Assessing Homelessness Impacts on Water Quality, Riparian and Aquatic Habitat in Upper Santa Ana River Watershed

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Acronyms

BAT	Best Available Treatment
BCT	Best Conventional Treatment
BMI	Benthic Macroinvertebrate
CASQA	California Stormwater Quality Association
CBRP	Comprehensive Bacteria Reduction Plan
CCFC&WCD	Contra Costa County Flood Control & Water Conservation District
CoC	Chain-of-Custody
CoSA	City of San Antonio
EIR	Environmental Impact Report
Fwy	Freeway
GC	Geovironment Consulting
HF183	Human Fecal Genetic Marker
HOPE	Homeless Outreach and Proactive Enforcement
I-215	Interstate 215
I-15	Interstate 15
IEWK	Inland Empire Waterkeeper
lbs	Pounds
LMA	Lynn Merrill and Associates
m^3	Cubic meters
MBB	Mission Boulevard Bridge
MDL	Method Detection Limit
MQO	Measurement Quality Objective
MS	Matrix Spike
MSAR	Middle Santa Ana River
MSAR Bacteria TMDL	Middle Santa Ana River Bacterial Indicator Total Maximum Daily Load
MSAR Task Force	Middle Santa Ana River Watershed TMDL Task Force
MSB	Market Street Bridge
MSD	Matrix Spike Duplicate
North Coast Water Board	North Coast Regional Water Quality Control Board
PHab	Physical Habitat and Bioassessment
PIT	Point-in-Time
PPCP	Pharmaceuticals and Personal Care Products
QA/QC	Quality Assurance/Quality Control
RCFC&WCD	Riverside County Flood Control & Water Conservation District
REC-1	Water Contact Recreation
REC-2	Non-contact Water Recreation
Riverside RWQCP	Riverside Regional Water Quality Control Plant
RPD	Relative Percent Difference
RWB	Reach-wide Benthos
Santa Ana Water Board	Santa Ana Regional Water Quality Control Board
San Diego Water Board	San Diego Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Project Authority

SCCWRP	Southern California Coastal Water Research Project
SCVWD	Santa Clara Valley Water District
SOP	Standard Operating Procedure
SRM	Standard Reference Material
State Water Board	State Water Resources Control Board
SWAMP	Surface Water Ambient Monitoring Program
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
VBB	Van Buren Boulevard Bridge
WARM	Warm Freshwater Habitat
WDR	Waste Discharge Requirements
WWTP	Wastewater Treatment Plant

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Introduction

The Santa Ana Watershed Project Authority (SAWPA) commissioned a study to (a) assess the current nature and extent of homeless encampments within waterbodies in the upper Santa Ana River watershed; and (b) provide the best available information about the relationships between the presence of homeless encampments and impacts to water quality and riparian and aquatic habitats. The findings from this project can support SAWPA's watershed planning activities in the Santa Ana River region.

Homeless encampments have the potential to impact water quality in a number of ways, including elevated bacterial indicator concentrations from human waste and buildup of trash, which may contain pollutants. Homeless encampments also may impact the integrity of riparian and aquatic habitats and aquatic and terrestrial species that rely on those habitats. For example, the mainstem Santa Ana River below Seven Oaks Dam and portions of selected tributaries are designated as critical habitat for the Santa Ana Sucker. In addition, other threatened and endangered species or species of concern are associated with Santa Ana River riparian habitat, e.g., the least Bell's Vireo.

The *potential* for homeless encampments to impact water quality and habitat can be documented, at least anecdotally. For constituents such as trash, just the presence of the trash is itself an impact. However, for other constituents, e.g., bacteria or toxic chemicals, actual data that directly links homeless encampment activity to lower water quality, appear to be limited or unavailable. Regardless, it is generally assumed that impacts do occur because of the lack of adequate sanitary waste disposal facilities and presence of trash containing toxic chemicals.

Given this background, SAWPA and its member agencies directed the implementation of a study[1] to evaluate homeless encampments in the upper Santa Ana River watershed through a two-step process. The first step was to (a) develop a better understanding of potential impacts of homeless encampments on water quality and riparian and aquatic habitat based on an assessment of existing information; and (b) identify areas in the upper watershed where encampments are concentrated. The findings from this assessment are provided below in Section 1 - *Task 1 Memorandum: Assessment of Homeless Encampments/Literature Review Findings*.

Based on the findings presented in Section 1 of this report, a Preliminary Monitoring Program was developed for potential implementation by SAWPA. The purpose of the monitoring program is to gather data from areas within the upper Santa Ana River watershed

[1] This study was funded through a grant from the Proposition 1 Integrated Regional Water Management, Disadvantaged Community Involvement grant program.

where homeless encampments are typically present to evaluate potential impacts to water quality and aquatic and riparian habitats. This proposed Preliminary Monitoring Program is presented in Section 2 - *Task 2 Memorandum: Upper Santa Ana River Watershed Homelessness Preliminary Monitoring Program*.

Task 1 Memorandum: Assessment of Homeless Encampments/Literature Review Findings

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1.1 Project Background and Approach

1.1.1 Background

SAWPA commissioned a study to (a) assess the current nature and extent of homeless encampments within waterbodies in the upper Santa Ana River watershed; and (b) provide the best available information about the relationships between the presence of homeless encampments and impacts to water quality and riparian and aquatic habitats. The findings from this project can support SAWPA's watershed planning activities in the Santa Ana River region.

For the purposes of this study, the upper watershed generally includes the portions of the Santa Ana River and tributaries above Prado Dam. For the mainstem of the Santa Ana River, the project area is downstream of the San Gabriel and San Bernardino Mountains in the north and east (e.g., downstream of Seven Oaks Dam; downstream of where Hwy 38 enters the San Bernardino Mountains). For the Temescal Creek subwatershed the project area is the portion of Temescal Creek generally downstream of where Temescal Wash begins to parallel Interstate 15 downstream of Lake Elsinore.

Homeless encampments have the potential to impact water quality in a number of ways, including elevated bacterial indicator concentrations from human waste and buildup of trash, which may contain pollutants. Several waterbody segments in the upper watershed are listed as water quality-impaired and have been placed on the State 303(d) List because they do not currently meet beneficial uses for one or more constituents. Currently, several waterbodies in the upper Santa Ana River watershed, including Santa Ana River Reach 3, are subject to the requirements of the Middle Santa Ana River (MSAR) Bacterial Indicator Total Maximum Daily Load (TMDL) ("MSAR Bacteria TMDL"). Other waterbodies remain listed as impaired, but to date TMDLs have not yet been developed (e.g., Santa Ana River Reach 4, Warm Creek, San Timoteo Creek, and Mill Creek Reach 1).

Homeless encampments also may impact the integrity of riparian and aquatic habitats. The mainstem Santa Ana River below Seven Oaks Dam and portions of selected tributaries are designated as critical habitat for the Santa Ana Sucker. In addition, other threatened and endangered species or species of concern are associated with Santa Ana River riparian habitat, e.g., the least Bell's Vireo.

The *potential* for homeless encampments to impact water quality and habitat can be documented, at least anecdotally. For constituents such as trash, just the presence of the trash is itself an impact. However, for other constituents, e.g., bacteria or toxic chemicals, actual data that directly links homeless encampment activity to lower water quality, appear to be limited or unavailable. Regardless, it is generally assumed that impacts do occur because of the lack of adequate sanitary waste disposal facilities and presence of trash containing toxic

chemicals. The purpose of this memorandum is to develop a better understanding of potential impacts of homeless encampments on water quality and riparian and aquatic habitat in the upper Santa Ana River watershed based on an assessment of existing information.

1.1.2 Assessment Approach

To assess potential impacts of homeless encampments on water quality and riparian and aquatic habitat in the upper Santa Ana River watershed, we carried out the following two activities:

- *Assessment of Homeless Encampments* – This effort focused on identifying where homeless encampments are most prevalent within the upper Santa Ana River watershed. This information was gathered through meetings and discussions with various entities with direct knowledge of homeless encampment activity in the watershed. A general set of questions was prepared for discussion with each of the interviewees. While the focus was on these questions, we allowed interviewees to share any information they deemed appropriate. Where relevant, we requested supplemental information from the interviews (e.g., homeless encampment data and photographs). The findings from this activity are provided in Section 1.2.

- *Review Literature, Studies and Reports* – This activity included a review of published literature, studies and reports that provide information and insight regarding the relationship between the presence of homeless encampments and impacts to water quality and riparian and aquatic habitats. This effort focused primarily on California sources, but additional information was developed from other locations outside of California, especially in other western states. The findings from the literature review are provided in Section 1.3.

Based on the findings from the two activities described above, this memorandum provides the following:

- *Characterization of Homeless Encampment Areas in Study Area* – One of the goals of this study was to develop criteria for selection of up to five homeless encampment areas to evaluate their inherent characteristics. However, based on the findings of the study, it is not possible to distinguish different camp types based on the information readily available. Instead, we found that areas with encampments have very similar characteristics and types of impacts on the environment. Therefore, this memorandum characterizes typical conditions observed in encampments and impacts observed. In addition, this memorandum identifies five key areas where homeless encampments are concentrated in the upper watershed.

- *Conclusions and Recommendations* – The memorandum uses the characterization of homeless encampments to draw conclusions and recommendations for consideration

regarding the development of a Preliminary Monitoring Program – the second part of the two-step process to better understand homeless encampment impacts in the watershed. These recommendations will be discussed with SAWPA prior to initiation of the development of such a program.

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1.2 Assessment of Homeless Encampments

In this section we provide the findings from discussions with watershed stakeholders regarding the presence of homeless encampments in project area. Section 1.2.1 summarizes the key findings regarding identification of homeless encampments in the watershed and observed impacts from these camps on water quality and habitat. Section 1.2.2 provides input from stakeholder interviews that provides the basis for the summary of findings.

1.2.1 Summary of Key Findings

Information to support the assessment of homeless encampments in the upper watershed was gathered from the following entities:

- Santa Ana Watershed Project Authority
- San Bernardino County Sheriff Department
- San Bernardino County Department of Public Works
- Riverside County Flood Control & Water Conservation District (including information from County of Riverside County Executive Office)
- Inland Empire Waterkeeper
- City of Rialto (represented by Lynn Merrill and Associates, Inc. and Geovironment Consulting)
- Riverside Regional Water Quality Control Plant
- Santa Ana Regional Water Quality Control Board
- San Bernardino Valley Water Conservation District

The following subsections provide an overview of the findings from discussions with these entities. Section 1.2.2 provides the specific information and data obtained from each entity.

1.2.1.1 Location of Homeless Encampments

In 2016, SAWPA compiled data from the San Bernardino and Riverside County Sheriff Departments and the Orange County Public Works Department to illustrate locations for homeless camps within the Santa Ana River watershed. These data provide the earliest assessment we have available of overall homeless encampment activity in the upper watershed. At that time camps were concentrated in an approximate 2.5 mile reach above and below the 60 Freeway (Fwy) crossing and around the Interstate 215 (I-215) crossing. Additional camps were noted above the City Creek confluence with the Santa Ana River and Tequesquite Landfill in San Bernardino County and Riverside County, respectively.

In 2019, homeless encampments appear to have expanded in scope and are concentrated in five key areas in the Santa Ana River:

- Van Buren Boulevard Bridge (VBB) upstream to Anza Drain
- Along the Tequesquite Landfill
- Above and below the Mission Boulevard Bridge (MBB) crossing
- Upstream of the 60 Fwy
- Between the I-215 bridge and Tippecanoe Road

The general opinion of most interviewees was that the number homeless encampments is on the increase; however, insufficient data exist to actually affirm this belief. Most agreed that a typical encampment includes 2-4 people. While we do not have total numbers of encampments or numbers of individuals residing in riverbeds in the watershed, we did obtain the following information regarding potential numbers of homeless encampments/residents within specific reaches of the Santa Ana River:

- *Inland Empire Waterkeeper (IEWK)* documented 187 encampments in the Santa Ana River reach from the VBB upstream to the MSB in February 2019. Using the 2-4 people estimate/encampment, it is estimated 400 – 800 people likely reside in this reach.
- *Riverside County Flood Control & Water Conservation District (RCFC&WCD)* identified a total of 256 encampments between Interstate 15 (I-15) and the Riverside County line in 2018. Using the 2-4 people/encampment number, this results in an estimate of 500-1000 people in this reach of the Santa Ana River. This estimate is generally consistent with the above IEWK estimates given the RCFC&WCD data is from a longer river reach.
- *San Bernardino County Sheriff Department* staff estimated 300-400 people living in encampments in riverbeds in the portion of the upper Santa Ana River watershed portion that is in San Bernardino County.

1.2.1.2 Water Quality Impacts

No water quality data were found for the Santa Ana River watershed that demonstrates a direct link between homeless encampment activity and degraded water quality. While no such data were found, it is notable that the ongoing MSAR Bacteria Synoptic Study being implemented by SAWPA's MSAR Watershed TMDL Task Force ("MSAR Task Force") recently observed detectable levels of human source bacteria in the Santa Ana River near the MBB crossing on one of six sample dates. Given the high concentration of homeless encampments in that area (see Section 1.2.2.4 below), this finding should not be surprising; however, interestingly the observation only occurred once in the six-week Synoptic Study. More data would be needed to use this finding to make broad statements regarding

relationships between homeless encampment activity in the Santa Ana River watershed and degraded water quality.

1.2.1.3 Riparian and Aquatic Habitat Impacts

The environmental impacts from the presence of homeless encampments in the upper Santa Ana River watershed were noted by many of the entities interviewed. Examples of impacts noted through various means include:

- Trash;
- Degradation of riparian areas, including vegetation, habitat, and riverbanks;
- Man-made diversions built in the river;
- Impacts to the physical integrity of levees; and
- Fire

1.2.2 Specific Findings from Interviewed Entities

We reached out to a number of entities to obtain current information on: (a) the location of homeless encampments in the upper Santa Ana river watershed; (b) observed impacts from these encampments; and (c) obtain any data relevant to the purposes of this study. **Attachment A** provides the basic list of questions that guided each discussion.

Figure 1-1 provides an overall aerial image of the upper watershed. The following figures provide a more close-up aerial view of each of the areas highlighted in Figure 1-1 and identifies areas where information regarding homeless encampments was obtained:

- **Figure 1-2** – Lower portion of the study area from the 60 Fwy downstream to Prado Basin. Information was obtained on homeless encampment from discussions with the RCFC&WCD, Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) and Riverside Regional Water Quality Control Plant (Riverside RWQCP).
- **Figure 1-3** – Middle portion of study area from I-215 downstream to the 60 Fwy. With the exception of the lower most portion of the reach, the riverbed in this area is typically dry with minimal vegetation. Vegetation begins to appear downstream of where the treated effluent from the City of Rialto Wastewater Treatment Plant (WWTP) enters the mainstem Santa Ana River. Data for this area were obtained from the City through the work of its consultant, Lynn Merrill and Associates, Inc.
- **Figure 1-4** – Upper portion of the study area from I-215 upstream to the beginning of the foothills. For this area, were able to obtain information from the San Bernardino County Sheriff Department, San Bernardino County Public Works and the San Bernardino Valley Water Conservation District.

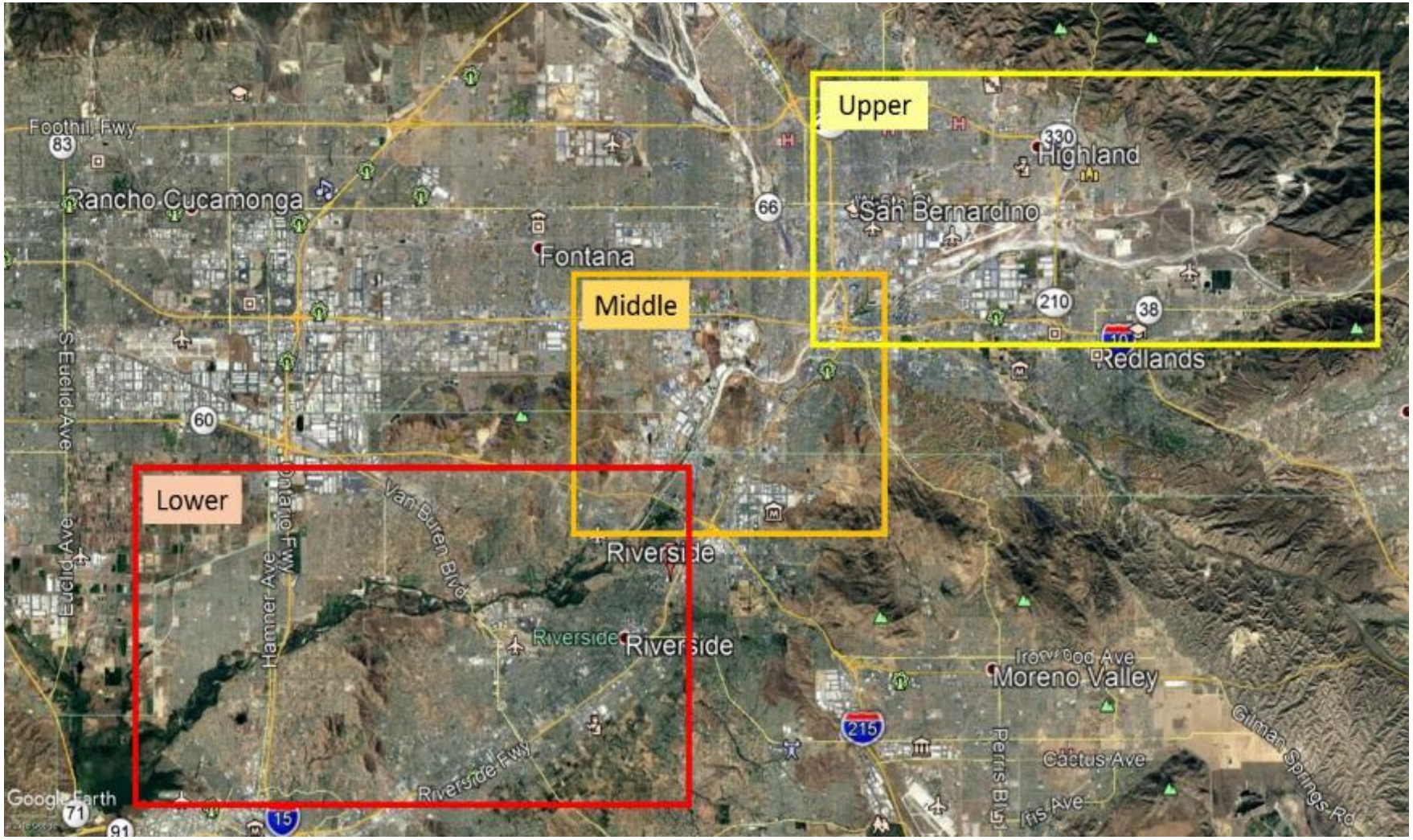

Figure 1-1. Locations of Lower, Middle and Upper Portions of the Upper Santa Ana River Watershed Study Area (see Figures 1-2, 1-3 and 1-4 for a more close-up view of each of the highlighted areas and where information was obtained for the purposes of this project)

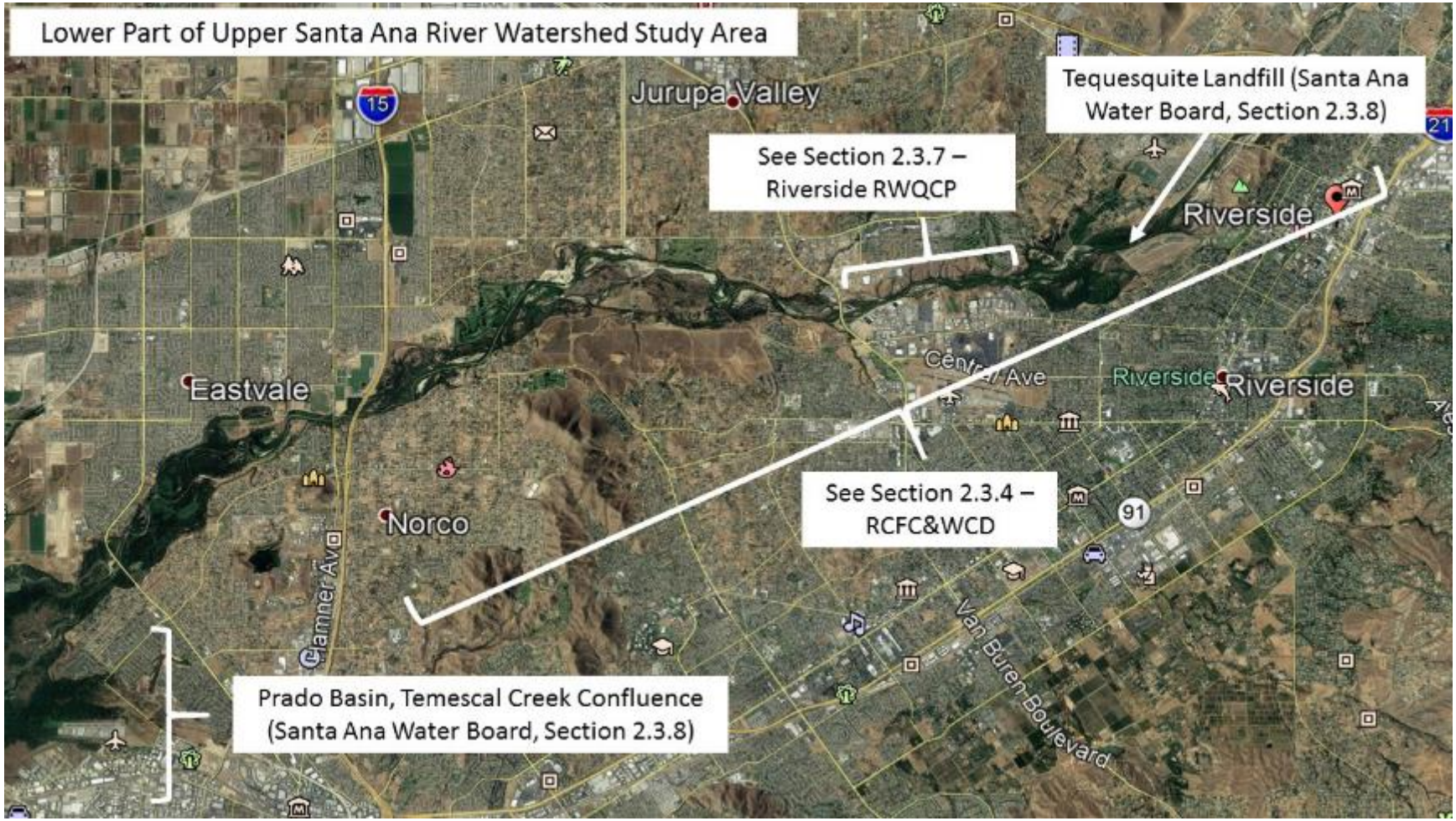

Figure 1-2. Lower Portion of the Upper Santa Ana River Watershed Study Area (see referenced sections for information on homeless encampments in those areas)

Figure 1-3. Middle Portion of the Upper Santa Ana River Watershed Project Study Area (see referenced sections for information on homeless encampments in those areas)

Figure 1-4. Upper Portion of the Upper Santa Ana River Watershed Project Study Area (see referenced sections for information on homeless encampments in those areas)

The following subsections summarize the findings from each of the interviews conducted as part of this project. The overall findings are synthesized above in Section 1.2.1.

1.2.2.1 Santa Ana Watershed Project Authority

SAWPA compiled 2016 homeless encampment location data from the San Bernardino and Riverside County Sheriff Departments and the Orange County Public Works Department to in the Santa Ana River watershed (**Figure 1-5)**. While these data show key areas where camps were prevalent (e.g., above and below the 60 Fwy bridge), we cannot conclude that there were no camps in other areas, especially in the lower portion of the Santa Ana River shown in the figure. Today, agencies are more active in documenting presence/absence of encampments, and the lack of data points in 2016 may simply represent a data gap.

SAWPA facilitates the work of the Santa Ana Sucker Conservation Team, which works to determine reasons for the decline of the Santa Ana sucker in the Santa Ana River watershed and devise strategies for the recovery of the species (https://sawpa.org/task-forces/santa-ana-sucker-conservation-team/). Every year the Team oversees the annual Riverwalk. Its purpose is to survey the status of the Santa Ana sucker fish's habitat. For the 2019 survey, we coordinated with SAWPA's Ian Achimore to include a place on the survey form to note homeless encampment observations. **Figure 1-6** identifies the locations where a surveyor noted observations regarding homeless activity. While most forms simply noted the presence of an encampment at the survey location, some forms indicated other impacts, e.g., fire pit evidence, man-made channel diversions, presence of a treehouse, and steps carved into the riverbank. It was notable that the areas where volunteers were most likely to note homeless encampment activity is consistent with the locations where the RCFC&WCD noted the highest concentrations of homeless encampments in 2018 (see Section 1.2.2.4 below).

SAWPA administers two Task Forces that have missions that may be relevant to the purposes and findings of this project:

- *MSAR Task Force* – This Task Force was formed to implement the Bacterial Indicator TMDLs adopted by the Santa Ana Water Board to address impairments in Chino Creek (Reaches 1 and 2), Mill Creek (Prado Area), Cucamonga Creek Reach 1, Santa Ana River Reach 3 and Prado Park Lake.[2] This Task Force will soon begin work to revise this TMDL. In preparation for the TMDL revision, the Task Force recently completed a Synoptic Study to update baseline information on bacterial indicators and presence of human sources of bacteria in the MSAR watershed and key tributaries. Findings from this study that may be relevant to the purposes of this memorandum are discussed below in Section 1.2.2.4.

[2] Adopted by Santa Ana Water Board Resolution No. R8-2005-0001 on August 26, 2005. The adopted TMDL was approved by the State Water Resources Control Board on May 15, 2006 (Resolution No 2006-030) and by US Environmental Protection Agency (USEPA) Region 9 on May 16, 2007.

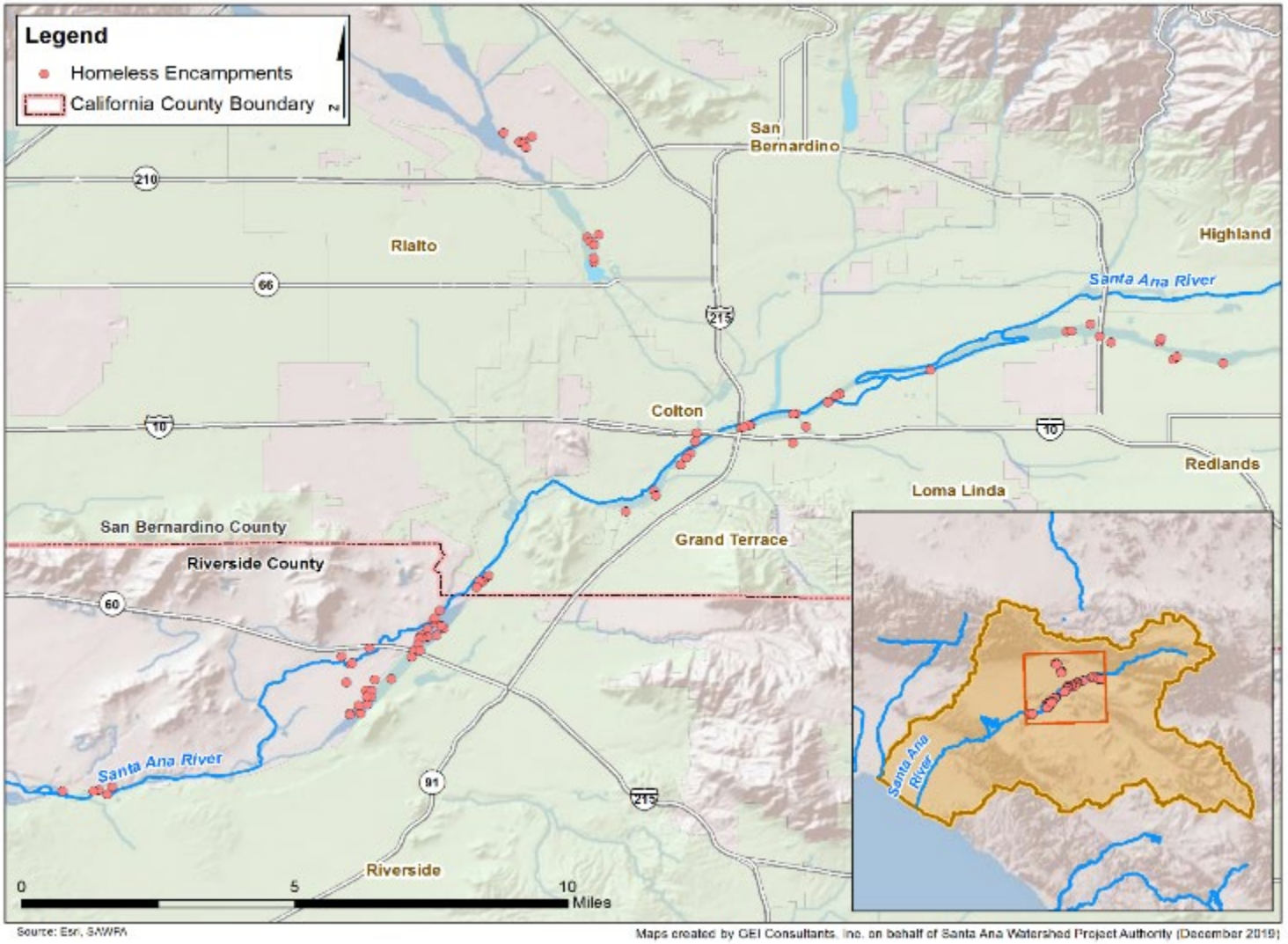

Figure 1-5. Locations of Homeless Encampments in the Upper Santa Ana River Watershed in 2016 (Data provided by SAWPA; original data sources are the San Bernardino County and Riverside County Sheriff Departments)

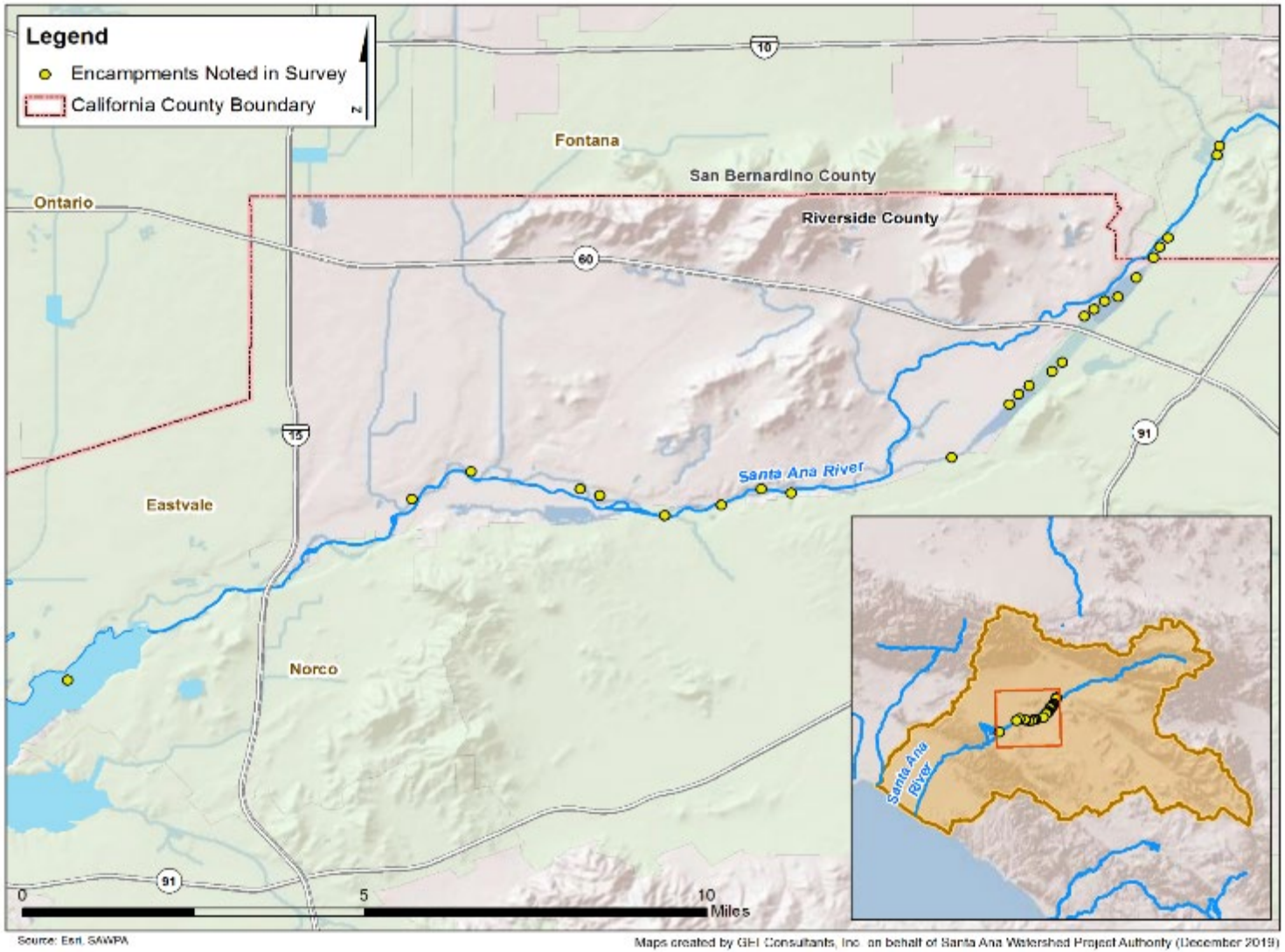

Figure 1-6. Locations of Homeless in the Upper Santa Ana River Watershed Noted during Santa Ana Sucker Riverwalk Survey, November 7, 2019 Based on notations in field forms provided by SAWPA)

- *Regional Water Quality Monitoring Task Force* – This Task Force is responsible for implementing the Regional Bacteria Monitoring Program[3] that implements the (a) surveillance and monitoring requirements for the Basin Plan amendment that revised the Recreation Standards for Inland Freshwaters in the Santa Ana Region;[4] and (b) the monitoring requirements established by the MSAR Bacteria TMDL.

Given the nature of this review of homeless encampments and their potential to impact water quality, the above Task Forces were briefed on the nature of this project in fall 2019.

1.2.2.2 San Bernardino County Sheriff Department

The San Bernardino County Sheriff Department is one of the lead agencies in the county to address homeless concerns. We met with Deputy Sheriffs Mike Jones, Mike Catalano and Aaron Halloway on September 10, 2019 to gather their insights, in particular with regard to the presence of homeless encampments in riverbeds. All serve in San Bernardino County's Homeless Outreach and Proactive Enforcement (HOPE) Program. HOPE is a pro-active approach intended to ultimately reduce calls for service and other resources currently required to deal with the homeless population. HOPE works to link the homeless population with resources and service providers throughout the county.

Figure 1-7 illustrates locations within two miles of the Santa Ana River mainstem where the county has had contact with homeless. The county database includes information on where contact occurs; it does not indicate that an encampment is present at that location. During the interview, the HOPE team provided the following information regarding where homeless encampment activity is typically found in the Santa Ana River study area:

- Santa Ana River, Orange Avenue to Palm Avenue, east of the Airport – Cluster of camps in this area, in particular along the shooting range.
- Santa Ana River, Along the Airport – No camps located noted in this reach.
- Santa Ana River, Tippecanoe Avenue to E Street/I-215 Fwy bridge – Largest concentration of camps are in this area (**Figure 1-8**). Based on most recent data, it is estimated that approximately 30 encampments are located in this reach with potentially up to 100 people in this area (an encampment is defined as having a tent; on the average there are 2-4 people per tent). In the opinion of the interviewees, the number of people in the camps in this area has increased over the past two years.

[3] Regional Bacteria Monitoring Program: https://sawpa.org/task-forces/regional-water-quality-monitoring-task-force/#geographic-setting

[4] Amendment to the Basin Plan approved June 15, 2012 (Resolution No. R8-2012-0001); approved by State Water Resources Control Board: January 21, 2014 (Resolution No. 2014-0005); USEPA: April 8, 2015.

Figure 1-7. Records of Contacts with Homeless within Two Miles of the Santa Ana River in San Bernardino County (Map provided by the San Bernardino County Sheriff Department, October 10, 2019)

Figure 1-8. Records of Contacts with Homeless in Area with Highest Concentration of Encampments: Tippecanoe Avenue to E Street/I-215 (Map provided by the San Bernardino County Sheriff Department, October 10, 2019)

- Santa Ana River, Under I-215 bridge - Some camps are present, but not many.
- Santa Ana River, Below Lytle Creek Confluence - May get a few camps in this area. Considered "rural" as compared to upstream. Camps remain sparse until downstream beginning near the South Riverside Avenue Bridge.

In general, the highest concentrations of encampments in the Santa Ana River mainstem occur where there is the most water and, therefore, more instream vegetation. **Figure 1-9** is a closeup aerial image of the same area illustrated in Figure 1-8. As can be seen, this area of the river has significantly more vegetation providing cover for homeless encampments. **Figure 1-10** provides some example photographs of the encampments located in this area. The most important habitat impact observed by the HOPE Team has been the significant amount of trash (including needles). They have observed an encampment that was dug into the levee wall to create a living space.

Overall, the HOPE team estimates that the number of homeless in encampments in the upper Santa Ana River watershed within San Bernardino County outside of the mountains is 300-400. The next largest concentration of homeless in the County is in the Victorville area. They stated that they get few reports of homeless encampment activity on county lands in the mountains.

1.2.2.3 San Bernardino County Department of Public Works

We met with Arlene Chun, Stormwater Program Manager for the San Bernardino County Stormwater Program, and selected Public Works staff on September 11, 2019. They actively work with a variety of agencies to address homeless encampments in county facilities. The most significant homeless encampment problem in the past year has been in City Creek along the reach from the boundary with the National Forest downstream to Baseline Road (see Figure 1-4). **Figures 1-11 and 1-12** provide an overview of homeless encampments in the area involved in the most recent clean-up. The targeted camp was described as very large with multiple dwellings. **Figure 1-13** provides an example of the amount of trash in the area. **Figure 1-14** illustrates one area before and after the clean-up. All together more than 50 tons of trash were removed from the camp.

The Public Works staff stated that a typical homeless encampment could be described as a clearly-defined area with tents. On the average 2-4 people occupy the tents. The biggest impacts have been trash – especially what gets mobilized in flood control channels during wet weather events. Other impacts noted included accidental fire, impacted endangered species habitat, e.g., removing the undergrowth which can be important habitat for birds, and presence of pets which can impact local wildlife.

Figure 1-9. Aerial Imagery of the Mainstem Santa Ana River: Tippecanoe Avenue to E Street (Note the significant greening of the channel in this area – an indication of water at or near the surface to support increased vegetation, which provides cover for homeless encampments)

Figure 1-10. Examples of Homeless Encampments in Santa Ana River Upstream of I-215 Bridge (Photographs courtesy of the San Bernardino County Sheriff Department)

Figure 1-11. Location of City Creek Homeless Encampment Clean-up in San Bernardino County (see Figure 1-4 for location, potential for encampment activity to impact the MS4 in Cities of San Bernardino and Highland) (from presentation delivered by Arlene Chun, Stormwater Program Manager for the San Bernardino County Department of Public Works at the California Stormwater Quality Association [CASQA] Quarterly Meeting, May 9, 2019)

Figure 1-12. Location of Homeless Encampments in City Creek Clean-up Area (see Figure 1-4 for location , potential for encampment activity to impact the MS4 in Cities of San Bernardino and Highland) (from presentation delivered by Arlene Chun, Stormwater Program Manager for the San Bernardino County Department of Public Works, at the CASQA Quarterly Meeting, May 9, 2019)

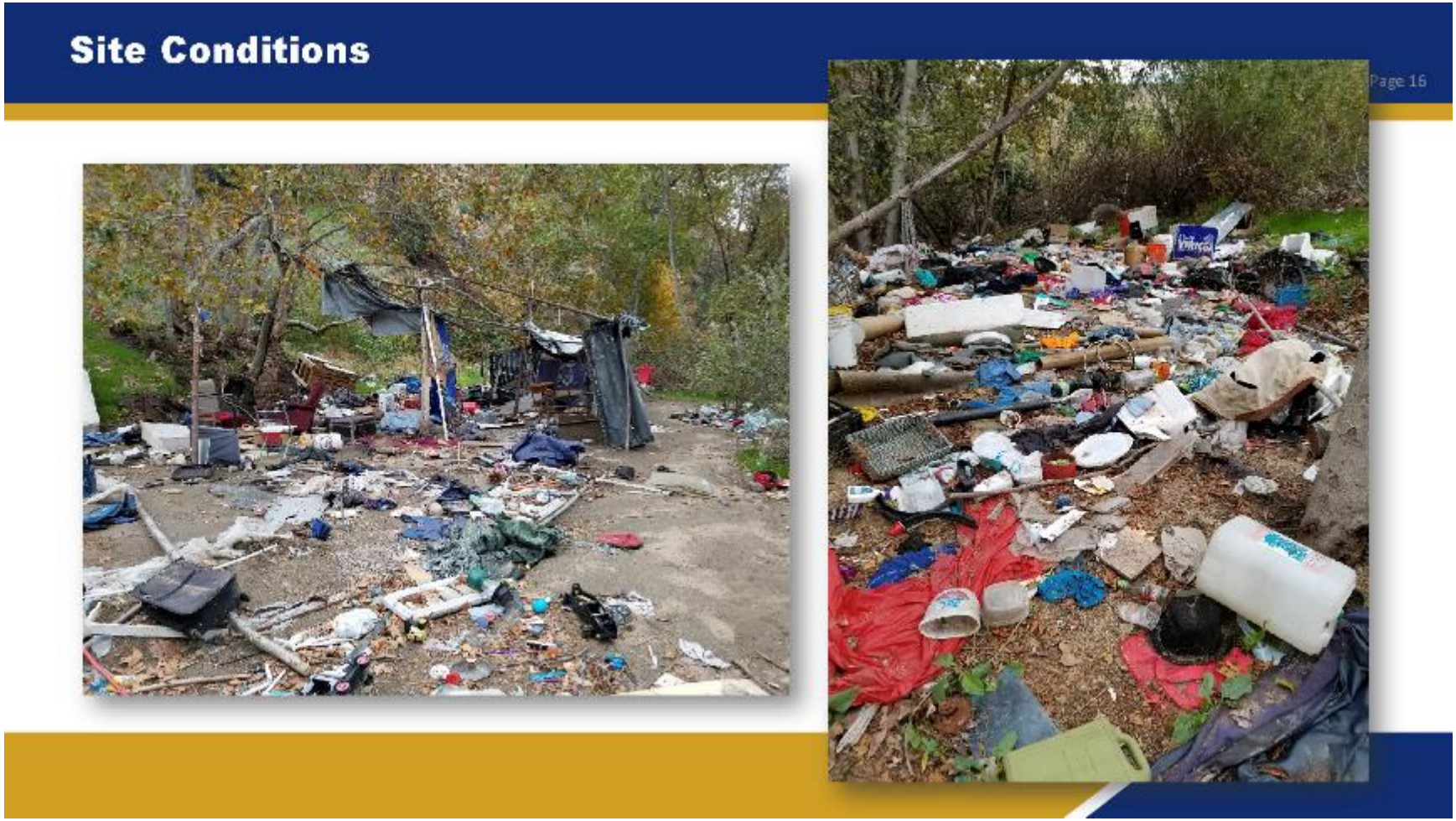

Figure 1-13. Example of Impacts from Homeless Encampments along City Creek (from presentation delivered by Arlene Chun, Stormwater Program Manager for the San Bernardino County Department of Public Works, at the CASQA Quarterly Meeting, May 9, 2019)

Figure 1-14. Example of Outcome after Clean-up of Impacts from Homeless Encampments along City Creek (from presentation delivered by Arlene Chun, Stormwater Program Manager for the San Bernardino County Department of Public Works, at the CASQA Quarterly Meeting, May 9, 2019)

1.2.2.4 Riverside County Flood Control & Water Conservation District

RCFC&WCD provided results of two drone surveys of the Santa Ana River from the Riverside County line downstream to the I-15 bridge. The first survey occurred in July 2018 from the Riverside County line downstream to < ½ mile below the MBB; the second survey occurred November 2018 from the lower end of the first survey to the I-15 bridge. RCFC&WCD staff reviewed the aerial imagery to note where encampments were likely present, based on characteristics such as presence of structures or trash/debris.

Figure 1-15 illustrates the results of these drone surveys. Combined, 286 homeless encampment locations were identified: 101 encampments in the upper portion of the area surveyed (over a distance of approximately 2.8 river miles) and 185 encampments in the lower portion of the surveyed area (over approximately 9.5 river miles). In the upper area surveyed, homeless encampments are concentrated in two areas: around the MBB and upstream of the 60 Fwy bridge. In the lower area surveyed most encampments were noted between the VBB upstream to along the Tequesquite Landfill. The largest cluster of homeless encampments in this reach was generally in the river along the Riverside RWQCP.

Figure 1-15 shows the locations where (a) water quality samples are regularly collected to evaluate compliance with the MSAR Bacteria TMDL; and (b) mainstem Santa Ana River sites included in the MSAR Bacteria Synoptic Study. All of these sample locations were recently sampled over a six-week period as part of the 2019 MSAR Bacteria Synoptic Study being implemented by the SAWPA MSAR Task Force. One of the interesting findings from that sample program was the sample results from August 14 that detected the presence of human source bacteria at the sample site located near the MBB crossing. This sample location is the middle of an area with a high concentration of homeless encampments.

In addition to providing the drone survey results, RCFC&WCD allowed us to attend a presentation by Natalie Komuro, Deputy County Executive Officer, Homeless Solutions, to the Riverside County MS4 Stormwater Managers on September 26, 2019. Ms. Komuro shared information regarding County procedures to address homeless encampments when identified (**Figure 1-16**) and the roles and responsibilities of key personnel designated to respond to a need to clean-up homeless encampments (**Figure 1-17**). These figures illustrate well the complexity of the process and issues that need to be considered when addressing homeless encampments.

