should be performed to verify the results. Sediments can be spiked with the suspected chemicals to verify that they are indeed toxic at the concentrations observed in the field. Alternately, animals can be transplanted to suspected sites for *in situ* toxicity and bioaccumulation testing.

When stressor Identification yields inconclusive results for sites classified as Possibly Impacted, the Water Board shall require the Permittee or regional monitoring coalition to perform a one-time augmentation to that study or, alternatively, the Water Board may suspend further stressor identification studies pending the results of future routine SQO monitoring.

3. Sources Identification and Management Actions.
   a. Determine if the sources are ongoing or legacy sources.
   b. Determine the number and nature of ongoing sources.
   c. If a single discharger is found to be responsible for discharging the stressor pollutant at a loading rate that is significant, the Regional Water Board shall require the discharger to take all necessary and appropriate steps to address exceedance of the SQO, including but not limited to reducing the pollutant loading into the sediment.
   d. When multiple sources are present in the water body that discharge the stressor pollutant at a loading rate that is significant, the Regional Water Board shall require the sources to take all necessary and appropriate steps to address exceedance of the SQO. If appropriate, the Regional Water Board may adopt a TMDL to ensure attainment of the sediment standard.

G. CLEANUP AND ABATEMENT

Cleanup and abatement actions covered by Water Code section 13304 for sediments that exceed the objectives in Chapter IV shall comply with Resolution No. 92-49 (Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304), Cal. Code Regs., tit. 23, §§2907, 2911.

H. DEVELOPMENT OF SITE-SPECIFIC SEDIMENT MANAGEMENT GUIDELINES

The Regional Water Boards may develop site-specific sediment management guidelines where appropriate, for example, where toxic stressors have been identified and controllable sources of these stressors exist or remedial goals are desired.

Development of site-specific sediment management guidelines is the process to estimate the level of the stressor pollutant that will meet the narrative sediment quality objective. The guideline can serve as the basis for cleanup goals or revision of effluent limits described in B. 4

above, depending upon the situation or sources. All guidelines when applied for cleanup, must comply with 92-49.

Guideline development should only be initiated after the stressor has been identified. The goal is to establish a relationship between the organism's exposure and the biological effect. Once this relationship is established, a pollutant specific guideline may be designated that corresponds with minimum biological effects. The following approaches can be applied to establish these relationships:

1. Correspondence with sediment chemistry. An effective guideline can best be derived based upon the site-specific, or reach- specific relationship between the stressor pollutant exposure and biological response. Therefore the correspondence between the bulk sediment stressor concentration and biological effects should be examined.
2. Correspondence with bioavailable pollutant concentration. The concentration of the bioavailable fraction of the stressor pollutants is likely to show a less variable relationship to biological effects that bulk sediment chemistry. Interstitial water analysis, SPME, desorption experiments, selective extractions, or mechanistic models may indicate the bioavailable pollutant concentration. The correspondence between the bioavailable stressor concentration and biological effects should be examined.
3. Correspondence with tissue residue. The concentration of the stressor accumulated by a target organism may provide a measure of the stressor dose for some chemicals (e.g., those that are not rapidly metabolized). The tissue residue threshold concentration associated with unacceptable biological effects can be combined with a bioaccumulation factor or model to estimate the loading or sediment concentration guideline.
4. Literature review. If site-specific analyses are ambiguous or unable to determine a guideline, then the results of similar development efforts for other areas should be reviewed. Scientifically credible values from other studies can be combined with mechanistic or empirical models of bioavailability, toxic potency, and organism sensitivity to estimate guidelines for the area of interest.
5. The chemistry LOE of Section V.H.2, including the threshold values (e.g. CSI and CALRM), shall not be used for setting cleanup levels or numeric values for technical TMDLs.

VIII. GLOSSARY

BENTHIC: Living on or in bottom of the ocean, bays, and estuaries, or in the streambed.

BINOMIAL DISTRIBUTION: Mathematical distribution that describes the probabilities associated with the possible number of times particular outcomes will occur in series of observations (i.e., samples). Each observation may have only one of two possible results (e.g., standard exceeded or standard not exceeded).

BIOACCUMULATION: A process in which an organism's body burden of a pollutant exceeds that in its surrounding environment as a result of chemical uptake through all routes of chemical exposure; dietary and dermal absorption and transport across the respiratory surface.

BIOAVAILABILITY: The fraction of a pollutant that an organism is exposed to that is available for uptake through biological membranes (gut, gills).

CHEMICALS OF CONCERN (COCS): Pollutants that occur in environmental media at levels that pose a risk to ecological receptors or human health.

CONTAMINATION: An impairment of the quality of the waters of the State by waste to a degree that creates a hazard to the public health through poisoning or through the spread of disease. “Contamination” includes any equivalent effect resulting from the disposal of waste whether or not waters of the State are affected (CWC section 13050(k)).

EFFECT SIZE: The maximum magnitude of exceedance frequency that is tolerated.

ENCLOSED BAYS: Indentations along the coast that enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes, but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

ENDPOINT: A measured response of a receptor to a stressor. An endpoint can be measured in a toxicity test or in a field survey.

ESTUARIES AND COASTAL LAGOONS: Waters at the mouths of streams that serve as mixing zones* for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include, but are not limited to, the Sacramento-San Joaquin Delta as defined by Section 12220 of the California Water Code, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

EUHALINE: Waters ranging in salinity from 25–32 practical salinity units (psu).

INLAND SURFACE WATERS: All surface waters of the State that do not include the ocean, enclosed bays, or estuaries.

LOAD ALLOCATION (LA): The portion of a receiving water's total maximum daily load that is allocated to one of its nonpoint sources of pollution or to natural background sources.

MECHANISTIC BENCHMARKS: Chemical guidelines developed based upon theoretical processes governing bioavailability and the relationship to biological effects.

MIXING ZONE: A limited zone within a receiving water that is allocated for mixing with a wastewater discharge where water quality criteria can be exceeded without causing adverse effects to the overall water body.

NONPOINT SOURCES: Sources that do not meet the definition of a point source as defined below.

NULL HYPOTHESIS: A statement used in statistical testing that has been put forward either because it is believed to be true or because it is to be used as a basis for argument, but has not been proved.

OCEAN WATERS: Territorial marine waters of the State as defined by California law to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. Discharges to ocean waters are regulated in accordance with the State Water Board’s California Ocean Plan.

POINT SOURCE: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock,

concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture.

POLLUTANT: Defined in section 502(6) of the CWA as "dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

POLLUTION: Defined in section 502(19) of the CWA as the "the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." *Pollution* is also defined in CWC section 13050(1) as an alternation of the quality of the waters of the State by waste to a degree that unreasonably affects either the waters for beneficial uses or the facilities that serve these beneficial uses.

POLYHALINE: Waters ranging in salinity from 18–25 psu.

REFERENCE CONDITION: The characteristics of water body segments least impaired by human activities. As such, reference conditions can be used to describe attainable biological or habitat conditions for water body segments with common watershed/catchment characteristics within defined geographical regions.

SPECIES RICHNESS: The number of species in a sample.

SURFICIAL SEDIMENTS: Those sediments representing recent depositional materials and containing the majority of the benthic invertebrate community.

STATISTICAL SIGNIFICANCE: When it can be demonstrated that the probability of obtaining a difference by chance only is relatively low.

TOXICITY IDENTIFICATION EVALUATION (TIE): Techniques used to identify the unexplained cause(s) of toxic events. TIE involves selectively removing classes of chemicals through a series of sample manipulations, effectively reducing complex mixtures of chemicals in natural waters to simple components for analysis. Following each manipulation the toxicity of the sample is assessed to see whether the toxicant class removed was responsible for the toxicity.

WASTE: As used in this document, waste includes a discharger's total discharge, of whatever origin, i.e., gross, not net, discharge.

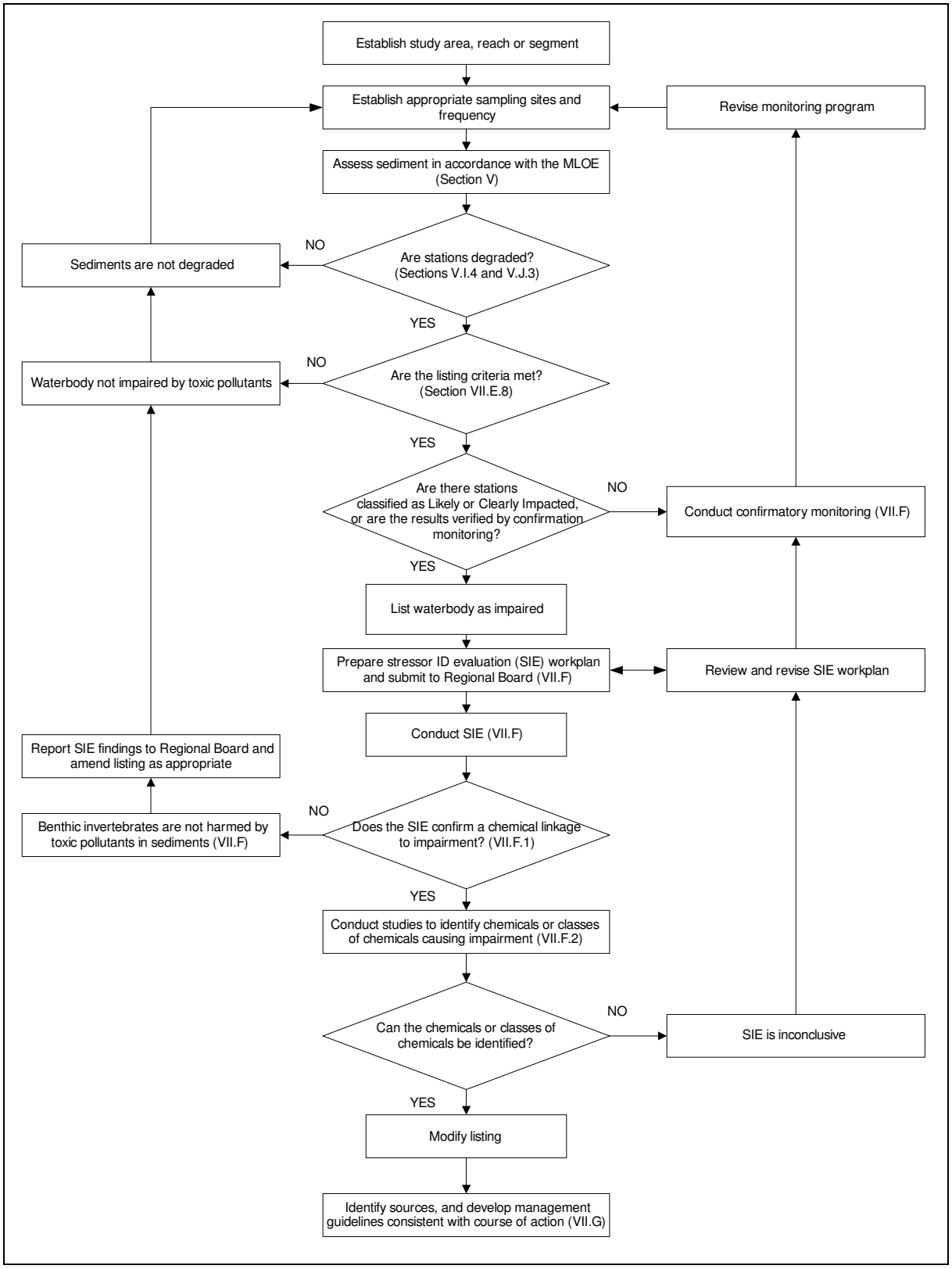

Figure 1. Waterbody Assessment Process

Figure 2. Point Source Assessment Process

Attachment A. List of chemical analytes needed to characterize sediment contamination exposure and effect.

Chemical Name	Chemical Group	Chemical Name	Chemical Group
Total Organic Carbon	General	Alpha Chlordane	Pesticide
Percent Fines	General	Gamma Chlordane	Pesticide
		Trans Nonachlor	Pesticide
Cadmium	Metal	Dieldrin	Pesticide
Copper	Metal	o,p'-DDE	Pesticide
Lead	Metal	o,p'-DDD	Pesticide
Mercury	Metal	o,p'-DDT	Pesticide
Zinc	Metal	p,p'-DDD	Pesticide
		p,p'-DDE	Pesticide
		p,p'-DDT	Pesticide
Acenaphthene	PAH	2,4'-Dichlorobiphenyl	PCB congener
Anthracene	PAH	2,2',5-Trichlorobiphenyl	PCB congener
Biphenyl	PAH	2,4,4'-Trichlorobiphenyl	PCB congener
Naphthalene	PAH	2,2',3,5'-Tetrachlorobiphenyl	PCB congener
2,6-dimethylnaphthalene	PAH	2,2',5,5'-Tetrachlorobiphenyl	PCB congener
Fuorene	PAH	2,3',4,4'-Tetrachlorobiphenyl	PCB congener
1-methylnaphthalene	PAH	2,2',4,5,5'-Pentachlorobiphenyl	PCB congener
2-methylnaphthalene	PAH	2,3,3',4,4'-Pentachlorobiphenyl	PCB congener
1-methylphenanthrene	PAH	2,3',4,4',5-Pentachlorobiphenyl	PCB congener
Phenanthrene	PAH	2,2',3,3',4,4'-Hexachlorobiphenyl	PCB congener
Benzo(a)anthracene	PAH	2,2',3,4,4',5'-Hexachlorobiphenyl	PCB congener
Benzo(a)pyrene	PAH	2,2',4,4',5,5'-Hexachlorobiphenyl	PCB congener
Benzo(e)pyrene	PAH	2,2',3,3',4,4',5-Heptachlorobiphenyl	PCB congener
Chrysene	PAH	2,2',3,4,4',5,5'-Heptachlorobiphenyl	PCB congener
Dibenz(a,h)anthracene	PAH	2,2',3,4',5,5',6-Heptachlorobiphenyl	PCB congener
Fluoranthene	PAH	2,2',3,3',4,4',5,6-Octachlorobiphenyl	PCB congener
Perylene	PAH	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	PCB congener
Pyrene	PAH	Decachlorobiphenyl	PCB congener

Attachment B. Station assessment category resulting from each possible MLOE combination

LOE Category Combination	Sediment Chemistry Exposure	Benthic Community Condition	Sediment Toxicity	Station Assessment
1	Minimal	Reference	Nontoxic	Unimpacted
2	Minimal	Reference	Low	Unimpacted
3	Minimal	Reference	Moderate	Unimpacted
4	Minimal	Reference	High	Inconclusive
5	Minimal	Low	Nontoxic	Unimpacted
6	Minimal	Low	Low	Likely unimpacted
7	Minimal	Low	Moderate	Likely unimpacted
8	Minimal	Low	High	Possibly impacted
9	Minimal	Moderate	Nontoxic	Likely unimpacted
10	Minimal	Moderate	Low	Likely unimpacted
11	Minimal	Moderate	Moderate	Possibly impacted
12	Minimal	Moderate	High	Likely impacted
13	Minimal	High	Nontoxic	Likely unimpacted
14	Minimal	High	Low	Inconclusive
15	Minimal	High	Moderate	Possibly impacted
16	Minimal	High	High	Likely impacted
17	Low	Reference	Nontoxic	Unimpacted
18	Low	Reference	Low	Unimpacted
19	Low	Reference	Moderate	Likely unimpacted
20	Low	Reference	High	Possibly impacted
21	Low	Low	Nontoxic	Unimpacted
22	Low	Low	Low	Likely unimpacted
23	Low	Low	Moderate	Possibly impacted
24	Low	Low	High	Possibly impacted
25	Low	Moderate	Nontoxic	Likely unimpacted
26	Low	Moderate	Low	Possibly impacted
27	Low	Moderate	Moderate	Likely impacted
28	Low	Moderate	High	Likely impacted
29	Low	High	Nontoxic	Likely unimpacted
30	Low	High	Low	Possibly impacted
31	Low	High	Moderate	Likely impacted
32	Low	High	High	Likely impacted
33	Moderate	Reference	Nontoxic	Unimpacted
34	Moderate	Reference	Low	Likely unimpacted
35	Moderate	Reference	Moderate	Likely unimpacted
36	Moderate	Reference	High	Possibly impacted
37	Moderate	Low	Nontoxic	Unimpacted
38	Moderate	Low	Low	Possibly impacted
39	Moderate	Low	Moderate	Possibly impacted
40	Moderate	Low	High	Possibly impacted
41	Moderate	Moderate	Nontoxic	Possibly impacted
42	Moderate	Moderate	Low	Likely impacted
43	Moderate	Moderate	Moderate	Likely impacted
44	Moderate	Moderate	High	Likely impacted

LOE Category Combination	Sediment Chemistry Exposure	Benthic Community Condition	Sediment Toxicity	Station Assessment
45	Moderate	High	Nontoxic	Possibly impacted
46	Moderate	High	Low	Likely impacted
47	Moderate	High	Moderate	Likely impacted
48	Moderate	High	High	Likely impacted
49	High	Reference	Nontoxic	Likely unimpacted
50	High	Reference	Low	Likely unimpacted
51	High	Reference	Moderate	Inconclusive
52	High	Reference	High	Likely impacted
53	High	Low	Nontoxic	Likely unimpacted
54	High	Low	Low	Possibly impacted
55	High	Low	Moderate	Likely impacted
56	High	Low	High	Likely impacted
57	High	Moderate	Nontoxic	Likely impacted
58	High	Moderate	Low	Likely impacted
59	High	Moderate	Moderate	Clearly impacted
60	High	Moderate	High	Clearly impacted
61	High	High	Nontoxic	Likely impacted
62	High	High	Low	Likely impacted
63	High	High	Moderate	Clearly impacted
64	High	High	High	Clearly impacted

CALIFORNIA

Water Boards

STATE WATER RESOURCES CONTROL BOARD

REGIONAL WATER QUALITY CONTROL BOARDS

Office of Public Affairs: (916) 341-5254
Office of Legislative Affairs: (916) 341-5251
Office of the Ombudsman (916) 341-5254

P.O. Box 100, Sacramento, CA 95812-0100
www.waterboards.ca.gov

Water Quality information: (916) 341-5455
Water Rights information: (916) 341-5300
Financial Assistance information: (916) 341-5700

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARDS

NORTH COAST REGION (1)
www.waterboards.ca.gov/northcoast
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403
E-mail: info1@waterboards.ca.gov
(707) 576-2220 TEL • (707) 523-0135 FAX

SAN FRANCISCO BAY REGION (2)
www.waterboards.ca.gov/sanfranciscobay
1515 Clay Street, Suite 1400
Oakland, CA 94612
E-mail: info2@waterboards.ca.gov
(510) 622-2300 TEL • (510) 622-2460 FAX

CENTRAL COAST REGION (3)
www.waterboards.ca.gov/centralcoast
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401
E-mail: info3@waterboards.ca.gov
(805) 549-3147 TEL • (805) 543-0397 FAX

LOS ANGELES REGION (4)
www.waterboards.ca.gov/losangeles
320 W. 4th Street, Suite 200
Los Angeles, CA 90013
E-mail: info4@waterboards.ca.gov
(213) 576-6600 TEL • (213) 576-6640 FAX

CENTRAL VALLEY REGION (5)
www.waterboards.ca.gov/centralvalley
11020 Sun Center Drive, Suite 200
Rancho Cordova, CA 95670
E-mail: info5@waterboards.ca.gov
(916) 464-3291 TEL • (916) 464-4645 FAX

Fresno branch office
1685 E Street, Suite 200
Fresno, CA 93706
(559) 445-5116 TEL • (559) 445-5910 FAX

Redding branch office
415 Knollcrest Drive
Redding, CA 96002
(530) 224-4845 TEL • (530) 224-4857 FAX

LAHONTAN REGION (6)
www.waterboards.ca.gov/lahontan
2501 Lake Tahoe Blvd.
South Lake Tahoe, CA 96150
E-mail: info6@waterboards.ca.gov
(530) 542-5400 TEL • (530) 544-2271 FAX

Victorville branch office
14440 Civic Drive, Suite 200
Victorville, CA 92392
(760) 241-6583 TEL • (760) 241-7308 FAX

COLORADO RIVER BASIN REGION (7)
www.waterboards.ca.gov/coloradoriver
73-720 Fred Waring Dr., Suite 100
Palm Desert, CA 92260
E-mail: info7@waterboards.ca.gov
(760) 346-7491 TEL • (760) 341-6820 FAX

SANTA ANA REGION (8)
www.waterboards.ca.gov/santaana
3737 Main Street, Suite 500
Riverside, CA 92501-3339
E-mail: info8@waterboards.ca.gov
(951) 782-4130 TEL • (951) 781-6288 FAX

SAN DIEGO REGION (9)
www.waterboards.ca.gov/sandiego
9174 Sky Park Court, Suite 100
San Diego, CA 92123
E-mail: info9@waterboards.ca.gov
(858) 467-2952 TEL • (858) 571-6972 FAX

State Water Resources Control Board (Headquarters)
1001 I Street, Sacramento, CA 95814

State of California
Arnold Schwarzenegger, Governor

California Environmental Protection Agency
Linda S. Adams, Secretary

State Water Resources Control Board
Charles R. Hoppin, Chair

Appendix B

Sediment Monitoring Plan
Quality Assurance Project Plan

APPENDIX B

SAN DIEGO RIVER WATERSHED MANAGEMENT AREA RESPONSIBLE COPERMITTEES SEDIMENT MONITORING QUALITY ASSURANCE PROJECT PLAN

Prepared on:

November 2014
Revised in January 2015

GROUP A:
PROJECT MANAGEMENT

ELEMENT 1 TITLE AND APPROVAL SHEET

Final

Appendix B

San Diego River Watershed Management Area Responsible Copermittees
Sediment Monitoring
Quality Assurance Project Plan

January 2015

APPROVAL SIGNATURES

San Diego River WMA Responsible Copermittes:

Title	Name	Signature	Date
Senior Project Manager			
Project Manager			

Contractor:

Title	Name	Signature	Date
Contractor Sr. Project Manager			
Contractor Project Manager			
Contractor Quality Assurance Officer			

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LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
Bight	Southern California Bight Regional Monitoring Program
BPJ	best professional judgement
CA EPA	California Environmental Protection Agency
CA LRM	California Logistic Regression Model
CEDEN	California Environmental Data Exchange Network
COC	chain of custody
Copermittees	San Diego County Regional Copermittees
CRM	certified reference materials
CSI	Chemical Score Index
CVAA	cold vapor atomic absorption
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System
DQO	data quality objective
DTSC	Department of Toxic Substances Control
EC_{50}	median effect concentration
EPA	Environmental Protection Agency
GC/ECD	gas chromatography/ electron capture detector
GC/MS	gas chromatography/ mass spectrometry
HDPE	high density polyethylene
ICP/MS	inductively coupled mass spectrometry
ID	inner diameter
LC_{50}	median lethal concentration
LCS	laboratory control sample
LOE	line(s) of evidence
$MgSO_4$	magnesium sulfate
MLOE	multiple lines of evidence
MS/MSD	matrix spike/matrix spike duplicate
MS4	municipal separate storm sewer system
OEHHA	Office of Environmental Health Hazard Assessment
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RL	reporting limit
RCs	Responsible Copermittees
RPD	relative percent difference
RWQCB	Regional Water Quality Control Board
SCAMIT	Southern California Association of Marine Invertebrate Taxonomists
SDR	San Diego River
SRM	standard reference material
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board

SIM	selective ion capture
SM	Standard Method
SOP	standard operating procedure
SP	solid phase
SQO	sediment quality objective
SWI	sediment water interface
TBD	to be determined
TOC	total organic carbon
USEPA	United States Environmental Protection Agency
WMA	Watershed Management Area
WQIP	Water Quality Improvement Plan

Units of Measure

ppt	parts per thousand
ft	feet
m^2	square meters
L	liter
cm	centimeter
mm	millimeter
%	percent
mL	milliliter
^oC	degrees Celsius
kg	kilogram
mg	milligram
μg	microgram

ELEMENT 3 DISTRIBUTION LIST

Table 1 identifies those individuals who will receive one copy of the approved Sediment Monitoring Quality Assurance Project Plan (QAPP). The Titles and roles listed in the table can be expanded based on the monitoring and team assembled.

Table 1. Quality Assurance Project Plan Distribution List

Title	Name (Affiliation)	Telephone No.	QAPP No.
San Diego River Watershed Responsible CopermitteesProject Manager			01
Contractor Project Manager			02
Contractor Project Quality Assurance (QA) Officer			03
Contractor Field Task Manager			04
Laboratory Contractor Quality Assurance (QA) Officer			05

ELEMENT 4 PROJECT/TASK ORGANIZATION

1.6.8 Involved Parties and Roles

This section details the specific roles of key individuals who will be conducting and managing the sediment monitoring project. The Titles and roles listed in the table can be expanded based on the monitoring and team assembled.

Table 2. Key Personnel Responsibilities and Contact Information

Name	Organizational Affiliation	Title	Contact Information (telephone number, fax number and email address)
	San Diego River WMA Responsible Copermittees	Project Manager	
	Contractor	Project Manager	
	Contractor	Field Task Manager	
	Contractor	QA Officer	
	Laboratory Contractor	QA Officer	

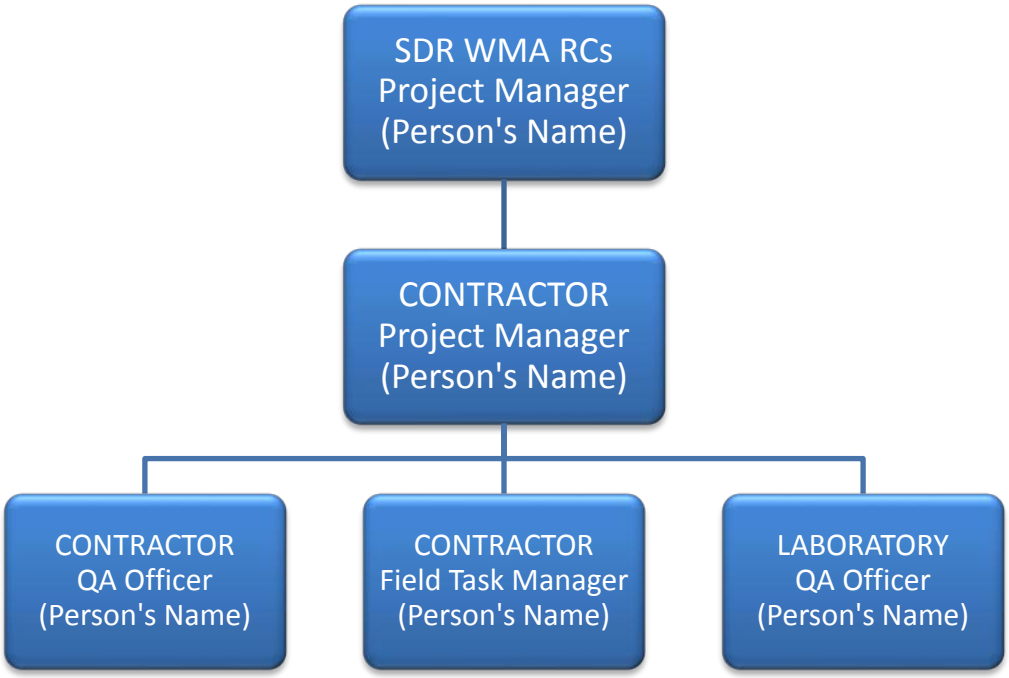

Figure 1. Organizational Chart

1.6.9 Quality Assurance Officer Role

The project Quality Assurance (QA) Officer will be responsible for the overall QA and quality control (QC) procedures found in this plan as part of the sampling and field analyses, laboratory analysis, and the overall quality of the data.

1.6.10 Persons Responsible for QAPP Update and Maintenance

Changes and updates to this QAPP may be made after a review of the evidence for change by the Contractor Project Manager and QA Officer with the concurrence of San Diego River WMA Responsible Copermittees Project Manager. The Contractor Project Manager, with input from the QA Officer, will be responsible for making the changes, submitting drafts for review by the San Diego River WMA Responsible Copermittees Project Manager, preparing a final amended copy, and submitting the final for signature. Project work must be halted while revisions to the QAPP are made, unless authorized by the San Diego River WMA Responsible Copermittees Project Manager.

ELEMENT 5 PROBLEM DEFINITION/BACKGROUND

1.6.11 Problem Statement

The Copermittees are required to conduct sediment quality monitoring in accordance with the requirements of the San Diego Regional Water Quality Control Board (RWQCB) Order No. R9-2013-0001 (Permit), effective June 27, 2013. The Copermittees are required, either individually, in association with multiple Copermittees, or through participation in a water body monitoring coalition to perform sediment quality monitoring to assess compliance with the sediment quality receiving water limits applicable to municipal separate storm sewer system (MS4) discharges to enclosed bays and estuaries. Urban runoff from the MS4 poses a risk to beneficial uses in receiving waterbodies. An understanding of the quality of sediments in relation to MS4 discharges is needed to direct and prioritize management actions.

Provision D.1.e.(2) of the Permit requires the Copermittees to develop a Sediment Monitoring Plan for incorporation into the Water Quality Improvement Plan (WQIP) which satisfies the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality* (Sediment Control Plan; State Water Quality Control Board [SWRCB] and California Environmental Protection Agency [CA EPA], 2009; see Appendix A). This QAPP supports the Sediment Monitoring Plan by describing the sampling, analysis, and quality assurance procedures that are needed to comply with Permit-required sediment quality monitoring.

1.6.12 Decisions or Outcomes

The primary objective of the sediment monitoring program is to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries of San Diego County. Sediment toxicity, chemistry, and benthic community condition will be assessed using SQOs as described in the Sediment Monitoring Plan. The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful.

The goal of the Sediment Monitoring Plan and Sediment Monitoring QAPP is to provide the key elements that are required to successfully conduct field sediment sampling, processing, testing, and analysis of the results in accordance with SQO guidelines. Analyses of chemistry, toxicity, and benthic community condition require that samples be collected, preserved, processed, and analyzed using proper field and laboratory equipment, methods, and techniques. The Sediment Monitoring Plan and Sediment Monitoring QAPP describe the collection and analysis of surface sediment samples necessary to provide representative assessments of in-situ conditions for the enclosed bays and estuaries of San Diego County. By adhering to SQO protocols, sediment quality in subtidal marine and estuarine habitats can be assessed as to whether it is protective of aquatic life and human health.

ELEMENT 6 PROJECT/TASK DESCRIPTION

1.6.13 Work Statement and Produced Products

The San Diego County Regional Copermittees (Copermittees) are required to conduct sediment quality monitoring in accordance with the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality* (Sediment Control Plan; SWRCB and CA EPA, 2009; see Appendix A). The Sediment Control Plan outlines a multiple lines of evidence (MLOE) approach to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful to humans. Sediment monitoring will be conducted at least twice during the Permit cycle except at stations that have consistently been classified as Unimpacted or Likely Unimpacted using the MLOE approach. At the Unimpacted or Likely Unimpacted stations, monitoring may be reduced to a frequency of once during the Permit cycle. The participating agencies propose to conduct one round of sediment sampling each permit term. The second required round of sampling will be satisfied by conducting additional follow up sampling in the vicinity of potentially impacted sites identified in the first round. For the San Diego River Estuary, this requirement is met for the 2013-2018 MS4 Permit term based on sampling and assessments conducted through the participation in the Bight'13 monitoring program and the subsequent follow-up sediment sampling carried out in 2014.

Sediment samples will be analyzed for toxicity, chemistry, and benthic infauna at a designated number of stations (station selection is outlined in ELEMENT 10) within a waterbody. An SQO analysis will be conducted on each station to determine a final station assessment that indicates whether the aquatic life SQO has been met. Depending on the outcome of the SQO assessments at the designated stations located in San Diego County waterbodies, follow-up monitoring may be necessary to meet all of the Permit requirements. Upon completion of the sediment quality monitoring, a Sediment Monitoring Report will be incorporated into the WQIP Annual Report. An additional stressor identification study may be required by the San Diego RWQCB for stations not meeting SQOs.

Provision D.1.e.(1)(a) of the Permit also requires the Copermittees to participate in the Southern California Bight Regional Monitoring Program. Participation in the Bight Program can be used to simultaneously fulfill all or part of the sediment quality monitoring requirement (Provision D.1.e[2]) because sediment monitoring and SQO analyses are incorporated into the Bight Program to regionally assess the sediment quality of Southern California's waterbodies. The Copermittees can also decide to conduct the initial sediment quality monitoring of San Diego County's water bodies independently of the Bight Program. Depending upon the outcome of the initial SQO assessments, the Copermittees may need to perform follow-up monitoring to meet all of the Permit requirements.

1.6.14 Constituents to be Monitored and Measurement Techniques

Chemical and toxicity analyses of all sediment samples collected as part of the SQO assessment must be tested in accordance with United States Environmental Protection Agency (USEPA) or American Society for Testing and Materials (ASTM) protocols. If appropriate protocols do not exist, the SWRCB or San Diego RWQCB may approve the use of other methods. All analytical laboratories must be certified by the California Department of Health Services in accordance with Water Code 13176.

Physical and chemical measurements of sediment were selected to comply with the Sediment Control Plan and to provide data on chemicals of potential concern in bays and estuaries located in San Diego County. The physical and chemical analyses of sediments will include, at a minimum, grain size, percent solids, total organic carbon (TOC), trace metals, organochlorine pesticides, polychlorinated biphenyl (PCBs) congeners, and polynuclear aromatic hydrocarbons (PAHs). Chemical analyses of these constituents are necessary in order to compare to the California Logistic Regression Model (CA LRM) and the Chemical Score Index (CSI) for SQO analyses. Additional physical or chemical analyses may be included in order to aid in the interpretation of the individual lines of evidence (LOEs) (e.g. pyrethroids or ammonia).

Sediment toxicity testing will be performed for each station using a minimum of one short-term survival toxicity test and one sublethal toxicity test. Acceptable short-term sediment survival tests include the *Eohaustorius estuarius* 10-day survival test, the *Leptocheirus plumulosus* 10-day survival test, or the *Rhepoxynius abronius* 10-day survival test. Acceptable sublethal sediment toxicity tests include the the *Mytilus galloprovincialis* sediment-water interface (SWI) 48-hour embryo development test or the *Neanthes arenaceodentata* whole sediment 28-day growth test. The *E. estuarius* short-term survival test and the *M. galloprovincialis* sublethal toxicity test have been the test methods used in previous San Diego County bay and estuary monitoring programs including the Bight program where the SQO analytical tool was used to assess aquatic health.

Benthic community condition samples will be screened by field personnel and then sorted and identified to the lowest possible taxon by qualified taxonomists in accordance with the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing for nomenclature and orthography.

For the purposes of this QAPP, the constituent list for chemical analyses includes only those analytes that are required for compliance with SQO analyses and physical analyses that will aid in the interpretation of the SQO data. Analytical physical and chemistry methods provided in Table 3 are suggested methods that have been used in previous sediment monitoring programs within San Diego County's waterbodies (e.g. Bight), but are not the only acceptable methods. A detailed list of individual analytes is provided in Element 13.

Table 3. Analyte list and Suggested Testing Methods for SQO analyses

Analyte/ Test	Method
Physical Analyses	
Grain size	Plumb 1981 or use of a Horiba LA920 (Laser Particle Analyzer)*
Percent solids	SM 2540B*
TOC	USEPA 9060A*
Chemical Analyses	
Trace Metals	USEPA 6020A (Mercury- 7471B)*
Oganochlorine pesticides	USEPA 8081B*
PCB congeners	USEPA 8082A*
PAHs	USEPA 8270D*
Toxicity	
Short-term amphipod survival using *Eohaustorius estuarius*	USEPA (1994) *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods*, ASTM E1367-03
Sublethal testing using *Mytilus galloprovincialis*	USEPA (1995) *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms;* Anderson et al. (1996) *Assessment of Sediment Toxicity at the Sediment-Water Interface*
Sublethal testing using *Neanthes arenaceodentata*	ASTM E1562 with modifications described in Farrar and Bridges (2011)
Benthic Infauna	
Benthic Community Condition	See Element 13

* may be substituted with equivalent methods

Short-term survival toxicity testing will be performed in accordance with procedures for amphipod testing outlined in *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006). Sublethal sediment toxicity testing for *Mytilus galloprovincialis* should follow procedures outlined in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and *Assessment of Sediment Toxicity at the Sediment-Water Interface* (Anderson et al., 1996), whereas sublethal sediment toxicity testing for *Neanthes arenaceodentata* should follow ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure. Equivalent toxicity testing methods that meet the requirements of the Sediment Control Plan may be substituted for ones described above.

1.6.15 SQO Analyses

Protocols for assessing sediment chemistry, toxicity, and benthic community conditions for San Diego County waterbodies using California's SQOs are described in Section 3.2 of the Sediment Monitoring Plan.

1.6.16 Project Schedule

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the Sediment Monitoring Report is shown in Table 4.

Table 4. Sediment Monitoring Program Schedule

Activity/Deliverable	Dates(s)*
San Diego RWQCB Order No. R9-2013-0001	Adopted May 8, 2013 and effective June 27, 2013
Southern California Bight Regional Monitoring Program	August-September 2013
Follow-up confirmation monitoring	August-September 2014
Final Sediment Monitoring Plan and Sediment Monitoring QAPP incorporated into WQIPs	December 2014
Draft Sediment Monitoring Report	December 2014
Final Sediment Monitoring Report incorporated into Transitional Monitoring and Assessment Program Report	January 31, 2015
Potential Stressor ID Studies	Not required

*Table does not include future permit cycles

The San Diego County Regional Copermittees participated in the 2013 Bight Program and conducted follow-up monitoring in 2014 to satisfy Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit prior to the development of the Sediment Monitoring Plan. Monitoring was conducted in accordance with *San Diego County Municipal Copermittees Bight 2013 Workplan* (WESTON, 2013) and data were collected using methods consistent with previous Bight surveys and the current SQO guidelines as described in the Sediment Control Plan. Follow-up confirmation monitoring was conducted in 2014 in accordance with the *San Diego County Municipal Copermittees 2014 Sampling and Analysis Plan for Bight '13 Follow-up Investigations* (WESTON, 2014). The Sediment Monitoring Report summarizing results of the 2013 Bight Program and the follow-up monitoring conducted in 2014 was included in the Transitional Monitoring and Assessment Program Report submitted to the San Diego RWQCB on January 31, 2015. Any sediment quality monitoring or stressor identification studies conducted after 2014 will be included as needed in the WQIP Annual Reports.

1.6.17 Constraints

Sediment monitoring must occur in subtidal areas located within a waterbody between the months of June through September. SQOs have been fully developed for only two of California's six enclosed bay habitats: euhaline (salinity = 25 to 32 parts per thousand [ppt]) bays and estuaries south of Point Conception and polyhaline (18 to 25 ppt) central San Francisco Bay. The benthic species assemblage used to calculate the benthic LOE in San Diego bays and estuaries is Habitat C- Southern California Marine Bays, which requires a salinity greater than 27 ppt (Bay et al 2014; Ranasinghe et al 2008). In order to select a sampling station applicable to the SQO assessment using Habitat C for the benthic LOE, it is recommended to verify that a proposed sampling station is both subtidal and has salinity greater than 27 ppt. Salinity measurements should be taken near the sediment-water interface. Sediment samples will be collected with a 0.1 m^2 Van Veen grab sampler or other similar device. Certain types of benthic habitat such as hard clay, cobble, coarse sand, and areas with thick eel grass may be difficult to sample using this type of device. A slight relocation of the target sampling location may be necessary to avoid areas in which obtaining acceptable grab samples is not achievable.

Nesting periods for threatened or endangered bird species inhabiting coastal water bodies may prevent or delay sampling during certain summer months. Species of particular concern include least terns, snowy plovers, California clapper rails, and Belding's savannah sparrows. Permission from California Fish and Wildlife may be required to enter restricted areas that are known to contain these species. Additionally permission from private land owners may be necessary to gain access to private property and/or private boat launches.

ELEMENT 7 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

All quality assurance/quality control (QA/QC) procedures for chemistry and toxicity samples must be employed in accordance with the QAPP for the State of California's Surface Water Ambient Monitoring Program (SWAMP) (SWAMP Quality Assurance Team, 2008). The data quality objectives (DQOs) are summarized by category in Table 5. If sediment quality monitoring is conducted as part of the Bight Program (i.e. SQO analysis as stated in the Sediment Control Plan), the work plans and associated QA/QC documents pertaining to the Bight Program should be followed in conjunction with this QAPP.

Table 5. Summary of Data Quality Objectives

Measurement or Analysis Type	Applicable Data Quality Objective
Chemistry Laboratory Analyses	Accuracy, precision, and completeness
Toxicity Laboratory Analyses	Precision and completeness
Benthic Infauna Analyses	Accuracy and completeness

Acceptance criteria will be based on the implementation of acceptable and recognized QA/QC procedures. Acceptable data must have proper sample collection and handling methods, sample preparation and analytical procedures, holding times, stability issues, and QA protocols.

Accuracy is a measure of how closely the analytical result or field measurement represents the true quantity found in the sample. Evaluation of the accuracy of laboratory samples will be achieved through the preparation and analysis of either reference materials (e.g. certified or standard reference materials [CRM/SRM]) or laboratory control samples [LCS]) with each analytical batch. For sediment toxicity samples, the accuracy of sediment toxicity tests cannot be determined since a reference material of known toxicity is not available. The accuracy of benthic infaunal sorting will be evaluated via a QA/QC procedure that ensures a 95% sorting efficiency of each sample.

Precision is the measure of agreement among repeated measurements of the same property under identical or substantially similar conditions calculated as either the range or as the standard deviation. The precision of chemistry laboratory measurements will be controlled by comparison of the sample to either a laboratory duplicate or a laboratory matrix spike/matrix spike duplicate (MS/MSD). For toxicity samples, a water only reference toxicant test will be run with every batch of test samples in order to document organism relative sensitivity and test precision. Reference toxicant test results that fall outside of control chart limits (2 standard deviations of the mean) will trigger a review of test procedures and a possible retest of the corresponding sediment samples. A negative control will be run with each test batch for both the short term survival and sublethal toxicity tests.

Completeness is a measure of the percentage of sample results that are collected and analyzed and determined to be valid. A goal of 90% completeness exists for each measurement process.

Completeness will be assessed in all chemistry samples with qualifiers indicating the reasons for any samples that did not meet acceptance criteria. All toxicity tests will be run with toxicity control tests to assess validity of the toxicity test results. Benthic infauna samples that do not meet acceptance criteria will be re-sorted.

"Representative" is a qualitative term that expresses "the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition" (ANSI/ASQC, 1994). Best professional judgement (BPJ) will be used in the field to evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied. Sample selection and use of approved/documented analytical methods will control to the best extent possible that the measurement data represent the conditions at the investigation site.

Quality control samples and data quality objectives for analyzing chemistry and toxicity samples collected as part of the sediment monitoring program must be conducted in accordance with the QAPP for the State of California's SWAMP (SWAMP Quality Assurance Team, 2008) if SWAMP quality objectives are available. The quality objectives are outlined in Table 6 through Table 8. Depending on the physical or chemical analysis of the sediment samples, the following QA/QC sample types may be required to be included in the analytical run:

- A laboratory blank to determine the likelihood of contamination in the samples.
- A laboratory duplicate sample to estimate the precision of the results through the calculation of the relative percent difference (RPD) between the sample and the duplicate sample.
- A certified or standard reference material to determine the accuracy of the analyses.
- A matrix spike to determine if interference has occurred between the sample matrix and the analysis of the target analyte.
- A surrogate compound to estimate losses of the target analyte during the sample extraction phase and analysis of the sample (for organic measurements only).

SWAMP quality control measurements for toxicity testing of marine sediments are provided in Table 7. It should be noted that these SWAMP measurements currently only apply for the short term 10-day survival test using *Eohaustorius estuariu*s. SWAMP is developing quality guidelines for *Mytilus galloprovincialis*.. For the SQO analysis, quality assurance recommendations for toxicity testing are also provided in the Sediment Quality Assessment Technical Support Manual (Bay et al., 2014).

