Bioassessment Survey of the Stormwater Monitoring Coalition

Workplan for Years 2015 through 2019
Version 1.0

Raphael D. Mazor

Southern California Coastal Water Research Project

SCCWRP Technical Report 849

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February 2015

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INTRODUCTION

Southern California's coastal watersheds contain important aquatic resources that support a variety of ecological functions and environmental values, but results of the Stormwater Monitoring Coalition's (SMC's) 5-year survey ending in 2013 suggest that few perennial, wadeable streams are in good biological condition (SMC Report 2015). However, important knowledge gaps remained, such as the condition of nonperennial streams, and whether conditions were changing over time. Therefore, the SMC will continue this survey to support management decisions that may improve or protect stream condition. Key modifications to the survey will address knowledge gaps, such as the condition of nonperennial streams, the effects of stressors of interest, and changes in regional condition over time.

Comprising over 7,000 stream-kilometers, both humans and wildlife depend on southern California's coastal watersheds for habitat, drinking water, agriculture, and industrial uses. In order to assess the health of streams in these watersheds, the Stormwater Monitoring Coalition (SMC), a coalition of multiple state, federal, and local agencies, began monitoring stream condition in 2009 using multiple indicators of ecological health. This survey documented the condition of perennial wadeable streams in the region and set a baseline for monitoring regional trends. In 2015, a new five-year program will build off the initial survey to answer key management questions about the condition of streams in the region.

The SMC stream survey is a collaborative effort of leading stormwater and regulatory agencies in southern California. Through a re-allocation of permit-required monitoring efforts, this survey is intended to provide valuable data about the condition of Southern California coastal streams in a cost-effective way. Additionally, the SMC's stream survey serves as the southern California component of the statewide stream condition survey (i.e., the Perennial Stream Assessment, PSA).

The goal of this document is to describe a collaborative large-scale, regional monitoring program of southern California's coastal streams. It describes sample draw parameters, analytes that will be assessed, quality assurance requirements, standard protocols, and other information needed to ensure comparability across different programs. While the details concerning implementation (such as specific labs and contractors) will vary among participants, each agency can use this document to create sampling programs within their regions that will contribute to an assessment of the entire region.

KEY MONITORING QUESTIONS & APPROACH

The Southern California Stream Survey is designed to generate the data to answer three key management questions.

1. What is the condition of streams in Southern California?
2. What stressors are associated with poor condition?
3. Are conditions changing over time?

Although these questions are essentially the same as in the first survey, key refinements are described below.

What is the condition of streams in Southern California?

Summary of previous survey: Biologically healthy streams are a scarce resource, comprising only ~13% of the regional population of perennial wadeable streams (SMC Report 2015, in prep). Based on four biological indicators (i.e., benthic macroinvertebrates, benthic diatoms, soft algae, and riparian wetland condition), streams in good biological condition are largely restricted to the undeveloped portions of watersheds; most indicators identified slightly better conditions at agricultural streams than urban streams. Ventura, Santa Clara, Upper Santa Ana, and Southern San Diego watersheds were in better condition than other watersheds for most indicators, whereas streams in poor condition were most extensive in the Calleguas, Los Angeles, San Gabriel, and Lower and Middle Santa Ana watersheds.

Limitations: The survey was restricted to perennial, wadeable streams, 2nd order or higher. Perennial streams comprise only 25% of the region as a whole, and as little as 5% in certain watersheds. This restriction may also bias estimates of regional health by disproportionately excluding many streams in undeveloped areas.

Modifications for the 2015 – 2019 survey: Expand survey to sample both perennial and nonperennial streams, including first-order streams. Use existing assessment tools (specifically, benthic macroinvertebrates, benthic diatoms, soft algae, and CRAM). Nonperennial streams (where flow lasts many weeks to months after rain events) may be assessed using the same biological indicators as perennial streams. Ephemeral streams (where flow lasts only a few days after rain events) may be added to the survey if additional assessment tools become available. Document flow regime through a combination of site visits, water level loggers, and stream gauges (where possible) to estimate the extent of stream types. Add vertebrate indicators in an opportunistic and low-cost manner. Approximately 70% of the monitoring effort will be allocated towards providing an assessment of the region, inclusive of nonperennial streams. (The remaining 30% will be allocated to answer the third question, described below.)

What stressors are associated with poor biological condition?

Summary of previous survey: Relative risk analysis showed that physical habitat degradation, nutrients, and certain major ions were high-risk and extensive stressors for both benthic macroinvertebrate and algae indices. Water toxicity, metals, and pyrethroids had weaker associations and/or were limited in extent.

Limitations: Findings are strictly associative and do not prove causation, and are limited to stressors that were measured. Mechanisms for nutrient impacts are unclear, and physical habitat degradation is difficult to quantify. Co-occurrence of multiple stressors makes it difficult to assess the risk of individual stressors.

Modifications for the 2015 – 2019 survey: Continue measuring high-priority stressors (specifically, habitat, nutrients, and ions, which were associated with poor biological condition at >25% of stream-miles). Discontinue low-priority stressors (specifically, water column metals and toxicity, which were associated with poor biological condition at <10% of stream-miles). Enhance physical habitat assessment with hydromodification module and channel engineering checklist. Add new stressors of interest (specifically, sediment pyrethroids, sediment toxicity,

and bioanalytical screens for contaminants of emerging concern). Note: Sediment sampling will be deferred until further action by the SMC Executive Committee.

Are conditions changing over time?

Summary of previous study: Extent of streams in good biological condition fluctuated from year to year, but were always limited to less than 25% of the region.

Limitations: Because sites were not revisited, the relative extents of stable, improving, or degrading streams are unknown, nor are the causes of change. Characteristics of stable sites are also unknown.

Modifications for the 2015 – 2019 survey: A subset of probabilistic sites from previous surveys will be revisited over multiple years to provide an estimate of change in condition, which may be extrapolated to the region as a whole. Sites will be designated as stable, improving, or degrading, and environmental changes associated with changing condition will be identified. Approximately 30% of the monitoring effort will be allocated towards estimating trends.

Summary of Major Changes from the First Survey

- ***Nonperennial streams*** will be deliberately sampled if they are flowing during the index period
- The ***index period*** will be expanded so that nonperennial streams that dry before May can be sampled; sampling may begin as early as March, or February in particularly dry years.
- ***First-order streams*** will be included in the sample frame
- A subset of probabilistic sites will be ***revisited*** over several years
- Several ***parameters will be dropped***: water toxicity, metals and pyrethroids
- Several new ***parameters will be added***: Sediment pyrethroids and toxicity (deferred until further action by the SMC Executive Committee); hydromodification module; bioanalytic screens, channel engineering checklist; vertebrate occurrence, and flow regime documentation.
- The ***cost of added parameters shall be offset*** by the cost of dropped parameters, by reducing the number of sites where certain parameters are measured, and by support from SWAMP.