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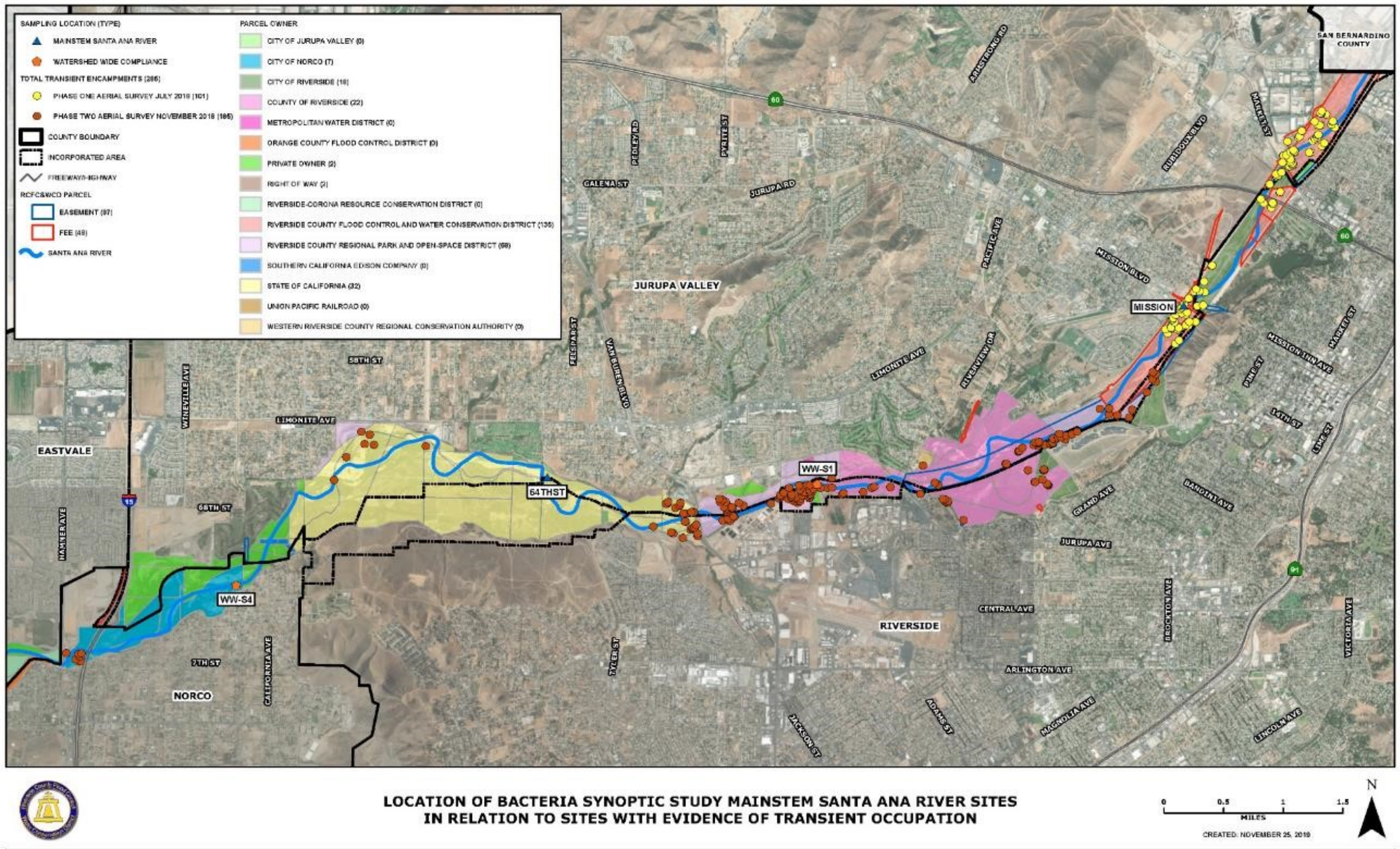

Figure 1-15. Documentation of Homeless Encampments along Santa Ana River between I-15 and Riverside County Line Based on 2018 Drone Surveys (Map provided by RCFC&WCD; figure includes locations of mainstem river and MSAR Bacteria TMDL compliance sites recently sampled as part of the MSAR Bacteria Synoptic Study)

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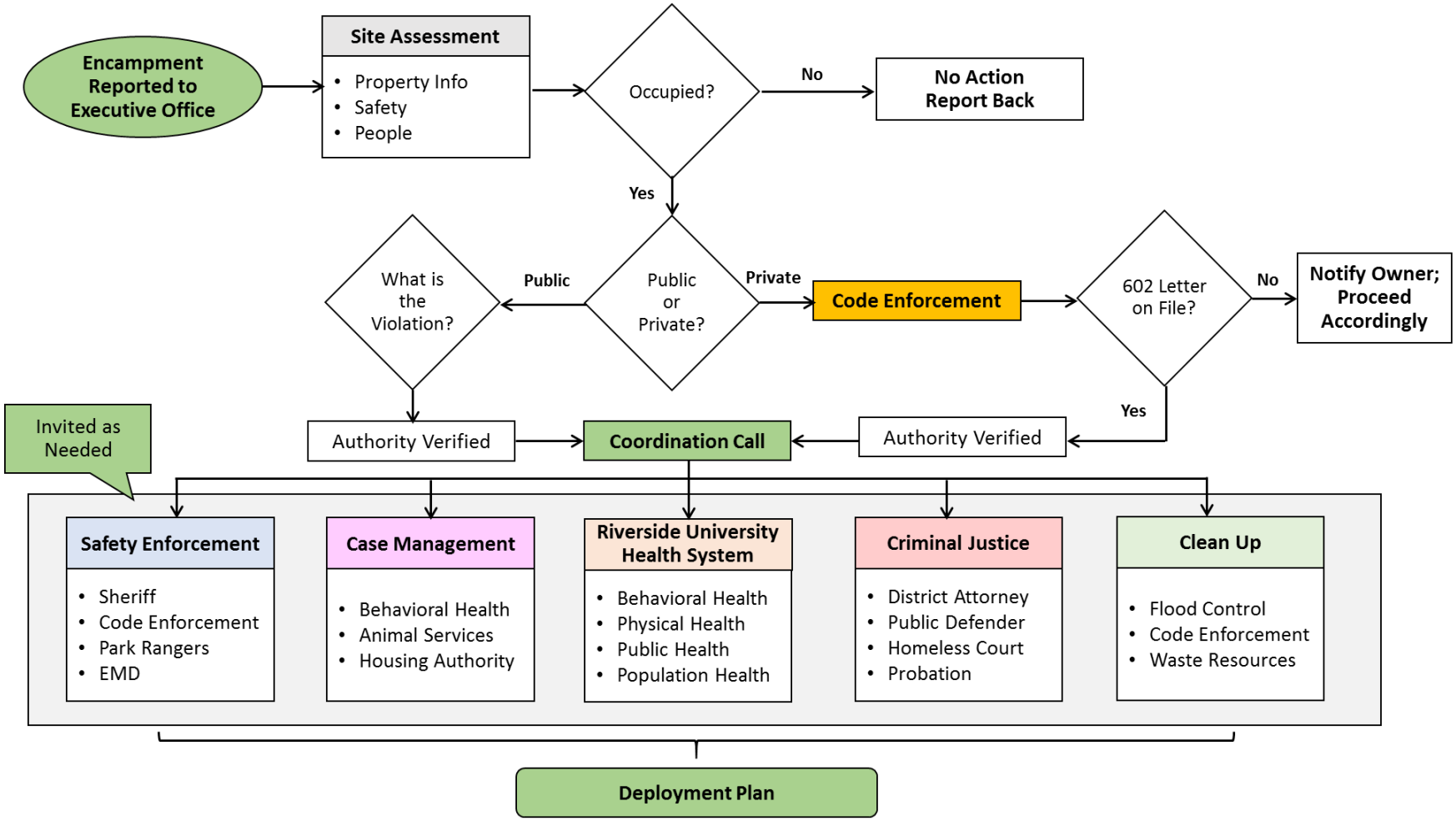

Figure 1-16. Process to Respond to a Report of an Encampment to the Riverside County Executive Office, August 30, 2019 (adapted from presentation by Natalie Komuro, Deputy County Executive Officer, Homeless Solutions, to Riverside County MS4 Stormwater Managers, September 26, 2019)

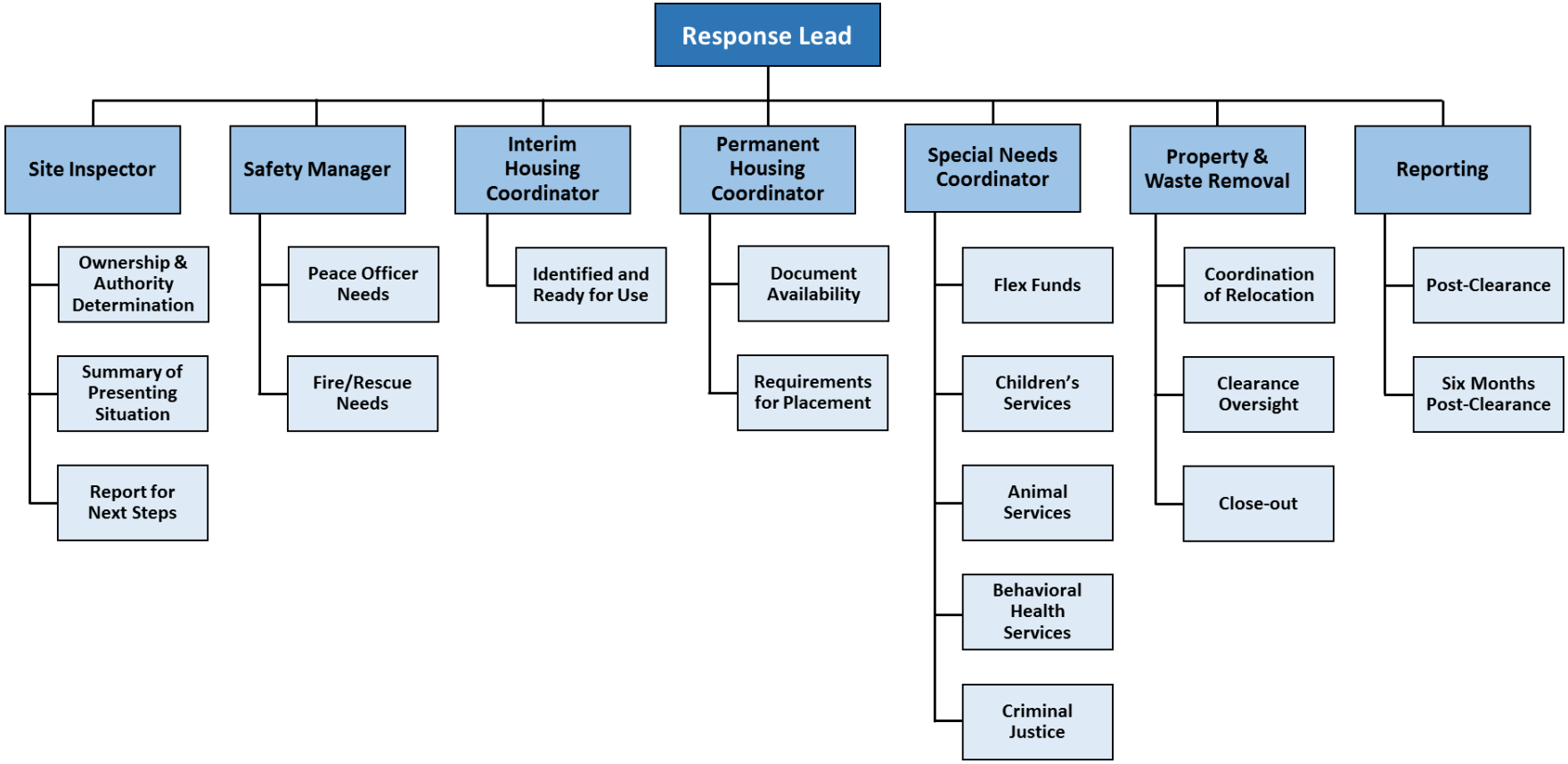

Figure 1-17. Encampment Response – Designated Roles and Responsibilities During Efforts to Clean-up a Homeless Encampment in Riverside County (Adapted from presentation by Natalie Komuro, Deputy County Executive Officer, Homeless Solutions, to Riverside County MS4 Stormwater Managers, September 26, 2019)

1.2.2.5 Inland Empire Waterkeeper

IEWK has been working on homeless encampment issues and potential impacts to the Santa Ana River mainstem for many years. For example, through the Clean Camp Coalition trash services have been provided to individuals living within the riverbed.[5] We met with Megan Brousseau, IEWK's Associate Director, on September 9, 2019 to discuss IEWK's efforts to evaluate and where possible address water quality concerns associated with homeless encampments in the Santa Ana River. As of February 2019, IEWK had documented 187 homeless encampments in an approximate eight mile reach of the Santa Ana River, generally from the Market Street bridge downstream to the VBB. A typical encampment includes 2-4 people meaning that it is likely that 400 to 800 people reside in the riverbed. IEWK stated that while camps move around some, the number of encampments and number of residents has remained similar over time. To address concerns regarding trash impacts from homeless encampments in the riverbed, IEWK led an effort to implement trash service in the area. IEWK's partner in this project, Rivers & Lands Conservancy, recently posted the following on Facebook regarding the outcome to date from implementation of the trash service program:[6]

> "It's been one year since we launched a weekly trash service for individuals experiencing homelessness in a targeted stretch of the Sant Ana River. Participants have helped remove over 13 TONS of trash to date that would have otherwise polluted the river environment! Thanks to our partners at Inland Empire Waterkeeper for spearheading the project and for inviting us to be part of such important work" (emphasis added).

IEWK has collected information on homeless encampment activity in the riverbed. They indicated that they can provide the following types of data: mapping of camp locations,[7] information on how camps may have changed over time, and photographs of impacts to habitat. Obtaining these data would require compensation to IEWK. At our request, they provided an estimate of up to $14,200 to provide the data listed above.

1.2.2.6 City of Rialto

Lynn Merrill and Associates, Inc. (LMA) is a consultant to the City of Rialto, representing the City on various environmental issues. We met with Lynn and Paul Merrill of LMA and Andy Minor, Geovironment Consulting (GC) on September 10, 2019 to obtain input on

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[5] Guerre, Regina. 2018. Clean Camp Coalition Report submitted to the Inland Empire Waterkeeper. July 16, 2018.

[6] Rivers & Land Conservancy Facebook blogpost, December 18, 2019.

[7] Note if detailed mapping were provided, it is likely that much of this information would need to be kept confidential to protect the privacy of homeless living in the riverbed (personal communication, Megan Brousseau, IEWK Associate Director).

potential homeless encampments in the area below the City of Rialto's WWTP effluent discharge. From July 31 to August 21, 2019 LMA and GC conducted weekly drone surveys of the channel that receives treated effluent from the City's WWTP and the Santa Ana River from where the effluent channel enters the river downstream to the South Riverside Avenue bridge. The purpose of the surveys was to evaluate the degree to which homeless encampments were present in their study area. **Figure 1-18** illustrates the area surveyed by drone on July 31 (similar areas were surveyed in subsequent weeks), and where homeless encampments and trash/debris were observed. Homeless encampments were observed in both the effluent channel and at the South Riverside Avenue bridge. **Figure 1-19** provides photograph examples of homeless encampment activity around the bridge.

1.2.2.7 Riverside Regional Water Quality Control Plant

We met with Ed Filadelfia, City of Riverside Public Works, Sewer Systems, on September 11, 2019 to discuss homeless encampment activity at the Riverside RWQCP's effluent outfall and along the Santa Ana River adjacent to their facility. **Figure 1-20** illustrates the location of the facility's effluent outfall to the Santa Ana River. The resulting effluent channel flows parallel to the mainstem Santa Ana River for a short distance before merging with the mainstem river near the VBB. Homeless encampment impacts are clearly visible in the aerial image (Figure 1-20). **Figure 1-21** illustrates additional examples of habitat impacts from homeless encampments.

As part of the interview, we walked along the Santa Ana River Trail down to VBB crossing. Even though there is a fence along the Trail to keep people away from the effluent channel, on the day of the visit the fence was cut open, a common occurrence noted by Mr. Filadelfia. In addition to the area along the Riverside RWQCP, Mr. Filadelfia noted concerns with homeless encampment activity upstream along the Tequesquite Landfill.

1.2.2.8 Santa Ana Regional Water Quality Control Board

We met with Santa Ana Water Board staff (Adam Fischer, Barbara Barry, Nam Nguyen and Ray Akhtarshad) on September 10, 2019 to obtain their insights on homeless encampment activity in the project study area. The Board staff do not directly work on homeless encampment clean-up activities unless they receive a complaint. Instead, they rely on local jurisdictions to address any identified concerns.

Figure 1-18. Flight Path of Drone Surveys Conducted in Santa Ana River Reach between South Riverside Avenue Bridge and City of Rialto WWTP Effluent Channel (Drone survey conducted July 31, 2019 by Andy Minor, GC, on behalf of LMA representing the City of Rialto)

Figure 1-19. Presence of Homeless Encampments in the Santa Ana River at or Immediately Upstream of the South Riverside Avenue Bridge (Photographs taken in August 2019; courtesy of LMA, Inc. representing the City of Rialto)

Figure 1-20. Homeless Encampments in the Santa Ana Riverbed along Riverside RWQCP Upstream of the Van Bureau Boulevard Bridge. Note location of Plant's Effluent Outfall (Image courtesy of Ed Filadelfia, City of Riverside, Public Works, Sewer Systems)

Figure 1-21. Examples of Homeless Encampments in Santa Ana River Riparian Area Near the Riverside RWQCP Outfall (Photographs courtesy of Ed Filadelfia, City of Riverside, Public Works, Sewer Systems)

Beginning in 2017 Board staff conducted an audit of the Comprehensive Bacteria Reduction Plans (CBRP) for the Riverside and San Bernardino County MS4 Programs.[8] The CBRPs describe how the stormwater programs for each county will comply with the MSAR Bacteria TMDL requirements applicable to urban runoff within their respective jurisdictions. The resulting audit reports discussed homeless encampment issues in the study area.[9] As part of the discussion, the Santa Ana Water Board noted the following areas where homeless encampments have been noted by staff: Temescal Creek, in particular where it drains into Prado Basin, Santa Ana River along the Tequesquite Landfill, and in the Eastvale area, south and west of the sport complex/west of the I-15 crossing. Figure 1-15 above shows clusters of homeless encampments along the landfill and in the Eastvale area described above.

1.2.2.9 San Bernardino Valley Water Conservation District

The San Bernardino Valley Water Conservation District provided information on the upper part of the Santa Ana River upstream of the confluence of City Creek with Santa Ana River Reach 4. **Figure 1-22** illustrates the locations of the few camps located in this area in winter 2018. Staff noted that homeless encampments in this portion of the Santa Ana River are not common, likely due to the limited or non-existent water or vegetative cover.

[8] For example, RCFC&WCD. 2011. *Comprehensive Bacteria Reduction Plan*. Submitted to the Santa Ana Water Board June 28, 2011; approved February 10, 2012 (R5-2012-0015).
[9] Santa Ana Water Board. 2018. *MSAR Comprehensive Bacteria Reduction Plan Audit Report, Riverside County (R8-2020-0033)*. October 2018; Santa Ana Water Board. 2018. *MSAR Comprehensive Bacteria Reduction Plan Audit Report, San Bernardino County (R8-2020-0036)*. October 2018.

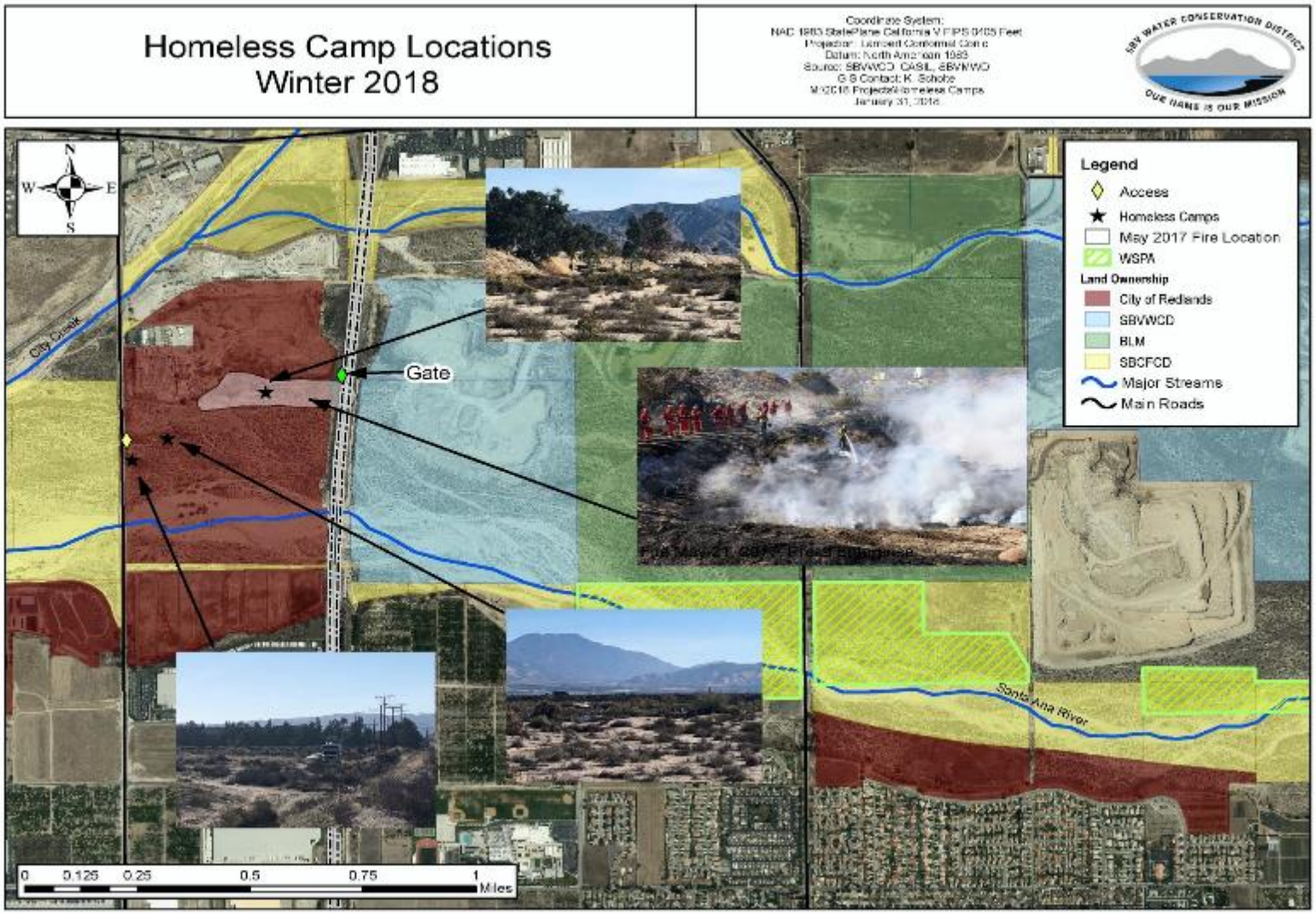

Figure 1-22. Homeless Encampments in the Santa Ana Riverbed Upstream of the Confluence of City Creek with the Santa Ana River (Provided courtesy of Daniel Cozad and Jeff Beehler, San Bernardino Valley Water Conservation District)

1.3 Literature Review Findings

A literature review of published literature, studies and reports was conducted to identify any additional information that may provide insight into the relationship between the presence of homeless encampments and impacts to water quality and riparian and aquatic habitats. The literature review primarily focused on California sources, but also included a review of sources outside California (mostly in the west). Our focus during the literature review was water quality and habitat impacts – not homeless policies, solutions, or management decisions. As will be seen below, finding a study or report relevant to the topics searched was rare. More often, we found that the available "literature" was often either news reports of local situations or regulatory documents related to water quality impairments where homeless encampments may be contributing to the impairment. The following subsections provide our findings:

- *Section 1.3.1, Summary of Literature Review Findings* - Provides a brief overall summary of the key findings from this literature review effort.
- *Section 1.3.2, Literature Review Findings Relevant to California Waterbodies* - Provides annotated summaries from a review of key sources of information from California waterbodies. Each source includes a link to the original information.
- *Section 1.3.3, Literature Review Findings from Outside of California* - Provides annotated summaries from a review of sources of information outside of California (focus was on the west). Each source includes a link to the original information.

1.3.1 Summary of Literature Review Findings

Following is a summary of the key findings from the literature review:

- The environmental impact concerns from the presence of homeless encampments in riverbeds in the upper Santa Ana River watershed are no different than what is observed in other areas. Key concerns include:
  - Trash - both the presence of the trash itself and the potential for the leakage of toxic chemicals from items in the trash;
  - Human waste disposal;
  - Degradation of riparian areas, including vegetation, habitat, and riverbanks;
  - Fish barriers created by large trash (e.g., shopping carts);
  - Impacts to the physical integrity of levees; and
  - Fire.

- While the concerns are broad and widespread, we did not find any study that clearly demonstrates a direct relationship between the presence of homeless encampments and poor water quality, e.g., elevated bacterial indicators. Any statements regarding impacts to water quality are anecdotal and based on assumptions regarding the expected impacts.
- This lack of direct data demonstrating an impact from homeless encampments may be addressed at least in part through a developing Southern California Coastal Water Research Project (SCCWRP) study in the in San Diego River watershed (see Section 1.3.2.3 below). However, even though SCCWRP is designing a study to evaluate direct water quality impacts, the proposed study demonstrates how difficult it is to design a study to collect sufficient data to test hypotheses regarding the expected impact of homeless encampments on water quality.
- While no water quality data have been found, data on trash volume has been reported in other areas. However, there is insufficient information at this time to relate numbers of homeless encampments or numbers of campers to volumes of trash present.
- While searching for information to support this literature review effort, we found one source where the concern was about the potential impact of homeless encampments on the quality of the water supply (see Section 1.3.2.2 below). While the article noted that the concern was misplaced (the waterbody was not a drinking water source), it does illustrate the potential for misperception of potential impacts from homeless encampments in waterways.

1.3.2 Literature Review Findings Relevant to California Waterbodies

As was noted in the summary above, data on direct impacts to water quality are difficult to find, but conclusions regarding likely impacts are not uncommon. For example, a recent California Healthline article discussing potential impacts from homeless encampments on water quality included the following comment from the Executive Officer of the San Francisco Regional Water Quality Control Board:

> "…But the regional water boards, which make key water quality decisions for their regions and take enforcement actions when necessary, aren't testing to determine if and how homeless encampments affect water quality.
>
> Contamination from homeless camps is so easy to observe — and smell — that there is no 'need to monitor to know there's a problem,' said Thomas Mumley, executive officer of the San Francisco Bay Regional Water Quality Control Board, which stretches from Napa County to Santa Clara County.
>
> If there are no bathrooms in or near a homeless encampment, 'we can assume there's a discharge of waste' where there shouldn't be, he said."

Almendrala, A. 2020. *Fecal Bacteria In California's Waterways Increases With Homeless Crisis.* California Healthline Daily Edition. January 6, 2020. https://californiahealthline.org/news/fecal-bacteria-in-californias-waterways-increases-with-homeless-crisis/

The following sections provide information that was obtained from reports and news articles discussing water quality and habitat concerns from homeless encampment activity in specific watersheds across the State of California.

1.3.2.1 Santa Ana River

California State University Fullerton

California State University, Fullerton, in coordination with IEWK, conducted a study to characterize water quality issues in Santa Ana River Reach 3 as part of an effort to evaluate concerns of people in homeless encampments along the river being exposed to poor water quality. Findings from the study are reported in the following university report:

Gedalanga, P., L. Nguyen, and C. Puga. 2019. *Microbial Source Tracking at the Santa Ana Watershed.* California State University, Fullerton. August 2018 - June 2019.

Overall, the study evaluated the relationship between areas with high human activity and water quality using microbial source tracking techniques. Per the study's executive summary:

> "While human activities were implicated as a potential source of fecal contamination in the Santa Ana River, [the study was] unable to differentiate among the diverse human-related activities occurring in the Santa Ana River such as wastewater effluent discharges, recreational uses, and/or homeless populations."

San Bernardino Valley Municipal Water District

The San Bernardino Valley Municipal Water District has proposed constructing and maintaining four tributary restoration sites and create a Mitigation Reserve Program along the Upper Santa Ana River. The four project sites are Anza Creek, Old Ranch Creek, Lower Hole Creek, and Hidden Valley Creek. The purpose of the proposed project is to reestablish, enhance, rehabilitate, and/or preserve jurisdictional aquatic resource habitat and/or improve conditions for Santa Ana sucker. Two relevant documents were reviewed:

- San Bernardino Valley Municipal Water District. 2019. *Upper Santa Ana River Tributaries Restoration Project and Mitigation Reserve Program; Draft Environmental Impact Report.* Prepared by ICF. April 2019. https://www.sbvmwd.com/Home/ShowDocument?id=6225
- San Bernardino Valley Municipal Water District. 2018. *Upper Santa Ana River Tributaries Restoration Project Initial Study.* Prepared by ICF and Stillwater Sciences. July 2018. https://www.sbvmwd.com/Home/ShowDocument?id=5936

Generally documented impacts include channel blockages from human modification to channels such as log paths and dam construction, as well as from debris such as garbage and shopping carts. These blockages can be barriers to fish passage. Concerns regarding trash were documented throughout project area. The description of the conditions around the Old Ranch Creek site west of the Tequesquite Landfill includes:

> "The site is heavily used by the homeless population in the area, entailing encampments and excessive trash littered throughout the site. In particular, trash includes multiple cathode-ray television sets that were observed smashed in the river channel. Other trash includes large and small appliances such as refrigerators and microwaves. Electronics and appliances of this kind are a source of heavy metal contamination and represent a human and wildlife health risk. Other types of trash, including concrete construction debris, clothes, and plastic, were pervasive throughout the channel but concentrated in the upstream portion. The trash on the sites may also include other household hazardous waste items including medical waste (syringes and lancets). Household hazardous waste refers to used or leftover contents of consumer products that contain materials with one of the four characteristics of a hazardous waste: toxicity, ignitability, corrosivity, or reactivity."

A final Environmental Impact Report (EIR) was recently released for the proposed project:

- San Bernardino Valley Municipal Water District. 2019. *Upper Santa Ana River Tributaries Restoration Project and Mitigation Reserve Program; Final Environmental Impact Report.* Prepared by ICF. November 2019. http://www.uppersarhcp.com/documents/UpperSAR_Restoration_Final_EIR_Nov2019.pdf

This document summarizes homeless encampment concerns raised during development of the draft EIR and provides responses regarding how such concerns will be addressed.

1.3.2.2 San Gabriel River Watershed

A recent news article in the San Gabriel Valley area illustrates how the public can become concerned about the safety of their drinking water given the presence of homeless encampments in riverbeds. The article first raised the concern of potential impacts from homeless encampments on drinking water, but then clarified that the source of delivered drinking water was from uncontaminated groundwater that was treated before it was delivered.

Yee, Christopher. 2019. *Is the San Gabriel Valley's Water at Risk Due to Homeless Camps along the San Gabriel Riverbed?* San Gabriel Valley Tribune. September 17, 2019. https://www.sgvtribune.com/2019/09/17/is-the-san-gabriel-valleys-water-at-risk-due-to-homeless-camps-along-the-san-gabriel-riverbed/

The article referenced an NBC 4 report that suggested that water in the San Gabriel River was contaminated by homeless living along the riverbed and that the community was at risk as this was the source of their drinking water.

NBC 4 Video: https://www.nbclosangeles.com/news/local/streets-of-shame/homeless-camps-azusa-san-gabriel-valley-threaten-water_los-angeles/1965242/

Per the above referenced article, Ken Manning, Executive Director of the San Gabriel Basin Water Quality Authority, clarified that drinking water is obtained from groundwater and that it is treated before it is delivered to anyone's tap. No contamination of groundwater has been detected.

1.3.2.3 San Diego Area

San Diego River

The Executive Officer of the San Diego Regional Water Quality Control Board (San Diego Water Board) recently commented on concerns regarding homeless encampments in the San Diego River:

> "'I've carried 5-gallon buckets that were unambiguously being used as toilets,' said David Gibson, executive officer of the San Diego Regional Water Quality Control Board, describing his experience cleaning up homeless encampments. 'They were taking it to the San Diego River, dumping it there, and rinsing it out there.'"

Almendrala, A. 2020. *Fecal Bacteria In California's Waterways Increases With Homeless Crisis.* California Healthline Daily Edition. January 6, 2020. https://californiahealthline.org/news/fecal-bacteria-in-californias-waterways-increases-with-homeless-crisis/

The above statement reinforces the basis for the San Diego Water Board recently issuing an Investigative Order to public agencies to evaluate sources of bacteria to the San Diego River and downstream waters:

San Diego Water Board. 2019. *Investigative Order No. R9-2019-0014 - An Order Directing the City of San Diego, the City of Santee, the City of El Cajon, the City of La Mesa, the County of San Diego, the San Diego County Sanitation District, the Padre Dam Municipal Water District, San Diego State University, the Metropolitan Transit System, and the California Department of Transportation To Submit Technical and Monitoring Reports to Identify and Quantify the Sources and Transport Pathways of Human Fecal Material to the Lower San Diego River Watershed*. June 12, 2019. https://www.waterboards.ca.gov/sandiego/board_decisions/adopted_orders/2019/R9-2019-0014.pdf

While potential sources of bacteria to the river are likely diverse, the Order includes a requirement to evaluate the impact of homeless encampments on water quality. Per the San Diego Water Board's Press Release:

San Diego Water Board. 2019. *Ten Public Agencies Are Ordered to Investigate their Systems for Discharges of Human Waste into the Lower San Diego River; Poor Ocean Water Quality Is Making Surfers, Beachgoers Sick*. California Water Board Media Release. June 12, 2019. https://www.waterboards.ca.gov/sandiego/press_room/press_releases/docs/pr061219_FNL.pdf

> "Ten public agencies suspected of discharging human fecal waste into the Lower San Diego River and its tributaries today were ordered to investigate and identify the sources of the harmful material and report the extent of their involvement to the San Diego Water Board… Based on the best available information, these potential sources include:
>
> - Overflows and leakage from publicly owned sewer collection systems
> - Discharges and leakage from private pipelines
> - Faulty septic systems on residential properties
> - Homeless encampments located near the Lower San Diego River and its tributaries."

Within 180 days of the effective date of the Investigative Order (unless extended), the responsible parties must submit an Investigative Study Work Plan. The Investigative Order references a February 20, 2019 draft workplan proposal from SCCWRP that is anticipated will form the basis for the studies to be completed under the Investigative Order:

SCCWRP. 2019. *Quantifying Sources of Human Fecal Contamination Loading to the San Diego River: A Conceptual Workplan developed by the Southern California Coastal Water Research Project*. February 20, 2019. https://www.waterboards.ca.gov/sandiego/water_issues/programs/san_diego_river_io/docs/Fecal_Loading_Workplan_20190314.pdf

Task 4 in the draft workplan proposal, Quantifying Direct Inputs from Homeless Encampments, provides an approach to evaluate water quality impacts from homeless encampments, but notes the significant challenges expected to be encountered in such a study. For example, SCCWRP estimates that the necessary sample size to confirm water quality impacts from homeless populations for a basic upstream/downstream study would be 30 sample events for dry weather and 60 samples collected during storm events to evaluate wet weather impacts.

SCCWRP has previously written on the challenges of identifying sources human fecal material in the San Diego River watershed:

Steele, J., J. Griffith, R. Noble and K. Schiff. 2017. *Tracking Human Fecal Sources in an Urban Watershed During Wet Weather.* Southern California Coastal Water Research Project. Technical Report 1002. October 2017. http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1002_HumanMarkerTracking.pdf

> "It appears that human fecal inputs occur ubiquitously throughout the San Diego River watershed during wet weather. HF183 [Human Fecal Genetic Marker] was detected at every site in both sampled storm events. This ubiquitous human signal occurred in both large and small tributaries, and along the mainstem…There are potentially four sources of HF183 in the San Diego River watershed; exfiltration from the sewage collection system, septic system contributions, direct deposition from homeless populations, and illegal discharges of human sewage to the storm drains (e.g., discharges from recreational vehicles or connection of sewage laterals to the storm drain system)."

Regarding homeless encampments as a source, SCCWRP states:

> "There are an estimated 300 people living in encampments along the San Diego River between the city of Santee and the coast. It is unknown how many homeless use the river or its banks as a latrine. In-stream inputs of HF183 along the river were estimated near 15% in 2017, however, HF183 has also been detected upstream of the camps. Therefore, the homeless population is not the sole source of human fecal inputs in the river. The HF183 concentrations did appear to be related to storm size, so higher flood waters might result in more fecal material from the banks being washed into the river."

Other San Diego Area Examples

Concerns with homeless encampments and their potential to impact habitat and water quality have been documented in the San Diego Area. Two examples from news articles include:

Puterski, Steve. 2019. *Homeless Camps Jeopardizing Habitat in Vista*. The Coast News Group. January 31, 2019 – https://www.thecoastnews.com/homeless-camps-jeopardizing-habitat-in-vista/

The Vista City Council approved an amendment to its Biological Preserve Overlay Zone to address homeless encampment concerns in La Mirada Canyon. Mayor John Franklin described the homeless camps as looking like a landfill with thousands of pounds of discarded trash, which results in huge quantities of waste running off into the watershed. John Conley, Community Development and Engineering Director, stated that the unauthorized use in these areas is damaging sensitive habitat and water quality.

Curlee, Doug. 2017. *Homeless Encampment an 'Ecological Disaster.'* Mission Times Courier. May 19, 2017. https://missiontimescourier.com/homeless-encampment-an-ecological-disaster/

During a cleanup of the San Diego River in Grantville, River Park Foundation CEO Rob Hutsel estimated that they would remove 100,000 pounds (lbs) of trash and garbage out of the site. Hutsel was concerned with how much hazardous material and trash was released into the San Diego River during recent floods. The goal of cleanup was to remove trash and begin repairing the riparian habitat. Dave Gibson, Executive Officer of the San Diego Water Board, stated:

> "What people don't know, but should know, is that encampments like this use the San Diego River as an open-air toilet, and this puts dangerous human pathogens in the river," he said. "You can compare it to what happens when there's flooding in the Tijuana River valley down south. Human waste carries dangerous pathogens that can sicken people all along the river route, all the way down to our beaches. People can die from the effects of those waste products. And we know this is far from the only such problem along the river route. We don't really know how many such encampments there are, and we need to find out and do whatever is necessary to put a stop to it."

1.3.2.4 Contra Costa County

Contra Costa County commissioned research on homelessness in relation to its requirements to manage water quality in association with the implementation of its stormwater discharge permit. The following sources provide information from research conducted in this area.

Saneta DeVuono-Powell. 2013. *Homeless Encampments in Contra Costa County: A Report for the Contra Costa County Flood Control and Water Conservation District.* Summer 2013. https://www.contracosta.ca.gov/DocumentCenter/View/27388/Homeless-Encampments-in-Contra-Costa-County-Report?bidId=

Contra Costa County Flood Control & Water Conservation District (CCFC&WCD) saw the presence of homeless encampments in county waterways as a concern regarding compliance with permit requirements to reduce pollution. The ten month study of camps and their residents resulted in the development of a number of management recommendations for agency adoption to reduce pollution caused by camps.

The report provides information on the types of camps observed in the study area, e.g., Old-timer, Newcomer and Veteran camps. The potential impacts on the environment from these different types of camps varied, but with regards to human waste disposal the distinctions were not as clear. For example, while Old-timer and Veteran camps were more likely to have designated toilet areas or functional outhouses, how human waste was actually disposed of was unclear.

While the reported impacts to habitat and water quality are no different than what is observed in southern California (e.g., see community meeting presentation[10]), the timing of the report in 2013 is interesting in that it provided an early warning of the challenges ahead for resource agencies responsible for the management of surface water resources:

> "[CCFC&WCD] (and other water districts) face a huge challenge, one that is unlikely to disappear any time soon. Perhaps the largest impediment to resolving the question is the fact that even where the complexity is grasped and there is a willingness to address the systemic issues implicated, the local agencies that are dealing with the problem do not have the capacity to implement many meaningful measures alone. This means that in addition to contending with rigorous environmental requirements, the specific characteristics of the populations within the encampments and the particular landscape of the area, competing mandates, jurisdictional complexity and political pressure the agency must also implement strategies that involve other government agencies, non-governmental agencies and charities. All of which requires time and money, something that most county agencies today do not have in excess."

This 2013 conclusion is now routinely playing out in many jurisdictions. The need for a collaborative response is now the norm as shown in Figures 1-16 and 1-17 that illustrate the homeless encampment reporting process and roles and responsibilities when cleanups are initiated.

Subsequent to the 2013 Report, Contra Costa County created a document titled: *Contra Costa County Homeless Camps: Improved Risk Assessment for Targeted Interventions* (date unknown) (https://www.contracosta.ca.gov/DocumentCenter/View/27390/Suitability-Map?bidId=). The purpose of the document was to develop an assessment method for determining where homeless encampments were most likely to become established based on landscape features (e.g., nearness to a waterbody or intersection of the waterbody and a highway and walking/biking distance to services). While the methodology was intended to assist resource agencies with planning efforts for directing resources, the document includes the following conclusion:

> "Knowing what spots are considered appropriate for camps from a homeless perspective can help the county. Eradicating all of these sites without providing alternative housing opportunities will not be effective. In the past year the county has cleared 3 sites 63 times. To mitigate pollution, County should use this data to target areas for garbage collection, sanctioned sites or targeted services in some suitable areas, based on an assessment of their interests."

[10] https://www.contracosta.ca.gov/DocumentCenter/View/29632/Homeless-Presentation-Walnut-Creek-Community-Meeting-2014-03-12?bidId=,

1.3.2.5 Santa Clara County

Santa Clara Valley Water District

Santa Clara Valley Water District presented a summary of its efforts to address impacts from homeless activities to waterways in its jurisdiction a the 2018 CASQA annual meeting:

Struve, Kirsten and E. Wilkinson. 2018. *Every District Counts, What One Special District is Doing to Reduce the Pathway of Encampment Trash to Waterways*. Presentation by Santa Clara Valley Water District at the CASQA 2018 Annual Conference.

A presentation by the Santa Clara Valley Water District (SCVWD) provided a wide range of illustrations of the types of habitat damage that can occur because of homeless encampment impacts, including not only the expected trash buildup, but bank excavations, wildfires and debris disposal that can create fish barriers (**Figures 1-23 through 1-27**).

In addition to photographic evidence, SCVWD has also been collecting information on the number of encampment cleanups (**Figure 1-28**) and annual volume of trash removed from sites between 2014 and 2018 (~10,000 to 17,000 cubic yards) (**Figure 1-29**).

Guadalupe River Watershed Study

A study that evaluated the environmental impacts of homeless encampments was completed in the Guadalupe River watershed in Santa Clara County in 2013:

White, Courtenay. 2013. *Environmental Impacts of Homeless Encampments in the Guadalupe River Riparian Zone*. Masters Thesis. Royal Roads University, British Columbia, Canada. November 19, 2013. https://viurrspace.ca/bitstream/handle/10170/665/white_courtenay.pdf?sequence=1&isAllowed=y

This study focused on the impacts of homeless encampments along San Jose's Guadalupe River. Field data consisted of trash collection within encampments in the riparian zone, and also included examination of other impacts such as stream-bank alteration, destruction of vegetation, and wildfire incidences. Three sample locations were chosen which represented heavy, moderate, and minimal usage by the homeless population. Baseline trash volumes were collected and subtracted from the average total trash volume determined over four sampling events to determine trash attributable to homeless activity. Trash was categorized into cigarette waste, fabrics/clothing, food packaging, miscellaneous paper, and miscellaneous plastic, with the highest total volume being fabrics/clothing with 3295.5 cubic meters (m^3). In addition to the categories above, large item such as lumber and shopping carts were observed/documented. **Table 1-1** below provides the measured trash volume at the three study sites with the "adjusted average" representing the average volume of trash attributable to homeless activity.

The author assumed that the majority of the plastic material observed contains endocrine-disrupting compounds that would be leached to the soil and water. Pharmaceuticals and Personal Care Products (PPCPs) were only a small volume of the debris (88.2 m^3); however, discharge of PPCPs into surface water has the potential to affect freshwater organisms, and may infiltrate the alluvial aquifer.

Figure 1-23. Example of Riverbank Impacts (from Struve and Wilkinson 2018)

Figure 1-24. Example of Riverbank Impacts (from Struve and Wilkinson 2018)

Figure 1-25. Example of Riverbank Impacts (from Struve and Wilkinson 2018)

Figure 1-26. Example of Habitat Impacts from Fire (from Struve and Wilkinson 2018)

Figure 1-27. Example of Aquatic Habitat Impacts (from Struve and Wilkinson 2018)

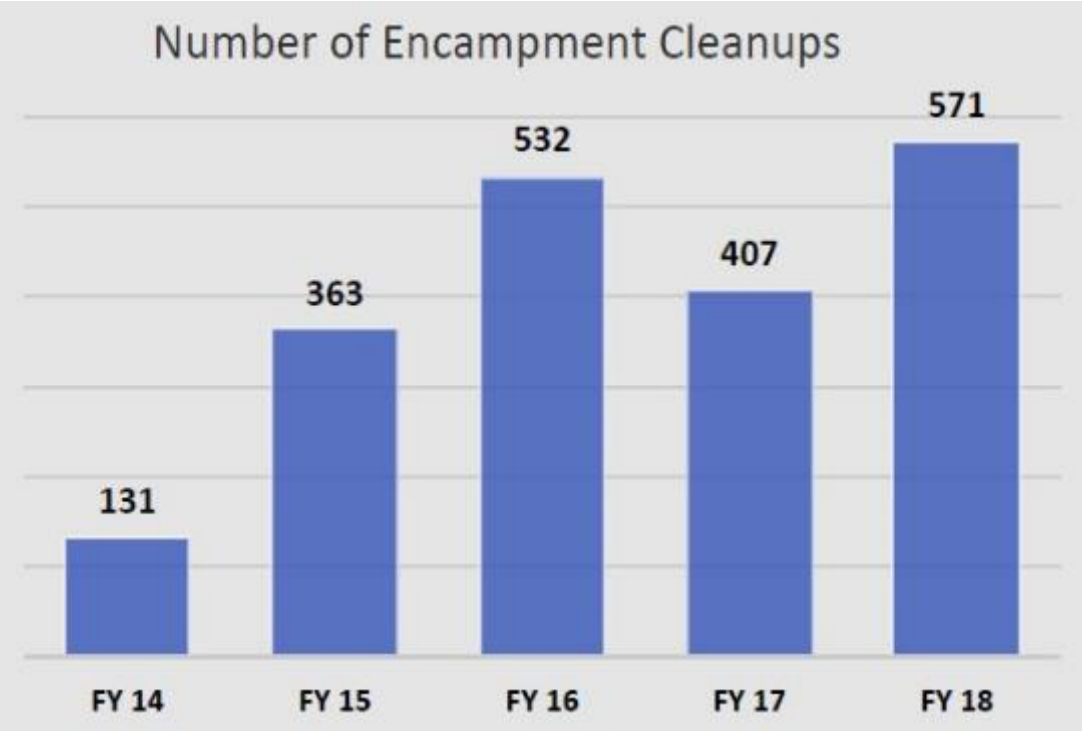

Figure 1-28. Trend in Number of Encampment Clean-ups Over Five Year Period in Santa Clara County (from Struve and Wilkinson 2018)

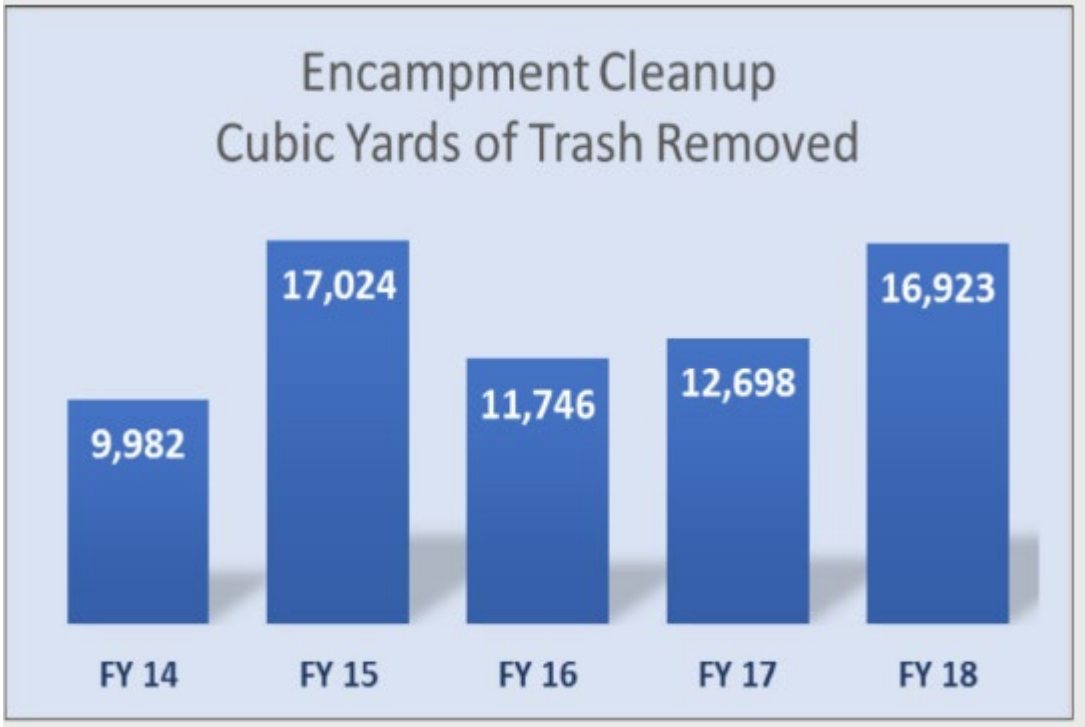

Figure 1-29. Trend in Encampment Clean-up of Cubic Yards of Trash Over Five Year Period in Santa Clara County (from Struve and Wilkinson 2018)

Table 1-1. Trash Volume and Number of Streambank Alterations Observed (adapted from White 2013)

Sample Site (Level of Usage)	Trash Total (m^3)		Streambank Alterations	
	Average Trash (m^3)	Adjusted Average Trash (Attributed to Homeless Activity) (m^3)	Total No.	Average No. per Sample Event
Minimal	787.5	525	4	1
Moderate	2062.5	1500	23	5.75
Heavy	2212.5	2025	21	5.25

Total number of streambank alterations were also recorded at all three study sites and averaged per sampling event (Table 1-1). Examples of streambank alterations documented include terracing and trail building which affects slope stability and causes erosion and sedimentation in the stream channel.