Table 6. Frequency of Chemistry Analysis for Laboratory Quality Assurance/Quality Control Samples

Analysis Type	Laboratory Blanks	Laboratory Duplicate	SRM or LCS[1]	Matrix Spikes	Matrix Spike Duplicates	Surrogate
Total solids	1 per analytical batch	1 per analytical batch	N/A	N/A	N/A	N/A
Total organic carbon	1 per analytical batch	1 per analytical batch	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A	N/A	N/A
Grain size	N/A	1 per analytical batch	N/A	N/A	N/A	N/A
Trace Metals	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A
Organochlorine Pesticides	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A	1 per 20 samples or 1 per analytical batch	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	Included in all samples and all QC samples
PCB Congeners	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A	1 per 20 samples or 1 per analytical batch	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	Included in all samples and all QC samples
PAHs	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A	1 per 20 samples or 1 per analytical batch	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	Included in all samples and all QC samples

LCS = Laboratory control sample

N/A = not applicable

SRM = standard reference material

[1] When a Standard Reference Material is not available, an LCS will be analyzed.

Table 7. Quality Control Measurements for Sediment Toxicity Testing

QC Control	Frequency of Analysis and Control Limits
Negative Controls Laboratory Control Water	Laboratory Control water consistent with Section 7 of appropriate EPA method/manual must be tested with each analytical batch/ Laboratory control water must meet all test acceptability criteria for the species of interest.
Negative Controls Conductivity/Salinity Control Water	A conductivity or salinity control must be tested when these parameters are above or below the species tolerance/ Follow EPA guidance on interpreting data.
Negative Controls Additional Control Water	Additional method blanks are required whenever manipulations are performed on one or more of the ambient samples within each analytical batch/ There must be no statistical difference between the laboratory control water and each additional control water within an analytical batch.
Negative Controls Sediment Control	Sediment control consistent with Section 7 of the appropriate EPA method/manual must be tested with each analytical batch of sediment toxicity tests/ Sediment control must meet all data acceptability criteria for the species of interest.
Positive Controls Reference Toxicant Tests	Reference toxicant tests must be conducted monthly for species that are raised within a laboratory, or per analytical batch for commercially-supplied or field-collected species/ Last plotted data point (LC50 or EC50) must be within 2 SD of the cumulative mean (n=20). Reference toxicant tests that fall outside of recommended control chart limits are evaluated to determine the validity of associated tests. An out of control reference toxicant test result does not necessarily invalidate associated test results. More frequent and/or concurrent reference toxicant testing may be advantageous if recent problems have been identified in testing.
Sample Duplicate	5% of total project sample count/ Recommended acceptable RPD<20%

[1] SWAMP quality control measurements currently only apply for marine sediment toxicity testing for the 10-day survival *Eohaustorius estuarius* test. SWAMP is in the process of developing guidelines for the *Mytilus galloprovincialis* 48-hr SWI test.

Table 8. Data Quality Objectives for Laboratory Measurements

Group	Parameter	Accuracy	Precision	Completeness
Sediment Samples				
Laboratory analyses	Total Solids	N/A	Laboratory duplicate RPD < 25%	90%
Laboratory analyses	TOC	Laboratory Blank <RL or <30% of lowest sample; SRM or LCS with 80–120% recovery of true value	Laboratory duplicate RPD < 25%	90%
Laboratory analyses	Grain Size	N/A	Laboratory duplicate RPD < 25%	90%
Laboratory Analyses	Trace Metals	Laboratory Blank< RL for target analyte; SRM or LCS 75-125% recovery	Laboratory duplicate, MSD RPD < 25%; MS/MSD 75-125% recovery	90%
Laboratory Analyses	Organochlorine Pesticides	Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery	MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better)	90%
Laboratory Analyses	PCB Congeners	Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery	MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better)	90%
Laboratory Analyses	PAHs	Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery	MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better)	90%

Table 8. Data Quality Objectives for Laboratory Measurements

Group	Parameter	Accuracy	Precision	Completeness
Toxicity Samples				
Toxcity Testing	Short-term 10-day Amphipod Survival Tests	N/A	Reference toxicity testing; test results within 2 standard deviations of the mean are re-evaluated.	90%
Toxicity Testing	Sublethal Sediment Toxicity Tests	N/A	Reference toxicity testing; test results within 2 standard deviations of the mean are re-evaluated.	90%
Benthic Infauna Samples				
Benthic Infauna	Benthic Infaunal Sorting	95% sorting efficiency	N/A	90%

ELEMENT 8 SPECIAL TRAINING NEEDS/CERTIFICATION

1.6.18 Specialized Training or Certifications

1.6.18.1 Field Sampling

Field personnel will have current and relevant experience in the aspects of standard field monitoring, including use of relevant field equipment such as boats, field instruments, and monitoring equipment. Field personnel will also have been trained and have experience in the collection and handling of samples, and chain-of-custody (COC) procedures. Training will be reviewed in proper field sampling and sample-handling techniques prior to sampling and only those staff with proficiency will be permitted to conduct field work.

1.6.18.2 Analytical Laboratory

All analytical tests including chemistry and toxicity will be conducted by laboratories certified by the California Department of Health Services in accordance with Water Code Section 13176.

1.6.19 Training and Certification Documentation

Personnel are responsible for complying with QA/QC requirements that pertain to their organizational/technical function. Each technical staff member must have a combination of experience and education to adequately demonstrate a specific knowledge of their particular function and a general knowledge of laboratory operations, test methods, QA/QC procedures, and records management.

1.6.19.1 Field Sampling

Field personnel training will be documented and records kept in the project files at each organization's offices.

1.6.19.2 Analytical Laboratory

Training documents for each subcontracting laboratory will be detailed in the individual QAPPs for each laboratory.

1.6.20 Training Personnel

The Project Manager and/or Field Task Manager will provide training for field personnel in proper field sampling techniques prior to work initiation to ensure consistent and appropriate sampling, sample handling/storage, and COC procedures.

ELEMENT 9 DOCUMENTS AND RECORDS

The San Diego River WMA Responsible Copermittees or their subcontractor(s) will document and track the aspects of the sample collection process, including generating field logs at each site and COC forms for the samples collected. COC forms will accompany samples to the appropriate laboratory for analysis. Each laboratory will document and track the aspects of receipt and storage, analyses, and reporting related to their respective samples.

A database of information collected during the sediment monitoring will be maintained by each San Diego River WMA Responsible Copermittees or their subcontractor(s). The database will include field observations, data sheets, COC records, and analytical results. The original data sheets, statistical worksheets, and reports produced will be accumulated into project-specific files maintained in file cabinets following submittal of the draft report. Data from outside contractors will be kept exactly as received. Monitoring data and analytical results will be uploaded into California Environmental Data Exchange Network (CEDEN).

Persons responsible for maintaining records for this project will be specified by the project manager and will be tasked with overseeing the operations of the project, and maintaining the sample collection, sample transport, COC, field analysis forms, and laboratory data. They will also be responsible for arbitrating any issues relative to records retention and any decisions to discard records.

Copies of this QAPP will be distributed to all parties identified previously in Element 3. Updates to this QAPP will be distributed in like manner, and previous versions will be discarded from the project file. The Project Manager under the direction, supervision, and review of the QA Officer, will be responsible for distributing an updated version of the QAPP.

Copies of the final report, including laboratory results and field records, will be maintained for a minimum of five years after project completion.

GROUP B:
DATA GENERATION AND ACQUISITION

ELEMENT 10 SAMPLE PROCESS DESIGN

1.6.21 Station Selection

The selection of suitable station locations is critical to assessing benthic conditions. Justification for selecting locations for sediment sampling is provided in Section 2.1.1 of the Sediment Monitoring Plan. The Sediment Control Plan does not give guidance as to how many stations should be sampled in each waterbody. The number of sampling stations in the San Diego River Estuary can vary based on the spatial extent of the area likely to be impacted. If the Bight Program is utilized to fulfill the Sediment Quality Monitoring requirement of the Permit, then the number of stations within San Diego River Estuary will be dictated by the Bight Program. If a stressor identification study becomes necessary following the original SQO assessment of the Estuary, then the number of stations will be based upon the drivers of the impacted scores (e.g. algae, physical factors, or chemical factors) and statistical power (i.e., having enough samples to statistically support meaningful findings).

All station locations will be pre-plotted prior to sampling activities. Locations will be identified in the field using a Differential Global Positioning System (DGPS). The system uses U.S. Coast Guard differential correction data, and is accurate within 10 feet (ft). All final station locations will be recorded in the field using positions from the DGPS.

In the event that a pre-plotted sample location is found to be unsuitable for collecting sediment, because of factors such as inaccessibility, the salinity does not meet the SQO criteria, disturbance to wildlife, or safety considerations, the station may be abandoned and an alternate station may be selected. Reasons for abandonment should be recorded on field data sheets.

The San Diego River WMA Responsible Copermittees are responsible for sediment monitoring in the San Diego River Estuary. Although the number of stations selected may vary, three monitoring stations were selected in accordance with the Sediment Monitoring Plan. The selected stations are presented in Table 9.

Table 9. San Diego River Estuary Selected Monitoring Stations*

Site ID	Latitude	Longitude
8129	32.7568	-117.2353
8134	32.7574	-117.2380
8136	32.7579	-117.2274

*Specific station locations and number of stations selected are subject to change based on the spatial extent of the study area, study requirements, and safety and access considerations

Monitoring Season and Frequency

Sediment for SQO programs must be collected between June and September. Physical environments and benthic community composition and abundance within enclosed bays and estuaries are generally most stable during this time of year (Bay et al., 2014).

According to Section VII.D of the Sediment Control Plan, sediment monitoring associated with Phase I stormwater discharges and major discharges shall be conducted at least twice during the Permit cycle except at stations that have consistently been classified as Unimpacted or Likely Unimpacted using the MLOE approach described in Section 3.2 of the Sediment Monitoring Plan. At the Unimpacted or Likely Unimpacted stations, monitoring may be reduced to a frequency of once during the Permit cycle. The San Diego RWQCB may also limit receiving water monitoring to a subset of outfalls to focus where the risk to sediment quality is greatest. The participating agencies propose to conduct one round of sediment sampling each permit term. The second required round of sampling will be satisfied by conducting additional follow up sampling in the vicinity of potentially impacted sites identified in the first round. For the San Diego River Estuary, this requirement is met for the 2013-2018 MS4 Permit term based on sampling and assessments conducted through the participation in the Bight'13 monitoring program and the subsequent follow up sediment sampling carried out in 2014.

ELEMENT 11 SAMPLING METHODS

1.6.22 Sediment Sampling

Information regarding the sampling vessel and site acceptability are provided in Sections 2.1.4 and 2.1.5 of the Sediment Monitoring Plan. Benthic sediments will be collected as surface grabs using an appropriate sampler, such as a stainless steel Van Veen grab sampler. The size of the grab sampler to be used for sediment programs in Southern California should be 0.1 m^2 across the top of the sampler. An appropriate sampler for the collection of benthic sediments will have the following characteristics:

- Constructed of a material that does not introduce contaminants.
- Causes minimal surface sediment disturbance.
- Does not leak or mix during sample retrieval.
- Has a design that enables safe/easy sample verification that samples meet all applicable sampling criteria (e.g., collects sediments to at least 5 centimeters (cm) below the sediment surface, has access doors allowing visual inspection and removal of undisturbed surface sediment).

Sediment grabs will be collected for the following analyses: benthic infauna, chemistry, grain size, and toxicity. A sample will be considered acceptable if the surface of the grab is even, there is minimal surface disturbance, and there is a penetration depth of at least 7 cm. Rejected grabs will be discarded, and the station will be re-sampled. Acceptable sediment grabs to be utilized for chemistry, grain size, and toxicity analyses will have the overlying water carefully drained from the sediment surface prior to removing the sediment to be placed in the appropriate sample containers. Overlying water will not be drained from sediment samples collected for benthic infaunal analysis. Station location and grab event data will be recorded on pre-formatted field data sheets (hard copies or via computer). At a minimum, field data will include station identification, station location, date, time of sample collection, depth of water, depth of penetration of grab in sediment (e.g. 5 cm), sediment composition, sediment odor and color, and sample type (e.g. sediment chemistry). Photographs of each sediment sample may be taken as needed and stored.

The entire contents of one grab sample will be utilized for benthic community analyses with a minimum penetration depth of 7 cm. Samples collected for benthic infaunal analysis will be rinsed through a 1.0-millimeter (mm) mesh screen. The material retained on the screen will be transferred to a labeled glass or plastic sample container. A 7% magnesium sulfate ($MgSO_4$) seawater solution will be added to the sample container to 85-90% of its volume to relax the collected specimens. The sample container will be inverted several times to distribute the relaxant solution. After 30 minutes, add enough sodium borate buffered formaldehyde to top off the sample container and gently invert the container several times to ensure the sample is mixed. This will make a 10% formalin solution.

Sediment samples for chemistry and toxicity testing will be collected from the top 5 cm of a grab sample using a pre-cleaned stainless steel scoop. Sediment within 1 cm of the sides of the grab

will be avoided to prevent interaction of any contaminants and the steel sampling device. For chemistry and grain size analysis, equal portions of sediment will be aliquoted from a single grab and placed into the appropriate samples containers. The sediment aliquots will be representative of the entire 5 cm depth of the surface sediment. According to the Sediment Control Plan, the preferred method of collection for SWI toxicity tests is to collect intact cores directly from the sediment sampler by pressing polycarbonate core tubes (7.3-cm inner diameter [ID] and 16 cm in length) into the top 5 cm of sediment. However, homogenizing sediment for SWI testing is also acceptable according to the Sediment Control Plan. This method is more practical to implement in the field and is consistent with previous sediment quality objective methodology (e.g., Bight protocols and previous lagoon monitoring implemented by the Copermittees). A stainless steel scoop will be used to remove aliquots of the top 5 cm of surface sediment from two grab samples and evenly distributed into the appropriate toxicity sample container(s) until the necessary volume is reached.

All sampling equipment will be cleaned prior to sampling. Between sampling locations, grab sampling equipment will be scrubbed with a brush and rinsed with site water. Stainless steel scoops will be rinsed with seawater and rinsed with de-ionized water between stations. Clean gloves will be worn by sampling personnel at each new station.

ELEMENT 12 SAMPLE HANDLING CUSTODY

Sediment samples will be uniquely identified with sample labels in indelible ink or by equivalent method. All sample containers will be identified with the project title, appropriate identification number, date and time of sample collection, and preservation method. All samples will be kept on wet ice or equivalently chilled from the time of sample collection until delivery or transport to the analytical laboratory. All samples will be transferred to the appropriate laboratory and analyses initiated within the method specified holding time (Table). Sample volumes required for each analysis will be provided by the analytical laboratory conducting the analyses.

Table 10. List of Analytes with Container Type, Holding Time, and Preservation Method

Analyte	Recommended Container Type	Required Holding Time	Recommended Preservation
Field Measurements			
Salinity (conductivity & temperature if using a YSI sonde)	*In situ*		
Depth			
Sediment Chemistry			
Total Solids	Glass jar	7 days	Cool to ≤6 °C
Total Organic Carbon	Glass jar	28 days at ≤6 °C; 1 year at ≤- 20°C	Cool to ≤6 °C or freeze to ≤ -20°C
Grain Size	HDPE, Glass jar, or plastic bag	1 year	Wet ice to ≤6 °C in the field, then refrigerate at ≤6 °C
Trace Metals	Glass jar	1 year; samples must be analyzed within 14 days of collection or thawing	Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C
Organochlorine Pesticides	Glass jar	1 year; samples must be extracted within 14 days of collection or thawing and analyzed within 40 days of extraction	Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C
PCB Congeners	Glass jar	None	Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C
PAHs	Glass jar	1 year; samples must be extracted within 14 days of collection or thawing and analyzed within 40 days of extraction	Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C
Sediment Toxicity			
Toxicity Testing	10L Polyethylene bag or 1-L glass jar	1 month	Wet ice then 4°C for transport; 4°C for storage
Benthic Infauna			
Benthic Community Condition	1-L HDPE or 1-L Glass jar – sample volume will vary so may need multiple jars per sample	Formalin: 2-5 days 70% Ethanol: Indefinite-sample jars should be periodically checked for evaporation of ethanol	Initially samples are placed in 10% Buffered Formalin for 2-5 days; samples are then transferred to 70% ethanol

1.6.23 Chain-of-Custody Procedures

Samples will be considered to be in custody if they are (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a container and secured with an official seal such that the sample could not be reached without breaking the seal. The principal documents used to identify samples and to document possession will be COC records, field logbooks, and field tracking forms. COC procedures will be used for samples throughout the collection, transport, and analytical process.

Chain of custody procedures will be initiated during sample collection. A COC record will be provided with each sample or group of samples. Each person who will have custody of the samples will sign the form and ensure the samples will not be left unattended unless properly secured. Documentation of sample handling and custody includes the following:

- Sample identifier.
- Sample collection date and time.
- Any special notations on sample characteristics or analysis.
- Initials of the person collecting the sample.
- Date the sample was sent to the analytical laboratory.
- Shipping company and waybill information.

Completed COC forms will be placed in a water proof (ex. plastic) envelope and kept inside the cooler containing the samples. Once delivered to the analytical laboratory, the COC form will be signed by the person receiving the samples. The condition of the samples will be noted and recorded by the receiver. COC records will be included in the final reports prepared by the analytical laboratories and are considered an integral part of the report.

1.6.24 Sampling Transport, Shipping, and Storage Procedures

Sediment samples collected in the field for chemistry and toxicity analyses will initially be placed on ice and stored in the dark. Prior to shipping or transport, sample containers will be packed inside coolers with ice. COC forms will be filled out, and the original signed COC forms will be inserted in a sealable water proof (ex. plastic) bag and placed inside the coolers. The cooler lids will be securely taped shut and then samples will be delivered or shipped on ice, or otherwise chilled, to the appropriate analytical laboratory for analysis. Sediment designated for benthic infauna analysis will be screened on location by field personnel. The material and organisms retained on the screen will be put into appropriate 1-L containers, treated with magnesium sulfate relaxant, and preserved with formalin (or relaxed and preserved using equivalent methods). Once preserved, benthic infauna samples will be delivered with accompanying COC forms to the laboratory tasked with sorting macroinvertebrates into broad taxonomic groupings. Following sorting, taxonomic samples will be shipped/ delivered to specialized taxonomists who will identify benthic macroinvertebrates to the lowest possible taxon.

ELEMENT 13 ANALYTICAL METHODS

1.6.25 Field Analytical Methods

A YSI water quality data sonde (e.g. YSI 6600 Multiparameter Sonde) or similar device can be utilized to take salinity measurements at each station location. Salinity measurements should be taken approximately six inches above the SWI. At a minimum, it is recommended that salinity measurements should be taken at a spring high and low tide to get an estimate of the salinity range for a proposed station. If feasible, it is recommended that salinity should be monitored throughout an entire spring tidal cycle to ensure it meets the salinity criteria prior to sampling. Water depth should also be measured when visiting the station at a spring low tide or deploying a continuous monitoring device over a spring tidal cycle to ensure the station is subtidal. Operation of field equipment will be conducted as per manufacturer instructions. Calibrations will be performed and recorded to ensure accurate functionality.

1.6.26 Laboratory Analytical Methods

Chemistry Samples

A list of sediment chemical constituents and maxiumum reporting limits (RLs) for analytes that are required for SQO analysis are provided in Table 11. Additional physical parameters including grain size and TOC are also listed. While these physical parameters are not required to calculate the chemistry LOE, they should be analyzed in order to provide additional information to aid in the interpretation of the toxicity and benthic LOEs. Percent solids must be measured to convert concentrations of the chemical parameters from a wet-weight to a dry-weight basis.

Target RLs listed in Table 11 are those that are provided in the Sediment Quality Assessment Technical Support Manual (Bay et al., 2014) for SQO analyses. The maximum RLs provided in Table 11 are based on the CSI classification ranges and are expressed on a dry weight basis. Lower RLs may be achievable depending on available analytical methods. As stated in Element 6, the analytical methods listed in Table 8 are suggested methods that have been used in previous sediment monitoring programs within San Diego County's waterbodies (e.g. Bight), but are not the only acceptable methods. Chemical analyses of all sediment samples collected as part of the SQO assessment must be tested in accordance with USEPA or ASTM protocols. If appropriate protocols do not exist, the SWRCB or San Diego RWQCB may approve the use of other methods.

Table 11. Physical and Chemical Parameters, Suggested Methods, and Maximum Reporting Limits for SQO Analysis

Parameter	Method*	Procedure*	Maximum Reporting Limit (dry weight)
Physical/ Conventional			
Grain Size	Plumb 1981	Wet sieving	1.00 %
Percent Solids	SM 2540B	Gravimetric	0.10 %
Total Organic Carbon (TOC)	USEPA 9060A	Combustion/ oxidation	0.01 %

Table 11. Physical and Chemical Parameters, Suggested Methods, and Maximum Reporting Limits for SQO Analysis

Parameter	Method*	Procedure*	Maximum Reporting Limit (dry weight)
Chemistry			
Trace Metals			
Cadmium (Cd)	USEPA 6020A	ICP/MS	0.09 mg/kg
Copper (Cu)	USEPA 6020A	ICP/MS	52.8 mg/kg
Lead (Pb)	USEPA 6020A	ICP/MS	25.0 mg/kg
Mercury (Hg)	USEPA 7471B	CVAA	0.09 mg/kg
Zinc (Zn)	USEPA 6020A	ICP/MS	60.0 mg/kg
Organochlorine Pesticides			
2,4′-DDD	USEPA 8081B	GC/MS	0.50 µg/kg
2,4′-DDE	USEPA 8081B	GC/MS	0.50 µg/kg
2,4′-DDT	USEPA 8081B	GC/MS	0.50 µg/kg
4,4′-DDD	USEPA 8081B	GC/MS	0.50 µg/kg
4,4′-DDE	USEPA 8081B	GC/MS	0.50 µg/kg
4,4′-DDT	USEPA 8081B	GC/MS	0.50 µg/kg
Chlordane-alpha	USEPA 8081B	GC/MS	0.50 µg/kg
Chlordane-gamma	USEPA 8081B	GC/MS	0.54 µg/kg
Dieldrin	USEPA 8081B	GC/MS	2.5 µg/kg
trans-Nonachlor	USEPA 8081B	GC/MS	4.6 µg/kg
PCB Congeners			
2,4'-Dichlorobiphenyl (8)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',5-Trichlorobiphenyl (18)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,4,4'-Trichlorobiphenyl (28)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,5'-Tetrachlorobiphenyl (44)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',5,5'-Tetrachlorobiphenyl (52)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,3',4,4'-Tetrachlorobiphenyl (66)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',4,5,5'-Pentachlorobiphenyl (101)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,3,3',4,4'-Pentachlorobiphenyl (105)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,3',4,4',5-Pentachlorobiphenyl (118)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,3',4,4'-Hexachlorobiphenyl (128)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,4,4',5'-Hexachlorobiphenyl (138)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',4,4',5,5'-Hexachlorobiphenyl (153)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,3',4,4',5-Heptachlorobiphenyl (170)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,4,4',5,5'-Heptachlorobiphenyl (180)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,4',5,5',6-Heptachlorobiphenyl (187)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,3',4,4',5,6-Octachlorobiphenyl (195)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (206)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
Decachlorobiphenyl (209)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
Low Molecular Weight PAHs			
Acenaphthene	USEPA 8270D	GC/MS SIM	20 µg/kg
Anthracene	USEPA 8270D	GC/MS SIM	20 µg/kg
Phenanthrene	USEPA 8270D	GC/MS SIM	20 µg/kg

Table 11. Physical and Chemical Parameters, Suggested Methods, and Maximum Reporting Limits for SQO Analysis

Parameter	Method*	Procedure*	Maximum Reporting Limit (dry weight)
Biphenyl	USEPA 8270D	GC/MS SIM	20 µg/kg
Naphthalene	USEPA 8270D	GC/MS SIM	20 µg/kg
2,6-Dimethylnaphthalene	USEPA 8270D	GC/MS SIM	20 µg/kg
Fluorene	USEPA 8270D	GC/MS SIM	20 µg/kg
1-Methylnaphthalene	USEPA 8270D	GC/MS SIM	20 µg/kg
2-Methylnaphthalene	USEPA 8270D	GC/MS SIM	20 µg/kg
1-Methylphenanthrene	USEPA 8270D	GC/MS SIM	20 µg/kg
High Molecular Weight PAHs			
Benzo(a)anthracene	USEPA 8270D	GC/MS SIM	80 µg/kg
Benzo(a)pyrene	USEPA 8270D	GC/MS SIM	80 µg/kg
Benzo(e)pyrene	USEPA 8270D	GC/MS SIM	80 µg/kg
Chrysene	USEPA 8270D	GC/MS SIM	80 µg/kg
Dibenzo(a,h)anthracene	USEPA 8270D	GC/MS SIM	80 µg/kg
Fluoranthene	USEPA 8270D	GC/MS SIM	80 µg/kg
Perylene	USEPA 8270D	GC/MS SIM	80 µg/kg
Pyrene	USEPA 8270D	GC/MS SIM	80 µg/kg

DDD Dichlorodiphenyldichloroethane
DDE dichlorodiphenyldichloroethylene
DDT dichlorodiphenyltrichloroethane
mg/kg milligrams per kilogram
µg/kg micrograms per kilogram* Other equivalent methods or procedures may be used

Toxicity Samples

To evaluate the benthic condition of the San Diego River Estuary, sediment toxicity testing will be conducted in accordance with ASTM and USEPA methods. Toxicity testing involves a short-term survival test, a sublethal endpoint test, and an assessment of sediment toxicity. For each test type, more than one specific test is acceptable. The appropriate species tested for a sample will depend on the characteristics of the sample such as grain size, salinity, and suspected toxic constituents, if any. When historical data are available for a sample location, it is recommended that the same species be used in order to make comparisons and to conduct trend analysis. In addition, when testing is conducted as part of a regional monitoring program such as the Bight program, the species selection will be dictated by the program.

Short-Term Survival Testing

SQO analysis requires that at least one short-term survival test be conducted. There are three acceptable short-term survival tests, each of which is a 10-day test exposing amphipods to whole sediment. The three acceptable test organisms are *Eohaustorius estuarius*, *Leptocheirus plumulosus*, and *Rhepoxynius abronius*. The *E. estuarius* short-term survival test has been the 10-day test method used in previous San Diego County enclosed bay and estuary monitoring programs, including the Bight Program, where the SQO analytical tool was used to assess aquatic health. These amphipod bioassays will be conducted in accordance with procedures outlined in *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006) or equivalent methods that satisfy the requirements of the Sediment Control Plan. Test conditions

are summarized in Table 12. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans.

A water-only reference toxicity test should be conducted concurrently with the whole sediment amphipod test to assess the relative sensitivity of test organisms used in the evaluation of project sediments. Amphipod reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 12. Summary of Conditions for 10-Day Whole Sediment Amphipod Bioassay

Test Conditions 10-Day Whole Sediment Bioassay				
	Test Species	***E. estuarius***	***L. plumulosus***	***R. abronius***
	Test Procedures	USEPA (1994); ASTM E1367-03 (2006)		
	Test Type/Duration	Static - Acute Whole Sediment/10 days		
	Sample Storage Conditions	4 °C, dark, minimal head space		
	Age/Size Class	3-5 mm	2-4 mm; immature	3-5 mm
	Grain Size Tolerance	0.6-100% sand	0-100% sand	10-100% sand
Recommended Water Quality Parameters	Temperature	15 ± 1 °C	25 ± 1 °C	15 ± 1 °C
	Salinity	20 ± 2 ppt	20 ± 2 ppt	28 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation		
	Total Ammonia	< 60 mg/L	< 60 mg/L	< 30 mg/L
	Test Chamber	1 L glass		
	Exposure Volume	2 cm sediment, 800 mL seawater		
	Replicates/Sample	5		
	No. of Organisms/Replicate	20		
	Photoperiod	Continuous light		
	Feeding	None		
	Water Renewal	None		
	Aeration	Constant gentle aeration		
	Acceptability Criteria	Mean control survival ≥ 90%; ≥80% survival in each replicate		

mg/L milligram per liter

1.6.26.1

Sublethal Testing

The second type of testing required for SQO analysis is a sublethal test. Either a 48-hour development test exposing embryos of the bivalve *Mytilus galloprovincialis* to the sediment-water interface may be conducted or a 28-day survival and growth test exposing the polychaete worm *Neanthes arenaceodentata* to whole sediment. Test condition summaries for the bivalve and polychaete tests are presented in Table 13 and Table 14, respectively. The *M.*

galloprovincialis sediment-water interface test has been the sublethal test method used in previous San Diego County enclosed bay and estuary monitoring programs, including the Bight Program, where the SQO analytical tool was used to assess aquatic health.

1.6.26.1.1 *Mytilus galloprovincialis* Sediment-Water Interface Development Sublethal Test

Sediment-water interface bioassays are performed to estimate the potential toxicity of contaminants fluxing from test sediments into the overlying water. The sediments will be tested in a 48-hour sediment-water interface test using the bivalve *M. galloprovincialis* in accordance with procedures outlined in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and Assessment of Sediment Toxicity at the Sediment-Water Interface (Anderson et al., 1996). If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. Sediment-water interface bioassays will be tested on intact cores collected in the field or on homogenized sediment samples as described in Section 2.1.6 of the Sediment Monitoring Plan.

A water-only reference toxicity test should be conducted concurrently with the sediment-water interface bivalve test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 13. Test Conditions for the 48-Hour *M. galloprovincialis* Sediment-Water Interface Bioassay

Test Conditions 10-Day Whole Sediment Bioassay		
	Test Species	***M. galloprovincialis***
	Test Procedures	USEPA (1995), Anderson et al. (1996)
	Test Type/Duration	Static - Acute sediment-water interface/48 hours
	Sample Storage Conditions	4 °C, dark, minimal head space
	Age/Size Class	< 4 hour old larvae
Recommended Water Quality Parameters	Temperature	15 ± 1 °C
	Salinity	32 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation
	Total Ammonia	< 4 mg/L
	Test Chamber	Polycarbonate core tube 7.3-cm inner diameter, 16 cm high
	Exposure Volume	5 cm sediment, 300 mL water
	Replicates/Sample	4
	No. of Organisms/Replicate	Approximately 250 larvae
	Photoperiod	16 hours light: 8 hours dark

Test Conditions 10-Day Whole Sediment Bioassay	
Feeding	None
Water Renewal	None
Aeration	Constant gentle aeration
Acceptability Criteria	Mean control normal-alive ≥ 80%

1.6.26.1.2 *Neanthes arenaceodentata* Whole Sediment Survival and Growth Sublethal Test

The *N. arenaceodentata* test will be conducted in accordance with ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. A water-only reference toxicity test should be conducted concurrently with the whole sediment polychaete test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Polychaete reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 14. Test Conditions for the 28-Day Whole Sediment *N. arenaceodentata* Bioassay

Test Conditions 10-Day Whole Sediment Bioassay		
	Test Species	***N. arenaceodentata***
	Test Procedures	ASTM E1562 (2002), Farrar and Bridges (2011)
	Test Type/Duration	Static - Acute Whole Sediment/28 days
	Sample Storage Conditions	4 °C, dark, minimal head space
	Age/Size Class	≤ 7 days post-emergence
	Grain Size Tolerance	5-100% sand
Recommended Water Quality Parameters	Temperature	20 ± 1 °C
	Salinity	30 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation
	Total Ammonia	< 20 mg/L
	Test Chamber	300 mL glass
	Exposure Volume	2 cm sediment, 125 mL seawater
	Replicates/Sample	10
	No. of Organisms/Replicate	1
	Photoperiod	12 hours light: 12 hours dark
	Feeding	Twice per week
	Water Renewal	Weekly
	Aeration	Constant gentle aeration
	Acceptability Criteria	Mean control survival ≥ 80%; positive growth in controls

Benthic Infauna Samples

The benthic infaunal samples will be transported from the field to the laboratory and stored in a formalin solution for a minimum of 48 hours and no longer than 5 days. The samples will then be transferred from formalin to 70% ethanol for laboratory processing. Alternative specimen preservation methods may be used if equivalent. The organisms will initially be sorted using a dissecting microscope into five major phyletic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla. While sorting, technicians will keep a count for quality control purposes. After initial sorting, samples will be distributed to qualified taxonomists who will identify each organism to species or to the lowest possible taxon. Taxonomists will use the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing for nomenclature and orthography. If sediment monitoring is conducted as part of the Bight Program, then procedures should be in accordance with Bight Workplans.

ELEMENT 14 QUALITY CONTROL

1.6.27 QA/QC Field Procedures

Field measurements for salinity will be made using a water quality probe, such as a YSI data sonde, that has been calibrated according to manufacturer specifications. Operation of field equipment will be conducted as per manufacturer instructions. Calibrations will be performed and recorded to ensure accurate functionality. Proper storage and maintenance procedures will be followed.

QA/QC for sampling processes begins with proper collection of the samples to minimize the possibility of contamination. Sediment samples will be collected in appropriate containers, kept on wet ice or otherwise chilled during the sampling event, and placed into coolers along with completed COC for transfer to the analytical laboratory. Field crews will ensure that sampling containers are being filled properly and the requirement to avoid contamination of samples at all times is met. The field data log sheets will include empirical observations of the site and water quality characteristics. Field duplicates will be collected at a minimum of 5% of total project sample count. A minimum of one equipment blank will be collected during the monitoring event. The equipment blank will be analyzed for the same target SQO analytes specified for the sediment samples (excluding grain size and percent solid analyses).

1.6.28 QA/QC Laboratory Analyses

Chemistry Analyses

The chemistry analysis of the samples will be performed under the guidelines of the analytical laboratories respective standard operationg procedures (SOPs) and QAPPs as well as meet the DQOs and quality objectives set forth in this QAPP. This includes analyzing the appropriate QC laboratory controls for each analysis in accordance with SWAMP criteria such as laboratory blanks and duplicates, MS/MSDs, certified or standard reference materials, and surrogates (see Element 7 for frequency of analysis and DQOs for QC laboratory controls).

Toxicity Analyses

A water-only reference toxicity test will be conducted concurrently with each batch of sediment tests to establish the sensitivity of the test organisms used in the evaluation of the sediments and to evaluate the potential influence of ammonia toxicity on the test organisms. Typically, amphipod and polychaete reference toxicant tests are conducted using cadmium and bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. The LC_{50} and/or EC_{50} values of the reference toxicant test will be compared to historical laboratory data for each respective test species. The results of these reference toxicant tests will be used in combination with the control mortality to assess the health of the test organisms.

Benthic Infauna Analyses

A QA/QC procedure will be performed on each of the sorted samples to ensure a 95% sorting efficiency. This procedure is the same one followed in the Bight programs. A 10% aliquot of a sample will be re-sorted by a senior technician trained in the QA/QC procedure. The number of organisms found in the aliquot will be divided by 10% and added to the total number found in the sample. The original total will be divided by the new total to calculate the percent sorting efficiency. When the sorting efficiency of the sample is below 95%, the remainder of the sample (90%) will be re-sorted.

ELEMENT 15 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

1.6.29 Field Sampling

Prior to conducting field sampling, field technicians will be responsible for preparing sampling kits that include field logs, COC forms, sample labels, sampling containers, decontamination equipment and tools. Field measurement equipment should be checked for operation in accordance with the manufacturer's specifications. Equipment should be inspected prior to use and when returned from use for damage.

1.6.30 Analytical Laboratories

All analytical laboratories including chemistry, toxicity, and benthic infaunal will maintain their equipment in accordance with their SOPs, which include those specified by the manufacturer and those specified by the method. Each laboratory's QAPP will specify equipment and system evaluations.

ELEMENT 16 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

The equipment and instruments used at each analytical laboratory will be operated and calibrated according to manufacturer recommendations as well as by criteria defined in each analytical laboratory's SOPs. Operation and calibration will be performed by properly trained personnel. Documentation of routine and special calibration information will be recorded in appropriate logbooks and reference files. If a critical measurement is found to be out of compliance during analysis, the results of that analysis will not be reported, corrective action will be taken and documented, and the analysis will be repeated.

1.6.31 Field Equipment

Water quality instruments used for salinity measurements will be calibrated per manufacturer's specifications prior to each monitoring event. Complete records of calibration will be maintained for each field instrument that requires periodic calibration.

1.6.32 Analytical Laboratories

All analytical labortatories including chemistry, toxicity, and benthic infaunal will calibrate their instrumentation at a frequency that ensures the validity of the results. Each laboratory's calibration procedures must follow EPA guidelines and the recommendations of the instrument manufacturer. Each laboratory's QAPP should provide detailed information on calibration procedures.

ELEMENT 17 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

It is the duty of each person who is responsible for equipment ordering to inspect equipment and materials for quality and report any equipment or materials that do not meet acceptance criteria to the Project Manager, Laboratory Manager, and/or QA Officer, as appropriate. Upon receipt of materials or equipment, a designated employee must receive and sign for the materials. The items will then be reviewed to ensure the shipment is complete, prior to delivery to the proper storage location. Chemicals must be dated upon receipt. Supplies will be stored appropriately and discarded on their expiration date. The equipment and supplies purchased for use in field sampling activities will be inspected for damage as they are received. Confirmation that sample bottles are laboratory-certified clean will be made when received.

Critical Supplies and Consumables

Chemistry Sample Bottles – Chemistry sample bottles will be provided by the analytical laboratory. They will be shipped from the laboratory and stored appropriately by the field sampling team prior to use in the field. Confirmation that sample bottles are laboratory-certified clean will be made when received from the analytical laboratories. Preservatives may be required for the analysis of certain analyte groups and the laboratory supplied bottles should already contain any required preservatives.

Toxicity Sample Containers – Clean, food-grade, heavy duty 0.004 gauge polyethylene bags capable of holding up to 20-L, or clean glass jars with Teflon-lined lids should be used as the sample container for sediment toxicity samples. If bags are used, samples should be double bagged, twisted at the top with excess air removed, and cable tied to ensure sample integrity.

Benthic Infauna Jars– Clean, 1-L HDPE or glass sample jars should be used as containers for benthic infauna samples following sediment processing in the field. Additionally, magnesium sulfate and 10% formalin solutions that are used for processing benthic infauna samples will need to be on hand during sampling events and should be provided by San Diego River WMA Responsible Copermittees or their subcontractor(s).

ELEMENT 18 NON-DIRECT MEASUREMENTS

Data will be reviewed against DQOs in Section 7 prior to SQO analysis. Only data meeting the DQOs will be used in the SQO analysis.

ELEMENT 19 DATA MANAGEMENT

Data will be maintained as described in Element 9. The original data sheets and reports produced will be accumulated into project-specific files that are kept by either the San Diego River WMA Responsible Copermittees or Contractor Project Manager.

The San Diego River WMA Responsible Copermittees or Contractor Project Manager will document and track the aspects of the sample collection process, including generating field logs at each site and COC forms for the samples collected. COC forms will accompany samples to the appropriate laboratories for analysis. Each analytical laboratory will document and track the aspects of sample receipt and storage, analyses, and reporting. Each analytical laboratory's results will be stored in a database system at their office and will be provided to the San Diego River WMA Responsible Copermittees or Contractor Project Manager both electronically and by hard copy. Further details of each laboratory's data management protocols can be found in each laboratory's respective QAPP.

Field logs and analytical data will be entered into or transferred to the San Diego River WMA Responsible Copermittees or Contractor's database. After the data is added to the database, the Contractor Project QA Officer will validate the data by checking for errors and ensure the data is complete. The database will be updated with finalized data. The results of the laboratory QC analyses will be reported with the final data. Any QC samples that fail to meet the specified QC criteria in the methodology or the DQOs described in Element 7 will be identified, and the corresponding data will be appropriately qualified in the final report. All QA/QC records will be kept on file for review by regulatory agency personnel. Once data are finalized, all monitoring data and analytical results will be formatted and uploaded into CEDEN. All records should be maintained for at least five years.

GROUP C:
ASSESSMENT AND OVERSIGHT

ELEMENT 20 ASSESSMENTS AND RESPONSE ACTIONS

1.6.33 Corrective Actions

The following sections identify the responsibilities of key project members and corrective actions to be taken if issues arise during field sampling or laboratory analyses that may result in noncompliance with protocols established in the Sediment Monitoring Plan.

1.6.34 Field Sampling

The initial responsibility for monitoring the quality of field measurements lies with the field personnel. The Field Task Manager is responsible for verifying that QC procedures are followed. This requires that the Field Task Manager assess the accuracy of the field methods as well as the ability to meet QA objectives and make a value judgment regarding the impact a procedure has on field objectives and subsequent data quality. If a problem occurs that might jeopardize the integrity of the project, hinder a QA objective, or impact data quality, the Field Task Manager will immediately (within 24 hours) notify the San Diego River WMA Responsible Copermittees or Contractor Project Manager. Corrective action measures are then decided upon and implemented. The Field Task Manager documents the situation, the field objective affected, the corrective action taken, and the results of that action. Copies of the documentation are provided to the San Diego River WMA Responsible Copermittees or Contractor Project Manager and the QA Officer.

1.6.35 Laboratory

The need for corrective action comes from several sources, including equipment malfunction, failure of internal QA/QC checks or to follow-up on performance or system audit findings, and noncompliance with QA requirements. All laboratory personnel are responsible for documenting and correcting problems that might affect quality. When measurement equipment or analytical methods fail QA/QC requirements, the problem(s) will be brought immediately to the attention of the Laboratory Manager and QA Officer. Corrective measures will depend entirely on the type of analysis, the extent of the error, and whether or not the error is determinant. The corrective action is determined by either the Laboratory Manager, technicians, the San Diego River WMA Responsible Copermittees or Contractor Project Manager, the QA Officer, or by all of them in conference, if necessary, but final approval is the responsibility of the San Diego River WMA Responsible Copermittees or Contractor QA Officer and/or Project Manager.

If failure is due to equipment malfunction, the equipment will not be used until repaired. Precision and accuracy will be reassessed, and the analysis will be rerun. Attempts will be made to reanalyze the affected parts of the analysis so that in the end, the product is not affected by failure of QC requirements. When a result in a performance audit is unacceptable, the laboratory will identify the problem(s) and implement corrective actions immediately. A step-by-step analysis and investigation to determine the cause of the problem will take place as part of the

corrective action program. If the problem cannot be controlled, the laboratory will analyze the impact on data. If the data is affected, the problem will be documented and the San Diego River WMA Responsible Copermittees or Contractor QA Officer and/or Project Manager will be notified. When a system audit reveals an unacceptable performance, work will be suspended until corrective action has been implemented and performance has been proven acceptable. If the problem is instrumental or specific only to preparation of a sample batch, samples are reprocessed after the instrument is repaired and recalibrated. In the event that a QC measure is out-of-control and the data are to be reported, qualifiers are reported together with sample results.

ELEMENT 21 PROJECT REPORTS

The Project Manager is responsible for preparation and submittal of all project deliverables. Each analytical laboratory's QA Officer is responsible for the preparation of all data packages and laboratory reports originating from their laboratory. Provision D.1.e.(2)(c) of the Permit requires incorporation of a Sediment Monitoring Report into the WQIP Annual Report. The Sediment Monitoring Report will contain an evaluation, interpretation, and tabulation of monitoring data, including an assessment of whether receiving water limits outlined in the Permit were attained; a sample location map; and a statement of certification that monitoring data and results have been uploaded into CEDEN.

Based on the conclusions of the Sediment Monitoring Report, a human health risk assessment may be necessary in order to determine whether human health objectives have been obtained at each sample location. Provision A.2.a.(3)(b)(ii) states that "pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health." The potential risk assessments must consider any relevant information, such as guidelines set forth in the CA EPA's Office of Environmental Health Hazard Assessment (OEHHA) fish consumption policies, CA EPA's Department of Toxic Substances Control (DTSC) risk assessment, and the USEPA human health risk assessment policies.

The San Diego River WMA Responsible Copermittees included the 2012-2014 Sediment Monitoring Report with the Transitional Monitoring and Assessment Report submitted to the San Diego RWQCB on January 31, 2015. The Sediment Monitoring Report includes the results from the 2013 Bight Program and follow-up monitoring conducted in the San Diego River Estuary in 2014 to satisfy Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit. Any sediment quality monitoring or stressor identification studies conducted after 2014 will be included in the WQIP Annual Reports.