Participating agencies:

Sampling entities	Other entities providing other forms of support
Ventura County Watershed Protection Division	Los Angeles Regional Water Quality Control Board (funding, sampling)
Los Angeles Flood Control District	Santa Ana Regional Water Quality Control Board (funding, sampling)
Los Angeles River Watershed Monitoring Program	San Diego Regional Water Quality Control Board (funding)
San Gabriel River Regional Monitoring Program	State Water Resources Control Board (funding)
Orange County Public Works	California Department of Fish and Wildlife (analysis, training)
San Bernardino County Department of Public Works	Southern California Coastal Water Research Project (administration, data management, training, and reporting)
Riverside County Flood Control and Water Conservation District	
San Diego County Co-Permittees	

DESIGN DETAILS

Sampling effort

Contributions from stormwater agencies are typically prescribed by permit requirements. Effort will be divided among condition sites (~70%, new probabilistic sites), and trend sites (~30%, revisits to previously sampled probabilistic sites). The number of samples expected from each agency per year are indicated in Table 1. The total number of sites contributed by each agency is determined by permit requirements and can only be changed by the appropriate regulatory authorities; however, the relative number of trend and condition sites may be modified by the workgroup.

Table 1: Contributions from SMC participants

Agency	Total sites per year	Condition sites	Trend sites
Ventura County	15	10	5
Los Angeles County	7	5	2
LARWMP	6	4	2
SGRRMP	6	2	4
Orange County	8	5	3
San Bernardino County	4	3	1
Riverside County	6	3	3
San Diego County	16	12	4
TOTAL	68	44	24

Condition sites shall be distributed across different watersheds within each participant's geographic area (Table 2).

Table 2. Number of condition sites sampled by each stormwater agency each year.

Agency	Condition sites per year
Ventura	10
Ventura	3
Santa Clara (county line)	3
Calleguas	3
Santa Monica (county line)	1
Los Angeles	5
Santa Clara (county line)	2 to 3
Santa Monica (county line)	2 to 3
LA Regional Watershed Program	
Los Angeles	4
San Gabriel Regional Watershed Program	
San Gabriel	2
Orange	5
Santa Ana (county line)	3
San Juan (county line)	2
San Bernardino	
Santa Ana (county line)	3
Riverside	3
Santa Ana	2
Northern San Diego + San Mateo (county line, no military)	1
San Diego	12
Northern San Diego + San Mateo (county line, no military)	3
Central San Diego	3
Mission Bay San Diego River (no military)	3
Southern San Diego (county line)	3
TOTAL	**46**

Trend sites shall be distributed across different land use types within each participant's geographic area (Table 3).

Table 3. Number of condition sites sampled by each stormwater agency each year.

Agency	Trend sites per year	Open sites	Developed sites	Unspecified sites
Ventura	5	2	3	0
Los Angeles	2	1	1	0
LARWMP	2	1	1	0
SGRRMP	2	1	1	0
Orange	3	1	2	0
San Bernardino	1	0	0	1
Riverside	3	2	1	0
San Diego	4	2	2	0
TOTAL	22	10	11	1

Contributions from other agencies

Additional samples or other forms of support may be provided by other agencies, such as the Regional Water Quality Control Boards, the Perennial Stream Assessment, the San Diego Ag-Waiver program, the San Diego River Monitoring Program, or the National Parks Service. This workplan may be modified to leverage these added contributions when opportunities arise.

Sample Size

Based on these expected levels of participation, 68 samples per year will be collected, for a total of 340 over 5 years. This level of effort is the same as the previous survey, but does not include potential contributions from Regional Boards. Approximately 70% of these samples (235) will be from a new sample draw, and will be used to estimate the condition of streams in the region. Approximately 30% of these samples (105) will be revisits to previously sampled probabilistic sites, and will be used to estimate trends in condition. These candidate trend sites may come from a number of earlier surveys in the region, including those that preceded the first SMC stream survey.

Sampling Frame

The sampling frame is the stream network represented by the National Hydrography Dataset (NHD Plus) (US EPA and USGS 2007) within the three Southern Californian regional boards, as modified for use by the Perennial Stream Assessment. Streams on the Channel Islands, on Camp Pendleton, and on Miramar military lands excluded because of limited access.

The sampling frame was divided into strata based on agency jurisdictions, as well as other units of interest. Watersheds and land use classifications follow the designations used by the Perennial Stream Assessment.

Reporting strata shall be determined by the technical workgroup at the time of report preparation, and may include reporting units like hydrologic or channel engineering classes, watersheds, land

use classes, or counties. The sample draw will be flexible enough to support diverse reporting unit designations.

Sample draws and site selection

Selecting condition estimates

For the condition estimate, sites are selected from the sample frame using a spatially balanced design (Stevens and Olsen 2004). Each agency will have its own sample draw, and most agencies will have multiple strata, each with their own list of sites to evaluate. Every stratum will also have an extensive oversample to allow replacement of unsampleable sites. These sample draws will implement multidensity intensifications for certain stream types; specifically, higher order streams and agricultural streams will be weighted to improve representation of these scarce and/or frequently rejected stream types. These sampling strata are shown in the map below (Figure 1). The final distribution of sites will depend on the sampling success rate, but is expected to range from 10 to 30 per watershed.

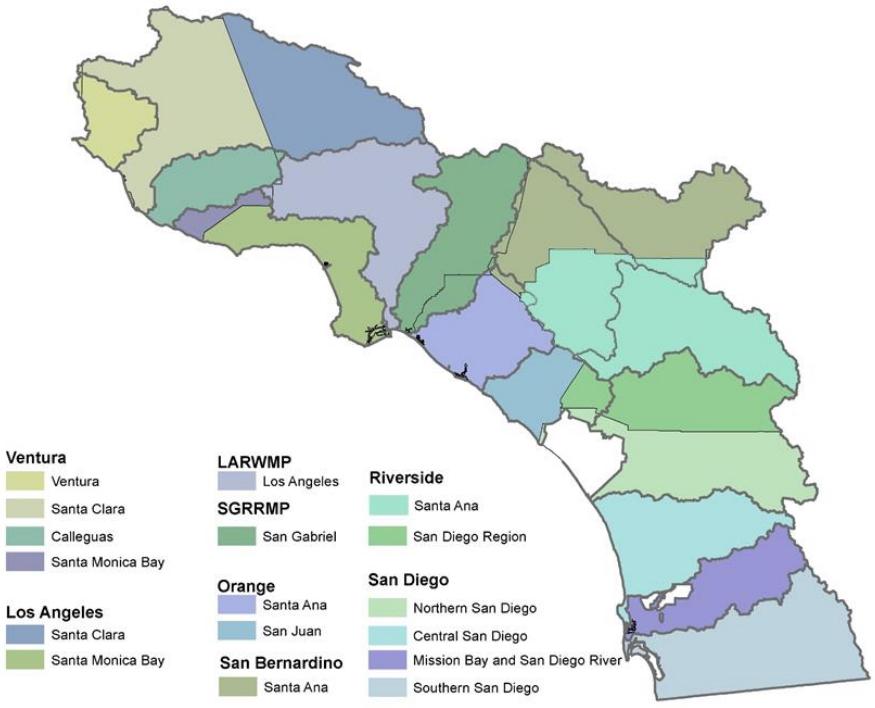

Figure 1. Sampling Strata for each participating agency. The white spaces correspond to military land excluded from the survey.