1.3.2.6 Sacramento Area

Water Quality Impacts

There have been a number of articles from the Sacramento area that document concerns regarding potential impacts from homeless encampments – water quality and physical integrity impacts to levees:

Branan, B. 2017. *Lower American River contains unsafe levels of E. coli. Are homeless camps to blame?* The Sacramento Bee. August 27, 2017. https://www.sacbee.com/news/investigations/the-public-eye/article169515922.html

In a report summarizing results from 2007 to 2014, *E. coli* was higher than the EPA standard at three sites in the westernmost section of the American River Parkway near downtown Sacramento. Although the exact cause was not identified, these sites were near the highest concentration of homeless encampments. Andrew Altevogt, of the Central Valley Regional Water Quality Control Board indicated that staff were still investigating the exact causes of the elevated bacteria but "clearly it comes from animal and human waste, including from the homeless camps along the lower American River between the Nimbus Dam and the Sacramento River".

Local residents observed the following: (a) Campers along Steelhead Creek (tributary to the American River) place toilet seats on plastic containers and then dump the waste into the creek; (b) during high water events human waste and other harmful waste from camps is discharged into the American River; and (c) "we have seen people dumping human feces in the water…People swimming in the water don't need turds floating around them."

Levee Impacts

Heap, B. 2019. *Could be Catastrophic: Homeless Camps on Sacramento-area Levees Cause Concern*. KRCA3. May 10, 2019. https://www.kcra.com/article/could-be-catastrophic-homeless-camps-on-sacramento-area-levees-cause-concern/27440429

This is a recently published article regarding the potential for homeless encampments built on levees to cause flooding risks in the Sacramento-San Joaquin Valley. The primary concern is that the camps carved into the sides of levees can in some places go as deep as eight feet into the levee. According to an interviewed civil engineer, these cuts could potentially weaken the structure if the water reaches the camps:

> "A very small hole results in damage to hundreds of thousands of people, or tens of thousands of people…homeless people have been digging into and damaging levees underneath Interstate 5 in a number of places in the Valley, including the Smith Canal…We've had a situation on Smith Canal, where we've repaired it three times in the last six years and they've destroyed it every time…"

Documentation developed by Reclamation District 1000 in the Sacramento area provided a more detailed description of levee concerns:

Reclamation District 1000. 2019. *Agenda Item No. 6.3: Review and Consider Authorizing the General Manager to Submit a Letter to the Appropriate Agencies Requesting Assistance with the Immediate Removal of Unauthorized Encampments on the District Levee System, which Impede the District's Ability to Perform its Public Safety Responsibilities to Monitor, Maintain, Rebuild, Construct and Operate the Levee System*. https://www.arfcd.org/files/d956e9fa1/9a.+RD+1000+Unauthorized+Encampment+Policy+-+City+Enforcement.pdf

We have directly quoted much of the source and incorporated associated figures to best illustrate the Reclamation District's concerns:

> "The District is currently experiencing a rapid and unprecedented increase in unauthorized encampments along the District's Levee System. These encampments pose a risk to public safety within and around the Natomas Basin, as they impede the District from carrying out its responsibility to monitor, maintain, rebuild, construct and operate the Levee System. Specifically, due to the nature of the encampments, the District is unable to ensure the Levee System is protected from potentially dangerous degradation of the levees.
>
> For the majority of the two-month period from February 14, 2019 through April 11, 2019, the District was on 24-hour monitoring patrols due to elevated river elevations. During this same time period, the number of unauthorized encampments exponentially increased on the Levee System, as the flood channels swelled, the inhabitants moved to higher ground atop the levees. On March 25, 2019, the District was alerted to an excavation into the levee at an abandoned encampment near

Northgate Boulevard along the Garden Highway. Figures 1 and 2 [**Figures 1-30 and 1-31** below]…show the excavation and damage at the abandoned encampment site.

By April 4, 2019, when the District returned to monitor the excavation and ensure stability of the site, the site had been completely covered over again by tarps, tents and other debris. Figure 3 [**Figure 1-32** below], shows the re-established encampment, as seen by the District on April 4, 2019.

Figure 3 [Figure 1-32] is typical of the encampments along the District's Levee System. Due to the nature of the unauthorized encampments, it is nearly impossible for the District to visually inspect the system. Without the ability to pull back the tarps and tents, there is no way to know if the levee system is protected."

Figure 1-30. Abandoned Encampment along Garden Highway near Northgate (Figure 1 in Reclamation District 1000, 2019)

Figure 1-31. Abandoned Encampment along Garden Highway near Northgate (Figure 2 in Reclamation District 1000, 2019)

Figure 1-32. Re-established Encampment along Garden Highway near Northgate (Figure 3 in Reclamation District 1000, 2019)

1.3.2.7 Russian River

The North Coast Regional Quality Control Board (North Coast Water Board) is in the process of establishing a TMDL to address bacterial indicator impairment in the Russian River:

North Coast Water Board. 2019. *Draft Staff Report for the Action Plan for the Russian River Watershed Pathogen Total Maximum Daily Load*. May 2019. https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/russian_river/pdf/190509/Pathogen%20TMDL_Staff%20Report_%20Action%20Plan_blackline.pdf

The draft Staff Report identifies potential sources of bacteria. Specifically, the primary nonpoint sources of fecal waste identified as contributing to elevated pathogens were septic systems, homeless encampments, recreational water use, and manure from livestock. The Staff Report notes that there are many homeless encampments within riparian areas in the Russian River watershed, and that these encampments could be one cause of fecal indicator bacteria as a result of discharge of human waste directly to surface waters. Even though this potential link may exist, the TMDL does not contain any water quality data demonstrating a direct link:

> "The source analysis for this Pathogen TMDL did not attempt to assess the potential of pathogen contamination specifically associated with homeless encampments or sites of other illegal camping. However, monitoring results for Santa Rosa Creek downstream of known homeless encampments routinely indicate high levels of fecal indicator bacteria. Further, anecdotal reports of poor waste disposal practices by the occupants of the encampments lead Regional Water Board staff to conclude that homeless encampments are a likely potential source of pathogens in surface waters as measured by fecal indicator bacteria. The same potential applies to sites of other illegal camping, in close proximity to surface water and without adequate sanitation facilities."

As part of the implementation of the TMDL, Sonoma County and Mendocino County plan to enter into a Memorandum of Understanding with the North Coast Water Board, to address water quality impacts from homeless encampments: https://www.waterboards.ca.gov/northcoast/board_info/board_meetings/08_2019/pdf/1/20190730_Basin%20Plan%20Amendment_Strike%20Out%20Underline_hardened.pdf

1.3.3 Literature Review Findings from Outside of California

We conducted a high level search of potential homeless encampment impacts to waterways in areas outside of California. The impression resulting from our search is that the degree of concern about homeless camp impacts on waterbodies is less outside of California. Regardless of impressions, there are certainly many examples to draw from which show that the impacts observed or the potential concerns identified in California waterbodies is no

different elsewhere. Also, similar to California, we found no studies that provide direct information linking the presence of homeless encampments to water quality, e.g., elevated bacterial indicator concentrations. The following sections provide examples of information found from other areas.

1.3.3.1 Colorado

Hindi, Saja. 2019. *Englewood Police, City Crews Remove Homeless Camp along South Platte River*. Denver Post. June 4, 2019.
https://www.denverpost.com/2019/06/04/englewood-homeless-encampment-removal/

An Englewood, Colorado homeless encampment near the South Platte River has increased in size and was destroying vegetation, polluting the river, and causing safety issues. Englewood police Sergeant Chad Read stated that during the cleanup they encountered human waste, trip wires and needles, which would eventually end up in the river. The concerns in this area of the South Platte River (south of downtown Denver, Colorado) have been a concern for some time as noted in the following article:

del Castillo, Amanda. 2018. *25 Truckloads of Transient Trash Cleared from South Platte River Encampment*. Denver 7, The Denver Channel. April 10, 2018.
https://www.thedenverchannel.com/news/our-colorado/nearly-40000-spent-cleaning-up-homeless-camps-along-south-platte-river

> "Homelessness along our Colorado riverbanks is a growing issue that has extended outside of Denver and deep into our suburbs…In January, several agencies took part in a Platte River Clean-up Project throughout a quarter-mile stretch of the river [South Platte River near West Dartmouth Avenue in Englewood]….Reid McGrath with Englewood PD's Impact Team [said] there was a total of 21 camps located along that specific stretch of the river, and roughly 31 people who were relocated because of the project. He said, 'in the end, 25 truckloads of trash were taken away from the area…While in some ways, it seems like an ideal place, it's not…There's no water here. There's no sanitation here. There's no trash disposal here.'"
>
> "'The trash and debris are one portion of it,' Stephen Materkowski with the Urban Drainage and Flood Control District said. 'Then there's also the degradation of the banks--the environmental impacts…the dozens of people also destroyed nearby plants and trees, which serve as a natural way to prevent floods…It then creates water quality issues because all that's ending up in the South Platte River…'"

1.3.3.2 Oregon

The Springwater Corridor in the Portland, OR area has a lengthy history of concerns with impacts from homeless encampments. From the following article:

Hernandez, Tony. 2016. *Springwater Corridor Homeless Camps Strain Resources, Patience*. The Oregonian. July 15, 2016
https://www.oregonlive.com/portland/2016/07/springwater_corridor_grapples.html

> "People have cut trees down and made make-shift toilets in the creeks," said Maggie Skenderian, the bureau's Eastside Watersheds Program manager…The reality is that we've restored over 250 acres, and so we've had folks express concerns that what's going on now negates the work we've done."

Skenderian stated that the sanitation issues currently have more of an impact on human health than fish and wildlife. Volunteers have reported that newly planted trees and vegetation have been removed, and don't feel safe working in the area due to seeing syringes throughout the nature areas. The Springwater Corridor has continued to be a location requiring regular attention with regards to establishment of homeless encampments, e.g., https://pamplinmedia.com/pt/9-news/435558-346321-gresham-clears-homeless-camps-from-springwater-corridor-.

1.3.3.3 Texas

Austin, Texas Area

A numbered of publicized reports have been observed in the past year regarding homeless encampment concerns in the Austin, Texas area. Following are two related articles from early 2019:

Devenyns, Jessi. 2019. *Watershed Department Works with City to Clean-up Homeless Camps.* Austin Monitor. February 11, 2019.
https://www.austinmonitor.com/stories/2019/02/watershed-department-works-with-city-to-clean-up-homeless-camps/

The City of Austin has set up a program within its Watershed Protection Department to address homeless camp concerns:

> "In addition to a new "homelessness czar," the budget includes funding for the Watershed Protection Department to hire a contractor for an estimated $1 million over four years to clean up refuse in creeks or drainage facilities such as trash, propane tanks, syringes and human waste that homeless people are leaving behind. As many homeless camps are situated in watersheds, along with public safety issues come stormwater conveyance contamination and flood risk to those living in the camps. According to Assistant Director Jose Guerrero of the Watershed Protection Department, even if the city cleans up a camp, "As soon as we clean it out, it frequently gets backed up in another one or two months." In an effort to stop the perpetual cycle, Guerrero told the Environmental Commission at its Feb. 6 meeting that instead of merely clearing camps and tossing the debris into dumpsters, the Watershed Protection Department is going to try a "service-oriented approach" at nine different campsites. At each site, the cleanup crews will try to connect

> homeless people with services before commencing with any cleanup work. In order to accomplish this goal, the Watershed Protection Department is partnering with the Parks and Recreation Department, Austin Police Department, Austin Resource Recovery, Emergency Medical Services, and the Downtown Austin Community Court."

Perez. Pattrick. 2019. *Concerns Over Safety, Water Quality Spurs Austin Homeless Camp Cleanup.* KVUE ABC. March 8, 2019. https://www.kvue.com/article/news/concerns-over-safety-water-quality-spurs-austin-homeless-camp-cleanup/269-2f8ff7e2-154d-47b4-9e34-4b5d2a1d34e9

The City's Watershed Protection Department has become concerned about an encampment in a tunnel because a creek runs through the tunnel which results in trash and human waste mixing with the water:

> "It's not just a danger to water quality, according to managing engineer Ramesh Swaminathean, but for the people who take shelter in there. 'When there's a flood or rainfall that comes into this box culverts, they're going to literally be trapped in there. It's going to result in potential loss of life or some other health issue,' Swaminathean said. Swaminathean said the camp is one of nine spots his department will clean up within a few weeks as part of a pilot program. 'What we're trying to do is take a sort of a complete look at each of these sites and try to figure out a way that we can solve this problem both from a watershed mission area perspective and also from a humane service-oriented perspective,' Swaminathean said."

San Antonio, Texas Area

Another example from the Texas area is an effort to address sources of bacteria in a TMDL established for three waterbodies in the San Antonio area:

Texas Commission on Environmental Quality (TCEQ). 2016. I*mplementation Plan for Three Total Maximum Daily Loads for Bacteria in the Upper San Antonio Watersheds; Segments: 1910, 1910A, 1911.* TCEQ Water Quality Planning Division, Office of Water; Approved April 6, 2016. https://www.tceq.texas.gov/assets/public/waterquality/tmdl/34uppersa/34F_UpperSanAntonio_TMDLIPlan_Approved.pdf

A bacteria TMDL was established for three waterbodies in the San Antonio area in 2007. The TMDL does state that homeless encampments are a potential source of bacteria to the impaired waterbodies. In 2016, a TMDL Implementation Plan was approved by TCEQ. This Implementation Plan includes 30 "Management Measurements" to reduce bacteria loading to waterbodies. Only one targets homeless encampments:

> "A population of homeless/transients is common in urban areas. The transient population is often encamped under street bridges and other similar areas that

> provide some amount of shelter from the elements. Another potential source of human waste in the study area could be untreated waste from transients or homeless people. Several encampments were observed at locations in the San Antonio urban area. There is evidence that this transient population is affecting bacteria concentrations in some of the smaller watercourses in the study area. These individuals do not always have access to centralized plumbing and restroom facilities. They may deposit waste directly into or in close proximity to the area's waterways. This is a plausible source, since bridges along the waterway may provide temporary or semi-permanent shelter. To help reduce this potential load, CoSA [City of San Antonio] provided restroom facilities and adequate maintenance cleaning in areas with concentrated homeless populations. A control measure for this source of bacteria would be an increased effort for provision of sanitary restroom facilities at strategic locations throughout the City. In the past, there were few, if any, public restroom or shower facilities within the City, except for those that are located near various public places, such as the Brackenridge Park…"

The implementation measures are essentially no different than approaches being implemented in California. Under the "measurable milestones" for a five year planning period, the difficulty in measuring the impact on the environment was noted:

> "…CoSA will continue to coordinate with the Code and Police Departments and document through their annual report to TCEQ the amount of debris removed by this management measure. Efforts to curb the impact of vagrants and homeless people on the environment will continue for the next 5 years. Since it is difficult to measure the size of the homeless population and their impact on the environment, there is not a measurable milestone other than the reporting of refuge removal by CoSA."

1.3.3.4 Utah

Following is an example of a typical report describing reports of impacts from homeless encampments along the Jordan River in the Salt Lake City area.

Moody, Sean. 2018. *South Salt Lake Police Clear Out Homeless Encampments along Jordan River*. KSL TV. September 14, 2018. https://www.ksl.com/article/46390973/south-salt-lake-police-clear-out-homeless-encampments-along-jordan-river

> "South Salt Lake Police Chief Jack Carruth said trash and human waste from the campsites pollute the nearby Jordan River…'We cleaned up approximately seven to eight camps and roughly 8,000 pounds of trash. Now, that brings us to today, where we've got a count of 21 camps – and I'm going to estimate with what you see going out, 25,000 to 30,000 pounds of trash. Somewhere between 15 to 20 large dump truck loads of garbage will be removed from this area,'"

In another article is a discussion of how a park management has been working to address homeless encampments in an area under their jurisdiction, going so far as to removing healthy vegetation to discourage the camps:

Neild, M. and J. Rose. 2019. *Addressing Homelessness in Public Parks*. National Recreation and Parks Association. Parks & Recreation Magazine, January 7, 2019. https://www.nrpa.org/parks-recreation-magazine/2019/january/addressing-homelessness-in-public-parks/

Park management's quick response to the community complaints about homeless resulted in maintenance crews being pulled from their duties and tasked with eviction and camp cleanup and removing healthy vegetation to discourage homeless camps. Removal of vegetation has caused additional concern as it is intended to absorb urban stormwater, mitigate soil erosion, and enhance park aesthetics.

1.4 Conclusions and Recommendations

This memorandum focuses on the findings from the first step of the process implemented to evaluate homeless encampments in the upper Santa Ana River watershed, i.e., develop a better understanding of potential impacts of homeless encampments on water quality and riparian and aquatic habitat based on an assessment of existing information. The findings from this effort are intended to inform the development of a Preliminary Monitoring Program to assess actual impacts from selected camps within the upper Santa Ana River watershed (See Section 2 below). In this section, we will first provide our conclusions from the assessment completed to date. From that we will provide recommendations for development of a Preliminary Monitoring Program.

1.4.1 Conclusions from the Assessment

1.4.1.1 Characterization of Impacts

Homeless encampment impacts are similar regardless of geography. These impacts vary and fell into three categories:

- *Quantifiable Impacts* – The only impact identified with quantifiable data was trash volume. The volume of trash that may need to be removed during the clean-up of an encampment can be significant, as noted from various sources either in the Santa Ana River watershed or from documentation obtained in the literature review. This trash not only builds up around the encampments but can become mobilized during wet weather events.
- *Qualitative Impacts* - Observable, but unquantified, impacts are commonly associated with homeless encampments in riverbeds:
  - Visual presence of trash
  - Damaged riparian vegetation
  - Excavated riverbanks and levees
  - Damaged habitat for aquatic and riparian species of concern
  - Modified aquatic habitat, e.g., creation of diversions, fish passage barriers
- *Anecdotal/Potential Impacts* – Perceived impacts are noted by various sources; however, direct documentation of the anticipated impact is generally not available:
  - Water quality impacts from human waste
  - Water quality impacts from toxic chemicals in trash
  - Habitat damaged by fire resulting from campfires
  - Avoidance of homeless encampment areas by wildlife/species of concern

One of the more interesting aspects of this study was the inability to find any water quality data for bacteria or toxic chemical data demonstrating direct impacts from homeless encampments. Numerous sources mention the water quality concerns but actual data are lacking. Even the recently completed Synoptic Study suggests there may be an impact to water quality in the Santa Ana River from homeless encampments in the Mission Blvd area, but the findings were not consistent from week to week.

In Section 1.3.2.3 we note that the Investigative Order adopted for the San Diego River includes a component to evaluate the water quality impacts of homeless encampments on the river. Of particular interest in that literature source is the preliminary estimate on the numbers of bacteria samples that will be necessary to confirm whether or not homeless encampments impact water quality in the San Diego River. While this was the only example found of a serious effort to determine the relationship between the presence of encampments and water quality, by itself it does illustrate well the challenges associated with developing a monitoring program to assess such impacts. Moreover, when one considers the transient nature of camps, differences in how they may operate or handle waste or differences in site-specific conditions from one camp to another, one can see that any study designed to quantify any water quality impacts would be a challenging effort.

1.4.1.2 Extent of Homeless Encampments in the Upper Santa Ana River Watershed

Based on the information gathered from the project study area there are five key areas where camps are currently concentrated. All are in various reaches of the Santa Ana River:

- VBB upstream to Anza Drain
- Along the Tequesquite Landfill
- Above and below the MBB crossing
- Upstream of the 60 Fwy
- Between the I-215 bridge and Tippecanoe Road

All of these locations have two things in common – there is water present and because water is present there is vegetative cover. The majority of those interviewed believe the number of encampments and numbers of residents is on the increase. However, some interviewees believe that the number of camps is unchanged from a few years ago. We did not find anyone who thought the number of encampments is decreasing.

1.4.2 Recommendations for Development of a Preliminary Monitoring Program

The purpose of this section is to provide recommendations regarding the development of a Preliminary Monitoring Program. Per the project workplan, the purpose of this program is to (a) provide data to evaluate impacts of selected homeless encampments on water quality during both dry- and wet-weather; and (b) assess riparian and aquatic habitat degradation impacts caused by these same homeless encampments.

Monitoring programs can take a number of forms ranging from direct measurements, e.g., collection and analysis of water quality samples or measures of habitat impacts, to indirect measurements, e.g., trends in numbers and size of homeless encampments. Inherent in the use of an indirect approach is two assumptions: (a) the presence of homeless encampments does impact water quality and habitat; and (b) increasing numbers of encampments likely increases that impact.

Development of a Preliminary Monitoring Program will consider the pros and cons of implementing direct or indirect monitoring approaches for consideration by SAWPA. However, it is important to note that even without the collection of any new monitoring data an already known water quality concern exists in the form of trash. The State Water Resources Control Board Policy on Trash notes that trash is a significant pollutant of California's waters and its presence adversely affects beneficial uses of surface waters, including uses related to the protection of aquatic life, wildlife and public health.[11] Therefore, regardless of other water quality impacts potentially occurring because of homeless encampment activity (e.g., human waste or toxic chemicals) concerns regarding water quality already exist.

Given this as background and as directed by SAWPA, a Preliminary Monitoring Program was developed under this project. Section 2 below describes this Preliminary Monitoring Program, which will be considered for potential implementation in the future.

[11] State Water Resources Control Board, Statewide Water Quality Control Plans for Trash: https://www.waterboards.ca.gov/water_issues/programs/trash_control/

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Task 2 Memorandum: Upper Santa Ana Rivers Watershed Homelessness Preliminary Monitoring Program

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2.1 Introduction

As described above, SAWPA and its member agencies directed the implementation of a study to evaluate homeless encampments in the upper Santa Ana River watershed through a two-step process. The first step was to (a) develop a better understanding of potential impacts of homeless encampments on water quality and riparian and aquatic habitat based on an assessment of existing information; and (b) identify areas in the upper watershed where encampments are concentrated. The findings from this assessment were provided above in Section 1.

Based on the conclusions and recommendations provided in Section 1.4 above, a Preliminary Monitoring Program was developed for consideration by SAWPA for potential future implementation. The purpose of the monitoring program was to gather data from areas within the watershed where homeless encampments are typically present to evaluate potential impacts to water quality and aquatic and riparian habitats. This Preliminary Monitoring Program is presented in the following sections.

2.1.1 Project Setting

The project takes place in the Santa Ana River Watershed, a drainage area of nearly 2,650 square miles, and includes Orange County, Riverside County, San Bernardino County, and a small portion of eastern Los Angeles County. The mainstem Santa Ana River flows 96 miles, beginning from its headwaters in the San Bernardino Mountains to where it drains into the Pacific Ocean. This project focuses on the Upper Santa Ana River Watershed which generally includes the portions of the Santa Ana River and tributaries above Prado Dam.

This proposed monitoring program would take place within the northeastern portion of the Santa Ana River watershed and the northwestern portion of Riverside County, along the mainstem Santa Ana River in Reaches 3 and 4. Monitoring locations for homeless encampments, previously recommended in Task 1 above, are shown on **Figure 2-1**. Numerous watershed stakeholders agreed that the number of homeless encampments is on the increase. For example, this anecdotal evidence was verified in studies conducted by the RCFC&WCD and IEWK, which both documented hundreds of encampments along the mainstem Santa Ana River within Riverside County (see Section 1.2.2.4). Because of the ongoing increase in the number of homeless encampments in the Upper Santa Ana Watershed, water quality issues associated with encampments are likely on the rise and will continue to create underlying challenges that will need to be addressed in the future.

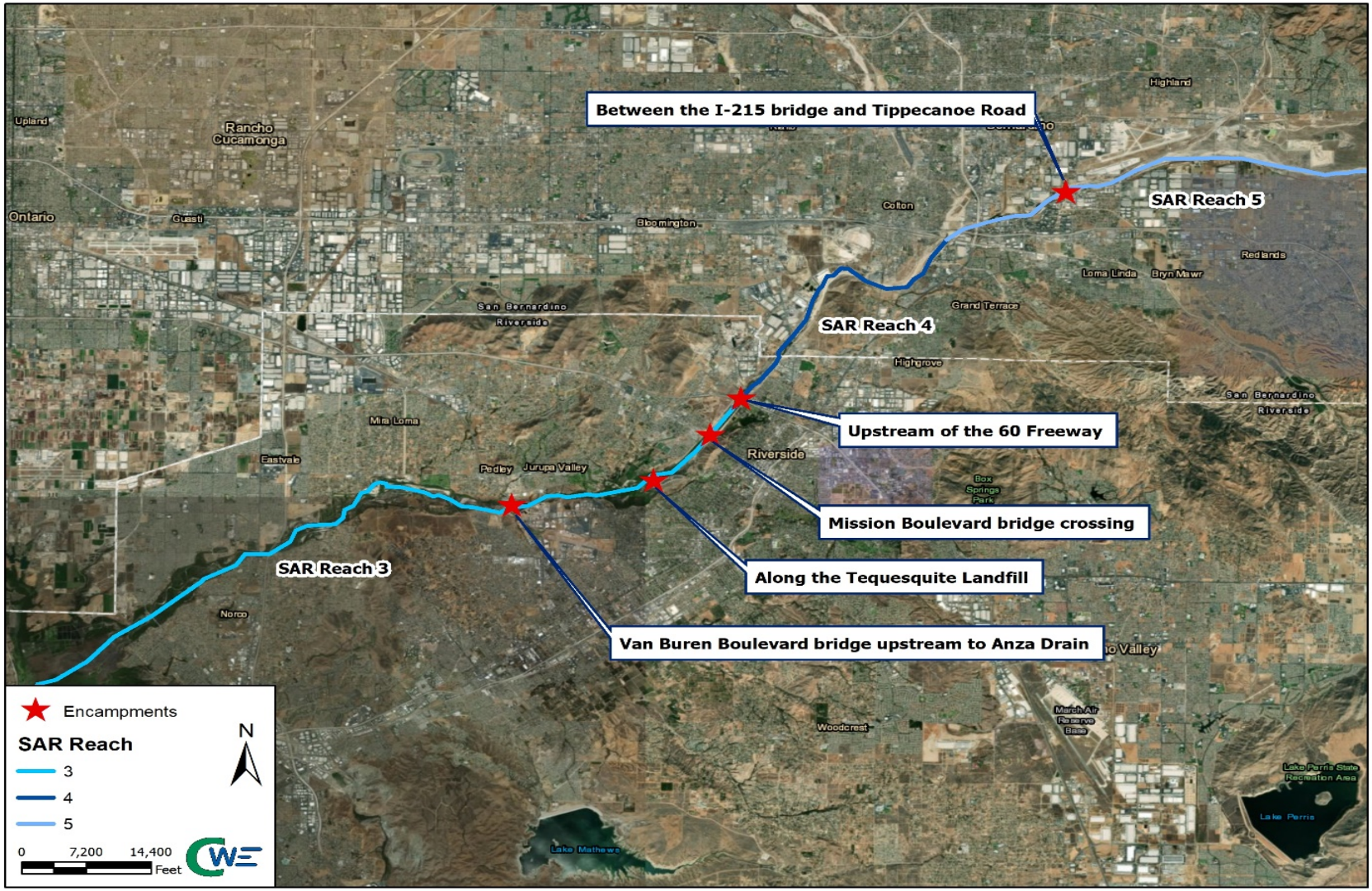

Figure 2-1. Location of Five Major Areas of Encampments in the Upper Santa Ana River Watershed

2.1.2 Regulatory Background

Although data that directly links homeless encampment activity to lower water quality appears to be limited or unavailable, the potential for homeless encampments to impact water quality and habitat can be documented. Trash generated by encampments affects water quality standards, including designated beneficial uses for specific waterbodies, water quality objectives to protect beneficial uses, and the California State Water Resources Control Board (State Water Board) Resolution 68-16 (Antidegradation Policy).

Besides negatively affecting aesthetic purposes for the environment, trash generated by homeless encampment activity has the potential to affect numerous beneficial uses of the Upper Santa Ana River Watershed, including REC-1, REC-2, and WARM. Trash negatively affects wildlife in the form of entanglement, ingestion, and alterations of habitat. Trash further poses a significant threat to human health during water recreational activities due to discarded medical waste, broken glass, or wastes that contain toxic substances of concern, including batteries, pesticide containers, and fluorescent light bulbs. Water quality objectives, designed to protect beneficial uses, and are applicable to trash include:

- Floating Material – Waters shall not contain floating material, including solids, liquids, foams, and scum in concentrations that cause nuisance or adversely affect beneficial uses;
- Settleable Material – Waters shall not contain substances in concentrations that result in the deposition of material that cause nuisance or adversely affect beneficial uses; and
- Suspended Material – Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

To prevent trash from affecting California's waters and their beneficial uses, the State Water Board incorporated Trash Amendments into the California Ocean Plan (State Water Board 2015a) and the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries (State Water Board 2015b). Because the Trash Amendments have set a prohibition on the discharge of trash, any type of litter or waste generated from homeless encampment activities could result in the implementation of trash control Waste Discharge Requirements by the Regional Board.

Furthermore, homeless encampments often lack adequate sanitary waste disposal facilities, and therefore, human and pet feces are exposed to the environment and may affect water quality by increasing bacterial concentrations. The MSAR Bacteria TMDL, which became effective on May 16, 2007, was adopted because the Santa Ana River, Reach 3, was impaired for bacterial indicators and is still currently on the State's 303(d) list. Per the TMDL, the compliance target for *E. coli* is as follows:

E. coli: 5-sample/30-day logarithmic mean less than 113 organisms/100 mL and not more than 10 percent of the samples exceed 212 organisms/100 mL for any 30-day period.

Because homeless encampments are a controllable pollutant source (Santa Ana Water Board 2019), encampment activities may affect compliance with the MSAR Bacteria TMDL. Controllable bacteria sources in the Santa Ana River Watershed must be reasonably reduced or eliminated to the maximum extent practicable by using the Best Available Treatment technology (BAT) and Best Conventional Treatment technology (BCT). Therefore, implementation of the proposed monitoring program will assess the impacts that homelessness has on surface water quality and will assist watershed stakeholders to develop practices to prevent potential bacteria from entering waterways.

2.1.3 Project Purpose and Program Overview

This homelessness preliminary monitoring plan was prepared to fulfill the following objectives:

- Assess the potential impacts of three homeless encampments on water quality and riparian and aquatic habitats.
- Quantify the potential water quality, riparian and aquatic habitat impacts caused by homeless encampments to assist SAWPA and its member agencies in assessing the magnitude of impacts and determining appropriate needed actions, if any.

These objectives can be met by conducting routine sampling, analysis, and monitoring upstream and downstream of the three selected homeless encampments.

2.2 Monitoring Approach

This monitoring program entails a science-based approach following the California State Surface Water Ambient Monitoring Program (SWAMP) protocol. Additionally, this program was modeled after the SCCWRP workplan prepared in the San Diego region, *Quantifying Sources of Human Fecal Contamination Loading to the San Diego River* (SCCWRP 2019).

2.2.1 Monitoring Locations

Section 1.4 identified five key areas where homeless encampments are currently concentrated within the Upper Santa Ana River Watershed. Each location has two things in common – water is present and because water is present, there is vegetative cover. The five areas identified are listed below in **Table 2-1**.

Table 2-1. Location of the Five Major Encampments in the Upper Santa Ana River Watershed

Location	Latitude	Longitude
Van Buren Boulevard bridge upstream to Anza Drain	33.96477	-117.46575
Along the Tequesquite Landfill	33.97423	-117.41366
Mission Boulevard Bridge crossing	33.99081	-117.39312
Upstream of the 60 freeway	34.00399	-117.38194
Between the I-215 bridge and Tippecanoe Road	34.07957	-117.26353

Figure 2-1 above shows the location of the five encampments in the Upper Santa Ana River Watershed, and their locations within their respective Santa Ana River reaches. Three of the five locations were selected to be monitored based on the best available data. According to data collected by RCFC&WCD drone surveys, and anecdotal data from numerous organizations within the Inland Empire, including SAWPA, IEWK, and the Riverside RWQCP, it appears that three encampment locations have remained constant over a period of at least a couple years, and therefore, are best suited to be monitored.[12] Locations selected for the monitoring program are:

- VBB upstream to Anza Drain (Van Buren Boulevard Bridge
- Mission Boulevard bridge crossing (Mission Boulevard Bridge)
- Upstream of the 60 Freeway (Market Street Bridge)

[12] A pre-field visit will be required prior to the implementation of the monitoring program to verify existing conditions. Monitoring locations are subject to change based on the movement of homeless encampments.

Locations for the three monitoring sites can be found in **Figure 2-2**. The three encampment sites all involve a bridge crossing, which acts as a permanent overhead structure for encampments, and are easily accessible via the Santa Ana River Trail. Additionally, these three homeless encampments are relatively grouped together, as shown in Figure 1-15 above, a map created by RCFC&WCD after conducting two drone surveys to evaluate the locations of homeless encampments in the mainstem Santa Ana River.

For this proposed monitoring plan, upstream and downstream monitoring locations were selected for each of the encampment locations based on the following considerations:

- Upstream monitoring locations are intended to provide defensible baseline water quality and habitat data. Therefore, upstream locations were selected to minimize potential impacts from the sphere of influence of homeless encampment activities.
- Downstream monitoring locations were selected based on maximizing the respective homeless encampment's sphere of influence and drainage area; the downstream monitoring locations were selected to minimize disturbances to homeless encampment residents and safeguard monitoring personnel. Furthermore, selected locations were evaluated for ease of monitoring team access.

2.2.1.1 Van Buren Boulevard Bridge (VBB)

VBB has the smallest encampment density of the three locations, as the encampments tend to be stretched out over a 2-mile section of the mainstem Santa Ana River. Coordinates for the upstream location, VBB 1, and the downstream location, VBB 2, can be found in **Table 2-2**, while an aerial view of the monitoring locations can be found in **Figure 2-3**. VBB 1 is approximately 1.8 miles upstream of the VBB, just upstream of the Santa Ana River Viaduct, also known as the Union Pacific Railroad bridge. VBB 1 is easily accessible via Martha Mclean – Anza Narrows Park, which has an access gate to the Santa Ana River Trail. VBB 2 is underneath the VBB and is accessible via the Santa Ana River Trail to the south, or via an access gate north of the bridge, just below the In-N-Out Burger restaurant. This monitoring site is upstream of the Hole Lake confluence and upstream of the Riverside RWQCP effluent outfall confluence.

Table 2-2. Monitoring Locations for Van Buren Boulevard Bridge

Location	Latitude	Longitude
VBB 1 (Upstream)	33.96816°	-117.43455°
VBB 2 (Downstream)	33.96317°	-117.46547°

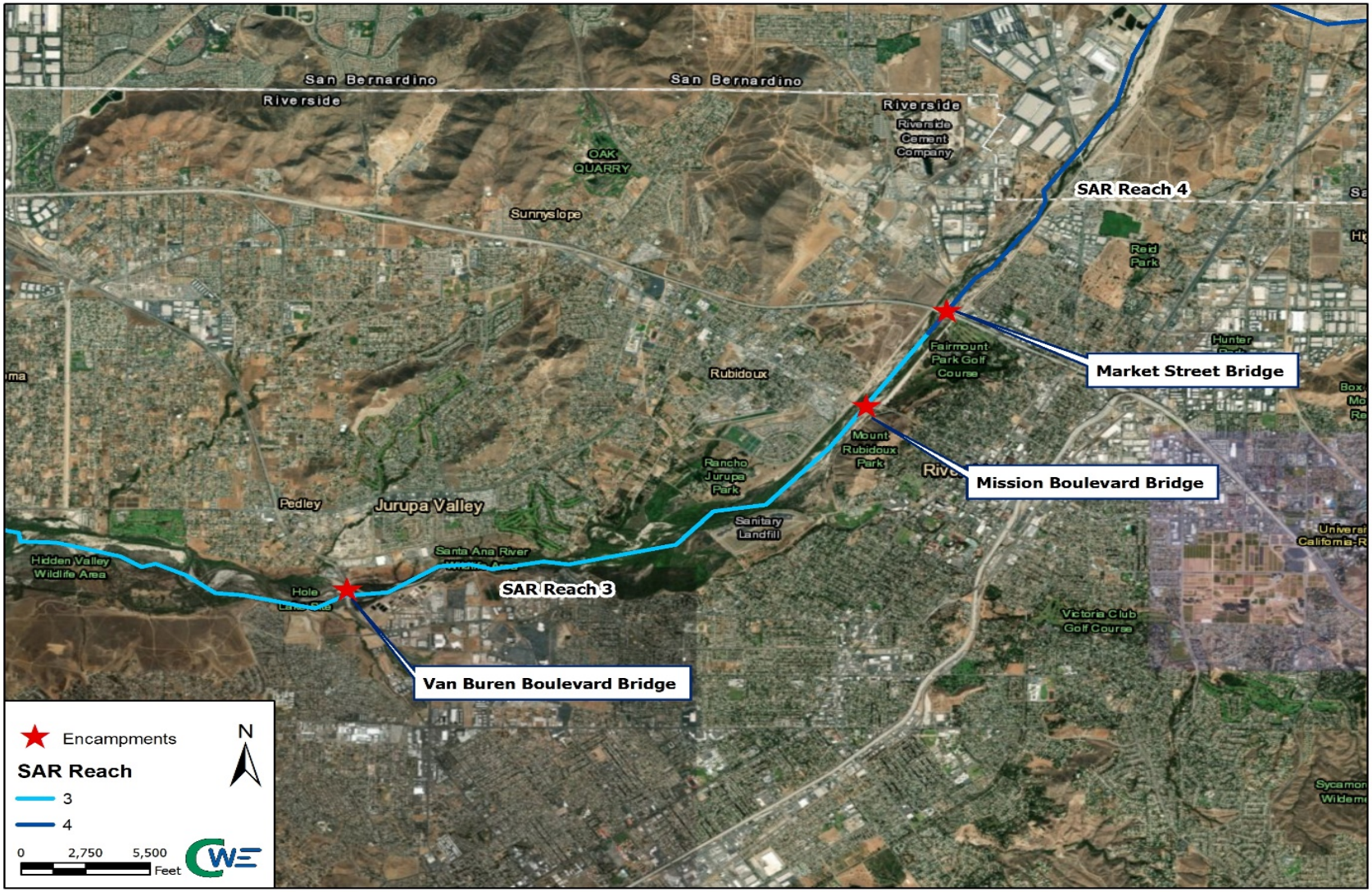

Figure 2-2. Aerial View of the Three Proposed Monitoring Sites for the Homelessness Preliminary Monitoring Program

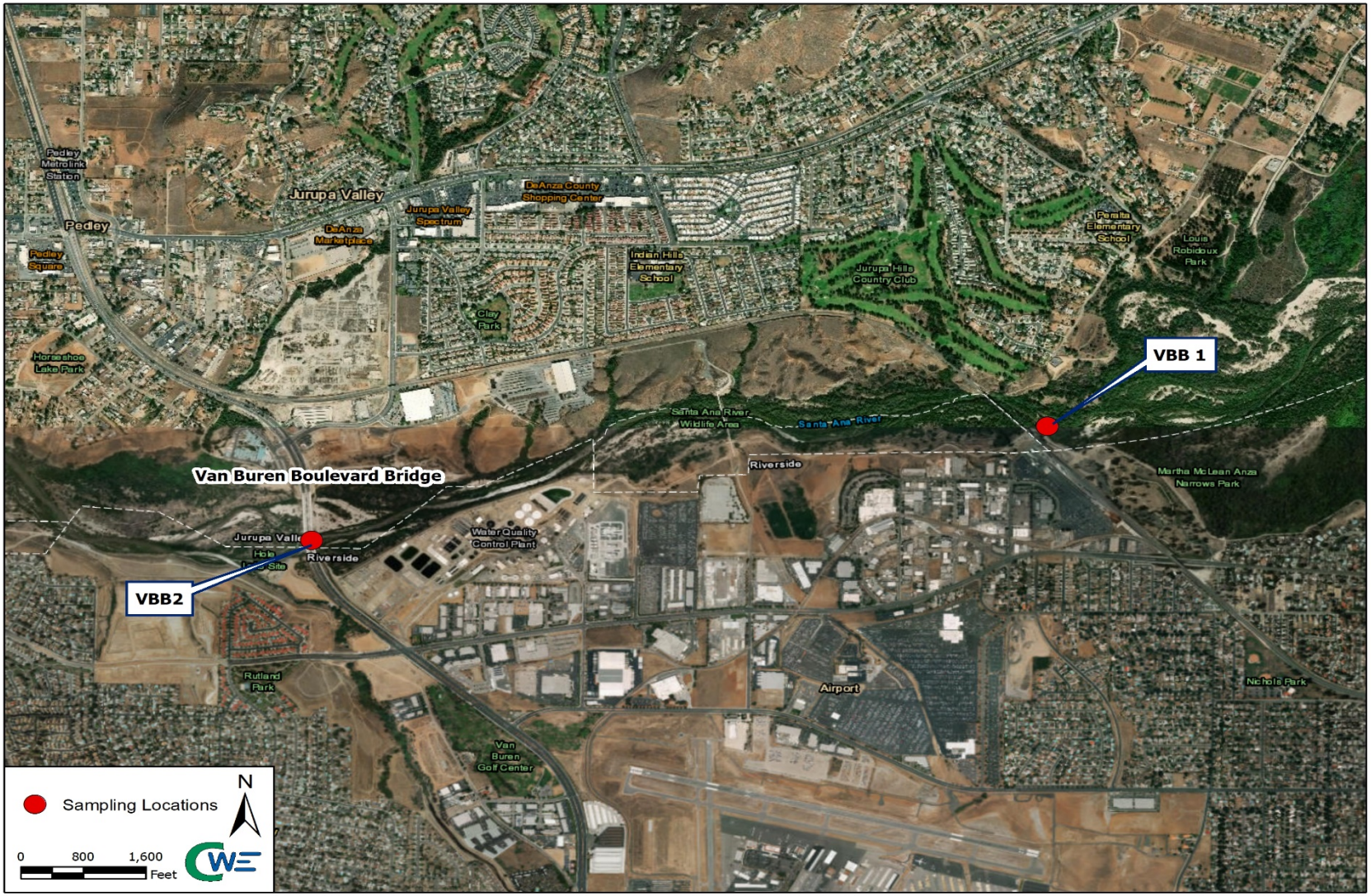

Figure 2-3. Aerial View of the Upstream and Downstream Monitoring Locations for Van Buren Boulevard Bridge

2.2.1.2 Mission Boulevard Bridge (MBB)

MBB appears to have the highest population density of people among the three encampments. MBB 1 and MBB 2 are the proposed upstream and downstream monitoring sites, respectively, and their coordinates can be found in **Table 2-3**, while an aerial view can be found in **Figure 2-4**. MBB 2 was a sample location included in the MSAR Bacteria Synoptic Study and the only location that detected the presence of human source bacteria. Due to the results of the Synoptic Study, the Regional Water Quality Monitoring Task Force added MBB 2 to the Santa Ana River Watershed Bacterial Monitoring Program; however, additional data is necessary to determine if the homeless encampments have a direct impact on water quality. The monitoring team can access MBB 1 via the Santa Ana River Trail, which is accessible through the Rubidoux Dog Park, on the southeastern edge of the MBB. The monitoring team will need to obtain an access permit from the RCFC&WCD and can access MBB 2 through the access gate at approximately 4660 Crestmore Road, Riverside, CA 92509.

Table 2-3. Monitoring Locations for Mission Boulevard Bridge

Location	Latitude	Longitude
MBB 1 (Upstream)	33.99216°	-117.39071°
MBB 2 (Downstream)	33.98302°	-117.40215°

2.2.1.3 Market Street Bridge (MSB)

MSB is the only monitoring location within Santa Ana River, Reach 4, and the northernmost location in this monitoring program. Coordinates for the upstream location, MSB 1, and the downstream location, MSB 2, can be found in **Table 2-4**. while an aerial view of the locations can be found in **Figure 2-5**. MSB 1 was selected as the upstream monitoring location, as this is where the riparian vegetation thins out, resulting in less homeless encampment concentrations due to no overhead cover. MSB 2 is approximately 500 feet downstream of the 60 Freeway crossing and was selected in reference to the drone surveys conducted by RCFC&WCD, where it appears few or no homeless encampments exist. These sites are accessible via MSB, which has multiple access points to the Santa Ana River Trail, both north and south of the bridge.

Table 2-4. Monitoring Locations for Market Street Bridge

Location	Latitude	Longitude
MSB 1 (Upstream)	34.01405	-117.37265
MSB 2 (Downstream)	34.00251	-117.38418

Figure 2-4. Aerial View of the Upstream and Downstream Monitoring Locations for Mission Boulevard Bridge

Figure 2-5. Aerial View of the Upstream and Downstream Monitoring Locations for Market Street Bridge

2.2.2 Preliminary Field Visits

Before implementation of the monitoring program, several preliminary field visits will be required to obtain the best available data and verify initial conditions. Although this monitoring plan is written based on present-day, best available data, this does not mean that encampment locations and conditions will not change from the present-day until implementation of the proposed monitoring program.

2.2.2.1 Baseline Conditions

A preliminary field visit will be required to evaluate initial water quality, riparian habitat, and aquatic habitat conditions as a baseline condition. In the event that encampments move away from proposed monitoring locations, population density changes, or other factors change over the course of the monitoring program, the degrees of impact can only be evaluated if baseline conditions are known before implementation of the proposed monitoring program. During this field visit, photographs will be taken to begin documenting and establishing a record of historical photographs of the monitoring locations.

Prior to the preliminary field visit, implementation of the proposed monitoring program will require a process for reviewing previous historical photographs and special studies to document trends within the homeless encampment spheres of influence. The monitoring team should seek to work collaboratively with watershed stakeholders to obtain this information. By reviewing historical data, the monitoring team can determine pre-existing conditions at the monitoring locations.

2.2.2.2 Encampment Population Estimate

To confirm existing conditions and follow-up on previous homeless population estimations provided by RCFC&WCD and IEWK (see Sections 1.2.2.4 and 1.2.2.5, respectively), another preliminary field visit will be required to estimate the number of people experiencing homelessness in the proposed monitoring locations. An estimate of homeless encampment populations is important to determine the impact each encampment has on the Upper Santa Ana River Watershed in relation to the concentration of bacteria and human genetic markers from collected water samples.