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the Sediment Monitoring Report(s) is shown in Table 15.

Table 15. Sediment Monitoring Report Schedule

Activity/Deliverable	Dates(s)*
San Diego RWQCB Order No. R9-2013-0001	Adopted May 8, 2013 and effective June 27, 2013
Southern California Bight Regional Monitoring Program	August-September 2013
Follow-up confirmation monitoring	August-September 2014
Final Sediment Monitoring Plan and Sediment Monitoring QAPP incorporated into WQIPs	December 2014
Draft Sediment Monitoring Report	December 2014
Final Sediment Monitoring Report incorporated into Transitional Monitoring and Assessment Report	January 31, 2015
Potential Stressor ID Studies	TBD

*Table does not include future permit cycles

GROUP D:
DATA VALIDATION AND USABILITY

ELEMENT 22 DATA REVIEW, VERIFICATION, AND VALIDATION

Data reduction, verification, validation, and reporting are ongoing processes, which involve the field technicians, laboratory technicians, Laboratory Managers, and QA personnel. Data generated by the sediment monitoring activities including field sampling and laboratory analyses will be reviewed against the DQOs presented in Element 7 and the QA/QC practices cited in this QAPP. This includes field logbooks, COC forms, and all data related to laboratory analytical procedures (e.g., sample preparation logs, instrument logs, etc.). Data entry of field sampling data will be reviewed to check for accuracy and completeness. Analytical laboratory electronic data deliverables and hard copy reports will be reviewed to ensure that the proper QC elements are included (e.g., blanks, lab duplicates, etc.), all sample analyses are correct, holding times were met, and data failing to meet QC criteria are properly qualified. Data that does not meet the DQOs will be evaluated to determine the impact of the failure on the data quality. If sufficient evidence is found to support the use of the data, the data will be qualified, and entered into the database.

ELEMENT 23 VERIFICATION AND VALIDATION METHODS

After each sampling event, the field data sheets will be removed from the field logbooks, and the sheets will be checked for completeness and accuracy by the QA Officer or Project Manager. The appropriate field sheets must be present. If there are any questions, clarification from the Field Task Manager will be obtained as soon as possible.

In the laboratory, sample preparation activities will be documented in bound laboratory notebooks or on bench sheets. Data validation includes dated and signed entries by technicians on the data sheets and logbooks used for the samples, the use of sample tracking and numbering systems to track the progress of samples through the laboratory, and the use of QC criteria to reject or accept specific data. The laboratory generating the data will have the prime responsibility for the accuracy and completeness of the data. Each laboratory will review the data to ensure that the following information is correct and complete: sample description information, analysis information, results, and documentation of the data. Further data validation is performed by the Laboratory Manager. Validation is accomplished through routine audits of the data collection and flow procedures and by monitoring of QC sample results. In the data review process, the data will be compared to information such as the sample's history, sample preparation, and QC sample data to evaluate the validity of the results. Corrective action will be minimized through the development and implementation of routine internal system controls. Analysts are provided with specific criteria that must be met for each procedure, operation, or measurement system.

ELEMENT 24 RECONCILIATION WITH USER REQUIREMENTS

The QA personnel will review data after each survey to determine if DQOs have been met. If data do not meet project specifications, the QA personnel will review errors and determine if the problem is due to calibration/maintenance, sampling techniques, or other factors, and they will suggest corrective action. It is expected that the problem would be correctible through personnel re-training, technique revision, or supplies/equipment replacement. If not, the DQOs will be reviewed for feasibility. If specific DQOs are not achievable, the QA personnel will recommend appropriate modifications. Any revisions would need approval by the San Diego River WMA Responsible Copermittees or Contractor Project Manager.

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WESTON (Weston Solutions, Inc.). 2013. *San Diego County Municipal Copermittees Bight 2013 Workplan*. Prepared for the County of San Diego Municipal Copermittees. July 25, 2013.

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ATTACHMENT 4A-3: SAN DIEGO RIVER WATERSHED BACTERIA TMDL MONITORING PLAN

SAN DIEGO RIVER WATERSHED

BACTERIA TMDL MONITORING PLAN

Prepared For:
San Diego River Watershed
Participating Agencies

Prepared By:
AMEC Environment and Infrastructure, Inc.
9177 Sky Park Court
San Diego, California 92123
January 2015

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ACRONYMS AND ABBREVIATIONS

Abbreviation/ Acronym	Meaning
303(d) List	Clean Water Act (CWA) Section 303(d) List of Water Quality Limited Segments
AMEC	AMEC Environment & Infrastructure, Inc.
Bacteria TMDL	*A Resolution Amending the Water Quality Control Plan for the San Diego Basin (9) to Incorporate Revised Total Maximum Daily Loads for Indicator Bacteria Project I-Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek)*
Basin Plan	San Diego Region Basin Plan
BPA	Basin Plan Amendment
CEDEN	California Environmental Data Exchange Network
CFU	Colony Forming Units
CLRP	Comprehensive Load Reduction Plan
COC	Chain of Custody
CWA	Clean Water Act
DEH	Department of Environmental Health
EDD	Electronic Data Deliverable
FIB	Fecal Indicator Bacteria
HA	Hydrologic Area
HSA	Hydrologic Sub-Area
LA	Load Allocation
LARWQCB	Los Angeles Regional Water Quality Control Board
mL	Milliliter
mm	millimeter
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer System
NA	Not Applicable
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
*.pdf	Portable Document Format
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
REC-1	Water Contact Recreation
SDRWQCB	San Diego Regional Water Quality Control Board
State Board	State Water Resources Control Board
SWAMP	Surface Water Ambient Monitoring Program
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
WLA	Waste Load Allocation

PROJECT DESCRIPTION

1.1 INTRODUCTION

The San Diego Regional Water Quality Control Board (SDRWQCB) issued Resolution No. R9-2010-0001, A Resolution Amending the Water Quality Control Plan for the San Diego Basin (9) to Incorporate Revised Total Maximum Daily Loads (TMDL) for Indicator Bacteria Project I-Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek), herein referred to as the Bacteria TMDL (SDRWQCB, 2011a). Subsequently, the Bacteria TMDL has been incorporated into to the National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds Within the San Diego Region Order No. R9-2013-0001 (SDRWQCB, 2013) (MS4 Permit). In the MS4 Permit, Bacteria TMDL is included as "Attachment E: Specific Provisions for Total Maximum Daily Loads 6. Revised Total Maximum Daily Loads for Indicator Bacteria, Project I –Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek)" Provision 6 of MS4 Permit Attachment E outlines an Implementation Plan that includes a compliance schedule and a description of minimum monitoring requirements to assess compliance with the TMDLs, WLAs, and Load Allocations (LAs). The Phase I MS4s (hereafter called the Responsible Parties) have developed this Monitoring Plan for the San Diego River Watershed to meet the requirements of the MS4 Permit.

The ultimate goal of the Bacteria TMDL is to achieve the necessary pollutant load reductions to restore and protect the designated beneficial use of water contact recreation (REC-1). Beneficial uses within the San Diego River Watershed, as designated by the State Water Resources Control Board's (State Board) San Diego Region Basin Plan (Basin Plan) for surface waters, are provided in Table 1-1 (SDRWQCB, 2011c).

Table 1-1. Beneficial Uses for the 303(d) Listed Waterbodies

Hydrologic Unit	Waterbody Type	Beneficial Use																
		IND	NAV	REC1	REC2	COMM	BIOL	EST	WILD	RARE	MAR	AQUA	MIGR	SPWN	WARM	SHELL	MUN	AGR
Coastal Waters																		
Mouth of San Diego River	Pacific Ocean Shoreline			•	•	•		•	•	•	•		•	•		•		
Inland Surface Waters																		
Lower San Diego River (lower 6 miles)	River	•		•	•		•		•	•					•		+	•
Forester Creek (lower 1 mile)	River	•		•	•				•						•		o	

Notes:
Source: SDRWQCB, 2011c
- • Existing Beneficial Use
- O Potential Beneficial Use
- + Exempted from Use

1.2 PURPOSE

This Monitoring Plan is designed to fulfill the compliance monitoring requirements of the MS4 Permit. The San Diego River Bacteria TMDL Monitoring Program will collect data to evaluate the approved TMDL pollutants. A list of the applicable pollutants for the San Diego River Watershed is provided in Table 1-2. The goals of the San Diego River Bacteria TMDL Monitoring Program include the following:

- Characterize the current conditions of receiving waters in terms of approved TMDL pollutants
- Assess progress toward meeting the Bacteria TMDL numeric targets

1.3 WATERSHED BACKGROUND

The San Diego River Watershed is located in central San Diego County, California. It is the fourth largest of the nine major watersheds in San Diego County, extending over 52 miles inland and covering approximately 277,543 acres. The watershed is primarily undeveloped (44%), followed by open space/parks and recreation, residential, and transportation uses (23%, 19%, and 6%, respectively) (SanGIS, 2009). The lower San Diego Hydrologic Area (HA) (907.1), which is the HA addressed by the San Diego River Comprehensive Load Reduction Plan (CLRP), is the westernmost portion of the San Diego River Watershed. It drains approximately 173 square miles and supports the following main land uses: residential (30%), open space/parks and recreation (25%), and undeveloped land (18%).

The Bacteria TMDL is based on the 2002 303(d) List, which indicated that the greatest cause of waterbody impairments in the San Diego Region was elevated bacteria levels (United States Environmental Protection Agency [USEPA], 2003). Table 1-2 presents the targeted segments identified in the Bacteria TMDL. These segments include the lower one mile of Forester Creek, the lower six miles of the Lower San Diego River, and the Pacific Ocean Shoreline at Dog Beach.

Table 1-2. Waterbodies and Pollutants Listed in the Bacteria TMDL for SDR WMA

Waterbody	TMDL Pollutants
Pacific Ocean Shoreline, Dog Beach at San Diego River Mouth (HSA 907.11)	Total coliform, Fecal coliform, *Enterococcus*
Lower San Diego River[(a)] (HSA 907.11)	Fecal coliform, *Enterococcus*
Forester Creek[(b)] (HSA 907.12)	Fecal coliform, *Enterococcus*

Notes:
[(a)] Lower Six Miles
[(b)] Lower One Mile Only

1.4 RESPONSIBLE PARTIES

Attachment E of the MS4 Permit identifies the Responsible Parties for the San Diego River Watershed. The Responsible Parties are working on implementation of the monitoring programs for their watershed. The Responsible Parties, excluding owners and operators of small MS4s, are:

- County of San Diego
- City of El Cajon
- City of Santee
- City of San Diego
- City of La Mesa

1.5 BACTERIA TMDL RECEIVING WATER LIMITATIONS

The receiving water limitations (RWLs) are a combination of numeric targets for bacteria density and allowable exceedance frequencies. The MS4 Permit clarifies the final RWLs (in most probable number [MPN]) for total coliform, fecal coliform, and *Enterococcus* as numeric targets. For dry weather days, the 30-day geometric mean RWLs must be achieved with a 0 percent exceedance frequency. The single-sample maximum RWLs are required to be achieved during wet weather, with an allowable exceedance frequency of 22 percent.

Table 1-3 provides the final numeric and exceedance targets for the San Diego River Watershed per the Bacteria TMDL. Monitoring data collected under the San Diego River Watershed Bacteria TMDL Monitoring Program will be used to evaluate progress and attainment of TMDL numeric targets.

Table 1-3. Final Numeric Targets in Bacteria TMDL

Parameter	Dry Weather[a]		Wet Weather[b]	
	Numeric Target (MPN/100mL)[c]	Allowable Exceedance[c]	Numeric Target (MPN/100mL)[d]	Allowable Exceedance[e]
Enterococcus	33[g]/35[f]	0%	61[g]/104[f]	22%
Fecal Coliform	200	0%	400	22%
Total Coliform[f]	1,000	0%	10,000	22%

Notes:
mL – milliliter
Source: SDRWQCB, 2011a

(a) Dry weather days defined as days with less than 0.1 inch of rainfall observed in the previous 72 hours

(b) Wet weather days defined as days with rainfall events of 0.1 inches or greater and the following 72 hours.

(c) Dry weather numeric objectives based on the 30-day geometric mean water quality objectives in the California Ocean Plan (SWQCB, 2009) as well as the Basin Plan (SDRWQCB, 2011c) and the MS4 Permit (SDRWQCB, 2013). Compliance with the dry weather TMDLs in the receiving water is based on the frequency that the dry weather days in any given year exceed the dry weather numeric objective. The TMDL set a zero percent (0%) allowable exceedance frequency of the Final REC-1 Dry Weather Numeric Targets.

(d) Wet weather numeric objectives based on the single sample maximum water quality objectives in the California Ocean Plan (SWQCB, 2009) as well as the Basin Plan (SDRWQCB, 2011c) and the MS4 Permit (SDRWQCB, 2013). Compliance with the wet weather TMDLs in the receiving water is based on the frequency that the wet weather days in any given year exceed the wet weather numeric objective, but 30-day geometric mean must also be met.

(e) The wet weather allowable exceedance frequency is set at 22%. In the calculation of the wet weather TMDLs, the San Diego Regional Board chose to apply the 22% allowable exceedance frequency as determined for Leo Carillo Beach in Los Angeles County (LARWQCB, 2010a,b). At the time the wet weather watershed model was developed, the 22% exceedance frequency from Los Angeles County was the only reference beach exceedance frequency available.

(f) Marine beach Numeric Target. Applies only to Pacific Shoreline site, FM-010.

(g) Freshwater Designated Beach Numeric Target. Applies to sites SDR-MLS, SDR-CDE, SDR-FC1, SDR-FC2.

1.6 EXISTING, INTERIM, AND FINAL EXCEEDANCES FREQUENCIES

Interim and final RWLs used to determine progress toward achieving compliance milestones are presented in Table 1-4. These numbers were calculated using the “existing” exceedance frequencies which were derived from dry weather FIB data collected at the historical AB411 monitoring site (FM-010) between 2004 and 2010. The interim reduction is a 50 percent reduction of an existing exceedance frequency; a final exceedance frequency is the final numeric goal for a given FIB species.

Table 1-4. San Diego River Watershed TMDL Compliance Reduction Milestones

Classification	Segment	Analyte	"Existing" Exceedance Frequency	Interim Milestone 50% Reduction	Final 100% Reduction
Dry Weather	San Diego River Watershed	Enterococcus[a]	3.0%[a]	1.5%[a]	0%
		Fecal coliform[a]	0%[a]	0%[a]	0%
		Total coliform[a,d]	0.56%[a]	0.28%[a]	0%
Wet Weather	Pacific Ocean Shoreline	Enterococcus	76%[b]	51%[c]	22%
		Fecal coliform	70%[b]	43%[c]	22%
		Total coliform	63%[b]	46%[c]	22%
	San Diego River	Enterococcus	79%[b]	49%[c]	22%
		Fecal coliform	70%[b]	43%[c]	22%
		Total coliform[d]	63%[b]	46%[c]	22%
	Forrester Creek	Enterococcus	79%[b]	49%[c]	22%
		Fecal coliform	70%[b]	43%[c]	22%
		Total coliform[d]	63%[b]	46%[c]	22%

Notes:

a. Interim exceedance frequencies were provided by the County of San Diego and were calculated on a watershed-wide basis from the DEH AB411 data collected at site FM-010 (Dog Beach) between 2004 and 2010.

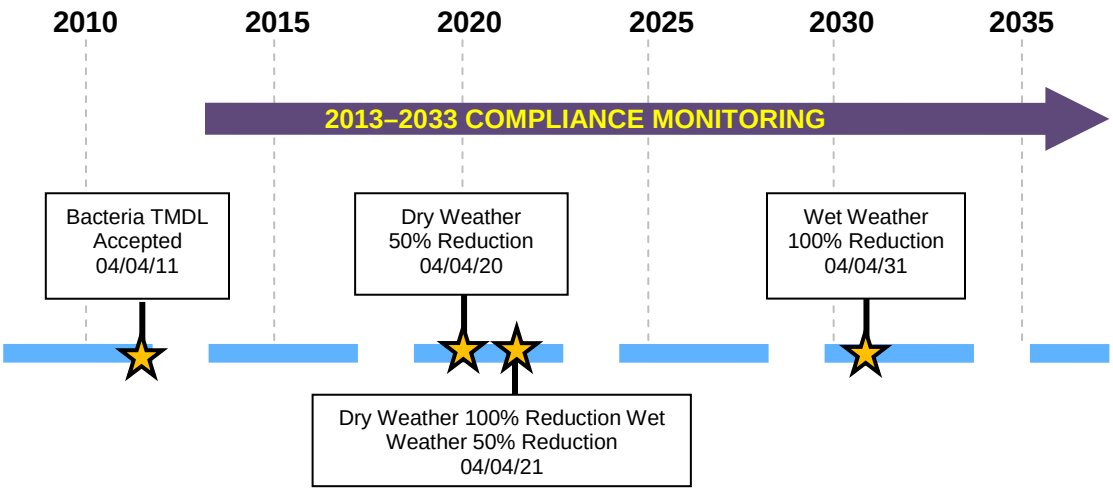
b. Per the Bacteria TMDL (page A-56). See Appendix H

c. Per the MS4 Permit (Attachment E Table 6.5). See Appendix H.

d. Not applicable for creeks per the MS4 Permit

1.7 IMPLEMENTATION SCHEDULE

The effective date of the Bacteria TMDL is April 4, 2011 (SDRWQCB, 2011a). The TMDL provides a compliance timeline outlining the interim reduction milestones over the 20-year compliance period. Figure 1-1 provides an overall timeline for the San Diego River Bacteria TMDL Monitoring Program. Compliance Monitoring is scheduled to begin 50 days after the adoption of the MS4 Permit (June 27, 2013).



Legend:
CLRP – Comprehensive Load Reduction Plan

Figure 1-1. San Diego River Monitoring Program Timeline

MONITORING APPROACH

This section describes the purpose, scope, and types of sampling conducted. Additional details of the sampling and analytical methodology and data quality objectives are described in the Quality Assurance Project Plan (QAPP) (County of San Diego, 2015).

1.8 MONITORING

Monitoring is designed to meet the receiving water monitoring requirements of the recently adopted MS4 Permit (SDRWQCB, 2013). The monitoring, including wet and dry weather sampling, will be conducted at locations listed in Table 2-1. The data generated will be used to address the following questions:

- Are bacteria levels improving at the compliance monitoring locations?
- Are TMDL numeric targets for bacteria indicators being met at the compliance monitoring locations?

Table 2-1. Scope of the Monitoring Program

Months	Number of Monitoring Locations	Event Type	Grab Samples Per Site Per Event	Event Frequency
Apr. 1 to Oct. 31	5	Dry	1	Weekly (5 events per month)
Nov. 1 to Mar. 31	5	Dry	1	At least Monthly
Oct. 1 to Apr. 30	5	Wet	1	At least once within the first 24 hours of the end of the storm event during the rainy season (Oct. 1 through Apr. 30).

Notes:
[(a)] Not including QA Samples

1.8.1 Monitoring Locations

According to Provision 6.d.(1)(a) of Attachment E of the MS4 Permit, for beaches addressed by the TMDL, monitoring locations should consist of, at a minimum, the same locations used to collect data required pursuant to Order Nos. R9-2007-0001 and R9-2009-0002, and beach monitoring for Health and Safety Code section 115880.3. Therefore, the location historically sampled under the AB411 beach monitoring program (SDRWQCB, 2011a), FM-010, has been selected for the current monitoring program. Data collected at FM-010 between years 2004 and 2010 have been used in the calculation of the “existing” exceedance frequencies from which the interim and final exceedance frequencies for the Bacteria TMDL have been derived. Even if the AB 411 location is changed by the State Water Resources Control Board, Participating Agencies request that compliance with the Bacteria TMDL be assessed at the current AB411 location (FM-010), as these are the data used to develop the 303(d) listing and to develop the baseline of exceedance frequency.

According to Provision 6.d.(2)(a) of Attachment E of the MS4 Permit, for creeks addressed by the TMDL, monitoring locations should consist of, at a minimum, a location at or near the mouth of the creek and one or more locations upstream of the mouth. Therefore, two sites have been selected for monitoring in this manner along the lower 6 miles of the San Diego River, and two along the lower one mile of Forester Creek. Table 2-2 provides the location names and coordinates. Figure 2-1 presents a map of the locations within the San Diego River Watershed.

Table 2-2. Monitoring Locations

Site ID	Site Name	Site Type	Site Descirption	Latitude	Longitude
FM-010	Dog Beach at San Diego River Mouth	Pacific Ocean Shoreline	Historical AB411 Location[(a)]	32.75631	-117.25318
SDR-MLS	San Diego River MLS at Lower San Diego River	River	San Diego River Mass Loading Station	32.76515	-117.16863
SDR-CDE	Lower San Diego River at Camino Del Este	River	San Diego River at Camino Del Este	32.77255	-117.14456
SDR-FC1	Lower Forester Creek	River	Forrester Creek at the mouth	32.83986	-117.00395
SDR-FC2	Forester Creek at Prospect Avenue	River	Forrester Creek upstream site	32.83130	-116.98572

[(a)] Historical AB411 location is approximately 25 meters downcoast of river outlet

Figure 2-1. Monitoring Locations

1.8.2 Constituents

Fecal indicator bacteria (FIB) are the target constituents as indicated by the TMDL. For beach samples, grab samples will be collected in a manner consistent with the AB411 program. Samples collected at freshwater sites will be analyzed for fecal coliform and *Enterococcus*; beach water samples will be analyzed for fecal coliform, *Enterococcus* and total Coliform. All samples will be analyzed for FIB in accordance with Surface Water Ambient Monitoring Program (SWAMP) requirements provided in the QAPP (County of San Diego, 2015). Table 2-3 presents the constituents and reporting limits.

Table 2-3. Water Sample Analyses for Bacteria TMDL Monitoring

Parameter	Project Reporting Limit[(a)]
Enterococcus	1 CFU/100mL
Fecal Coliform	2 CFU/100mL
Total Coliform[(b)]	2 CFU/100mL

Notes

CFU – Colony Forming Units

(a) The target reporting limits are consistent with methodology of the Assembly Bill 411 program to facilitate overlap with that program. However, reporting limits may increase depending on dilution in countable range.

(b) Applies to beach samples only.

1.8.3 Dry Weather Monitoring

Dry weather monitoring will be conducted from April through October as described in Table 2-1. Samples will be collected at the monitoring locations listed in Table 2-2 on dry weather days, after an antecedent dry period of 72 hours with less than 0.1 inches of rainfall. During each dry weather monitoring event, field observations will be recorded and a grab water sample will be collected at each location. The methodology for field observations and sample collection/transport is described in the QAPP (County of San Diego, 2015).

1.8.4 Wet Weather Monitoring

Wet weather monitoring will be conducted at the locations listed in Table 2-2 during at least one storm event during the wet season, (October 1, to April 30). Storms resulting in greater than 0.1 inches of precipitation will be targeted for sampling. During each wet weather monitoring event, a grab water sample will be collected within 24 hours of the end of precipitation using the same sample collection technique as during a dry weather monitoring event, taking additional safety precautions as needed. Field observations are not required but will be recorded, if feasible. The methodology for field observations and sample collection/transport is described in the QAPP (County of San Diego, 2015).

1.8.5 Storm Selection Criteria

The following criteria will be used to determine if mobilization will occur for an impending storm event:

- Storms must be forecast to produce at least 0.10 inch (2.54 millimeters [mm]) of rain.
- Storm events must be preceded by at least 72 hours of dry conditions (<0.10 inch of precipitation).

DATA MANAGEMENT AND REPORTING PROCEDURES

This section describes the management of field and analytical data and reporting procedures for the San Diego River Bacteria TMDL Monitoring Program.

1.9 DATA MANAGEMENT

Field Data Records and Analytical Data Reports will be sent to and kept by the Project Manager. Data will be submitted in a standardized California Environmental Data Exchange Network (CEDEN)-compatible format to the County of San Diego.

Specific data review, storage and maintenance procedures for field and laboratory data are described in the QAPP (County of San Diego, 2015).

Follow-up monitoring may be conducted based on indicator bacteria results obtained at the compliance monitoring locations. Detailed follow-up investigations are not required until the first interim milestone is reached; however, Copermittees may choose to voluntarily conduct follow-ups to identify and abate sources, where there is a preponderance of evidence to support the action.

1.10 ASSESSMENT AND REPORTING PROCEDURES

Compliance Monitoring Reports will be prepared annually to be included in the Transitional Monitoring and Assessment Program Reports or WQIP Annual Reports as appropriate. The annual reports will summarize the collected data and provide the results of analysis and assessments of dry and wet weather data collected herein as described in Provisions 6.d.(1)(c) and 6.d.(2)(c) of Attachment E to the MS4 Permit. This will include assessments of whether the interim and final WQBELs for the Pacific Ocean Shoreline at San Diego River mouth at Dog Beach, Forrester Creek (lower 1 mile) and San Diego River (lower 6 miles) as listed in Table 6.0 in Attachment E of the MS4 Permit have been achieved. The following assessments will be conducted and results presented in the reports:

1. Exceedance frequencies for dry weather data:

   Thirty-day geometric means for dry weather samples will be calculated and used to determine dry weather exceedance frequencies by dividing the number of geometric means that exceed receiving water limitations by the total number of geometric means for the dry season.

2. Exceedance frequencies for wet weather data:

   Single sample maximum exceedance frequencies will be calculated for wet weather data by dividing the number of wet weather days that exceed the single sample maximum receiving water limitations by the total number of wet weather days during the rainy season.

Dry weather data will be used in addition to wet weather data to calculate the wet weather 30-day geometric means. The exceedance frequency of the wet weather 30-day geometric means will be calculated by dividing the number of geometric means that exceed the geometric mean receiving water limitations by the total number of geometric means calculated from samples collected during the wet season.

In calculating exceedance frequencies for wet weather data, the following assumptions will be made:

a) If only one sample is collected for a storm event, the bacteria density for every wet weather day associated with that storm event will be assumed to equal the results from the one sample collected;

b) If more than one sample is collected for a storm event, but not on a daily basis, the bacteria density for all wet weather days of the storm event not sampled will be assumed to equal the highest bacteria density result reported from the samples collected;

c) For the storm events not sampled, the bacteria density for every wet weather day of those storm events will be assumed to equal the average of the highest bacteria densities reported from each storm event sampled;

For assessing and determining compliance with the concentration-based effluent limitations under Provision 6.b.(2)(b)(i) of Attachment E of the MS4 Permit, dry and wet weather discharge bacteria densities may be calculated based on a flow-weighted average across all major MS4 outfalls along a water body segment or within a jurisdiction if samples are collected within a similar time period.

The resulting data will also be submitted to the California Environmental Data Exchange Network (CEDEN).

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ATTACHMENT 4A-4: SAN DIEGO RIVER WATERSHED TOXICITY IDENTIFICATION EVALUATION/ TOXICITY REDUCTION EVALUATION WORK PLAN

Toxicity Identification Evaluation / Toxicity Reduction Evaluation Implementation Draft Work Plan

Prepared for:

San Diego County Regional Copermittees

Prepared by:

Weston Solutions, Inc.
5817 Dryden Place, Suite 101
Carlsbad, California 92008

January 16, 2015

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LIST OF ACRONYMS

2007 Permit	RWQCB Order No. R9-2007-0001
2013 Permit	RWQCB Order No. R9-2013-0001
BMP	best management practice
BSA	bovine serum albumin
CLRP	Comprehensive Load Reduction Plan
Copermittees	San Diego Regional Copermittees
EDTA	ethylenediaminetetraacetic acid
IWC	instream waste concentration
JRMP	Jurisdictional Runoff Management Plan
LC_{50}	median lethal concentration
LID	low impact development
MAP	Monitoring and Assessment Plan
MEP	maximum extent practicable
MS4	multiple separate storm sewer system
NOEC	no observed effect concentration
NPDES	National Pollutant Discharge Elimination System
PBO	piperonyl butoxide
QA/QC	quality assurance/quality control
RWQCB	Regional Water Quality Control Board
SMC	Stormwater Monitoring Coalition
SPE	solid phase extraction
STS	sodium thiosulfate
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TIE	toxicity identification evaluation
TMDL	Total Maximum Daily Load
TRE	toxicity reduction evaluation
TST	Test of Significant Toxicity
USEPA	United States Environmental Protection Agency
WMA	Watershed Management Area
WQIP	Water Quality Improvement Plan
WURMP	Watershed Urban Runoff Management Program

UNITS OF MEASURE

ppt	parts per thousand
%	percent
<	less than
>	greater than

1.0 INTRODUCTION

In May of 2013, San Diego Regional Water Quality Control Board (RWQCB) Order No. R9-2013-0001 (2013 Permit) was adopted. Provision B of the 2013 Permit requires Copermittees in each Watershed Management Area (WMA) to develop a Water Quality Improvement Plan (WQIP) which, per Provision B.4, incorporates a Monitoring and Assessment Program (MAP). Also, per Provision D.1.c.(4)(f), "*If chronic toxicity is detected in receiving waters, the Copermittees must discuss the need for conducting a TIE/TRE in the assessments required under Provision D.4.a.(2), and develop a plan for implementing the TIE/TRE to be incorporated in the Water Quality Improvement Plan*."

A toxicity identification evaluation (TIE) is defined by the 2013 Permit as "*A set of procedures for identifying the specific chemical(s) responsible for toxicity. These procedures are performed in three phases (characterization, identification, and confirmation) using aquatic organism toxicity tests*." A toxicity reduction evaluation (TRE) is defined as "*A study conducted in a step-wise process designed to identify the causative agents of effluent or ambient toxicity, isolate the sources of toxicity, evaluate the effectiveness of toxicity control options, and then confirm the reduction in toxicity. The first steps of the TRE consist of the collection of data relevant to the toxicity, including additional toxicity testing, and an evaluation of facility operations and maintenance practices and best management practices. A TIE may be required as part of the TRE, if appropriate*."

This Work Plan outlines the process used to identify chronic toxicity in receiving waters, as well as guidance to prioritize the need to implement a TIE/TRE based on the magnitude and persistence of chronic toxicity. The Work Plan refers to the appropriate references for detailed sampling and analytical/toxicity test methods specific to the TIE/TRE treatment process. An example of a potential TRE decision process for receiving water samples (Stormwater Monitoring Coalition (SMC) Model Monitoring Technical Committee, 2004) is presented in Figure 1-1. The process should be modified on location-specific and pollutant-specific basis, and a detailed work plan should be developed for the implementation of a pollutant reduction program once the specific pollutant(s) causing toxicity exceedances are identified.

This Work Plan focuses primarily on the implementation of the TIE/TRE process, recognizing the limitations of utilizing TRE guidance developed for point source discharges. Receiving water stations potentially capture pollutants from many sources with runoff flows and contaminant concentrations likely more variable than those from point source discharges. However, with modifications to the TRE guidance developed for point source discharges, a TRE may be conducted to attempt to identify sources of toxicity, propose mitigation measures for these sources, and conduct follow-up studies to confirm toxicity reduction. Any activities that result in consistently reducing toxicity to an acceptable level may be considered TRE activities (USEPA 2001).

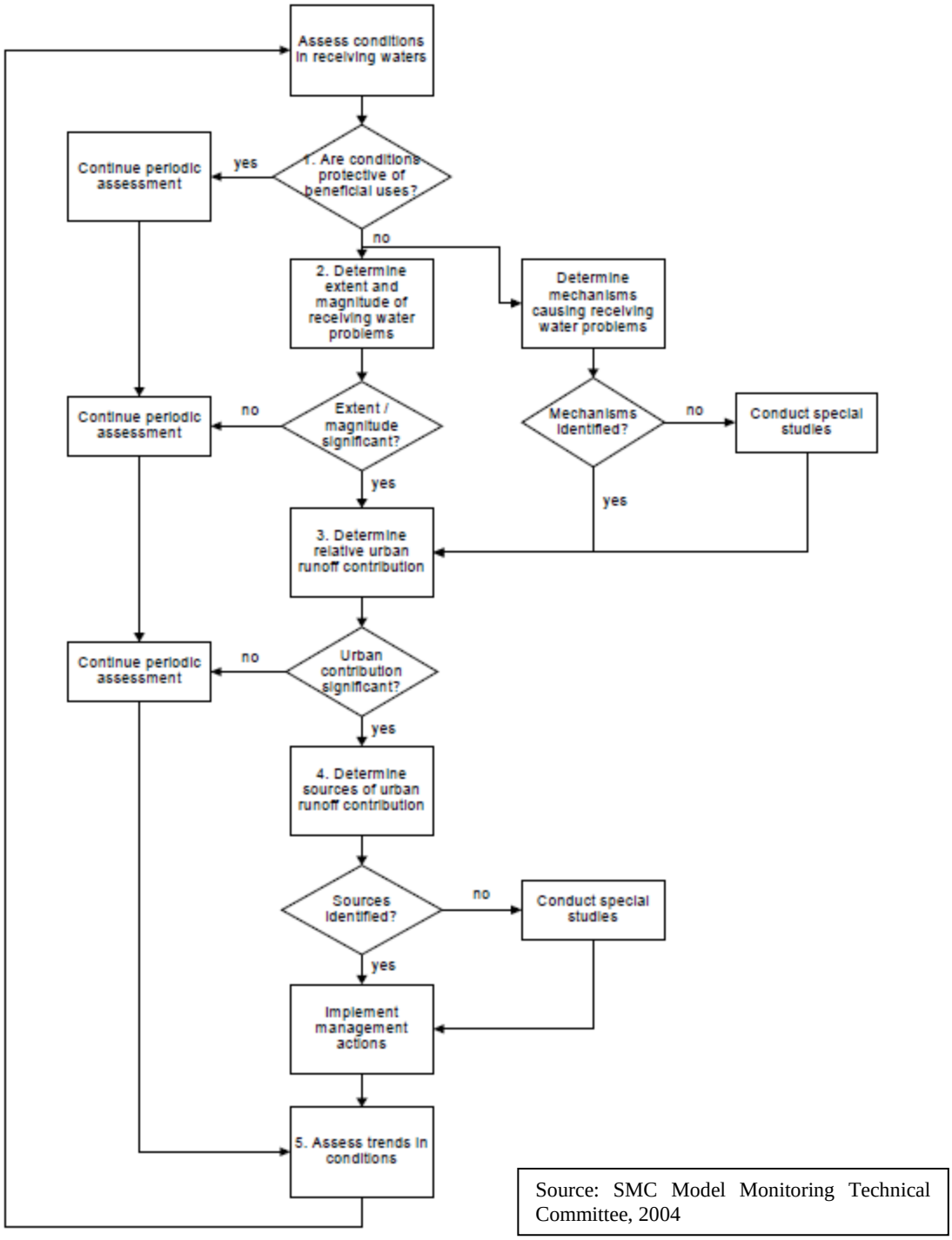

Figure 1-1. Example Receiving Water Monitoring and TIE/TRE Decision Framework

2.0 RECEIVING WATER TOXICITY TESTING

Receiving water monitoring is conducted by the San Diego Regional Copemittees (Copermittees) in accordance with Provision D of the 2013 Permit and chronic toxicity is one of the parameters evaluated in both wet and dry weather receiving water samples. Under the long-term monitoring requirements of the 2013 Permit, chronic toxicity tests are conducted in accordance with Provision D.1.c.(4)(e) as summarized in Table 2-1. Toxicity is evaluated using the Test of Significant Toxicity (TST) as outlined in the *National Pollutant Discharge Elimination System Test of Significant Toxicity Implementation Document* (USEPA, 2010). The TST approach assigns a Pass or Fail result based on whether the organism response observed at the chronic instream waste concentration (IWC) of 100 percent (%) receiving water is significantly different from that in the control treatment. When chronic toxicity is observed in receiving water samples (i.e., the sample receives a "Fail" based on the TST), implementation of a TIE/TRE process following the phased approach described in subsequent sections will be considered, as appropriate.

Table 2-1. Transitional and Long-Term Receiving Water Toxicity Tests

Organism	Endpoint	Toxicity Threshold	USEPA Protocol
Monitoring in accordance with Order No. R9-2013-0001, Salinity < 1 ppt			
Ceriodaphnia dubia	Chronic survival and reproduction	Pass/Fail	EPA-821-R-02-013
Selenastrum capricornutum	Chronic growth		
Pimephales promelas	Chronic survival and growth		
Monitoring in accordance with Order No. R9-2013-0001, Salinity ≥ 1 ppt			
Strongylocentrotus purpuratus	Chronic development	Pass/Fail	EPA-600-R-95-136

3.0 TIE/TRE PROCESS

3.1 Information and Data Acquisition

Prior to initiating the TIE/TRE process, an evaluation of sampling and toxicity testing procedures should be conducted to assess whether toxicity may have been introduced during these procedures or errors may have been made. This may include a review of the following:

- Sampling equipment decontamination procedures
- Field and laboratory logs
- Laboratory reports

If all test acceptability criteria are met and no errors are identified, Copermittees will consider implementing the TIE/TRE process. Conducting a TIE is often the first step to identifying the toxicant.

3.2 TIE Testing

TIEs may be conducted in accordance with USEPA guidance for characterizing, identifying, and confirming toxicity (USEPA 1991, 1992, 1993a, and 1993bPriority may be given to stations

exhibiting significant and persistent toxicity that has not previously been characterized and where analytical results indicate that a specific toxicant may be causing or contributing to toxicity. The sample may be evaluated for TIE suitability using the following assessments:

- Presence of Persistent Toxicity: toxicity is considered persistent if more than 50% of samples (generally during a monitoring year) collected at a station receive a "Fail" based on the test of significant toxicity (TST) .
- Magnitude of Toxicity: based on past experience, a 50% response rate(i.e. 50% of test organisms respond in a 100% receiving water sample) can provide a reasonable opportunity for a successful TIE.
- Previous Characterization: TIEs are generally prioritized for receiving water stations where previous TIEs have not characterized the pollutant(s) causing toxicity. However, TIE/TRE procedures should not be ruled out for previously characterized stations since contributor(s) to toxicity may change over time.

The TIE approach is divided into three phases, as described in USEPA (1991) and summarized as follows:

- Phase I – characterizes the physical/chemical nature of the constituent(s) which cause or contribute to toxicity. Such characteristics as solubility, volatility and filterability are determined without specifically identifying the toxicants.
- Phase II – utilizes methods to specifically identify toxicants.
- Phase III – utilizes methods to confirm the suspected toxicants.

Phase I (characterization) manipulations of receiving water samples generally include those presented in Table 3-1.

Table 3-1. Phase I TIE Receiving Water Sample Manipulations

Physical and Chemical Manipulations on Receiving Water Samples	Purpose of Test
Baseline	Confirms toxicity is still present in the sample at time of TIE testing
Filtration	Detects particulates or particulate-bound toxicants
Aeration	Detects volatile, oxidizable, sublatable, or spargeable compounds
Ethylenediaminetetraacetic acid (EDTA) addition	Detects cationic metals (e.g., cadmium)
Sodium thiosulfate (STS) addition	Detects oxidative compounds (e.g., chlorine)
Solid phase extraction (SPE) over C18 column (may be followed by methanol elution)	Detects non-polar organics and some surfactants (methanol elution adds toxicity back to sample)
Piperonyl butoxide (PBO) addition	Detects organophosphate pesticides and pyrethroids

Carboxyl esterase addition*	Hydrolyzes pyrethroids
Bovine serum albumin (BSA) addition	Protein BSA is used as a control for the carboxyl esterase
Temperature reduction	Increases toxicity of pyrethroid pesticides
pH adjustment	Detects pH-dependent toxicants (e.g., ammonia and sulfides)
* Carboxylesterase addition has been used in recent studies to help identify pyrethroid-associated toxicity (Wheelock et al., 2004; Weston and Amweg, 2007). However, this treatment is experimental in nature and should be used along with other pyrethroid-targeted TIE treatments (e.g., PBO addition).	

Adjustments may be made to these TIE protocols if specific contaminants are suspected to be contributing to toxicity. For example, total dissolved solids (TDS) controls and/or mock effluents to mimic TDS concentrations observed in samples are often added to the treatments listed in Table 3-1 if ionic imbalance or elevated TDS are suspected. Toxicity due to ionic imbalance occurs when ion concentrations are not within the tolerance range of the selected test organism; utilizing *S. purpuratus* for toxicity tests conducted for samples with salinity > 1 ppt may help to alleviate this common issue, especially during dry weather.

Phase II and III TIEs may be necessary, depending whether the Phase I determination of toxicant class is sufficient for identifying pollutants for outfall monitoring and/or identifying source control measures. If necessary, Phase II and III procedures may include toxicant removal and add-back, serial additions, and/or toxicant spiking experiments in accordance with USEPA 1993a and 1993b.

It should be noted that, due to intermittent toxicity and/or toxicity resulting from multiple toxicants, TIEs are not always conclusive. In such cases, conducting toxicity tests with additional organisms (SMC Model Monitoring Technical Committee, 2004) and/or serially identifying toxicants (USEPA, 2001) may help characterize observed toxicity. When a receiving water sample exhibits persistent toxicity of a high magnitude, as is generally the case when TIEs are conducted, TIEs are typically successful (USEPA, 2001).

3.3 Toxicity Source Evaluation

Once any toxicants have been identified during the TIE process, Copermittees must discuss the need for conducting a TRE. The following sections provide an outline for developing specific monitoring elements intended to focus the effort in locating the source(s) of the pollutant(s).

If urban runoff is suspected as a significant source of the pollutant(s) characterized by a TIE to be a contributor to toxicity at a receiving water station, source identification procedures may need to be considered. An evaluation of chemistry and bioassessment data for the receiving water station and chemistry data for upstream outfalls may help to confirm whether urban runoff is a significant source of the pollutant(s) causing toxicity and may justify further source identification procedures.

More comprehensive source identification procedures, if warranted, may include compiling descriptions of all potential sources to the receiving water station, determining actual sources and

their relative magnitudes, and quantitatively estimating loads from these sources. A model for a source identification investigation study is outlined in the *Model Monitoring Program for Municipal Separate Storm Sewer Systems in Southern California* (SMC Model Monitoring Technical Committee, 2004) and more detailed source identification study methodology is outlined in USEPA (1993c) and by Pitt (2004). The general approach may include a combination of the components presented in Figure 3-1.