Site selection for trend estimates

For each sampling agency, a list of potential trend sites will be generated, along with at least 10 backup sites; in some cases, the lists will be stratified by developed and open land use. A "potential" site is a probabilistic site that has been successfully sampled for benthic macroinvertebrates prior to 2014 (successful sampling of CRAM or algae is not a requirement to

be a candidate trend site). Each list shall be evaluated in numeric order, which will preserve the spatial balance of the original sample draws.

For the trend estimates, 21 previously sampled sites will be resampled each year of the survey, with the goal of having each trend site sampled a total of 5 times between 2015 and 2019. Substitutions may be required if a site becomes unsampleable during the survey, so trend estimates may ultimately be based on a higher number of sites sampled fewer times.

Special notes on selecting trend sites

Previously sampled sites from the "Region 8" Draw will not be sampled for trend estimates by the counties, and will be reserved for sampling by the Regional Board.

Certain previously sampled agricultural streams within Region 9 may be reserved for sampling by agricultural waiver permittees instead of SMC participants.

Sampling frequency and timing

Each condition site shall be sampled once during the survey, with no revisits. Each trend site shall be sampled once per year for all five years, unless substitutions are required.

The timing of sampling shall be determined on a site-by-site basis, based on information provided by field crews during reconnaissance. Typically, sites will be sampled between May 15 and July 15. Earlier sampling may be appropriate for nonperennial streams with relatively short durations, and may occur as early as March. Sampling should take place at least 4 weeks after storm events to avoid the effects of scouring. In years with severe or late-season winter storms, sampling of certain sites may be delayed until later in the summer if stream flows are too high to allow safe sampling during the normal index period. The appropriateness of a sampling date must be determined on a site-by-site basis at the discretion of the sampling crew or others who have experience with a site. Typical sampling periods are presented in Table 4:

Table 4. Typical sampling periods

Scenario	Typical sampling period
Nonperennial stream in a typical year	March 1 through May 1
Nonperennial stream in a dry year	February 15 through April 15
Perennial stream in a typical year	May 15 through July 15
Perennial stream in a dry year	April 15 through June 15
High-elevation sites in wet year (where snow or meltwater is a concern)	June 15 through August15

Site naming conventions

Condition site names shall preserve the unique random number associated with the sample draw, while also conforming as close as possible to SWAMP site naming conventions. They shall be assigned at the time of the sample draw. The station codes will be generated as follows:

HUCM#####

HUC: The 3-digit code corresponding to SWAMP's hydrologic units.

M: The letter "M".

#####: The 5-digit site id, corresponding to the order of the site in the random sample draw (see Appendix).

Trend site names will preserve the station code generated in the previous sampling efforts, as appropriate.

Program	Station Code
Environmental Monitoring and Assessment Program (EMAP)	HUCWE####
California Monitoring and Assessment Program (CMAP)	HUCCE####
National Rivers and Streams Assessment (NRSA)	FW08CA###
Perennial Streams Assessment (PSA)	HUCPS####
Stormwater Monitoring Coalition, first survey (SMC)	SMC#####
Santa Ana Watershed Monitoring Program (SMCR8)	SMCR8_###

HUC: The 3-digit code corresponding to SWAMP's hydrologic units.

ABC: Codes that designate the sample draw from which the site originated.

#####: The random site id, corresponding to the order of the site in the random sample draw (see Appendix).

PARAMETERS

Sampled parameters are described in this section. Details about methods, protocols, and quality assurance are provided in the appendix. The tables below summarizes which analytes are recommended at which sites. At the Executive Committee's discretion, this list of recommended parameters may be modified if they believe it is appropriate. Except where indicated, all SMC participants are expected to sample all parameters. Table 5 summarizes parameters, sites where the parameters are sampled, and approximate costs. Table 6 summarizes overall costs per site. Table 7 summarizes sample handling guidelines and relevant reporting limits.

Core continuing parameters

Core continuing parameters shall be sampled at all condition and trend sites. These include biological indicators (benthic macroinvertebrates, diatoms, soft algae, CRAM, and benthic algae biomass), physical habitat, nutrients (total N, ammonia-N, Nitate+Nitrite-N, total P, ortho-P), major ions (chloride, sulfate), and conventional water chemistry analytes (alkalinity, hardness, suspended solids, specific conductance, dissolved oxygen, pH, temperature, turbidity). With the exception of CRAM, all parameters are measured every year at both condition and trend sites.

Biological indicators

Benthic macroinvertebrates shall be sampled using standard SWAMP protocols (i.e., Ode et al. 2007). The reach-wide method shall be used in all cases; in low-gradient (<~1% slope), sandy streams the margin-center-margin modification may be used at the discretion of the field crew. Replicate samples are collected at 10% of sites. Data shall be submitted using standard SMC

taxonomic data formats. All samples shall be identified to SAFIT Level 2, with a target count of 600 organisms.

Benthic diatoms and soft algae shall be sampled using standard SWAMP protocols (i.e., Fetscher et al. 2009). Qualitative samples are required at all sites where samples will be analyzed for soft algae taxonomy. Replicate samples are collected at 10% of sites. Data shall be submitted using standard SWAMP taxonomic data formats.

CRAM assessments shall be conducted using standard CRAM protocols (Riverine Field Book version 6.1, www.cramwetlands.org). No replication is required. Data shall be submitted to eCRAM. CRAM is recommended at all condition sites. CRAM is recommended at trend sites if a CRAM assessment has not been conducted in the previous 2 years, or if there has been a major change (e.g., a severe flood, restoration) since the most recent CRAM assessment.

Benthic algae biomass (both ash-free dry mass and chlorophyll a) shall be sampled using standard SWAMP protocols (i.e., Fetscher et al. 2009). Replicates shall be collected at 10% of sites; field blanks are also recommended. These data shall be submitted (in units of mass per area) using standard SMC chemistry data formats.

Habitat

Physical habitat (PHAB) shall be assessed using standard SWAMP protocols (i.e., Ode 2007, plus the modifications included in Fetscher et al. 2009). Data shall be submitted using the SWAMP PHAB Data entry tool. The "full" suite of PHAB parameters shall be measured at every sampling event.