This preliminary field visit can likely be achieved by coordinating with Riverside County's Point-in-Time (PIT) count, an annual event in Riverside County that counts and surveys homeless populations within County borders[13]. Although the PIT count has existing data on homelessness throughout Riverside County, current surveys do not specify the approximate location of homeless individual's encampments if they are located within the riverbed. The

[13] http://dpss.co.riverside.ca.us/homeless-programs/homeless-count-and-summary

monitoring team will need to coordinate before the annual event in January to receive accurate data from the PIT count[14].

If population estimates have determined that homeless encampments have moved away from current locations, monitoring locations may need to be moved as well to accurately portray encampment conditions and their impacts on water quality and habitat degradation. The monitoring team will take photographs during this visit to continue establishing a historical record of the homeless encampments.

2.2.3 Field Parameters

Error! Reference source not found. summarizes the parameters to be measured during each dry-weather and wet-weather sampling event. The field and analytical methods presented in **Table 2-5** are in alignment with the Santa Ana River Watershed Regional Bacteria Monitoring Program's Monitoring Plan and Quality Assurance Project Plan. *E. coli* and *Bacteroides* HF183 are the primary constituents that will be monitored in this program to determine the relationship between homelessness and water quality. Hold times for *E.coli* and HF183 are 6 and 24 hours, respectively. Field parameters will be collected using a multiparameter water quality instrument, such as a YSI ProDSS, while laboratory parameters will be measured using the specified analytical methods.

Table 2-5. Monitoring Parameters at Monitoring Locations

Parameter	Type of Test	Units	Field or Analytical Method
Temperature	Field	°C	Water Quality Sonde (e.g., YSI or equivalent)
pH	Field	Standard Units	
Dissolved Oxygen	Field	mg/L	
Electrical Conductivity	Field	mS/cm	
Turbidity	Field	NTU	
Total Suspended Solids	Laboratory	mg/L	SM 2540D
E. coli	Laboratory	MPN/100 mL	SM 9223-B-b
HF183	Laboratory	10 gene copies/1000 mL	HF183 qPCR assay
Benthic Macroinvertebrates	Laboratory	-	SWAMP Physical Habitat and BMI SOP (Attachment B)

[14] CWE staff and Riverside County PIT staff have previously coordinated events to document and survey homeless populations in the Santa Ana River.

HF183's Project Action Limit is based on the presence or absence of the genetic marker. If HF183 is consistently found at a monitoring site, then the link between homelessness and water quality can be evaluated. The concentration of HF183 will also be collected to document if there is a relationship between the concentration of the genetic marker and water quality. Following the MSAR TMDL guidelines, the Project Action Limits for *E. coli* are: 5-sample/30-day logarithmic mean less than 113 organisms/100 mL and not more than 10 percent of the samples exceed 212 organisms/100 mL for any 30-day period.

2.2.4 Sampling Frequency and Event Criteria

Determining a direct link between homelessness and lower water quality is a difficult challenge, and although little to no current data is available, SCCWRP's workplan in San Diego, created in response to a San Diego Water Board Investigative Order, provides a strong approach to evaluate the connection between homelessness and water quality (SCCWRP 2019). SCCWRP's workplan was developed collaboratively with municipalities, universities, and regulatory agencies to address bacterial contamination issues in the San Diego River Watershed. The Santa Ana River Watershed faces similar challenges in addressing bacteria impairments, and therefore, SCCWRP's workplan is a well-researched model to follow.

SCCWRP estimates that the necessary sample size to confirm water quality impacts from homeless populations for an upstream/downstream study would be 30 paired sample events for dry-weather, and 60 paired sample events during wet-weather, as shown in **Figure 2-6**. These numbers were obtained via a statistical power analysis conducted on current HF183 detection rates in San Diego. For the statistical analysis, SCCWRP estimated an approximate 300 people living in encampments along the San Diego River, which are numbers similar to those estimated by RCFC&WCD and IEWK along the mainstem Santa Ana River. There are a couple of key assumptions for this monitoring plan:

- The counts of people experiencing homelessness, as discussed in Section 2.2.2, is representative of the true population living in the river bottom
- Homeless encampment populations are similar between each proposed monitoring location
- The sample sizes will be sufficient to detect the differences in HF183 concentrations from upstream and downstream locations, if they exist

Because of the large number of dry-weather and wet-weather sampling events required, multiple sites will need to be sampled to obtain sufficient data in a reasonable amount of time. By using SCCWRP's model in conjunction with the three proposed monitoring sites in this monitoring plan, 10 dry-weather events and 20 wet-weather events for each of the three monitoring sites will be required to potentially determine the link between homelessness and water quality. Southern California typically has 10 to 15 wet-weather events per year, it is

recommended to conduct this monitoring program over several years, as the proposed program requires the monitoring of more wet-weather events than the average number of wet-weather events annually. Therefore, it is recommended to conduct the proposed program over a period of three years. Following the three-year model, the first year will require monitoring of four dry-weather and six wet-weather events, and the following two years will each require the monitoring of three dry-weather and seven wet-weather events. However, monitoring six to seven wet-weather events per wet-weather season could be challenging, and therefore, increasing the duration of the proposed monitoring program would be a viable option. Although this monitoring program can be completed over a longer time period, the number of dry-weather and wet-weather events would need to be adjusted accordingly, and the potential for encampments to move or disperse would increase.

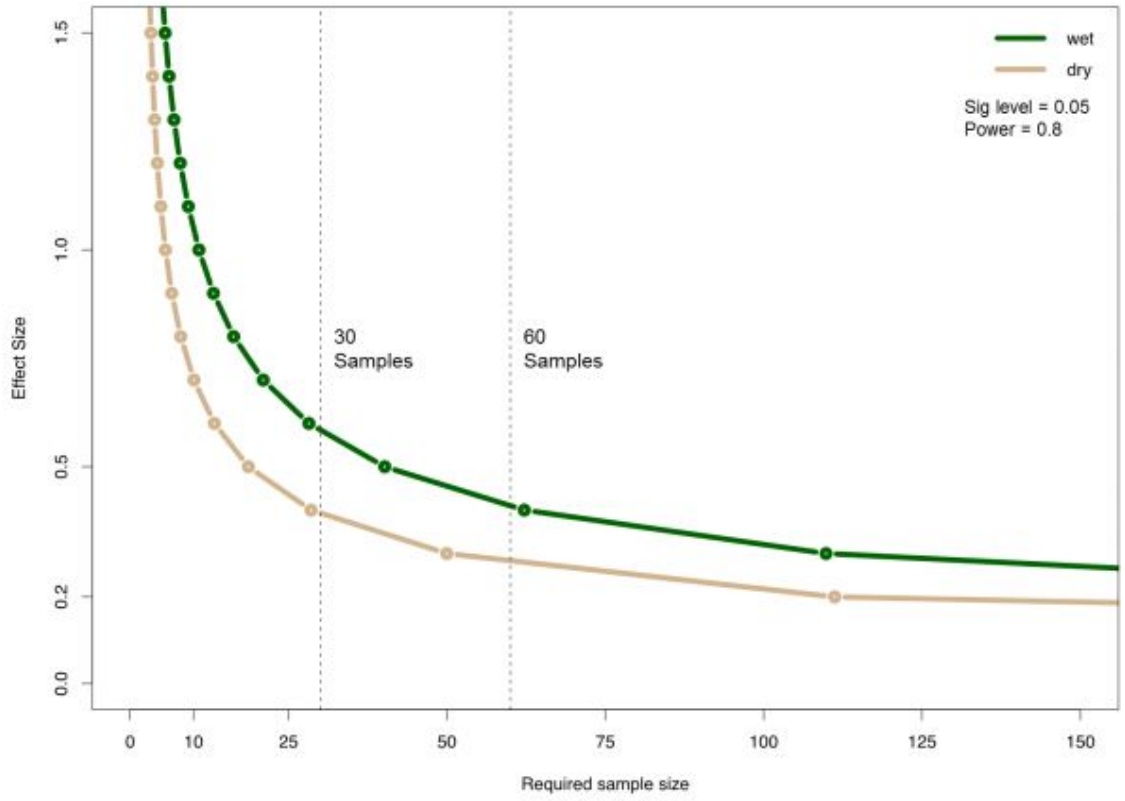

Figure 2-6. Statistical Power Analysis for Detecting Differences in HF183 Concentrations between Upstream and Downstream Sites (SCCWRP 2019)

Sampling during dry-weather events is defined as no measurable rainfall within a 72-hour period prior to sampling. If this condition is met, dry-weather sampling can proceed. Based on the three-year model, for the first year, two dry-weather events will be conducted during the summer, between June 20 and September 22, and two dry-weather events will be conducted during the wet-weather season, between October 1 and April 15. On the following

two years, two-dry weather events will be conducted during the summer for each year, and one dry-weather event will be conducted during the wet-weather season for each year.

Sampling during wet-weather events occurs during or immediately after a rain event, when visible runoff is produced, and flows are elevated above typical dry-weather conditions and occurs between October 1 and April 15. Based on the three-year model, for the first year, seven wet-weather events will need to be monitored. For the following two years, six wet-weather events will need to be monitored each year.

For monitoring wet-weather events, the sampling team will utilize the National Oceanic and Atmospheric Administration National Weather Service. Forecasts with precipitation depths greater than or equal to 0.1 inches, and probabilities greater than or equal to 75%, will be communicated to SAWPA and upon approval, mobilization efforts will be initiated. Mobilization efforts, which will further be discussed in Section 2.3, includes procurement of sample bottles from the analytical laboratory, preparation of sample bottles, printing of chain-of-custody (CoC) and bottle labels, preparation of sampling equipment, and loading of ice.

2.3 Sampling and Analysis Procedures

The monitoring protocols summarized in this section were developed to address the following objectives:

- Establish current homelessness conditions in the Upper Santa Ana River Watershed, which will assist SAWPA and its member agencies in assessing the magnitude of impacts and determining appropriate needed actions, if any
- Test methods designed to identify and estimate homelessness contributions to impacts on water quality and aquatic and riparian habitat

Sampling procedures will adhere to the guidelines found in the SWAMP water sample collection Standard Operating Procedure (SOP), "Field Collection Procedures for Water Samples" and is included in **Attachment B** (State Water Board 2014). This section outlines the monitoring event preparation, water sample collection procedures, and sample management procedures that will be followed.

2.3.1 Monitoring Event Preparation

The following sections refer to specific monitoring event preparation protocols to ensure proper procedures are followed and provide quality results.

2.3.1.1 Personnel Roles and Responsibilities

Homeless encampment monitoring requires a variety of skills and positions. There are three main roles that will be filled to ensure effective implementation of the monitoring program and quality assurance and quality control (QA/QC) procedures. Each role and associated responsibility is as follows:

- *Project Manager* – The Project Manager will oversee and coordinate all aspects of the homelessness monitoring program. This position requires a thorough understanding of the project requirements, including county homeless management procedures, sampling procedures, and equipment operations. Responsibilities include conducting and coordinating appropriate training for field staff, monitor the ability of field staff to safely and effectively complete their shifts, coordinating the management of data collected during monitoring events, overseeing and conducting QA/QC procedures, and overseeing the interpretation and reporting of data.
- *Field Coordinator(s)* – The Field Coordinator is responsible for overseeing field assessment and monitoring activities at each site or event and will assist field technicians with monitoring activities. This position requires a person trained in field protocol, monitoring procedures, and county homeless management procedures. This individual

will ensure samples are collected and data is recorded properly. Responsibilities include communicating with the Project Manager to aid in the determination of task priorities, lead the recording of information on data collection forms, and participate in QA/QC procedures in the field.

- *Field Technicians* – Field technicians will assist the Field Coordinator in conducting qualitative and quantitative field assessments. Field technicians will need to understand monitoring and health and safety procedures.

2.3.1.2 Field Mobilization

It is critical to plan and prepare field efforts well in advance. A staffing plan of personnel and equipment for each monitoring event will be established prior to the start of monitoring. The monitoring team is anticipated to consist of a two- to three-person team, as a precaution due to the uncertain nature around homeless encampments. A staffing plan will be prepared and include the following:

- Personnel assigned to each position
- A list of necessary sampling equipment
- Monitoring site access procedures
- Communication channels and alternate contacts

Field personnel will provide the necessary equipment to monitor in anticipated environmental and physical conditions. The necessary equipment will be loaded into an appropriate vehicle before mobilizing to the monitoring site locations. A list of necessary equipment is presented below:

- Assorted cable ties
- Camera
- Cellular phone
- Clean sample labels
- Clean stir rods
- Coolers and ice
- Deionized water squirt bottles
- Duct and electrical tape
- Field meters
- Field notebook with field forms
- First aid kit
- Grab pole
- GPS receiver
- Hazardous waste container
- Indelible markers
- Job Site Health Analysis
- Keys
- Measuring tape
- Net
- Nitrile gloves
- Pencils
- Personal change of clothes
- Personal protective equipment
- Pre-cleaned sample collection tools
- Rope
- Sample bottles
- Sample control paperwork (e.g., CoC)
- Sample scoops
- Shovel
- Signed access authorization letter
- Stakes or flags
- Straps
- Tailgate safety meeting forms
- Trash bags
- Utility knife and diagonal cutters
- Waders
- Warning lights and signs
- Working headlamp
- Ziploc baggies (assorted sizes)

2.3.1.3 Laboratory Coordination

The Field Coordinator will place a sample bottle order with the analytical laboratory before all monitoring activities. Immediately following each monitoring event, the bottle inventory will be checked, and additional bottles ordered as needed. The bottles must be of the proper size and material and contain preservatives as appropriate for the specified laboratory analytical methods. The laboratory order should also include blank water for the collection of required field blank samples.

2.3.2 Sampling Methods

A two- to three-person team will undertake each monitoring event. The field team will have access to a cellular phone in the event of an accident or emergency. Monitoring activities will be postponed if the field team determines that field conditions are unsafe. Failure to conduct monitoring due to safety concerns or technical issues will be promptly reported to the Project Manager, who will determine if corrective action is needed and decide to collect replacement data, if possible.

2.3.2.1 Grab Samples

For the collection of dry-weather water samples, the sampling team will adhere to guidelines found in the SWAMP sampling SOP, "Collection of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat," and will collect grab samples (State Water Board 2014). Sampling equipment will be properly cleaned prior to each sampling event. Samples will be collected by hand, when possible. Disposable powder-free nitrile gloves are to be worn for personal protection and prevent sample contamination. Where practical, grab samples will be collected by direct submersion at mid-stream, mid-depth, using clean hand, dirty hand techniques and the following procedures:

1. Safely access the mid-stream area, allowing disturbed sediments to move downstream
2. Remove the container lid, being careful to retain any preservatives, then submerge the container to mid-depth, and allow the container to fill, and then secure the lid
3. Collect remaining samples including quality control samples, if required, using the same protocols described above
4. Promptly place collected sample container(s) on ice

A copy of the SWAMP sampling SOP is found in Attachment B. If grab samples are being collected on the same day as other activities, such as the physical habitat assessment, grab samples would be collected prior to any other activity to avoid disturbance to the water column.

2.3.2.2 Composite Samples

For the collection of wet-weather water samples, the sampling team will manually collect flow-weighted composite samples. Composite samples are necessary to reduce storm variability and assess changes in mass flow as well as concentration. The manual collection of a flow-weighted sample is performed in the same manner as taking grab samples (see Section 2.3.2.1). The only differences are that (a) a series of samples, or aliquots, will be collected and (b) for safety precautions, one should not enter a body of water during a wet-weather event, so a bucket and rope, or a sterile bottle attached to a sampling pole, will be used to collect each aliquot. In this case, collecting three aliquots per hour, or every 20 minutes, will be required for a total duration of three hours.

2.3.2.3 Rapid Trash Assessment

Rapid Trash Assessment protocol (San Francisco Bay Regional Board 2004) involves picking up and recording trash items found within a 100-foot section of a stream. When repeated multiple times throughout a year, this protocol allows for the assessment of temporal changes in impairment, usage patterns, and trash deposition trends. Rapid Trash Assessment should be conducted during each dry-weather event and after each wet-weather event, once flooding conditions dissipate. The Rapid Trash Assessment includes activities such as trash collection, note taking, and scoring, and can take anywhere between thirty minutes to two hours per site, depending on how trash-impacted each site is. The length of the assessment is also dependent upon the size of the field team.

To begin the trash assessment, upon arrival at a designated monitoring site, a team of two or more people will define a 100-foot section of the stream that is associated with the monitoring site. The 100-foot length should not be a straight line, but rather the length of the shoreline, including sinuous curves. Starting and ending points should include easily identified landmarks and noted on the Rapid Trash Assessment Field Form, found in **Attachment C**. If the Rapid Trash Assessment is being conducted in conjunction with the Physical Habitat assessment and Bioassessment, then the Rapid Trash Assessment shall be conducted between the transects furthest upstream, as shown in **Figure 2-7**.

Trash surveying will be initiated at the downstream end, so that trash is not obscured after disturbing the streambed. For a team with two members, both people, equipped with gloves and garbage bags, pick up trash. One team member walks along the edge of the stream, looking for trash on the bank up to an upper bank boundary and shouts out any trash items found in the water body for the person on land to tally on the trash assessment sheet. The second team member walks along the opposite bank and marks down trash tallies on the trash assessment sheet while looking for trash as well. Only one team member should be tallying to keep results consistent. A three-member team is recommended and would include one designated note-taker as a lookout, particularly in dense encampment areas, and two trash monitors.

Once surveyors are finished tallying, the worksheet should be filled out before leaving the monitoring site. The Rapid Trash Assessment protocol includes an assessment of six condition categories, including Level of Trash, Actual Number of Trash Items Found, Threat to Aquatic Life, Threat to Human Health, Illegal Dumping and Littering, and Accumulation of Trash. These parameters will evaluate qualitative and quantitative levels of trash from encampments, examine the impacts that trash from encampments have on water quality, and document how trash enters the waterbody at the site. Within each parameter, narrative language is provided to assist with choosing a qualitative category. The system provides a range of five numbers within a given condition category, allowing for the range of conditions expected in the field. For example, heavy accumulation of trash in the water leads to lower scores in comparison to no trash being found. The survey includes a total score at the end of the sheet, indicating whether conditions are improving or worsening over time, and in this monitoring plan's case, examining trash deposit trends from homeless encampments. A total volume of trash can be calculated after concluding the assessment, and the collected trash can be weighed to determine if trash deposit quantities are changing between monitoring events.

2.3.2.4 Physical Habitat and Bioassessment

Homeless encampments have the potential to impact both the riparian and aquatic habitat within and surrounding the Santa Ana River. Therefore, it is important that this monitoring plan include a Physical Habitat and Bioassessment (PHab) to determine impacts that homelessness has on the surrounding habitat. A PHab should be conducted annually, at each downstream monitoring location, and at a minimum of 6 weeks after a qualifying storm event.

Physical Habitat assessment and collection of Benthic Macroinvertebrate (BMI) samples will be conducted in accordance to the guidelines found in the SWAMP sampling SOP, "Benthic Macroinvertebrates Samples and Associated Physical and Chemical Data" (State Water Board 2016). An experienced two to three-person team, separate from the Rapid Trash Assessment team, will conduct the Physical Habitat assessment and bioassessment sampling. The following subsections present typical procedures for each method, although modifications may be necessary based on unique characteristics of the Santa Ana River Watershed and the proposed monitoring locations.

Physical Habitat Assessment

A Physical Habitat assessment may be conducted as a stand-alone evaluation or in conjunction with other sampling activities. To conduct a Physical Habitat assessment, a 250-meter stretch of the river will be measured at each monitoring location and be divided into 11 equidistant transects arranged perpendicular to the direction of flow, as shown in Figure 2-7. More information on the Physical Habitat Assessment SOP can be found in Attachment B. The transects will be designated A through K and Physical Habitat assessment will be conducted using the following procedures:

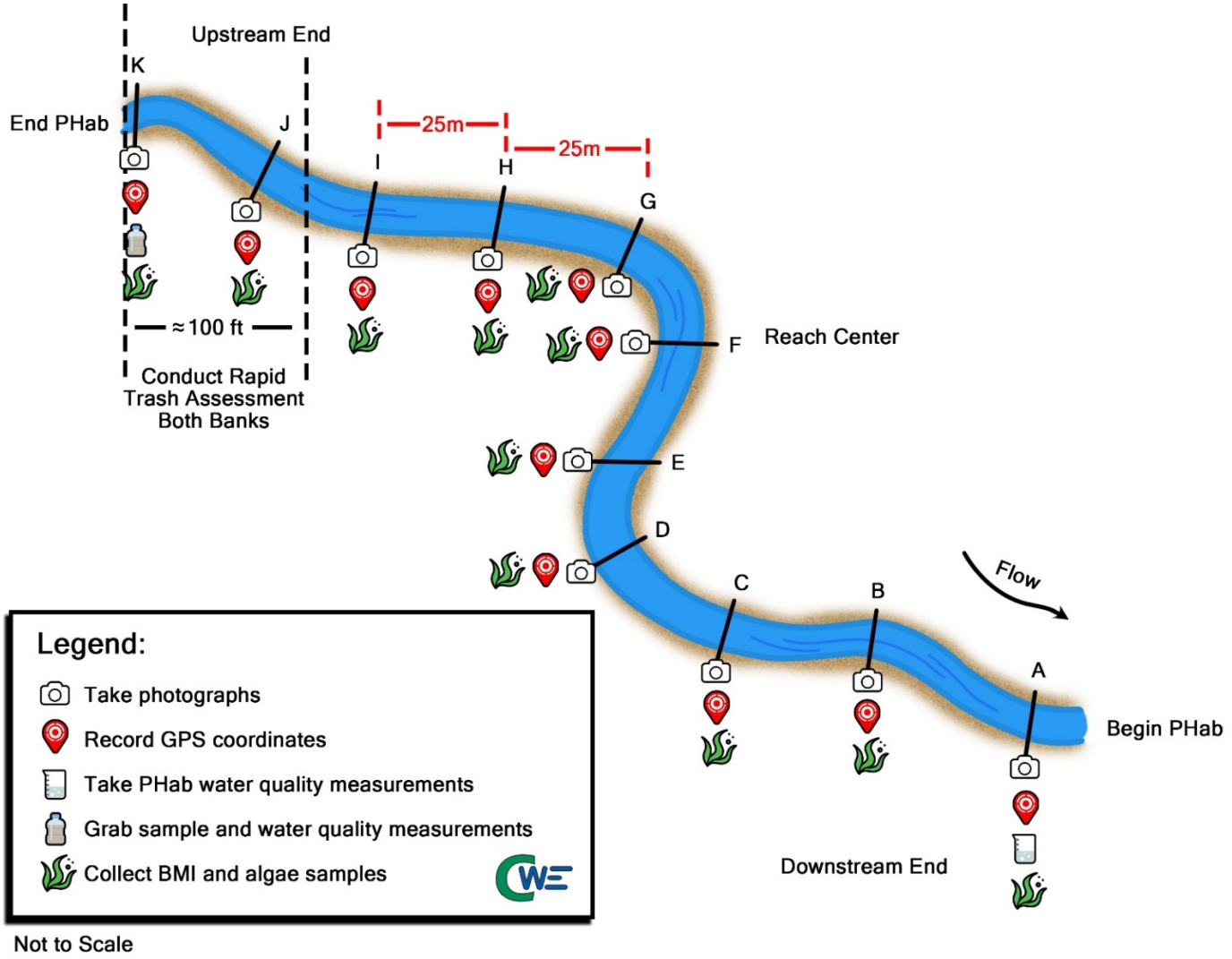

Figure 2-7. Transect Layout for Physical Habitat and Bioassessment in Conjunction with Other Monitoring Activities

1. Fill out field forms and determine the geographical coordinates, at the top of the 250-meter stretch of the river (Transect K), in decimal degrees to at least four decimal places with a GPS receiver.
2. Once the site has been identified, make an initial survey of the reach from the stream banks, being sure to not disturb the in-stream habitat.
3. Starting at one end of the reach, establish the position of the 11 transects (A through K, downstream to upstream) by measuring 25 meters along the bank from the previous transect. For easy setup and breakdown, mark the main transect with easily removable markers. Since the water quality data will be collected at the downstream end, begin establishing transects at the downstream end. Record the GPS coordinates of each transect.
4. Measure and record common ambient field water quality characteristics (pH, DO, specific conductance, alkalinity, and water temperature) prior to starting any physical habitat or bioassessment data collection to avoid disturbing the water column, starting at the downstream end of the reach (Transect A). Additional parameters such as channel cross section measurements will also be recorded for each transect.
5. Take a minimum of four photographs of the reach at each transect. Photographs for each transect will include a view of the waterbody facing upstream and downstream, and the right and left banks.
6. Record the dominant land use and cover in the area surrounding the reach (evaluate land cover using a scaled aerial photograph of the site and vicinity as an aid, within 50 meters of either side of the stream reach).
7. Record evidence of recent flooding, fire, or other disturbances that might influence bioassessment samples. Especially note if flow conditions have been affected by recent rainfall, which can cause significant under-sampling of BMI diversity.

Bioassessment

BMI samples will be collected utilizing the reach wide benthos (RWB) procedure (State Water Board 2016). The RWB procedure can be used to sample wadeable stream reaches since it does not target specific habitats. Sampling equipment will be properly cleaned prior to each sampling location and event. Where practical, the composite sample from the 11 transects, A through K, will be collected by net placement within each transect. Sampling position within each transect will be alternated between the left, center, and right position along the transection (25%, 50%, 75% of the wetted width, respectively). Sampling will begin at the furthest downstream transect, using the following procedures:

1. Position a 500-µ D-net, with the net opening perpendicular to the flow and facing upstream, quickly and securely on the stream bottom to eliminate gaps under the frame.
2. Visually define a 1 square foot (ft2) sample area and restrict sampling to that area.

3. Working backwards from the upstream edge of the sample area, look for heavy organisms such as mussels, snails, and stone-cased caddisflies. Remove these from the substrate by hand and place them into the net.
4. Collect remaining samples from the area by vigorously kicking the remaining finer substrate within the quadrat and move the net through the disturbed area to collect the organisms. Keep moving the net so the organisms trapped in the net will not escape.
5. Let water run clear of any insect or organic material before carefully lifting the net. Immerse the net in the stream several times to remove fine sediments and concentrate organisms at the end of the net. Continue kicking the substrate and moving the net for 30 seconds.
6. Repeat steps 1 to 5 at the next upstream transect area until all 11 transect areas have been sampled.
7. Empty the contents of the net into a large plastic bucket (10-20 liter (L)). If organisms are clinging to the net, remove and place them into the bucket. Add stream water to the bucket, making sure to not introduce entrained organisms from the source water. Gently swirl the contents of the bucket to suspend and remove the organic material from the bucket. Repeat process until only inorganic material is left in the net.
8. Prepare BMI sample jar and place collected samples from the 11 transect areas into the sample jar ensuring organisms are collected and placed in the sample jar.

Sampling will be postponed if the sampling team determines that the conditions are unsafe. Failure to collect a sample due to safety concerns or technical issues will be promptly reported to the Project Manager, who will determine if corrective action is needed and make arrangements to collect a replacement sample, if possible. The sampling SOP can be found in Attachment B.

2.3.3 Field Documentation

Field teams are required to complete a field data sheet for each monitoring site visited. The field data sheet (**Attachment D**) will accurately describe the conditions at the monitoring location. The data sheet will detail sample collection records, physical measurements, flow rate, and field observation records. The following general information will be entered for each event:

- Sampling site ID
- Date
- Time
- Monitoring Program
- Field Team Members

- Weather conditions and temperature
- Runoff characteristics
- Flow estimations
- Equipment condition
- Observations of surrounding area

Field teams will take digital photographs during each sampling event at each site and maintain a photo log of photographs taken during the sampling event. At a minimum, photographs for each monitoring location will include a view of the waterbody facing upstream and downstream, and the right and left banks. Additional photos to be taken during sampling events include evidence of trash or waste from encampments, evidence of new and/or nearby encampments since the last sampling event, and evidence of damaged habitat as a result of homelessness.

2.3.4 No Sample Taken Procedures

With any situation, there may be circumstances that would prevent samples from being collected at the monitoring locations. These circumstances include:

- Low flow conditions
- Site inaccessibility
- Dangerous site conditions

2.3.4.1 Low Flow Conditions

Sampling will be attempted even in low flow conditions. If a sample cannot be taken due to insufficient, or a lack of flow, a separate log sheet will be completed to explain why no sample was taken.

2.3.4.2 Site Inaccessibility

If the homeless encampment monitoring locations are blocked by a physical obstruction, such as downed vegetation, or large objects from encampments, the sampling team will attempt to sample immediately upstream from the monitoring site. If there is no suitable access, the sampling team will determine the possibility of sampling further away from the original monitoring site, without compromising the objectives of the monitoring program.

2.3.4.3 Dangerous Site Conditions

If the monitoring locations are inaccessible due to dangerous flow conditions or other circumstances that would be a safety concern, the sampling team will delay sampling for 24

to 48 hours until after the conditions are suitable for sampling. If the site is still deemed dangerous, the sampling team will discuss with SAWPA and the Project Manager.

2.3.5 Sample Handling and Custody

Water samples are collected in containers specific to the required analysis, labeled with a unique log number, sampling location ID, sample date and time, required analyses, and the sample preservative. Immediately following collection, processing, and addition of required preservative, samples are kept in an ice chest or refrigerator at 4°C until they are delivered to an analytical laboratory. Each sample has a maximum allowable holding time which will be followed by sampling staff. *E. coli* samples must be kept on ice and transferred to a qualified laboratory within six hours of sample collection, while HF183 samples have a 24-hour holding time.

Samples that are transferred from one agency to another for laboratory analysis requires the use of CoC procedures that include requirements for the laboratory to accept custody of the samples. CoC documentation is used to reduce the likelihood of sample contamination or mishandling. The CoCs will be completed in the field with dates, times, sample team names, and be cross-checked with sample bottles to make sure proper samples have been collected. Documentation of sample handling and custody will include the following:

- Sample identification
- Type of sample
- Sample collection date and time
- Special notations on sample characteristics or analysis
- Analyses to be performed
- Initials and/or signature of the sampling team member that collected the sample
- Date the sample was submitted to the laboratory

Upon delivery of samples to the contract laboratory, the laboratory staff will assess sample condition, reconcile label information with the CoC form, accept custody thereof, and countersign the CoC. The laboratory then becomes responsible for sample custody, storage at appropriate temperature until analysis, and completion of analyses within method hold time limitation. Sampling staff will maintain a duplicate CoC which will then be filed for QA/QC purposes.

2.3.6 Sample Bottle Labeling

Field samples, field blanks, and field duplicate samples will be labeled, recorded on the CoC form, and transported with the samples to the analytical laboratory. Water quality sample

bottles will be pre-labeled, to the greatest extent possible, before each monitoring event. Pre-labeling bottles simplifies field activities and the following information will be considered for each sample bottle:

- Project name
- Sample location or identification number
- Event number
- Date and time
- Sample matrix
- Sample type
- Collected by
- Preservative
- Analysis

2.3.7 Quality Assurance and Quality Control

QA/QC procedures are highly important to validate the quality of a sample taken. This section addresses QA/QC requirements for both field sampling and laboratory analyses. Field QA/QC samples are used to evaluate potential contamination and sampling errors introduced prior to submittal of the samples to the analytical laboratory, while laboratory QA/QC samples are used to evaluate potential laboratory contamination, analytical precision, and analytical accuracy.

2.3.7.1 Field Blanks

The purpose of analyzing field blanks is to demonstrate that sampling procedures do not result in contamination of the water quality samples. Per the Quality Assurance Management Plan for the SWAMP (State Water Board 2002), field blanks are to be collected as follows:

- At a frequency of one per sampling event for: trace metals in water (including mercury) and bacteria samples.
- Field blanks for other media and analytes will be conducted upon initiation of sampling, and if field blank performance is acceptable, further collection and analysis of field blanks for other media and analytes need only be performed on an as-needed basis, or during annual performance audits.

Field blanks will consist of laboratory-prepared blank water (certified to be contaminant-free by the laboratory), or distilled water, processed through the sampling equipment using the same procedures used for grab samples. If targeted analytes are detected at levels greater than

the Method Detection Limit (MDL), the source(s) of contamination will need to be identified and eliminated. Sampling staff will be notified so that the source of contamination can be identified, and corrective measures can be taken prior to the next sampling event.

2.3.7.2 Field Duplicates

The purpose of analyzing field duplicates is to demonstrate the precision of sampling and analytical processes. Field duplicates will consist of two samples collected simultaneously, to the extent practicable. One set of field duplicates will be collected for each sample event. Duplicate collection will be conducted on a rotational basis. The proposed monitoring program will rotate through each of the six sites. After all six sites have been replicated, the rotation will begin again with the first monitoring site.

2.3.7.3 Laboratory Quality Assurance/Quality Control

Internal laboratory quality control checks will include the use of laboratory replicate/split, method blanks, matrix spike and matrix spike duplicates (MS/MSDs), laboratory control samples, and standard reference materials (SRMs). These quality control samples are as follows:

1. *Laboratory Replicate/Split* – A sample is split by the laboratory into two portions and each sample is analyzed. Once the duplicate analyses have been analyzed, the results are evaluated by calculating the Relative Percent Difference (RPD) between the two sets of results. This serves as a measure of the reproducibility, or precision, of the sample analysis. Typically, duplicate results should fall within an accepted RPD range, depending upon the analysis.
2. *Method Blanks* – A method blank is an analysis of a known clean sample matrix that has been subjected to the same complete analytical procedure as the field sample to determine if potential contamination has been introduced during processing. Blank analysis results are evaluated by checking against reporting limits for that analyte. Results obtained should be less than the reporting limits for each analysis.
3. *Matrix Spike and Matrix Spike Duplicates* – MS/MSDs involve adding a known amount of the chemical(s) of interest to one of the actual samples being analyzed. One sample is split into three separate portions. One portion is analyzed to determine the concentration of the analyte in question in an un-spiked state. The other two portions are spiked with a known concentration of the analytes of interest. The recovery of the spike, after accounting for the concentration of the analyte in the original sample, is a measure of the accuracy of the analysis. By determining spike duplicate recoveries, another measure of precision is accomplished. An additional precision measure is made by calculating the RPD of the duplicate spike recoveries. Both the RPD values and spike recoveries are compared against accepted and known method dependent acceptance limits. Analyses outside these limits are subject to corrective action.

4. *Laboratory Control Sample* – The laboratory control sample procedure involves spiking known amounts of the analyte of interest into a known, clean, sample matrix to assess the possible matrix effects on spike recoveries. High or low recoveries of the analytes in the matrix spikes may be caused by interferences in the sample. Laboratory control samples assess these possible matrix effects since the laboratory control sample is known to be free from interferences.
5. *Standard Reference Material* – SRMs may be used in lieu of laboratory control samples. An SRM is a sample containing a known and certified amount of the analyte of interest and is typically analyzed with the analyst not knowing the analyte concentration. SRMs are typically purchased from independent suppliers who prepare them and certify the analyte concentrations. Results are evaluated by comparing results obtained against the known quantity and the acceptable range of results supplied by the manufacturer.

2.3.7.4 Equipment and Calibration Frequency

All field and laboratory equipment will be calibrated based on manufacturer recommendations and accepted laboratory protocol. Managers will also maintain calibration practices and records as part of their method SOPs which can be provided upon request.

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2.4 Data Management and Reporting

This section establishes the requirements for the management and reporting of data collected from this Preliminary Monitoring Program.

2.4.1 Database Management

Data collected from the monitoring program will be provided to SAWPA. Data management will be initiated with the use of field and laboratory data sheets. Each of the two categories of data management is summarized below.

2.4.1.1 Laboratory Data Management

The Project Manager is responsible for data management. Overall management of the data will be consistent with established procedures for the monitoring project. The Field Coordinator will be responsible for tracking the analytical process to assure the laboratory is meeting the required turnaround times and providing a complete deliverable package. The laboratory will conduct the quality control checks prior to data submittal. The Field Coordinator will receive the original hard copy from the laboratory, verify completeness, and log the date of receipt. Analysis results will be electronically sent to the Field Coordinator following the completion of quality control checks by the laboratory. Data will be screened for the following major items:

- A 100% check between electronic data provided by the laboratory and the hard copy reports;
- Conformity check between the CoC forms and laboratory reports;
- A check for laboratory data report completeness, errors, or suspect analytical data; and
- A check for typographical errors on the laboratory reports.

The original reports are transferred to the Project Manager and filed with other original project documentation to maintain complete project records. Following the initial screening, a more complete QA/QC review process will be performed, which will include an evaluation of holding times, method and equipment blank contamination, and analytical accuracy and precision. The laboratory may be requested to provide data in both hard copy and electronic formats. The form of electronic submittals will conform to reporting protocols that are compatible with the SWAMP. A relational database will not be developed or used for this project data. The laboratory data will be maintained and managed with Microsoft Excel and/or Microsoft Access by the Project Manager.

The Project Manager will control the access to the project's database. The laboratory electronic data deliverables will be maintained in a file separate to the cumulative database so

the original is maintained and can be used as a reference. If data is reissued, the file name will include the date and the word 'revised.' To manage the revision and prevent duplicate entries, the erroneous data set will be removed from the database prior to uploading the revised data set.

The Laboratory Manager will maintain their respective analytical laboratory records. The Project Manager will oversee the actions of these persons and arbitrate any issues relative to records retention and any decisions to discard records. All original laboratory notebooks and data summaries will be maintained in secure areas and electronic databases will be maintained and backed up.

2.4.1.2 Field Data Management

Field logs or records submitted to SAWPA will follow the guidelines and formats established by SWAMP. A Responsible Party, such as the Field Coordinator, will review Field Logs for completeness and maintain the original hard copies in the project file. Responses from the Field Logs will be manually entered into an electronic version and then be saved in an electronic database. The data will be manually entered, and the entries will be checked against the hard copies for accuracy by a different individual. Photographs of the monitoring sites taken by field personnel will be uploaded into the project file within three days of taking the photograph. Field crew members will name the photographs using the photograph naming convention developed for the project.

2.4.2 Data Analysis

Following the completion of each monitoring event, data assessment and validation will be performed as appropriate for the data use. Field and analytical data will be evaluated for the following, but not limited to:

- Review information collected for consistency, reasonableness, and accuracy to the extent practicable, prior to the use of data.
- Identify potential errors or inconsistencies in data obtained from available resources that may require further evaluation, prior to the use of data.
- Review applicable field and laboratory documentation to ensure that the applicable SOPs were followed.
- Review field and laboratory QA/QC reports to understand the quality and usability of data including:
  - Results of QA/QC samples that were collected and analyzed
  - Overall Measurement Quality Objectives (MQO) performance for analytical laboratory data by evaluating representativeness, comparability, and sensitivity

  - Data qualifier flags assigned to analytical laboratory data to assess sample collection, handling, or laboratory QA/QC issues

- Calculation of basic quantitative characteristics of the data using common statistical parameters, including range, mean, medium, and frequency of detection.
- Graphing the data using appropriate methods to identify patterns or trends in the data. These patterns or trends may be used to describe the data, identify potential correlations or problems with the data set, and to convey information to others.
- Outliers or irregularities will be assessed and the value of their inclusion in the analysis determined.

To fully understand the relative impacts of homelessness on water quality and habitat degradation in the watershed, data collected as part of this monitoring program will be compared, to the extent appropriate, to other established monitoring programs in the region. Data from this program will be compared to, but not limited to, data collected from the following agencies and/or programs in the Upper Santa Ana Watershed:

- MSAR Task Force
- Santa Ana Sucker Conservation Team
- Regional Water Quality Monitoring Task Force
- Riverside County Flood Control & Water Conservation District
- Inland Empire Waterkeeper
- Santa Ana Regional Water Quality Control Board

2.4.3 Project Reporting

Analysis and reporting of data is an integral part of verifying primary monitoring objectives. Water quality data will be submitted to SAWPA. Contracted laboratories will prepare a QA/QC report to summarize errors in analytical SOPs. Results from the monitoring program will be summarized in an Annual Report that will summarize results from the current sample year, previous data collected under the monitoring program and other relevant watershed data, as available. The Annual Report will compare the results from the monitoring program to the data generated from other established monitoring programs, as discussed in Section 2.4.2. The Annual Report will assist SAWPA and its member agencies determine the magnitude of impacts from homelessness and determine appropriate needed actions.

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2.5 Project Costs and Implementation Alternatives

This section goes into detail regarding the cost of implementing the proposed monitoring program. The monitoring program has several parts that could be implemented in phases. Within those phases, a couple of alternatives are proposed to assist SAWPA in establishing a preliminary assessment of the relationship between homelessness and water quality.

2.5.1 Total Project Cost Estimate

Table 2-6 provides an estimate of the total cost to implement the entire proposed monitoring program over a three-year period. The budget of the program would vary should SAWPA choose to extend the program from three to five years to alleviate the challenge of capturing six to seven wet-weather events per year.

Table 2-6. Estimated Cost to Implement Entire Proposed Monitoring Program Over Three-Year Period

Task	Estimated Fee
Kickoff meeting and project management	$10,000
QAPP preparation	$8,500
Preliminary field visits	
Baseline condition assessment	$8,000
Population estimate and coordination	$25,000
Dry-weather event sampling	$100,000
Physical Habitat and bioassessment (PHab)	$270,000
Wet-weather event sampling	$350,000
Data management and annual reporting	$75,000
Total	**$846,500**

2.5.2 Implementation Alternatives

Given the high cost estimated to implement the entire proposed monitoring program, an alternative but viable option would be to implement the program in two phases.

2.5.2.1 Phase 1

In Phase 1, the monitoring team would conduct an initial sampling program during the first year to provide a preliminary evaluation of impacts from homeless encampments to the river. This evaluation would be conducted only during dry-weather conditions to evaluate potential impacts to water quality during the time when recreation is most likely to occur in the Santa

Ana River and when potential impacts to habitat can best be evaluated. There are two alternatives proposed for implementation:

Alternative A: Dry-Weather Event Monitoring Only

The Upper Santa Ana River Watershed is subject to high flow suspension of recreation standards (Santa Ana Water Board 2019), and therefore, REC-1 and REC-2 are temporarily suspended when high flows preclude safe recreation during wet-weather conditions. Consequently, dry-weather water quality data is of the greatest importance when evaluating potential impacts of homeless encampments on protection of recreational beneficial uses.

Under Alternative A, the emphasis of initial sampling would be on collection of data from four dry-weather events, in alignment with the proposed monitoring program's first year. The findings from this sampling effort would allow SAWPA and watershed stakeholders to make a preliminary assessment of the relationship between homelessness and water quality. Alternative A would include only dry-weather water quality monitoring and rapid trash assessment activities. The monitoring team would follow the schedule as described in Section 2.2.4. This proposed alternative would still require the preparation of a QAPP, a baseline condition assessment, and a population estimate. The monitoring team would compile and analyze the results from the dry-weather monitoring tasks and prepare a report for SAWPA to determine if any trends were found. **Table 2-7** provides an estimate of the cost to implement only Alternative A.

Table 2-7. Estimated Cost to Implement Phase 1, Alternative A

Task	Estimated Fee
Kickoff meeting and project management	$3,800
QAPP preparation	$8,500
Preliminary field visits	
Baseline condition assessment	$8,000
Population estimate and coordination	$8,500
Dry-weather event sampling	$40,000
Data management and one annual report	$20,000
Total	**$88,800**

Alternative B: Dry-Weather Event Monitoring and PHab Data Collection

The proposed monitoring program includes areas designated as critical habitat for endangered species, such as the Santa Ana Sucker. Homeless encampments have the potential to impact the integrity of surrounding riparian and aquatic habitats; therefore, another implementation alternative would be to include the PHab analysis with the dry-weather monitoring activities proposed in Alternative A. However, because the PHab would

only be conducted once at each monitoring site during the monitoring program's first year, the monitoring team would not be able to evaluate potential trends from homeless encampments on habitat. In other words, the outcome of this effort would be a description of existing conditions during the sample year. PHab data collection requires a significant amount of labor and specialized staff with specific skill sets and certifications, which increases the cost of this alternative. **Table 2-8** provides an estimate of the cost to implement Alternative B, which includes all the work completed under Alternative A plus one PHab assessment at all monitoring sites.

Table 2-8. Estimated Cost to Implement Phase 1, Alternative B

Task	Estimated Fee
Kickoff meeting and project management	$4,700
QAPP preparation	$8,500
Preliminary field visits	
Baseline condition assessment	$8,000
Population estimate and coordination	$8,500
Dry-weather event sampling	$40,000
Physical Habitat and bioassessment (PHab)	$90,000
Data management and one annual report	$22,000
Total	**$181,700**

2.5.2.2 Phase 2

Based on the findings from the Phase 1 preliminary evaluation, the monitoring team could expand the program to include additional sampling to supplement what was sampled during Phase 1. Expansion of the program could include all the remaining elements not included in Phase 1 (see total program cost under Section 2.5.1) or continue to enhance the program as needed. For example, supplementing the Phase 1 program could include a range of options, such as:

- Conduct additional dry-weather monitoring to augment the data already collected during the first year;
- Conduct additional PHab sampling to augment year one data, if collected in Phase 1;
- Incorporate wet-weather event sampling into the monitoring program; or
- Some combination of the above.

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Attachments

Attachment A

Task 1 Interview Questions

Task 1 Interview Questions

1. How does your organization gather information on the presence/absence of homeless encampments in waterbodies within your jurisdiction or area of interest?
2. What data collection have you done to identify locations of camps, e.g., mapping, census, longevity, transient vs. permanent, trends, photographs, etc.
3. How recent is the data collection?
4. Do you have information of the locations of homeless encampments along waterbodies in the project study area (including maps)?
5. What would be your assessment or best professional judgment be regarding the following: (a) longevity/permanence of encampments; (b) typical numbers of people; (c) overall trend - up, down, same? Is it the same people just moving around or does it change?
6. Of known camps with some longevity/permanence, do you have any information regarding how camp is handling disposal of human waste?
7. Can we obtain the data for use in this study (all information will be cited per instructions of the source)?
8. What role, if any, does your agency/organization have in mitigating homeless camps within waterbodies? What do you do with the information?
9. Finally, is there anything else that you can share that may be relevant but was not addressed by one of my questions?

Attachment B

SWAMP Standard Operating Procedures

SWAMP Surface Water Ambient Monitoring Program

SWAMP Bioassessment Procedures 2016

Standard Operating Procedures (SOP) for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat

March 2016 v2 (unformatted)

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California Water Boards

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ABBREVIATIONS AND ACRONYMS

AFDM	Ash-Free Dry Mass
BMI	Benthic Macroinvertebrate
chl *a*	Chlorophyll *a*
CPOM	Coarse Particulate Organic Matter
CSBP	California Stream Bioassessment Procedure
DI	Deionized water
DO	Dissolved Oxygen
DFW	(California) Department of Fish and Wildlife
EMAP	Environmental Monitoring and Assessment Program (of the U.S. EPA)
EPA	Environmental Protection Agency (of the United States)
GPS	Global Positioning System
IBI	Index of Biotic Integrity
LRBS	Log Relative Bed Stability
MCM	Margin-Center-Margin
NAD	North American Datum
NBO	Neutrally Buoyant Object
NNE	Nutrient Numeric Endpoints
NRSA	National Rivers and Streams Assessment (of the U.S. EPA)
PHab	Physical Habitat
QA	Quality Assurance
QAPrP	Quality Assurance Program Plan (of SWAMP)
RBP	Rapid Bioassessment Procedures
RWB	Reachwide Benthos
SOP	Standard Operating Procedures
SCCWRP	Southern California Coastal Water Research Project
SWAMP	Surface Water Ambient Monitoring Program (of the California State Water Resources Control Board)
TRC	Targeted Riffle Composite
VAM	Velocity-Area Method (for determining stream discharge)

1. INTRODUCTION

This document describes the Standard Operating Procedures (SOP) for bioassessment of wadeable streams for the California State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAM). These procedures are recognized by the US Environmental Protection Agency (EPA) as California's standard bioassessment procedures and are designed to support general assessment of the ecological condition of wadeable streams and rivers based on the composition of the benthic macroinvertebrate and benthic algal assemblages. The procedures also produce standardized measurements of instream and riparian habitat and ambient water chemistry to support interpretation of the biological data.