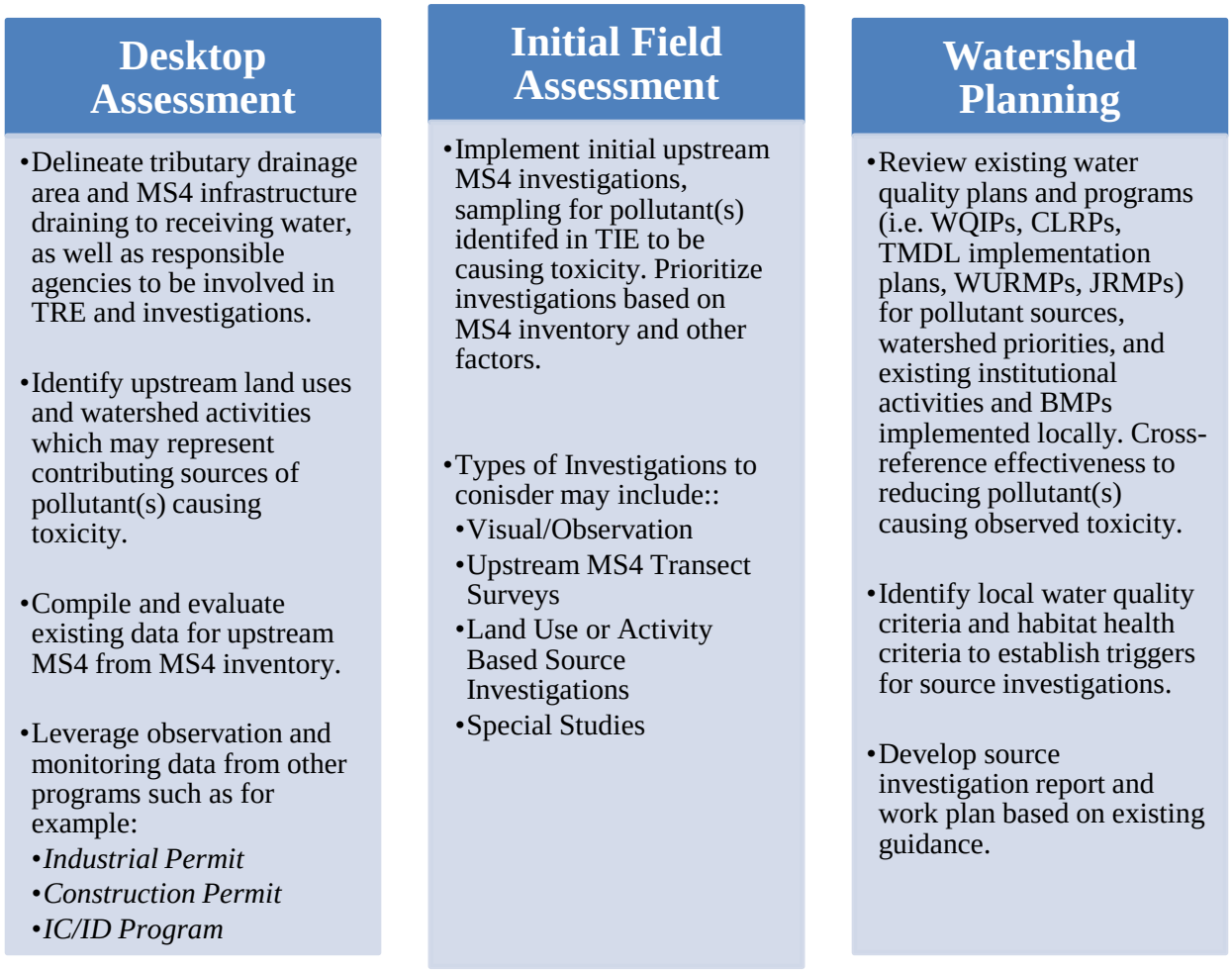

Figure 3-1. The Toxicity Source Evaluation Approach

Source identification efforts may coordinate with monitoring and assessment activities necessary for compliance with the following Provisions:

- Provision A.4.a.(2) – If it is determined that discharges from the MS4 are causing or contributing to a new exceedance of an applicable water quality standard not addressed by the WQIP, update the WQIP with the water quality improvement strategies implemented or to be implemented, the implementation schedule, and the monitoring and assessment program updates intended to track progress toward achieving compliance.

- Provision B.2.d – identify and prioritize known and suspected sources of stormwater and non-stormwater pollutants from MS4 outfalls that contribute to the highest priority water quality conditions, as identified in the WQIP.
- Provision B.3 – identify water quality improvement goals and strategies to address the highest priority water quality conditions, as identified in the WQIP.
- Provision D.2.b – perform dry weather MS4 outfall monitoring to identify non-storm water flows and illicit discharges within its jurisdiction and to prioritize these discharges for investigation and elimination.
- Provision D.2.c – perform wet weather MS4 outfall monitoring to identify pollutants in storm water discharges from the MS4, guide pollutant source identification efforts, and determine compliance with applicable Total Maximum Daily Loads (TMDLs).
- Provision D.3 – conduct special studies related to the highest priority water quality conditions. Provision D.3.c specifies that special studies related to pollutant and/or stressor source identification should include a compilation of known information on the pollutant and/or stressor, an identification of data gaps intended to be filled by the studies, and a monitoring plan which includes, among other required elements, a prioritization of sources of the pollutant and/or stressor.
- Provision E.2 – implement a program to detect and eliminate illegal discharges and improper disposal into the MS4.

If no source can be identified as a major contributor to receiving water toxicity, more intensive follow-up studies may be required.

3.4 Toxicity Control Evaluation

Using the results from the TRE elements conducted to this point, alternatives for reducing receiving water toxicity may be identified and the most feasible approach(es) may be selected. Pollution Prevention measures are designed to target pollutants and wastes before they are generated, while Source Controls are designed to reduce or eliminate pollutants before entering the MS4. These measures may include outreach, incentive programs, regulatory controls, and enforcement activities, as well as broader “true source controls” that must be implemented at a national or state level (e.g., product regulation). Institutional Programs, such as street sweeping, MS4 cleaning and repair, and other institutional services are typically maintenance activities implemented by agencies at various targeted frequencies to meet pollutant load reduction goals and minimum National Pollutant Discharge Elimination System (NPDES) Permit compliance criteria. Treatment Controls include structural systems designed to remove pollutants from stormwater and non-stormwater flows and may include a variety of low impact development (LID) and best management practices (BMPs) (e.g., infiltration-type, bioremediation, treatment trains, etc.). These BMPs are intended to protect receiving waters by eliminating or reducing the discharge of pollutants to the maximum extent practicable (MEP). Advantages and disadvantages of BMP alternatives should be considered, and appropriate BMPs should be selected based on site-specific conditions and pollutant(s) of concern. An integrated approach using a combination of Pollution Prevention measures, Institutional Programs, and Treatment Controls may be appropriate if more than one pollutant is identified to be causing or contributing to toxicity, or if

the source is unknown. These three components of the toxicity control evaluation are shown in Figure 3-2.

Figure 3-2. Components of Toxicity Control Evaluation

3.5 Toxicity Control Implementation

Once the selected toxicity control method(s) are implemented, monitoring may be continued and possibly accelerated to confirm that toxicity reduction objectives are being met. Depending on the location and pollutant(s) being evaluated, some of this monitoring may be satisfied by Permit-required monitoring of receiving water and outfall locations (see Section 3.3).

Compliance with the monitoring and assessment requirements of the 2013 Permit, including Provision D.1.c.(4)(f) which requires the implementation of the TIE/TRE process described in this Work Plan, is intended to meet the discharge and receiving water limitations outlined in the 2013 Permit to the MEP. Updates to the monitoring programs developed to comply with these provisions will be incorporated into the WQIP through the adaptive management process outlined in Provisions B.4 and B.5 in order to continually monitor effectiveness and re-evaluate the programs.

3.6 Quality Assurance/Quality Control

A quality assurance/quality control (QA/QC) program for the TIE/TRE should be developed in order to ensure reliability of data collected throughout the process. The QA/QC program should include the QA/QC objectives, sample collection and preservation techniques, chain of custody procedures, analytical QA/QC, laboratory equipment maintenance, QA/QC training requirements, documentation and reporting procedures, and corrective action protocols (USEPA, 1993c). In addition, toxicology and analytical laboratories should be experienced and qualified to conduct the TIE/TRE.

3.7 TIE/TRE Limitations

There are inherent limitations associated with the TIE/TRE process summarized in this Work Plan, including the difficulty of characterizing intermittent toxicity (USEPA, 1993c) and/or toxicity resulting from multiple toxicants (USEPA, 2001). In addition, existing TRE guidance was developed primarily for point source discharges from wastewater treatment plants whereas receiving waters potentially capture pollutants from many sources and contain contaminants at more variable concentrations than those from a wastewater treatment facility, especially during a storm event.

4.0 REFERENCES

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ATTACHMENT 4A-5: SAN DIEGO RIVER WATERSHED STORM DRAIN OUTFALL MONITORING PLAN

San Diego River Watershed
Storm Drain Outfall Monitoring Plan

Prepared For:
San Diego River Watershed
Participating Agencies

Prepared By:
AMEC Environment and Infrastructure, Inc.
9177 Sky Park Court
San Diego, California 92123
January 2015

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LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
<	less than
303(d) list	Clean Water Act Section 303(d) List of Impaired Waterbodies
Bacteria TMDL	A Resolution Amending the Water Quality Control Plan for the San Diego Basin (9) To Incorporate Revised Total Maximum Daily Loads for Indicator Bacteria Project I—Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek) (Regional Board, February 10, 2010)
CMP	corrugated metal pipe
CP	concrete pipe
CWA	Clean Water Act
ELAP	California Environmental Laboratory Accreditation Program
GIS	Geographic Information System
IDDE	Illicit Discharge Detection and Elimination
JRMP	Jurisdictional Runoff Management Program
STORM DRAIN	Municipal Separate Storm Sewer System
Permit	San Diego Regional Water Quality Control Board Order Number R9-2013-0001, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer System (MS4) Draining the Permits Within the San Diego Region
NAL	non-stormwater action level
NPDES	National Pollutant Discharge Elimination System
PID	photoionization detector
QA	quality assurance
RCC	reinforced concrete channel
RCP	reinforced concrete pipe

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

Regional Board	Regional Water Quality Control Board, San Diego Region
SAL	stormwater action level
SWAMP	Surface Water Ambient Monitoring Program
TBD	to be determined
TKN	total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WATERSHED	Permit Management Area
WQBEL	Water Quality Based Effluent Limit
WQIP	Water Quality Improvement Plan
WQO	Water Quality Objective
WURMP	Permit Urban Runoff Management Program

INTRODUCTION

In May 2013, the San Diego Regional Water Quality Control Board (Regional Board) Order No. R9-2013-0001, *National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirement for Discharges From The Municipal Separate Storm Sewer Systems (MS4s) Draining The Permits Within the San Diego Region* (Permit; Regional Board, 2013) was adopted, replacing REGIONAL BOARD Order No. R9-2007-0001 (Regional Board, 2007), and became effective June 27, 2013. The Permit prescribes monitoring programs for the storm drain outfalls during wet and dry weather for the duration of the Permit cycle.

PROGRAM OVERVIEW

In the San Diego River Permit Watershed Management Area (Watershed), five Municipal Copermittees (Copermittees) are named under the Permit:

- City of El Cajon
- City of La Mesa
- City of San Diego
- City of Santee
- County of San Diego

The Copermittees are required to perform storm drain outfall monitoring in accordance with Provision D of the Permit. Permit-required storm drain outfall monitoring is composed of two major components:

- Dry Weather Storm Drain Outfall Discharge Monitoring (Provision D.2.b; Regional Board, 2013)
- Wet Weather Storm Drain Outfall Discharge Monitoring (Provision D.2.c; Regional Board, 2013)

The purpose of this monitoring plan is to describe the monitoring and assessment requirements and procedures for the San Diego River Watershed Storm Drain Outfall Discharge Monitoring Program required by the Permit.

DRY WEATHER STORM DRAIN OUTFALL DISCHARGE MONITORING

This section details the dry weather storm drain outfall monitoring required to comply with the Permit. Each Copermittee is required to perform dry weather Storm Drain outfall prioritization and monitoring to aid in the identification of non-stormwater and illicit discharges within its respective jurisdictions as required by Provision D.2.b of the Permit.

STORM DRAIN OUTFALL INVENTORY

The Copermittees have identified the known major storm drain outfalls that discharge directly to receiving waters within their respective jurisdictions within the San Diego River Watershed. The identified major storm drain outfalls have been geo-located on respective Geographic Information

System (GIS) jurisdictional map of the San Diego River Watershed as required by Provision D.2.a.(1) of the Permit. Each Copermittee will individually maintain, confirm, and update its respective maps during annual field screening (Provision D.2.2). The respective jurisdictional storm drain maps contain the following items that, at a minimum, will be confirmed and updated during annual field screening as applicable:

- Segments of the storm drain owned, operated, and maintained by the Copermittee
- Known locations of inlets that discharge and/or collect runoff into the Copermittee's storm drain
- Known locations of connections with other storm drains not owned or operated by the Copermittee
- Known locations of storm drain outfalls and private outfalls that discharge runoff collected from areas within the Copermittee's jurisdiction
- Segments of receiving waters within the Copermittee's jurisdiction that receive and convey runoff discharged from the Copermittee's storm drain outfalls
- Locations of the storm drain outfalls within each Copermittee's respective jurisdiction
    - Latitude and longitude of storm drain outfall point of discharge
    - Permit Management Area
    - Hydrologic subarea
    - Outlet size
    - Accessibility (i.e. safety and without disturbance of critical habitat)
    - Approximate drainage area
    - Classification of whether the storm drain outfall is known to have persistent non-stormwater flows, transient non-stormwater flows, no non-stormwater flows, or unknown non-stormwater flows
- Locations of the selected non-stormwater persistent flow storm drain outfall discharge monitoring stations within each Copermittee's respective jurisdiction (Provision D.2.3.2)

Because of their size, geo-located storm drain outfall maps are not included in this monitoring plan. Table 2-1 presents the number of identified major outfalls in the San Diego River Watershed by Copermittee.

Table 2-1. Number of Identified Major Storm Drain Outfalls by Copermittee

Copermittee	Number of Identified Major Outfalls
City of El Cajon	To Be Determined (TBD)
City of La Mesa	13
City of San Diego	502
City of Santee	57
County of San Diego	50

Field Screening

Each Copermittee is required to conduct field screening to determine which non-stormwater storm drain outfall discharges are transient flows and which are persistent flows, and to prioritize the non-stormwater storm drain discharges that will be investigated and eliminated in accordance with the Illicit Discharge Detection and Elimination (IDDE) program.

Monitoring Locations And Frequency

Per the requirements of Provision D.2.a.(2).(a) of the Permit, the number of major outfalls required to be screened is dependent upon the number of known major outfalls present in a Copermittee's inventory. For the San Diego River Watershed Copermittees, the following requirements apply:

- For Copermittees with fewer than 125 known major storm drain outfalls that discharge to receiving waters within a Watershed, at least 80 percent of the outfalls are required to be visually inspected two times per year during non-stormwater conditions. The following Copermittees in the San Diego River Watershed fall into this category:
  - City of El Cajon (TBD, not confirmed)
  - City of La Mesa
  - City of Santee
  - County of San Diego
- For Copermittees with 125 major storm drain outfalls or more, but fewer than or equal to 500 that discharge to receiving waters within a Watershed, all the outfalls are required to be visually inspected at least annually during non-stormwater conditions. The following Copermittees in the San Diego River Watershed fall into this category:
  - City of San Diego

Based on these criteria, Table 2-2 details the number of major outfalls and inspection frequency for each Copermittee 's jurisdiction.

Table 2-2. Storm Drain Outfall Screening Number and Frequency by Copermittee

Copermittee	Number of Identified Major Outfalls	Frequency of Screening
City of El Cajon	TBD	TBD
City of La Mesa	11[1] (13)	80% of major outfalls, twice annually
City of San Diego	500	500 major outfalls, once annually
City of Santee	46[1] (57)	80% of major outfalls, twice annually
County of San Diego	40[1] (50)	80% of major outfalls, twice annually

1. For Copermittees with fewer than 125 major STORM DRAIN outfalls in the WATERSHED, 80% of major outfalls must be screened twice per year. Total number of major outfalls within each jurisdiction in the WATERSHED is provided in parentheses.

Visual Observations

Per the Permit, during a field screening visual observation inspection, each storm drain outfall selected for screening will be inspected following at least 72 hours of dry weather after any storm event producing greater than 0.10 inch of rainfall within a 24-hour period. Table 2-3 details the visual observations that will be recorded during each field screening visual observation inspection, per the requirements of Provision D.2.a.(2) of the Permit. An example field observation form used

to record field screening visual observations is included in Attachment A. Example procedures for flow estimation are described in Attachment B.

Table 2-3. Field Screening Visual Observations for Storm Drain Outfall Discharge Monitoring Stations

Field Observations
Station identification and location Presence of flow, or pooled or ponded water If flow is present: Flow estimation (i.e., width of water surface, approximate depth of water, approximate flow velocity, flow rate) Flow characteristics (i.e., presence of floatables, surface scum, sheens, odor, color) Flow source(s) suspected or identified from non-stormwater source investigation Flow source(s) eliminated during non-stormwater source identification If pooled or ponded water is present: Characteristics of pooled or ponded water (i.e., presence of floatables, surface scum, sheens, odor, color) Known or suspected source(s) of pooled or ponded water Station description (i.e., deposits or stains, vegetation condition, structural condition, observable biology) Presence and assessment of trash in and around station Evidence or signs of illicit connections or illegal dumping

Non-Stormwater Persistent Flow Storm Drain Outfall Discharge Monitoring

Each Copermittee is required to perform non-stormwater persistent flow storm drain outfall discharge monitoring to determine whether persistent non-stormwater discharges may be impacting receiving water quality.

Outfall Prioritization

Copermittees must each identify a minimum of the 5 highest priority major storm drain outfalls with non-stormwater persistent flows that they will monitor within their respective jurisdictions in the San Diego River Watershed, in accordance with Permit Provision D.2.b.(2)(b) (Regional Board, 2013). If a Copermittee has less than 5 major outfalls within the Watershed, the Copermittee will monitor all its major Storm Drain outfalls with persistent flow. The Copermittees selected dry weather storm drain outfall discharge monitoring stations from the inventories developed pursuant to Provision D.2.b.(2)(a) for the San Diego River Watershed as follows:

- *Based upon the dry weather storm drain outfall discharge field screening monitoring records developed pursuant to Provision D.2.a.(2)(c), each Copermittee must identify and prioritize the storm drain outfalls with persistent flows based on the highest priority water quality conditions identified in the Water Quality Improvement Plan and any additional criteria developed by the Copermittee, which may include historical data and data from sources other than what the Copermittee collects.*

Monitoring Locations and Frequency

The highest priority major storm drain outfalls with non-stormwater persistent flows selected by each Copermittee are presented in Table 2-4 and Figure 2-1.

Each selected highest priority major outfall will be monitored at least semi-annually. A Copermittee may substitute a next-highest priority major outfall for a selected major outfall in the event that one of the following criteria becomes applicable, until no qualifying major storm drain outfalls remain within the Copermittee's jurisdiction in the San Diego River Watershed:

- The non-stormwater discharges have been effectively eliminated (i.e., no flowing, pooled, or ponded water) for three consecutive non-stormwater monitoring events.
- The source of the persistent flows has been identified as a category of non-stormwater discharges that does not require an NPDES permit and does not have to be addressed as an illicit discharge because it was not identified as a source of pollutants.
- The constituents in the persistent flow non-stormwater discharge do not exceed NALs.
- The source of the persistent flows has been identified as a non-stormwater discharge authorized by a separate NPDES permit.

In the event of a substitution, each Copermittee will document the reprioritization of its highest priority persistent flow storm drain outfalls in the Water Quality Improvement Plan (WQIP) Annual Report.

Table 2-4. Selected Highest Priority Major Storm Drain Outfalls for Non-Stormwater Persistent Flow Monitoring

Jurisdiction	Site ID	Outfall Size	Outfall Type	Latitude	Longitude
City of El Cajon	TBD	TBD	TBD	TBD	TBD
	TBD	TBD	TBD	TBD	TBD
	TBD	TBD	TBD	TBD	TBD
	TBD	TBD	TBD	TBD	TBD
	TBD	TBD	TBD	TBD	TBD
City of La Mesa	OF-ALV-5	36 x 60	RCB	32.77373	-117.02757
	OF-ALV-8	(2x) 48	Manhole[1]	32.77411	-117.02288
	OF-ALV-11	57	Manhole[1]	32.7777	-117.01769
City of San Diego	DW0067	60"	CP	32.83539	-117.12212
	DW0369	54"	CP	32.80243	-117.06845
	DW0081	54"	CP	32.8205	-117.11705
	DW0681	48"	Manhole[1]	32.77597	-117.13115
	DW0696	36"	CP	32.83938	-117.09311
City of Santee	E5g1	2 x 72”	Manhole[1]	32.84885	-117.00471
	R20a	54	Outfall[2]	32.8319	-116.98602
	RCP1	42	Outfall[2]	32.84949	-116.96659
	S5c	60	Outfall[2]	32.84363	-116.98795
	S15h	48	Outfall[2]	32.84326	-116.98969
County of San Diego	STORM DRAIN-SDR-036	60"	CMP	32.8469	-116.87153
	STORM DRAIN-SDR-064	5 X 66"	RCC	32.86168	-116.94471
	STORM DRAIN-SDR-127	64"	CMP	32.84911	-116.88414
	STORM DRAIN-SDR-151	48"	RCP	33.00782	-116.82069
	STORM DRAIN-SDR-207	96" X 60"	RCB	32.83269	-116.90533

Notes:

RCB = Reinforced Concrete Box; CP = Concrete Pipe; CMP = Corrugated Metal Pipe; RCC = Reinforced Concrete Channel; RCP = Reinforced Concrete Pipe; TBD = To Be Determined

1. Manhole type structure; the outfall is not accessible
2. Outfall structure located at point of discharge

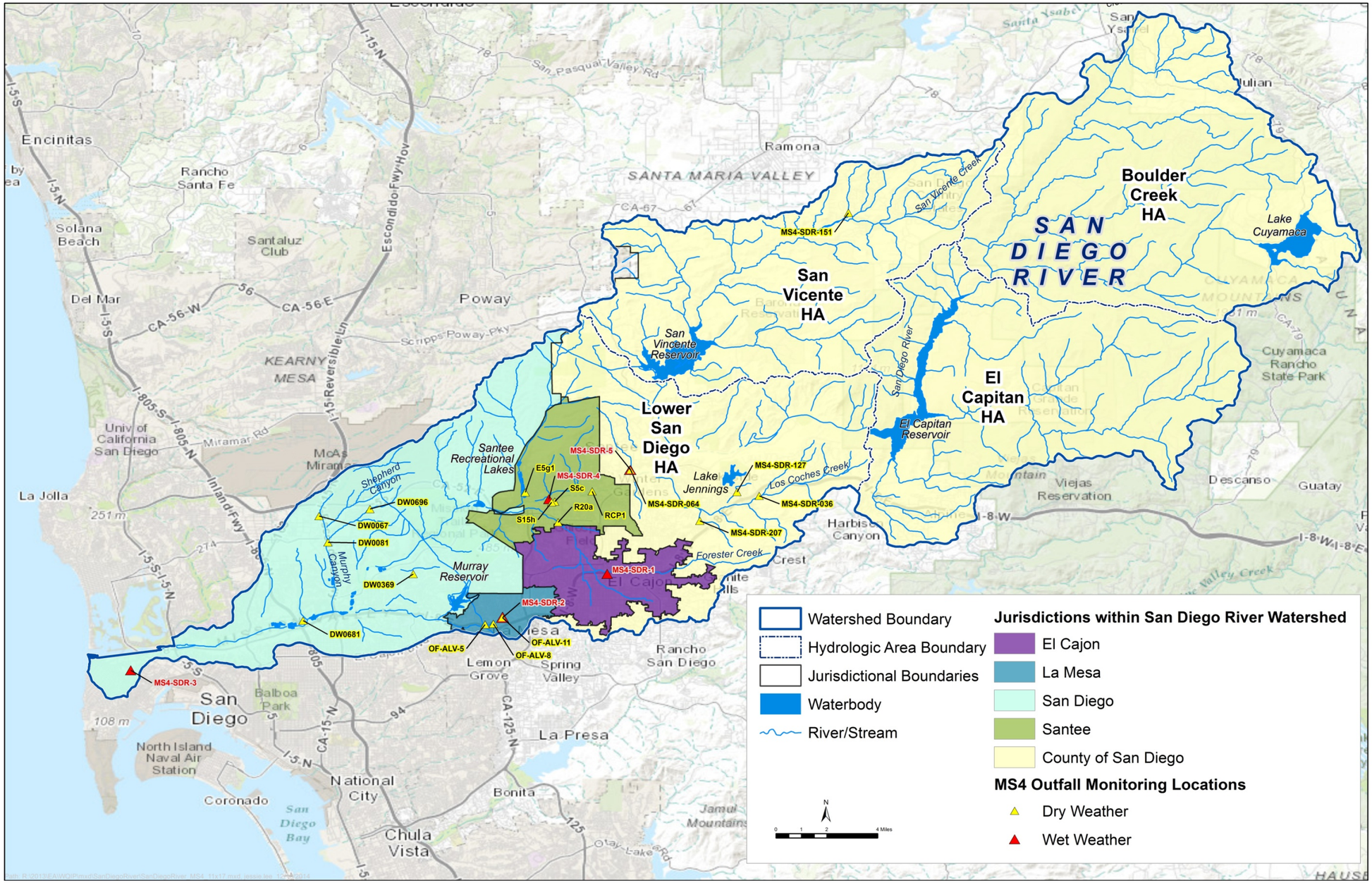

Figure 2-1. Selected Major Outfalls for Dry and Wet Weather Storm Drain Discharge Monitoring

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Field Observations

During the monitoring events, field observations will be recorded at each of the selected major outfall persistent flow monitoring sites. The flow rates and volumes will be measured or estimated using data from nearby USGS gauging stations, or by manual measurements performed in accordance with the USEPA Storm Water Sampling Guidance Document (EPA-833-B-92-001), section 3.2.1. Alternative flow measurement or estimation methods that are acceptable to the San Diego Water Board may be employed. An example dry weather field observations form is provided in Attachment A. A list of required field observations is presented in Table 2-3.

Field Monitoring

During the monitoring events, *in-situ* measurements will be collected at each of the selected major outfall persistent flow monitoring sites. These will include:

- pH
- Temperature
- Specific conductivity
- Dissolved oxygen
- Turbidity

Field monitoring will be documented on a field observation form. A list of parameters, monitored corresponding target reporting limits, and suggested analytical methods is provided in Attachment A.

Analytical Monitoring

Sample Collection

During the monitoring events, provided sufficient measurable flow is present, samples will be collected for analysis by an analytical laboratory. Grab samples will be collected in accordance with the Surface Water Ambient Monitoring Program (SWAMP) protocols. An example chain-of-custody (COC) form is included in Attachment C. Quality assurance and quality control procedures are outlined in Attachment F.

Laboratory Analysis

The required analyses are based upon the following five groupings of constituents:

1) Constituents contributing to the highest priority water quality conditions identified in the San Diego River Watershed WQIP
2) Constituents listed as a cause for impairment of receiving waters in the San Diego River Watershed as listed on the 303(d) list
3) Constituents for implementation plans or load reduction plans (e.g., Bacteria Load Reduction Plans, Comprehensive Load Reduction Plans) developed for the San Diego River Watershed where the Copermittees are listed responsible parties to a Total Maximum Daily Load (TMDL)

4) Applicable NAL constituents listed in Provision C.1 of the Permit
5) Constituents listed in Table D-7 of the Permit

Attachment A details the analyses required for selected STORM DRAIN outfall persistent flow monitoring, including target reporting limits. Per Provision 2.i.(3)in Attachment B of the Permit, all chemical and bacteriological analysis of samples will be performed by laboratory(ies) certified for such analyses by the California Department of Public Health or laboratory(ies) approved by the San Diego Water Board.. All sampling, analysis and quality assurance/quality control will be conducted in accordance with the Quality Assurance Management Plan (QAMP) for the State of California's Surface Water Ambient Monitoring Program (SWAMP), adopted by the State Water Resources Control Board (State Water Board).

WET WEATHER STORM DRAIN OUTFALL DISCHARGE MONITORING

This section details the wet weather storm drain outfall monitoring required to comply with the Permit. Each Copermittee is required to perform wet weather storm drain outfall monitoring to identify pollutants in stormwater discharges from the storm drains, guide pollutant source identification efforts, and determine compliance with the Water Quality Based Effluent Limits (WQBELs) associated with the Bacteria TMDL within its respective jurisdiction as required by Provision D.2.c of the Permit.

STORMWATER STORM DRAIN OUTFALL DISCHARGE MONITORING

Each Copermittee is required to perform wet weather storm drain outfall prioritization and monitoring to aid in the identification of pollutants in stormwater discharges from the storm drains, to guide pollutant source identification efforts, and to determine compliance with the WQBELs associated with the applicable TMDLs within its respective jurisdiction as required by Provision D.2.c of the Permit.

OUTFALL PRIORITIZATION

The Copermittees selected wet weather storm drain outfall discharge monitoring stations from the inventories developed pursuant to Provision D.2.a.(3).(a).(1) of the Permit for the San Diego River Watershed as follows:

- *At least five wet weather storm drain outfall discharge monitoring stations that are representative of stormwater discharges from areas consisting primarily of residential, commercial, industrial, and typical mixed-use land uses present within the Permit Management Area*
- *At least one wet weather storm drain outfall discharge monitoring station for each Copermittee within the Permit Management Area*

The Copermittees may adjust the wet weather storm drain outfall discharge monitoring locations in the San Diego River Watershed, as needed, to identify pollutants in stormwater discharges from storm drains, to guide pollutant source identification efforts, and to determine compliance with the

WQBELs associated with applicable TMDLs in accordance with the highest priority water quality conditions identified in the San Diego River Permit WQIP

Monitoring Locations and Frequency

The monitoring locations for wet weather storm drain outfall monitoring are provided in Table 3-1 and Figure 2-1.

Table 3-1. Wet Weather Storm Drain Outfall Monitoring Locations

STORM DRAIN Site Name	Jurisdictional Identifier	Jurisdiction	Latitude	Longitude
MS4-SDR-1	27	City of El Cajon	32.80256	-116.95808
MS4-SDR-2	OF-ALV-11	City of La Mesa	32.77776	-117.01751
MS4-SDR-3	DW136	City of San Diego	32.74773	-117.22927
MS4-SDR-4	G30c	City of Santee	32.84501	-116.99122
MS4-SDR-5	COSD MS4 SDR01	County of San Diego	32.86165	-116.94474

Per the requirements of the Permit, the Copermittees will monitor wet weather storm drain outfall discharge monitoring station(s) in the San Diego River Watershed once annually.

Wet Weather Events

Storm events will be considered viable for mobilization if they are predicted to produce at least 0.1 inch of rainfall in the drainage area. Storm forecasts can be obtained from the National Weather Service website (http://www.wrh.noaa.gov/sgx/) or an equivalent source.

Field Observations

During each wet weather monitoring event, narrative descriptions and field observations will be recorded at each wet weather storm drain outfall discharge monitoring station. Narrative descriptions and observations include:

- Station location
- Date and duration of the storm event(s) sampled
- Rainfall estimates of the storm event
- Duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event

Flow estimation or measurement will be performed as described in Attachment B, using data from nearby United States Geological Survey (USGS) gauging stations, or flow rates may be measured or estimated in accordance with the United States Environmental Protection Agency (USEPA) Storm Water Sampling Guidance Document (EPA-833-B-92-001), Attachment B, or other method proposed by the Copermittees that is acceptable to the Regional Board.

Field Monitoring

During each wet weather monitoring event, *in-situ* measurements for field monitoring parameters will be collected at each of the selected outfall sites. Field monitoring parameters include:

- pH
- Temperature
- Specific conductivity
- Dissolved oxygen
- Turbidity

Field monitoring will be documented on the field observation form. A list of field monitoring parameters and corresponding target reporting limits for field monitoring parameters is provided in Attachment A.

Analytical Monitoring

Sample Collection

Samples will be collected as follows:

- Consistent sample collection methods will be employed for regional comparability of data, unless site-specific conditions indicate the need for alternate methods;
- Grab samples will be collected for the analytes not amenable to composite sampling. These include pH, temperature, specific conductivity, dissolved oxygen, turbidity, and indicator bacteria;
- For all other constituents, composite samples will be collected for a duration adequate to be representative of changes in pollutant concentrations and runoff flows using one of the following techniques:
    - Time-weighted composites collected over the length of the storm event or the first 24 hour period whichever is shorter, composed of discrete samples, which may be collected through the use of automated equipment, or
    - Flow-weighted composites collected over the length of the storm event or a typical 24 hour period, whichever is shorter, which may be collected through the use of automated equipment, or
    - If automated compositing is not feasible, a composite sample may be collected using a minimum of 4 grab samples, collected during the first 24 hours of the stormwater discharge, or for the entire stormwater discharge if the storm event is less than 24 hours; and

All samples will be collected, transported, processed and analyzed in accordance with SWAMP protocols.

LABORATORY ANALYSIS

The required analyses are based upon the following four groupings of constituents:

1) Constituents contributing to the highest priority water quality conditions identified in the San Diego River Watershed WQIP
2) Constituents listed as a cause for impairment of receiving waters in the San Diego River Watershed as listed on the 303(d) list
3) Constituents for implementation plans or load reduction plans (e.g., Bacteria Load Reduction Plans, Comprehensive Load Reduction Plans) developed for the San Diego River Watershed where the Copermittees are listed as responsible parties under a TMDL
4) Applicable stormwater action level (SAL) constituents listed in Provision C.2 of the Permit.

Attachment A details the analyses required for wet weather storm drain outfall monitoring, including corresponding target reporting limits and suggested analytical methods. Equivalent analytical methods may be substituted for those listed in Attachment A. Analytes that are field measured are not required to be analyzed by a laboratory. Per Provision 2.i.(3)in Attachment B of the Permit, all chemical and bacterial analysis of samples will be performed by laboratory(ies) certified for such analyses by the California Department of Public Health or laboratory(ies) approved by the San Diego Water Board.. All sampling, analysis and quality assurance/quality control will be conducted in accordance with the Quality Assurance Management Plan (QAMP) for the State of California's SWAMP, adopted by the State Water Board.

STORM DRAIN OUTFALL ASSESSMENT AND REPORTING

San Diego River Watershed Copermittees will evaluate dry and wet weather storm drain data collected pursuant Permit Provisions D.2.b and D.2.c as outlined in Provision D.4.b. Assessments required for the WQIP Annual Reports are presented in Section 4.1. Assessments required for inclusion in the Report of Waste Discharge (ROWD) in Section 4.2.4.

WQIP ANNUAL REPORT ASSESSMENTS

The STORM DRAIN outfall discharge assessments include evaluating both the dry weather monitoring data associated with the IDDE program collected as part of the Jurisdictional Runoff Management Program (JRMP) and wet and dry weather storm drain outfall monitoring data collected by the Copermittees as described in Sections 2 and 3 above. Details of the wet and dry weather storm drain outfall assessments are provided below. The San Diego River Watershed Copermittee will report the results in the San Diego River Watershed WQIP Annual Report.

DRY WEATHER STORM DRAIN OUTFALL ASSESSMENTS

Each Copermittee must assess and report the progress of its IDDE program (required pursuant to Permit Provision E.2) toward effectively prohibiting non-stormwater and illicit discharges into the storm drains within its jurisdiction. Additionally, each Copermittee will assess its dry weather storm drain outfall monitoring data and provide results annually for inclusion in the San Diego River Watershed WQIP Annual Report. The following dry weather storm drain outfall assessments

are required per Provision D.4.b.(1) of the Permit (a summary of the assessments is provided in Table 4-1).

- Identify sources of non-stormwater discharges.
  - Identify the known and suspected controllable sources (e.g., facilities, areas, land uses, and pollutant generating activities) of transient and persistent flows within each Copermittee's jurisdiction in the San Diego River Watershed.
  - Identify sources of transient and persistent flows within each Copermittee's jurisdiction in the San Diego River Watershed that have been reduced or eliminated.
  - Identify modifications of the field screening monitoring locations and frequencies for the storm drain outfalls in each Copermittee's inventory necessary to identify and eliminate sources of persistent flow non-stormwater discharges (Provision D.2.b).
  - The JRMP Annual Report will be used to guide this assessment in the WQIP Annual Report. Known and suspected sources will be identified during the implementation of JRMP activities. These activities include the facility inspections that complement the IDDE program and information gathered by the stormwater hotline or other public complaints. The JRMP Annual Report now consists of a one-page form that summarizes the JRMP activities in Attachment D of the Permit, along with supporting information. Section IV of the JRMP Annual Report Form summarizes the findings of the IDDE Program. The back-up that will be provided along with the form may include the following information to help identify sources:
    - Identify the subPermit of the source or complaint
    - Identify the potential receiving water of the source or complaint
    - Identify the potential pollutant or pollutant category that could be contributed by the source or complaint
- Rank and prioritize non-stormwater discharges.
  - Based on the data collected and applicable numeric action levels described in San Diego River Watershed WQIP, the Copermittees must rank the persistently flowing major outfalls in their jurisdictions according to the potential threat to receiving water quality and produce a prioritized list of major storm drain outfalls. The WQIP will be updated annually on the basis of these findings and with the goal of implementing (in the order of the ranked priority list) targeted programmatic actions and source investigations to eliminate persistent non-stormwater discharges and/or pollutant loads. The list will be reprioritized according to one or more of the following criteria (Provision D.2.b.(2)(b)(ii)):
    - The non-stormwater discharges have been effectively eliminated (i.e., there is no flowing, pooled, or ponded water) for three consecutive dry weather monitoring events.
    - The sources of the persistent flows have been identified as a category of non-stormwater discharges that do not require an NPDES permit and do not have to be addressed as an illicit discharge because they were not identified as sources of pollutants (i.e., the constituents in the non-stormwater discharge do not exceed numeric action level) and the persistent flow can be reprioritized to a lower priority.

    - The constituents in the persistent flow non-stormwater discharge do not exceed NALs (Provision C.1).
    - The source(s) of the persistent flows has (have) been identified as a non-stormwater discharge authorized by a separate NPDES permit.
  - Where these criteria have not been met but the threat to water quality has been reduced by the Copermittee, the highest priority persistent flow storm drain outfall monitoring stations may be reprioritized accordingly for continued dry weather storm drain outfall discharge field screening monitoring as part of the Dry Weather Storm Drain Outfall Discharge Field Screening Program.
  - Each Copermittee must document removal or reprioritization of the highest priority persistent flow storm drain outfall monitoring stations identified under the Non-Stormwater Persistent Flow Storm Drain Outfall Discharge Monitoring Program in the WQIP Annual Report. When a Copermittee removes a persistent flow storm drain outfall monitoring station, it will be replaced with the next highest prioritized major storm drain outfall designated by that jurisdiction in the San Diego River Watershed. If there are no remaining qualifying major storm drain outfalls within its jurisdiction, the number of major storm drain outfalls monitored will be reduced.
- Identify sources contributing to NAL exceedances.
  - For the highest priority major storm drain outfalls with persistent flows that exceed NALs (Provision C1.), each Copermittee must identify the known and suspected sources within its jurisdiction in the San Diego River Watershed that may cause or contribute to the numeric action limit exceedances and report them annually.
- Estimate volumes and loads of non-stormwater discharges.
  - Annually, each Copermittee must (1) analyze the data collected as part of the Non-Stormwater Persistent Flow storm drain Outfall Discharge Monitoring Program from the highest priority major storm drain outfalls, and (2) use a model or another method to calculate or estimate and report the non-stormwater volumes and pollutant loads collectively discharged from all the major storm drains outfalls in its jurisdiction that have persistent dry weather flows during the monitoring year. These calculations or estimates must include:
    - The percent contribution from each known source for each storm drain outfall
    - The annual non-stormwater volumes and pollutant loads collectively discharged from the Copermittee's major storm drain outfalls to receiving waters within the Copermittee's jurisdiction
    - The annual volumes and pollutant loads for sources of non-stormwater not subject to the Copermittee's legal authority that are discharged from the Copermittee's major storm drain outfalls to downstream receiving waters

Table 4-1. Annual Dry Weather STORM DRAIN Outfall Assessments

Assessment	Components	Reporting
Identify known and suspected controllable sources	Identify known and suspected controllable sources (e.g., facilities, areas, land uses, pollutant generating activities) of transient and persistent flows	Provide annually in WQIP Annual Report
Identify sources that have been reduced or eliminated	Identify sources of transient and persistent flows that have been reduced or eliminated	
Identify necessary modifications to monitoring locations and frequencies	Identify necessary modifications to monitoring locations and frequencies necessary to identify and eliminate sources of persistent flows	
Rank and prioritize non-stormwater discharges	Rank persistently flowing outfalls according to potential threat to receiving water quality	
	Produce/update prioritized list of outfalls	
Identify sources contributing to NAL exceedances	Identify known and suspected sources that may cause or contribute to exceedances	
Estimate volumes and loads of non-stormwater discharges	Analyze data collected as part of the Permit-required dry weather outfall monitoring	
	Use a model or other method to calculate and estimate collective persistent non-stormwater discharge volumes and pollutant loads. Specific calculations/estimates include: 1) Annual non-stormwater volumes and loads discharged from the Copermittee's major storm drain outfalls to receiving waters within its jurisdiction, with an estimate of the percent contribution from each known source for each storm drain outfall 2) Annual identification and quantification (by volume and pollutant load) of sources of discharged non-stormwater not subject to the Copermittee's legal authority	
Evaluate progress in achieving non-stormwater volume and load reductions	Identify reductions and progress in achieving reductions	Provide at minimum once during Permit cycle in WQIP Annual Report
	Assess the effectiveness of WQIP improvement strategies, with estimates of volume and load reductions attributed to specific strategies when possible	
	Identify modifications necessary to increase the effectiveness of WQIP strategies	
Identify data gaps	Identify data gaps in the monitoring data necessary to fulfill assessment requirements	Provide annually in WQIP Annual Report

WET WEATHER OUTFALL ASSESSMENTS AND ILLICIT DISCHARGES

According to the Permit Provision D.4.b.(2), the Copermittees must assess and report the progress of the water quality improvement strategies implemented as part of the WQIP and the JRMP toward reducing pollutants in stormwater discharges from the storm drains. This is designated as the Wet Weather Storm Drain Outfall Discharge Monitoring Program. The assessment of this program will contain the elements provided below and summarized in Table 4-2.

The elements for assessment of this program include the following:

- Estimate volumes and loads of stormwater discharges.
  - Analyze data collected as part of the Wet Weather storm drain Outfall Discharge Monitoring Program. For each monitoring year, calculate or estimate the following:
    - The average stormwater runoff coefficient for each land use type within the San Diego River Watershed.
    - For storm events with measurable rainfall greater than 0.1 inch, the volume of stormwater and pollutant loads discharged from the monitored storm drain outfalls to receiving waters within the San Diego River Watershed.
    - The total flow volume and pollutant loadings discharged from each Copermittee's jurisdiction within the San Diego River Watershed over the course of the wet season, extrapolated from the data produced from the monitored storm drain outfalls.
    - For storm events with measurable rainfall greater than 0.1 inch, the percent contribution of stormwater volumes and pollutant loads discharged from the land use type within (1) each hydrologic subarea with a major storm drain outfall to receiving waters or (2) each major storm drain outfall to receiving waters.
- Evaluate WQIP analysis.
  - The Copermittees will evaluate the WQIP analysis on the basis of the wet weather storm drain outfall monitoring data collected and the applicable stormwater numeric action levels (Provision C.2). This evaluation will include analyzing and comparing the monitoring data collected as part of the wet weather storm drain outfall monitoring program to the analysis and assumptions used to develop the WQIP. This will include the water quality improvement strategies developed pursuant Provision B.3 of the Permit. Additionally, the Copermittees will evaluate whether those analyses and assumptions should be updated as a component of the adaptive management described in the WQIP.

Table 4-2. Annual Wet Weather Storm Drain Outfall Assessments

Assessment	Component	Reporting
Estimate loads and volumes	Calculate or estimate the average stormwater runoff coefficient for each land use type	Provide annually in WQIP Annual Report
	Calculate or estimate the volume of stormwater and pollutant loads discharged from each monitored storm drain outfall for each qualifying storm event	
	Calculate or estimate the total volume and pollutant load discharged from the Copermittee's jurisdiction over the course of the wet season	
	Calculate or estimate the percent contribution of stormwater volumes and pollutant loads discharged from each land use type within each hydrologic subarea with a major storm drain outfall or each major storm drain outfall for each qualifying storm event	
Evaluate WQIP analysis	Using data and applicable SALs, evaluate and compare data collected to the analyses and assumptions used to develop the WQIP	
	Evaluate whether analyses and assumptions should be updated as a component of the adaptive management efforts	
Evaluate progress in achieving stormwater pollutant reductions	Identify reductions and progress in achieving reductions from different land uses and/or drainage areas	Provide minimum once during Permit cycle in WQIP Annual Report
	Assess the effectiveness of WQIP improvement strategies, with estimates of volume and load reductions attributed to specific strategies when possible.	
	Identify modifications necessary to increase the effectiveness of WQIP strategies	
Identify data gaps	Identify data gaps in the monitoring data necessary to fulfill assessment requirements	Provide annually in WQIP Annual Report

Report of Waste Discharge Once Per Permit Cycle Assessments

Dry Weather STORM DRAIN Outfall Assessments

Progress in achieving non-stormwater volume and load reductions will be assessed based on the data collected under the dry weather storm drain outfall monitoring program and annual assessments at least once per Permit cycle as follows:

- Identify reductions and progress in achieving reductions in non-stormwater and illicit discharges to each Copermittee's storm drain system.