Water chemistry

Core *water chemistry* analytes include nutrients, major ions, solids, and conventional analytes. Nutrients include total N, total P, Ammonia-N, and Orthophosphate. Major ions and conventional analytes include total suspended solids, alkalinity as $CaCO_3$, hardness as $CaCO_3$, chloride, sulfate, turbidity, specific conductance, dissolved oxygen, pH, and temperature. Specific analytes and recommended reporting limits for the parameters listed above are presented in the tables below.

New parameters

A number of new parameters provide important data on stressors of interest. The costs of these parameters vary, as do the types of sites where they are recommended.

Invasive vertebrates checklist provides a rapid, low-cost assessment of biotic stressors that may affect the condition of a site. This checklist is recommended at all sites. These observations shall be reported using the custom SMC checklist in the appendix. Field crews are not expected to dedicate time searching for vertebrates, but instead to record vertebrates encountered during the normal course of sampling. The checklist is geared towards invasive species; however, reporting of observations of native species, particularly species of conservation concern, is strongly encouraged.

Hydromod PHAB add-on is a reduced hydromodification screening assessment (modified from Bledsoe et al. 2010), designed as an add-on to the standard PHAB protocol (Ode 2007). It is

recommended at all unarmored or partially armored condition sites. Participants should consider assessing trend sites as well at least once during the 5-year study. Fully armored streams, with hardened banks and streambed, may be assumed to be in stable condition and do not need to be assessed. Data shall be submitted using the custom SMC hydromodification data templates.

Channel engineering checklist is a rapid, low-cost assessment of channel engineering structures. It is recommended at all condition sites, and at all trend sites once during the 5-year survey. Data shall be submitted using the custom SMC channel engineering data template.

Bioanalytic screens and non-target chemicals of emerging concern provides data on potential stressors affecting the biological condition of a site. It is recommend at all condition sites. In 2015, these parameters are fully supported by SWAMP. In subsequent years, the workgroup shall make a recommendation about whether to continue these parameters. Samples shall be analyzed using protocols developed by SCCWRP (attached). Samples shall be collected in 1-L pre-washed amber glass bottles, field-preserved with methanol (if possible) and stored on ice for a maximum holding time of 48 hours. Field blanks will be analyzed at 5% of sites.

Hydrologic state checklist is a rapid way to document the flow regime at a site derived from Gallart et al. (2010). A minimum of three visits is recommended at both condition and trend sites, although additional visits are preferable, particularly if no additional data on hydrologic regimes are available. These visits should occur, at minimum, once during recon, once during sampling, and again in late summer or fall (when stream flow is at its lowest level). Data shall be submitted using standard SMC data templates.

Water level loggers provide higher quality data on the flow regime at a site than the hydrologic state checklist. It is recommended at all sites, as resources and site conditions allow. Data shall be submitted using standard SMC continuous data templates. Although water level loggers are preferred, other alternatives to measuring flow intermittency (e.g., Chapin et al. 2014) may be appropriate; consult with program coordinator (Raphael Mazor: raphaelm@sccwrp.org) if alternative loggers are desired.

Sediment toxicity measured with a 10-day *Hyalella azteca* growth and survival test is recommended at all condition sites where fine-grained sediment can be sampled. Preliminary analyses suggest that ~80% of sites are sampleable for sediment. Data shall be submitted using standard SMC toxicity data formats. Sediment sampling will be deferred until further action by the SMC Executive Committee.

Sediment chemistry, including pyrethroids, grain size, and total organic carbon, is recommended at all sites that show evidence of sediment toxicity. Nontoxic samples shall be archived for chemistry analysis pending additional support. Data shall be submitted using standard SMC chemistry data formats. Sediment sampling will be deferred until further action by the SMC Executive Committee.

Discontinued parameters

Discontinued parameters may be dropped to cover the costs of new parameters. These parameters were identified as low priority stressors in the SMC Report (2015). Participants may

opt to continue these indicators at their discretion: Water column toxicity, water column metals, and water column pyrethroids. It is recommended that participants who choose to measure these variables adhere to the quality assurance requirements and sample handling guidelines in the SWAMP QAPrP. Data for discontinued parameters may still be submitted to the SMC database.

Sampling plan and approximate costs

The recommend sampling plan and approximate costs are presented in Table 5.

Table 5. Sampling frequency, responsibility, and cost for each parameter.

Core continuing parameters	Approximate cost [a]	Responsibility [b]	Condition sites	Trend sites
Biological and habitat				
Bioassessment SOP	$3500	SMC	All	All
BMI taxonomy (SAFIT Level 2)	$809	SMC	All	All
Algae taxonomy	$940	SMC [c]	All	All
CRAM	$1500	SMC	All	If not done in past 2 years, or after major flood
Benthic ash-free dry mass	$64	SMC	All	All
Benthic chlorophyll a	$97	SMC	All	All
Water chemistry				
Ammonia-N	$44	SMC	All	All
Total-N [d]	$67	SMC	All	All
Nitrate-Nitrite-N	$47	SMC	All	All
Ortho-P	$52	SMC	All	All
Total-P	$67	SMC	All	All
Alkalinity as $CaCO_3$	$44	SMC	All	All
Hardness as $CaCO_3$	$44	SMC	All	All
Chloride	$47	SMC	All	All
Sulfate	$47	SMC	All	All
Total Suspended Solids	$55	SMC	All	All
New Parameters				
Vertebrates	No estimate [e]	SMC	All	All
Channel engineering checklist	No estimate	SMC	All	Once
GIS data	No estimate	TBD [f]	All	Not necessary
Hydromod PHAB module	$1000 [g]	SMC [h]	All non-fully armored channels [i]	Recommended (once)
Bioanalytic screens	$1000	SWAMP [j]	All	Not required
Sediment toxicity [k]	$1320	SMC	Where sampleable	Not required
Sediment pyrethroids [k]	$590	SMC	Where toxic	Not required
Sediment grain size [k]	$120	SMC	Where toxic	Not required
Sediment TOC [k]	$90	SMC	Where toxic	Not required
Hydrologic state	No estimate [l]	SMC	All	All
Water level loggers	$300 [m]	SMC	Recommended	Recommended