Instructions are provided for collection of the following:

- samples for taxonomic analysis of benthic macroinvertebrate (BMI) assemblages
- samples for taxonomic analysis of benthic algal assemblages (diatoms & non-diatom (soft) algae (including cyanobacteria))
- samples for determination of biomass based on benthic chlorophyll *a* and benthic ash-free dry mass (AFDM)
- stream physical habitat (PHab) data
- water chemistry samples

1.1 Previous SOPs

This document represents a consolidation of two closely related previous SOPs, and supersedes them:

- **Ode (2007)**, which focused on stream BMI sampling and associated PHab data collection and replaced previous bioassessment protocols referred to as the California Stream Bioassessment Procedure (CSBP, Harrington 1995, 1999, 2002), and
- **Fetscher et al. (2009)**, which focused on stream benthic algae and biomass sampling, and associated PHab data collection.

Most of the methods described here are close adaptations of those developed by the EPA's Environmental Monitoring and Assessment Program (EMAP) and currently used by the EPA's National Rivers and Streams Assessment (NRSA) surveys. Table 1 provides a summary of the major changes to field procedures since the previous SOPs.

Summary of Changes

Table 1 Summary of Changes

Section	Category	Current Protocol	Previous Versions (Ode 2007 & Fetscher et al. 2009)
General	General	For SWAMP, the "Full" set of PHab modules must be carried out, even if just collecting algae (and not BMIs) as the biotic assemblage.	Previously, modules such as Riparian Vegetation and Instream Habitat Complexity were not required if only algae were

			being collected for bioassessment.
1.4	Diagnosing Recent Scour	Guidance is now provided for diagnosing recent scour, which may be of concern under the rare circumstance in which sampling must occur shortly following a large storm or discharge release (e.g., from a dam); field sheets now include a place to mark for scour so that applicable analytes are flagged in the database.	No previous guidance provided for diagnosing scour; no data flags for influence of recent scour.
1.8	QA	For SWAMP, duplicate sampling of BMIs and benthic algae is required at 10% of study sites.	No previous requirement for duplicate sampling.
2	Notable Field Conditions	Field forms and database now allow users to mark whether or not the sampling reach lies within an engineered channel.	No place for recording this information was previously available.
3	Water Chemistry	For SWAMP, TN and TP are now required if collecting algae for bioassessment.	No previous requirement for TN/TP.
4.5	Algae sample collection - sediment	Delimiter (coring device) to collect sediment is now properly termed "ABS delimiter".	Was previously (erroneously) called "PVC delimiter".
5.2	Soft Bodied Algae Processing	If there appears to be more than one type of macroalgae (i.e., obviously different species based on color/texture) in the sample, separate cylinders should be made for each one.	Previous version had all soft algae rolled together into a single cylinder.
5.2	Processing Quantitative Benthic Algal Taxonomy and Biomass Samples	The final concentration of glutaraldehyde required for the fixed (quantitative) soft-algae sample is now 2% (qualitative samples are still to be left *unfixed*). **This change will be realized by using a more dilute (20%) stock solution of glutaraldehyde, rather than changing the volume of stock fixative added to the soft-algae sample.**	The final concentration of glutaraldehyde required in the fixed (quantitative) soft-algae sample was previously 2.5%. The previous concentration of stock solution for glutaraldehyde was 25%.
5.2	Processing Quantitative Benthic Algal Taxonomy and Biomass Samples	The final concentration of formalin required in the diatom sample is now 1%; also, the formalin used no longer needs to be buffered, *but* if it is, then phosphate buffer, **NOT BORAX** should be used; COCs should indicate whether phosphate buffer has been added to the formalin or not. **This change will be realized by using a more dilute (5%) stock solution of formalin, rather than changing the volume of stock fixative added to the diatom sample.**	The final concentration of formalin required in the diatom sample was previously 2% and the formalin was buffered with borax. The previous concentration of stock solution for formalin was 10%.
6.2	Pebble Count	In the Pebble Count, users must now circle "D" (dry) for CPOM and Macrophytes when they correspond to a point that is not submerged/moist.	Those fields were previously left blank when the point was dry.
6.2	Pebble Count	In the Pebble Count, SWAMP now requires that users measure pebbles rather than simply putting them into bins.	Previously, users reporting to SWAMP had the option to bin or measure the

		However, binning is still allowed when, for some reason, particles cannot be measured.	pebbles.
6.2	Pebble Count	For SWAMP, presence/absence of macroalgae is recorded during the pebble count, even if only BMIs (and not algae) are being sampled.	No previous requirement for recording macroalgae presence/absence if only collecting BMIs for bioassessment.
6.4	Pebble Count; Coarse particulate organic matter	Size for coarse particulate organic matter has been changed to those which are >1 mm in size, but no larger than 10.	Previous version had no maximum size.
6.4 , 6.8	Pebble Count; Instream Habitat Complexity	Mosses are explicitly not included in macrophytes (regardless of the module).	In the previous BMI SOP (Ode 2007) mosses were included in the macrophytes.
6.5	Bank Stability	Bank stability is now assessed along the imaginary line running from where the transect ends meet the wetted margin, to the bankfull boundary.	Previously, bank stability was estimated in the area between the upstream and downstream inter-transects.
6.8	Instream Habitat Complexity	For instream habitat complexity, estimates should include only those features within the stream's wetted margin.	Previous guidance was that estimates should include features within the banks and outside the wetted margins of the stream.
6.9	Stream shading	For SWAMP, 6 densiometer readings (four in the center of the stream and one at each bank) are now required in streams > 10 m wide.	Previously, users reporting to SWAMP could collect only the four center-stream densiometer readings, with the bank readings optional.

1.2 Sampling Overview

This SOP describes methodology for biotic sampling procedures as well as for assessing instream and riparian habitats and ambient water chemistry associated with biotic assemblage samples (Table 2). The sampling layout described in this SOP provides a framework for systematically collecting a variety of biotic, physical, and chemical data. The biotic sampling methods are designed to nest within the overall framework for assessing the biotic, physical, and chemical condition of a reach. The physical habitat characterization methods can be implemented for a stand-alone evaluation or in conjunction with a bioassessment sampling event. This information can be used to characterize stream reaches, associate physical and chemical condition with biotic condition, and explain patterns in the biotic data. Measurements of instream and riparian habitat and ambient water chemistry are essential to interpretation of bioassessment data, and must always accompany bioassessment samples for SWAMP projects.

Because bioassessment data requirements vary widely across different applications, this document describes the component measures of instream and riparian habitat as independent "modules", which may be implemented as needed for each application. For instance, if the goal is to evaluate stream primary production, one may wish to collect only biomass samples and algal cover point-intercept data, and exclude modules focusing on instream habitat complexity. Alternatively, one may need to collect BMI and/or algal taxonomic samples in order to make more refined inferences about stream condition (e.g., by applying a multimetric index based on community composition). Recommendations for modules to include in a reduced-effort ("Basic") version of this SOP, e.g., for citizen monitoring groups on a limited budget, are provided in the Guidance Document.

In order to ensure high-quality bioassessment data, certain tasks must be carried out prior to others. A work-flow diagram depicting the order in which tasks should be undertaken is provided in Figure 1 (see Guidance Document for suggestions to maximize efficiency).

Assuming an adequate crew size, the total time required to carry out the full suite of field procedures described in this SOP is approximately 2 to 4 hours in a typical stream, or up to 6 hours in a complex stream. These estimates include only the time spent at the site, not travel time (which varies widely). Table 2 provides a rough breakdown of time requirements per module.

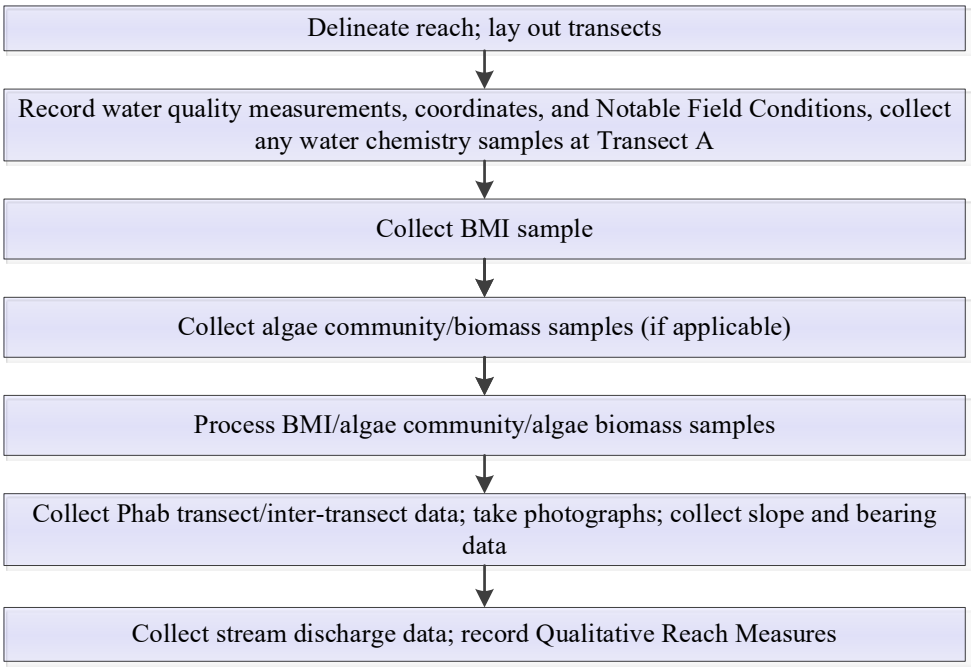

Figure 1. Recommended work flow (order of tasks) for conducting stream bioassessment.

1.3 Scope and Applicability

This SOP is intended for use in ambient monitoring of California wadeable streams that are flowing at the time of assessment, meaning that it may be used in both perennial and nonperennial streams as long as sampleability criteria are met[1]. A reach is considered "sampleable" with this protocol if at least half of the reach has a wetted width of at least 0.3 m (the width of a D-frame net) and there are no more than three transects that are completely dry within the monitoring reach at the time of assessment. If more than three transects are completely dry, then the stream reach should not be sampled for biota; however, if the monitoring program allows it, the reach may be shifted in order to reduce the number of dry transects, thus allowing biota to be sampled (for more details, see Section 2 on reach delineation and transect placement). The wadeability limitation is determined by the practical ability to safely obtain a consistent sample of the benthic community from a reach. In general, a reach is considered wadeable if it is less than one meter deep for at least half the length of the reach.

It is recommended that biotic sampling be carried out during the period from May through September, depending upon the region (i.e., toward the earlier end of this range in southern California, and later in the range for higher latitudes). See Figure 2. Samples intended for ambient bioassessments are generally collected when streams are at or near base flow (i.e., not influenced by storm runoff), as sudden flow increases can displace benthic organisms from the

[1] The sampleability criteria defined here are intended to ensure comparability of data collected for ambient monitoring or regulatory compliance monitoring. Less restrictive criteria may be acceptable for other uses.

stream bottom and dramatically alter local community composition. To be conservative, it is strongly recommended that sampling be carried out at least two, and preferably three, weeks after any storm event that has generated enough stream power to mobilize cobbles and sand/silt capable of scouring stream substrates. See Section 1.4, below, for tips on how to evaluate a site for recent scour. Two to three weeks will usually allow time for benthic fauna and algae to recolonize scoured surfaces (Round 1991; Kelly *et al*. 1998; Stevenson and Bahls in Barbour *et al*. 1999). Ultimately, the time of delay from a scouring event to the acceptable window for sampling will depend on environmental setting and time of year. The project manager should consult with the SWAMP bioassessment coordinator in questionable cases.

1.4 Diagnosing Recent Scour

As mentioned above, ideally, a stream reach should ***not*** be sampled for bioassessment shortly following a scour event that has mobilized bed materials and potentially disrupted benthic communities. However, for certain applications (e.g., wet-weather monitoring), sampling may need to occur under such circumstances. When this happens, a note must be made in the field sheets and the database that flags applicable analytes as having potentially been subjected to recent scour conditions. If a suspected recent scour has occurred, mark "Yes" in the **Notable Field Conditions** section of the bioassessment field form that says, "Site is affected by recent scouring event". High-flow/scour indicators that can be assessed to make the determination include:

- Lack of slime/color coating on the streambed (this may be inferred by a high frequency [i.e., near 100%] of microalgal cover scores of "0"; see Section 6.4)
- Lack of macroalgal mats, OR if present, mats displaced, as indicated by being "unnaturally" bunched up against fixed objects within the stream (like tree roots, large boulders) away from centroid of flow
- Non-rigid instream vegetation (e.g., emergent macrophytes like cattails and tules) bent over or lying down within the stream
- Absence of leaves and other detritus in pools, despite riparian cover

Following the sampling visit, under "Field Notes/Comments" on the field sheet, field crews or the project manager can add the size of, and actual time since, storms or discharge releases.

Figure 2. Index Period by Ecoregion

Table 2. Sample and data collection modules for BMI and algal bioassessment. The estimated time each task takes on average is provided after each Module name in parentheses. Very experienced crews may be faster in some settings.

Survey Task	Module	Time	Notes
REACH DELINEATION and WATER QUALITY	Layout of reach, marking transects, recording GPS coordinates	15 min	Use 150m reach length if wetted width ≤10 m or 250m if wetted width > 10 m
Conducted before entering stream to sample biota or collect PHab data	Temperature, pH, specific conductance, salinity, DO, alkalinity	10 min	Alkalinity, conductance, pH, and salinity may be measured in in the laboratory from collected samples if SWAMP holding times are met whereas DO and temperature must be measured in the field
	Turbidity	5 min	Use test kit/meter or collect samples for laboratory analysis
	Notable field conditions	5 min	
	Water chemistry for laboratory analysis (total phosphorus and total nitrogen)	15 min	Required by SWAMP when algae are sampled
BIOTIC ASSEMBLAGE/ ALGAL BIOMASS AND PHAB SAMPLING AT CROSS-SECTIONAL TRANSECTS	BMI Sampling for Taxonomic IDs	45 min	
	Algal Sampling for Taxonomic IDs and biomass assessment	45 min	
Measurements (BMIs, algae, PHab) at 11 main transects (A – K), or 21 transects (11 main plus 10 inter-transects for wetted width, substrate size, algal cover, and flow habitat)	Depth and Pebble Count + CPOM	35 min	5-point substrate size, depth, and CPOM records at all 21 transects and intertransects

BIOTIC ASSEMBLAGE/ ALGAL BIOMASS AND PHAB SAMPLING AT CROSS-SECTIONAL TRANSECTS (Continued)	Cobble Embeddedness (incl. in "Pebble Count" time)		Include all cobble-sized particles in pebble count. Supplement with "random walk" if needed for 25, total
	Percent Algal Cover (part of pebble count)		Attached/unattached macroalgae presence/absence; microalgal thickness codes
	Bankfull Dimensions (10-20 min)	60-70 min	
	Wetted Width (5 min)		
	Bank Stability (5 min)		
	Human Influence (5 min)		
	Riparian Vegetation (5 min)		
	Instream Habitat Complexity (5 min)		
	Stream Shading (10 min)		6 densiometer readings required at streams where mean wetted width is > 10m; the 4 center points are sufficient in narrower streams
	Flow Habitat Delineation (15 min)		Record proportion of habitat classes in each inter-transect zone
	Slope (%) (25 min for autolevel method; 15 min for clinometer method)	15-25 min	Average slope calculated from 10 transect-to- transect slope measurements. Use autolevel for slopes ≤ 1% (clinometer acceptable for steeper gradients); time requirements increase considerably in complex streams
	Sinuosity	10 min	Record compass readings between transect-to-transect centers
	Excess Sediment Transect Measures		Optional measure: Bankfull width and height, bank angles; Large woody debris counts (tallies of woody debris in several size classes); thalweg profile (100 equidistant points along thalweg); refer to NRSA SOP for details.

DISCHARGE TRANSECT	Discharge measurements (15 min for velocity-area method; 10 min for neutrally-buoyant-object method)	10-15min	Velocity-Area Method (VAM; preferred) or Neutrally Buoyant Object Method, somewhere within, or very near to, the monitoring reach; VAM may not be feasible in all streams
REACH-SCALE MEASUREMENTS	Qualitative Reach Measures (subset of Rapid Bioassessment Procedure, RBP, visuals)	5 min	Channel alteration, sediment deposition, epifaunal substrate
	Photo documentation	5 min	Upstream (Transects A, F), Downstream (Transects F, K) at minimum, but ideally add an overview picture

1.5 Training

Procedures described here are designed to produce repeatable, quantitative measures of a stream's BMI and algal assemblages and physical/habitat condition. *It is important to note that in order to generate usable data, formal field training of sampling crews is required, and Quality Assurance (QA) measures must be implemented throughout the field season.* Training courses are made available by the Water Boards Training Academy. Courses are posted regularly at: http://www.waterboards.ca.gov/water_issues/programs/academy/home.htm.

In addition, regular (e.g., yearly) field audits of sampling crews, conducted by an experienced individual, are highly recommended, with additional training and follow-up auditing carried out as necessary depending upon audit outcomes. Annual intercalibration events involving multiple crews with experience in different regions of California are strongly recommended. Contact the Department of Fish and Wildlife's Aquatic Bioassessment Laboratory to participate in intercalibration events.

1.6 Permitting

Collection of benthic samples in California waterbodies without a valid California Department of Fish and Wildlife (DFW) Scientific Collection Permit is illegal. Prior to the onset of fieldwork, a Scientific Collecting Permit (for sampling of stream biota) MUST be acquired from DFW for at least one member of the field crew. Additional information on requirements and how to obtain permits can be found in the Guidance Document. Likewise, for streams supporting species listed as sensitive under the State or Federal Endangered Species Act (including, but not limited to, California red-legged frog, least Bell's vireo, southwestern willow flycatcher, arroyo toad, and salmonids), sampling cannot be conducted at certain times of the year, or a permitted escort may be required to supervise sampling activities to ensure that resident sensitive species are not impacted. More information can be found at http://www.fws.gov/ENDANGERED/permits/index.html and https://www.dfg.ca.gov/wildlife/nongame/research_permit/.

1.7 Avoiding the Transfer of Invasive Species and Pathogens Amongst Sites

Proper field hygiene must be practiced at all times in order to avoid transferring invasive organisms or pathogens between sites. Examples include, but are not limited to, New Zealand mud snail and chytrid fungus. Before approaching any stream, precautions must be taken to ensure that all equipment that will come into contact with the stream or its immediate surroundings has been properly decontaminated. Such equipment includes, but is not limited to, footwear, D-frame net, algae sampling devices, water chemistry sample fill bottle, transect tape, flags, stadia rod, flow meter, water chemistry probes, and autolevel tripod. Furthermore, under no circumstances shall stream water (e.g., from water bottles used for algae sample processing) or other material collected at one site be introduced into another stream. Detailed information on acceptable decontamination procedures is provided in the Guidance Document.

1.8 SWAMP Requirements

The "reachwide benthos" (RWB) sampling procedure, as described in this SOP, is the required sampling method for ambient bioassessment under the SWAMP program. However, other sampling methods (e.g., Targeted Riffle Composite (TRC)) may be desirable if data comparability within long-term monitoring projects that have historically used other methods is sought. In general, SWAMP-funded projects must adhere to the directives of the SWAMP Quality Assurance team as detailed in: *Amendment to SWAMP Interim Guidance on Quality Assurance for SWAMP Bioassessments 9-17-08*. This memo can be found in the Guidance Document. The project manager must have the approval of the SWAMP Bioassessment Program Lead Scientist and the SWAMP Quality Assurance Officer **before** the use of alternative methods that deviate from this SOP and the above-referenced memo will be accepted. For other projects and/or programs desiring SWAMP comparability, deviations should be approved by the project manager and project QA officer.

SWAMP requires that duplicate sampling of BMIs and benthic algae occur at 10% of study sites (preferably at the same set of sites, when both assemblages are being sampled together). The recommended location for collecting duplicates is at adjacent positions along the sampling transects (described in Section 4). In addition, regular (e.g., yearly) field audits of sampling crews should be conducted by an authorized individual (e.g., qualified personnel of DFW). Note also that SWAMP requires 5% field duplicates for water chemistry measurements. In general, the SWAMP Quality Assurance Program Plan (QAPrP) in place at the time of monitoring or subsequent revisions to that QAPrP and the SMC Bioassessment QAPP (2009) should be followed for quality assurance procedures, when applicable. For more information, refer to: http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa

SWAMP participants collecting water-quality and water-chemistry measurements may reference the California Department of Fish and Wildlife - Marine Pollution Studies Laboratory SOP: *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California. Version 1.1, updated March-2014*. This procedure may be used to collect samples for a number of analyses covered by the SWAMP

Quality Assurance program. Use of this procedure is a recommendation and not a requirement for SWAMP projects. Prior to sample collection, participants using this procedure shall check its requirements against the latest SWAMP *Quality Control and Sample Handling Guidelines*.

SWAMP is planning to develop additional guidance for bioassessment quality assurance and control procedures. This may include more specific information covering personnel qualifications, training and field audit procedures, procedures for field calibration, procedures for chain of custody documentation, requirements for measurement precision, health and safety warnings, cautions (to avoid actions that would result in instrument damage or compromised samples), and interferences (regarding consequences of not following the SOP).

1.9 Supplemental Guidance

A companion document, SWAMP Bioassessment Supplemental Guidance (herein referred to as the "Guidance Document"), is referenced throughout this SOP. It provides more detailed information on the various applications of the modules described here, as well as recommendations for where, when, and/or how to implement the procedures. It also provides suggestions for how to deal with special circumstances that may be encountered during stream bioassessment sampling and more detailed information to aid in interpretation of PHab field indicators. The Guidance Document is a "living" supplement to the field sampling protocol, in the sense that it is regularly updated (unlike this SOP, which is static between versions) and serves as a repository for implementation advice. The Guidance Document is posted on the SWAMP website at
Http://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/sops.shtml
Please check this site regularly in order to review the most recent information on execution of the SOP.

2. REACH DELINEATION AND SCORING NOTABLE FIELD CONDITIONS

Before biotic sample and PHab data collection can begin, the monitoring reach must be identified and delineated, information about reach location and condition is to be documented, water chemistry parameters are to be recorded, and water samples may also be collected. A set of field forms for recording information about monitoring sites, biotic samples, and associated water chemistry and PHab data is available on the SWAMP website at http://www.swrcb.ca.gov/water_issues/programs/swamp/tools.shtml#methods. Field crews using paper forms must designate someone (other than the field recorder) to review the forms for completeness[2] and legibility. It is imperative to confirm throughout the data collection effort at each site that all necessary data have been recorded on the field forms correctly by double-checking values and confirming spoken values with field partner(s). All SWAMP data management tools including an electronic data entry interface of the field forms are available

[2] If parameters cannot be measured for some reason, "NR" (i.e., "Not Recorded") should be entered in the corresponding field.

from the SWAMP website for use on a portable field computer. Please visit the SWAMP Data Management Resources website for webinar training, tools, templates, and more. http://www.waterboards.ca.gov/water_issues/programs/swamp/data_management_resources/index.shtml A list of supplies needed for sampling and data collection is provided in the Guidance Document.

Step 1. Upon arrival at the site, fill out the "Reach Documentation" section of the field forms. Record the Station Code following SWAMP formats[3]. Record the geographic coordinates of the **downstream end** (Transect A) of the reach (in decimal degrees to at least five decimal places) with a Global Positioning System (GPS) receiver and record the datum setting (preferably NAD83) of the unit. Coordinates are to be averaged based on procedures outlined in the GPS device manual. This average is recorded as actual coordinates on field sheet. Target coordinates need to be determined before the field sampling, and should be placed on a map (paper or digital) for visual orientation in case the GPS is not functioning in the field (e.g., in steep canyons or in mountainous regions). Sampling locations for probability sites can be moved up or downstream as much as **300 m** from the target location for reasons such as avoiding obstacles, mitigating issues regarding safety or permission to access, and GPS error. If for some reason the GPS measurements for the actual site assessed are not taken at Transect A (e.g., if no GPS signal was available at Transect A), then the actual site location must be noted on the field data sheets.

For probabilistically selected sites "target coordinates" are selected at random. Because GIS information about stream locations is imperfect, the target coordinates may not fall exactly on a streambed, but rather nearby, requiring a geospatial shift in order to correspond to the nearest streambed. The potential discrepancy between the target coordinates and where sampling actually occurs makes it essential to record the actual field coordinates on the field sheet.

Step 2. To delineate the monitoring reach, first scout it to ensure it is of adequate length for sampling biota. The length to use depends upon the average "wetted width" of the stream reach. The "wetted channel" is the zone that is inundated with water, and "wetted width" is the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water. If the average wetted width $\leq$ 10 m, delineate a 150 m reach for sampling. If the average wetted width > 10 m, delineate a 250 m reach. When delineating the reach, *stay out of the channel as much as possible* to avoid disturbing the stream bottom, which could compromise the water and biotic samples, and PHab data, that will subsequently be collected.

Starting at one end of the reach, walk along the stream bank, taking large steps (for most adults, a large step is roughly equal to a meter) and count the steps until reaching 150 m (or 250 m for larger streams). This will give a rough idea about the location of the ends of the sampling reach. If the monitoring program affords flexibility in terms of where the sampling reach can be placed, scout for any features that should ideally be excluded (e.g., tributaries, "end-of-pipe" outfalls feeding into the channel, bridge crossings, major changes between natural and artificial channel structures, waterfalls, and impoundments). If any such features are near the target sampling location, and there is not enough room to accommodate a full 150 m reach or 250 m reach

[3] Before going in the field, a station code needs to be assigned to each of the sampling sites. For SWAMP-funded projects, please contact the SWAMP database management team for station codes.

entirely upstream or downstream of the feature(s), then the reach may be shortened (to as little as 100 m) in order to exclude them. Record on the datasheet under "Actual Reach Length" the length of the reach that has been delineated.

Step 3. Use markers (e.g., wire-stemmed flags) to indicate locations of transects and intertransects. The standard sampling layout consists of 11 "main" transects (A-K) interspersed with 10 "inter-transects", all of which are arranged perpendicularly to the primary direction of stream flow (usually the thalweg), and placed at equal distances from one to the next (Figure 3). The first flag should be installed at water's edge on one bank at the downstream limit of the sampling reach to indicate the first main transect ("A"). The positions of the remaining transects and inter-transects are then established by heading upstream along the bank and using the transect tape or a segment of rope of appropriate length to measure off successive segments of 7.5 m (if sampling reach is 150 m), or 12.5 m (if it is 250 m). [4]

Step 4. Under "Notable Field Conditions", record evidence of recent flooding, fire, or other disturbances that might influence bioassessment samples, such as scour, for which specific guidance is provided in Section 1.4, above. These are subjective determinations, so use whatever cues are available to make the call. If unaware of recent fire or rainfall events, select the "no" option on the form. Also, to the best of your ability, record the dominant land use and land cover in the area surrounding the reach (*i.e.*, evaluate land cover within 50 m of either side of the stream reach). Use a scaled aerial photograph of the site and vicinity as an aid. Finally, mark whether or not the sampling reach occurs within an engineered channel[5].

[4] Although it is usually easiest to establish transect positions from the banks (this also prevents disturbance to the stream channel), this can result in uneven spacing of transects in complex stream reaches. To avoid this, estimate transect positions by projecting from the mid-channel to the banks. Refer to Figure 3 for a visual clarification of proper transect alignment relative to the stream's direction of flow. For monitoring reaches of non-standard length (*i.e.*, < 150 m; see Step 2 above), divide the total length of the reach by 20 to derive the distance between the adjacent main, and inter-, transects. Alternating between two different flag colors (e.g., orange and yellow, or blue), to demarcate main- vs. inter-transects is recommended, as well as writing the transect/inter-transects names on the flags.

[5] Engineered channels include streams that have been straightened or armored (with riprap, rocks, grout, concrete, or earthen levees) on the banks, streambed, or floodplain of the channel. Partially armored channels (e.g., armored only at bridge abutments) are considered to be "engineered".

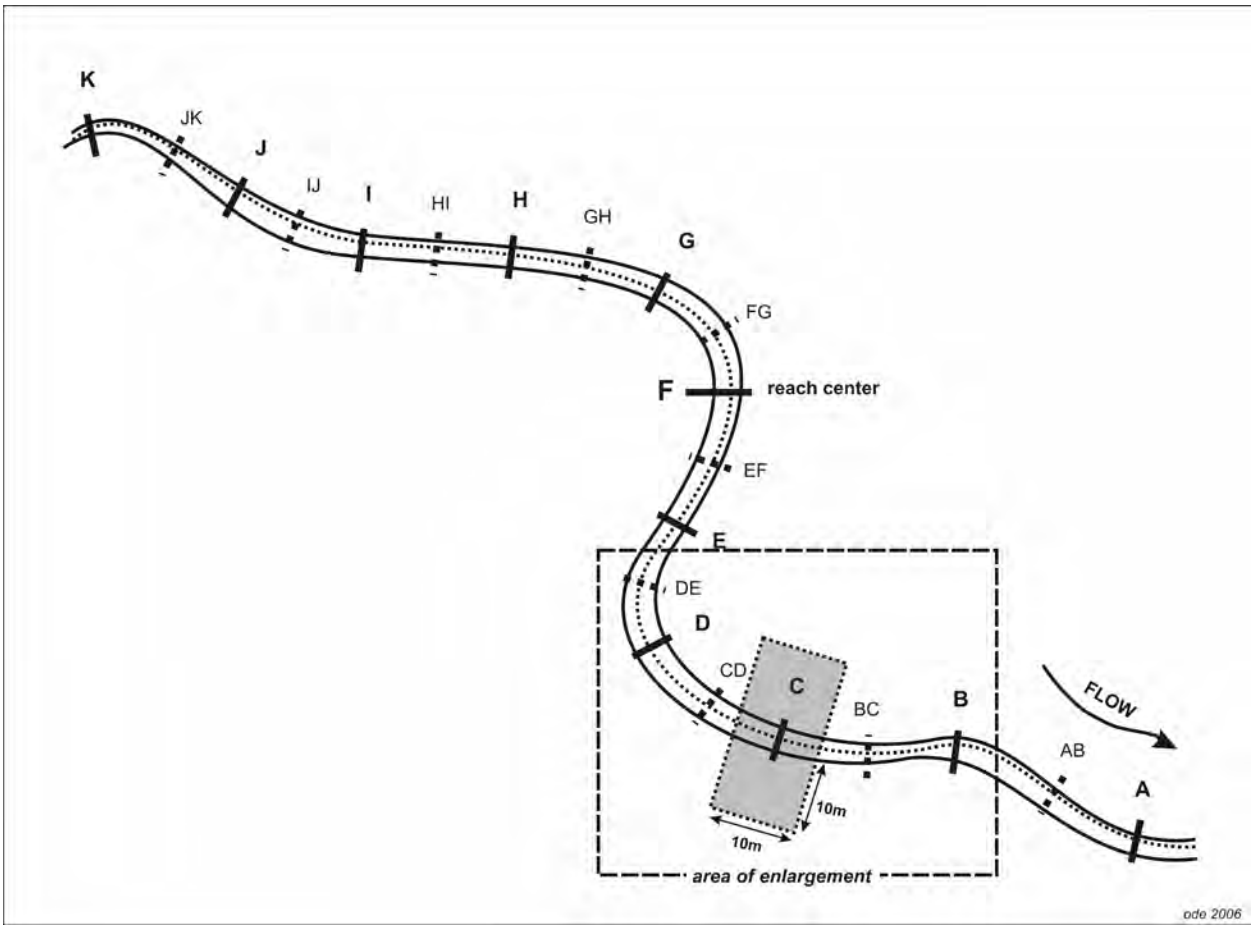

Figure 3. Reach layout geometry for physical habitat (PHab) and biotic sampling showing positions of 11 main transects (A-K) and the 10 inter-transects (AB-JK). The "area of enlargement" highlighted in the figure is expanded in Figure 17. *Note*: reach length = 150 m for streams ≤ 10 m average wetted width, and reach length = 250 m for streams > 10 m average wetted width.

3. WATER CHEMISTRY SAMPLING

Before entering the stream to sample water, remember to adhere to proper field hygiene practices (see Section 1.7 for more details) at all times. In addition, be sure to sample water in such a way that it does not interfere with subsequent biotic sampling and PHab data collection, but also in such a way that water samples are not compromised by other sampling activities upstream (e.g., by suspension of matter from the stream bottom into the water column, and the consequent introduction of this matter into the water chemistry samples). All water chemistry/toxicology samples should be collected prior to stepping in the water anywhere upstream of the water/toxicology sampling spot and should not be collected in a location where subsequent biotic samples or PHab data are to be collected. Sampling water chemistry just downstream of Transect A, the same general location as where the GPS coordinates were taken[6], and before any other sampling activities take place, achieves both of these goals.

Step 1. Calibrate probes as necessary (some require daily calibration) and record the calibration date on the field form. For calibration procedures, follow the SWAMP QAPrP in place at the time of monitoring or subsequent revisions to that QAPrP (http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa), or the manufacturer's guidelines, whatever is more stringent. Field measurements in this SOP are typically taken with a handheld water-quality meter (e.g., YSI, Hydrolab), but field test kits (e.g., Hach) may provide acceptable information as well.

Step 2. Measure and record common ambient water-chemistry parameters[7]:

- Turbidity (NTU)
- Water temperature (°C)
- Specific conductivity (µS/cm)
- Salinity (ppt)
- Alkalinity (mg/L)
- pH
- Dissolved oxygen (mg/L and % saturation)

Because it may be affected by disturbance of the streambed that occurs during sampling, measure turbidity (if applicable) first. If water samples are also to be collected, such sampling should also occur at this location and time, and collection should also precede probe measurements. Measurements and water chemistry sample collection should take place in areas with flowing water, avoiding depositional zones (e.g., pools), if possible.

[6] If, for whatever reason, measurements are not taken at Transect A before biotic sampling in the reach has begun, they should be taken immediately upstream of Transect K (the most undisturbed transect), and this change of sampling location should be noted on the field sheet.

[7] SWAMP-required ambient water chemistry parameters measured in the field are: pH, DO, specific conductivity, salinity, alkalinity, and water temperature. Samples for all other ambient water chemistry should be analyzed in the laboratory (except for silica, which can be measured in the field with kits *or* in the laboratory). Turbidity and silica are optional measurements for SWAMP purposes.

Turbidity can be measured with a multi-probe (e.g., YSI) or a turbidimeter, or it can be analyzed in the laboratory. If using a portable meter, collect approximately 250 mL of water for turbidity measurements approximately 10 cm below the water surface (if possible), and take two separate readings from subsamples of the same grab sample and report the average. Likewise, all probe measurements should be made 10 cm below the water surface.

Alkalinity (mg/L) may be measured with a field test kit (e.g. Hach AL-AP #2444301) or in the laboratory. A digital titrator (e.g., Hach) using low-concentration acid (such as 0.16N H_2SO_4) as the titrant is recommended for determining alkalinity in low-alkalinity streams (i.e., < ~100 mg/L $CaCO_3$). If algae samples are being collected, SWAMP requires that samples also be collected for analysis of water-column total nitrogen (TN) and total phosphorus (TP); nitrate-nitrite, and orthophosphate are also recommended. TN/TP samples should not be filtered. Sample holding times, field preparation, bottle types, and recommended volumes for each water-chemistry analyte can be found in the Quality Control and Sample Handling Guidelines [8] (http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#field). Greater detail on field sampling methods for water chemistry can be found at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/final_collect_water_sed_phys_habitat.pdf.

[8] Crews can opt to collect water at the end of sampling for holding time purposes, in which case sampling should be conducted in undisturbed water.

4. BIOTIC COMMUNITY SAMPLING

Once the transects have been laid out and water sampling is complete, the biotic samples (BMIs and/or algae) can be collected. On a transect-by-transect basis, any biotic sampling should occur before PHab data are collected, and BMIs should always be collected before algae because BMIs are often highly motile and could be flushed by the algae sampling activity.

4.1 The Reachwide Benthos (RWB) Method for Biotic Sample Collection

The RWB procedure employs an objective method for selecting subsampling locations that is built upon the layout of the 11 main transects that will be also used for physical habitat measurements. This method can be used to sample any wadeable stream reach, since it does not target specific habitats. Because sampling locations are defined by the transect layout, the position of individual sub-samples may fall in a variety of "erosional[9]" or "depositional[10]" habitats.

For the RWB method, the sub-sampling position alternates between left, center, and right portions of the main transects, as one proceeds upstream from one transect to the next. These sampling locations are defined as the points at 25% ("left[11]"), 50% ("center") and 75% ("right") across the wetted width in most systems. The left and right sides of the stream are determined when facing downstream.

SWAMP programs should employ a modified version of the RWB method, called the Margin-Center-Margin (MCM) method when all three of the following stream conditions are met: 1) very low slope (generally < ~ 0.3%); 2) uniform sandy/fine-substrate; and 3) stable habitat at stream margins. The MCM protocol modification is to collect subsamples at 0%, 50%, and 100% of wetted width instead of 25%, 50%, and 75%, to ensure collection of biota from marginal habitats. There is no hard rule for using the MCM variation, but in general it should be reserved for reaches where the bulk of the streambed consists of unstable habitat (e.g., shifting sands), and the only stable microhabitats (e.g., macrophytes, algae) are restricted to the margins and would otherwise be missed. The type of sampling method used (RWB, MCM, or TRC) should be circled on the field sheet under "collection method".

The recommended method for collecting duplicate biotic samples is at adjacent positions along the sampling transects according to the scheme depicted in Figure 3 (the duplicates are shown in light grey, with dashed-line outlines). Both samples should be collected at each transect before moving on to the next transect.

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[9] Erosional – habitats in the stream that are dominated by fast-moving water, such as riffles, where stream power is more likely to facilitate erosion (suspension) of loose benthic material than deposition; examples of "erosional" substrates include cobbles and boulders.

[10] Depositional – habitats in the stream that are dominated by slow-moving water, such as pools, where deposition of materials from the water column is more likely to occur than erosion (or (re)suspension) of bed materials; examples of "depositional" substrates include silt and sand.

[11] Conventionally, "left bank" has been defined as the left bank when facing *downstream* (i.e., in the direction of the current).

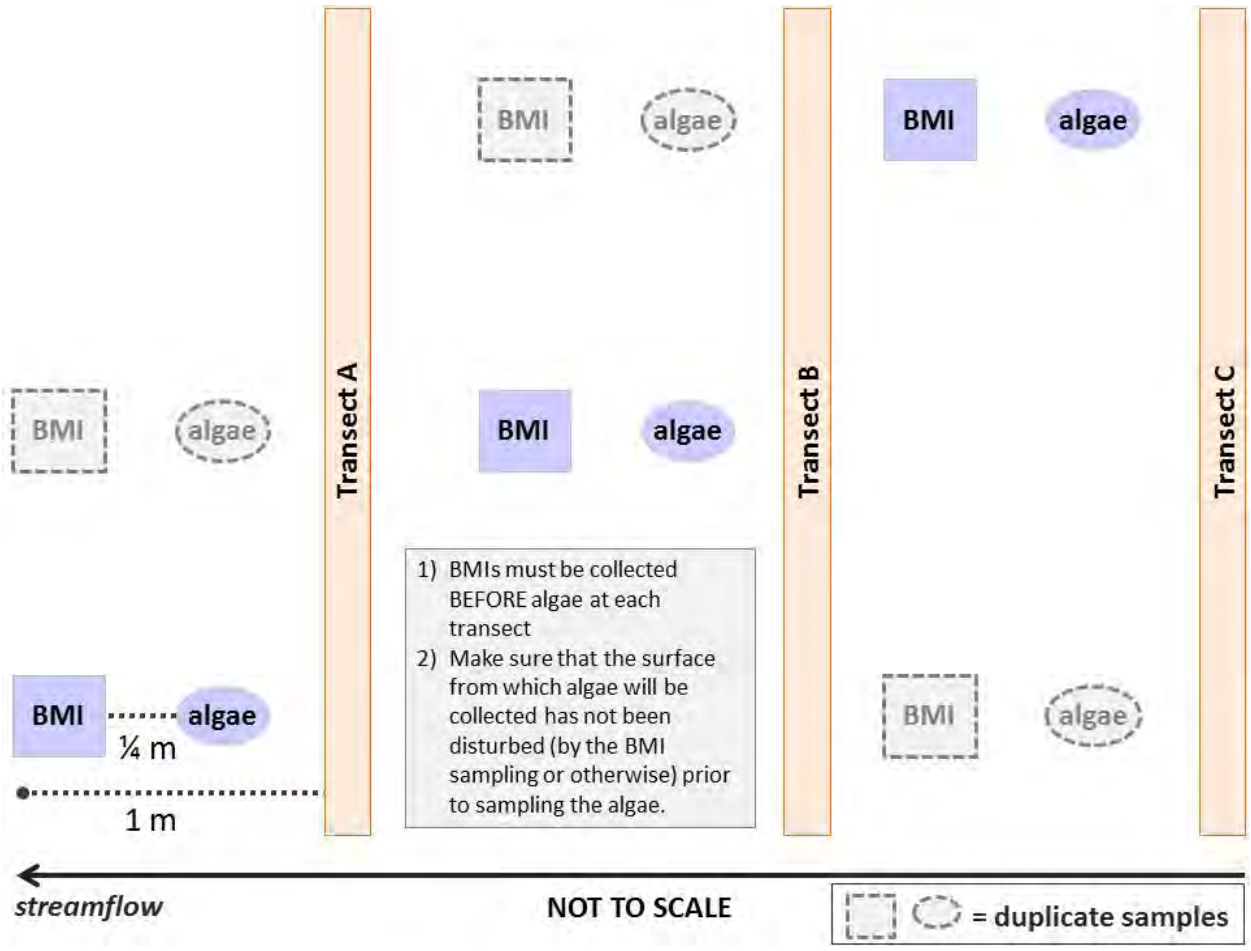


Figure 4. Sampling array for collection of BMIs, algae, and duplicate samples (outlined with dashed lines) for each assemblage. The lower left corner of diagram shows distances between BMI and algae sampling points relative to a transect (i.e., one sample collected at the Left location while the duplicate is collected at the Center). For convenience, only Transects A through C of the sampling reach are shown, but the same pattern of placement should be rotated across all 11 transects.

4.2 General Considerations for Sampling BMIs

While TRC sampling for BMIs may be considered useful for some programs, RWB is the required procedure for SWAMP programs. The following section describes only the RWB method. Supplemental information on TRC can be found in the Guidance Document.

Before sampling BMIs at any given site, be sure to thoroughly inspect the D-frame net to ensure that no organisms are carried over from previous sites, which could contaminate the sample.

4.3 Module A: RWB Sampling Procedure for BMIs

Step 1. Starting with the downstream transect (Transect A), identify a point that is 25% (or 0% for the MCM modification) of the stream width from the left bank. If it is not possible to collect

a sample at the designated point because of deep water, obstacles, or unsafe conditions, adjust the sampling spot while keeping the point as close as possible to the designated position. Always be as objective as possible when identifying the sampling spot; resist the urge to sample the "best looking" or most convenient area of the streambed.

Step 2. Once the sampling spot is identified, place the 500-µm D-frame net in the water 1 m downstream of the target transect. In order to avoid affecting subsequent PHab data collection, do not sample directly on the transect. Position the net so its mouth is perpendicular to, and facing into, the flow of the water. If there is sufficient current in the area at the sampling spot to fully extend the net, use the normal D-net collection technique (as described in steps 3-6 below) to collect the sub-sample.[12]

Step 3. Holding the net in position on the substrate, visually define a square shape (a "sampling plot") on the stream bottom upstream of the net opening, approximately one net-width wide and one net-width long. Because standard D-nets are 12 inches wide, the area within this plot is $1ft^2$ ($0.09\ m^2$). Restrict sampling to within that area.

Step 4. Working backward from the upstream edge of the sampling plot, check the sampling plot for heavy organisms such as mussels, caddis cases, and snails. Remove these organisms from the substrate by hand and place them into the net. Carefully pick up and rub stones directly in front of the net to remove attached animals. Pick up and clean all of the rocks larger than a golf ball within the sampling plot such that all the organisms attached to them are washed downstream into the net. Set these rocks outside the sampling plot after they have been cleaned. Large rocks that protrude less than halfway into the sampling area should be pushed aside. If the substrate is consolidated, bedrock, or comprised of large, heavy rocks, kick and dislodge the substrate (with the feet) to displace BMIs into the net. If a rock cannot be removed from the stream bottom, rub it with your hands or feet (concentrating on cracks or indentations), thereby loosening any attached insects. While disturbing the plot, let the water current carry all loosened material into the net. Do not use a brush to dislodge organisms from substrates.

Step 5. Once the coarser substrates have been removed from the sampling plot, dig through the remaining underlying material with fingers or a digging tool (e.g., rebar or an abalone iron) to a depth of about 10 cm (less in sandy streams), where gravels and finer particles are often dominant. Thoroughly manipulate the substrates in the plot to encourage flow to dislodge any resistant organisms. Note: the sampler may spend as much time as necessary to inspect and clean larger substrates, but should take a standard time of 30 seconds for the digging portion of this step. To the extent practical, reduce the amount of sand particles in the net, as they damage organisms and degrade taxonomic data quality.

[12] When sampling in slack water and flow volume is insufficient to use a D-frame net to capture dislodged BMIs drifting downstream, spend 30 seconds hand picking a sample from $1ft^2$ area of substrate at the sampling location. Then stir up the substrate with gloved hands and use a sieve with 500-µm mesh size to collect the organisms from the water in the same way the net is used in larger pools to wash the organisms to the bottom of the net.

For slack-water habitats, vigorously kick the remaining finer substrate within the plot using the feet while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds. For vegetation-choked sampling points, sweep the net through the vegetation within a 1-ft^2 (0.09 m^2) plot for 30 seconds. After 30 seconds, remove the net from the water with a quick, upward motion to wash the organisms to the bottom of the net.

Step 6. Let the water run clear before carefully lifting the net. Dip the lower portion of net in the stream several times to remove fine sediments and to concentrate organisms into the end of the net, while being careful to prevent water or foreign material from entering the mouth of the net. ***Be particularly careful to avoid "backflow" situations, in which collected material restricts flow through the net and the resulting turbulent flow causes collected material to escape the net; this is a major potential source of loss of BMIs during sampling.***

Step 7 Move on to the next transect to repeat the sampling process across all 11 main transects. The sampling position within each transect is alternated between the left, center, and right positions along a transect (25%, 50%, and 75% of wetted width, respectively, for standard RWB, or 0%, 50%, and 100% if using the MCM collection method), then cycling through the same order over and over again while moving upstream from transect to transect. Ultimately, you will collect from the left and center 4 times each, and the right 3 times. [13]

Step 8. Fill and label sample jars. Once all 11 subsamples have been collected, proceed to Section 5.1 "Processing Benthic Macroinvertebrate Samples".