- Evaluate the effectiveness of the water quality improvement strategies being implemented toward reducing or eliminating non-stormwater and pollutant loads discharging from each Copermittee's storm drain to receiving waters, with an estimate of the volume and/or pollutant load reductions attributable to specific strategies, if possible.
- Identify modifications necessary to increase the effectiveness of the WQIP strategies being implemented toward reducing or eliminating non-stormwater and pollutant loads discharging from the storm drain to receiving waters.

Dry Weather STORM DRAIN Outfall Assessments

Progress in achieving stormwater pollutant reductions will be assessed based on the data collected under the wet weather storm drain outfall monitoring program and annual assessments at least once per Permit cycle as follows:

- Identify reductions and progress in achieving reductions in stormwater discharges to the Copermittee's storm drain system from different land uses and/or drainage areas
- Evaluate the effectiveness of the water quality improvement strategies being implemented toward reducing pollutants in stormwater discharging from the Copermittee's storm drain to receiving waters, with an estimate of the pollutant load reductions attributable to specific strategies, if possible
- Identify modifications necessary to increase the effectiveness of the WQIP strategies being implemented toward reducing pollutants discharging from the storm drain to receiving waters.

Data Management and Reporting

Data sharing templates have been developed to support reporting under previous Permit cycles. Copermittees may leverage existing data sharing templates in order to facilitate compilation of Watershed-wide datasets for assessment and reporting purposes. Data compiled should be CEDEN-compatible and contain the following categories of information:

- General site description
- Visual observations
- Field measurements
- Laboratory data

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Regional Water Quality Control Board, San Diego (Regional Board). 2007. Resolution No. R9-2007-0001, Waste Discharge Requirements for Discharges Of Urban Runoff fromthe Municipal Separate Storm Sewer Systems (Storm drains) Draining The Permits Of The County Of San Diego, The Incorporated Cities Of San Diego County, The San Diego Unified Port District, And The San Diego County Regional Airport Authority.

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REGIONAL BOARD. 2013. Resolution No. R9-2013-0001, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the STORM DRAINs Draining the Permit in the San Diego Region (Permit). May 14.

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ATTACHMENT A
FIELD OBSERVATION FORMS

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COUNTY OF SAN DIEGO
WATERSHED PROTECTION PROGRAM

DEPARTMENT OF PUBLIC WORKS
5510 OVERLAND AVE., SUITE 410
SAN DIEGO, CA 92123

SAMPLE

MS4 Outfall Visual Observation Field Datasheet

New Site? ☐ Yes ☐ No ☐ **Source Investigation Follow-up for**_____

General Site Description

Site ID				**Site Type**		**Sample Event ID**	
Location						**Sample Event Type**	
Date		**Time**		**Latitude**	° N (NAD83)	**HU**	
Staff		**TB Guide**		**Longitude**	° W (NAD83)	**HSA**	

Historical Outfall Dry Weather Flow Info: ☐ Unknown ☐ Persistent ☐ Transient ☐ Dry

Conveyance (Check one only) ☐ Concrete Channel ☐ Natural Creek ☐ Earthen Channel ☐ Manhole ☐ Outfall ☐ Other_____

Flow Status ☐ Flowing ☐ Ponded ☐ Tidal ☐ Dry

Flow Reaches Receiving Water? ☐ Yes ☐ No

Non-Stormwater Flow Source? ☐ Yes ☐ No ☐ Unknown

Evidence of Obvious IC/ID?* ☐ Odor ☐ Color ☐ High Flow

***Requires immediate follow-up**

Outfall Structural Condition
☐ Normal
☐ Damaged
☐ Scour Pond
☐ Blockage

Potential Source ☐ Ground Water ☐ Irrigation Runoff ☐ Permitted Discharge
☐ Vehicle Washing ☐ Power Washing ☐ Pool/Spa Discharge ☐ Water Line Break
☐ Unknown ☐ Tidal ☐ Other_____

Was Flow Source Eliminated? ☐ Yes ☐ No
Notes:_____
_____

Weather ☐ Clear ☐ Partly Cloudy ☐ Overcast ☐ Fog
Last Rain ☐ > 72 hours ☐ < 72 hours but ≤ 0.1"
Tide ☐ N/A ☐ Low ☐ Incoming ☐ High ☐ Outgoing Tide Height_____ft.

Observations

Odor	☐ None	☐ Sewage	☐ Sulfides	☐ Petroleum	☐ Manure	☐ Other
Color	☐ None	☐ Yellow	☐ Brown (Silty)	☐ White (Milky)	☐ Gray	☐ Other
Clarity	☐ Clear	☐ Cloudy(>4" vis)	☐ Murky(<4" vis)			☐ Other
Floatables	☐ None	☐ Trash	☐ Bubbles/Foam	☐ Sheen ☐ Algae	☐ Biofilm	☐ Other
Deposit	☐ None	☐ Coarse Particulate	☐ Fine Particulate	☐ Stains/Minerals	☐ Oily Deposit	☐ Other
Vegetation	☐ None	☐ Limited	☐ Normal	☐ Excessive		☐ Other
Biology	☐ None	☐ Insects	☐ Algae ☐ Snails	☐ Fish	☐ Birds ☐ Cray Fish	☐ Other

MS4 Outfall Flow Estimate

Width		ft
Depth		ft
Velocity		ft/sec
Length of Ponded Area		ft

Flowing Pipe Diameter _____ft. Depth_____ft. Velocity_____ft/sec
Bottle Fill Volume_____ml Time to Fill_____seconds
Leaf Float Distance_____ft. Time_____seconds

Estimated Flow Rate _____ ☐ cfs ☐ gpm

Trash Present? ☐ Yes ☐ No **Trash Assessment** ☐ High (>400 pieces) ☐ Medium (50 to 400 pieces) ☐ Low (<50 pieces)
Evidence of Illegal Dumping ☐ Yes ☐ No **Evidence of Illegal Connection** ☐ Yes ☐ No
Accessibility ☐ Easy ☐ Moderate ☐ Difficult ☐ Critical Habitat

Comments:_____

COUNTY OF SAN DIEGO
WATERSHED PROTECTION PROGRAM

DEPARTMENT OF PUBLIC WORKS
5510 OVERLAND AVE., SUITE 410
SAN DIEGO, CA 92123

Site Type: VOM (Visual Outfall Monitoring) – For sites that are within the visual outfall monitoring program.
A, B, C, D… (Source Investigation) – For locations that are aimed at source follow-up investigations.

Sample Event Type: Visual Observation
Confirmation
Source Investigation
Duplicate
Blank
Lab Standard

Watersheds

Hydro. Unit	Watershed
902	Santa Margarita River
903	San Luis Rey River
904	Carlsbad Management Area
905	San Dieguito River
906	Los Penasquitos
907	San Diego River
908	Pueblo San Diego
909	Sweetwater River
910	Otay River
911	Tijuana River

COUNTY OF SAN DIEGO
WATERSHED PROTECTION PROGRAM

DEPARTMENT OF PUBLIC WORKS
5510 OVERLAND AVE., SUITE 410
SAN DIEGO, CA 92123

SAMPLE

MS4 Outfall Inventory Field Datasheet

GENERAL SITE DESCRIPTION

New Site? ☐ Yes ☐ No

Site ID				**Site Type**		**Sample Event ID**	
Location						**Sample Event Type**	
Date		**Time**		**Latitude**	° N (NAD83)	**HU**	
Staff		**TB Guide**		**Longitude**	° W (NAD83)	**HSA**	
Outfall Drainage Area			**Acres**				

Accessibility ☐ Easy ☐ Moderate ☐ Difficult ☐ Critical Habitat
☐Barbed wire fence ☐ Other fence ☐ County Gate ☐Steep hillside ☐Behind house/building ☐Under bridge ☐ Other_____

Historical Outfall Dry Weather Flow Info: ☐ Unknown ☐ Persistent ☐ Transient ☐ Dry

OUTFALL DESCRIPTION

OUTFALL	MATERIAL	SHAPE		DIMENSIONS	SUBMERGED
☐ **Closed Pipe**	☐ RCP ☐ CMP ☐ PVC ☐ CPP ☐ Steel ☐ HDPE ☐ Other _____	☐ Circular ☐ Elliptical ☐ Box ☐ Other _____	☐ Single ☐ Double ☐ Triple ☐ Other _____	Diameter: _____inches Dimensions:_____inches by_____inches Diameter: (If different sized outfalls)_____inches	In water: ☐ No ☐ Partially ☐ Fully With sediment: ☐ No ☐ Partially ☐ Fully
☐ **Open Channel**	☐ Concrete ☐ Earthen ☐ Rip-rap ☐ Other: _____	☐ Trapezoid ☐ Parabolic ☐ Other _____		Depth: _____feet Top width: _____feet Bottom width: _____feet	
☐ **Man Hole access (only if outfall is not accessible)**	☐ RCP ☐ Other _____	☐ Circular ☐ Elliptical ☐ Box ☐ Other _____		Diameter/Dimensions: _____feet by_____feet	In water: ☐ No ☐ Partially ☐ Fully With sediment: ☐ No ☐ Partially ☐ Fully
Upstream Conveyance	☐ Natural Creek ☐ Concrete Channel ☐ Earthen Channel ☐ County MS4 pipe ☐ Private pipe (i.e. French drain, irrigation pipe, unknown pipe) ☐ Street Inlet ☐ Street drainage channel ☐ Gutters ☐ Curb drains ☐ Other _____				
Flow Status	☐ Flowing ☐ Ponded/Pooled ☐ Dry		**Flow Description** ☐ Trickle ☐ Moderate ☐ Substantial		
Does Flow Reaches Receiving Water?	☐ Yes ☐ No ☐ Unknown				
If no flow, indication of intermittent flows?	☐ None ☐ Minor ☐ Medium ☐ Significant Describe _____				
Flows Adjacent to Outfall (If present)	☐ Seepage ☐ Drain pipes ☐ Irrigation drainage ☐ Overland flow ☐ Other_____ Describe_____				
Outfall Condition	☐ Good ☐ Spalling, cracked, or chipped ☐ Heavily damaged ☐ Corrosion (i.e. rust) ☐ Other_____ ☐ Blockage, if so what %_____ and with what? ☐ Vegetation ☐ Sediment ☐ Rock ☐ Other_____ ☐ Refer for Cleaning				
Deposits/Stains	☐ Oily ☐ Flow line ☐ Minerals ☐ Paint ☐ Sediment ☐ Organics (i.e. algae) ☐ Other_____				
Vegetation around outfall	☐ Normal ☐ Limited ☐ Excessive ☐ Poison Oak ☐ Stinging Nettle ☐ Other_____				

Comments: _____

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ATTACHMENT B
FLOW MONITORING AND EQUIPMENT CALIBRATION PROCEDURES

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B FLOW MONITORING AND EQUIPMENT CALIBRATION PROCEDURES

This attachment describes potential methodologies and equipment that may be used to complete flow monitoring and field measurements for the Storm Drain Outfall Monitoring Program, as well as the installation and maintenance procedures.

Flow estimation and water quality sampling are dynamic processes which may require modification based on current site and channel conditions. Thus, the methodologies presented are subject to modification or substitution in order to meet the requirements of this monitoring program.

B.1 FLOW MONITORING

B.1.1 DRY WEATHER STORM DRAIN OUTFALL FLOW MONITORING

B.1.1.1 FIELD-BASED FLOW ESTIMATION

During non-stormwater screening and storm drain outfall monitoring, flow will be estimated visually and/or manually using one of the methodologies detailed in Section 3.2.2 of the National Pollutant Discharge Elimination System (NPDES) Storm Water Sampling Guidance Document (EPA-833-B-92-001; United States Environmental Protection Agency (USEPA), 1992). These methodologies include, but are not limited to the "float method" and the "bucket and stopwatch method".

B.1.1.2 EQUIPMENT-BASED FLOW ESTIMATION

Copermittees may choose to perform optional equipment-based flow monitoring of non-stormwater persistent flows. Equipment-based flow estimation procedures are described in Section B.1.2.1.

B.1.2 WET WEATHER STORM DRAIN OUTFALL FLOW MONITORING

During wet weather storm drain outfall monitoring, the flow rates and volumes will be measured or estimated from the storm drain outfalls. Flow rates will be measured or estimated in accordance with the NPDES Storm Water Sampling Guidance Document Section 3.2.1 (USEPA, 1992), or by another method proposed by the Copermittees that is acceptable to the San Diego RWQCB. Flow monitoring may need to be adapted specifically for tidally influenced sites.

B.1.2.1 EQUIPMENT-BASED FLOW ESTIMATION

Flow hydrograph and volume estimations will be captured utilizing estimated flow rates in accordance with the Section 3.2.1 of the USEPA document NPDES Storm Water Sampling Guidance Document (USEPA, 1992).

Measurement devices, sensor types, and equipment program settings will be selected on a site specific basis using best professional judgment. Due to flood control concerns typically associated with storm drain outfalls during storm events especially, a primary measurement device such as a

weir or flume is unlikely to be selected. Thus, a lower profile secondary flow measurement device, such as an area-velocity senor or bubbler pressure transducer, is recommended for flow estimation from storm drain outfalls.

Flow will be monitored at each site to determine the volume of runoff. Flow may be estimated with a Sigma 920 Flow Meter (or similar type device) with an area velocity sensor and pressure transducer (Figure B-1). An area velocity sensor measures water level and velocity. Flow will be calculated based on the cross sectional area of the pipe, level of water, slope, and velocity. Flow may also be estimated using a HOBO level logger (or similar type device) (Figure B-2). The HOBO level logger is a pressure transducer only, and the flow will be estimated based on the area of the pipe, level of water, and slope.

Field teams will mount equipment securely using best professional judgment. Sampler tubing and wiring will be routed through conduits that will be placed between the monitoring locations and the sampling equipment or enclosures. Above-ground instruments will be protected within a site equipment enclosure. Depending on site configuration, enclosures may be semi-permanent (installed before monitoring begins and removed only when the monitoring program ends) or temporary. Exposed conduit, intakes, and sensors will be securely fastened using stainless steel brackets, screws, and anchors (Figure B-3).

Figure B-1. Sigma 910 Flowmeter and Area/Velocity Pressure Sensor

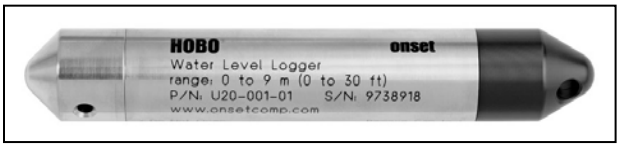

Figure B-2. HOBO Level Logger

Figure B-3. Example of Sensor Installation

The flow meter may be connected to an automated sampler through a 4-20 milliampere (mA) range output. In this configuration, the flow meter provides a method to control or pace the sampler, and store sampling data and other auxiliary data. The flow meter may measure and log estimated flow, rainfall, and sample history.

At each site, the pipe diameter and slope will be measured and recorded. Level and flow measurements will be logged at minimum 5-minute intervals for the duration of the monitoring event when using continuous logging devices. Data downloads will occur after the monitoring event is complete. Due to the velocities and potential for debris to be carried by storm flows, it is possible that the flow sensor may be damaged during storm flows. Damage to a flow sensor may result in a data gap of actual recorded flows. In this event, flows from the respective drainage area will be modeled for any data gaps based on the drainage area and impervious cover.

B.1.2.1.1 Data Downloads and Storage

All recorded flow data downloaded to a field computer will be immediately copied to a main office data server. The server will be backed up daily in accordance with standard server practices. Data will also be copied to project folders for QA review and approval prior to moving to the project file.

B.2 EQUIPMENT CALIBRATION

B.2.1 FIELD METER CALIBRATION

Calibration of all field meters will be conducted immediately prior to deployment or use. Water quality probes will be calibrated with specified calibration solutions, and it will be verified that the solution expiration date has not been exceeded. All calibrations will be conducted in accordance with the manufacturer's specifications.

B.2.2 FLOW EQUIPMENT CALIBRATION

Calibration of flow equipment will be conducted immediately prior to deployment or use using the procedures described in the corresponding operations and maintenance manual.

All level logging equipment will be calibrated on-site and field verified for accuracy with a level measurement tape.

B.2.3 AUTOSAMPLER CALIBRATION

Calibration of autosampling equipment will be conducted immediately prior to deployment or use using the procedures described in the corresponding operations and maintenance manual.

All autosampling equipment will be calibrated on-site and field verified for aliquot collection accuracy using a graduated flask or beaker.

B.3 REFERENCES

United States Environmental Protection Agency (USEPA). 1992. NPDES Storm Water Sampling Guidance Document Storm Water Sampling Guidance Document (EPA-833-B-92-001). July, 1992. Available online at: http://www.epa.gov/npdes/pubs/owm0093.pdf.

ATTACHMENT C
CHAIN-OF-CUSTODY FORM

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EXAMPLE - CHAIN-OF-CUSTODY FORM

Date: _____ ***Page*** ____ ***of*** ____

Analyzing Laboratory: _____

Project Name / Project Number

Project Manager / Contact

Client

Address

Phone / Fax / Email

Site ID (Location)	Sample ID	Date	Time	Matrix	Container Type / Volume	Total Number of Containers	Analysis / Test Requested								Preservation	Laboratory Use Only: Temp (C) Upon Receipt	Laboratory Use Only: Laboratory ID

Sample Matrix Code: FW = Freshwater; SW = Storm Water; SLT = Saltwater; SED = Sediment; BIO = Biologic; O = Other (Specify) _____

Container Code: G = Glass; P = Plastic; B = Bags; O = Other (Specify) _____

Shipped By: ☐ Courier ☐ FedEx ☐ UPS ☐ USPS ☐ Client Drop-Off ☐ Other _____

Turnaround Time: ☐ 2-day ☐ 5-day ☐ 7-day ☐ 10-day ☐ 14-day ☐ Standard ☐ Other _____

Reporting Requirements: ☐ PDF ☐ EDD ☐ Hard Copy ☐ Email ☐ Other _____

Sampled By:

Name (Print): _____

Signature: _____

Comments/Special Instructions:

Relinquished By				Received By			
Print Name	Signature	Firm	Date/Time	Print Name	Signature	Firm	Date/Time
1				1			
2				2			
3				3			
4				4			
5				5			

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ATTACHMENT D
LIST OF ANALYTES, SUGGESTED METHODS, AND TARGET REPORTING LIMITS

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Storm Drain Outfall Monitoring Analyte List

Analyte	Suggested Analytical Method*	Target Reporting Limit	Dry Weather Storm Drain Outfall Monitoring	Wet Weather Storm Drain Outfall Monitoring
Conventional Parameters				
Chloride	USEPA 300.0	0.5	X[4]	X[4]
Color	SM 2120B	3	X[4]	X[4]
Dissolved Oxygen	Meter	0.01	X[1,2,4,6C]	X[1,2,4,9]
pH	Meter	0.01	X[1,2,4,6B,6C]	X[1,2,4,9]
Specific Conductivity	Meter	1	X[1,2]	X[1,2,9]
Sulfates	USEPA 300.0	0.5	X[4]	X[4]
Temperature	Meter	0.1	X[1,2]	X[1,2,9]
Total Hardness	SM 2340B	0.662	X[7]	X[9]
Turbidity	Meter	0.1	X[1,2,6B,6C]	X[1,2,8,9]
Indicator Bacteria				
Enterococcus	SM 9230C	20	X[3,4,5,6A,6B,6C,7]	X[3,4,5,9]
Fecal Coliform	SM 9221E	20	X[3,4,5,6A,6B,6C,7]	X[3,4,5,9]
Total Coliform	SM 9221B	20	X[3,4,5,6A,7]	X[3,4,5,9]
Inorganic Analytes				
Cadmium (Dissolved)	USEPA 200.8	0.0001	X[6B,6C,7]	-
Cadmium (Total)	USEPA 200.8	0.0001	X[6B,6C,7]	X[8]
Chromium (Dissolved)	USEPA 200.8	0.0002	X[6B,6C,12]	-
Chromium (Total)	USEPA 200.8	0.0002	X[6B,6C,12]	-

Storm Drain Outfall Monitoring Analyte List (Continued)

Analyte	Suggested Analytical Method*	Target Reporting Limit	Dry Weather Storm Drain Outfall Monitoring	Wet Weather Storm Drain Outfall Monitoring
Chromium III (Dissolved)	Calculated from Chromium and Chromium VI	NA	X[6B,6C]	-
Chromium III (Total)	Calculated from Chromium and Chromium VI	NA	X[6B,6C]	-
Chromium VI (Dissolved)	USEPA 218.6	0.0003	X[6B,6C]	-
Chromium VI (Total)	USEPA 218.6	0.0003	X[6B,6C]	-
Copper (Dissolved)	USEPA 200.8	0.0005	X[6B,6C,7]	-
Copper (Total)	USEPA 200.8	0.0005	X[6B,6C,7]	X[8]
Iron (Dissolved)	USEPA 200.7	0.01	X[6C]	-
Iron (Total)	USEPA 200.7	0.01	X[6C]	-
Lead (Dissolved)	USEPA 200.8	0.0002	X[6B,6C,7]	-
Lead (Total)	USEPA 200.8	0.0002	X[6B,6C,7]	X[8]
Manganese (Dissolved)	USEPA 200.8	0.0002	X[4,6C]	X[4]
Manganese (Total)	USEPA 200.8	0.0002	X[4,6C]	X[4]
Nickel (Dissolved)	USEPA 200.8	0.0008	X[6B,6C]	-
Nickel (Total)	USEPA 200.8	0.0008	X[6B,6C]	-
Selenium (Dissolved)	USEPA 200.8	0.0002	X[4]	X[4]
Selenium (Total)	USEPA 200.8	0.0002	X[4]	X[4]

Storm Drain Outfall Monitoring Analyte List (Continued)

Analyte	Suggested Analytical Method*	Target Reporting Limit	Dry Weather Storm Drain Outfall Monitoring	Wet Weather Storm Drain Outfall Monitoring
Silver (Dissolved)	USEPA 200.8	0.0002	X[6B,6C]	-
Silver (Total)	USEPA 200.8	0.0002	X[6B,6C]	-
Zinc (Dissolved)	USEPA 200.8	0.005	X[6B,6C,7]	-
Zinc (Total)	USEPA 200.8	0.005	X[6B,6C,7]	X[8]
Nutrients				
Ammonia	USEPA 350.1	0.1	X[4,7]	X[4]
Dissolved Phosphorus	USEPA 365.1	0.01	X[4]	X[4]
Nitrate	USEPA 353.2	0.1	X[4,7,10]	X[4,8,11]
Nitrite	USEPA 353.2	0.1	X[4,7,10]	X[4,8,11]
Orthophosphate	USEPA 365.1	0.002	X[4,7]	X[4]
TKN	USEPA 351.2	0.1	X[4,7]	X[4]
Total Nitrogen	Calculated from TKN, Nitrate, and Nitrite	NA	X[4,5,6C]	X[4,5]
Total Phosphorus	USEPA 365.1	0.01	X[4,5,6C,7]	X[4,5,8]
Solid Parameters				
TDS	SM 2540C	10	X[4,7]	X[4]
TSS	SM 2540D	5	X[7]	-
Synthetic Organic Compounds				
MBAS	SM 5540C	0.05	X[6C]	-

NA = Not applicable; mL = milliliter; L = liter; D = day; H = hour; M = month

Storm Drain Outfall Monitoring Analyte List (Continued)

* The methods presented in the table are optional. Other equivalent EPA-approved methods may be substituted as long as the target reporting limits are met for the corresponding constituents

1. Parameter listed in Table D-2 of the Permit.
2. Analytes that are field measured are not required to be analyzed by a laboratory.
3. Parameter contributes to a highest priority water quality condition identified in the San Diego River Watershed Water Quality Improvement Plan.
4. Parameter listed as a cause for impairment of receiving waters in the San Diego River Watershed on the 303(d) list.
5. Parameter for CLRP developed for a TMDL in the San Diego River Watershed.

6A. Parameter listed in NALs for discharges from storm drains to Ocean Surf Zone (Permit Provision C.1.a(1))

6B. Parameter listed in NALs for discharges from storm drains to Bays, Harbors, and Lagoons/Estuaries (Permit Provision C.1.a(2))

6C. Parameter listed in NALs for discharges from storm drains to Inland Surface Waters (Permit Provision C.1.a(3))

7. Parameter listed in Table D-7 of the Permit.
8. Parameter listed in SALs for discharges from storm drains to receiving waters (Table C-5 of the Permit).
9. Grab samples may be collected for pH, temperature, specific conductivity, dissolved oxygen, turbidity, hardness, and indicator bacteria.
10. Nitrite and nitrate may be combined and reported as nitrite+nitrate.
11. Nitrite and nitrite will be reported as nitrite+nitrate.
12. Analysis of Chromium in storm drain discharges is not explicitly required in the permit. Chromium is analyzed to calculate Chromium III.

ATTACHMENT E
SAMPLE COLLECTION PROCEDURES

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E. SAMPLE COLLECTION PROCEDURES

This attachment describes the sampling procedures for the Storm Drain Outfall Monitoring Program.

E.1 DRY WEATHER STORM DRAIN OUTFALL SAMPLE COLLECTION

For dry weather monitoring events, the Copermittees will collect and analyze grab samples from each dry weather storm drain outfall discharge monitoring station to satisfy the requirements of the Permit. Analytes that are field measured are not required to be analyzed by a laboratory.

E.2 WET WEATHER STORM DRAIN OUTFALL SAMPLE COLLECTION

For wet weather monitoring events, the Copermittees will collect and analyze samples from each wet weather storm drain outfall discharge monitoring station to satisfy the following requirements in accordance with the Permit:

- Analytes that are field measured are not required to be analyzed by a laboratory;
- The Copermittees must implement consistent sample collection methods for regional comparability of data, unless site-specific conditions indicate the need for alternate methods;
- Grab samples may be collected for pH, temperature, specific conductivity, dissolved oxygen, turbidity, and indicator bacteria;
- For all other constituents, composite samples must be collected for a duration adequate to be representative of changes in pollutant concentrations and runoff flows using one of the following techniques:
    - Time-weighted composites collected over the length of the storm event or the first 24 hour period whichever is shorter, composed of discrete samples, which may be collected through the use of automated equipment, or
    - Flow-weighted composites collected over the length of the storm event or a typical 24 hour period, whichever is shorter, which may be collected through the use of automated equipment, or
    - If automated compositing is not feasible, a composite sample may be collected using a minimum of 4 grab samples, collected during the first 24 hours of the stormwater discharge, or for the entire stormwater discharge if the storm event is less than 24 hours; and
- Only one analysis of the composite of aliquots is required

To ensure the most consistent sample collection method for all sites, the Copermittees will collect a single time-weighted composite at each site. When unattended automated sampling is feasible, time-weighted composites will be collected over the length of the storm event or in the first 24 hour period, whichever is shorter, composed of discrete samples, which may be collected through the use of automated equipment set at the time intervals listed in Table E-1 based on the anticipated size of the storm.

Table E-1. Automated Sample Pacing for Time-Weighted Composites Per Storm Duration

Storm Duration (Hours)	Sample Aliquot Interval (Minutes)	Sample Volume (mL)	Total Sample Aliquots	Total Volume (mL)
2	10	800	12	9,600
4	10	800	24	19,200
6	10	400	36	14,400
8	10	400	48	19,200
12	10	400	72	28,800
16	20	400	48	19,200
20	20	400	60	24,000
24	20	400	72	28,800

mL = milliliter

When unattended automated sampling is not feasible (i.e., security or safety issues), a composite sample will be collected using a minimum of four grab samples, collected during the first 24 hours of the stormwater discharge, or for the entire stormwater discharge if the storm event is less than 24 hours at the time intervals listed in Table E-2 based on the anticipated size of the storm. Some variation may occur depending on the actual storm intensity and duration. After the storm event, the discrete samples will be composited into one time-weighted composite for chemistry analysis.

Table E-2. Grab Sample Pacing for Time-Weighted Composites Per Storm Duration

Storm Duration (Hours)	Sample Aliquot Interval (Minutes)	Sample Volume (mL)	Total Sample Aliquots	Total Volume (mL)
2	20	2,000	6	12,000
4	20	2,000	12	24,000
6	40	2,000	9	18,000
8	40	2,000	12	24,000
12	60	2,000	12	24,000
16	60	2,000	16	32,000
20	120	2,000	10	20,000
24	120	2,000	12	24,000

Automated samples for chemistry will be collected with a Sigma 900MAX autosampler (or similar type device). Teflon-lined tubing will be installed and secured at each monitoring location prior to the wet weather event. The autosampler will be deployed by the field team upon arrival at each site. Samples will be pumped with the autosampler into a clean glass bottle. The sample bottle will be appropriately labeled with the sample identifier (ID), date, and time, and will be preserved on ice for transport to the laboratory. After compositing, samples will be subsampled into the appropriate

bottles for analysis. Grab samples will be collected using either the Sigma 900MAX autosampler or a sample bottle connected to a sample pole that will be used to collect the sample directly from the outfall location. Nitrile or latex gloves will be worn during sample handling.

Bacteria samples and field measurements will not be taken from the composite sample; therefore, a grab sample will be collected for bacteria and field measurements during elevated flows. The grab sample will be collected after the second hour of stormwater runoff and before the sixth hour of stormwater runoff. If the stormwater runoff is less than 2 hours, the grab sample will be collected as close to the peak of flow as possible.

Bacteria samples will be collected using sterile techniques. Nitrile or latex type gloves will be worn during sample handling. During the sampling event, a 100-milliliter (mL) sterile bacteria bottle will be secured to a sample pole that will be used to collect the sample directly from the outfall location. Care will be employed to not allow contact with area structures or the bottom sediments. The container will be opened only for the needed time to collect the sample and will then be closed immediately following sample collection. If it is suspected that the container was compromised at any times, the sample container will be discarded, and a new sample will be collected with a new sample bottle. The sample bottle must be filled only to the 100-mL mark on the bottle (not over topped or under filled).

Field parameters will include hydrogen ion concentration (pH), conductivity, temperature, dissolved oxygen (DO), and turbidity. Samples will be collected and the measurements will be made using a YSI Inc. 6600 series water quality probe or similar type device. Calibration of the instruments will be conducted in accordance with Attachment D.

A field observation data sheet will be completed (Attachment A) for each sample collected to be representative of site conditions during each sample collection. Chain-of-custody (COC) documentation (Section E.3) will be completed, and samples will be delivered to the respective laboratory to allow for all applicable analyte holding times.

E.3 CHAIN-OF-CUSTODY PROCEDURES

Chain-of-custody (COC) procedures will be used for all samples throughout the collection, transport, and analytical process. A copy of a COC form is included in Attachment C. Samples will be considered to be in custody if they are: 1) in the custodian's possession or view, 2) retained in a secured place (under lock) with restricted access, or 3) placed in a container and secured with an official seal so that the sample cannot be reached without breaking the seal. The principal documents used to identify samples and to document possession will be COC records, field logbooks, and field tracking forms.

The COC procedures will be initiated during sample collection. A COC record will be provided with each sample or group of samples. Each person who had custody of the samples will sign the form and ensure that the samples were not left unattended unless properly secured. Documentation of sample handling and custody will include the following:

- Sample identifier.
- Sample collection date and time.

- Any special notations on sample characteristics or analysis.
- Initials of the person collecting the sample.
- Date the sample was sent to the analytical laboratory.
- Shipping company and waybill information.

Completed COC forms will be placed into a plastic envelope and kept inside the cooler containing the samples. Upon delivery to the analytical laboratory, the COC form will be signed by the person receiving the samples. COC records will be included in the final reports prepared by the analytical laboratories and will be considered an integral part of the laboratory report.

E.4 Health and Safety

Field sampling events have the potential for dangerous situations to arise. Field personnel need to be aware of safety hazards and take appropriate precautions. A health and safety tailgate meeting will be held prior to any on-site activity. During this meeting, site-specific hazards will be discussed and addressed appropriately. There are several health and safety issues that pertain to the proposed sampling and equipment installation within any areas.

E.4.1 Traffic Hazards and Traffic Control

Because this study is being conducted in residential areas, traffic control procedures must be employed. All traffic rules and regulations and all traffic control signs and devices should be obeyed. Field personnel should allow for extra time when planning travel routes. Vehicle traffic is a major concern during field monitoring activities. Traffic presents hazards when site workers are working close to roadways and the potential exists to be hit by oncoming traffic, and when driving to, from, and on the site. Driving during rain events also presents hazards as slick roadway conditions exist. It is recommended that safe speeds and distances be maintained to avoid rain-related accidents.

Whenever possible, field personnel should park as far off the road as possible to avoid interfering with any traffic flow and should comply with the following guidelines when working:

- Turn on the vehicle's flashing yellow warning light and hazard lights.
- Put out safety cones to mark off the work area.
- Place yellow barricade around open manhole to clearly mark the area.
- Avoid steep slopes and stream banks.
- Always use a flashlight in the dark.
- Always wear bright orange and reflective safety vests to be more visible.

E.4.2 Confined Space

Several monitoring locations for this project are located in the underground storm drain conveyance system. To install, maintain, and uninstall monitoring equipment within the storm drain conveyance system, confined space entry will need to be performed. Confined spaces are defined as any space with only one entry and exit point; therefore, an outfall is considered a confined space. To perform confined space entry, project personnel must have confined space

entry, attendant, and supervisor training, and must have their certificate card. Entering confined spaces presents many health and safety hazards if not performed properly. These hazards include asphyxiation, falls, burns, drowning, engulfment, toxic exposure, and electrocution. A confined space represents the potential for unusually high concentrations of contaminants, explosive atmospheres, limited visibility, physical injury, and restricted movement.

A five-gas meter will be used to monitor the atmosphere within the storm drain outfall prior to any personnel entering the system. If the outfall is unsafe for entry, field personnel may attempt to ventilate the space. If the outfall is still determined to be unsafe for entry, then no personnel will enter the outfall. Once the outfall has been determined to be safe for entry, the personnel may enter. A harness and retrieval system are used for personnel entering the system. When field personnel are in the outfall, continued air monitoring will occur to ensure that the atmosphere remains non-hazardous. Should air monitoring determine at any time that the air is becoming hazardous, field staff will immediately evacuate the confined space.

E.4.3 Weather Hazards

Installation and maintenance activities will be conducted during dry weather periods only. Though the San Diego region is generally mild during the fall season, the most likely safety issue related to weather is excessive heat. Extreme heat can adversely affect monitoring instrument response and reliability, respiratory protection performance, and chemical protective clothing materials. Standard precautions should be taken to mitigate heat exhaustion during field monitoring events.

Storm event monitoring will occur during wet weather. Wet weather conditions increase slipping and tripping hazards, braking distances of vehicles, and the potential for slippage or handling difficulties of field equipment. Rain fills holes and obscures trip-and-fall hazards. Tools and personnel can slip on wet surfaces. Rain and wet weather conditions may decrease visibility and increase the potential for driving accidents. Rain and high humidity may also limit the effectiveness of certain direct-reading instruments (e.g., photoionization detectors (PIDs)).

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ATTACHMENT F
QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

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F. QUALITY ASSURANCE / QUALITY CONTROL

F.1 FIELD QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance (QA) and quality control (QC) for sampling processes will include proper collection of the samples to minimize the possibility of contamination. All samples will be collected in laboratory-supplied, laboratory-certified, contaminant-free sample bottles. Field staff will wear powder-free nitrile gloves or a similar type of gloves at all times during sample collection.

Target measurement objectives for field quality control samples are provided in Table F-1

Table F-1. Field Quality Control Samples

Sample Type	Measurement Objective			Frequency of Analysis
	Field Duplicate	Field Blank	Equipment Blank	
Conventionals	RPD<25%[a]	<RL for target analyte	<RL for target analyte	Per batch of samples submitted to the laboratory[b]
Indicator Bacteria	RPD<25%[c]	Negative Response	Negative Response	Per batch of samples submitted to the laboratory[b]
Metals	RPD<25%[a]	<RL for target analyte	<RL for target analyte	Per batch of samples submitted to the laboratory[b]
Nutrients	RPD<25%[a]	<RL for target analyte	<RL for target analyte	Per batch of samples submitted to the laboratory[b]
Solid Parameters	RPD<25%[a]	<RL for target analyte	<RL for target analyte	Per batch of samples submitted to the laboratory[b]
Organics	Per method	<RL for target analyte	<RL for target analyte	Per batch of samples submitted to the laboratory[b]
Toxicity	NA	NA	NA	NA

Notes:
RL = reporting limit.
RPD = relative percent difference.
a. NA if native concentration of either sample<RL.
b. For equipment blanks, the frequency is 10% of the cleaned material. Equipment blanks are only analyzed for TOC and total metals per Section F.1.5
c. Field duplicates are not a current SWAMP requirement for indicator bacteria. However, the collection and analysis of a field duplicate is recommended.

F.1.1 TRAINING

All sampling personnel will be trained according to field sampling standard operating procedures (SOPs). Additionally, the field staff will be made aware of the significance of the project's detection limits and the requirement to avoid contamination of samples at all times.

F.1.2 Field Blank

A field blank will be collected and analyzed to assess contamination from field-related conditions to ensure that positive bias of the sample has not been introduced, and to remain in compliance with the Surface Water Ambient Monitoring Program (SWAMP) protocols. One field blank will accompany each batch of samples submitted to the analytical laboratory.

F.1.3 Field Duplicate

A duplicate sample may be collected and analyzed to assess the variability in sampling and to remain in compliance with the SWAMP protocols. One field duplicate will accompany each batch of samples submitted to the analytical laboratory.

F.1.4 Temperature Blank

A temperature blank will be used to ensure that sample holding temperatures were maintained from sample collection through delivery to the laboratory.

F.1.5 Equipment Blank

The selected analytical laboratory Teflon-lined tubing, silicone pump tubing, silicone bottle stoppers, and stainless steel sample intake strainers. The following blank samples will be created for analysis:

- One blank sample representative of the cleaned silicone and Teflon-lined tubing. Blank water will be passed through at least 10% of cleaned tubing and be representative of both silicone and Teflon-lined tubing.
- One blank representing the bottles and stoppers. Blank water will be passed into/over at least 10% of cleaned bottles and stoppers.

The analytical laboratory will analyze the equipment blanks for total organic carbon and total metals at a minimum. The analytical laboratories will analyze blank water from the cleaned sampling equipment at the same detection level proposed for sample analysis; this will verify that the sampling equipment in contact with sample water is clean and is not a likely source of contamination.

If a blank sample produces an analyte detection above the RL, the equipment will be cleaned and blanked again. Cleaned and blanked sampling equipment will not be deployed for sampling until an acceptable blank analysis has occurred unless directed by the Copermittees.

F.1.6 Inspection/Acceptance of Supplies and Consumables

Sample bottles (provided by the laboratory) and collection equipment will be inspected prior to their use. Procured supplies will be examined for damage prior to use per Table F-2.

Field supplies will be stored at the sampling team's offices; laboratory supplies will be stored at the laboratory. Inspection and testing requirements for laboratory supplies are covered in the laboratory's QA/QC procedures.

Table F-2. Inspection/Acceptance Testing Requirements for Consumables and Supplies

Project-Related Supplies/ Consumables	Inspection/ Testing Specifications/ Source	Acceptance Criteria	Frequency	Responsible Party
Pre-cleaned sample bottles	Closed bottle	Lids screwed on bottles	100%	Sampling Team
Silicone tubing	Laboratory cleaned	Pass blanking analysis	New tubing each season	Laboratory/Sampling Team
Teflon tubing	Laboratory cleaned	Pass blanking analysis	New tubing each season	Laboratory/Sampling Team
Gloves	New box	New box	As needed	Sampling Team

F.2 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

This section addresses QA/QC activities associated with laboratory analyses. Laboratory QA/QC samples provide information to assess potential laboratory contamination, analytical precision, and accuracy. Analytical quality assurance for this program includes the following:

- Employing analytical chemists trained in the procedures to be followed.
- Adherence to documented procedures, United States Environmental Protection Agency (USEPA) approved methods, and written Standard Operating Procedures (SOPs).
- Calibration of analytical instruments.
- Use of quality control samples, internal standards, surrogates, and Standard Reference Materials (SRMs).
- Complete documentation of sample tracking and analysis.

Internal laboratory quality control checks will include the use of laboratory replicates, method blanks, matrix spikes/matrix spike duplicates (MS/MSDs), and laboratory control samples (LCSs). The quality control checks performed by constituent class is presented in Table F-3. The frequency of the laboratory QA/QC samples will a minimum of once per batch per analyte unless otherwise adjusted by Copermittees.

Table F-3. Laboratory Quality Control Samples by Constituent Class

Laboratory Quality Control	Constituent Class							
	Conventionals	Indicator Bacteria	Inorganic Analytes	Nutrients	Solid Parameters	Acute Toxicity	Chronic Toxicity	Synthetic Organic Compounds
Calibration Standard	✓	–	✓	✓	–	–	–	–
Calibration Verification	✓	–	✓	✓	–	–	–	✓
Laboratory Blank	✓	✓	✓	✓	✓	–	–	✓
Reference Material	✓	–	✓	✓	–	–	–	✓
Matrix Spike	✓	–	✓	✓	–	–	–	✓
Matrix Spike Duplicate	✓	–	✓	✓	–	–	–	✓
Laboratory Duplicate	✓	✓	✓	✓	✓	–	–	–
Internal Standard	✓	–	✓	–	–	–	–	✓
Sterility Checks	–	✓	–	–	–	–	–	–
Laboratory Positive Control	–	✓	–	–	–	–	–	–
Laboratory Negative Control	–	✓	–	–	–	–	–	–
Laboratory Water Control	–		–	–	–	✓	✓	–
Conductivity/Salinity Control Water	–	–	–	–	–	✓	✓	–
Additional Control Water	–	–	–	–	–	✓	✓	–
Sediment Control	–	–	–	–	–	✓	✓	–
Reference Toxicant Tests	–	–	–	–	–	✓	✓	–
Tuning	–	–	–	–	–	–	–	✓
Surrogate	–	–	–	–	–	–	–	✓
Calibration	–	–	–	–	–	–	–	✓

F.2.1 Data Quality Objectives

Data quality objectives (DQOs) are quantitative and qualitative statements that define project objectives and specify the acceptable ranges of field sampling and laboratory performance. DQOs include accuracy, precision, and completeness.

Accuracy describes how close the measurement is to its true value. Accuracy is the measurement of a sample of known concentration and comparing the known value against the measured value. The accuracy of chemical measurements will be checked by performing tests on a standard prior to and/or during sample analysis. A standard is a known concentration of a certain solution. Standards can be purchased from chemical or scientific supply companies. Standards might also be prepared by a professional partner (e.g., a commercial or research laboratory). The concentrations

of the standards should be within the mid-range of the equipment. Recovery measurements are determined by spiking a replicate sample in the laboratory with a known concentration of the analyte. Accuracy of the project data will be determined by comparing results from MS/MSDs, LCSs, field blanks, and equipment blanks to the accuracy objectives to be developed by Copermittees.

Precision describes how well repeated measurements agree. The evaluation of precision described here applies to repeated measurements and samples collected in the field (field duplicates) or the laboratory (laboratory replicates and MS/MSDs). Precision measurements will be determined by comparing results from field duplicates, laboratory replicates and MSD to the precision objectives. Relative Percent Differences (RPDs) will be calculated to determine the precision between duplicate samples. This calculation is presented in Equation 1. Precision objectives will be developed by the Copermittees.

$$RPD = \frac{abs[x_1 - x_2]}{0.5 * (x_1 + x_2)} \qquad \text{Equation 1}$$

where:
abs is the absolute value.
x1 is measurement 1.
x2 is measurement 2.