[a] All costs are best estimates, based on costs associated with SWAMP bioassessment programs. Costs will vary for each participant. All costs include associated data management. [b] If responsibility is indicated as "SMC", SMC participants are expected to cover the costs, even if in some years these costs are subsidized by SWAMP funds. [c] Algae taxonomy shall be fully subsidized in 2015. Subsidies are expected in future years, but responsibility may fall to SMC participants should SWAMP support end. [d] Direct measurements of Total-N are preferred. Calculated values (through measurements of Nitrate-Nitrite-N and Total Kjehldahl N) may have different costs. [e] Costs associated with the invasive species checklist primarily come from a 1-day training. Minor costs associated with data management. [f] Agencies capable of producing GIS delineations are encouraged to do so on their own. Past support for GIS analysis was provided by SWAMP; while this support may continue, it may not occur in a timely manner. [g] Cost estimate is for stand-alone hydromod assessment. Cost will go down by up to 50% as an add-on module for PHAB. [h] Partial support for hydromod assessment is provided by some regional boards. [i] "Fully armored" means that the channel has armored banks, and a hardened streambed. [j] SWAMP will provide support for bioanalytic screens in 2015. Support for this parameter in future years shall be determined, but it shall not be considered a required analyte of the SMC workplan. [k] Fine-grained sediment is expected at ~80% of stream

reaches; sediment sampling is deferred until further action from the SMC Executive Committee. [l] Hydrologic state assessments require at least one addition site visit in the fall (although additional visits are strongly recommended). Costs will vary widely depending on site accessibility, but on average, about 4 sites can be visited in a single day where no other sampling occurs. [m] Cost of a HOBO U20-L water level logger. Loggers may be reused multiple years. At sites far from a weather station that records air pressure, a second logger may be required.

The cost of the program will vary from year to year, given inflation and the number of parameters requiring analysis. Table 6 summarizes overall expected costs of a single site under a number of different scenarios.

Table 6. Approximate costs of sampling condition and trend sites.

Scenario	Total cost	Cost to SMC	Cost to SWAMP [a]	Cost to SMC w/o SWAMP [b]
Condition site with sediment tox and chemistry [c]	$11,798	$9858	$1940	$10,798
Condition site with sediment tox, but no chemistry [d]	$10,998	$9058	$1940	$9998
Condition site with no sediment sampling [e]	$9678	$7738	$1940	$8678
Trend site (year 1) [f]	$8678	$7738	$940	$8678
Trend site (year 2) [g]	$6178	$4938	$940	$5878

[a] Assumes SWAMP support for algae taxonomy and bioanalytic screens. Does not assume SWAMP support for hydromod assessment. [b] Assumes costs of algae taxonomy are shifted to SMC. [c] Assumes all parameters are measured. [d] Assumes sediment chemistry is not measured. e Assumes sediment chemistry and toxicity is not measured. Affects approximately 20% of sites. [f] Assumes that all parameters (including CRAM and the hydromod module) are measured, except sediment chemistry and toxicity. [g] Year 2 at trend sites differs from Year 1 in that CRAM and hydromod are not measured.

Table 7. Sample handling guidelines for major analytes. These guidelines are not intended to override laboratory recommendations. RL: Maximum reporting limits.

Table 7a. Water chemistry analytes

Analyte	RL	Container type	Holding time	Holding conditions
Water				
Conventionals and major ions				
Suspended solids	1 mg/L	Polyethylene	7 days	Cool to $\leq$ 6°C
Alkalinity as $CaCO^3$*	5 mg/L	Polyethylene	14 days	Cool to $\leq$ 6°C
Hardness as $CaCO^3$	5 mg/L	Polyethylene	6 months	Cool to $\leq$ 6°C; HNO_3 or H_2SO_4 to pH < 2
Chloride	1 mg/L	Polyethylene	28 days	Room temperature OK
Sulfate	1 mg/L	Polyethylene	28 days	Cool to $\leq$ 6°C
Turbidity*	1 NTU	Polyethylene	48 hours	Cool to $\leq$ 6°C
Specific conductance*	1 uS/cm	Polyethylene	48 hours	Room temperature OK
Dissolved oxygen	0.1 mg/L	NA	NA	Measured in field
Temperature	0.1 °C	NA	NA	Measured in field
pH*	0.1 units	Polyethylene	48 hours	Cool to $\leq$ 6°C
Nutrients				
Ammonia as N	0.1 mg/L	Polyethylene	48 hours; 28 days if acidified	Cool to $\leq$ 6°C; H_2SO_4 to pH < 2
Nitrogen,Total	0.2 mg/L	Polyethylene	28 days	Cool to $\leq$ 6°C; H_2SO_4 to pH < 2
Nitrate + Nitrite as N	0.1 mg/L	Polyethylene	48 hours; 28 days if acidified	Cool to $\leq$ 6°C; H_2SO_4 to pH < 2
Phosphorus as P	0.05 mg/L	Polyethylene	28 days	Cool to $\leq$ 6°C; H_2SO_4 to pH < 2
OrthoPhosphate as P	0.05 mg/L	Polyethylene	48 hours	Cool to $\leq$ 6°C
Optional nutrients (required if not measuring TN directly)				
Nitrate + Nitrite as N	0.1 mg/L	Polyethylene	48 hours; 28 days if acidified	Cool to $\leq$ 6°C; H_2SO_4 to pH < 2
Nitrogen, Total Kjeldahl	0.1 mg/L	Polyethylene	7 days; 28 days if acidified	Cool to $\leq$ 6°C; H_2SO_4 to pH < 2
Bioanalytic screens				

CECs	NA	Amber glass (pre-washed)	48 hours	Cool to ≤ 6°C; methanol
Benthic				
Algae biomass				
Ash-free dry mass	1 g/m^2	Glass-fiber filter within petri dish, wrapped in aluminum foil	28 days	Freeze to -20°C
Chlorophyll-a	10 mg/m^2		28 days	Freeze to -20°C

*May be measured in the field

Table 7b. Field measurements

Parameter	Resolution	Calibration or check frequency
Dissolved oxygen	0.01 mg/L	Daily, or change in 500 m elevation
pH	0.01 pH units	2-point calibration, per manufacturer
Specific conductance	1 uS/cm	Per manufacturer
Temperature	0.1°C	Per manufacturer
Turbidity	0.1 NTU	2-point calibration, per manufacturer
Velocity (flow meter)	0.1 ft/s	Per manufacturer

Table 7c. Sediment analytes and sample handling (Sediment sampling deferred until further action by the SMC Executive Committee)

Analyte	RL	Container	Holding time	Holding conditions
Sediment				
Pyrethroids				
Bifenthrin	0.025 ng/g	Amber glass	1 year if frozen; samples must be extracted within 14 days of collection or thawing, and analyzed within 40 days of extraction	Short-term storage: < 6°C in the dark; long-term storage: < -20°C in the dark
Cyfluthrin, Total	1.25 ng/g			
Cyhalothrin, Total lambda-	0.5 ng/g			
Cypermethrin, Total	1.25 ng/g			
Deltamethrin/Tralomethrin	1 ng/g			
Esfenvalerate/Fenvalerate, Total	0.5 ng/g			
Fenpropathrin	0.25 ng/g			
Permethrin, cis-	1.25 ng/g			
Permethrin, trans-	2.5 ng/g			
Conventional				
Total Organic Carbon	0.01%	Glass	28 days; 1 year if frozen	Cool to ≤ 6°C or ≤ -20°C
Grain size	1%	Glass	1 year	Cool to ≤ 6°C, do not freeze
Toxicity				
10-day survival and growth *Hyalella azteca* sediment toxicity test	NA	Amber glass	14 days	Cool to ≤ 6°C, do not freeze

QA REQUIREMENTS

Field replicates are collected as required by the SWAMP QAPrP: 10%, or one per project: benthic macroinvertebrates, diatoms, soft algae, and benthic algae biomass, and 5% for sediment toxicity, bioanalytic screens, and all water and sediment chemistry analytes. This requirement may be reduced or waived by the SWAMP Bioassessment Coordinator. In 2015, no duplicates for diatoms or soft algae shall be required. No duplicates are required for CRAM, vertebrates, phab, hydromod, channel engineering, and hydrology.