4.4 General Considerations for Sampling Benthic Algae

The following is a short introduction to several types of algal indicators that can be monitored as part of a bioassessment effort. For a more detailed discussion, see Fetscher and McLaughlin (2008). The most appropriate indicators to include in a given program will ultimately depend upon that program's goals, because the various indicators provide information at varying levels of resolution and applicability to different uses. Likewise, the various indicators require different levels of investment in terms of fieldwork and laboratory work. Percent algal cover, for instance, is a rapid means of estimating algal primary production that can be carried out entirely in the field and is conducted in tandem with the PHab pebble count. Therefore, the percent algal cover is an appropriate, fast, and inexpensive parameter for citizen monitoring groups if they are concerned about increased algal biomass. Other estimators of algal biomass include chlorophyll *a* and AFDM, which involve quantitative collection of algae, preservation, and subsequent laboratory analysis. Algal biomass is a key component of the California Nutrient Numeric Endpoints (NNE) framework (Tetra Tech 2006). Higher resolution taxonomic information about algal assemblages can be used in algal Indices of Biotic Integrity (IBIs; *e.g.*, Fetscher *et al*. 2014), and offers more in-depth insight into water quality. For this type of data, algal specimens

[13]Care should be taken in transporting samples between reaches. The use of a reachwide sample bucket can help minimize any possible sample loss. Samples from each transect can be placed in the bucket for transport. This method would be similar to the reach wide sample bucket used for algae sampling.

must be collected quantitatively (and qualitatively, in the case of soft-bodied algae). The quantitative samples are fixed (preserved) and both quantitative and qualitative samples are subjected to taxonomic analysis. While the percent algal cover data are recorded in conjunction with standard PHab procedures and do not require the collection of samples, all the other types of algal data described in this SOP require RWB or MCM sampling of algal specimens in a manner analogous to that which is carried out for BMIs.

With the exception of the qualitative soft-algae sample, all of the algae samples described in this SOP can be obtained from a single "composite sample" (Figure 5) generated by the RWB (or MCM) method. Which combination of these samples to prepare and submit for laboratory processing will depend on the needs of the monitoring program. To aid in the selection of algal indicators, Table 3 provides a summary of their attributes.

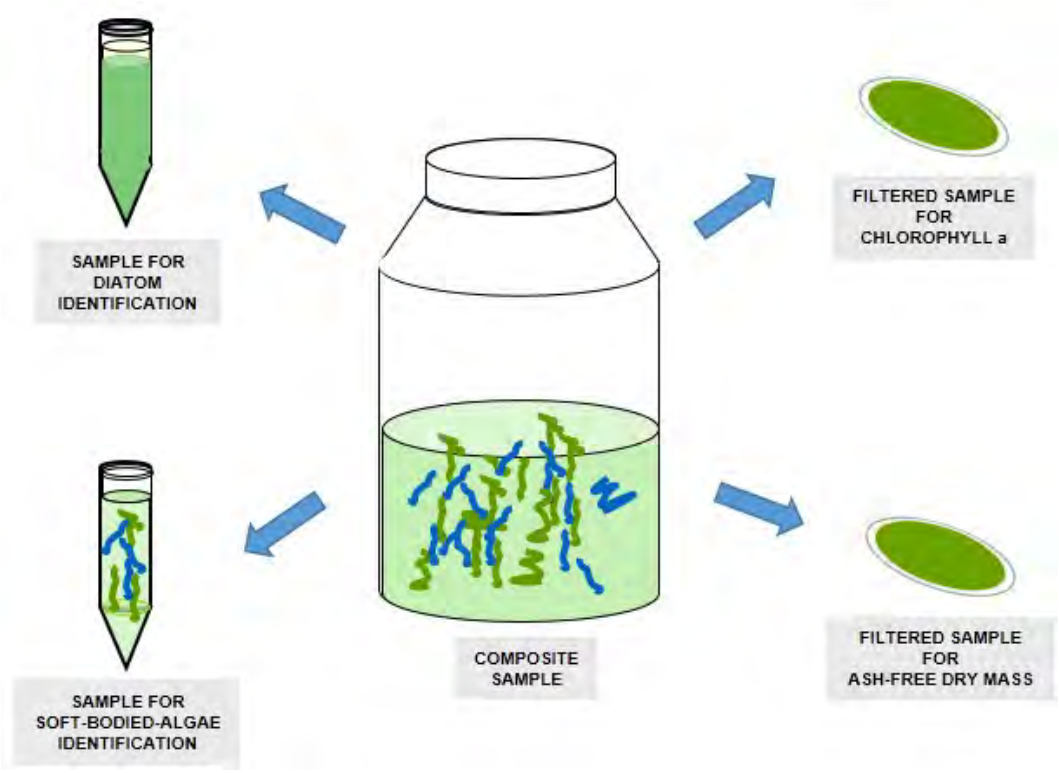


Figure 5. The four sample types that can be prepared from the algae "composite sample".

Table 3. Types of algal indicators and considerations for their assessment.

	Algal indicator for	Collection method	Collection vessel	Preservation / fixation method / holding times
Percent Algal Cover	Stream primary production measured as algal abundance	Point-intercept component of the PHab pebble count	N/A	N/A
Chlorophyll *a*	Stream primary production measured as algal biomass; key indicator for the Nutrient Numeric Endpoints (NNE) framework	RWB or MCM sample collection	Glass-fiber filter	Filter, wrap in foil, store on wet ice in the field, but freeze (pref. -80ºC) within 4h of collection; analyze within 28d
AFDM	Stream primary production measured as biomass of organic matter, including algae; indicator for the NNE framework	RWB or MCM sample collection	Glass-fiber filter (pre-combusted[14])	Filter, wrap in foil, store on wet ice in the field, but freeze (pref. -80ºC) within 4h of collection; analyze within 28d
Diatoms	Indicative of factors such as trophic status, organic enrichment, low DO, siltation, pH, metals.	RWB or MCM sample collection	50 mL centrifuge tube	Add 5% formalin for a 1% final concentration immediately after collection; keep dark and away from heat; fixed samples can be stored for at least 2 years
Soft-bodied algae <u>quantitative</u> sample[15]	Indicative of factors such as nitrogen limitation/ trophic status; siltation; pH; temperature, light availability, nuisance/ toxic algal blooms	RWB or MCM sample collection	50 mL centrifuge tube	Keep unfixed samples in dark on wet (not dry) ice; add glutaraldehyde (to a 2% final concentration) *under a fume hood*, as soon as possible, but no later than 96 hours after sampling; after fixing, refrigerate and keep in dark; fixed samples can be stored for at least 2 years
Soft-bodied algae <u>qualitative</u> sample	Used for IBI calculation as well as to help laboratory identify specimens in the quantitative sample (above)	By hand	Whirl-Pak™ bag	No fixative; keep fresh sample on wet ice (or refrigerated) and in the dark; tally species present within 2 weeks of collection (preferably much sooner)

[14] Pre-combustion removes any possible residual organic matter from the filter.
[15] For the purposes of this SOP, the soft-bodied assemblage includes cyanobacteria

During all phases of algae sampling and processing, in order to preserve specimen integrity, every attempt should be made to keep the sample material out of the sun, and in general, to protect the algae from heat and desiccation, as much as possible. This is necessary in order to reduce the risk of chlorophyll *a* degradation, limit cell division post-collection, and curb the decay of soft-bodied algae (especially for the fresh qualitative samples; see Section 4.6, "Procedure for Collecting and Storing Qualitative Benthic Algal Samples").

4.5 Module B: RWB Sampling Procedure for Benthic Algae – Quantitative Samples

As with the RWB and MCM methods for BMIs, a quantitative subsample of benthic algae is collected at each of the 11 main transects, and these are combined into a single composite sample. Up to four aliquots are then drawn from the composite sample, and these can be used for analysis of the following: diatom assemblage, soft-bodied algae assemblage, benthic chlorophyll *a* concentration, and benthic AFDM concentration. A qualitative sample of soft bodied algae is collected in addition to the quantitative sample (see Section 4.6, below). Also, as with BMIs (see Section 4.3, Step 1; and Fig. 4), algae sample collection should begin at Transect A and proceed upstream to Transect K, rotating through the "left", "center", "right", "left", etc. positions along the 11 main transects. At each transect, BMIs must be collected before algae in order to minimize the chances of disturbing BMIs (potentially causing some to flee the area) during collection of algae. It is likewise important to make sure that the surface from which algae will be collected has not been recently disturbed (by the BMI sampling, or otherwise) prior to sampling the algae.

After the BMIs are collected at a given spot, the algae sample should be taken ¼ m upstream from the center of the upper edge of the scar in the stream bottom left from the BMI sampling, according to the schematic in Figure 3. The best way to guarantee that BMI sampling does not interfere with algae sampling is for the person sampling algae to witness exactly where the BMI collector is disturbing the stream bottom in the process of sampling the BMIs. One should not rely upon guessing where the BMIs were collected in order to determine this. Sometimes the "scar" where BMIs were collected will be obvious, but often it will not. If only algae (and not BMIs) are being collected, then the specimens should be collected 1 m downstream of the transects. If only algae (and not BMIs) are being collected in a low-slope reach in which the MCM method is employed, the collection location should be 1 m downstream of the main transect and, for each of the "margin" positions, at a distance of 15 cm (i.e., ½ the width of a D-frame net) inward from the wetted margin of the bank.

To ensure that samples of the stream's algal community and algal biomass concentration are representative of the sampling reach, samples should always be collected by centering the sampling device on the specific point indicated in the above guidelines (*i.e.*, resisting the urge to subjectively choose where to sample). This is particularly important for yielding a representative biomass sample, because subjectively choosing or avoiding spots with high or low levels of algal growth can easily bias the results.

Because in the RWB and MCM methods, subsample locations are objectively defined by the transect layout, the position of individual subsampling points may fall within a variety different types of habitats, each of which has implications for the type of substrate likely to be encountered and therefore the type of algae sampling device to use. When confronted with a

situation in which an algae sampling location straddles two substratum types, overlay a sampling device (e.g., the rubber delimiter) centered on the sampling spot and determine which substrate occupies the majority of the area inside the delimiter, then shift the sampling spot the minimal distance necessary for that substrate type to be entirely within the delimiter, and sample there. Three devices are possible: a syringe scrubber (for hard, immobile surfaces, such as bedrock), a rubber delimiter (for hard, mobile surfaces, such as cobbles and small boulders), and an ABS delimiter (for soft, particulate substrates, such as sand). As the subsamples are collected, a tally must be taken of the number of times each of the classes of sampling device is used: 1) delimiter (either ABS or rubber), and 2) the syringe scrubber. The tallies are used to estimate the total surface area sampled (i.e., 12. 6 cm^2 for each use of the rubber or ABS delimiter and 5.3 cm^2 for each use of the syringe scrubber). The tallies are recorded in the "Algae Samples" field form under "Collection Device". The total surface area is used to estimate the soft-bodied algal total biovolume and the chlorophyll a and AFDM values. Instructions for making all algae-sampling devices are provided in the Guidance Document.

The recommended method for collecting duplicate algae samples is analogous to that described for BMIs: at adjacent positions along the sampling transects according to the scheme depicted in Figure 3. Both the sample and the duplicate should be collected at each transect before moving on to the next transect.

Before sampling, the dish tub or bucket that will contain the material to be collected must be scrubbed with a ***stiff-bristled brush or scouring pad*** and thoroughly rinsed with stream water from the site to be sampled, so that no algal material is carried over from the previous site to contaminate the current sample. The same applies to all other algae sampling apparati (e.g., toothbrushes, graduated cylinders, delimiters, trowels, syringe scrubbers, turkey basters).[16]

4.5.1 Collecting from Cobbles, Large Gravel, and Wood Using the Rubber Delimiter

Step 1. If the substrate type corresponding to the algae sampling point is located on a large piece of hard substrate that can be easily removed from the stream (*e.g.*, a cobble, a piece of wood, or a piece of large gravel), use the rubber delimiter. These substrates typically occur in erosional habitats, such as riffles and runs. Carefully lift the substrate, moving slowly to avoid disturbing its top surface as much as possible, and remove it from the water. Always collect the algae sample from the substrate that is most exposed to the sun. If a sampling point is covered by a thick mat of macroalgae, the "substrate" collected at that point would be macroalgae itself (see Section 4.5.3), not the material that lies beneath it.

Step 2. Hold the substrate over a dish tub or bucket and wrap a rubber delimiter (Figure 6) around the piece to expose the sun-exposed surface through the hole. Center the hole on the exact point on the cobble that had been identified as the "algae sampling point" for that transect, and avoid subjectively choosing the spot that is easiest to sample or has the most algae.

[16] Scrubbing of the collection bucket/tub can be done prior to arriving at the site but must be checked upon arrival.

Step 3. Dislodge attached algae from this area by brushing it with a clean, firm-bristled toothbrush. If there is a thick mat of attached algae on the piece of substrate, or the algae is firmly encrusted on its surface, use forceps or a razor blade first to scrape the larger algal matter and place this in the dish tub. Then scrub the area with the brush. Collect only algal material that is visible within the area defined by the hole, as the algal filaments are laying down on the surface of the substrate and within the delimiter. Portions of algae filaments that extend beyond the opening of the hole are not part of the sample. Make sure that the entire surface within the delimiter has been scrubbed well in order to remove all the algae in that area.

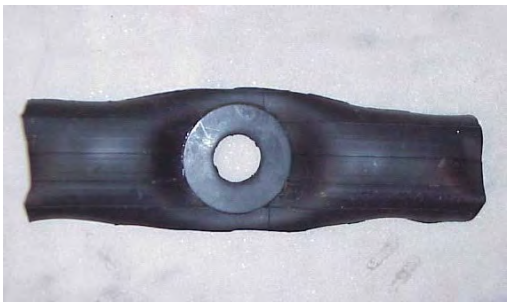


Figure 6. Rubber delimiter

Step 4. Fill a wash bottle or turkey baster with stream water from the current site. Using as small a volume of water as possible, rinse the scrubbed algae from both the toothbrush and the sample area on the piece of substrate into the dish tub. Take care to squirt water only on the surface that is showing through the hole in the delimiter, and not anywhere else on the substrate's surface. It is helpful to invert the rock when rinsing so that the target surface is facing down toward the dish tub, and the rinsate drips off the sampling point directly into the tub rather than flowing along the (non-target) sides of the substrate. Use water sparingly for each piece of substrate, because ideally less than 500 mL water, total, should be used for the full set of 11 samples collected along the transects; this includes any water used for rinsing algae off of sampling devices into the dish tub. The scrubbed part of the substrate should feel relatively rough, indicating that most of the algae have been removed. Several rounds of scrubbing and toothbrush-rinsing may be required in order to achieve this state. After thoroughly scrubbing and rinsing the sampling area on the piece of substrate, return it to the stream.

4.5.2 Collecting from Sediment

Step 1. If the substrate type that falls under the sampling point is made of particulate matter, such as silt and fine gravel, use the ABS delimiter. Typically, this occurs in depositional habitat, such as pools. The ABS delimiter is a plastic corer with an internal diameter of 4 cm (Figure 6). Quantitatively isolate sand/silt/gravel, centered on the sampling point, by pressing into the top 1 cm of sediment with the delimiter. A brightly colored line painted around the periphery of the delimiter, at 1 cm above the lip of the opening, is helpful for confirming insertion depth.

Figure 7. ABS delimiter, showing pink line at 1cm depth mark

Step 2. Gently slide a pointed, flat masonry trowel beneath the delimiter, being careful to keep the collected sediment contained within the area demarcated by the delimiter. Lift the delimiter,

keeping a tight seal between the delimiter and trowel to prevent the water inside from leaking out, resulting in loss of sample material.

Step 3. Remove sediment around the outside of the delimiter, and then empty the entire delimiter's contents into the dish tub. Using water sparingly, rinse any leftover sediment from the trowel into the tub.

4.5.3 Collecting a Mass of Macroalgae Using the ABS delimiter

Step 1. If the target substrate on a given transect is a mass of macroalgae (*e.g.*, a mass of attached filamentous algae underwater, or an unattached, floating mat that is believed to be native to the reach being sampled), position the trowel directly under the macroalgae and press the ABS delimiter into the algae to define a 12.6 cm^2 area. Note: when collecting a mass of macroalgae, it is important to capture the full thickness of the macroalgae within the delimiter. To do this, from the side of the sampling area, feel under the mat to determine where the bottom is, slide the trowel down to that spot, and then press the ABS delimiter downward slowly to "sandwich" the targeted section of macroalgae between the delimiter and the trowel. The goal is to collect a representative sample of the algae, by stream bottom area, as it exists in the stream.

Step 2. Use a sharp razor blade or knife to cut away and discard algae material from around the edges of the delimiter. Do not pull filaments without cutting them, and do not bunch the macroalgae up nor stretch it out during this process.

Step 3. Add the macroalgal specimen that was isolated by the ABS delimiter to the dish tub.

4.5.4 Collecting from Macrophytes

Step 1. If the material to be sampled is part of a submerged, living macrophyte, or old, dead leaves settled at the bottom of a pool, use the ABS delimiter/trowel combination to isolate a 12.6 cm^2 section of macrophyte that has been exposed to the surface of the stream.

Step 2. As with the macroalgae (Section 4.5.3), cut away and discard the extra material that falls outside the delimiter.

Step 3. Add the macrophyte specimen that was isolated by the ABS delimiter to the dish tub.

4.5.5 Collecting from Hard, Submerged, Anchored Substrates: Concrete, Bedrock, and Boulders

Step 1. If the substrate at a sampling point cannot be removed from the water (as in the case of bedrock, a large or deeply embedded boulder, a concrete channel bottom, or hardpan), use a "syringe scrubber" device (Davies and Gee 1993; Figure 7) to collect a sample underwater. To use this device, affix a fresh, white scrubbing pad circle onto the bottom of the syringe

Figure 8. Syringe scrubber.

plunger using the Velcro hooks on the end of the plunger. Submerge the device in the stream and work the plunger up and down a couple times to lubricate it. Then press the plunger down so that the bottom of the scrubbing pad is flush with the bottom of the barrel.

Step 2. Submerge the syringe in the stream again, this time pressing the syringe bottom firmly against the substrate, centered on the sampling point. Once a good seal with the substrate is achieved, rotate the syringe scrubber completely 3 times in order to collect the biofilm from the substrate surface onto the pad. If the surface of the substrate where the sampling point fell is not flat enough to allow for a tight seal with the syringe barrel, move the collection point to the nearest area that is sufficiently flat and collect the sample there.

Step 3. After rotating the syringe scrubber, and before removing it from the substrate, gently retract the plunger slightly (e.g., <5 mm), so that the pad is no longer touching the substrate, but not so much that a lot of water enters the barrel. Carefully slide the trowel under syringe barrel, slightly tilting the barrel to allow the trowel to enter. If there is a strong current, lift the downstream side of the barrel. Then pull the instrument back out of the water with the trowel still firmly sealed against the syringe-barrel bottom.

Step 4. Hold the syringe scrubber over the dish tub and remove the trowel, allowing any water that was between the trowel and the scrubber pad to fall into the tub (but discard the water inside the plunger-handle end of the barrel—there is no need to add this water to the dish tub, as it does not contain sample material and will only serve to dilute the sample).

Step 5. Carefully detach the pad from the plunger and hold the pad over the tub. Using rinse water sparingly, remove as much algal material from the pad as possible by rinsing it off with the wash bottle filled with stream water from the current site, and wringing the pad into the dish tub before discarding it. Start this process by rinsing from the backside of the pad (the side that had been affixed to the plunger) to push the collected algae forward out of the front surface of the pad. If there are filaments of algae entrained within the pad, remove these using pointed-tip forceps, and place these in the dish tub, before wringing the pad out. It is recommended that a fresh (new) pad be used each time a sample is collected, even within the same stream reach. After completing sampling at a site, discard all used pads—they should never be reused between sites.

4.5.6 Collecting from Other Substrate Types

If other substrate types are encountered, they can be sampled from as long as there is good reason to believe that they were not recently introduced into the stream (*e.g.*, by flowing from the upstream regions, or by recently falling into the stream), as they would then not be representative of the local instream environment.

Use the collection instrument deemed to be most appropriate to sample the substrate and, as with any substrate, be sure to account for the surface area sampled (in this case, using the "*Other"* box on the *Collection Device* portion of the field forms).

As with BMIs, after collecting at each sampling spot, move on to the next transect to repeat the sampling process across all 11 main transects. The sampling position within each transect is alternated between the left, center, and right positions along a transect (25%, 50% and 75% of wetted width, respectively, or corresponding to the 0%, 50%, and 100% points across the stream if using the MCM protocol for BMI sampling), then cycling through the same order over and over again while moving upstream from transect to transect. Once all 11 subsamples have been collected, proceed to Section 5.2, "Processing Quantitative Benthic Algal Taxonomy and Biomass Samples".

4.6 Module B (continued): Procedure for Collecting and Storing Qualitative Soft Algae Samples

Whenever quantitative soft algae samples (Section 5.2) are collected for taxonomic analysis, a "qualitative" soft algae sample must also be collected. The qualitative sample consists of a composite of all types of soft-bodied algae observed within the reach. This sample is required for calculation of some of the metrics for the IBIs that use soft algae data, such as "H20" and "S2" (Fetscher et al. 2014). The qualitative sample can also aid identification of taxa captured in the RWB sampling, since it allows larger, more intact specimens to be collected than those that may end up in the more heavily processed quantitative sample. In addition, if the qualitative sample is kept cool and in the dark, and is delivered to the laboratory in a timely manner (*i.e.*, within two weeks of collection), there is a possibility of culturing live specimens, which is sometimes essential for standard taxonomic effort-level identifications.

Collection of the qualitative soft-bodied algae sample can be conducted at any time during the field visit, as long as its collection does not in any way interfere with the water chemistry, biotic, and PHab sampling/data collection (i.e., by kicking up sediment, displacing BMIs, and/or disturbing the stream bottom). It helps to have the collection bag on hand at all times so that it can be used for spontaneous grabs of specimens that are spotted during the course of the other fieldwork (e.g., conducting PHab data collection). However, the entire sampling reach should be visually scoured at least one time during the course of the day's fieldwork in an effort to see, and collect samples from, all patches of distinct soft-bodied-algal specimens therein.

Step 1. Using a thick, waterproof marker, label a Whirl-Pak™ bag with the Station Code, Date, and Sample ID.

Step 2. Hand-pick specimens of all visibly different types of macroalgal filaments and mats, as well as microalgae (in the forms of scrapings using a razor blade or knife), and depositional samples (suctioned from along the surface of sediments using a clean turkey baster). The Guidance Document includes photos that will help collectors develop an eye for the variety of types of algae that may be encountered in streams. A few helpful tips:

- Some algae (*e.g.*, species of *Chara*, *Paralemanea*, and *Vaucheria*) look like submerged macrophytes or mosses.
- Algae come in many colors, and may be green, dark-brown, golden, red, black, or bluish-green.
- Some cyanobacteria, such *Nostoc* spp., look like gelatinous globules or "deflated" sacs, ranging in size from smaller than a pea to larger than a lime.

- Collect from as many distinct locations as possible throughout the reach so as to capture as much of the apparent diversity as possible.
- Include any holdfast structures that had attached the macroalgae to the substrate, as these structures can be useful for taxonomic identification.
- Since these samples are merely qualitative, it is not necessary to collect them in a manner that is representative of their relative abundances within the reach.
- When in doubt as to whether a candidate specimen qualifies as "algae", add it to the sample; final determinations will be made by the taxonomist.
- A qualitative sample should be collected at *every* site for which soft-bodied algae are being sampled, whether or not macroalgae are visible in the reach. In the absence of macroalgae, rock scrapings, substrate particles, and CPOM should still be collected (as described above).
- Macroalgae growing within 10 m of the reach may also be added to the qualitative sample.

Step 3. Fill the bag with a total volume of up to 100 mL of qualitative algae sample + stream water. Purge extra air from the bag, and seal with the wire tabs by twisting them together (not just folding them over, as this can result in leakage). Tuck the ends of the wire tabs inward so that they cannot poke holes in the bag. Collect as many bags as needed, based on the variety of algae visible in the stream reach. If multiple bags are collected, number them accordingly (e.g., "bag 2 of 4") so that the laboratory will know how many bags to process for that site.

Step 4. Double-bag the qualitative samples, and slip a filled-out (with pencil) label (Figure 9) printed on waterproof paper into the outer bag. Store in cool, dark conditions (i.e., in the wet ice cooler,not on dry ice). Do not let the bags touch ice (or 'blue-ice" packs) directly, which could cause the samples to freeze, thus destroying them. Do not add any fixative to these samples.

Step 5. Refrigerate the qualitative samples immediately upon return to the laboratory. Because they are not preserved, these samples should be examined by a taxonomist as soon as possible (and within two weeks, at most), as they can decompose rapidly. Coordinate beforehand with the receiving laboratory, as necessary, in order to ensure that samples are processed in a timely fashion.

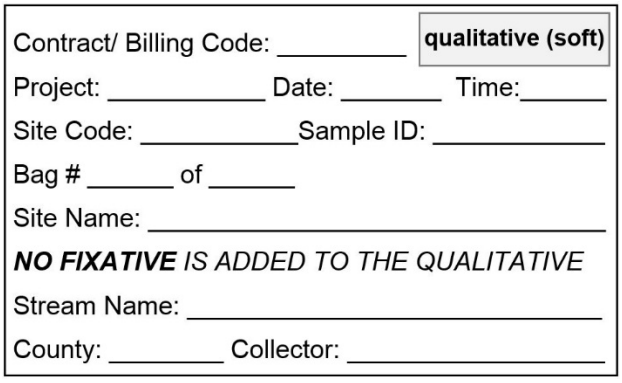


Figure 9. Label for soft-bodied algae qualitative sample.

5. BIOTIC SAMPLE PROCESSING

5.1 Module A (continued): Processing Benthic Macroinvertebrate Samples

Step 1. Once all BMI subsamples (11 for RWB or MCM) have been collected and composited, transfer the composited sample to one or more 500-mL wide-mouth plastic sample jar, preferably one with straight edges. Never fill a jar more than halfway with sampled material; use as many jars as necessary in order to prevent this.

Samples with a lot of organic material (e.g., plants, algae, leaf litter) tend to contain a lot of water that may inhibit sample preservation. Gently squeeze out as much water as possible (through the mesh of the D-frame net) before placing the sample in the jar, to prevent diluting the alcohol too much. Approach this task gingerly, so as not to damage invertebrates during this process.

Invert the contents of the D-frame net into the sample jar. Perform this operation over a large, white tray to avoid loss of any sampled material and make recovery of spilled organisms easier. If possible, remove the larger twigs and rocks by hand after carefully inspecting for clinging organisms. Use forceps to remove any organisms clinging to the net and place these in the sample jar. All samples should be completely transferred to the sample jar without elutriation.

If the samples contain a lot of fine particles, confirm that the sampling procedure is being executed correctly (i.e., use care to disturb the substrate as gently as possible and avoid kicking).[17]

Step 2. Place a date/locality label (Figure 10), filled out in pencil, on the inside of the jar and completely fill the jar with 95% ethanol[18]. To ensure proper preservation of BMIs, gently rotate jars that contain mostly mud or sand so that the ethanol is well distributed. Affix a second waterproof label on the outside of the jar. It is recommended that the label for the outside of the jar be printed with a laser printer (with alcohol-proof toner); otherwise, fill the label out by hand in pencil. Tape the label with transparent tape. Make sure all samples have both internal and external labels.

[17] Samples with an abundance of sand or organic material should be processed expeditiously at the lab, as specimens in these samples can degrade quickly. Therefore, the presence of these kinds of samples should be communicated to the taxonomy lab as soon as possible and they should not be stored for a long time before delivering to the taxonomy lab for processing. See Woodard et al. 2012 for details

[18] Note that the target concentration of ethanol is 70%, but 95% ethanol is used in the field to compensate for dilution from water in the sample. Final concentration of ethanol can be confirmed in the laboratory upon receipt of samples.

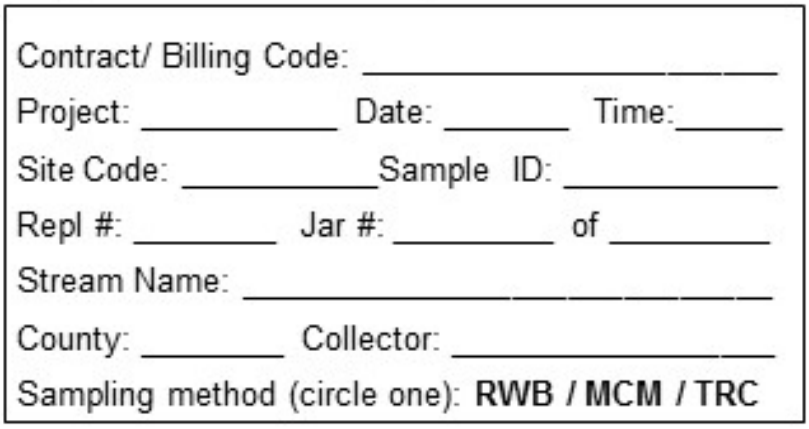


Figure 10. Example date/locality label for BMI samples.

If field crews do not ship samples directly to the laboratory, then section 2.3 of the SOP for laboratory processing and identification of benthic macroinvertebrates in California (Woodard et al. 2012; http://www.swrcb.ca.gov/water_issues/programs/swamp/docs/bmi_lab_sop_final.pdf) should be followed for long-term storage of the samples.

5.2 Module B (continued): Processing Quantitative Benthic Algal Taxonomy and Biomass Samples

After having sampled substrates across the monitoring reach, there should be material from all 11 transects in the dish tub. Depending on the types of habitats in the stream and substrates encountered, the dish tub may contain stream water with suspended microalgae, and silt, and/or sand, and/or fine gravel, and/or small pieces of wood or macrophyte. The algae clinging to these substrates must be detached and suspended into the water to form a "composite sample".

Step 1. Any pieces of macrophyte (i.e., vascular plants, not algae), twigs, or dead leaves that had been collected with the ABS delimiter should be massaged thoroughly between the fingers and rinsed into the tub in order to remove the algae coating them. These vascular plant fragments can then be discarded. If there are any clumps of macroalgae in the dish tub, there is a special step required for processing them. The procedure is described in detail below.

Step 2. Systematically massage all the sand and/or silt in the dish tub between the fingers to dislodge clinging microalgae (to be thorough, try to make contact with "every grain" while doing this). For pieces of gravel, use a toothbrush to remove algal material from surfaces. Rinse toothbrush and brushed gravel into the tub. Rinse the sediment thoroughly (but as sparingly as possible) with stream water so as to create a suspension of the dislodged microalgae (*i.e.*, the sample).

The final volume of the *liquid* in the dish tub will be measured before the algal taxonomic and biomass samples are prepared. To do this, the liquid in the tub will be separated from the rinsed sediment such that the volume measured does not include sediment (see below). After the liquid

sample has been retrieved and measured, the rinsed sediment will be discarded back into the stream. Whereas a single sample type is collected for BMIs, 4 different types of quantitative[19] laboratory samples may be prepared from the composite sample when collecting algae (Figure 4):

- for taxonomic ID/enumeration
    1. diatoms
    2. soft-bodied algae
- for biomass
    3. chlorophyll *a* ("chl *a*")
    4. ash-free dry mass ("AFDM")

The general process for sample preparation is as follows. The taxonomic ID/enumeration samples are each aliquoted into 50 mL centrifuge tubes and chemically fixed (preserved). Diatom samples are fixed in the field with formalin immediately following collection, and soft-bodied algae samples are fixed with glutaraldehyde in a laboratory under a fume hood within 96 hours of collection. The chl *a* and AFDM biomass samples are collected on filters in the field and stored on wet ice, and then frozen as soon as possible after returning from the field (and within four hours of collection). The filters are kept frozen until analysis, which must occur within 28 days of collection. If the filters will not be brought to the laboratory freezer on the same day they were collected, they should be kept on dry ice. The taxonomic ID samples are kept on wet ice until they are fixed, and then stored in the refrigerator (never frozen).

Algae sample labels are shown in Figure 11. Recorded on each sample label are the volume of the composite sample (see below), as well as the volume aliquoted (for the taxonomic ID samples) or filtered (for the chl *a* and ADFM samples). All of these volumes are recorded on the field forms, as well, under the "Algae Samples" section. On the sample labels, the sample type: "chl *a*", "AFDM", "diatoms", or "soft" is circled, and all the remaining information on each label (Station Code, Date, stream name, etc.) is filled out.

[19] Qualitative samples are also collected, when soft-bodied algae are to be analyzed (Section 4.6)

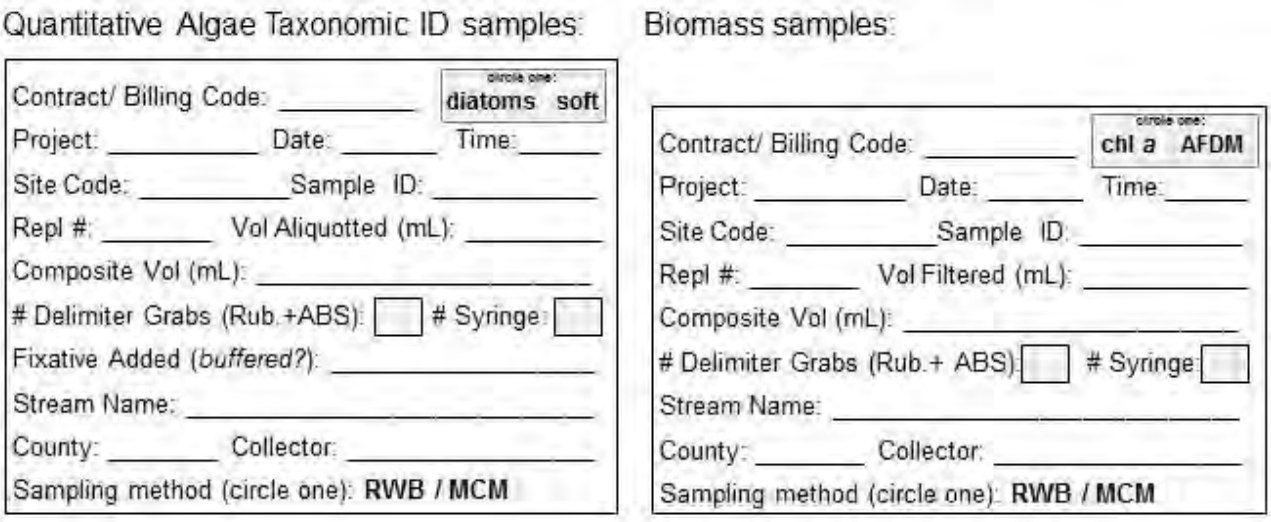


Figure 11. Labels for algae quantitative taxonomic identification (left) and biomass samples.

Before preparing the algae samples, it is necessary to determine two things:

- **Are there any clumps of macroalgae in the composite sample (as opposed to just microalgae suspended in liquid)?**

AND

- **Is a soft-bodied algae taxonomic sample going to be prepared?**

The answers to these questions will determine the course of action for preparing the algae samples for a given site**.** Figure 12 provides a decision tree for how to proceed with the algal sample-processing steps.

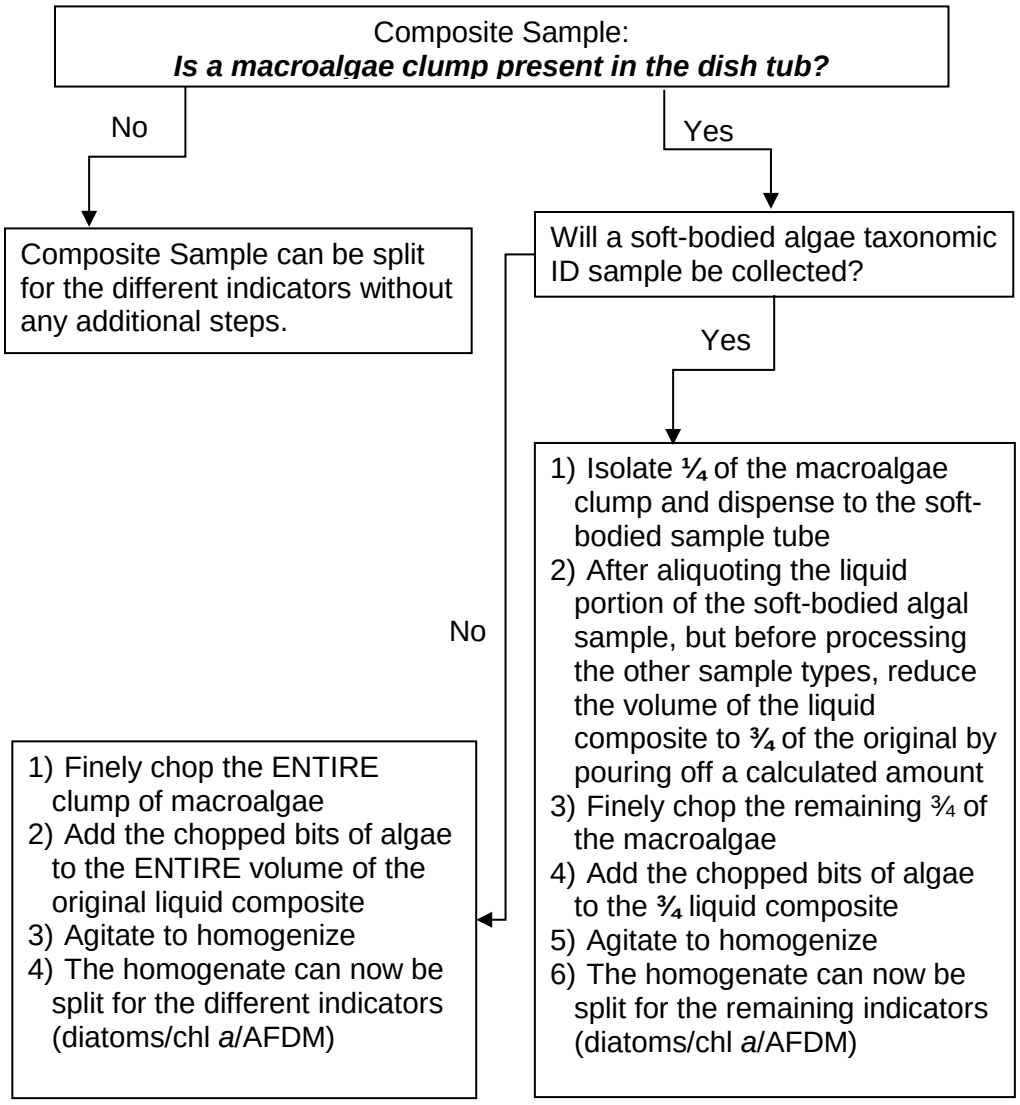
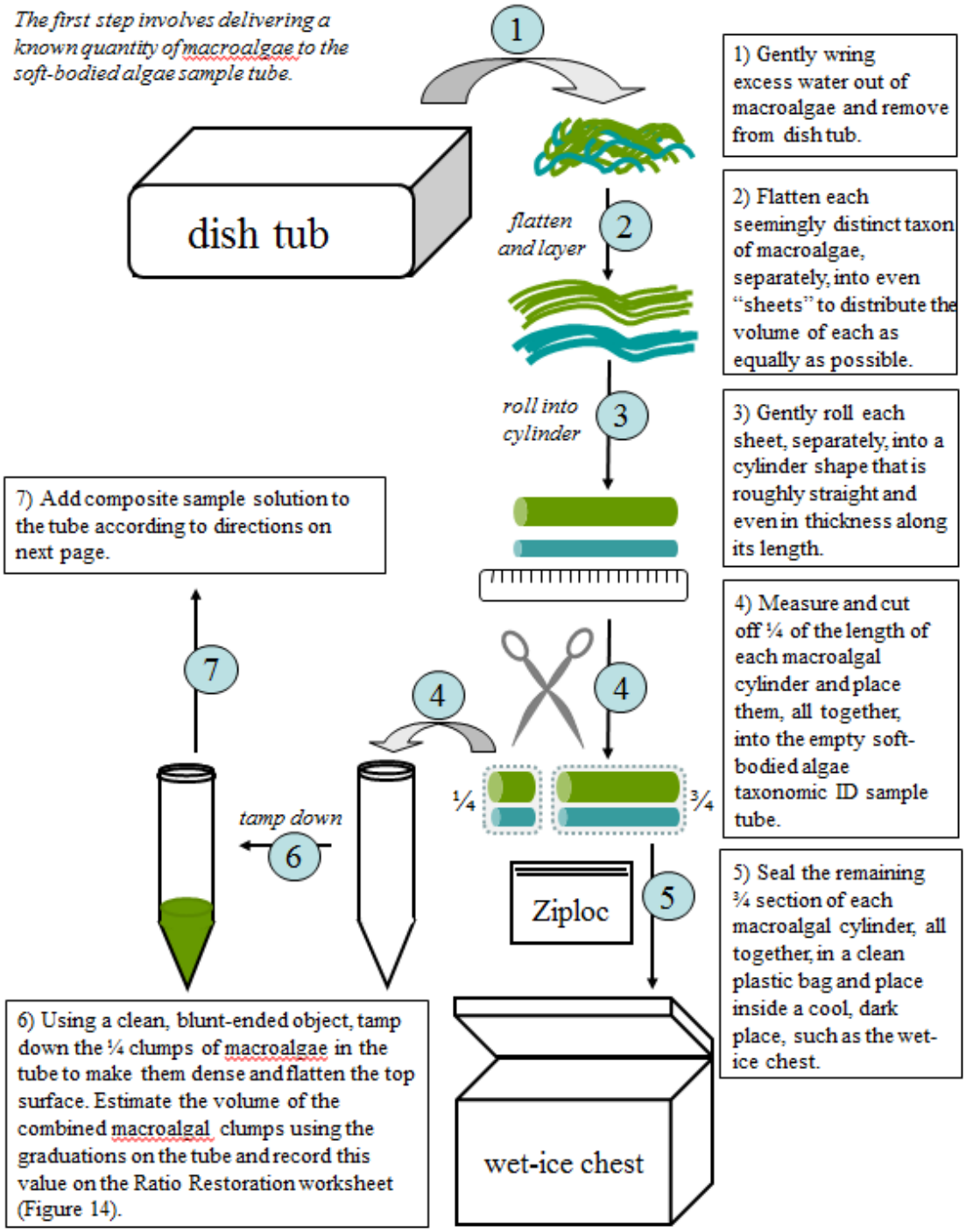


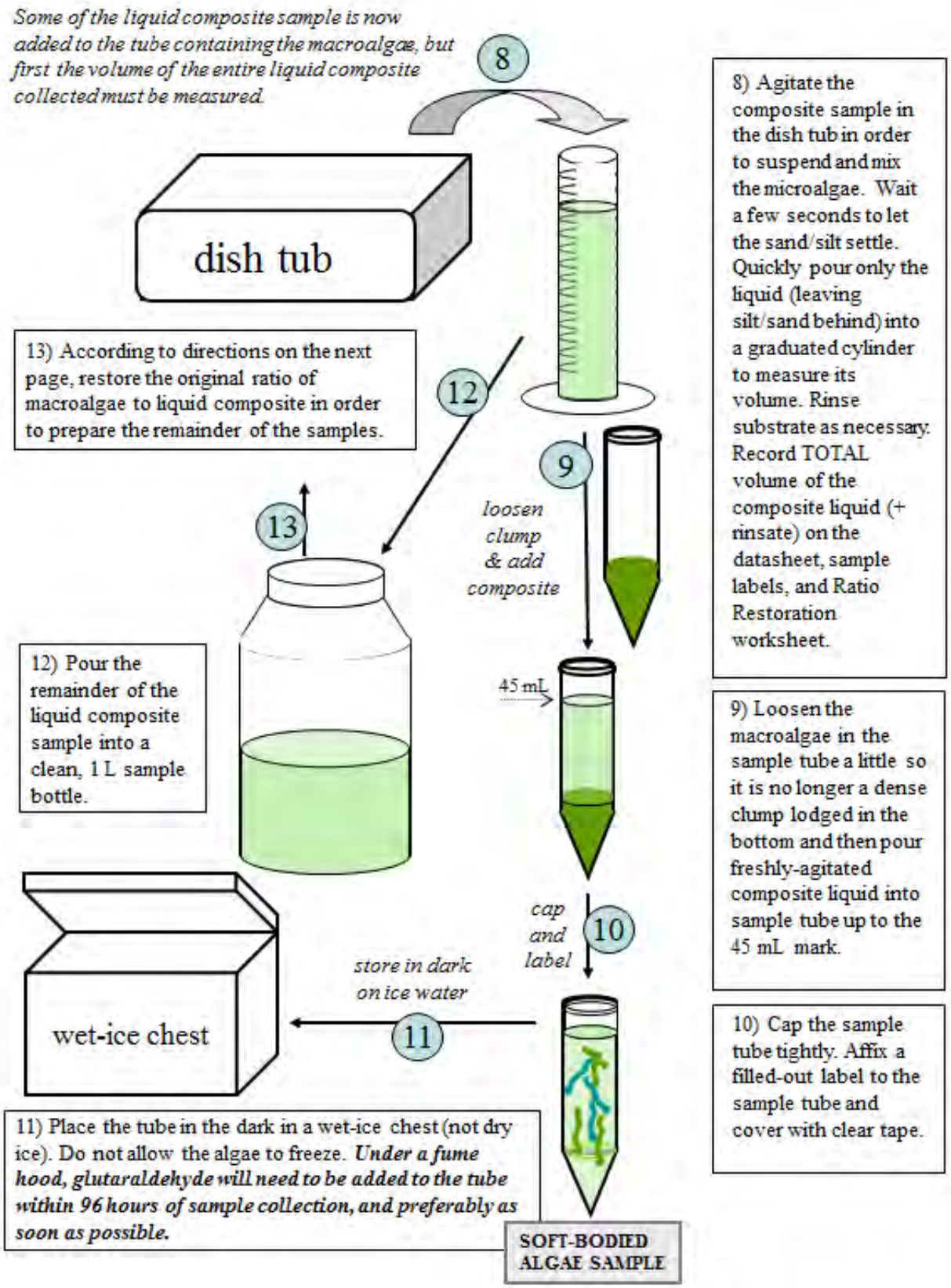
Figure 12. Summary of major sample-processing decision points based on presence of macroalgal clump(s) and need to prepare a soft-bodied algal sample.

The following is a description of how to proceed when a soft-bodied algal taxonomic ID sample is to be prepared AND macroalgal clump(s) are present in the sample in the dish tub. A flowchart of this procedure is provided in Figure 13. *It is recommended that this flowchart be printed in color, laminated (if possible) or printed on water-proof paper, and brought along to the field for a quick reference on handling macroalgal clumps in the composite sample.*

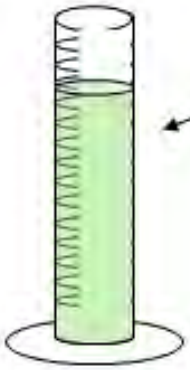
Note: It is unlikely that the ¼ macroalgal clump will occupy all the space in the soft-bodied algae quantitative sample tube, but if it does, a second tube will be needed in order to accommodate all the sample material plus liquid. If such an action is taken, it should be noted in the Comments section of the field sheets and the tubes should be clearly identified as belonging to the same sample, for record-keeping purposes. Do not fill either tube so full that there will not be enough room for the fixative.