Completeness is the fraction of planned data that must be collected to fulfill the statistical criteria of the project. There are no statistical criteria that require a certain percentage of data. However, the anticipated target is 90%. This accounts for adverse weather conditions, safety concerns, and equipment problems. The project team determined completeness by comparing the number of measurements planned to be collected with the number of measurements actually collected that are deemed valid. An invalid measurement would be one that does not meet the sampling method requirements. Completeness will be measured as a percentage of the number of samples collected that meet the respective DQOs compared to the anticipated number of samples. This calculation is presented in Equation 2.

$$Completeness = \frac{Actual\ number\ of\ samples\ collected}{\text{Pr}oject\ required\ total\ samples\ to\ be\ collected} * 100 \qquad \text{Equation 2}$$

F.2.2 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Laboratory equipment will be calibrated based on manufacturer recommendations and in accordance with the method and laboratory SOP. The laboratory SOP is maintained by the respective Laboratory Directors and QA officers, and is available upon request.

F.2.3 Corrective Action

Corrective action will be taken when an analysis is deemed suspect. Reasons a sample may be considered suspect consist of exceedances of the RPD ranges, spike recoveries, and blanks. The corrective action may vary from analysis to analysis, but typically will involve the following:

Check of procedures.

- Review of documents and calculations to identify possible errors.
- Error correction.
- Re-analysis of the sample extract, if available, to see if results can be improved.
- Reprocessing and re-analysis of additional sample material, if it is available.

Malfunctions that occur during data collection and laboratory analyses will be the responsibility of the field crew or laboratory conducting the work, respectively. In the case of field instruments, problems will be addressed through instrument cleaning, repair, or replacement of parts or the instrument, as warranted. Field crews should carry basic spare parts and consumables with them, and have access to spare parts. The laboratories have procedures in place to follow when failures occur, and have identified individuals responsible for corrective action and developed appropriate documentation as needed.

ATTACHMENT G
VOLUME AND LOAD ESTIMATE CALCULATIONS

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G. CALCULATION OF RUNOFF VOLUMES AND LOAD ESTIMATIONS FOR ASSESSMENT AND REPORTING

The methods to complete the wet weather storm drain outfall discharge monitoring assessment, as described in the Transitional Wet Weather Storm Drain Outfall Monitoring Work Plan prepared by Weston Solutions, are detailed in this section (Weston, 2014)

The assessment methods were formulated with the purpose of providing a means to calculate various parameters required by Section II.D.4.b.(2)(b) of the Permit based on the storm drain outfall wet weather monitoring data collected during the 2013-2014 and 2014-2015 wet seasons. Section II.D.4.b.(2)(b) of the Permit states:

(b) Based on the transitional wet weather storm drain outfall discharge monitoring required pursuant to Provision D.2.a.(3) the Copermittees must assess and report the following:

- (i) The Copermittees must analyze the monitoring data collected pursuant to Provision D.2.a.(3), and utilize a watershed model or other method, to calculate or estimate the following for each monitoring year:
  - [a] The average stormwater runoff coefficient for each land use type within the Watershed;
  - [b] The volume of stormwater and pollutant loads discharged from each of the Copermittee's monitored storm drain outfalls in its jurisdiction to receiving waters within the Watershed Management Area for each storm event with measurable rainfall greater than 0.1 inch;
  - [c] The total flow volume and pollutant loadings discharged from the Copermittee's jurisdiction within the Watershed Management Area over the course of the wet season, extrapolated from the data produced from the monitored storm drain outfalls; and
  - [d] The percent contribution of stormwater volumes and pollutant loads discharged from each land use type within each hydrologic subarea with a major storm drain outfall to receiving waters or within each major storm drain outfall to receiving waters in the Copermittee's jurisdiction within the Watershed for each storm event with measurable rainfall greater than 0.1 inch.
- (ii) Identify modifications to the wet weather storm drain outfall discharge monitoring locations and frequencies necessary to identify pollutants in stormwater discharges from the storm drain conveyance system in the Watershed Management Area pursuant to Provision D.2.c.(1) (RWQCB, 2013).

G.1 LAND USE CATEGORIZATION

Geographic information system (GIS) mapping software, in combination with data from the San Diego Geographic Information Source (SanGIS), will be used to determine the quantities of the various land use types within each monitored outfall drainage area. The SanGIS land use dataset has numerous land use classifications, and the assessment included categorizing the SanGIS land use classifications into several assessment land use categories. The correlations between SanGIS land use data and the assessment land use classes are shown in Table G-1. Table G-2 shows the assessment land use classes along with the San Diego Hydrology Manual (Hydrology Manual) land use types runoff coefficient (Runoff "C") values.

SanGIS land uses will be grouped into a minimum of four assessment categories listed by the Permit (e.g., Commercial, Industrial, Residential, and Mixed Land Use). The Commercial land use category will incorporate all "commercial" and most of the "public facility," "parking lot," and "commercial recreation" SanGIS classifications. The Industrial land use category will incorporate "industrial," "airport," "communications and utilities," and "terminal" SanGIS classifications. The Residential land use category will incorporate Rural Residential (1 to 4 dwelling units per acre (DU/A)), Single-Family Residential (4.3 to 20 DU/A), and Multi-Family Residential (>20 DU/A). The Multi-Family Residential land use categorization will incorporate high density housing types, such as barracks, dormitories, monasteries, and other group quarters. The Mixed Land Use classification will incorporate the SanGIS classes 9700 (mixed use). These additional land uses will include a combination of roads, parking areas, various types of impervious surfaces (tennis courts, buildings, sidewalks/paved areas), and less than 90% open space (maintained fields and undeveloped lands).

SanGIS land uses classes that are not easily grouped into one of the four main land use categories will be identified as "other" and will undergo further assessment. Two additional land use categories, Open Space and Agriculture, will be used to address less developed regions in San Diego County. In accordance with the Hydrology Manual (County of San Diego, 2003), these land uses will undergo a separate analysis based on the soil type and associated pervious Runoff "C" value.

The Open Space land use category will include open space, vacant and undeveloped land, parks and recreation, and most of the remaining military SanGIS land uses. Given that areas classified as water, bay, lagoon, lake, reservoir, and large pond would likely turn into a sink for runoff storage, water-related land use classifications (9200, 9201, and 9202) will be excluded from this analysis.

Traditionally, Transportation land uses were considered a unique land use classification. The Hydrology Manual does not include unique Runoff "Cs" for roads, freeways, right of ways, and other Transportation land uses. These SanGIS classes will be grouped into a Transportation land use category and assigned a Runoff "C" based on the approximate percentage of impervious cover and associated Runoff "C" listed in the Hydrology Manual.

Table G-1. Assessment Land Use Categories Developed from SanGIS Land Use Classes

Assessment Land Use Category	SanGIS Land Use Classification	
Agriculture	7204	Golf Course
	8001	Orchard or Vineyard
	8002	Intensive Agriculture
	8003	Field Crops
Commercial	1401	Jail/Prison
	1501	Hotel/Motel (Low-Rise)
	1502	Hotel/Motel (High-Rise)
	1503	Resort
	4111	Rail Station/Transit Center
	4114	Parking Lot - Surface
	4115	Parking Lot - Structure
	4116	Park and Ride Lot
	5001	Wholesale Trade
	5002	Regional Shopping Center
	5003	Community Shopping Center
	5004	Neighborhood Shopping Center
	5005	Specialty Commercial
	5006	Automobile Dealership
	5007	Arterial Commercial
	5008	Service Station
	5009	Other Retail Trade and Strip Commercial
	6001	Office (High-Rise)
	6002	Office (Low-Rise)
	6003	Government Office/Civic Center
	6101	Cemetery
	6102	Religious Facility
	6103	Library
	6104	Post Office
	6105	Fire/Police Station
	6108	Mission
	6109	Other Public Services
	6501	UCSD/VA Hospital/Balboa Hospital

Table G-1. Assessment Land Use Categories Developed from SanGIS Land Use Classes (Continued)

Assessment Land Use Category	SanGIS Land Use Classification	
Commercial (continued)	6502	Hospital - General
	6509	Other Health Care
	6807	School District Office
	7201	Tourist Attraction
	7202	Stadium/Arena
	7203	Racetrack
	7205	Golf Course Clubhouse
	7206	Convention Center
	7207	Marina
	7209	Casino
	9501	Residential Under Construction
	9502	Commercial Under Construction
	9504	Office Under Construction
	7208	Olympic Training Center
	7210	Other Recreation - High
	7607	Residential Recreation
Educational	6801	SDSU/CSU San Marcos/UCSD
	6802	Other University or College
	6803	Junior College
	6804	Senior High School
	6805	Junior High School or Middle School
	6806	Elementary School
	6809	Other School
	9505	School Under Construction

Table G-1. Assessment Land Use Categories Developed from SanGIS Land Use Classes (Continued)

Assessment Land Use Category	SanGIS Land Use Classification	
Industrial	2001	Heavy Industry
	2101	Industrial Park
	2103	Light Industry - General
	2104	Warehousing
	2105	Public Storage
	2201	Extractive Industry
	2301	Junkyard/Dump/Landfill
	4101	Commercial Airport
	4102	Military Airport
	4103	General Aviation Airport
	4104	Airstrip
	4113	Communications and Utilities
	4120	Marine Terminal
	9503	Industrial Under Construction
Transportation	4112	Freeway
	9507	Freeway Under Construction
	4117	Railroad Right of Way
	4118	Road Right of Way
	4119	Other Transportation
	9506	Road Under Construction
Mixed Use	9700	Mixed Use
Residential: Multi-Family	1200	Multi-Family Residential
	1280	Single Room Occupancy Units (SRO's)
	1290	Multi-Family Residential Without Units
	1300	Mobile Home Park
	1402	Dormitory
	1403	Military Barracks
	1404	Monastery
	1409	Other Group Quarters Facility

Table G-1. Assessment Land Use Categories Developed from SanGIS Land Use Classes (Continued)

Assessment Land Use Category	SanGIS Land Use Classification	
Residential: Rural	1000	Spaced Rural Residential
Residential: Single-Family	1100	Single Family Residential
	1110	Single Family Detached
	1110	Single Family Detached
	1120	Single Family Multiple-Units
	1190	Single Family Residential Without Units
Open Space	6701	Military Use
	6702	Military Training
	6703	Weapons Facility
	7211	Other Recreation - Low
	7601	Park - Active
	7603	Open Space Park or Preserve
	7604	Beach - Active
	7605	Beach - Passive
	7606	Landscape Open Space
	7609	Undevelopable Natural Area
	9101	Vacant and Undeveloped Land
Water	9200	Water
	9201	Bay or Lagoon
	9202	Lake/Reservoir/Large Pond
Source: SanGIS, 2014		

Table G-2. Assessment Land Use Hydrology Manual Runoff "C" Values

Land Use Type	Hydrology Manual Runoff "C"
Agriculture-A	0.2
Agriculture-B	0.25
Agriculture-C	0.3
Agriculture-D	0.35
Commercial	0.82
Educational	0.58
Industrial	0.87
Mixed Use	0.66
Multi-Family Residential	0.6
Open Space-A	0.2
Open Space-B	0.25
Open Space-C	0.3
Open Space-D	0.35
Rural-Residential	0.41
Single-Family Residential	0.49
Transportation	0.71

Source: County of San Diego, 2003

G.2 STORMWATER RUNOFF COEFFICIENT CALCULATIONS

Measured flow values will be used in combination with the hydrological features associated with the drainage areas of the monitored outfalls to calculate the average stormwater Runoff "C" for each land use type within the WMA. First, for each monitored outfall, the actual event Runoff "C" will be calculated based on outfall drainage area, rainfall, and measured flow. Next, the Hydrology Manual land use Runoff "C" values and overall outfall drainage area Hydrology Manual Runoff "C" value will be calculated based on the individual land use areas within each monitored outfall drainage area. For each monitored outfall, a correction factor will be calculated based on the comparison between the actual Runoff "C" value and the overall Hydrology Manual Runoff "C" value. The associated correction factor will be applied to the individual land use Runoff "C" values for each outfall. Finally, the WMA individual land use Runoff "C" values will be determined based on the area-weighted average of the monitored outfalls' individual land use Runoff "C" values. The steps in this process are discussed in more detail in the following paragraphs

The actual Runoff "C" for each outfall will be calculated based on the measured stormwater runoff, rainfall, and overall size of the drainage area. Flow equipment will be installed in each monitored outfall, except in rare cases where it is not feasible, in order to estimate the volume of stormwater runoff for the monitored event. Rainfall data for each event will be obtained from the County of San Diego Automatic Local Evaluation in Real Time (ALERT) System rain gauge database for the gauge nearest to the monitored outfall. The delineation of each monitored outfall drainage area will be performed by the responsible Copermittee. The actual Runoff "C" for each outfall will be calculated using the following formula:

$$Runoff\ "C"_{Outfall\ Actual} = \left(\frac{Monitored\ Storm\,Water\ Runoff\ Volume}{Area \times Rainfall} \right)_{Outfall} (UC)$$

Volume in cubic feet (ft3)
Area in acres
Rainfall in inches (in)

$$UC = Unit\ Conversion = \left(\frac{1\ ft}{12\ in} \right) \left(\frac{43{,}560\ ft^2}{1\ acre} \right)$$

The Hydrology Manual Runoff "C" for each monitored outfall will be selected based on the guidance found in Section 3 (Rational Method) of the Hydrology Manual. The area-weighted Hydrology Manual Runoff "C" for each monitored outfall will be calculated using the following formula:

$$Runoff\ "C"_{Outfall\ HM\ Calculated} = \frac{\sum \left(Area_{Outfall\ LU} \times HM\ Runoff\ "C"_{LU} \right)}{\sum Area_{Outfall\ LU}}$$

Where: LU = land use type
HM = Hydrology Manual

A Runoff "C" correction factor will be calculated for each monitored outfall using the following formula:

$$CF_{Outfall\ Runoff\ "C"} = \frac{Runoff\ "C"_{Outfall\ Actual}}{Runoff\ "C"_{Outfall\ HM\ Calculated}}$$

Where: CF = correction factor

For each monitored outfall, the calculated correction factor will be applied to the Hydrology Manual land use Runoff "C" values within the applicable drainage area as follows:

$$Runoff\ "C"_{Outfall\ LU} = CF_{Outfall\ Runoff\ "C"} \times Runoff\ "C"_{HM\ LU}$$

The land use type Runoff "C" calculation results for the monitored outfalls within the WMA will be compiled as follows to determine the WMA Runoff "C" value for each land use type:

$$Runoff\ \ "C"_{WMALU} = \frac{\sum\left(Runoff\ \ "C" \times Area\right)_{Outfall\ LU}}{\sum Area_{Outfall\ LU}}$$

Monitored Outfalls Annual Runoff Volumes and Pollutant Loads Calculations

The annual stormwater runoff volumes and pollutant loads discharged from monitored storm drain outfalls for storm events greater than 0.1 inch of measurable rainfall will be calculated using the actual Runoff "C" values, drainage area sizes, ALERT rain gauge data, and chemistry results obtained from the collection of stormwater samples during the 2013-2014 and 2014-2015 wet seasons. The actual Runoff "C" value and drainage area size for each monitored outfall will be determined as described in Section 5.2. Annual rainfall will be obtained from the ALERT rain gauge database for the gauge nearest to each monitored outfall. The rain gauge data will be analyzed, and rainfall values will be identified and excluded from the annual stormwater volume calculations when precipitation totals do not exceed 0.1 inch over a 24-hour period. The annual volume discharge from each monitored outfall will be calculated as follows:

$$Storm\,Water\,Volume_{Outfall} = \left(Runoff\ \ "C"_{Outfall\ Actual} \times Area_{Outfall}\right)\left(\sum Rainfall_{Event}\right)\left(UC\right)$$

Where:

$$UC = Unit\,Conversion = \left(\frac{1\ ft}{12\,in}\right)\left(\frac{43{,}560\ ft^2}{1\,acre}\right)$$

The pollutant loads discharged from each monitored storm drain outfall will be calculated based on the calculated annual volume and the chemistry results specific to each outfall as follows:

$$Pollutant\ Load_{Outfall} = \left(Storm\ \ Water\,Volume \times\ Pollutant\,Concentration\right)_{Outfall}\left(UC)\right)$$

Where:

$$UC = \left(\frac{28.317\ L}{1\ ft^3}\right)\left(\frac{1\,g}{1000\,mg}\right)\left(\frac{1\,lbs}{453.592\ _g}\right),\ for\ \frac{mg}{L}\ \ concentration\,units;$$

$$UC = \left(\frac{28.317\ L}{1\ ft^3}\right)\left(\frac{1\,g}{10^6\ \mu g}\right)\left(\frac{1\,lbs}{453.592\ _g}\right),\ for\ \frac{\mu g}{L}\ \ concentration\,units;\ or$$

Watershed Jurisdictional Annual Runoff Volumes and Pollutant Loads Calculations

The total flow volume and pollutant loads discharged from each Copermittee's jurisdiction within the watershed over the course of the wet season will be calculated based on the data produced from monitoring storm drain outfalls during the 2013-2014 and 2014-2015 wet seasons. The Watershed Runoff "C" values, calculated as described in Section 5.2, will be used in combination with land use

data and ALERT rain gauge data to calculate the total flow volume for each jurisdiction. The annual volumes will be applied to pollutant event mean concentrations (EMCs) in order to estimate the annual pollutant loads conveyed by the storm drain conveyance system in each Copermittee's jurisdiction. The EMC for each applicable pollutant will be determined by compiling the results from the outfalls monitored in the WMA. More details on the flow volume and pollutant load calculations are provided in the paragraphs that follow.

The total flow volume conveyed by each Copermittee's storm drain conveyance system will be calculated using the land use data, watershed land use type Runoff "C" values (see Section 5.2), and ALERT rain gauge data. GIS mapping software will be used to determine the quantities of the various land use types for each Copermittee by comparing the watershed boundary with the Copermittees' boundaries. The areas associated with hydrologic subareas (HSAs) without a major outfall will be included in the total area to calculate the assessment required by Section II.D.4.b.(2)(b)(i)[c]; however, an HSA without a major outfall will not be included in the assessment required by Section II.D.4.b.(2)(b)(i)[d].

Properties owned by state or federal agencies and indian reservations will also be excluded from the total jurisdictional watershed area. An ALERT rain gauge located within the watershed will be selected for the volume calculations. In the event that data from more than one ALERT gauge are available for the watershed, the ALERT gauge that has the most representative data related to the monitored outfalls will be selected (i.e., the station closest to the majority of monitored outfalls was selected to perform outfall-specific calculations for more of the outfalls and was also selected for watershed calculations). The ALERT data will be analyzed, and rainfall values will be identified and excluded from the calculations when precipitation totals do not exceed 0.1 inch of rainfall over a 24-hour period. The following formulas will be used to calculate the annual flow volume from each land use type and total flow volume within each Copermittee's jurisdiction in the watershed during the wet season:

$$Storm\ Water\ Volume_{WMA\ Jurisd\ LU} = \left(Runoff\ \ "C"_{WMA\ LU}\right)\left(Area_{WMA\ LU}\right)\left(\sum Rainfall_{Event}\right)\left(UC\right)$$

Where:

$$UC = \left(\frac{1\ ft}{12\ in}\right)\left(\frac{43{,}560\ ft^2}{1\ acre}\right)$$

$$Storm\ Water\ Volume_{WMA\ Jurisd,} = \sum Storm\ Water\ Volume_{WMA\ Jurisd\ LU}$$

The chemistry results obtained from analyzing samples collected at the monitored outfalls during the 2013-2014 and 2014-2015 wet seasons will be evaluated in order to estimate the watershed EMC values for the measured constituents for each general land use type assessed. This evaluation includes estimating each monitored outfall drainage area's EMC values for the measured constituents for each general land use type assessed. The monitored outfalls will be selected, where practical, to have a single primary land use type in order to facilitate the correlation between land use type and pollutant loading; however, due to the general mixed composition of urban development, the drainage areas of the monitored outfalls may typically consist of a combination of

land use types (e.g., primarily single-family residential with some commercial, open space, transportation.).

The correlation of measured pollutant concentrations to EMC values for various land use types, therefore, will incorporate the use of published, typical EMC values so that the measured chemistry results will be proportioned to the different land use types within each drainage area. The methods to proportion the measured chemistry results will be similar to the methods to determine the land use type Runoff "C" values (Section 5.2). The measured chemistry results will be the actual EMC values for each monitored outfall drainage area. Typical EMC values will be selected from the literature for each land use type for the measured constituents. The typical EMC values that will be selected are shown in Table 7. Typical overall or comingled EMC values will be calculated for each monitored outfall based on the weighted average of the outfall land use type Runoff "C" values and drainage area land use type areas. The actual EMC values (comingled chemistry results) of the monitored outfall will then be compared to the calculated, typical outfall EMC values in order to determine correction factors for each constituent. For each constituent, the correction factor will then be applied to the typical land use type EMC values for the associated monitored outfall drainage area. The WMA EMC values for the various land use types will be calculated based on corrected land use type EMCs of the monitored outfalls within the WMA, which are weighted by the product of the land use type Runoff "C" values and land use type areas. The following formulas will be used to complete these calculations:

$$EMC_{Outfall\ Actual} = Sampling\ \ Chemisty\ Result_{Outfall}$$

The overall or comingled outfall typical EMC for each measured constituent will be calculated using the following formula:

$$EMC_{Outfall\ Calculated} = \frac{\sum\left(Area_{Outfall\ LU} \times Runoff\ "C"_{Outfall\ LU} \times Typical\ EMC_{LU}\right)}{\sum\left(Area_{Outfall\ LU} \times Runoff\ "C"_{Outfall\ LU}\right)}$$

An EMC correction factor will be calculated for each constituent for each monitored outfall using the following formula:

$$CF_{Outfall\ EMC} = \frac{EMC_{Outfall\ Actual}}{EMC_{Outfall\ Calculated}}$$

For each monitored outfall for each constituent, the calculated EMC correction will be applied to the land use type typical EMC value as follows:

$$EMC_{Outfall\ LU} = CF_{Outfall\ EMC} \times Typical\ EMC_{LU}$$

The calculation results for the monitored outfalls within the watershed will be compiled to determine the EMC value for each constituent of each land use type assessed within the watershed.

$$EMC_{WMA\ LU} = \frac{\sum\left(Runoff\ "C" \times Area \times EMC\right)_{Outfall\ LU}}{\sum\left(Area \times Runoff\ "C"\right)_{Outfall\ LU}}$$

The total watershed pollutant load for each constituent within each jurisdiction will be calculated utilizing the follow the formula:

$$Pollutant\ Load_{WMA\ Jurisd,} = \sum \left(Storm\ Water\ Volume_{WMA\ Jurisd\ LU} \times EMC_{WMA\ LU} \times UC \right)$$

Where:

$$UC = \left(\frac{28.317\ L}{1\ ft^3} \right) \left(\frac{1\ g}{1000\ mg} \right) \left(\frac{1\ lbs}{453.592\ _g} \right),\ for\ \frac{mg}{L}\ concentration\ units;$$

$$UC = \left(\frac{28.317\ L}{1\ ft^3} \right) \left(\frac{1\ g}{10^6\ \mu g} \right) \left(\frac{1\ lbs}{453.592\ _g} \right),\ for\ \frac{\mu g}{L}\ concentration\ units;\ or$$

$$UC = \left(10\ \frac{100\ mL}{L} \right) \left(\frac{28.317\ L}{1\ ft^3} \right),\ for\ \frac{MPN}{100\ mL}\ EMC\ units;$$

G.3 REFERENCES

Weston, 2014. 2013-2014 and 2014-2014 Transitional Wet Weather Storm Drain Outfall Discharge Monitoring Work Plan. Prepared for San Diego County Regional Copermittees. October.

ATTACHMENT 4A-6: SAN DIEGO RIVER WATERSHED SURFER HEALTH STUDY

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FULL STUDY WORKPLAN:

Wet Weather Epidemiology Study and Quantitative Microbial Risk Assessment In San Diego, California

FINAL: October 20, 2014

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Problem Statement

Fecal indicator bacteria (FIB) such as *Enterococcus* are commonly used for monitoring water quality at marine recreational beaches. FIB do not cause human illness, but are used as indicators of human fecal contamination because they are found in sewage at high concentrations, are relatively easy and cheap to measure in the laboratory, and co-vary with the human pathogens found in sewage that do cause illness. Several epidemiology studies, almost exclusively conducted at beaches impacted by human fecal pollution, have demonstrated predictive relationships between FIB and swimming related illness. It is for this reason that FIB water quality objectives have been adopted for public health decision making at swimming beaches.

One important caveat to the use of FIB for public health decision making is that not all FIB come from human sources. FIB can arise from any warm blooded animals including dogs, cats, horses, and birds. However, the human pathogen content of these non-human sources is often lower than in human sources. Hence, the potential risk of illness from these sources can also be less. Regardless of the risk, water quality objectives currently remain the same regardless of fecal source.

Wet weather is particularly problematic for virtually all beach managers. Stormwater runoff has consistently high concentrations of FIB. Because of the dynamic nature of rainfall, runoff, and source locations, reducing FIB concentrations in stormwater discharges to attain existing water quality objectives is an extremely difficult and expensive proposition. However, most beach managers are uncertain if human sources exist in stormwater runoff, and, if present, what relative proportion of FIB is of human origin. If the relative human fecal contribution to stormwater is negligible, then existing water quality objectives may be over-protective (Soller et al, 2014).

The US EPA has recently promulgated revised national beach water quality criteria for FIB. One element of the new regulation is the option of using Quantitative Microbial Risk Assessment (QMRA) for establishing site-specific FIB water quality objectives. Similarly, California has existing regulatory options for altering FIB water quality objectives through the use of natural source (i.e., non-human) exclusions. However, neither QMRA nor natural source exclusions have been used previously for successfully creating a site-specific objective in California.

Purpose Statement

The purpose of this study is to evaluate the risk of illness after body contact recreation following storm events. If the risk is lower than expected based on current FIB water quality objectives, then options for new site-specific objectives that are equally protective as current water quality objectives will be developed. To accomplish this goal, this study will answer four questions:

(Q1) Is water contact associated with an increased rate of illness?

(Q2) Are illness rates greater following exposure to wet weather events compared to dry weather?

(Q3) What is the association between levels of *Enterococcus* and illness following wet

weather events?

(Q4) What level of *Enterococcus* corresponds to the same risk of illness as current water quality standards?

The questions build one upon the other; the approach to answering the next question is dependent upon the answer to the previous question.

General Study Approach

We will use a two-phased approach for this study. The first phase is an epidemiology study that will quantify the illness associated with body contact recreation following wet weather. Epidemiology studies have been used for decades to establish health standards. We will use a study design relatively similar to previous epidemiology studies in California and by the US EPA to set current water quality objectives. This first phase will address Q1, Q2, and Q3. However, this study will be unique in that this design has never been used at beaches specifically following storm events.

The second phase is a QMRA that will predict future risk of illness after body contact recreation following wet weather. QMRA studies have also been used for decades to establish benchmarks for human exposure to pathogens and other toxicants. We will use and build upon risk models recommended by the US EPA as part of their recent revised national beach water quality criteria. This second phase will address Q4. However, this study will be unique in that QMRA has not previously been attempted in California for the purposes of establishing a site specific criteria for recreational activities.

Together, these two phases will identify if there is an increased risk of illness from recreational water contact, if this illness is related to FIB concentrations, then identify options for FIB site-specific objectives that provides equivalent (or greater) health protections as the existing water quality objective.

Pilot Study Resolution of Three Key Issues

There are three key issues that require special consideration for our study approach. These include: a) using surfers as our target population; b) following individuals across multiple beach exposures, and; c) utilizing multiple beaches. We will target surfers as our body contact recreation users because they are the most abundant group of beach users in the winter. Sufficient sample size to make confident assessments of illness is a critical element of a successful epidemiology study. That is why previous epidemiology studies have focused on dry, summertime conditions when swimmers are most abundant. Swimming is relatively rare in San Diego during the winter, especially following wet weather events. In contrast, surfing can increase following wet weather conditions when wave conditions excel. Moreover, surfers are an important target population because they will have full-body water contact and frequent head underwater exposures. Higher levels of water exposure have consistently been associated with greater illness risk among swimmers.

Following surfers also requires an approach that examines multiple water contact exposures. Previous epidemiology studies have focused on one-time swimmers in order to isolate water exposure, but this approach is insufficient for surfers for three reasons. First, multiple exposures is a realistic scenario for wet weather users like surfers. Second, this approach provides us the opportunity to evaluate different sized storm events. Third, this approach allows us to increase effective sample size through the use of multiple water contact days. Longitudinal surveys (following an individual through time) allow not only comparisons among different surfers, but also comparisons within an individual surfer by comparing illness rates during periods following ocean contact with periods when they do not enter the ocean.

Following surfers also requires an approach that examines multiple beaches. Some surfers will visit different beaches to chase good waves, while others return to the same beach repeatedly. To accommodate these different utilization patterns, our study approach will prioritize beaches into two categories. The first category is a broad spectrum approach, which includes any beach in San Diego County to capture the range of beaches (and water exposures) encountered by surfers. Our second category is a fixed approach, which includes a pair of "sentinel" beaches for focused effort.

These three key issues were addressed in a Pilot Study completed in the winter of 2013-14. During this Pilot Study, we were able to demonstrate the feasibility and applicability of the study approach. We were able to recruit surfers into the study, utilize their multiple water contact exposures to our advantage in the study design, and quantify their rate of single vs. multi-beach exposures. We demonstrated that the study approach was capable of identifying changes in health effects in a surfing population that is exposed in wet and dry weather conditions. We will use the insights from the Pilot Study to ensure success of the full-scale study design, described by task, below. Moreover, the information about surfer exposure and illness from pilot study was so successful that we plan to incorporate all of the data into the main study results.

Specific Approach

This project will consist of five major tasks including: 1) creation of an Advisory Committee; 2) creation of a project Workplan; 3) epidemiology study; 4) QMRA study, and; 5) Reporting. The general task descriptions follow.

Task 1. Advisory Committee

Much of the technical work for this project is being conducted to address policy issues of great magnitude. It is important that this type of study be formulated, evaluated, and interpreted with policy relevance in mind. That is, the primary goal of this study is to fill the information gaps policy makers need to make the wisest decisions regarding public health protection and water quality regulation. Equally important, is the need to set precedence when implementing regulatory-based studies such as QMRA.

The goal of this task is to convene an Advisory Committee to provide guidance on both technical robustness and policy relevance. The Committee will be comprised of representatives from the following agencies and/or sectors, at a minimum:

- County of San Diego
- Environmental Advocacy Group
- San Diego Public Health Services
- Regional Water Quality Control Board
- State Water Resources Control Board
- US Environmental Protection Agency, Office of Science and Technology
- US Environmental Protection Agency, Region IX

The Advisory Committee shall meet for milestone specific decisions and guidance including:

- Study design development
- Workplan approval
- Epidemiology study review and interpretation
- QMRA study review and interpretation
- Contingency approval
- Oral presentation and Final report approval

Task 2. Workplan (This document)

The Study Team will prepare a Workplan that will detail each of the design elements and tasks. The workplan will include sampling locations, frequency and timing, laboratory methods, quality assurance and quality control, contingency plans, reporting requirements, and schedule. The workplan will be reviewed and approved by the project Advisory Committee.

Task 3. Epidemiology Study (Details: Appendix B)

We propose to conduct a prospective cohort based epidemiology study. The epidemiology study task will be divided into three subtasks: a) surfer recruitment and illness reporting; b) water quality sampling and analysis, and; c) data management and analysis.

Task 3a. Surfer recruitment and illness reporting

Surfer recruitment into the study is a key element of the epidemiology study because these individuals will form the basis of our illness evaluations. We will target a cohort of 22,000 person-days of exposure, or roughly 200 surfers followed longitudinally for 16 weeks. Based on the Pilot Study, this level of follow-up should provide comparable statistical confidence to previous epidemiology studies under assumptions of similar surfing and illness rates observed in the pilot study, and a similar number of storm events during the winter (which is conservative – 2013-14 winter was the driest in decades). This level of reporting and follow-up is very achievable, but is subject to variables such as quantity and timing of rainfall. Since our pilot study was so successful, we plan to incorporate all of the surfer exposure and illness information collected in the pilot study into the overall analysis of the full study.

To maximize surfer enrollment, we will develop smartphone applications and web sites with online consent forms. Online enrollment proved to be equally effective as placing staff on the beach with tablet computers during the Pilot Study. We also found that individuals enrolled online were highly similar to those we enrolled on the beach based on all measurable characteristics. We will still place staff members on the beach following storm events to help advertise (i.e., post cards or QR codes) the study and specifically ensure enrollment of post-storm surfers.

After enrollment, we will use weekly surveys to collect daily information about surfer marine water exposure activities and reported illness using incentivized mobile- and web- based data collection. Incentives may include Swell.com gift cards. The data entry for water exposure will include location, timing, duration, and volume estimate of water ingestion. The data entry for illness will include symptoms on gastrointestinal illness (nausea, cramps, vomiting), sinus pain/infections, ear pain/infections, eye infections, fever, infected cuts or scrapes, cough, congestion, and skin rash. The data entry will also include potential confounding factors such as food consumption or illness in the household, age, employment status, and household income. The data entry will also include economic impacts such as lost work or school days and doctor's visits. All data will be blind to surfer identity and the Office for the Protection of Human Subjects at the University of California, Berkeley will continue to oversee the study protocol.

Task 3b. Water quality sampling and laboratory analysis

Water quality sampling and laboratory analysis will focus on assessing exposure of surfers to FIB. FIB monitoring will mimic existing protocols used by the City of San Diego and San Diego County Department of Environmental Health, which sample beaches during the swimming season (April to October). Samples will be analyzed for *Enterococcus*, fecal and total coliforms (the same FIB as City and County monitoring programs). However, there will be three important differences between this study and routine monitoring programs. First, the samples will be collected during the wet season. Second, samples will be collected only at two sentinel beaches. Third, there will be more collection sites and times at the sentinel beaches than just those collected by the routine monitoring agencies.

The two sentinel beaches will include Tourmaline Surfing Park and Ocean Beach. These two beaches were evaluated in the Pilot Study and identified as appropriate for this project. These beaches met several important selection criteria including:

- Surfing location with numerous return users (local surfers)
- Northwest facing for good winter swell
- Creek, stream, or storm drain outlet nearby
- Ongoing FIB monitoring program
- Access and safety of crew, even in wet weather
- Proximity to microbiology laboratory

To ensure a robust assessment of surfer exposure, our monitoring design will include additional sites (at least one per beach) and enhanced frequency (daily) relative to the City and County routine monitoring design. One of these additional sites will be collected from the Ocean Beach Pier, located offshore in the line-up of surfers waiting for waves.

All FIB water quality data will be provided to the San Diego County Department of Environmental Health.

Task 3c. Data management and analysis

All data on recruitment, water contact, and water quality will be compiled for analysis. Three categories of analysis will be completed. The first analysis will quantify the relationship between surfer exposure and illness in subsequent time periods. By following a cohort of surfers over time, we will observe individuals during periods when they surf and recreate in marine water ("exposed periods") and during periods when they do not ("unexposed periods"). Comparing the rate of illness following exposed periods and unexposed periods will allow us to estimate the excess rate (if any) associated with surf exposure (question Q1). We will conduct an analogous analysis comparing water exposure during or following wet weather events to water exposure during dry weather and to periods of no water exposure (question Q2). Finally, the daily reports that surfers provide will enable us to match exposure with water quality data and quantify the association between FIB levels with subsequent surfer illness (question Q3).

Task 3d. Drought contingency

The Governor of California declared a drought emergency in early 2014. In southern California, annual rainfall totals have been below the long term average for three years in a row. Since this project is entirely contingent upon rain storms, a contingency plan is in place to maximize information collection if insufficient rain falls to sample our six planned storm events and optimum number of surfer exposure days. The contingency has three optional components, which are not mutually exclusive and can be used in combination. The decision to engage the contingency plan(s) will be made in consultation with the Advisory Committee. The three contingencies include:

1) extend the study for two additional weeks, until approximately April 15, utilizing the existing sampling plan. This contingency works well if recent wet weather has occurred or an approaching storm is imminent and we can easily and confidently capture additional post-storm sampling days.

2) if the daily concentrations are consistently and predictably low when not raining, reduce daily dry weather sampling to every other day and utilize these resources to extend the sampling until April 30, This contingency must make an assumption that water quality on unsampled days is comparable to sampled days. This contingency is most attractive if the near-term forecast is predicting an upcoming storm pattern. Since an additional four weeks of sampling is necessary, the decision to utilize this

contingency should occur approximately four weeks before the end of the study (February 28).

3) if the daily concentrations are consistently and predictably low when not raining, reduce daily dry weather sampling to every other day and utilize these resources to extend the sampling to a third beach. Like contingency 2, this contingency makes an assumption that water quality on unsampled days is comparable to sampled days. The third beach is La Jolla Shores, the next beach to meet all of our beach selection criteria. Inclusion of a third beach will also require the sampling of a third discharge to support the QMRA. Therefore, this decision will need to be made at least 8 weeks before the end of the study (January 30).

Task 4. QMRA (Details: Appendix D)

The goal of the QMRA task is to predict future risk of illness after body contact recreation following wet weather. The QMRA is linked, but separate from the epidemiology study for two reasons. First, the epidemiology study will be distributed across surfers countywide, but the QMRA (especially if it used for developing site-specific water quality objectives) needs to be focused at a single beach. Second, this study will be used to help set precedence for how to conduct a QMRA so that future site-specific water quality objectives have an example to follow. Undoubtedly, the issue of setting appropriate water quality objectives, particularly if the epidemiology study identifies reduced risk following wet weather relative to existing water quality standards, will continue well beyond this project.

Conceptually, QMRA risk modeling requires four pieces of information to estimate illness. Those pieces of information are pathogen concentration, volume of water ingested, a mathematical relationship between the number of pathogens ingested and infection, and the proportion of infections that result in illness. This QMRA study follows EPA's recommended procedures for using QMRA for developing site specific alternative water quality criteria (US EPA, in preparation) and will require three subtasks: a) Source identification and pathogen loading; b) Swimmer exposure; and c) Illness response modeling.

Task 4a. Source identification and Pathogen loading

The first task of the QMRA is to identify source(s) of fecal contamination and quantify the loading of pathogens and FIB to the waterbodies of interest. For this study, we are considering the watershed discharge as a "point source" and are using a study approach focused on quantification and confirmation.

The first step in this process is to conduct a sanitary characterization of the sentinel watersheds. EPA has developed and tested an approach specifically for the purpose of informing QMRA activities. We will use the EPA sanitary characterization template for each of our sentinel watersheds to identify and document the most likely sources of fecal contamination. The predominant source of contamination in a waterbody is important to understand because different sources (i.e. birds, humans, etc) can

contribute different relative levels of FIB and pathogens. These different contributions can result in relatively higher or lower risks at a specific level of FIB (Soller et al., 2010).

For quantification, we will sample wet weather discharges at the terminus of each watershed discharging to our sentinel beaches. Storm composite samples, approximately 20 L in volume, will be collected from Tourmaline Creek and San Diego River for a minimum of six storm events. Samples will be collected using automated sampling equipment that includes rainfall and flow sensors, as well as programmable peristaltic pumps. All pump tubing and sample bottles will be sterilized prior to each storm event. Each sample will be analyzed for host-specific markers, which may include other types of bacteria, genetic markers of host origin, chemical signatures, and direct pathogen measurements. The goal will be to understand the myriad of sources responsible for FIB and pathogens during wet weather. The hosts to be quantified include humans, birds, dogs, cattle, and horses. These sources and methods are consistent with the new Source Identification Project Protocol developed by SCCWRP and being promulgated by the State of California.

In addition to source tracking measurements, human pathogens will also be measured in wet weather watershed discharges. These measurements will include the 7 most common pathogens responsible for swimming related activities published by the Center for Disease Control (CDC). These pathogens are comprised of viruses (i.e., norovirus, adenovirus, enterovirus), bacteria (i.e., *Salmonella, Campylobacter*), and protozoans (i.e., *Giardia, Cryptosporidium*).

For confirmation, we will sample scats of non-human fecal contamination sources identified from the sanitary characterization and wet weather host marker analysis for human pathogens and FIB content. This will be especially important if non-human hosts are quantified and low levels of human pathogens are detected in the discharge. The number of scat samples required from these non-human host sources is a function of number of hosts, host density, proportion of host population with infection, and host pathogen concentration in the scats. Variation in any of these parameters will ultimately require more samples to attain the confidence necessary for confirming lack of pathogen loading.

Task 4b. Swimmer exposure

Once the pathogen load is quantified, the next step in the QMRA modeling is to quantify exposure. Exposure is a function of water ingestion rate including the frequency and duration of swimming (or surfing), along with pathogen concentration. Together, these factors provide the estimate of "dose". This portion of the QMRA will be inextricably linked to epidemiology study.

To estimate water ingestion, we will use the data from the epidemiology study to provide frequency and duration of exposure. These data will be used in conjunction with literature-based data on water ingestion rates to confirm that the site specific ingestion data are consistent with the data from the literature which are commonly used in QMRA.

Pathogen concentrations will initially be derived from watershed loads measured in the previous task (Task 4a). The Pilot Study indicated that discharge plume fate and transport played a significant role in the distribution of FIB following storm events. Therefore, we will incorporate two fate and transport models into this study to account for dispersion and advection of FIB and pathogens after the discharge enters the ocean. We intend to use two model approaches to assess the level of complexity necessary for future QMRA applications, either at additional beaches or at the sentinel beaches following some management action that involves changes in fate and transport. The first model will be a straightforward statistical model based upon monitoring data collected along the beach during surfer exposure immediately following storm events. These measurements will include FIB (e.g. sampled from the epidemiology study) and physical water quality parameters (i.e., temperature, salinity) measured at regular intervals upcoast and downcoast from the discharge. This type of model provides either measured point-in-time exposure during monitored events or estimates of average condition when combining time estimates.

The second model approach will be a mathematical computational model such as Qual2K, available from the US EPA. This model predicts shoreline FIB concentrations based on several parameters that drive advection and dispersion including watershed loading, wind strength and direction, wave height and direction, and bacterial decay. Watershed loading will be measured in the previous task, wind and wave data are available from local measurements through NOAA. Calibration and validation data will be derived from the shoreline physical water quality, surface currents from the Southern California Coastal Ocean Observing System, and FIB measurements used in the statistical model. This model can estimate exposure either point-in-time or average condition similar to the statistical model, but can also provide these estimates for unmeasured storm events, which will be useful if many events occur at our sentinel beaches or if one attempts a QMRA at another beach.

Task 4c. Illness response modeling

Illness-response modeling predicts the illness rates in swimmers (surfers) based on exposure, ingestion, and pathogen dose-response relationships. Exposure and ingestion will be estimated based on the previous task. As is commonplace in QMRA studies worldwide, we will use peer reviewed dose response relationships for this study. We will also use peer reviewed data from the scientific literature to characterize the proportion of infections that lead to illness for each of the reference pathogens. EPA has summarized the scientific literature and we will use that information as a basis for this work.

We will focus much of our illness modeling on sensitivity analysis using monte-carlo simulations. The sensitivity analysis will help us to assess if uncertainty or variability in the modeled parameters are important components of the risk modeling. The sensitivity analysis of illness rates will help to determine which model parameters (ingestion rate, fate and transport, pathogen concentration, dose-response relationship)

are the most critical factors, and then focus refinements in these assumptions for this (and future) QMRA interpretations.

More importantly, the sensitivity analysis will provide decision-makers with estimates of confidence in the risk analysis. This estimate of uncertainty is crucial for managers to determine if risks of swimming related illnesses are greater or less than existing predictions of illness rates based on commonly used FIB water quality objectives and if further consideration of regulatory options are warranted.

One way to capture the management response to the combination of epidemiology and QMRA results is captured in Figure 1. In this paradigm, managers will make some initial decisions based on a comparison of risk estimates from the empirical epidemiology results at the beach to the modeled QMRA risk estimates of undiluted stormwater discharge at the outfall:

- If both the epidemiology and QMRA indicate little to no risk, then managers can assume that an effort at site specific objectives dilution is likely productive.
- If the epidemiology results from the beach indicate little to no risk, but the QMRA at the outfall does indicate risk, then application of the study fate and transport models is the next management step. In this scenario, the epidemiology study may not have sufficient resolution to detect health risks this low, and the QMRA model will be the key to successful site specific objectives.
- If the epidemiology results from the beach indicate risk, but the QMRA at the outfall indicates little to no risk, then there are likely other sources of pathogens than just the storm discharge. In this management scenario, a site specific objective is unlikely until the additional source of pathogens is identified and removed.
- If both the epidemiology results from the beach and the QMRA at the outfall indicate risk, then application of the study fate and transport models are appropriate. In this management scenario, site specific objectives may be appropriate based upon the magnitude of risk and how well the model fits the empirical results.