Field or travel blanks are collected as required by the SWAMP QAPrP (i.e., one per method): bioanalytic screens, and all water chemistry analytes. Field blanks are also recommended for sediment chemistry and toxicity samples. Not required: benthic macroinvertebrates, diatoms, soft algae, benthic algae biomass, CRAM, vertebrates, phab, hydromod, channel engineering, and hydrology.

Matrix spikes are required by the SWAMP QAPrP: 5% or one per batch for water chemistry and sediment chemistry samples (pyrethroids). Matrix spikes are not required for algae biomass, or suspended solids.

Toxicity tests shall be consistent with requirements of the SWAMP QAPrP. Sediment toxicity control consistent with Section 7 of the appropriate EPA method/manual must be tested with each analytical batch of sediment toxicity 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.

Training and auditing

For the first year of the survey, field crews should expect to participate in 3 to 4 days of training. In subsequent years, crews should participate in 1 to 2 days of training and intercalibration events. Training will be provided by SCCWRP staff or by the UC Davis Training Academy.

For the first year of the survey, all field crews will be audited, with repeat audits conducted as needed. Thereafter, crews will be audited every other year. The project coordinator may require additional audits as he or she sees fit.

Total training/auditing costs per agency (expected; additional training or audits may be required for individual crews as determined by the project coordinator):

First year: 3-4 days

- PHAB intercalibration, CRAM refresher: 1 day
- Hydromod training: 1/2 day
- Vertebrate ID training: 1/2 day
- Auditing: 1-2 days

Subsequent years: 1-2 days

- PHAB intercalibration, CRAM refresher, hydromod: 1 day
- Auditing: 1 day (50% of crews)

DATA SUBMISSION

Prior to every sampling season, each participating agency shall identify a single contact person responsible for all data submission from that agency. Most data should be submitted by the end of November of the year of sampling; taxonomic data should be submitted by the end of February the year following sampling. Data submission guides are attached in the appendix. Most data types are submitted through the SCCWRP data portal: http://sccwrp.org/Data/DataSubmission/SMCStreamDataSubmission.aspx.

Data type	What is submitted?	How is it submitted?	Typical deadline
Site evaluation data	1 Excel template	Data portal	Nov
Chemistry	2 Excel templates	Data portal	Nov
Toxicity	3 Excel templates	Data portal	Nov
Bug taxonomy	2 Excel templates	Data portal	Feb
Algae taxonomy	2 Excel templates	Email	Feb
PHAB	Access shell database	FTP	Nov
CRAM	eCRAM forms	eCRAM	Nov
Hydromod PHAB module	X Excel template(s)	Email	Nov
Channel engineering	1 Excel template	Email	Nov
Vertebrate observations	1 Excel template	Email	Nov
Time series data	1 to 3 Excel templates	Email	Nov
Site photos	JPEG file	Email	Nov
GIS data	2 shapefiles (points and polygon)	Email	Nov

Receipts for data submission, if not provided by the data portal, may be requested from the Information Management Officer (Shelly Moore: shellym@sccwrp.org). Submitting correct data is the responsibility of each participating agency. If problems are discovered with submitted data, the participating agency shall resubmit corrected data. Although formal training for data submission will not be provided, SCCWRP will support the data submission process on an individual basis.

Data submission for discontinued paraemters (such as water column toxicity) will be supported for participants who wish to continue sampling them.

DATA ANALYSES

The purpose of this section is to outline the intended analyses that answer key questions of the program. The workgroup may modify the analyses at any time if they believe there are better ways to get the desired answers.

Reporting units

Where possible, condition estimates will be provided for each reporting unit based on watershed or land use class. Additional reporting units (e.g., engineered channels) may be added at the workgroup's discretion. A map of watershed reporting units is shown below (Figure 2). Major changes from the previous survey include the addition of the Dominguez Channel, and the exclusion of Camp Pendleton and Miramar military bases. These reporting units may be modified at the workgroup's discretion.