Figure 13. Processing Soft-Bodied Algal and Diatom Samples When Macroalgal Clumps are in the Sample




Some of the liquid composite sample is now added to the tube containing the macroalgae, but first the volume of the entire liquid composite collected must be measured.
8
dish tub
13) According to directions on the next page, restore the original ratio of macroalgae to liquid composite in order to prepare the remainder of the samples.
12
9
loosen clump & add composite
13
12) Pour the remainder of the liquid composite sample into a clean, 1 L sample bottle.
45 mL
cap and label
10
store in dark on ice water
wet-ice chest
11
11) Place the tube in the dark in a wet-ice chest (not dry ice). Do not allow the algae to freeze. Under a fume hood, glutaraldehyde will need to be added to the tube within 96 hours of sample collection, and preferably as soon as possible.
SOFT-BODIED ALGAE SAMPLE
8) Agitate the composite sample in the dish tub in order to suspend and mix the microalgae. Wait a few seconds to let the sand/silt settle. Quickly pour only the liquid (leaving silt/sand behind) into a graduated cylinder to measure its volume. Rinse substrate as necessary. Record TOTAL volume of the composite liquid (+ rinsate) on the datasheet, sample labels, and Ratio Restoration worksheet.
9) Loosen the macroalgae in the sample tube a little so it is no longer a dense clump lodged in the bottom and then pour freshly-agitated composite liquid into sample tube up to the 45 mL mark.
10) Cap the sample tube tightly. Affix a filled-out label to the sample tube and cover with clear tape.

The remainder of the macroalgae is now cut into tiny bits, which are added back to the liquid composite. ***But the original ratio of macroalgae:liquid must first be restored.*** *The diatom and biomass samples are then prepared.*



14

measure & discard calculated volume

14) Use your *Ratio Restoration* worksheet to determine how much of the liquid composite to pour off and discard. First agitate the bottle thoroughly, then immediately measure and discard the appropriate volume.

¾

chop into fine bits

15

15) Remove the combined ¾ macroalgal cylinder pieces from the wet-ice chest. Chop the algae into *very fine pieces* and add these to the liquid composite.

agitate

16

16) Cap and agitate the bottle sufficiently to homogenize the chopped algae into the liquid as thoroughly as possible.

17) Pour 40 mL of the freshly-agitated homogenate into the diatom sample tube. Add 10 mL 5% formalin solution, observing all formalin safety precautions. Cap the tube, agitate, and affix the sample label.

17

dispense homogenate, add formalin, cap and mix to distribute formalin throughout

DIATOM SAMPLE

18

18) After both taxonomic ID samples have been prepared, the remainder of the homogenate is used for the biomass samples (chl *a* and AFDM). 25 mL of freshly agitated homogenate is filtered for each biomass sample. See text for details.

Step 3. If one or more macroalgal clumps are present in the dish tub, first remove them from the dish tub, wring them out gently into the tub, and roll them into cylinder shapes that are relatively even in thickness along their length. If there appears to be more than one type of macroalgae (i.e., obviously different species based on color/texture) in the sample, separate cylinders should be made for each one.

Step 4. Measure the length of the cylinder(s) with a ruler and cut a quarter off of each one, lengthwise, with scissors. Place all the quarter pieces together into the (still empty) soft-bodied algae ID sample (50 mL centrifuge) tube. Push the clump of combined macroalgal specimens down into the sample tube, and flatten the top so that the volume of the clump can be estimated using the graduations on the tube. The estimated volume of this clump will be used in a calculation (see Equation 1 and Figure 13).

Step 5. Place the remaining three-quarters length of the cylinder(s) in a Whirl-Pak™ bag. Seal and label the bag and store it in the wet ice cooler.

Step 6. Once algal specimens have been removed from all the substrates (sand, gravel, cobble, wood, leaves) in the dish tub, according to the procedure described in Steps 1 and 2 at the beginning of Section 5.2, gently agitate the dish tub to suspend the microalgae in the liquid, and then start pouring this suspension into a clean graduated cylinder to measure the volume of the liquid. Try to leave all sediment (silt, sand) behind. Transfer the measured liquid into a clean 1L plastic bottle. Rinse the sediment once or twice until it appears that little to no additional suspended material (microalgae) is coming off because the rinsate is clear (or nearly clear). Add this rinsate to the graduated cylinder to measure it also. If necessary, repeat this process (regularly agitating the dish tub) until all the liquid has been measured and transferred to the sample bottle. *Note: use water sparingly, because the total sample volume plus rinsate should be no more than about 400-500 mL.* Because as much of the silt and sand as possible is being left behind, the final volume should ideally reflect only the liquid component of the sample. On the field sheet, under the Algae Samples section, record the total volume of all the liquid that had been in the dish tub, plus the water used for rinsing the substrates and sampling devices. This is the "**composite volume**". Record this value on *all* algae sample labels (biomass and taxonomic samples).

Step 7. Pour freshly-agitated liquid composite sample from the 1 L bottle into the soft-bodied algae sample tube (on top of the clump of macroalgae, if present) up to the 45 mL mark. If no macroalgal clumps had been collected during sampling, simply pour the liquid sample into the empty soft-algae sample tube to the 45 mL mark. Midway through pouring, swirl the composite sample some more (first clockwise, then counter-clockwise) to ensure that the microalgae are still fully suspended. Cap the tube tightly. Fill out a sample label and affix it to the sample tube. Cover the label completely with clear plastic tape to prevent the writing on the label from smearing. Place the tube in the wet ice chest to keep it in the dark and as cold as possible, but make sure it is never allowed to freeze.

Glutaraldehyde is necessary for fixing soft-bodied algae samples in order to preserve fine morphological features and pigment colors, as both can be crucial characters for taxonomic determination. *However, glutaraldehyde is a hazardous substance that poses a number of safety risks.* As such, it must be handled only in a fume hood, by trained personnel wearing appropriate protective gear. Refer to the Guidance Document for an SOP on handling glutaraldehyde.

To fix the soft-bodied algae sample: working under a fume hood, add glutaraldehyde to the tube to a final concentration of 2%. This can be achieved, for example, by adding 5 mL of 20% glutaraldehyde to 45 mL of sample. Distribute the glutaraldehyde throughout the sample by inverting the tightly closed tube repeatedly. Once the samples are fixed, they must be stored in the dark in a refrigerator. Wrap the tubes in foil, if necessary, to maintain darkness.

If no fume hood is available, arrangements should be made for the glutaraldehyde to be added to the samples by personnel with access to a hood (e.g., the taxonomy lab). In the meantime, the unfixed samples must be kept in the dark and on wet ice (but not allowed to freeze), and must be fixed within 96 hours of collection (and preferably sooner). Therefore, if the taxonomy laboratory or another party will be adding the fixative, it is imperative to plan ahead to arrange for this to be done in a timely manner, and also to clearly mark which tubes will need to have fixative added to them.

Step 8. In the field, after the (unfixed) soft-bodied algal sample has been prepared, and before preparing the diatom sample (and biomass samples, which will be discussed in the next steps), *if* a macroalgal clump had been present in the dish tub, then the volume of the remaining composite liquid must be reduced to equal ¾ of the original volume. This is necessary because ¼ of the macroalgal clump was taken out of the composite sample but a full ¼ was not removed from the liquid portion. As such, the original ratio between liquid and macroalgae must be restored before further sample preparation. The following procedure is used to reduce the volume of liquid composite to ¾ of the original. For convenience, the following formula (Equation 1) can be used to calculate how many mL to pour off and discard from the composite:

Equation 1. Adjusting the volume of composite sample. (Be sure to honor the rules governing algebraic "order of operations" in calculating the volume to pour off.)

volume (mL) of composite to pour off = (0.25 * C) – 45 + A

where "**C**" is the original composite volume and "**A**" is the approximate volume of the (combined) clump(s) of macroalgae placed in the soft-bodied algae sample tube (tamped down and flattened). A copy of the Ratio Restoration worksheet shown in Figure 14 can be used to calculate the amount of composite to pour off.

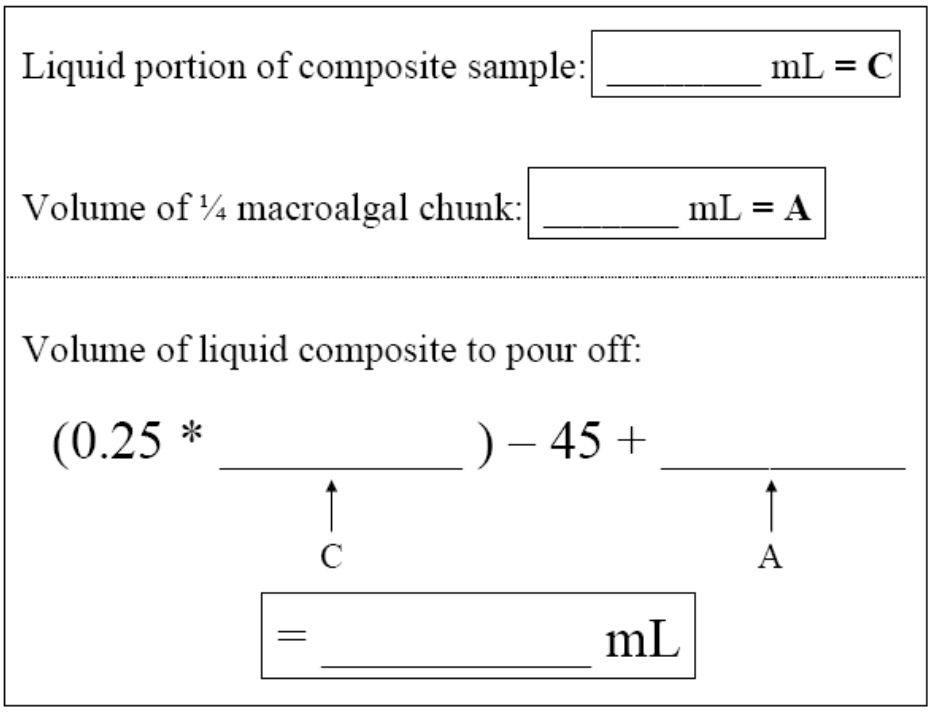


Figure 14. Ratio Restoration worksheet. Be sure to honor the rules governing "order of operations" in calculating the volume to pour off.

As always whenever pouring off aliquots, be sure to agitate the composite liquid adequately in order to resuspend any settled microalgae before pouring off the calculated volume.

Step 9. Once the required amount of composite liquid has been discarded, the remaining ¾ of the macroalgal cylinder (from the bag in the wet ice cooler) is cut with scissors into fine pieces (resulting in strands that are no more than ~3 mm long), and these are added to the reduced-volume composite liquid. The pieces should be chopped small enough so that they practically "blend" into the liquid such that distinct fragments of macroalgae are not easily discernible, because the goal is to "homogenize" the macroalgae into the liquid as much as possible. If a macroalgal clump was present in the dish tub, but no sample is to be prepared for analysis of the soft-bodied algal community, then ALL of the macroalgal clump should be finely chopped into the full volume of measured composite liquid. In this case, there would be no need to discard ¼

of the composite volume before introducing the (full amount of) chopped macroalgal into the liquid.

Step 10. After introducing the finely chopped macroalgae into the composite liquid, cap the composite bottle and agitate sufficiently to homogenize the tiny bits of algae into the liquid as much as possible, while not agitating so hard as to risk busting cells and releasing chl *a*.

Step 11. To prepare the diatom sample, aliquot 40 mL of freshly-agitated sample homogenate into the diatom ID sample tube, swirling the composite sample bottle again midway through pouring to keep the algae suspended. Add 10 mL of the 5% formalin to the sample (for a final concentration of 1%). *Fixatives such as formalin must be used with great care. Be sure to wear formalin-safe gloves and safety goggles when using the fixative, as it should never be touched with bare hands or allowed to splash onto skin or into eyes. Also make sure it is used only in a very well-ventilated place and avoid breathing in any fumes. Minimize the amount of time that vessels containing formalin are open. Fixative added to the sample must not be allowed to ooze outside the vessel that contains it, including the sample tubes.* Refer to the Guidance Document for instructions on preparing the buffered formalin solution and for an SOP on handling formalin.

Step 12. Cap the tube tightly and invert it several times to mix the formalin into the sample. Fill out a sample label and affix it to the sample tube. Cover the label completely with clear plastic tape to prevent the writing on the label from smearing. Keep the fixed diatom samples in the dark and away from heat. The remaining composite sample homogenate can be used to prepare the chl-*a* and AFDM filters as described below.

If no algal taxonomic data are required for the project at hand, and only biomass data are needed, finely chop *all* macroalgae (if present) directly into the *entire* volume of liquid (which must still be measured and recorded). Then proceed to Step 13.

Step 13. Now the biomass samples can be prepared. The procedure to filter chl *a* samples should be carried out quickly, and in the shade as much as possible, to minimize exposure of the sample to light/heat, thus minimizing chl *a* degradation. Use clean filter forceps to center a glass fiber filter (47 mm, 0.7 μm pore size) onto the mesh platform of a clean filtering apparatus, and rinse the filter a little with DI water to seat it well into the mesh before attaching the filter chamber on top. Never touch the filters with hands or anything other than clean forceps. Agitate the sample homogenate to resuspend all the macroalgal fragments and microalgal material. Measure 25 mL using a small, clean graduated cylinder. Midway through pouring the 25 mL, swirl the homogenate again to ensure that the material is still fully suspended. Pour the remainder of the 25 mL into the filter chamber. Once empty, rinse the graduated cylinder with a few mL of DI water, and add this to the filter chamber.

Step 14. To filter the sample, create a *gentle* vacuum with the hand pump. Be sure to proceed very slowly, and pump only one stroke at a time until all of the liquid in the sample is passed through the filter. *Pressure on the sample should never exceed 7 psi, as this could cause cells to burst and release contents, including chl a, into the filtrate and be lost.* If it becomes impossible to filter a whole 25 mL of the sample and remove the water efficiently, discard the filter and try

again with a smaller volume (*e.g.,* 10 mL). It is not necessary to collect on multiple filters to try to achieve a total volume of 25 mL. Simply filter as much as possible on a single filter, up to 25 mL, and then use that filter as the sample. Be sure to record the volume of the composite sample that was actually filtered, both on the datasheet, and on the sample label.

Rinse the sides of the filter chamber with a few mL of DI water, and continue filtering until the water is drawn down. The filter should not be sucked dry, but rather left slightly moist, in order to avoid applying excessive pressure to the sample, which could cause algal cells to burst. After all the liquid has passed through, check the filter to see if there are any bits of non-algal plant matter (like tiny seedlings or bits of leaves). If so, remove them with clean, pointed forceps, being careful not to remove any algae in the process. Remove the filter from the filtering device. Always thoroughly rinse the sides of the filter chamber and the interface between the mesh filter seating and the screw-on part of the apparatus with DI water between samples.

Step 15. Fold the filter in half (with the sample material on the inside, like a taco) using the forceps, and place it inside a clean, snap-top Petri dish. Envelope the Petri dish completely within a small sheet of aluminum foil in order to prevent any light from reaching the filter. Place the covered Petri dish and its corresponding, filled-out sample label (face outward) into a 100 mL Whirl-Pak™ bag, purge as much of the air out of the bag as possible, "whirl" it shut, and seal it tightly by twisting its wire tabs *together*, so that water in the cooler will not be able to enter the bag. Shove the sample packet down into the ice in the cooler to make sure it stays submerged and does not float to the top. This may be achieved by sealing the sample bags in a large Ziploc™ bag with a rock in it. Keep chlorophyll *a* filters as cold as possible and place them in the freezer (-80º, if available) or on dry ice as soon as possible (and within four hours of collection); the analytical holding time for the chl *a* filters is 28 days from collection, when kept frozen.

Step 16. For the AFDM samples, use glass-fiber filters (47 mm, 0.7 μm pore size) that have been pre-combusted[20]. Never touch the filters with hands or anything other than clean forceps. Follow the same process as that used for chl-*a* sample filtering. Record the volume filtered for the AFDM sample. Keep AFDM filters as cold as possible until the samples can be frozen back at the laboratory that evening, or place on dry ice until they can be stored in the laboratory freezer. The analytical holding time for the AFDM samples is 28 days from collection, when kept frozen.

[20] Check with the laboratory that will be analyzing the samples about obtaining pre-combusted filters.

6. PHYSICAL HABITAT TRANSECT-BASED MEASUREMENTS

After all biotic samples have been collected at a given transect, PHab data collection may begin. These data are designed to characterize a stream reach's physical habitat, knowledge about which can aid interpretation of the biotic data. In some cases, however, PHab data may be desired for a site assessment even when biotic/biomass samples are not being collected.

The majority of PHab measurements in this SOP are gathered relative to the 11 main transects (Figure 3), and data for the PHab parameters described in this section are entered on transect-specific field sheets (and in the case of the "Pebble Count" data, also on the inter-transect field sheets). PHab data collection starts at the downstream transect (Transect A) and proceeds working upstream along the monitoring reach. Some programs (*e.g.*, citizen monitoring efforts) may elect to collect a less-intensive subset of PHab data than the full suite described here. To this end, the Guidance Document provides suggestions for a "Basic" protocol.

6.1 Module C: Wetted Width and Bankfull Dimensions

Step 1. Measure the *wetted width* associated with the transect and record this (in meters) in the box at the top of the transect form. The wetted channel is the zone that is inundated with water and the *wetted width* is the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water (Figure 15). The wetted width can include emergent, unvegetated sandbars or boulders in the middle of a channel, but should not include emergent, vegetated "islands" (defined as features that are not flooded during average year high-water events). When a transect crosses an island, subtract the width of the island from the distance between the wetted margins.

Step 2. Scout beyond the wetted channel along the stream reach to identify the location of the *bankfull* margins on either bank by looking for evidence of annual or semi-annual flood events. The bankfull channel is the zone of maximum water inundation in a normal-flow year (i.e., one- to two-year flood events; see Figure 15 and the Guidance Document for a depiction of wetted width and bankfull dimensions). Because most channel-formation processes are believed to act when flows are within this zone (Mount 1995), bankfull dimensions provide a valuable indication of stream power during high-flow events and therefore relative size of the water body.

Examples of evidence for bankfull location include topographic, vegetation, and geologic cues (changes in bank slope, changes from annual to perennial vegetation, changes in the size distribution of surface sediments, location of water stains on concrete and bedrock channels, etc.). Although it is tempting to use the position of drift material caught in vegetation to identify bankfull location, it only indicates the discharge height during extreme recent flow events, and should not be used as an indicator by itself. Note that, perhaps more than any other component of PHab assessment, identification of bankfull location requires extensive experience in multiple ecoregions and stream types, and *training in the field under the supervision of experienced bioassessment practitioners is essential*.

It is helpful during the initial reach delineation to investigate the entire reach when attempting to interpret evidence for bankfull location, because the true bankfull margin may be obscured at various points along the reach. However, bear in mind also that bank dimensions may change in the middle of a sampling reach.

Step 3. Stretch a tape or stadia rod from bank to bank at the bankfull position along the transect. Record this distance (in meters) as bankfull width at the top of the transect form. If using flexible tape, make sure the tape is taut before taking a reading.

Step 4. Record bankfull height (in meters) as the vertical distance between the water surface and the height (Figure 15) of the bank at bankfull position. This can be done by standing at the wetted edge or transect center holding a meter stick vertically from the water surface to the stretched tape to measure the height.

Step 5. Carry out the above steps at each of the 11 main transects.

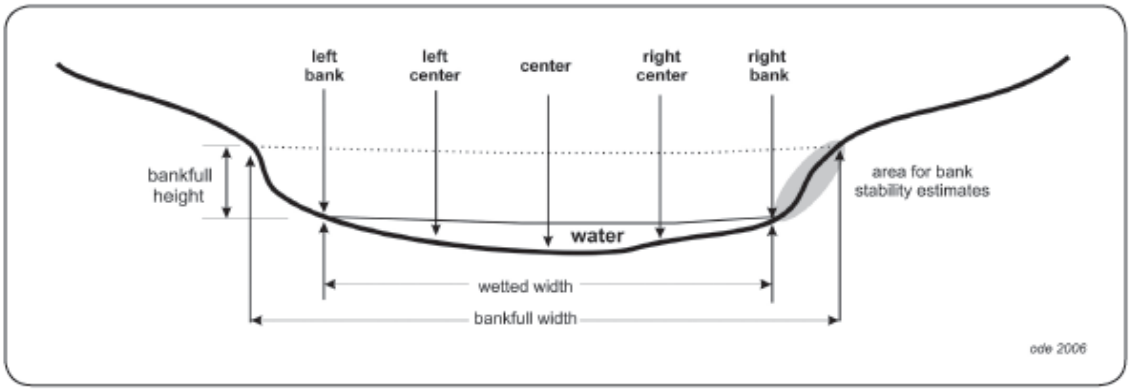


Figure 15. Cross sectional diagram of a typical stream channel showing locations of wetted and bankfull width measurements, substrate measurements, and bank stability visual estimates.

6.2 Module D: Substrate Size, Depth, and Coarse Particulate Organic Matter (CPOM)

Particle size frequency distributions often provide information about instream habitat conditions that affect BMI distributions, and may also reflect the stream's ability to accrue algal biomass. Changes in particle size distributions often accompany stream disturbances, and may be a key source of stress to benthic organisms.

The Wolman "pebble count" technique (Wolman 1954) is a widely used and cost-effective method for estimating the particle-size distribution that produces data that correlate with costly, but more precise, bulk-sediment samples. The method described here follows the NRSA protocol (which is a version of the Wolman count) and records sizes of 105 particles in a reach: five particles, equidistant from one another, along each of the 11 main transects and 10 inter-transects. Depth refers to the depth of surface water in the stream at each of these points. Coarse particulate organic matter (CPOM; small particles of organic material, such as leaves/twigs, that are >1 mm in size, but no larger than 10 mm) is an indicator of the amount of allochthonous

organic matter available at a site. Because CPOM is food resource for certain benthic macroinvertebrates, its abundance can provide information about the quality of the food web in a stream reach. Pebble count, depth, and CPOM are all measured in tandem at each of the 105 points along the sampling reach.

Step 1. At each transect (and inter-transect), use a stadia rod or tape measure to divide the wetted stream width by four to get the distance between the five points (Left, Left Center, Center, Right Center and Right; Figure 15) and locate the positions of these points along the transect. Once the positions are identified, lower a graduated rod (e.g., a waterproof meter stick) straight down though the water column to identify the particle located at the tip of the rod

Step 2. Measure the depth from the water surface to the top of the particle with the graduated rod and record to the nearest cm.

Step 3. Record the presence or absence of CPOM within 1 cm from the edge of the rod.

Step 4. Remove the particle from the streambed and measure and record the length of its intermediate axis (Figure 16) to the nearest mm. Actual measurements should always be recorded, whenever possible (i.e., for the fine gravel through large boulder-sized bed materials). If a direct measurement is impossible (e.g., the particle is deeply embedded or in a deep pool), an approximate size may be designated by assigning a particle size classes listed in Table 4 based on visual estimation. Regardless of the method, all particles < 0.06 mm should be recorded as fines, and all particles between 0.06 mm and 2.0 mm recorded as sand. “Wood” applies to woody material, living or dead. “Hardpan” applies to consolidated fines, where individual particles cannot be easily separated or dispersed. Substrates (e.g., trash, macrophytes, live tree roots, and any other substrate not captured by the other available categories) that do not fall into any of the categories should be recorded as “other” (OT).

Record particle measurement (or size class) on the transect sheet under “mm/size class” in the “Transect Substrates” portion of the form. If recording particle size class, use only the standard codes in Table 4 to record the information.

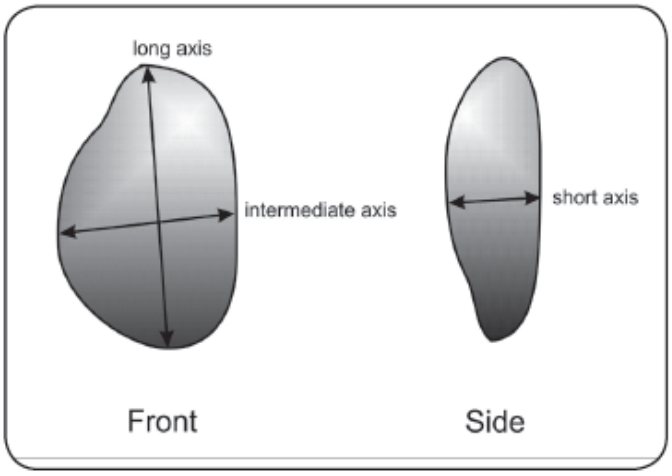


Figure 16. Diagram of three major perpendicular axes of substrate particles. The intermediate axis is recorded for pebble counts.

Table 4. Particle size class codes, descriptions, and measurements. SWAMP requires that actual measurements be recorded, whenever possible (i.e., for the fine gravel through large boulder-sized bed materials).

Size Class Code	Size Class Description	Intermediate Axis Common Size Reference	Size Class Range
RS	bedrock, smooth	larger than a car	> 4 m
RR	bedrock, rough	larger than a car	> 4 m
RC[21]	concrete/ asphalt	larger than a car	> 4 m
XB	boulder, large	meter stick to car	1 - 4 m
SB	boulder, small	basketball to meter stick	250 mm - 1 m
CB	cobble	tennis ball to basketball	64 - 250 mm
GC	gravel, coarse	marble to tennis ball	16 - 64 mm
GF	gravel, fine	ladybug to marble	2 - 16 mm
SA	sand	gritty to ladybug	0.06 - 2 mm
FN	fines	not gritty	< 0.06 mm
HP	hardpan (consolidated fines)		< 0.06 mm
WD	wood		
OT	other		

Step 5. If the particle is cobble-sized (64 - 250 mm diameter), record to the nearest 5% the percent of the cobble surface that had been embedded by fine particles (< 2 mm diameter; see Cobble Embeddedness measurement procedure, Section 6.3, below).

[21] Only continuous sections of concrete (e.g., concrete channel) should be coded as "RC". Concrete agglomerations smaller than 4 m should be treated as a single particle, and measured accordingly.

Sometimes points with dry (not submerged or moist) substrates are encountered during the course of PHab data collection along transects/inter-transects. To determine how to collect data at dry sampling points, it is necessary to first establish whether the dry area in question lies within the stream's active channel (i.e., therefore regularly inundated during storms), or whether the point is on a stable island (i.e., therefore rarely, if ever, inundated). Stable islands are typically vegetated, often with woody shrubs or trees, and have heights near or exceeding bankfull height. Pebble counts should not be conducted on stable islands. If the transect spans a portion of the study reach in which the channel is bifurcated such that there are two channels with an intervening island, the entire transect should be placed across the dominant channel, and all five pebble count points should be located on that side.
If the point falls on a dry surface that is within the usual active channel (i.e., subject to regular disturbance by flows), then pebble count and primary-producer cover data from the dry point should be recorded as follows:

- score Depth as 0
- score Particle Size/Class and Embeddedness as described above for wet particles
- score all the algae variables (Microalgae, Macroalgae Attached, and Macroalgae Unattached), as well as Macrophytes and CPOM, as "D" for "dry"

Ordinarily, the sampling transect would span the wetted width of the channel, but when no water is present at a given transect, evidence of the typical wetted extent of the active channel will need to be used to infer appropriate transect boundaries. Such indicators can include the transition from vegetated to unvegetated area (i.e., moving from banks toward the active channel), as well as the presence of dried algae, water stains, micro-topographic transitions, changes in substrate composition, soil cracks, and others.

6.3 Module E: Cobble Embeddedness

The degree to which fine particles fill interstitial spaces in the streambed has a significant impact on the ecology of benthic organisms and fish, but techniques for measuring this impact vary greatly (this is summarized by Sylte and Fischenich 2002, http://stream.fs.fed.us/news/streamnt/pdf/StreamOCT4.pdf). Here we define embeddedness as the percent of the surface area (not volume) of cobble-sized particles (64 - 250 mm) that is buried by fines or sand particles (< 2.0 mm diameter). Ideally, at least 25 cobbles are assessed for embeddedness in each sampling reach: Embeddedness is determined for each cobble that is measured for particle size, up to a total of 25 cobbles. If < 25 cobbles are encountered during the pebble count, the remainder are "made up" by assessing cobbles that lie outside of the PHab data collection transects (see Step 3, below). In certain streams, it may not be possible to find 25 cobbles.

Step 1. Every time a cobble-sized particle is encountered during the pebble count, remove the cobble from the stream bed and visually estimate the percentage of the cobble's surface area that had been buried by fine particles. If removal of the cobble is impossible, approximate embeddedness to the best extent possible. In the rare circumstances that multiple sample points

land on the same cobble, do not take a second embeddedness measurement. Once embeddedness has been assessed for 25 cobbles, no more need be assessed.

Step 2. Record the embeddedness values for the first 25 cobble-sized particles encountered during the pebble count in the "% Cobble Embed" field in the "Transect Substrates" portion of the transect sheet.

Step 3. If 25 cobbles are not encountered during the pebble count by the time Transect K has been sampled, supplement the data by conducting a "random walk" [22]. Starting at a random point in the reach, follow a line from one bank to the other at a randomly chosen angle, recording embeddedness of any cobbles encountered (that were not previously recorded) along the way. Upon arriving at the other bank, reverse the process with a new randomly chosen angle. Spend a maximum of 10 minutes on the random walk, even if 25 cobbles have not been encountered by that time. Embeddedness for any cobbles encountered outside of the pebble count locations should be recorded in the "Additional Cobble Embeddedness" section of the field sheets.[23]

6.4 Module F: Algal and Macrophyte Cover

Algal cover refers to the amount of algae in the stream reach, both in terms of 1) microalgal coatings ("slimy-ness") on stream substrates and 2) macroalgae (*e.g.*, filaments, mats, globules)[24]. It is a reflection of stream primary production and has implications for the health of food webs as well as the damaging effects of eutrophication stimulated by excess nutrients in concert with other environmental co-factors (e.g., loss of canopy cover).

Algal cover is estimated by a point-intercept approach that entails collecting information about the presence/absence of both types of algae (as well as thickness, for the microalgae) at each of the 5 points along the transects associated with the pebble count. If the point corresponding to each pebble in the pebble count intercepts algae, then algae is recorded as "present" at that point.

Step 1. For each point along the pebble count, record information about algae as follows. For any film-like coating of algae (referred to as "Microalgae" on the datasheet) present on the surface of the substrate at that point, estimate the presence / thickness category according to the scheme in Table 4. For thicker microalgal layers, a small ruler can be used for measurement. For layers too thin to measure, use the indicators listed in the last column of Table 4. Note that these thickness codes refer only to microalgal film, not macroalgal mats (macroalgal thickness is not assessed in this protocol).

[22] It is preferable to wait until the rest of the PHab transect/inter-transect measures are complete before doing this, so as not to trample any as-yet unsampled transects in the course of the random walk.
[23] An easy way to ensure that 25 embeddedness measurements are taken is to put an X in one of the boxes on the first data sheet each time a cobble is encountered during normal transect measurements. Then, after all transects are complete, fill in the remaining boxes with embeddedness estimates.
[24] Refer to the glossary for comprehensive definitions of microalgae and macroalgae and the Guidance Document for photos

Be sure to collect microalgal thickness data from whatever substrate is topmost within the stream, and therefore is most likely to be exposed to sunlight. Sometimes this substrate is not the actual pebble used in the pebble count, but rather a substrate type that occurs above the pebble, such as a thick mat of macroalgae that is above (and obscuring) the stream bottom. Microalgal species can grow as epiphytes upon macroalgal filaments and mats, coating them with a slimy, brown-tinted film. The Guidance Document provides some additional information to help distinguish between microalgae and macroalgae.

Table 5. Microalgal thickness codes and descriptions (modified from Stevenson and Rollins 2006).

Code	Thickness	Indicators
0	No microalgae present	The surface of the substrate is not at all slimy.
1	Present, but not visible	The surface of the substrate feels slimy, but the microalgal layer is too thin to be visible.
2	<1mm	Rubbing fingers on the substrate surface produces a brownish tint on them, and scraping the substrate leaves a visible trail, but the microalgal layer is too thin to measure.
3	1-5mm	
4	5-20mm	
5	>20mm	
UD	Cannot determine if a microalgal layer is present	(see explanation in text)
D	Dry point	

Sometimes, due to the nature of the substrate, it can be difficult to discern whether a microalgal layer is present. For example, deposits of very fine sediments might obscure the diagnostic color of a microalgal layer, and the slipperiness of very fine silt may make tactile determination of microalgae impossible. If presence/absence of a microalgal layer cannot be determined with confidence, score microalgal thickness as "UD".

Step 2. In addition to recording the presence and thickness of microalgae on the surfaces of substrates, record the presence/absence of attached macroalgae in the water column, as well as unattached, floating macroalgal mats on the water's surface, corresponding to each pebble count sampling point. Do this by envisioning an imaginary line extending from the water's surface down to the stream bottom where the target pebble lies (particularly in turbulent water, it may be helpful to use a viewing bucket (Guidance Document) in order to see below the water's surface). If this line intercepts macroalgae, either floating on the water's surface, or somewhere within the water column, the appropriate algal class(es) should be recorded as "present". Attached macroalgal filaments have an obvious, current, physical connection to something (like a cobble, boulder, or a gravel bed) lying on the bottom of the stream, whereas for unattached macroalgae, there is no obvious physical connection with the streambed at the time of the assessment, and the algae is freely floating at or near the water's surface. The data-collection point does not need to intercept attached algae at its point of attachment in order for it to be scored as "Attached"; all that is required is for the algae to be attached to the streambed somewhere, even if the attachment occurs far from the sample point. For each class of macroalgae (Attached and Unattached), mark

"P" (for "present") if intercepted by the sampling point and "A" (for "absent") if not intercepted.[25]

If any portion (above- or underwater) of a macrophyte is intercepted by the imaginary line associated with the pebble count point, mark "P" for "present" under "Macrophytes". Otherwise, mark "A" for absent. Macrophytes are defined as herbaceous, vascular plants rooted or floating within the stream's wetted channel, such as sedge, cattail, knotweed, *Arundo donax*, watercress, water-primrose, duckweed, etc. Our definition of aquatic macrophytes excludes trees, root mats, shrubs, mosses, and algae. This is the same as the definition of macrophytes used for Module J (Instream Habitat Complexity).

6.5 Module G: Bank Stability

The vulnerability of stream banks to erosion is often of interest in bioassessment because of its direct relationship with sedimentation. For each transect, record a visual assessment of bank vulnerability along an imaginary line between the wetted width and bankfull width of the stream channel (Figure 15)[26]. Choose one of three vulnerability states: *eroded* (evidence of mass wasting), *vulnerable* (unprotected banks), or *stable*. All three states may be evident in a single reach at both natural and highly modified streams. The following indicators help describe the states:

- Eroded: Exposed tree roots, obvious bank slumps, fallen trees.
- Vulnerable: Sparse vegetation
- Stable: Bank armoring, robust vegetation, few exposed tree roots

6.6 Module H: Human Influence

The influence of human activities on stream biota is a central question in bioassessment analyses. Quantification of human activities is used to evaluate stress and to identify minimally disturbed reference sites. Reach-scale observations provide a crucial supplement to data provided by aerial imagery and GIS analysis.

Anthropogenic features and activities associated with each main transect (for a distance of 5 m upstream and 5 m downstream from the transect, totaling a width of 10 m centered on the transect; Figure 17) are recorded in terms of zones based on how close they are to the wetted margins.[27] The area in which human influence is measured extends outward 50 m in both directions from the bank along the entire reach.

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[25] Because pebble counts span the "wetted width" of each transect, pebbles at the margin positions will often be at least moist, and sometimes even submerged. As such, it is important to realize that algal cover can occur at the bank positions of the pebble count as well as intermediate positions across the stream. Algal cover should therefore be recorded at all five observation points along each transect.

[26] Note that sandbars are not considered part of the bank.

[27] The relative distance between the wetted and bankfull margins can complicate the assessment of human influence. If the wetted edge and the bankfull margin are at the same point, then land uses between the wetted edge and bankfull margin are not present, and that location cannot be scored. Conversely, in some streams, the bank and the wetted edge may be many meters apart. In that situation, the wetted edge should be used as a consistent point for defining the area.

For each human disturbance feature/activity class, circle “Y” if it is present between the wetted margins; otherwise, circle “N”, and then assess each side of the stream as follows: If the feature/activity is present between the wetted edge and bankfull margin, circle “B”; if it is outside within 10 m of the bank circle “C”; if it is within 50 m of the bank, circle “P”; otherwise, circle 0. The relative distance between the wetted and bankfull margins can If the wetted edge and the bankfull margin are at the same point, then land uses between the wetted edge and bankfull margin are not present, and that location cannot be scored. Conversely, in some streams, the bank and the wetted edge may be many meters apart. In that situation, the wetted edge should be used as a consistent point for defining the area.

For each feature/activity, the most proximal category takes precedence and therefore is the distance at which that feature/activity should be scored. For example, if a feature/activity is observed within the channel, as well as on the banks, circle “Y” to denote the channel, and move on to scoring the next feature/activity class. Note that certain features (e.g., parks) are not applicable within the channel, and for these, “B” would represent the most proximal location possible.

Table 6 provides definitions of Human Influence features/activities. Circle only the closest location for each impact that applies, being careful not to double-count any human influence observations. [28]

[28] Double counts are prevented by SWAMP electronic forms.

Table 6. Definitions of Human Influence features/activities.

Feature/Activity	Description/Indicators
Walls/Rip-rap/Dams	Artificial stone, concrete, or cement structures that are built into the stream, including check dams
Buildings	(self explanatory)
Pavement/Cleared lot	Vacant land with disturbed soil or ruderal vegetation, or paved
Roads or Railroads	Includes unpaved roads and high use trails
Pipes (inlet/outlet)	A physical structure discharging into, or withdrawing from, the stream; does not need to be active and can include pipes within the banks
Landfill/Trash	Garbage; can include large, stable (e.g., cars) items, as well as ephemeral (candy wrappers)
Park/Lawn	Managed active or passive recreation areas; often irrigated.
Row crops	Agricultural fields; generally includes annual crops that are replanted each season or year
Pasture/Range	Areas where cattle, sheep, or other livestock are actively grazed; evidence includes manure, hoof prints, terracing of hillslopes, and reduced vegetation
Logging operations	Places where trees are cut down; evidence includes stumps, clearcuts, woodchips, slash, flumes
Mining activity	Tailings, borrow-pits, spoils, prospecting mines, sluices
Vegetation Management	Removal or reduction of vegetation for purposes (e.g., flood control, fuel reduction) other than logging; lawn maintenance should be covered under park/lawn
Bridges/Abutments	(self explanatory)
Orchards/Vineyards	Agricultural fields with woody vegetation that is infrequently replanted

6.7 Module I: Riparian Vegetation

Riparian vegetation has a strong influence on the composition of stream communities through its roles in directly and indirectly controlling the food base, moderating sediment inputs, and acting

as a buffer between the stream channel and the surrounding environment. These methods provide a cursory survey of the condition of the riparian corridor[29]. Observations are made in the same 10 m x 10 m riparian area, on either side of the wetted channel, used for assessing human influence "C" zone (Figure 17).

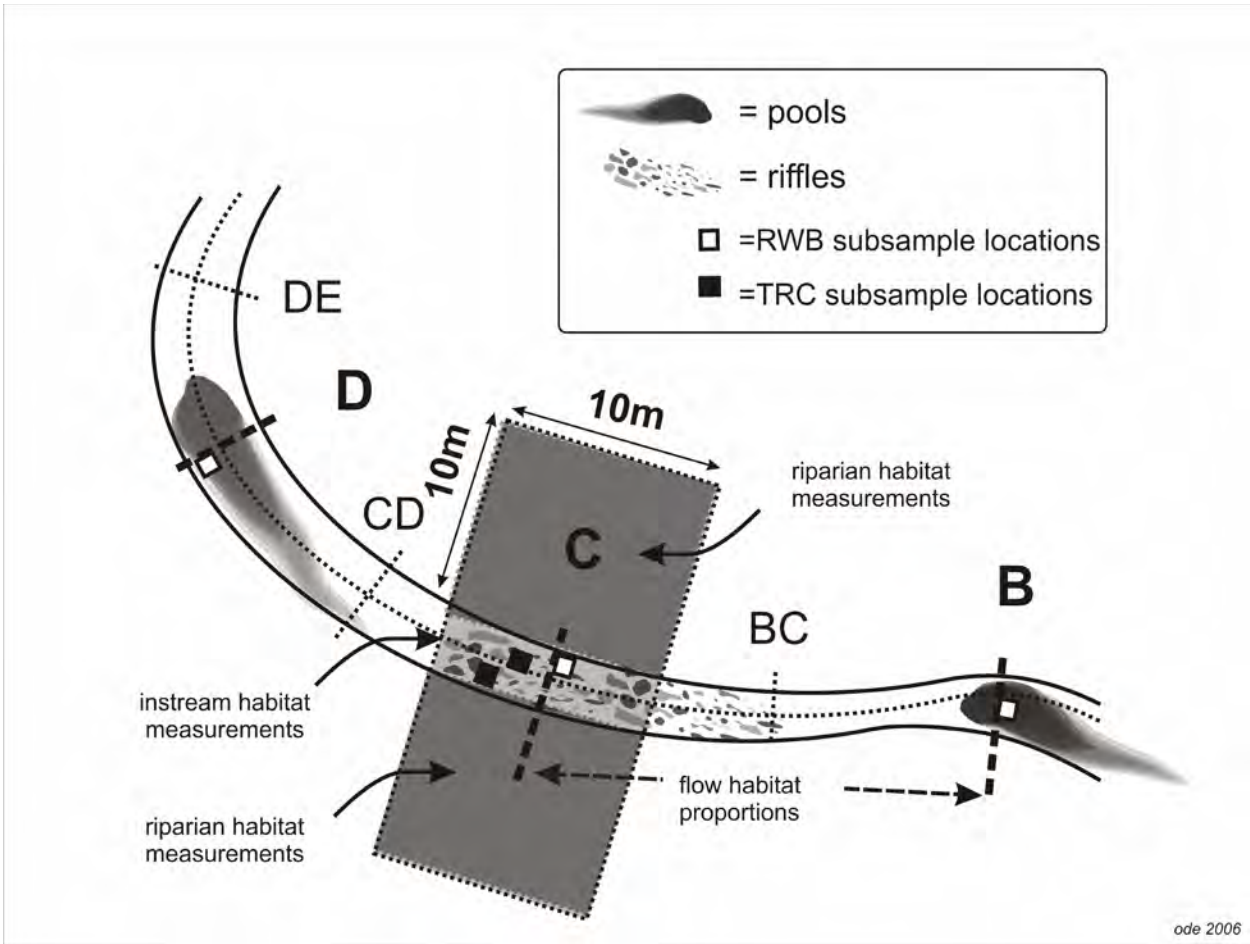

Figure 17. Section of the standard reach expanded from Figure 1 showing the appropriate positions for collecting riparian habitat and flow habitat proportion measurements. Also shown here is the human-influence zone corresponding to the area within 10m of the wetted width (i.e., zone "C").

Step 1. Mentally divide the riparian area into three elevation zones relative to the ground surface:

- Ground cover (< 0.5 m high)
- Lower canopy (0.5 m - 5 m)
- Upper canopy (> 5 m).

Within each zone, record the density of the following riparian classes:

[29] Programs may want to consider adding the California Rapid Assessment Method for wetlands (CRAM; http://www.cramwetlands.org/) to their stream bioassessment data collection efforts in order to obtain more comprehensive information on riparian condition of monitoring sites.

- Upper Canopy: Trees and Saplings
- Lower Canopy: Woody Shrubs and Saplings
- Ground cover:
    - Woody Ground Cover
    - Herbaceous Ground Cover
    - Barren, Bare Soil and Duff (artificial banks, rip-rap, concrete, asphalt, etc. should be recorded as "barren").

An individual plant may contribute to multiple elevation zones. However, low-hanging canopy vegetation should not contribute to groundcover.

Step 2. Indicate the areal cover (i.e., shading) by each riparian vegetation class as either: 1) absent, 2) sparse (< 10%), 3) moderate (10-40%), 4) heavy (40-75%), or 5) very heavy (> 75%).

Each of the elevation zones (upper canopy, lower canopy, and ground cover) should be evaluated independently of the others. All together, they do not need to total to 100%. However, the total for the three ground cover categories (Woody Ground Cover; Herbaceous Ground Cover; Barren, Bare Soil and Duff Ground Cover) should equal 100%.

6.8 Module J: Instream Habitat Complexity

The instream habitat complexity measure was developed by the EMAP program to quantify fish concealment features in the stream channel, but it also provides valuable information about the general condition and complexity of the stream channel for other fauna. Estimates should include only those features that are found between the stream's wetted margins.

Record the category (Table 7) best approximating percentage of areal cover of nine different instream (wetted channel) features within a zone 5 m upstream and 5 m downstream of the transect (Figure 17).Indicate the areal cover of each feature as either: 1) absent, 2) sparse (< 10%), 3) moderate (10-40%), 4) heavy (40-75%), or 5) very heavy (> 75%). Note that the sum of the percentages of the different features does not necessarily need to equal 100%.

Table 7. Instream Habitat Complexity components and descriptions.

Component	Description and Comments
Filamentous algae	• Visible growths of macroalgae. • Do not include non-filamentous macroalgae (e.g., *Nostoc* spp.)
Aquatic macrophytes and emergent vegetation	Herbaceous plants rooted or floating within the stream's wetted channel, such as sedge, cattail, knotweed, watercress, water-primrose, duckweed, etc.; our definition of aquatic macrophytes excludes trees, shrubs, mosses, and algae
Boulders	Intermediate axis ≥ 25 cm (Figure 16)
Small woody debris	< 30 cm diameter
Large woody debris	≥ 30 cm diameter
Undercut banks	• Banks providing sufficient cover for an item at least the size of a fist. • Estimate as an areal (not linear) feature: % of streambed area covered by undercut banks.
Overhanging vegetation	• Vegetation within 1 m of the surface of the water. • Estimate as an areal (not linear) feature: % of streambed area covered by overhanging vegetation.
Live tree roots	(self-explanatory)
Artificial structures	• Any items with an anthropogenic origin. • In concrete channels, do not count the channel itself. • In restored channels, do not count natural items introduced as part of restoration activities (e.g., root wads) • Include stable trash items (e.g., cars, tires, shopping carts) expected to remain in place after a typical storm, but do not include ephemeral trash items (e.g., soda cans, candy wrappers, diapers)

6.9 Module K: Stream Shading (Densiometer Readings)

The amount of sunlight that can reach the stream is important because it influences stream temperature as well as primary productivity, which in turn affects food webs and constrains eutrophication. Using a convex spherical densiometer, stream shading is estimated in terms of percent cover of objects (vegetation, buildings, etc.) that block sunlight. The method described uses the Strickler (1959) modification of a densiometer to correct for over-estimation of stream shading that occurs with unmodified readings. Taping off (Figure 18) the lower left and right portions of the mirror emphasizes overhead structures over foreground structures (the main source of bias in stream shading measurements).

The densiometer is read by counting the number of line intersections on the mirror that are obscured by overhanging vegetation or other features that prevent sunlight from reaching the stream. All densiometer readings should be taken at 0.3 m above the water surface, and with the bubble on the densiometer leveled. The densiometer should be held just far enough from the squatting observer's body so that his/her forehead is just barely obscured by the intersection of the two pieces of tape, when the densiometer is oriented so that the "V" of the tape is closest to the observer's face.

Take and record four 17-point readings from the center of each transect: a) facing upstream, b) facing downstream, c) facing the left bank, d) facing the right bank. The observer should revolve around the densiometer (i.e., the densitometer pivots around a point) over the center point of the transect (as opposed to the densiometer revolving around the observer).

For sites with a mean wetted width > 10 m, two additional readings must be taken: one at the left bank and one at the right, standing at the water's edge and facing away from the stream, toward the floodplain. These additional readings are useful in the case of larger streams and rivers, where the center of the channel does not provide adequate information about the degree to which shading is affecting the stream. For smaller streams, these additional two measures are recommended, but optional.