As is evident from Figure 1, we are most concerned about the uncertainty due to fate and transport of FIB and pathogens once they enter the ocean. If the relationship between the epidemiology study and the QMRA are not comparable when both indicate an increased risk of illness, then we may utilize a "reverse QMRA". A reverse QMRA, used by EPA, utilizes illness estimates from the epidemiology study in conjunction with the results of the sanitary characterization to estimate the dilution distribution between the discharge point and the points of exposure.

Figure 1. Management response based on comparisons between epidemiology study and QMRA results

	Epi at the beach indicates little to no risk	**Epi at the beach indicates risk**
QMRA at the outfall indicates little to no risk	Site specific objectives likely	Potentially unmeasured sources of pathogens. Site specific objectives unlikely.
QMRA at the outfall indicates risk	QMRA may provide estimate of risk below levels sensitive enough to capture empirically. Site specific objectives likely	Apply fate and transport models to QMRA for improving risk quantifications. If unsuccessful, may use reverse QMRA. Site specific objective may be possible, depending upon level of risk and uncertainty.

Task 5. Reporting

This task will be comprised of four subtasks: a) quarterly reports; b) oral reports and presentations; c) draft final report, and; d) final report.

Task 5a. Quarterly reports

Reports providing brief progress updates to the funding agencies will be provided quarterly.

Task 5b. Oral reports and presentations

Oral reports and presentations will be provided to the Advisory Committee. Since Advisory Committee meetings are milestone driven, each presentation also serves as task summary. Oral presentations will be given to the funding agencies upon request. Following completion of the study, additional presentations at scientific conferences may also be given.

Task 5c. Draft final report

A draft Final Report will be prepared for review by the Advisory Committee. The Advisory Committee will review and approve the draft final report.

Task 5d. Final report

The final report will be published as a SCCWRP Technical Report and one or more Peer-reviewed publications in appropriate scientific journals.

Study Team

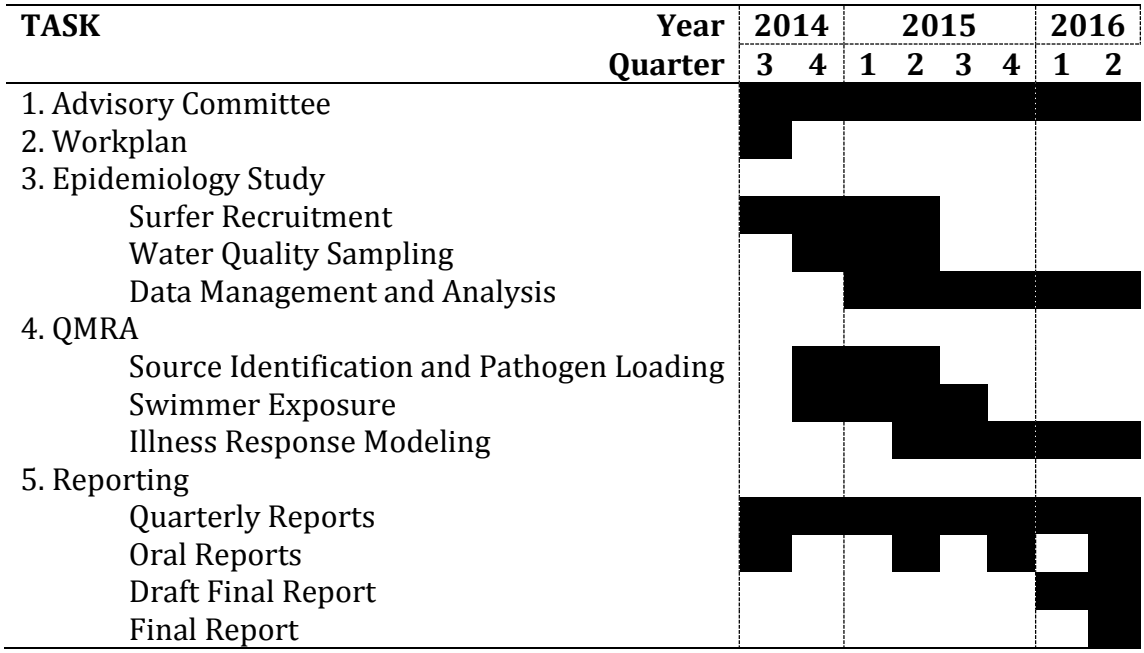
The study team for this proposed project consists of:

- Southern California Coastal Water Research Project (SCCWRP) is an international leader in beach water quality research, recently completing the State's Source Identification Project Plan and conducting the premier evaluation of genetic source

tracking tools. SCCWRP will be the Project Team Leader and will oversee all of the water quality sampling and analysis.

- UC Berkeley School of Public Health is an international leader in health effects studies for water contact recreation and drinking water. UC Berkeley has completed four epidemiology studies in southern California with SCCWRP including Mission Bay, Doheny State Beach, Avalon Bay, and Malibu Surfrider Beach. UC Berkeley will oversee the epidemiology study, with Professor Jack Colford as Principal Investigator.
- Soller Environmental is a private firm supporting the US EPA's development of QMRA guidance to accompany the recent beach water quality criteria. Soller is working with SCCWRP on a Clean Beach Initiative funded project to conduct a dry weather QMRA in California. Soller will oversee the QMRA.
- Surfrider Foundation is an internationally recognized non-profit grassroots organization dedicated to the protection and enjoyment of our world's oceans, waves and beaches. Surfrider will oversee the outreach and recruitment of surfers into the epidemiology study.

Schedule



Advisory Committee Schedule

(Meetings in bold)

Aug 2014 – Study plan design

Nov 2014 – Workplan approval

June-July 2015 Preliminary results from Epidemiology and QMRA studies

Nov-Dec 2015 Results from Epidemiology and QMRA studies

March 2016 Draft Final Report

June 2016 Final Report

Appendix A Study Sites

The study sites chosen were previously evaluated in the pilot study; Ocean Beach and Tourmaline Surfing Park (Fig 1). Both of these beaches fit the beach *a priori* selection criteria (see main workplan). Ocean Beach and Tourmaline Surfing Park both receive significant winter use by surfers as evidenced by survey responses during the pilot study (Fig 2). Both beaches receive stormwater discharges; Ocean Beach is adjacent to the San Diego River (Fig 3) and Tourmaline Surfing Park is adjacent to Tourmaline Creek. (Fig 4) Both beaches have many years of beach water quality monitoring by the San Diego County Department of Environmental Health and this science team monitored water quality daily at multiple locations at each beach and in the San Diego River (Figs 3,4), every day from January 15 -March 1 2014. Historically, water quality is best during the dry, AB411 beach season (Apr 1 – Oct 31) and exceedences of the State single sample water quality standard increase during the non-AB411 winter season (Nov 1 – Mar 31).

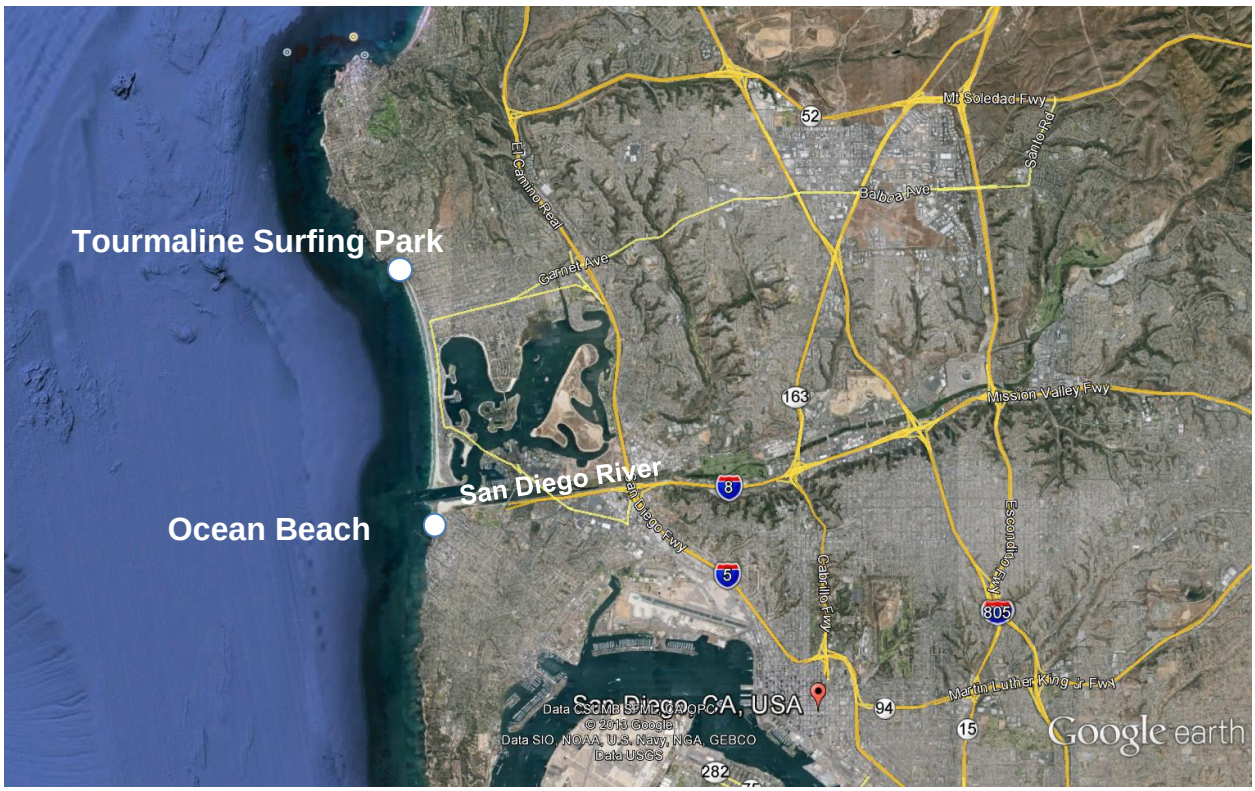


Figure 1. Overview map of study area including Ocean Beach and Tourmaline Surfing Park

While both beaches consistently met our *a priori* selection criteria, Ocean Beach and Tourmaline Surfing Park have important differences that make them useful for both the Surfer Health Epidemiology study and for the concurrent QMRA study. Ocean Beach is influenced by the San Diego River, a large (1,088 km^2), varied land use watershed, with many flow control structures (i.e., dams). Tourmaline Surfing Park is influenced by

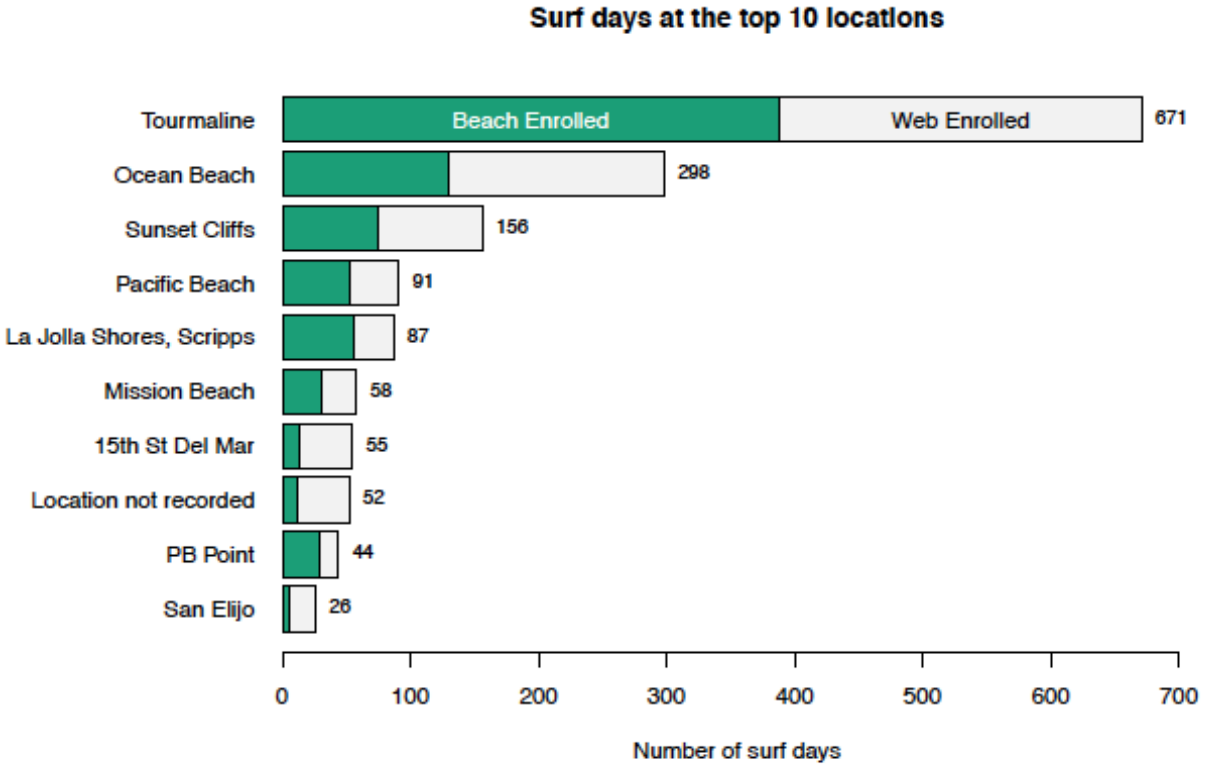


Figure 2. Survey responses indicating which break was most commonly surfed by surfers recruited during the Pilot Study. Green bars represent surfers enrolled on the beach, grey bars represent surfers enrolled on the internet.

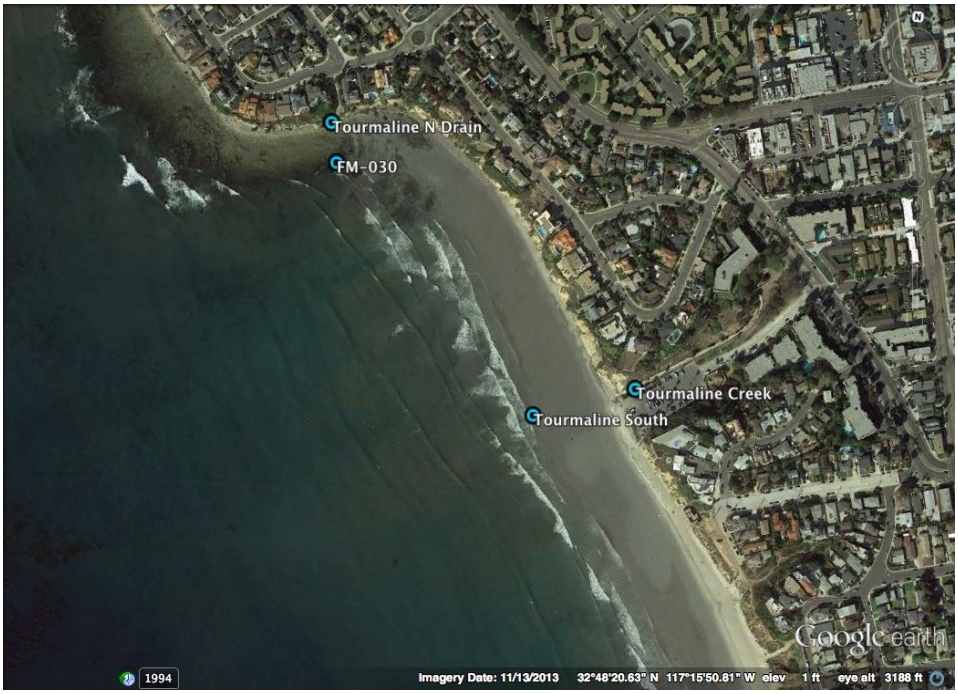
Tourmaline Creek, a much smaller (6 km^2), homogeneous land use (urban) watershed that is highly impervious with few flow control structures; it also has a small storm drain at the North end of the beach which drains the neighborhood immediately North of the bluffs and a small storm drain in between Tourmaline Creek and the Northernmost storm drain which drains the neighborhood immediately East of the bluffs.

Because of watershed imperviousness and flow control structures, the San Diego River will likely flow only during larger storms, but Tourmaline may flow during even the smallest of storms. Therefore, a greater number of days with wet-weather flows would occur at Tourmaline Surfing Park. However, the much larger volumes discharged from the San Diego River may impact the entire length of Ocean Beach or surrounding beaches, but the smaller discharge volumes at Tourmaline Creek may only impact portions of Tourmaline Surfing Park. Therefore, all concurrent surfers will likely receive a similar water quality exposure at Ocean Beach, but there may be differential exposure among concurrent surfers at Tourmaline Surfing Park based on size of storm, distance from creek mouth, tides, and prevailing ocean currents.

Tourmaline Creek and the San Diego River had exceedences of Fecal Indicator Bacteria during the February 2014 storm that occurred during the Pilot Study, but the San Diego River had a much higher and more consistent level of FIB, e.g. *Enterococcus* (Fig 5). Furthermore, the human fecal source markers (e.g. Bacteroidales HF183, Figure 5) were both higher at Ocean Beach compared to Tourmaline Surfing Park during the storm in late February-early March. Finally, surfers at Ocean Beach may be exposed to a greater number of pollution sources than surfers at Tourmaline Surfing Park because of the differences in land use composition between their respective watersheds.

Figure 3 Overview picture of Ocean Beach with sampling sites at the Beach, FM-010, PL-110, PL-100 and the Ocean Beach Pier site labeled.

Figure 4 Overview map of Tourmaline Surfing Park with sampling sites and discharge sites labeled.



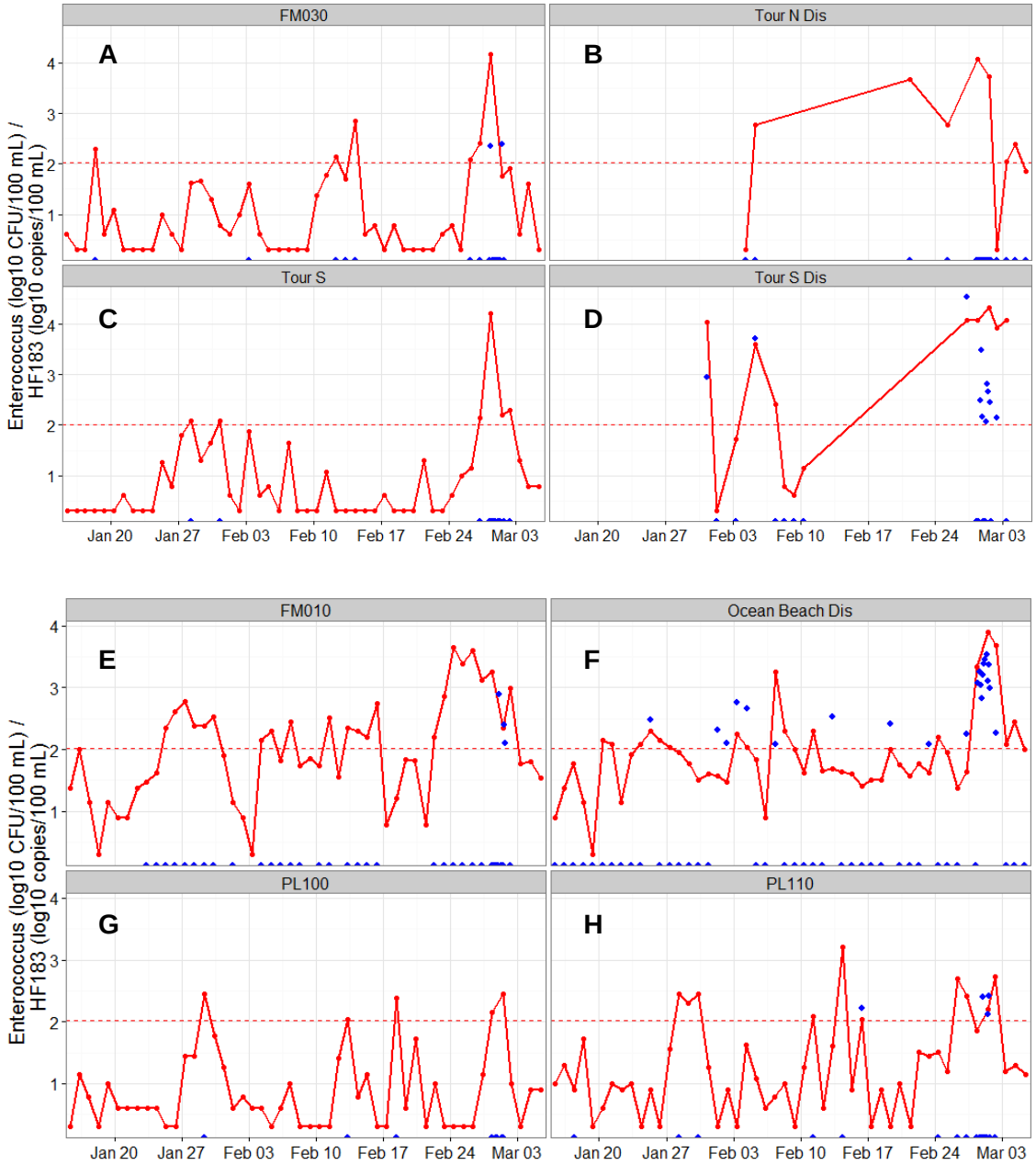


Figure 5. Enterococcus (red line) and human fecal marker (HF183, blue dots) at beach and discharge sites at Tourmaline Surfing Park (A-D) and Ocean Beach (E-H). The axis is in log CFU/100ml for *Enterococcus* and log copies/100ml for HF183.The dashed line indicates the single sample maximum for *Enterococcus.* Note: the break in the red line from panels B and D indicates that these storm drains did not flow during storms in February.

Appendix B Task 3: Epidemiology Study Details

Task 3a: Surfer Recruitment and Enrollment

Target population and inclusion criteria:
The epidemiology study will aim to enroll surfers in San Diego County who enter the ocean during the winter months. The rationale for focusing the study on surfers is that they are a segment of the population who consistently enters the ocean during the winter months and following wet weather events. Anecdotally, we expect this population to be predominantly male, and the study will focus enrollment on adults (details below). Our enrollment strategy and inclusion criteria are designed to help ensure that we enroll participants who fit this profile.

The study will have the following four inclusion criteria:

1. Can speak and read English
2. Is 18 years or older
3. Plan to surf in southern California during the study period
4. Has a valid email address and can access the internet with a computer or smart phone

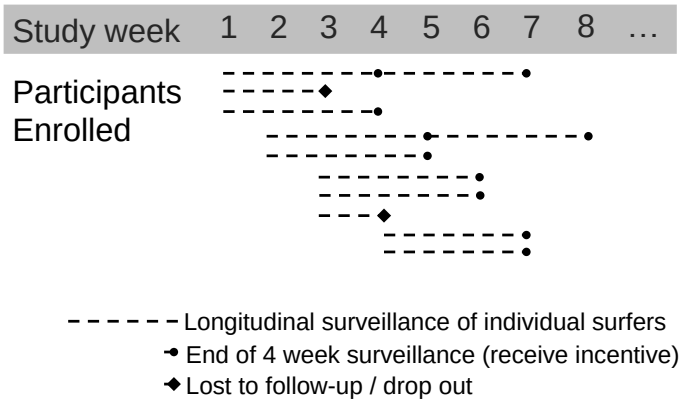
The rationale for these inclusion criteria is the following. We are restricting the study to people who can speak and read English to facilitate field staff hiring and survey development and administration (follow-up surveys will be self-administered by participants); based on past studies at California beaches, we expect the vast majority of individuals to speak and read English. We are restricting the study to adults (18+ years) to facilitate enrollment and follow-up: follow-up will require regular check-in via a web- or smartphone interface, and would likely require parental supervision for young children. We are restricting the study to individuals who plan to surf in southern California in the following 4 months because we want to ensure that participants have a reasonable likelihood of being exposed to marine water during the study period. Beyond the inclusion criteria, the analysis will exclude time periods when enrolled participants travel outside of California (e.g., to Mexico) to ensure that our measures of illness and exposure reflect conditions in California. Finally, we are restricting study to only include individuals who have Internet access through a computer or smartphone because our follow-up surveys will be web- or smartphone-based.

Targeting surfers for enrollment raises challenges: 1) surfers are a relatively small population, 2) surfers will have multiple exposures, and 3) surfers will enter the ocean at multiple locations. The study design will address these challenges by enrolling a smaller cohort than previous summer epidemiology studies, but collecting data on exposure and illness over many months with a smartphone application rather than single day exposures.

Surfer Recruitment and Enrollment:
The study will enable participants to self-enroll through a secure online website. The website will be advertised to members of the San Diego chapter of the Surfrider Foundation (N ≈ 10,000) through targeted emails sent from our partners at the Surfrider

Foundation, advertised on surfline.com, and will be advertised by volunteers at the targeted beaches (Ocean Beach and Tourmaline Surfing Park) periodically throughout the study. Advertisement will explain the objectives of the study, the activities involved should they choose to participate, and the incentives for participation. Our enrollment activities will begin in December 1, 2014, and will continue through March 30, 2015. More intensive outreach activities will take place at the start of the study and on the 3 days following each rainstorm. These activities will include on-beach distribution of study information cards and targeted emails to Surfrider San Diego chapter members. We will continue enrollment until we are confident we can achieve at least 22,000 person-days of observation during the 2014-15 winter season. Figure 5 includes a diagram of the enrollment plan for this longitudinal design:

Figure 5. Schematic of surfer enrollment and follow-up in the epidemiology study



At the time they first log-in to the study's survey software (either web-based or smartphone app-based), they will be asked to complete a 10 minute survey that collects contact information (mobile phone, email, zip code), recent ocean exposure, recent illness symptoms, basic surf history information and socio-demographic information. All survey instruments are based on EPA's National Beaches questionnaires used in many recent epidemiologic cohort studies [3–5,7–9]. Appendix C includes the current version of survey modules for this study. Our current IRB protocol proposes to cap the online enrollment at 3,200 person-weeks individuals, which is the number our study team felt, based on the pilot study, will provide a reasonable estimate of surf activity, illness, and drop-out among individuals enrolled through the online approach.

Longitudinal Measurement of Ocean Exposure and Illness

Surfers who enroll in the study will receive weekly notifications through SMS (text) or email to complete a short (<5 min) survey where they will report the following information irrespective of whether they entered the ocean (7 day recall):

- Daily surf and marine water activity (location, time) – from coded or mapped locations
- Daily illness symptoms
- Daily record of missed activities due to illness (e.g., work, school)

Participants will be able to complete the survey through a secure smartphone application or over a secure website that our team at SCCWRP has developed for this study. Participants will be reminded by SMS or email for 2 consecutive days each week (Monday, Tuesday) to complete the survey. During the Pilot Study, approximately 60% of surfers recruited into the study were retained for more than two weeks (Figure 6). Based on feedback from these participants, we will offer smaller incentives at more frequent intervals ($20 Swell.com gift cards after completing 4 weekly surveys). These smaller, more frequent incentives should promote increased participation and minimize dropout. We also expect lower levels of attrition by enrolling people through the web. Web-based enrollment establishes a relationship with the participants through their computers or phones from the beginning, and is likely one reason that web-enrolled participants had lower levels of attrition during the pilot compared to beach-enrolled participants (Figure 6).

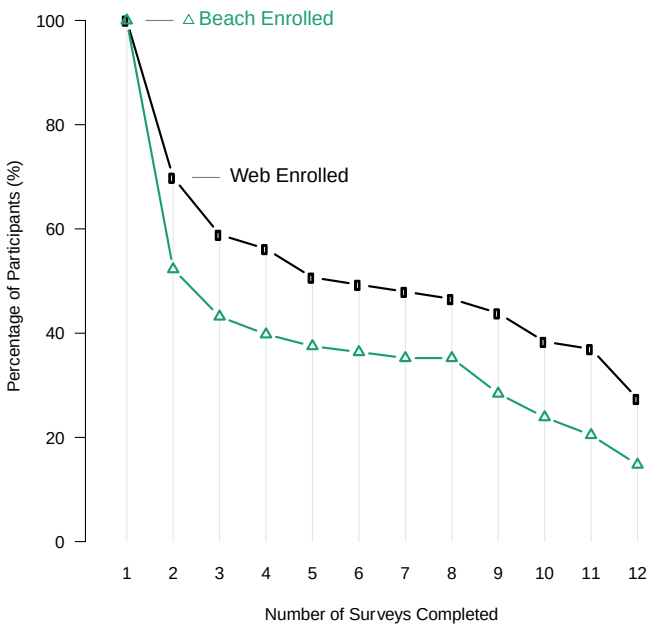


Figure 6. Proportion of participants who completed between 1 and 12 follow-up surveys during the pilot study, stratified by type of enrollment (beach vs. web).

Task 3b. Water Sample Collection and Analysis

The water quality portion of this study is designed to assess surfer exposure to fecal pollution in the ocean water near the storm water discharges. The exposure will be assessed with both qualitative and quantitative methods. Qualitative methods will examine relationship to rainfall. Currently, Public Health Departments issue blanket three-day warnings following measureable rainfall. We will use rainfall and channel flow data as proxies to wet weather exposure to see if the illness rate increases following precipitation and if that illness rate varies with quantity of rainfall. Rainfall and flow records will be collated from rain gauges and flow meters deployed in Tourmaline Creek and San Diego River just upstream of our sentinel beaches. For other beaches, we will use County Flood

Control rain gauges located nearest their location. Additional flow data will be compiled from USGS flow gauges on the San Diego River.

Quantitative methods will use traditional sampling and laboratory measures of FIB utilized by the City of San Diego and San Diego Public Health Laboratories. These methods examine *Enterococcus,* fecal coliforms, and total coliforms using approved culture-based assays: EPA method 1600 and Standard Methods 9222B and 9222D, or equivalent approved methods. In addition, we will analyze F+ coliphage(USEPA 1601, 1602), a virus that infects *E. coli* and as a result, is more numerous than human specific viruses. F+ coliphage has been linked to human sources of pollution and has been used by others to mimic human virus transport and survival (Cole et al 2003). There is some evidence that F+ coliphage has had some association with swimmer illness in previous epidemiology studies (Abdelzaher et al 2011; Colford et al 2003). However, this association has not been conclusive and the US EPA continues to pursue this indicator a possible tool for assessing swimmer risk.

We expect to collect at least 952 beach samples for FIB analyses during this portion of the study. These samples will be collected daily, beginning December 1, 2014 and continuing through March 30, 2015, to match water quality exposure data to surfer responses during the epidemiology survey. A contingency of two additional weeks, until April 15, 2015, will be utilized if insufficient rain has fallen or additional exposure weeks are necessary to meet our study targets. In addition, we will analyze at least 144 samples for F+ coliphage analysis during this same time period. Since this analysis requires live cultures we will sample only when we expect samples to have measureable quantities; following wet weather and during extreme tides. Results from the pilot study indicated that samples during routine dry weather were consistently non-detectable for F+ coliphage analysis.

A single sample of at least 500mL will be collected at ankle depth at a minimum of two locations at Tourmaline Surfing Park (sites FM030 and Tourmaline South; shown in Appendix A, Fig 3) and at a minimum of three locations at Ocean Beach (sites FM010, PL110, and PL100; shown in Appendix A, Fig 4) to replace public health monitoring sites, which are suspended during the non-AB411 winter time period. Samples will be taken between 7:00 and 9:00 in the morning to coincide with times of peak surfing activity and consistent with the timing of the public health monitoring program.

Samples taken from the shore will effectively measure exposure of surfers to FIB in the coastal zone, when they are entering or exiting the water. At Ocean Beach, a sample of at least 500mL will be taken from the Ocean Beach pier at a location adjacent to the surfer lineup to measure surfer exposure to FIB further from shore. For sample quality control, a replicate sample will be collected from each site on a rotating basis, and analyzed alongside the single 500mL samples (for a total of 7 samples per day) to assess field variability. In the laboratory, replicate samples will require a precision of <10% reproducible percent difference.

All sampling bottles will be sterilized with 10% HCl and rinsed three times with sample water prior to final sample collection. The samples will be delivered to City of San Diego Laboratory, Harbor Island. The standard 100 mL volume will be utilized for each FIB

measurement. Medium blanks, and reagent blanks (e.g. 100ml of sterile PBS filtered in the same manner as the samples) will be collected at a 10% frequency, in order to check for contamination and false positives.

Task 3c: Data Management and Analysis

Epidemiology Data Structure

Since we will collect information weekly (with 7-day recall), the study will collect daily information about surf activity and illness for each individual surfer. We will enroll surfers at different times and surfers will likely participate in the study for different lengths of time (Fig 5); for this reason each participant will contribute a different number of observed weeks to the study. For each individual, we will collect daily records of surf/ocean activity and illness. We will use each individual's reported surf locations to merge precipitation data and water quality data (if available) to their data series. For each surfer, we will thus have a daily record of surf activity, illness, beach location, precipitation, and (for exposure during our monitoring at Ocean Beach and Tourmaline Surfing Park) water quality data.

Outcome Definition

The health outcomes of primary interest will include:

- Diarrhea, defined as 3 or more loose or watery stools in 24 hours [29].
- Gastrointestinal Illness, defined as (i) diarrhea; or (ii) vomiting; or (iii) nausea and stomach cramps; or (iv) nausea and missed daily activities due to gastrointestinal illness; or (v) stomach cramps and missed daily activities due to gastrointestinal illness [5,8,9].
- Sinus infection
- Earache / ear infection
- Skin rash
- Infection of open wounds

For all health outcomes, we will define incident episodes as the onset of new symptoms in an individual. For diarrhea and GI illness, a new episode will need to be preceded by 6 or more disease-free days [23]. We are currently investigating whether there are evidence-based disease-free periods to use for skin rash, earache, and open wound infections. Survey Module 4 in Appendix C includes the instrument for these measurements. In addition to these symptoms, we will measure whether individuals missed work, school or daily activities due to the illness, whether they sought medical care or took medication during the past week, and whether they avoided entering the ocean due to their illness.

Marine water and wet weather exposure definition:

Marine water exposure:

We will have information about reported marine exposure for each participant that is geo-located to specific beaches in San Diego County (and more broadly encompassing Southern California). The study focuses on surfers because we expect that population to be most likely to enter the ocean during the winter season, but we will include all marine water exposure in the analysis. We will ask participants about their activity in the ocean, which will enable us to summarize illness risk separately by different ocean recreational activities (surfing, swimming, body boarding, etc.). Survey Module 3 in Appendix C includes the instrument for these measurements.

Wet weather exposure:

We will use meteorological data for the region to identify wet weather events. At least initially, we will use daily rainfall records from San Diego Lindbergh Field. Currently. The County Health Department utilizes rainfall quantities of 0.1 inch or greater to trigger wet weather beach warnings of 3 days. However, beaches with freshwater storm drain inputs likely have different periods of impact from storms due to differences in watershed size and drainage systems [24]. For this reason, and because the relevant window of potential health risk following wet weather remains unknown, we will consider multiple windows of exposure following wet weather events that range from <0.1 to >0.5 inch precipitation and 1 to 5 days following each event. In a secondary analysis, pending availability of third-party data, we will attempt to calculate beach-specific exposure risk windows following wet weather events.

Analysis Approach

Collect illness rates and dropout rates

We will calculate the incidence rate for of each illness symptom (new episodes / total days at risk), counting new episodes preceded by at least 6-symptom free days [23]. We will calculate dropout rates in the epidemiology study. Based on past experience we expect dropout rates to be highest during the first 1-2 months of the study, but calculating these rates will allow us to check our assumptions about the magnitude and time trend of drop out in this study population, which will inform the design of future studies.

Measure illness rates among surfers in San Diego and determine if there is any evidence of greater risk following ocean exposure and exposure following wet weather events (research questions 1 & 2).

Multiple studies of marine water exposure have demonstrated that most of the excess gastrointestinal illness cases among swimmers compared to non-swimmers occur in the first 2-3 days following exposure [8,9,13,25]. This short latency period is consistent with viral pathogens, but bacterial and protozoan pathogens have longer latency periods. We will focus our analysis on the rates of illness associated with ocean exposure in the previous 3 days and we will repeat the analysis for rates associated with ocean exposure in the previous 5 days. Our experience in the pilot study was that for the surfer population, extending the window of exposure beyond 5 days is infeasible due to the frequency of ocean exposure in this population (median = 3 days per week).

With longitudinal follow-up, most surfers in the study will have periods during which they are "exposed" to potential pathogens in the ocean while surfing and periods during which they are unexposed. Since we will measure outcomes following these periods of exposure for each individual, we will estimate the effect of surf exposure using information from individuals under both exposed and unexposed periods. This effectively treats each individual in the study as his or her own control, and helps remove time-invariant confounding that could bias our estimate of the risk associated with ocean exposure. To estimate the illness rate associated with water exposure, we will consider water exposure in the 3 days prior to an outcome measurement on any given day. For the statistical models below we introduce some notation. Let Y_{it} be a binary indicator equal to 1 if individual i is ill on day t (0 otherwise), let T_{it} be the days at risk in the 3 day period before day t, and let E_{it} be a binary indicator of equal to 1 if individual i entered the water on day t (0 otherwise). Define $E^*_{it} = \max(E_{i,t-1}, \ldots, E_{i,t-3})$, which is a binary indicator of whether the individual entered the water in the 3 days prior to the outcome measurement on day t. To estimate the incidence rate ratio associated with marine water exposure, we will use a log-linear regression model [26]. We will model surfer illness for individual i on day t using the following model:

$$(1) \qquad \log \mathrm{E}[Y_{it} \mid T_{it}, E^*_{it}, \mathbf{X}_{it}] = \log (T_{it}) + \alpha + \beta E^*_{it} + \gamma \mathbf{X}_{it}$$

where Y_{it} is a dichotomous indicator of illness as described above (e.g, has diarrhea), α is an intercept, E^*_{it} is a dichotomous indicator of marine water exposure in the 3 days prior to day t (defined above), and $\mathbf{X}_{it}$ is a vector of individual- and time- varying covariates that are either associated with the outcome (Y) or could potentially confound the relationship between ocean exposure and illness. Covariates in $\mathbf{X}$ will include age, number of years surfed, type of surf equipment used (board length, earplugs, hood, wet suit type), illness among other household members, suspected food poisoning (for GI illness), and whether previous illness caused them to avoid entering the ocean. The parameter $\exp(\beta)$ estimates the incidence rate ratio associated with ocean exposure in the prior 3 days compared to unexposed periods. We will repeat the analysis for the health outcomes of interest, as well as 2 "negative control outcomes" (still to be determined) that we would not expect to be associated with marine water exposure [27]. If marine water exposure were associated with these negative control health outcomes in addition to the main study outcomes, it would suggest that residual confounding is present or that the participant-reported outcome measurement approach is biased (for example, participants over-reporting all symptoms following ocean exposure).

The question of whether ocean exposure increases illness rates more following a wet weather event compared to dry weather is a question of effect modification. We will extend the analysis outlined above to allow ocean exposure to be modified by wet- and dry-weather. Let W_t be a binary indicator of whether it rained on day t, and define $W^*_{i,t} = \max(W_{i,t-1}, \ldots, W_{i,t-6})$ as a binary indicator of whether it rained during the previous 3-day period at the surf location reported by individual i. The indicator uses a 3-day window for W^* under the assumption of a 3-day window of risk following a wet weather event.

As with equation (1), we model surfer illness using a log-binomial model:

$$(2) \qquad \log E[Y_{it} \mid E^*_{it}, W^*_{it}, \mathbf{X}_{it}] = \log(T_{it}) + \alpha + \beta_1 E^*_{it} + \beta_2 W^*_{it} + \beta_3 E^*_{it} W^*_{it} + \gamma \mathbf{X}_{it}$$

Here, the model includes an interaction between whether the individual entered the ocean in the previous 3-day period (E^*_{it}) and whether it rained in the previous 3-day period where individual *i* surfed (W^*_{it}). We will estimate separate incidence rate ratios for surf exposure during dry periods [exp(β_1)] and for surf exposure during wet periods [exp($\beta_1 + \beta_3$)], and will test for the statistical significance of the interaction using a Likelihood Ratio test on the interaction term (β_3) [28]. While the pilot study provided us with preliminary information that suggests ocean exposure increases incidence rates more following wet weather events across a range of health symptoms, in this study we expect to have proper statistical power to rigorously test this hypothesis. The magnitude of the effects and the amount of exposure to wet weather conditions from the pilot study have informed the design for the main epidemiology study. We will estimate all parameters of interest using maximum likelihood and we will calculate the standard errors for all estimates using robust standard errors clustered at the individual level to account for repeated measures within individuals. We will summarize the results in a table similar to this for each health outcome:

Table 1. Example of health outcome Incidence Risk Ratio (IRR) results from San Diego pilot study. An incidence Rate Ratio of 1 indicates no difference.

	Unexposed Periods Episodes/Yr	Unadjusted IRR (95% CI)	Adjusted Model* IRR (95% CI)
Any illness	7.0	2.05 (1.39, 3.04)	1.81 (1.13, 2.92)
Any infectious symp†	3.7	1.56 (0.91, 2.66)	1.45 (0.70, 3.01)
Sinus pain / infection	1.7	3.59 (1.92, 6.73)	3.12 (1.46, 6.67)
Earache / infection	3.2	1.81 (0.93, 3.50)	1.56 (0.71, 3.44)
GI illness	1.9	1.89 (0.94, 3.79)	2.03 (0.82, 5.05)
Diarrhea	1.7	1.43 (0.66, 3.06)	1.46 (0.52, 4.05)
Infected cut	0.7	1.48 (0.36, 6.05)	0.90 (0.12, 6.76)

* IRR adjusted for day of the week, day of recall, survey number, and time spent in the water.

† Includes GI illness, diarrhea, vomiting, eye infections, infected cuts, and fever.

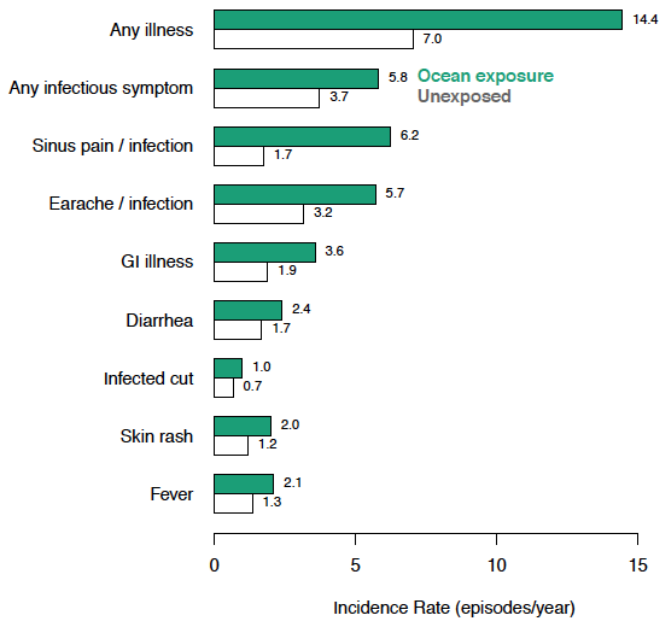


Figure 7 Incidence Rates for surfer illness estimated for ocean exposed and unexposed periods during the pilot study. Green bars show ocean exposed incidence rates and white bars show the rates when not exposed. The corresponding incidence rate ratios (IRRs) associated with ocean exposure are reported in Table 1.