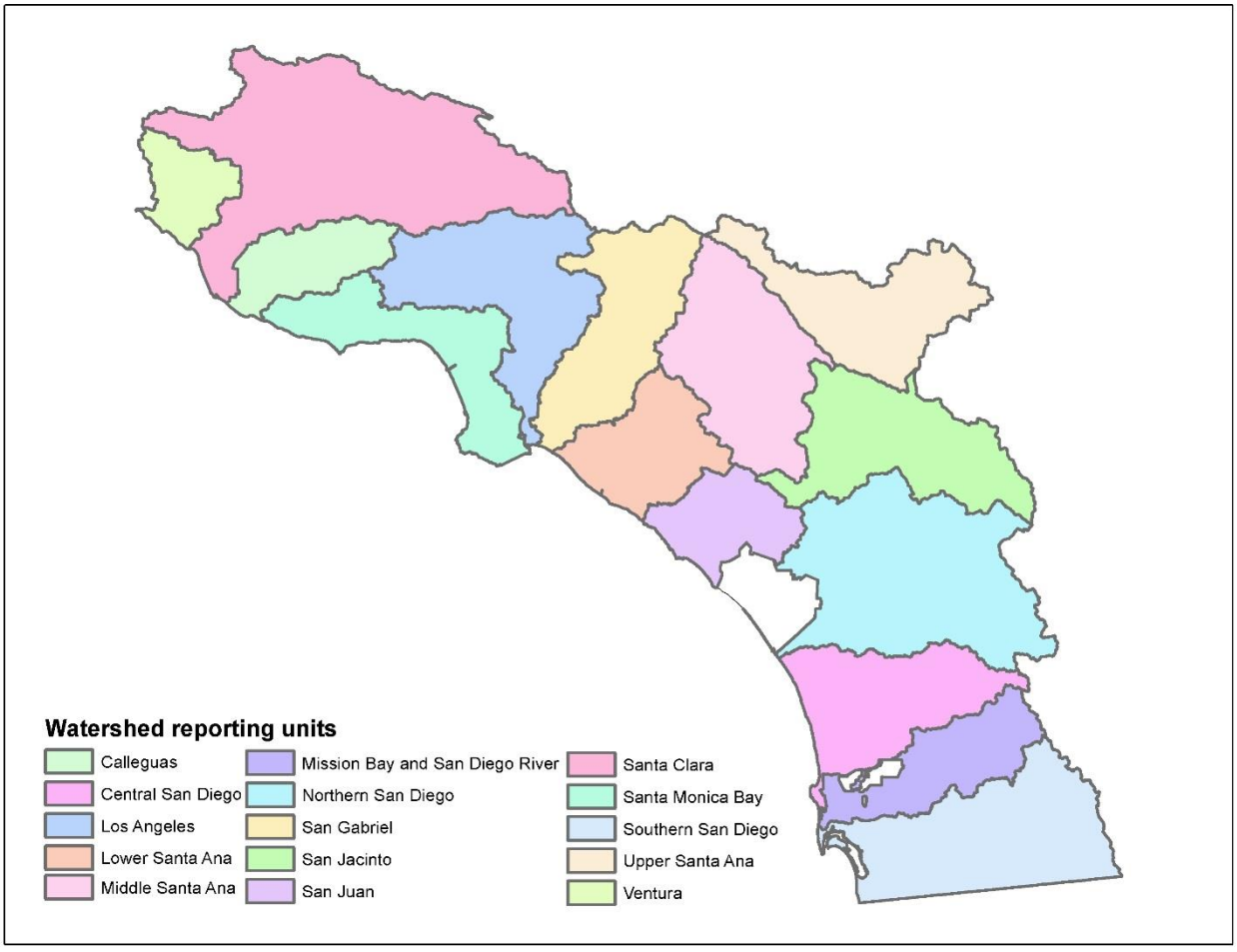

Figure 2. Watershed reporting units for the SMC Stream Survey.

Biological condition

Condition estimates shall be calculated by scoring biological indicators with appropriate indices (e.g., the California Stream Condition Index for benthic macroinvertebrates, D18 for benthic diatoms, S2 for soft algae, and CRAM for riparian wetlands), and compared with benchmarks

based on scores at appropriate reference sites. At the workgroup's discretion, indices and benchmarks may be modified if they believe it is appropriate. The extent of streams in different condition classes shall be estimated using properly adjusted weights for each sample. Biological condition will be estimated for all relevant reporting units.

Stressor associations

The extent of stressed streams shall be estimated by comparing stressor levels to appropriate benchmarks. Where possible, these benchmarks shall be based on regulatory thresholds, although reference-based benchmarks may be used in certain circumstances. Benchmarks may be modified at the workgroup's discretion. The extent of stressed streams shall be estimated using properly adjusted weights for each sample. Stressors shall be associated with biological condition through appropriate analyses, such as relative risk assessment (Van Sickle et al. 2006). Stressor extent will be estimated for all possible reporting units. Stressor associations will be conducted regionally, but not for smaller reporting units unless supported by sufficient data availability.

Trends

Trends shall be estimated in at least two ways: Comparing condition estimates across years (using all available probabilistic data), and by estimating within-site trends at revisited sites. Within-site trends shall be used to classify sites as stable, improving, or degrading, and the extent of streams in each of these classifications shall be estimated using properly adjusted weights for each sample. Temporally variable management activities and natural factors associated with changes in biological condition shall be analyzed using appropriate regression analyses. These analyses may be modified at the workgroup's discretion. Trend analyses will be conducted regionally, but not for smaller reporting units unless supported by sufficient data availability.

EXPECTED PRODUCTS

The workgroup will produce two types of products: Interim reports and a final report. Interim reports will be produced on a 1-2 year basis, and will provide updates on sampling successes or failures, changes to the program, information from special studies, or preliminary assessments as determined by the workgroup or the executive committee. The final report will provide estimates of condition, stressor associations, and trends, as described above. These reports are contingent on timely data submission and available funding.

Data requests

Data used in final reports or peer-reviewed publications shall be considered public, available through CEDEN or direct requests to SCCWRP. Unpublished data may be shared with the approval of a representative of the data owner. The data owner is the agency that funded the sampling event or analysis of the data. For cases where the funding is "split" (for example, a Regional Board funds algae taxonomy of samples collected by a County), both agencies will be informed about the request, but each agency is free to release the data it funded (in the example above, the Regional Board may approve the release of algae taxonomy data, but not water chemistry data). A formal data request procedure will be developed, but SCCWRP will facilitate these requests in the interim.

SCHEDULE

The regional monitoring program will be a five-year process. Sample preparation, including field and QA manuals will occur prior to the first year of sampling. Reconnaissance (both pre- and post-sampling) takes place in the fall of each year, and sampling takes place in the first two quarters of the following year.

Typical schedule for a single year of sampling (example: 2015):

Year	Months	Activity
2014	November to January	Site evaluations, reconnaissance
2015	January to February	Training / intercalibration
	February to July	Sampling
	October	Site re-evaluation, retrieval of loggers
	November	Non-taxonomic data submission: Site evaluations, water/sediment chemistry, sediment toxicity, physical habitat, water level loggers, CRAM, hydromod PHAB module, vertebrate observations, channel engineering, bioanalytic screens, GIS
2016	February	Taxonomic data submission: BMI and algae
	July	Annual Report

All data for this final survey is due in February 2020.

Publication of the final report is expected in Spring 2021.

LITERATURE CITED

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Stormwater Monitoring Condition. 2015. Bioassessment of streams in southern California: A report on the first five years of the SMC Stream Survey. Prepared by SCCWRP. Costa Mesa, CA

APPENDICES

Links to required documents

Document	Link
Bioassessment SOP (Ode 2007)	Original SOP (Ode 2007) http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/swamp_sop_bio.pdf Algae modification (Fetscher et al. 2009) http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/sop_algae.pdf Data sheets http://swamp.mpsl.mlml.calstate.edu/wp-content/uploads/2014/04/SWAMP_BA_Field_Data_Sheets_with_Algae_v2.5_040214.pdf Empty database shell: ftp://ftp.sccwrp.org/pub/download/smcstreamdata/SMCStreamsDataEntryTools_Aug2012.zip Training material for data entry: http://swamp.mpsl.mlml.calstate.edu/wp-content/uploads/2013/03/SWAMP_Data_Management_Plan_Bioassessment_Field_Data_Entry_032812_v2.pdf
Site reconnaissance and evaluation	Site evaluation data submission guide and templates ftp://ftp.sccwrp.org/pub/download/smcstreamdata/SubmissionGuides/SMCEvaluationSubmissionGuide_02-26-13.pdf
BMI taxonomy SOP	SOP: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/bmi_lab_sop_final.pdf BMI taxonomic conventions: http://www.waterboards.ca.gov/water_issues/programs/swamp/safit.shtml BMI taxonomy data submission ftp://ftp.sccwrp.org/pub/download/smcstreamdata/SubmissionGuides/SMCTaxonomySubmissionGuide_092613.pdf
Algae taxonomy data submission	http://swamp.mpsl.mlml.calstate.edu/wp-content/uploads/2013/03/SWAMP_Data_Management_Plan_Taxonomy_Template_102010_v2.pdf
SOP for field measurements of water and sediment samples	http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/collect_bed_sediment_update.pdf
Lab methods for pyrethroid analyses	http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/pyreth_swamp.pdf

SWAMP QAPrP and sample handling guidelines	http://www.waterboards.ca.gov/water_issues/programs/swamp/mqo.shtml
Chemistry data submission guide and templates	ftp://ftp.sccwrp.org/pub/download/smcstreamdata/SubmissionGuides/SMCChemistrySubmissionGuide_10-03-2012.pdf
Toxicity data submission guide	ftp://ftp.sccwrp.org/pub/download/smcstreamdata/SubmissionGuides/SMCToxicitySubmissionGuide_09-28-11.pdf
CRAM manual	Manual http://www.cramwetlands.org/sites/default/files/2013.03.19_CRAM%20Field%20Book%20Riverine%206.1_0.pdf Data sheets http://www.cramwetlands.org/sites/default/files/CRAM_Riverine%20datasheet_v.6.1.pdf
Logger deployment SOP, data submission guide, and templates	SOP for logger deployment: ftp.sccwrp.org/pub/download/SMC2015Workplan/LoggerSOP.pdf Data submission requirements ftp.sccwrp.org/pub/download/SMC2015Workplan/TimeSeriesDataSubmissionGuide.zip
Hydrologic state reporting form, vertebtrate reporting form, and channel engineering forms	Field forms: ftp.sccwrp.org/ftp/pub/download/SMC2015Workplan/SMCSupplementalFieldForms.zip Webpage in development
Bioanalytic screens QAPP	ftp.sccwrp.org/pub/download/SMC2015Workplan/BioanalyticScreensQAPP.pdf
Hydromod PHAB module SOP, field sheets, templates, and data submission guide	Documents and templates in development

Sample draw for the SMC 2015-2019 Stream Bioassessment Survey

Condition sites

Field definitions:

Field name	Definition
Agency	Agency responsible for evaluating the site
StationCode	The unique identifier for the station in SWAMP format. The format is HUCM#####, where "HUC" is the 3-digit hydrologic unit code, "M" indicates that the sites is from the second survey of the SMC program, and ##### is the random site number. Use this station code for all data submission and reporting. Note that because the first three digits are from the HUC, you cannot sort by this column and preserve the proper site order.
SiteNumber	Another unique identifier, in the format SMC2_#####. Unlike the StationCode, you can sort by this column and preserve the proper site order. Note that, in contrast to the previous survey, site numbers are sequential within stratum.
Stratum	Unique identifier of the stratum. Values are as follows: VR: Ventura River SC_V: Santa Clara River within Ventura County CC: Calleguas Creek SMB_V: Santa Monica Bay watershed within Ventura County SC_LA: Santa Clara River within Los Angeles County SMB_LA: Santa Monica Bay watershed within Los Angeles County LA: Los Angeles River SG: San Gabriel River SA_O: Santa Ana River within Orange County SJ_O: San Juan Creek within Orange County SA_SB: Santa Ana River within San Bernardino County SA_R: Santa Ana River within Riverside County NSD_R: Santa Margarita River and San Juan Creek within Riverside County NSD_SD: Northern San Diego watershed within San Diego County CSD: Central San Diego MBSD: Mission Bay and San Diego River SSD: Southern San Diego
mdcaty	Multi-density category. Concatenation of land use and stream order.
Longitude	Longitude in decimal degrees (datum NAD83)
Latitude	Latitude in decimal degrees (datum NAD83)
InitialWgt_m	Weight associated with the site, in meters
COMID	Unique identifier of the segment in the NHD+ shapefile. May help verify correct stream location.
GNIS_NAME	Standard geographic name of stream, from the NHD+. May help verify correct stream location. Note that GNIS_NAME is often missing, and sometimes incorrect.
HUC3	3-digit hydrologic unit code

Watershed	Watershed name corresponding to the reporting units used in the first SMC stream survey
LandUse	SMC land use class. These are based on 500-m buffer of NHD+ segments, using 1996 landcover layers. Classes are: Agricultural, Open, and Urban.
StreamOrder	Strahler stream order, using classifications from the Perennial Stream Assessment. Classes are: SO1, SO2, SO3, and SO4+. SO0 is for stream segments without stream order classifications.
OtherStrata	Stratifications used for programs nested within the SMC stream survey. LARWMP: Effluent: Streams receiving wastewater effluent Urban: Streams draining predominantly urban catchments Natural: Streams draining predominantly natural catchments SGRRMP: Mainstem: The San Gabriel River mainstem Lower: Tributaries below the Santa Fe dam. Upper: Tributaries above the Santa Fe dam San Diego River Boulder Creek San Vicente Creek El Capitan Lower San Diego

Trend sites

Field definitions:

Field name	Definition
Stratum	Stratum defining location and land use of each candidate trend site.
County	County where site is located
Draw	Identifies which survey that originally sampled the site: EMAP: Environmental Monitoring and Assessment Program CMAP: California Monitoring and Assessment Program NRSA: National River and Streams Assessment PSA: Perennial Streams Assessment SMC: Stormwater Monitoring Coalition SMCR8: Santa Ana Regional Monitoring Program
WgtCode	Unique identifier of the trend site, derived from the sample draw that was used in the original survey. The WgtCode preserves the random site order. Because sites have numerous aliases in different databases, the WgtCode should be used for data submission and reporting purposes. The format of the WgtCode varies from survey to survey: EMAP: WCAP99-#### CMAP: CAW03444-#### NRSA: FW08CA###

	PSA: smc.#### (other formats used for sites outside the South Coast region) SMC: SMC##### SMCR8: SMCR8_###
Longitude	Longitude in decimal degrees (datum NAD83)
Latitude	Latitude in decimal degrees (datum NAD83)
SMC_LU	SMC land use class. These are based on 500-m buffer of NHD+ segments, using 1996 landcover layers. Classes are: Agricultural, Open, and Urban.
SMC_SHED	Watershed name corresponding to the reporting units used in the first SMC stream survey
AdjWgt_km	Adjusted site weight used in the SMC 5-year report, in km
LU	Aggregated land use: Developed=Ag or Urban
Years Sampled	Years previously sampled, separated by an underscore
meanCSCI	Mean CSCI from previous samples
Agency	Agency or agencies that previously sampled the site, separated by an underscore
Distribution	Indicates which agency has been given the site to evaluate. Some sites are reserved for future use, and have not been distributed to anyone.

Sample draws and kml files may be downloaded here:

ftp.sccwrp.org/pub/download/SMC2015Workplan/SMC2015_SampleDraw.zip