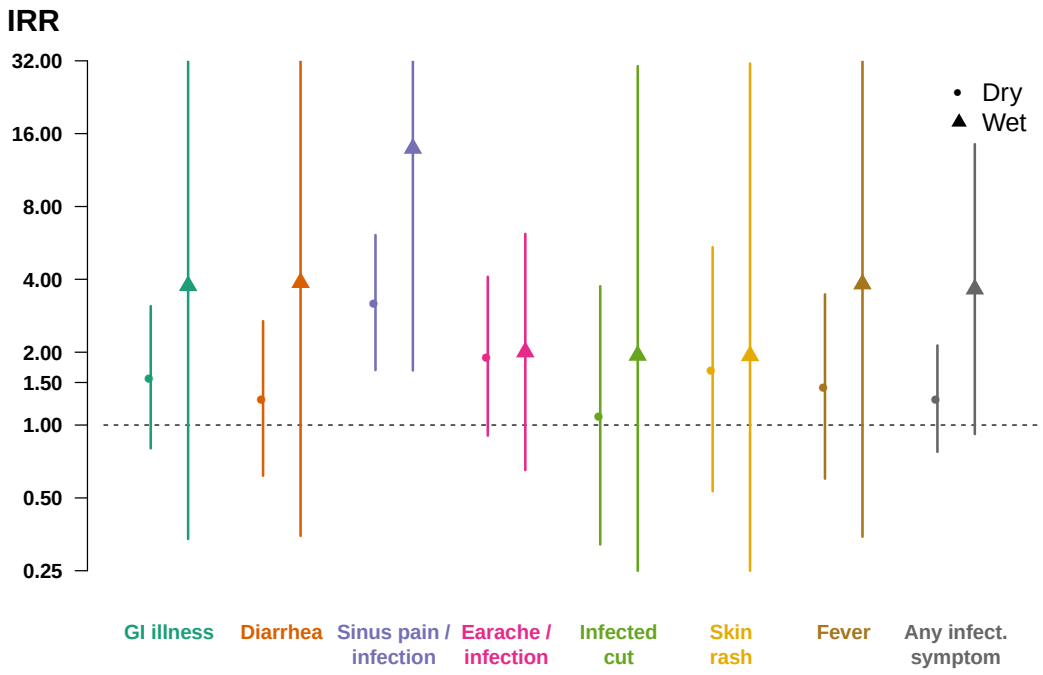


Figure 8. Summary of overall incidence rate ratios (IRRs) comparing ocean exposure to non-exposed periods during dry and wet weather from the San Diego pilot study

Measure the association between Fecal Indicator Bacteria and illness during the study period (research question 3).

In this analysis we will match individual surf sessions from participants that take place at Ocean Beach and Tourmaline Surfing Park with concurrent fecal indicator bacteria (FIB) counts measured on those same days. The FIB used in the analysis will include *Enterococcus* EPA method 1600 and fecal coliforms EPA method 9222D. Below, in the following section, we provide additional details about FIB measurement. Using the FIB measurements, we will examine the relationship between the FIB concentrations and subsequent illness rates using two approaches. First, we will estimate the log-linear relationship between continuous FIB concentrations and illness by estimating the following model:

$$(3) \qquad \log E[Y_{it} \mid T_{it}, FIB_{it}, \mathbf{X}_{it}] = \log(T_{it}) + \alpha + \beta FIB_{it} + \gamma \mathbf{X}_{it}$$

where FIB_{it} is the FIB concentration in the water that the individual was exposed to in the 3 days prior to day t and the other variables are the same as described above. This is the standard approach used in swimmer exposure studies. Note that in cases where an individual has multiple days of FIB concentrations during prior 3 days, we will calculate a weighted average FIB value for that person, by weighting the log-concentrations on each day by the minutes spent in the water on that day. The model estimate $\exp(\beta)$ will estimate the incidence rate ratio associated with a 1-log increase in the FIB concentration.

Second, we will reduce the FIB concentrations to dichotomous exposure variables by flagging days when they exceed the single sample regulatory limit. For example, we will identify days in which the *Enterococcus* concentrations exceed 104 CFU per 100 ml. We will then compare the increase incidence associated with ocean exposure above versus below that cutoff using a model analogous to model 1, but restricting the analysis to periods with ocean exposure linked to water quality data. For individuals with multiple days of FIB exposure information in the past 3 days, we will take the maximum of the dichotomous indicator (identifying whether an individual was ever exposed to the above-regulatory levels in the past 3 days).

Assess the presence and relative concentrations of fecal indicators in receiving waters

Data from the daily water quality samples at Ocean Beach and Tourmaline Surfing Park will be recorded and stored electronically. The data will be checked for quality by comparing to Fecal Indicator Bacteria (FIB) counts from blank filters. Outliers and non-detects will be compared to replicate samples (where available) and verified using laboratory records. The data will also be compared to the pilot study data to check for consistency. Since these two datasets are directly comparable, they will, in effect also generate a dataset spanning more than one winter. The quality checked data will be submitted to the San Diego County Health Laboratory on a daily basis. The data products will resemble the tables and figures shown below.

These data will help demonstrate if and when FIB are present in the receiving waters (summarized in Table 2). Also, the relative concentration of FIB can be used to compare between beaches, study days (i.e., days since rainfall), and to follow the timing of when FIB from the watershed arrive at the beach during a storm (Fig 9). The figures from the pilot study are included below as examples of the data products that will be generated. Although there was large variability in this limited data set, the pilot study showed a difference between wet and dry FIB at both Tourmaline Surfing Park (Fig 9A) and Ocean Beach (Fig 9B). *Enterococcus* exceeded the maximum at both beaches in the first 24 hours after a storm, with concentrations tapering off over the next 48 hours. These data will be combined with tide, rainfall, and discharge flow data (Task 4a) to determine if any of these factors influence FIB concentrations or health outcomes. Depending upon rainfall quantity and timing, we will also examine the potential confounding effects of differing storm sizes and back-to-back storm events.

Table 2. Summary data for assessing the presence of human sources of fecal pollution from the pilot study

Indicator	N	% ND	Min	Med	Max	% Exceed
Coliform, Fecal	250	8.4	2	14	>15,000	5.6
Coliform, Total	250	14.4	2	40	>16,000	0.8
Enterococcus	250	7.2	2	10	>16,000	20

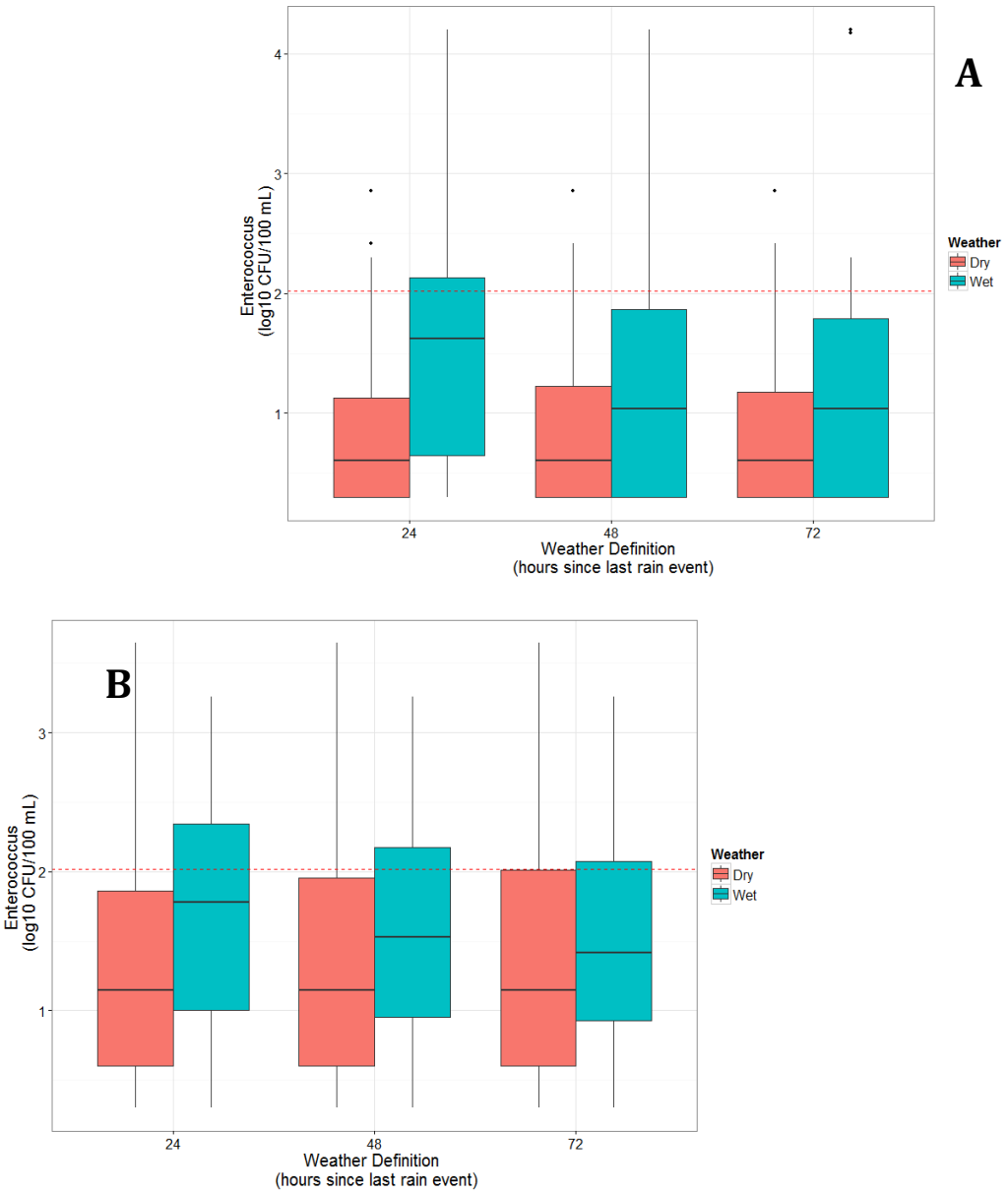


Figure 9. Enterococcus (log) concentration in wet vs dry weather at all Tourmaline Surfing Park (A) and Ocean Beach (B) beach sites.

Communication Strategy

Communication during any epidemiology study is crucial because of the significant public health implications. The Study also provides the opportunity to test and evaluate our communication strategy. Our Study communication strategy has three elements: 1) pre-survey announcements; 2) in-survey information resources, and; 3) post-survey statements. Pre-survey announcements are meant only to announce our presence on the beach so the local community is informed, which will avoid confusion, potential fears, and potential bias for the study. We will use several mechanisms to announce the onset of the study including outreach to lifeguards, police, parks and recreation department, local surf shops, and local surfing organizations (i.e., San Diego Surfrider Chapter, local surfing teams and clubs, etc.). We will not pursue a press release, but are glad to support the City or County if they choose to use the press. The in-survey information resources are perhaps the most important from a bias perspective. Once surfers are approached, they will naturally be curious about the water quality. Our intent is to provide several venues for additional information that will include signage, study brochures with frequently asked questions, a web site with the study description, and an email and telephone hotline. These materials will also be distributed to the outreach stakeholders in the first element and available to the public, particularly the surfers that we will be enrolling into the study. The post-survey communication elements will remain small and mostly directed at the Advisory Committee, who will be the primary end-users of the information. Keeping this element small and directed is also beneficial because we will likely have insufficient information for public health decision making until the full study is completed.

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Appendix C Surfer Health Survey Questionnaire

Overview

Surfer Health Study
Questionnaire
Module 0: Overview
Version 8 (5 Sep 2014)

This document provides an overview of the survey modules used for the Surfer Health Study.

The enrollment survey should take around 10-15 minutes to complete (not including consent), and the follow-up survey should take 10 minutes or less.

Below is a list of modules included in the enrollment survey and a summary of when they will be administered to study participants. We will administer the surveys both through in-person interviews on the beach and through self-enrollment, web-based surveys. The follow-up and exit surveys will only be web-based (or app based). We are tracking differences in dialog or any question wording / administration in the modules by including web-based dialog / questions in blue text if it differs from the beach interview.

Module	Description	Status, updated	Enroll.	Follow-up	Exit
1	Eligibility and enrollment	V7, 2 Jan 2014	X		
2	History	V7, 25 Nov 2013	X		
3	Recent ocean exposure	V7, 2 Jan 2014	X	X	
4	Recent health symptoms	V7, 23 Sep 2013	X	X	
5	Demographic information	V7, 23 Sep 2013	X		
6	Study exit survey	not started			X

* First time that a participant logs on to the study's web or mobile app.

Each question has a corresponding question number with numbering nested within module. In the database, it would be helpful to use an alphabetic prefix before each number since many statistical software programs do not allow variable names to start with a number. So, for example, we could use the prefix "q" before each question number in the database. Then module 1, question 1.1 would be named "q11" in the database, module 2, question 2.4 would be "q24", etc.

Example question	Question type	Suggested variable name(s) and formats

1.1	Single code (e.g., 1=yes, 2=no)	q11 with byte storage of 1 or 2
2.6	Mark all that apply, with 12 options	q26_1 – q26_12 each with a byte storage of 1 if marked and 2 if not marked (default)
2.8.a	Numeric (real) (e.g., number of days)	q28a with integer storage and a range restriction on plausible values

Eligibility and Enrollment

Surfer Health Study
Questionnaire
Module 1: Eligibility and enrollment

Version 8 (5 Sep 2014) [updated 5 Sep 2014]

NOTE: All surveys will be web and app-based beginning in December 2014

Welcome to the Surfer Health Study enrollment website. The Surfer Health Study is a research project in San Diego County led by investigators at the Southern California Coastal Water Research Project (www.sccwrp.org), the School of Public Health at the University of California at Berkeley (www.sph.berkeley.edu), and the Surfrider Foundation (www.surfrider.org). The objective of the study is to determine whether surfers are at risk of illness from ocean exposure on the California coast. The study will collect information about surf activity and illness over the next 4 months by having surfers report information each week through a website or smartphone app. If you are interested in participating, then please answer the following eligibility questions. If you are eligible, then you can read more details about the study, the benefits of participating, and then you can decide whether you are willing to participate. If you decide to participate, you'll need to complete an enrollment survey that will require about 10 minutes.

Eligibility questions

		Yes	No
1.1	Do you speak English?		
1.2	Are you 18 years or older?		
1.3	Do you plan to surf in California in the next 4 months?		
1.4	Do you have internet access with a computer or a smartphone?		

If "No" to any question in 1.1 – 1.4: We're sorry, but we are only enrolling surfers who
[speak English] [are 18 years or older]
[plan to surf in California in the next 4 months]

[have internet access, because the study will rely on reporting through the web]

If "Yes" to all questions 1.1 – 1.4: Great! You are eligible to participate in the study. Please continue to the next page, which will describe the details of what the study will involve, the benefits of participating, and will ask you for informed consent should you decide to participate.

[Go to web page that includes consent form]

1.5 [Internal (not seen by participants)]
Signed consent obtained?
1 Yes
2 No **--> END refused**

1.6
Please enter your primary phone number and email address where we can reach you (mobile phone preferred). This information remains completely confidential. We collect this information only so we can contact you if needed during the study. We will never share this information with anybody and will destroy this information at the end of the study.

1.6.a Please enter your phone number
[default 999-999-9999 if there is no phone number]
(__ __ __) __ __ __ – __ __ __ __

1.6.b Please re-enter your phone number (to confirm)
(__ __ __) __ __ __ – __ __ __ __

1.6.c Please enter your email address _____

1.6.d Please re-enter your email address (to confirm) _____

1.7
The study will send you a weekly reminder to fill out a quick, 10-minute survey of your surf activity and health. Would you prefer that the study contact you primarily by phone through text messages (SMS) or by email?
1 Phone / text / SMS
2 Email

1.8
How did you hear about the study?
1 Surfrider Foundation website
2 Surfrider Foundation email announcement
3 Flier posted at the beach
4 Flier posted at my local surf shop
5 Talked with a study representative on the beach

6 Friends / word of mouth
88 Other _____

1.9
What is your Zip Code?
__ __ __ __ __

History

Surfer Health Study
Questionnaire
Module 2: History

Version 8 (5 Sep 2014) [updated 10 Sep 2014]

This page includes a series of questions about your general surf activity. Please answer all of the questions to the extent that you can.

2.1
How many years have you surfed?

___ ___ Years [*record "0 0" for less than 1 year*]

2.6
Thinking back over the past year, in which months did you surf in California?
mark all that apply
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
[coded 1 – 12]

[if 2.6 = 1, 2, 3, 11, 12] ask 2.2, else skip to 2.3
2.2
About how often do you surf during the wet season (November – March)?
[enter "0 0" if less than once per month]
__ __
2.2.units [select one]
1 per week
2 per month

[if 2.6 = 4, 5, 6, 7, 8, 9, 10] ask 2.3, else skip to 2.4
2.3
About how often do you surf during the dry season (April – October)?
[enter "0 0" if less than once per month]

__ __
2.3.units [select one]
1 per week
2 per month

2.4
How long is the board that you usually ride?
1 Short board (< 7 feet)
2 Fun board (7 – 9 feet)
3 Long board (> 9 feet)

2.5
Do you usually wear earplugs when you surf?
1 Yes
2 No

2.7
If it rains, do you ever wait to go in the ocean?
1 Yes, always wait
2 Yes, sometimes wait
3 No

[If answer to 2.7 is 1 or 2]
2.7.a How long do you typically wait?

__ __
2.7.b (units)
1 Days
2 Hours

2.8
During the winter season (November – March), which beach do you consider your "home" beach (where you surf most often)?
mark one
[will include an auto-populated beach list]

2.11
Do you regularly go into the ocean for activities other than surfing?
1 Yes
2 No

2.11.a
(If yes, answer 1), *mark all that apply*
1 swimming
2 body surfing
3 body boarding
4 stand-up paddle boarding

5 wind surfing or kite boarding
6 free diving or scuba diving
88 Other (specify) _____

2.12
Do you have any of the following long-term health conditions?
mark all that apply

1 Allergies, other than drug allergies?
2 Surfer's ear?
3 Chronic sinus problems?
4 Chronic gastrointestinal problems such as Crohn's disease or irritable bowel syndrome?
5 Chronic respiratory disease such as asthma or emphysema?
6 Chronic skin problems such as psoriasis or eczema?

Recent Ocean Exposure

Surfer Health Study
Questionnaire
Module 3: Recent Ocean Exposure

Version 8 (5 Sep 2014) [updated 5 Sep 2014]

Think about your ocean activities since this day last week. Only report information for the last 7 days.

3.1
Did you enter the ocean on any days in the past week?

mark all that apply
[auto populate days of the week, depending on the day of the interview]
1 [Today]
2 [Yesterday]
3 [Day before yesterday]
4 … 5 … 6 … 7 …

For each day selected in 3.1, the software will ask the following questions (complete for each day) [question numbering 3.2.1, 3.2.2, 3.2.3… 3.2.7, 3.3.1, 3.3.2, … 3.3.7, etc.]

Recall Day [1=Today]:	1	2	3	4	5	6	7
3.2 What beach did you go to? [will include a add beach list]							
3.3							

Recall Day [1=Today]:	1	2	3	4	5	6	7
What was your main activity while in the ocean on [*day*]? 1 surfing 2 swimming 3 body surfing 4 body boarding 5 stand-up paddle boarding 6 wind surfing or kite boarding 7 free diving or scuba diving 8 other (specify _____)							
3.4 Did you immerse your head in the water on [*day*]? 1 Yes 2 No							
3.5 Did you swallow any water on [*day*]? 1 Yes 2 No							
3.6 Did you wear earplugs? 1 Yes 2 No							
3.7 Did you wear a wetsuit? 1 Full suit (full legs and arms) 2 Shorty (short sleeves and short legs) 3 Long john (covers torso and legs) 4 Rash guard only 88 No wetsuit							
Approximately when did you enter the ocean and exit the ocean? **3.8.a** Entered ___ ___ : ___ ___ [HH : MM] **3.8.b** Exited ___ ___ : ___ ___ [HH : MM]							

3.9
Were there any days in the past week that you would have gone into the ocean but didn't because of wet weather or bad weather?
mark all that apply [auto populate days of the week, depending on the day of the interview]
[include a logic check / dialog to make sure the entries do not contradict 3.1.1]

1 [Today]
2 [Yesterday]
3 [Day before yesterday]

4 … 5 … 6 … 7 …

Recent Health Symptoms

Surfer Health Study
Questionnaire
Module 4: Recent health symptoms

Version 8 (5 Sep 2014) [updated 5 Sep 2014]

Think about your ocean activities since this day last week. Only report information for the last 7 days.

[question numbering: 4.1, 4.1.a, 4.1.b, …, 4.1.g, 4.2, 4.2.a, 4.2.b, … etc.]
[in software, would be great to auto-populate the day of the week names for each day of recall. For both the beach interview and the web-based survey, it would be helpful to show only one symptom at a time to avoid confusion.]

		a	**b**	**c**	**d**	**e**	**f**	**g**
	Day of Recall [1=Today]:	1	2	3	4	5	6	7
	In the past 7 days (since this day last week), have you had: *[Web: If Yes, have a dialog that requests the user to mark each day that they had the symptom]* *If No, skip to the next symptom.*							
4.1	Fever 1 Yes **-->** 2 No							
4.2	Diarrhea (3 or more loose/watery stools in 24 hours) 1 Yes **-->** 2 No							
4.3	Stomach cramps 1 Yes **-->** 2 No							
4.4	Vomiting 1 Yes **-->** 2 No							
4.5	Nausea 1 Yes **-->** 2 No							
4.6	Sinus pain or sinus infection 1 Yes **-->** 2 No							

		a	b	c	d	e	f	g
	Day of Recall [1=Today]:	1	2	3	4	5	6	7
	In the past 7 days (since this day last week), have you had: *[Web: If Yes, have a dialog that requests the user to mark each day that they had the symptom]* *If No, skip to the next symptom.*							
4.7	Earache, ear infection, or runny ears 1 Yes **-->** 2 No							
4.8	Eye infection 1 Yes **-->** 2 No							
4.9	Negative control 1 1 Yes **-->** 2 No							
4.10	Negative control 2 1 Yes **-->** 2 No							
4.11	Infected cut 1 Yes **-->** 2 No							
4.12	Skin rash, itchy skin, or skin infection 1 Yes **-->** 2 No							
4.13	Cough 1 Yes **-->** 2 No							
4.14	Sore throat 1 Yes **-->** 2 No							
4.15	Runny nose / congestion 1 Yes **-->** 2 No							

If Yes to any symptom in 4.1 – 4.15, then ask 4.16 – 4.21. Otherwise skip to 4.22.

4.16
Did anybody else who lives in your house come down with the same symptoms before or about the same time as you?
1 Yes
2 No

4.17
[If Yes to any symptom in 4.1 – 4.5 then ask, otherwise skip to 4.18]
Since last *[auto-populate day 7 days ago]*, do you suspect that you or anybody in your home might have had food poisoning?
1 Yes
2 No

4.18
Since last *[auto-populate day 7 days ago]*, did you miss work, school, or other daily activities because of any of the symptoms above? If so, how many days in the past week?
___ Days *Record "0" if no days are missed.*

4.19
Since last *[auto-populate day 7 days ago]*, did you seek medical care from a clinic or hospital for any of the symptoms above?
1 Yes
2 No

4.20
Since last *[auto-populate day 7 days ago]*, did you take medication such as painkillers or antibiotics for any of the symptoms above?
1 Yes
2 No

4.21
Since last *[auto-populate day 7 days ago]*, did you avoid entering the ocean because of your symptoms?
1 Yes
2 No

4.22
Since last *[auto-populate day 7 days ago]*, did you avoid entering the ocean because of any illness not covered by the symptoms above?
1 Yes
2 No

Demographic Information

Surfer Health Study
Questionnaire
Module 5: Demographic information

Version 8 (5 Sep 2014) [updated 5 Sep 2014]

You are almost finished! After answering these questions, you will be taken to a final page that will remind you about future study activities and your progress toward getting a thank you gift.

5.1
What is your gender?
1 Female
2 Male

5.2
What year were you born?
_ _ _ _ Year

88 Refused
99 Don't know / not sure

5.3
What is the highest level of education that you have completed?
1 Less than high school
2 High school
3 Trade school, community college, or other 2-year college
4 Bachelor's degree (BA, BS, etc…)
5 Master's degree or other professional degree (MA, MS, ME, MPH, JD, etc…)
6 Doctoral degree (MD, PhD, etc…)

88 Refused
99 Don't know / not sure

5.4
Are you currently employed?
1 Yes
2 No

5.5
If you think back to your household's income in 2013, which category represents the total combined income of all members of your household reported on last year's tax return?

1 < $10,000
2 $10,000 - $15,000
3 $15,000 - $25,000
4 $25,000 - $35,000
5 $35,000 - $50,000
6 $50,000 - $75,000
7 $75,000 - $100,000
8 $100,000 - $150,000
9 > $150,000

88 Would prefer not to say / Refused
99 Don't know / not sure

Exit Survey

Surfer Health Study
Questionnaire
Module 6: Exit survey

Version 8 (5 Sep 2014) [updated 5 Sep 2014]

Thanks for participating in the Surfer Health Study. Your responses to the following questions will help us improve the way we conduct future studies of surfing and health in California.

Questions for those who dropped out early

6.1
What were your reasons for discontinuing participation in the study? Please mark all that apply.

1 It took too much time to complete the weekly surveys
2 I received too many emails/text messages about the study
3 Weekly surveys were too frequent
4 The website was difficult to use
5 The mobile app was difficult to use
6 Too busy
7 The incentives were not appealing
8 Other (specify)

If 6.1 = 7, go to 6.2. If not, go to 6.3.

6.2
Can you please give me an example of what kind of incentive you would have preferred? When would you have liked to receive it?

6.3
Would any of the following have made you want to participate in the study longer? Please mark all that apply.

1 Shorter surveys
2 Less frequent surveys
3 More reminders
4 Easier to use app
5 Guaranteed incentive (e.g. gift cards at Swell.com) for all participants instead of a drawing at the end of the study
6 Drawing for a larger/more valuable incentive at the end of the study
7 More frequent incentives (e.g. an incentive each time a questionnaire is filled out)
8 Other (specify)

Questions for everyone

6.4
How can we improve the app to make it more user friendly?

6.5
How can we improve the website to make it more user friendly?

6.6
If we were to conduct a similar study with longer follow-up starting in fall 2014, would you be interested in participating?

1 Yes
2 No
3 Not sure

6.7
Please share any other comments you have about this study.

Appendix D QMRA Study Details

Task 4a: Source Identification and Pathogen Loading

We will identify fecal contamination sources and quantify the loading of FIB and pathogens that surfers will come into with. Based on the pilot study our science team has determined that the watershed discharge can appropriately be used as a "point source". We will employ a study approach focused on quantification and confirmation.

The first step in this process is to conduct a sanitary characterization of the watersheds of interest. EPA has developed and tested a sanitary characterization approach specifically for the purpose of QMRA development. We will use the EPA sanitary characterization template for each of our sentinel beaches to identify and document the most likely sources of fecal contamination.

For quantification, we will sample wet weather discharges at the terminus of each watershed discharging to our sentinel beaches and use a spectrum of fecal bacterial indicators and markers to identify the most likely hosts and pathogen measurements for use in the exposure characterization.

We will collect flow-weighted composite storm discharge samples at Tourmaline Creek and at the San Diego River (Figure 1) for assessing inputs to our sentinel beaches. A minimum of six storm events will be targeted during the time span from December 1, 2014 through March 30, 2015. A contingency of two additional weeks, until April 15, 2015, will be utilized if insufficient rain has fallen or additional exposure weeks are necessary to meet our study targets.

Storm event mobilization will occur if there is an 80% probability of precipitation predicted to be greater than 0.1 inch by the National Weather Service. Sampling will commence when flow increases by 10% or sufficient stage exists to cover the pump intake. A 20L flow-weighted composite sampling will continue for 6 hours after the first sample is collected. A second 20L composite sample may be collected if the storm continues past 6 hours. Storm end will occur when flow returns to within 10% of baseline flow or 12 hours after sampling initiation, whichever occurs first. For up to 3 days following each storm, daily 20L grab samples will be collected once per day at Tourmaline Creek and the San Diego River between 7:00 and 9:00 AM, provided sufficient flow exists.

Composite storm discharge samples will be collected using automated equipment that relies on programmable peristaltic pumps; additional sensors and data loggers for rainfall and flow will be included. All pump tubing and sample bottles will be decontaminated and sterilized prior to each storm event. This process will be checked with an equipment blank at least once each storm. Decontamination will use a non-phosphate detergent followed by

a 10% acid rinse and a triple deionized water rinse. Sterilization will require rinsing with at least 70% ethanol and allowing to dry, then being capped tightly with ethanol rinsed aluminum foil.

The 20L stormwater runoff samples will be filtered to collect protists, viruses, and bacteria, using membrane filters or hollow fiber ultrafiltration methods recently optimized with representative stormwater at SCCWRP.

Figure 1. Sampling locations for the QMRA study in Tourmaline Creek and in the San Diego River.

Each composite sample will be analyzed for FIB using traditional culturable methods and q-PCR methods. Host-specific bacterial markers for humans (e.g. HF183, HumM2), birds (e.g. Gull2, LeeSeaGull), dogs(e.g. BacCan, DogBact), cattle (e.g. BacCow, CowM2), and horses (e.g. HoF597) will be analyzed using qPCR methods. These sources and methods are consistent with the new Source Identification Project Protocol developed by SCCWRP and being promulgated by the State of California (http://www.waterboards.ca.gov/water_issues/programs/beaches/cbi_projects/docs/sipp_manual.pdf). The host-specific marker spectrum may be modified based on the results of the sanitary characterization.

Each composite sample will also be analyzed for human pathogens. Either q-PCR and/or ddPCR will be used to quantify pathogens for swimming related activities published by the Center for Disease Control (CDC) that are likely to occur in this watershed. These pathogens are comprised of human viruses (e.g. norovirus (Jothikumar et al. 2005a, Gregory et al. 2011), adenovirus: (Jothikumar et al. 2005b), and enteroviruses) , bacteria (e.g. *Salmonella sp.(*Daum et al. 2002, Novinscak et al. 2007, Malorny et al. 2004) *, Campylobacter sp.(*Yang et al. 2003)), and protists (e.g. *Giardia intestinalis, Cryptosporidium parvum*: (Guy et al. 2003 , Alonso et al. 2011)). All q-PCR assays will be run with negative controls to check for false positives, filter controls, and a spiked internal control to account for inhibition from the sample matrix.

In order to confirm the suspected non-human sources identified in the sanitary characterization and the storm event sampling, we will sample scats of non-human sources for FIB and pathogens (e.g. bacteria, protists). Since viruses are generally host-specific, they will not be tested. If human sources of FIB or human pathogens are not detected or only detected at low levels, this will allow potential confirmation of the suspected pathogen source(s). We will first estimate the number of scat samples required from these non-human host sources from the quantification of the non-human markers in the discharge waters, and, if necessary we will collect additional samples in order to further characterize the contributing non-human sources. The extent of sampling will then depend on host abundance, host density, proportion of host population infected with the pathogens, and host pathogen concentration in the watershed feeding Tourmaline Creek or the San Diego River. Variation in any of these parameters will ultimately require more or less samples to attain the confidence necessary for confirmation of pathogen loading. A maximum of 9 scats will be measured for any single host.

Analysis Approach

The quantitative analyses for human and non-human FIB will help demonstrate which of these sources are present in the stormwater discharge to the beaches. These, along with pathogen analyses, the beach sampling from the epidemiology study, the storm-related beach sampling, and the scat survey will inform the pathogen loading in the QMRA model. The quantitative pathogen and FIB data will directly tie in to the predictions of surfer exposure and the illness response modeling. In addition, the stormwater discharge data will provide another parameter to be used in the epidemiology study. The data product would resemble Table 3.

Table 3 Example data product for assessing the presence of human sources of fecal pollution

Site ID	Sampling Time	Human (HF183) copies/100ml	Gull copies/100ml	Norovirus copies/100ml
Tourmaline	0-6	XXX	XXX	XXX
Tourmaline	6-12	XXX	XXX	XXX
Tourmaline	24	XXX	XXX	XXX
Tourmaline	48	XXX	XXX	XXX
Ocean Beach	0-6	XXX	XXX	XXX
Ocean Beach	6-12	XXX	XXX	XXX
Ocean Beach	24	XXX	XXX	XXX
Ocean Beach	48	XXX	XXX	XXX

Task 4b: Swimmer (Surfer) exposure

Exposure is a function of water ingestion rate including the frequency and duration of swimming (or surfing), along with pathogen concentration. Together, these factors provide the estimate of "dose". This portion of the QMRA will be inextricably linked to the epidemiology study.

To estimate water ingestion, we will use the data from the epidemiology study to provide frequency and duration of exposure. These data will be used in conjunction with literature-based data on water ingestion rates to confirm that the site specific ingestion data are consistent with the data from the literature (which are commonly used in QMRA).

Estimating the pathogen concentrations at the point of exposure is likely to be one of the most challenging components that feeds into the QMRA. Therefore, we will estimate this model parameter in three different ways: 1) with no dilution or decay (i.e., full strength effluent); 2) using a simple, empirically-based statistical model, and; 3) a more complex mathematical fate and transport model. All three approaches have their positive and negative aspects, but comparisons among all three approaches will provide insight for managers (see following section, Task 4c).

In the first approach, pathogen concentrations at the point of exposure will be estimated from watershed loads measured in Tourmaline Creek and the San Diego River during storm events (Task 4a). For illness response modeling, we will assume that concentrations at the point of exposure are the same as the effluent. This approach assumes that there is no dilution and no decay as the discharge is transported down the beach. This is clearly the most conservative of the three approaches.

The Pilot Study indicated that discharge plume fate and transport played a significant role in the distribution of FIB following storm events. Therefore, our second approach will utilize a simple, statistically-based fate and transport model to account for dispersion and advection of FIB and pathogens after the discharge enters the ocean. In this approach,

empirical data based on monitoring collected along the beach immediately following storm events will be used. The empirical measurements will include the flow and pathogen measurements made during and immediately following the storm (Task 4a), gradients in FIB from daily samples (i.e. sampled from the epidemiology study, Task 3b), and physical water quality parameters (i.e., temperature, salinity) measured at regular intervals upcoast and downcoast from the discharge. Simple ratios between the monitored data from the outfall and the beach sites will be derived. This type of model will provide either measured point-in-time exposure during monitored events or estimates of average conditions when combining time estimates across multiple events.

Samples of at least 50 ml for temperature and salinity will be taken in ankle deep water from no less than 5 sites spaced upcoast and downcoast from each discharge. Temperature and salinity will be measured in these samples using a hand held conductivity and temperature sensor (e.g. YSI Pro30: 0-70ppt, -5-55 deg C). Temperature and salinity will also be collected in the stormwater discharge sample.

The third approach to fate and transport model will be a mathematical computational model such as Qual2K, available from the US EPA (http://epa.gov/athens/wwqtsc/html/qual2k.html). This model predicts shoreline FIB concentrations based on several physical parameters that drive advection and dispersion including watershed loading, wind strength and direction, wave height and direction, and pathogen decay. Watershed loading will be measured in Task 4a, wind and wave data are available from local measurements through NOAA. Calibration and validation data will be derived from the shoreline physical water parameters, surface currents from the Southern California Coastal Ocean Observing System, and FIB measurements collected as part of the epidemiology study. This model can estimate exposure for either point-in-time or average condition similar to the statistical model, but can also provide these estimates for unmeasured storm events, which will be useful if many events occur at our sentinel beaches.

Task 4c: Illness response modeling

Illness-response (QMRA) modeling predicts the illness rates in swimmers (surfers) based on exposure, ingestion, pathogen dose-response relationships, and the conditional probability of illness given infection. Exposure and ingestion will be estimated based on the results from the previous tasks (Tasks 4a and b). As is commonplace in QMRA studies worldwide, we will use peer reviewed dose response relationships for this study. EPA has established a vetted set of dose response relationships for etiologic agents of public health concern in recreational waters. We will use those dose response relationships in this work (Soller et al. 2010 a,b). EPA also has established a vetted set of conditional probabilities of illness given infection for etiologic agents of public health concern in recreational waters. We will use those probabilities of illness given infection in this study.

We will use a static stochastic (Monte Carlo simulation based) model for the illness response simulations. Previously published work indicates that for recreational water exposures, under non-outbreak conditions, the complexity of a dynamic population-based

model that accounts for secondary transmission and immunity is not necessary (Soller and Eisenberg, 2008).

Model Sensitivity analysis:
One of the most important aspects of this work is sensitivity analyses. Sensitivity analysis provides information about which model parameters most strongly influence our confidence in the outcome. Therefore, we will use sensitivity analyses to evaluate the impact of numerous model parameters and/or assumptions on the QMRA output. Model parameters to be considered will include the pathogen concentrations at the discharge point, dilution of pathogens between the discharge point and the exposure point, water ingestion rates, and pathogen dose-response relationships.

Management response paradigm

One way to capture the management response to the combination of epidemiology and QMRA results is captured in Figure 2. In this paradigm, managers will make some initial decisions based on a comparison of risk estimates from the empirical epidemiology results at the beach to the modeled QMRA risk estimates of undiluted stormwater discharge at the outfall:

Figure 2. Management response based on comparisons between epidemiology study and QMRA results

	Epi at the beach indicates little to no risk	**Epi at the beach indicates risk**
QMRA at the outfall indicates little to no risk	Site specific objectives likely	Potentially unmeasured sources of pathogens. Site specific objectives unlikely
QMRA at the outfall indicates risk	QMRA may provide estimate of risk below levels sensitive enough to capture empirically. Site specific objectives likely	Apply fate and transport models to QMRA for improving risk quantifications. If unsuccessful, may use reverse QMRA. Site specific objective may be possible, depending upon level of risk and uncertainty

In the first scenario, we will assume that the epidemiological results do not detect a statistically significant increase in illness rates for surfers. In this case, we will use the illness response modeling to add context to the epidemiology study's results. We will use both types of fate and transport models and compare the results and make an assessment of the overall illness attributable to swimmers. The modeling will provide a quantitative [and likely low] estimate of risk that empirical data are not sensitive enough to provide. This scenario favors developing site specific objectives at a level that is equal to, or more protective of, current water quality objectives.

In the second scenario, we will assume that the epidemiology study does detect a statistically significant increase in illness rate and the illness response modeling without any dilution substantially underestimates the observed health risk. If this occurs, then additional investigation may be required to assess if additional sources of pathogens exist at our sentinel beaches. This scenario does not favor developing site specific objectives until the unidentified sources are remediated.

In the third scenario, we will assume that the epidemiology study does detect a statistically significant increase in illness rate and the illness response modeling without any dilution over-predicts the health risk. This would be expected if all of the major sources of pathogens and fecal indicator bacteria had been identified and quantified, but fate and transport are providing dilution and/or decay. In this scenario, we will evaluate the ability of the simple statistical vs the more complex computational model to estimate the accuracy of exposure. If the fate and transport model(s) is accurate, then the illness response model results should reasonably align with the empirical epidemiology results. If the results do not align, then additional work into the illness response modeling will occur, focusing on sensitivity in the model parameters above. Assuming that fate and transport will be one of the primary variables of concern, we will use a "reverse-QMRA", similar to the work conducted at EPA's freshwater NEEAR studies (Soller et al. 2010a). In this reverse QMRA approach, the illness estimates from the epidemiology component of this study will be used in conjunction with the results of the sanitary characterization to estimate the dilution distribution between the discharge point and the points of exposure. The reverse QMRA will assist future QMRA studies assess the level of detail necessary for fate and transport modeling at open beaches.

Figure 3 graphically illustrates QMRA results for scenario number three. For a *hypothetical* set of results, the box plots show how the QMRA results might vary depending of the type of fate and transport model employed. In this *hypothetical* example, QMRA results are shown under the assumption of no dilution from the discharge point, a constant dilution factor, a simple fate and transport model, and a more complex fate and transport model.

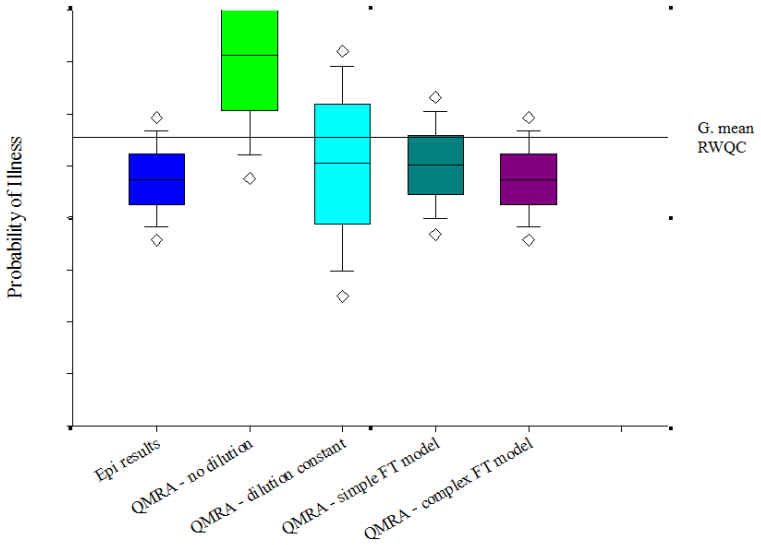

Figure 3. Hypothetical results demonstrating how the QMRA results can be utilized for making management decisions.

Based on the management paradigm in Figures 2 and 3, the QMRA modeling will address Q4 – "What level of *Enterococcus* corresponds to the same risk of illness as current water quality standards (WQS)?" If the epidemiology and QRMA studies find that either of the sentinel beaches are unimpacted or minimally impacted by human contamination, site specific recreational water quality criteria (that are at least as protective as the current WQS) may be worthy of consideration. Depending on the desired deviation from the benchmark risk (e.g. 0.5 to 1.0 log units), 10% to 30% human-derived ENT could serve as a potential threshold below which risk can be assumed to differ substantially from risk from exposure to pollution that is 100% human (Soller et al., 2014).

Recently published research indicates that for human/non-pathogenic, human/gull, human/pig, and human/chicken fecal mixtures with relatively low human contribution, the predicted culturable enterococci densities that correspond to the EPA benchmark risks are substantially greater than the current water quality criteria values (Soller et al., 2014) (Figure 4). Moreover, simulated ENT levels associated with illness levels of 36 GI illnesses per 1000 recreation events are driven predominantly by the proportion of the human (more potent) source. Also, the predicted median enterococci densities at any given human contribution are not widely different for the various mixtures thus far evaluated, until the proportion of human contamination is very low. For example, at a 20% human contribution to the culturable ENT, the simulated ENT densities for different mixtures vary from a low of 87 CFU 100mL^{-1} for a human / chicken mixture to 175 CFU 100mL^{-1} for a human / non-pathogenic mixture. For this investigation, we will follow the approach developed by Schoen and Ashbolt (2010) and extended by Soller et al. (2014) to derive appropriate site specific WQS recommendations that are equally protective to the 2012 RWQC recommended by US EPA (EPA, 2012).

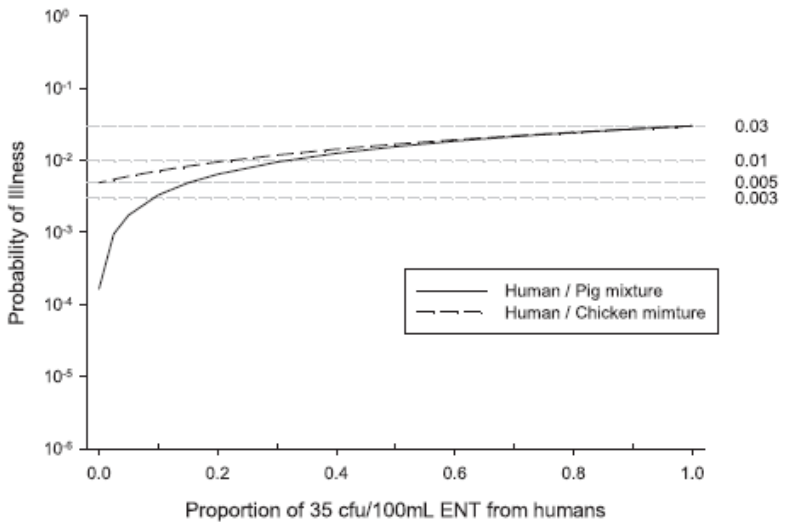

Fig. 4 – Evaluation of human/fresh pig manure and human/fresh chicken manure enterococci sources.

Figure 4. Evaluation of mixed fecal contamination source risks (From Soller et al., 2014)

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