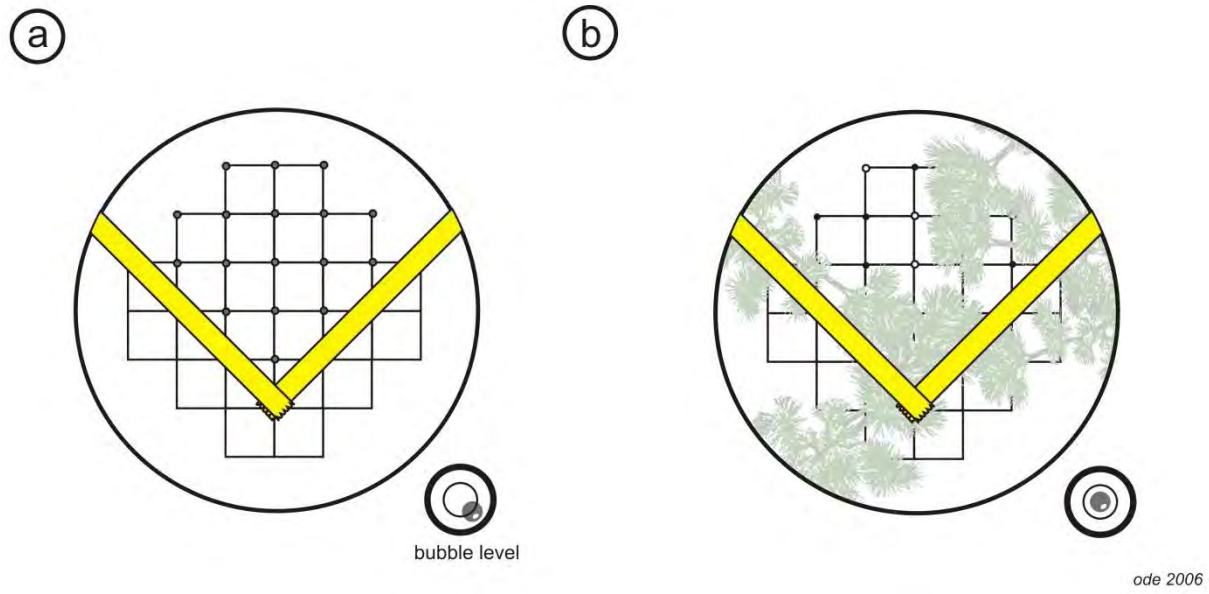

Figure 18. Representation of the mirrored surface of a convex spherical densiometer showing the position for taping the mirror and the intersection points used for the densiometer reading. The score for the hypothetical condition in (b) is 9 covered intersection points out of 17 possible (within the "V" formed by the two pieces of tape). Note the position of the bubble in (b) which indicates that the densiometer is leveled, as opposed to (a), which indicates it is not leveled.

6.10 Module L: Slope and Sinuosity

The slope of a stream reach is one of the major stream classification variables, being a primary determinant of potential water velocities and stream power, which are in turn important controls on aquatic habitat and sediment transport within the reach. The slope of a stream reach is often strongly correlated with many biotic metrics and other PHab measures, and is therefore very useful when interpreting biotic data.

The "Full" PHab method described in this SOP uses transect-to-transect measurements to calculate the average slope through a reach. Although this is more time-intensive than the reach-scale transect measures outlined in the "Basic" protocol (see Guidance Document), it results in more precise slope determination and affords the ability to quantify slope variability within a reach. Sinuosity (calculated as the ratio of the length of the flow path between the ends of the reach and the straight line distance between the ends of the reach; Kaufmann et al. 1999) is measured at the same time as slope. These two measurements work best with two people: one taking the readings at the upstream transect ("backsighting") and the other holding a stadia rod at the downstream transect (Figure 19).[30]

In small, highly sinuous or densely vegetated streams, it may not be possible to obtain a clear line of sight from one transect to the next. If the midpoint of the next transect is not visible from the starting point, divide the inter-transect distance into sub-sections, using the "Supplemental Sections" (indicating the proportion of the total length represented by each section) on the field sheet. Otherwise, leave Supplemental Sections blank. Do not measure slope across dry land/meanders in the stream.

[30] Slope measurements can be measured from a point on the transect at water's edge, but sinuosity measurements should be taken from mid channel. If water depth or obstructions prevent this, attempt to estimate the correct bearing.

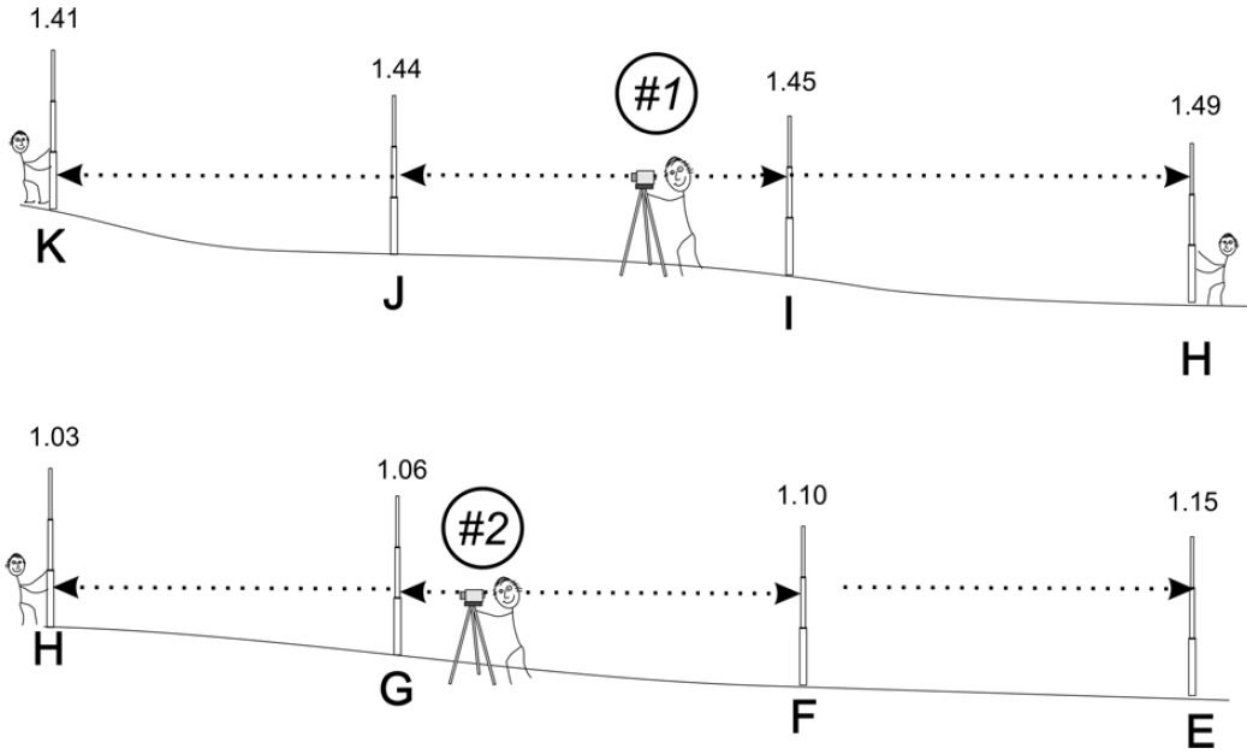

Figure 19. Use of an autolevel to measure slope of sampling reach.

Although slope and sinuosity are measured independently, always record the two data points at each location.

An autolevel should always be used for reaches with a slope of ≤ 1. Either a clinometer or an autolevel may be used for reaches with a slope of > 1%, and sometimes (*e.g.*, in steep areas that are also heavily vegetated) a clinometer is preferable for logistical reasons. If a reach is visually estimated to be close to 1%, use the autolevel. An autolevel or hand level measures the elevation difference (rise) between transects; the distance between transects (run) is also required for a slope calculation. Conversely, if a clinometer is used, the percent slope is recorded directly.

Do not measure slope across dry land (e.g., across a meander bend).

6.10.1 Slope - autolevel method

Step 1. Identify a good spot to set up the autolevel (ideally near the middle of the reach, if there is good visibility from this location to both Transects A and K). The autolevel should be positioned on stable, and preferably flat, ground. Set the height of the autolevel to comfortable eye level for the operator. Level the plane of view of the autolevel by centering its bubble. Start by adjusting placement and length of the tripod legs, and then fine-tune the adjustment using the knobs on the autolevel.

Step 2. Begin "shooting" the change in elevation of the water level of the stream from transect to transect. Try to start with one of the outer transects (like K)[31]. Have a crew member at Transect K hold the stadia rod at water's edge and perpendicular to the ground. Viewing through the autolevel (and focusing as necessary), look at the stadia rod and record, to the smallest demarcation on the stadia rod, the height at which the autolevel line of view (*i.e.*, the middle line in the viewfinder) hits. Record this information on the "Slope and Bearing Form" on the field sheet[32], and then have the stadia rod holder proceed to the next transect (*e.g.*, Transect J), again holding the base of the stadia rod at water's edge. Very carefully, rotate the head of the autolevel so that it points to the new stadia rod location. If executed correctly, the bubble should still be centered while in this new orientation, without any further height adjustments to the autolevel or tripod. If the autolevel is displaced from its original position, it will no longer be possible to take a height measurement of Transect J's water surface, relative to that of Transect K, to determine the slope between the two transects. In this case, the elevation must be measured anew (see Step 3).

Step 3. If there is a point along the reach at which there is no longer a clear line of sight from the autolevel to the stadia rod positioned at the transect, at water's edge (or if the length of the stadia rod is exceeded in a steep reach, or if the autolevel is bumped out of position before all the measurements are done), a new location must be set up for the autolevel. In order to maintain a relationship with water heights of the various transects already measured, it will be necessary to "re-shoot" the height of the water at the last transect for which a valid measurement was attained. From there, assuming there is no more disturbance to the position of the autolevel, the remaining transects can be sighted from the new position. On the Slope and Bearing Form corresponding to autolevel use, indicate the transect at which the autolevel's position has been changed (i.e., list the transect that was measured from the original and the new positions twice on the datasheet: once for the original position, and once for the new).

Also indicate the segment lengths or distance between main transects (*i.e.*, 15 m, 25 m or other). These data will later be used to determine the slopes between transects and for the reach as a whole.

6.10.2 Slope - clinometer method

Step 1. Stand erect next to the stadia rod (held perpendicularly to the ground) on level ground and a tie a highly visible piece of flagging around the rod at eye level. Then, beginning with the upper transect (Transect K), stand where the wetted margin intersects with the transect, and have a second person hold the flagged stadia rod perpendicularly to the ground at the wetted margin of the next downstream transect (Transect J).

Step 2. Use the clinometer to measure the percent slope of the water surface between the upstream transect and the downstream transect by sighting to the flagged position on the stadia

[31] It does not matter if the measurements of slope and/or elevation difference are determined starting at the upstream or downstream end of the reach, but they must be reported as positive numbers.

[32] Only the elevation difference (cm) will be recorded in the database. "Raw" stadia rod readings can be written on the hard copy sheets for reference and calculations but they will not be stored in the database.

rod, and record the value in the "Slope and Bearing Form" section of the field sheets. The clinometer gives both percent slope and degree of the slope (the measurements differ by a factor of ~2.2), so be careful to read and record ***percent slope*** rather than degrees slope. Percent slope is read from the scale on the right hand side when looking through most clinometers (but confirm this with the owner's manual for your own model).

Step 3. Continue measuring slope at each one of the transects. Note that when moving from transect to transect, the clinometer reader must stand exactly where the stadia rod had been placed during the previous reading.

Step 4. If the stream reach geometry makes it difficult to sight a line between transects, divide the distance into two or three sections and record the slope and the proportion of the total segment length between transects for each of these sections in the appropriate boxes on the slope form ("Supplemental Segment").

6.10.3 Sinuosity

Step 1. Take a compass reading from the center of each main transect to the center of the next main transect downstream and record this bearing to the nearest degree in the "Slope and Bearing Form" section of the field sheet. Bearing measurements should always be taken from the upstream to downstream transect.

Step 2. Proceed downstream to the next transect pair (I-J) and continue to record slope and bearing between each pair of transects until measurements have been recorded for all transects.

6.11 Module M: Photographs

Take a minimum of four (4) photographs of the reach at the following locations: a) Transect A, facing upstream, b) Transect F, facing upstream, c) Transect F, facing downstream, and d) Transect K, facing downstream. It is also desirable, albeit optional, to take a photograph at Transect A, facing downstream and Transect K, facing upstream to document conditions immediately adjacent to the reach. Use digital photographs. Record the image numbers on the front page of the field form under "Photographs". An easy way to keep track of which site each series of photographs belongs to is to take a close-up of the front data sheet (containing legible station code and date) for that site prior to taking the series of photos.

7. PHYSICAL HABITAT INTER-TRANSECT-BASED MEASUREMENTS

Although most measures are taken near the main transects, a few measures are also recorded at the "inter-transects" located at the midpoint between main transects. These measures are: 1) Wetted Width, 2) Substrate Measurements ("Pebble Count")/Depth/CPOM/Cobble Embeddedness/Algal and Macrophyte Cover, and 3) Flow Habitats.

7.1 Module C (part two): Inter-transect Wetted Width

Measure wetted width the same way it was measured for the main transects.

7.2 Modules D, E, and F (part two): Substrate Measurements, Depth, CPOM, and Algal/Macrophyte Percent Cover

Collect particle size measurements, water depth, CPOM, embeddedness and algal and macrophyte cover data the same way they were collected for the main transects.

7.3 Module N: Flow Habitats

Because many BMIs and algae prefer specific flow and substrate microhabitats, the proportional representation of these habitats in a reach is often of interest in bioassessments. Like the riparian and instream PHab measures, this procedure produces a semi-quantitative measure consisting of 10 transect-based visual estimates. A description of flow habitat types used for this SOP is provided in Table 7. These flow habitat types are products of geology, slope, and discharge, and one habitat type may change into another as water levels increase or decrease; therefore, the habitat types should be recorded at the time of sampling.

On the inter-transect field sheet, record to the nearest 5% percentages of the various flow habitats present within the region between the upstream inter-transect and downstream inter-transect bracketing each main transect (the total percentage of flow habitats for each stream section must total 100%). Although these definitions differ from geomorphological definitions presented in other hydrologic references, they were developed to produce more easily standardized and objective categories that improve data comparability. Please adhere to the definitions used in this text when employing this SOP.

Table 7. Flow habitat types

Type	Description
cascade/falls	Short, high-slope drops in stream bed elevation often accompanied by boulders and considerable turbulence. In high-slope streams, cascades and falls are often associated with step-pools. To qualify for this category, water must drop > 0.5 m in height within a short longitudinal distance (< 0.5 m).
rapid	Sections of stream with deep (>0.5 m), swiftly flowing (>0.3 m/s) water and considerable surface turbulence. Rapids tend to have larger substrate sizes than riffles.
riffle	"Shallow/fast" (< 0.5 m deep, > 0.3 m/s); riffles are shallow sections where the water flows over coarse stream bed particles that create mild to moderate surface turbulence.
runs/step-runs	"Deep/fast" (> 0.5 m deep, > 0.3 m/s); long, relatively straight, low-slope sections without flow obstructions. The streambed is typically even and the water flows faster than it does in a pool. Unlike rapids, runs have little surface turbulence.
glide	"Shallow/slow" (< 0.5 m deep, < 0.3 m/s); sections of stream with little or no turbulence, but faster velocity than pools. Includes still or slow-moving shallow backwaters and shallow margins of pools.
pool	"Deep/slow" (> 0.5 m deep, < 0.3 m/s); a reach of stream that is characterized by deep, low-velocity water and a smooth surface.
dry	Any surface area within the channel's wetted width that is above water (e.g., mid-channel point bars). When assessing dry habitats, only count areas with particulate substrate; do not count tops of emergent rocks and boulders.

8. PHYSICAL HABITAT REACH-BASED MEASUREMENTS

8.1 Module O: Stream Discharge

Stream discharge is the volume of water that moves past a point in a given amount of time and is generally reported as cubic feet per second. Discharge affects the concentration of nutrients, fine sediments, and pollutants, and its measurement is critical for understanding impacts of disturbances such as impoundments, water withdrawals, and water augmentation. Discharge is also closely related to many habitat characteristics including temperature regimes, physical habitat diversity, and habitat connectivity. As a direct result of these relationships, stream discharge is often also a strong predictor of biotic community composition. Since stream volume can vary significantly on many temporal scales (diurnal, seasonal, inter-annual), it can also be very useful for understanding variation in stream condition.

For this SOP, a single discharge measurement is conducted in order to estimate discharge through the sampling reach. There is no prescribed point in the reach where the measurement should be taken; rather, it is up to the discretion of the field crew, depending upon streambed morphology and flow. It is preferable to take the discharge measurement in a section where flow velocities are > 0.15 m/s and most depths are > 15 cm, but slower velocities and shallower depths can be used, if necessary. If flow volume is sufficient for a transect-based "velocity-area" discharge calculation (Section 8.1.1), this is the preferred method. If the velocity meter probe cannot be submerged, but there is visible flow, the following two options are available: 1) use of the Neutrally Buoyant Object approach (which is the second most preferred method to measure flow) OR 2) a visual estimation of the velocity based on best professional judgment. In small, shallow streams with complex substrate, it may still be difficult to accurately measure discharge, even where water movement is obvious. If visual estimation is used, the velocity measurement must be denoted with a "visual estimate" flag in the data base.

Data for this parameter are entered in the "Discharge Measurements" section of the field sheet.

8.1.1 Velocity Area Method

The layout for discharge measurements under the velocity-area method is illustrated in Figure 20. Flow velocity should be measured with either a Swoffer Instruments propeller-type flow meter or a Marsh-McBirney inductive probe flow meter with a top-setting rod. Refer to the manufacturer instrument manual for calibration procedures.

Step 1. Select the best location (cross-section) in the reach to place a transect across which to measure discharge. This does not need to coincide with any of the main or inter-transects where other PHab measurements were taken, however it should lie within, or very near, the stream reach being assessed. Choose a cross section with flow that is as uniform as possible (i.e., hydraulically smooth), and with the simplest possible cross-sectional geometry. It is helpful to move bed material or other obstacles to create a more uniform cross-section before beginning the discharge measurements, but this cannot be done after measurements have begun, or it will skew results.

Step 2. Measure the wetted width of the discharge transect and divide this into 10 to 20 equal segments. The use of more segments gives a better discharge calculation, but is impractical in small channels. At least 10 intervals should be used when stream width permits, but interval width should not be < 15 cm.

Step 3. Record the distance from the bank to the end of the first interval. Using the top-setting rod, measure and record the median depth of the first interval (Figure 20).

Step 4. Stand downstream of the transect and off to the side of the probe in order to avoid interfering with the flow measurement. Set the probe of the flow meter at the midpoint of the first interval along the discharge transect, facing upstream perpendicularly to the direction of flow. If necessary, a thin piece of flagging tape can be attached to the top-setting rod and submerged to identify the direction of flow and thus inform proper angling of the probe. Determine the depth of the water and adjust the top-setting rod accordingly, such that the probe is held at a depth of 0.6 of the total stream depth. This position generally approximates average velocity in the water column. See Figure 20 for positioning detail. Refer to the top-setting rod owner's manual for further instructions on positioning of probe height.

Step 5. Allow the flow velocity meter to equilibrate for at least 15 seconds, and then record velocity to the nearest ft/s. If the option is available, use the flow-averaging setting on the flow meter[33]. Record the flow velocity. Under very low flow conditions, flow velocity meters may register readings of zero even when there is noticeable flow. In these situations, record the appropriate ResQualCode (ND, Not Detected) and QACode (FLV, Velocity too low to be measured) and leave the Result field blank in the database. The Instrument Detection Limit (IDL) should be noted for the instrument used. In areas that are too shallow to measure velocity, use the Neutrally Buoyant Object method.

If the flow is moving upstream (such as near banks or in an eddy), point the probe into the flow and record the velocity with a negative symbol on the field sheet. Record an "NG" QA flag with this result in the database in order to identify the result as a negative value.

Step 6. Complete Steps 3 through 5 on the remaining intervals. Frequently, the first and last intervals have depths and velocities of zero.

[33] Set the averaging interval to at least 15 seconds (30 seconds if velocity is > 2 ft/s) and record the 15secondaverage velocity measurement for each segment.

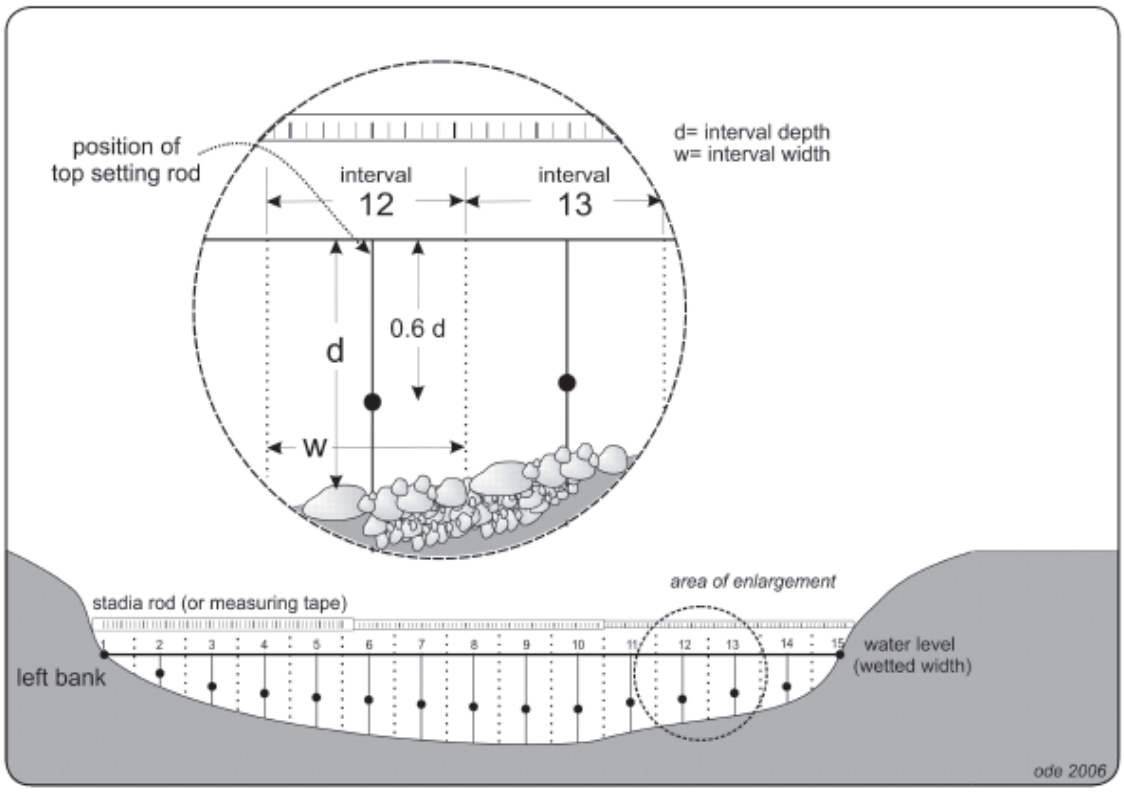

Figure 20. Diagram of layout for discharge measurements under the velocity-area method showing proper positions for velocity probe (black dots).

8.1.2 Neutrally Buoyant Object Method

If the reach is too shallow to use a flow velocity meter, the neutrally buoyant object (NBO) method can be used to measure flow velocity. However, since this method is less precise than the flow velocity meter, it should be used only if the velocity-area method will not work. The movement of an NBO (one whose density allows it to just balance between sinking and floating) will approximate that of the water it floats in better than a light object. Examples of NBOs include a large piece of fresh orange peel, a rubber ball, and a moderately heavy piece of wood.

To estimate the flow velocity, three transects are used to measure the cross-sectional areas within the test reach, and three flow velocity estimates are used to measure average velocity of water passing through it. To improve precision in velocity measurements, the test reach should be long enough for the float time to last at least 10-15 seconds. This will allow for an average of the instantaneous variation in flow and minimize the influence of error in the stopwatch timing. The use of longer times is recommended, when possible.

Step 1. Identify a sufficiently long test reach that has relatively uniform flow and a uniform cross-sectional shape. (The same criteria for selection of a discharge reach apply to selecting a test reach for the NBO method.)

Step 2. Record the length of the test reach.

Step 3. Measure the cross sectional area of the test reach in three places (an "Upper Section", a "Middle Section" and a "Lower Section"). Three evenly-spaced cross sections are preferred, but a single one may be used if the cross section through the test reach is uniform (*e.g.*, in a concrete channel). On the "Float Reach Cross Section" of the field sheet, record the width once, and the depth at five equally-spaced positions, across each of the three cross sections of the test reach.

Step 4. Place the NBO in the water upstream of the test reach and record the length of time (in seconds) that it takes for the object to pass between the reach's upstream and downstream boundaries. Repeat this twice more for a total of three timed "floats".

8.2 Module P: Post-Sampling Observations: Qualitative Reach Measures

EPA's Rapid Bioassessment Procedures (RBPs, Barbour et al. 1999) include a set of 10 visual criteria for assessing instream and riparian habitat. The RBP has been used in the CSBP since its first edition (1995), and thus this information is often valuable for comparison to legacy datasets. The criteria also have a useful didactic role, since they help force the user to quantify key features of the physical environment where bioassessment samples are collected. The full suite of RBP stream habitat visual estimates are not covered in this SOP because they are generally replaced by more quantitative measurements of similar variables. However, three of the RBP measures ("Epifaunal Substrate/Cover", "Sediment Deposition", and "Channel Alteration") have been found to be reasonably repeatable and thus are included.

Record observations in the "Additional Habitat Characterization" section of the field sheet.

8. OPTIONAL SUPPLEMENTAL MEASURES

Optional measures to supplement this SOP may be included in stream assessments according to program needs. These include the excess sediment index (sometimes referred to as log relative bed stability, LRBS) and additional measurements collected for the LRBS calculations (Kaufmann et al. 1999), such as tallies of woody debris and thalweg. The NRSA Field Operations Manual (USEPA 2009) provides more details on collecting these data types.

Large woody debris (logs, snags, branches, etc.) that is capable of obstructing flow when the channel is at bankfull (i.e., just short of flood) stage contributes to the "roughness" of a channel. The effect of this variable is to reduce water velocity and thereby reduce the stream's competence to move substrate particles. The NRSA (Section 6.2.4.2) protocol tallies all woody debris with a diameter > 10 cm (~4") into one of 12 size classes based on the length and width of each object. Tallies are conducted in the zone between the main transects.

A stream's thalweg is a longitudinal profile that connects the deepest points of successive cross-sections of the stream. The thalweg defines the primary path of water flow through the reach. Thalweg measurements (NRSA; Section 5.2.7) perform many functions in the NRSA protocols, producing measurements for the excess sediment calculations (residual pool volume, stream size, channel complexity) and flow habitat variability.

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10. GLOSSARY

Aliquot – a measured portion of a sample, or subsample

Allochthonous – derived from a source external to the stream channel (e.g., riparian vegetation as a source of organic matter) as opposed to autochthonous, which indicates a source inside the stream channel (e.g., algae or macrophytes rooted in the stream)

Ambient bioassessment – monitoring that is intended to describe general biotic condition as opposed to a diagnosis of sources of impairment

Ash-free dry mass (AFDM) – the portion, by mass, of a dried sample that is represented by organic matter; the concentration of AFDM per stream surface area sampled is often used as a surrogate for algal biomass

Bankfull – the bankfull channel is the zone of maximum water inundation in a normal flow year (one- to two-year flood events)

Benthic algae – algae that are attached to, or have at one point been anchored to, the stream bottom, in contrast to planktonic algae which are free-floating in the water column

Benthic macroinvertebrates (BMI) – bottom-dwelling invertebrates large enough to be seen with the unaided eye

Biofilm – a matrix/film adhering to stream substrates and consisting of microorganisms (*e.g.*, algae, fungi, bacteria, protozoans) and detritus

Chlorophyll *a* – primary light receptor/photosynthetic pigment in algae and cyanobacteria and higher plants; the concentration of this pigment per stream surface area sampled provides an estimate of algal biomass

Coarse particulate organic matter (CPOM) –particles of decaying organic material, such as leaves and twigs, that are between 1 and 10 mm in diameter and suitable for consumption by BMIs in the "shredder" functional feeding group

Cobble embeddedness – The percent of surface area of cobble-sized particles (64-250 mm) buried by fine particles (<2.0 mm diameter)

Composite sample - volume of all the liquid material amassed during sampling, including water used for rinsing substrate and sampling devices.

Cyanobacteria – historically referred to as "blue-green" algae, but actually chlorophyll-*a* containing prokaryotes that are capable of photosynthesis and co-occur with "true" (i.e., eukaryotic) benthic algae in streams; useful as a bioindicator, and field-sampled and laboratory-processed as soft-bodied algae

Depositional – habitats in the stream that are dominated by slow-moving water, such as pools, where deposition of materials from the water column is more likely to occur than erosion (or (re)suspension) of loose bed materials

Diatom – a unicellular golden-brown alga (Bacillariophyta) that possesses a rigid, silicified (silica-based) cell wall in the form of a "pill box"

Elutriation – the process of using a liquid (water) to separate denser material (e.g., stream sediments) from lighter materials (organic particles and benthic organisms). **-**.

Erosional – habitats in the stream that are dominated by fast-moving water, such as riffles, where stream power is more likely to facilitate erosion (suspension) of loose benthic material than deposition

Fines – substrate particles < 0.06 mm diameter (not gritty to the touch)

Guidance Document – a companion document to this SOP that provides more information on the various applications of the indicators described herein, as well as recommendations for where and when to use this SOP. It also provides more detailed information on how to deal with special circumstances that may be encountered during bioassessment sampling.

Homogenate – mixture of algae liquid composite sample and finely chopped fragments of macroalgae that comprises the quantitative sample for the diatom taxonomic ID, chlorophyll a, and AFDM subsamples

Index of Biotic Integrity (IBI) – a quantitative assessment tool that uses information about the composition of one or more assemblages of organisms to make inferences about condition, or ecological health, of the environments they occupy (*e.g.*, algae or benthic macroinvertebrates)

Inter-transects – transects established at points equidistant between the main transects

Macroalgae – soft bodied algae that form macroscopically discernible filaments, mats, or globose structures

Macrophyte, aquatic – herbaceous, vascular plant rooted or floating within the stream's wetted channel, such as sedge, cattail, knotweed, watercress, water-primrose, duckweed, etc.; our definition of aquatic macrophytes excludes trees, shrubs, mosses, and algae

Microalgae – diatoms and microscopic soft-bodied algae (can co-occur with other microorganisms in a biofilm)

Prospecting mine – a hand-excavated, hard-rock mining hole that is open to the surface (common in the Sierra Nevada)

Reach – a linear segment of the stream channel

Reachwide benthos (RWB) – method for biotic assemblage sample collection that does not target a specific substrate type, but rather objectively selects sampling locations across the reach, allowing for any of a number of substrate types to be represented in the resulting composite sample

Riparian – an area of land and vegetation adjacent to a stream that has a direct effect on the stream by providing shade, habitat for wildlife, contributing allochthonous organic matter, modulating water levels via evaporative transpiration, etc.

Sinuosity – the ratio of the length of the flow path between the ends of the reach and the straight line distance between the ends of the reach (Kaufmann et al. 1999)

Soft-bodied algae – non-diatom algal taxa; for the purposes of this SOP, cyanobacteria are included in this assemblage

Substrate – the composition of a streambed, including both inorganic and organic particles

Target coordinates – the nominal or tentative location of a sampling site, which may differ from the actual location from which samples are collected

Thalweg – the thalweg defines the primary path of water flow through the reach; it is often inferred by depth for practical purposes, but is not always the deepest point

Transects – lines drawn perpendicular to the path of flow used for standardizing biotic sampling and data collection locations

Wadeable stream – a stream that can be sampled by field crews wearing chest waders (generally < 1 meter deep for at least half the reach)

Wetted width – the width of the channel containing water (the active channel), defined as the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water

Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California.Version 1.1 updated March-2014

The SOPs below are for reference and information purposes only, the documents are recommended, not required by the Surface Water Ambient Monitoring Program (SWAMP). Please see the SWAMP Quality Assurance Program Plan at: http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for more information regarding SWAMP QA/QC requirements.

Table of Contents

Acknowledgements:

This procedure has been modified from the Texas Natural Resources Conservation Commission's Procedure Manual for Surface Water Quality Monitoring, with major input from the United State's Geological Survey's (USGS's) National Water Quality Assessment (NAWQA) Protocol for Collection of Stream Water Samples, for which due credit is here with given.

The current version of these protocols was written by Sean Mundell (Moss Landing Marine Labs MPSL Field Sampling Team) with most of the credit to Max Puckett (CDFW) for originally writing this document for part of the original SWAMP QAMP, 2001. Significant contributions also came from Eric von der Geest and the (SWAMP) Quality Assurance (QA) Team, The SWAMP Data Management Team(DMT), Billy Jakl(MPSL), Mary Hamilton (RWQCB 3), and Bettina Sohst(former MPSL employee),

Field Measurements

Field Data Sheets

Field data sheets are used to record field observations, probe measurements, and water and sediment chemistry sampling. Field data sheets are provided on the SWAMP Data Management Resources Website at: **Water Quality Field Data Sheet** *(updated 12/18/12).*

There are guidelines provided below to standardize what is recorded on all data sheets and that should be helpful in completing each form. The entries discussed below and on the field data sheets are recorded at each sampling site.

Notes to Standardize SWAMP Field Data Sheets (For in the field use)

KEY REMINDERS to IDENTIFY SAMPLES:

1. **SAMPLE TIME** is the SAME for all samples (Water, Sediment, & Probe) taken at the sampling event. Use time of FIRST sample; important for COC (is used for identification of sample).
2. **LEFT BANK/RIGHT BANK**
   Left bank is defined as the bank to the left of the observer when facing downstream, and the *right bank* is to the right of the observer when facing downstream
3. **GROUP;** many different ways to do a group, one suggestion is to create groups which assign trips to assess frequency of field QA

COLLECTION DETAILS:

1. **PERSONELL**: S. Mundell, G Ichikawa (first person listed is crew leader)
2. **LOCATION:** Bank, Thalweg, Mid-Channel, Open Water**.** Use "open water" in bay/estuary/harbor only if no distinguishable channel exists
3. **GRAB vs. INTEGRATED**: GRAB samples are when bottles are filled from a single depth; INTEGRATED sample are taken from MULTIPLE depths/grabs and combined.
   A. GRAB: use 0.1 for subsurface samples; if too shallow to submerge bottle; depth = 0
   B. INTEGRATED: -88 in depth sampled, record depths combined in sample comments
4. **TARGET LAT/LONG**: Refers to the existing station location that the sampling crew is trying to achieve; can be filled out prior to sampling
5. **ACTUAL LAT/ LONG**: is the location of the current sample event.
6. **HYDROMODIFICATION:** Describe existing hydro modifications such as a grade control, drainage pipes, bridge, culvert
7. **HYDROMOD LOC**: if there is an IMMEDIATE (with in range potentially effecting sample) hydro modification; Is the hydro modification upstream/downstream/within area of sample; if there is no hydro modification, NA is appropriate
8. **STREAM WIDTH and DEPTH**: describe in meters at point of sample.

FIELD OBSERVATIONS: (each one of these observations has a comment field in the database so use comment space on data sheet to add information about an observation if necessary)

1. **PICTURES:** use space to record picture numbers given by camera; be sure to rename accordingly back in the office. (StationCode_yyyy_mm_dd_unique code)
2. **WADEABILITY**: in general, is water body being sampled wadeable to the average person AT the POINT of SAMPLE
3. **DOMINANT SUBSTRATE**: if possible; describe DOMINANT substrate type; use UNK if you cannot see the dominant substrate type
4. **BEAUFORT SCALE**: use scale 0-12; refer to scales listed on page 28
5. **WIND DIRECTION**: records the direction from which the wind is blowing
6. **OTHER PRESENCE**: VASCULAR refers to terrestrial plants or submerged aquatic vegetation

(SAV) and NONVASCULAR refers to plankton, periphyton etc. These definitions apply to vegetation IN the water at the immediate sampling area.

7. **OBSERVED FLOW**: Visual estimates of flow range in cubic feet/second. Flow should be recorded even if flow is visible but not measurable on that sampling visit. This is an observational measurement that is highly dependent on the knowledge of monitoring personnel.
8. **WATER COLOR**: This is the color of the water from standing creek side
9. **WATER CLARITY**: this describes the clarity of the water while standing creek side; clear represents water that is clear to the bottom, cloudy may not be clear to bottom but greater than 4 inches can be seen through the water column.
10. **PRECIPITATION LAST24hrs:** refers to field crew's best categorization of rainfall in the last 24 hrs; may or may not effect Overland Runoff Last 24 hrs
11. **OVERLAND RUNOFF LAST 24 hrs**: Significant precipitation is defined as any amount that visibly influences water quality. Light Precipitation = fog, drizzle, and/or light rain with no overland runoff; Mod to Heavy Precipitation = rain such that site probably or definitely received at least some overland runoff.
12. **SEDIMENT COMP**: generally described sediments used for chemistry sample Note: these reminders do not give all details needed to maintain equivalent SWAMP sampling protocols, they are strictly for "infield" use to help insure comparability of field observations.
13. **WATER APPEARANCE:** Note general appearance (e.g., color, unusual amount of suspended matter, debris or foam)
14. **SEDIMENT APPEARANCE** Color, Odor and sediment composition should be noted.
15. **WEATHER:** Note recent meteorological events that may have impacted water quality; (e.g., heavy rains, cold front, very dry, very wet)
16. **BIOLOGICAL ACTIVITY:** Note excessive macrophyte, phytoplankton or periphyton growth. The observation of water color and excessive algal growth is very important in explaining high chlorophyll a values. Other observations such as presence of fish, birds and spawning fish are noted.
17. **WATERSHED or INSTREAM ACTIVITIES:** Note in stream or drainage basin activities or events that is impacting water quality (e.g., bridge construction, shoreline mowing, livestock watering upstream).
18. **RECORD of PERTINENT OBSERVATIONS RELATED to WATER QUALITY and STREAM USES:** If the water quality conditions are exceptionally poor, note that standards are not met in the observations, (e.g., dissolved oxygen is below minimum criteria). Note uses (e.g., swimming, wading, boating, fishing, irrigation pumps, navigation). Eventually, for setting water quality standards, the level of use will be based on comments related to the level of fishing and swimming activities observed at a station.
19. **SPECIFIC SAMPLE INFORMATION:** Note specific comments about the sample itself that may be useful in interpreting the results of the analysis (e.g., number of sediment grabs, or type and number of fish in a tissue sample). If the sample was collected for a complaint or fish kill, make a note of this in the observation section.
20. **MISSING PARAMETERS:** If a scheduled parameter or group of parameters is not collected, make some note of this in the comments.
21. **RECORD of DATA SUBMISSION:** Initials and date are recorded on the field data sheet showing a record that the data has been transcribed onto data forms and submitted to the SWAMP data management staff.

Record of Samples Collected for Purposes of Chemical Analysis

The general types of chemical samples to be collected are listed for each site, since this may vary from site-to-site (e.g., metals-in-water, pesticides-in-sediments, conventional water quality). Analyses authorization forms are recommended since different authorized laboratories perform different chemical analyses. The method of preservation for each chemical sample is recorded, as appropriate on the Chain of Custody Form (COC).

Field Data Measurements

While collecting water samples (see Field Collection Procedures for Water Samples page 29), record appropriate field measurements. When field measurements are made with a multi-parameter instrument, it is preferable to place the sonde in the body of water to be sampled and allow the dissolved oxygen (D.O.) to equilibrate. D.O. usually takes the longest to equilibrate out of the probe measurements (pH, Temperature, Conductivity and Turbidity) Field measurements are made at the centroid of flow, if the stream visually appears to be completely mixed from shore to shore. *Centroid* is defined as the midpoint of that portion of the stream width which contains 50% of the total flow. Probe measurements and water sampling are best to collect in the stream location that best represents the entire stream. For routine field measurements, the date, time and depth are reported as a grab. Quality control requirements for field measurements are listed in Quality Control and Sample Handling Tables for Field Measurements in Fresh and Marine Water.

Recommended Depths for Conducting Field Data Measurements

Water Depth Less than 5 ft (<1.5 m)	If the water depth is less than 5 ft (1.5 m), grab samples for water are taken at approximately 0.1 m (4 in.), and multi-probe measurements are taken at approximately 0.2 m (8 in.). This is because all sensors have to be submerged, so 0.1 m would not be deep enough. But taking a grab sample at 0.2 m is not always feasible, as it is difficult to submerge bottles to that depth, and in many cases the bottle will hit the stream bottom.
Water Depth Greater than 5 ft (>1.5 m)	If the water depth at the sampling point exceeds 5 ft (1.5 m) in depth, a vertical profile of dissolved oxygen, temperature, pH and specific conductance are made using the multi-parameter probe equipment. The depth of the sonde at the time of measurement is most accurately determined from the depth sensor on the multi-parameter sonde rather than depth labels on the cable.
Vertical Depth Profiles and Depth-Integrated Sample Collection	If depth integration sampling is being conducted, or if vertical profile measurements are requested, multi-probe measurements are made starting at a depth of 0.2 m, and are then conducted at 1.0, 2.0, 3.0, 4.0, and 5.0 m depths after that until 5.0 m depth is reached. Beginning at 5.0 m, measurements are made every 5.0 m through depth profile.

Field data for multi-parameter vertical depth profiles are recorded in final form on the SWAMP Field Data Sheets and submitted to the SWAMP data management staff. Go to http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Water Temperature (^{O}C)

Water temperature data are recorded for each site visit in final form on a Field Data Sheet and submitted to the SWAMP data management staff.

Temperature Sampling Procedures

Temperature is measured in-stream at the depth(s) specified above. Measuring temperature directly from the stream by immersing a multi-probe instrument or thermometer is preferred.

Hand Held Centigrade Thermometer

If an electronic meter is not available, the temperature is measured with a hand-held, centigrade thermometer (Rawson, 1982).

- In wadeable streams, stand so that a shadow is cast upon the site for temperature measurement.
- Hold the thermometer by its top and immerse it in the water. Position the thermometer so that the scale can be read.
- Allow the thermometer to stabilize for at least one minute, then without removing the thermometer from the water, read the temperature to the nearest 0.1^{o} C and record.
- Do not read temperature with the thermometer out of the water. Temperature readings made with modern digital instruments are accurate to within $\pm$ 0.1^{o} C.

Temperature Measurement from a Bucket

When temperature cannot be measured in-stream, it can be measured in a bucket-Nalgene or plastic container. Care must be taken to insure a measurement representative of in-stream conditions.

The following conditions must be met when measuring temperature from a bucket:

- The bucket must be large enough to allow full immersion of the probe or thermometer.
- The bucket must be brought to the same temperature as the water before it is filled.
- The probe must be placed in the bucket immediately, before the temperature changes.
- The bucket must be shaded from direct sunlight and strong breezes prior to and during temperature measurement.
- The probe is allowed to equilibrate for at least one minute before temperature is recorded.
- After these measurements are made, this water is discarded and another sample is drawn for water samples which are sent to the laboratory.

pH (standard units)

pH data is recorded for each SWAMP visit in final form on the Field Data Sheets and submitted to the SWAMP data management staff. Go to http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

pH Sampling Equipment

The pH meter should be calibrated according to the recommended procedures for calibration and maintenance of SWAMP field equipment. Calibration directions are listed in the manufactures field equipment operations manual. The pH function is pre and post calibrated every 24 h of use for multi-parameter instruments.

pH Sampling Procedures

In-stream Method

Preferably, pH is measured directly in-stream at the depth(s) specified earlier in this document. Allow the pH probe to equilibrate for at least one minute before pH is recorded to the nearest 0.1 pH unit.

pH Measurement from a Bucket

When pH cannot be measured in-stream, it can be measured in a bucket-Nalgene or plastic container. The following precautions are outlined above; “Temperature Measurement from a Bucket”.

Potential Problems

- If the pH meter value does not stabilize in several minutes, out gassing of carbon dioxide or hydrogen sulfide, or the settling of charged clay particles may be occurring (Rawson, 1982).
- If out gassing is suspected as the cause of meter drift, collect a fresh sample, immerse the pH probe and read pH at one minute.
- If suspended clay particles are the suspected cause of meter drift, allow the sample to settle for 10 min, then read the pH in the upper layer of sample without agitating the sample.
- With care, pH measurements can be accurately measured to the nearest 0.1 pH unit.

Dissolved Oxygen (mg/L)

Dissolved oxygen (D.O.) data is recorded for each SWAMP visit in final form on a Field Data Sheet and submitted to the SWAMP data management staff.
See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Dissolved Oxygen Sampling Equipment

The dissolved oxygen meter should be calibrated according to the recommended procedures for calibration and maintenance of SWAMP field equipment. Calibration directions are listed in the manufactures field equipment operations manual.

Multi-probe Instrument

Pre and post calibrate the D.O. sensor every 24 h and for elevations greater than 500 ft on the multi-probe instrument. Preferably, D.O. is measured directly in-stream at the depth(s) specified in the Field Measurements section above. The D.O. probe must equilibrate for at least 90 s before D.O. is recorded to the nearest 0.1 % saturation or mg/L. Care must be taken at profile stations to insure that the reading is stable for each depth. Since dissolved oxygen takes the longest to stabilize, record this parameter after temperature, conductivity and pH. If the D.O. probe has an operable, automatic stirrer attached, the D.O. probe does not have to be manually stirred. However, if the probe is not equipped with an automatic stirrer, manual stirring must be provided by raising and lowering the probe at a rate of 1 ft/s (0.3m/s) without agitating the water surface. If the stream velocity at the sampling point exceeds 1 ft/s, the probe membrane can be pointed upstream into the flow and manual stirring can be avoided (Rawson, 1982).

D.O. Measurement from a Bucket

When D.O. cannot be measured in-stream, it can be measured in a bucket-Nalgene or plastic container, following precautions outlined in the Temperature Measurement from a Bucket listed above. During equilibration and reading, water should be moved past the membrane surface at a velocity of 1 ft/s (0.3 m/sec), either by automatic stirrer or manual stirring. If stirred manually in a bucket, the water surface is not agitated (Rawson, 1982).

24-Hour Average D.O. Continuous Monitoring (if requested in special study)

Unattended 24-Hour D.O. Data Collection

Why Collect 24-Hour Data

Dissolved oxygen sampling for standards compliance is targeted to water bodies where low instantaneous D.O. levels indicate partial or nonsupport of designated aquatic life uses. Intensive monitoring is conducted with automated equipment that is preset to record and store field measurements hourly over one 24-h period. Four or more dissolved oxygen measurements may also be made manually at 4-6-h intervals over one 24-h period, as long as one is made near sunrise (0500-0900 h) to approximate the daily minimum. However, data collected with automated equipment is preferred.

When to Take Measurements

All 24-h D.O. monitoring events must be spaced over an index period representing warm-weather seasons of the year (approx March 15-October 15), with between one-half to two-thirds of the measurements occurring during the critical period (July 1-September 30). The ***critical period*** of the year is when minimum stream flows, maximum temperatures, and minimum dissolved oxygen concentrations typically occur in area streams. **A flow measurement must be taken at the time of deployment.** In a perennial stream, a 24-h data for standards compliance can not be used if the flow is less than the 7Q2. In perennial streams, the D.O. criterion to do not

apply for flows under the 7Q2. A period of about one month must separate each 24-h sampling event. Additional samples may be collected outside the index period to further characterize a water body, but that information is generally not used for assessing standards compliance.

Frequency of Measurements

The measurement interval should be no more than once per 15 min and no less than once per hour.

Where to Take Measurements

For purposes of determining standards compliance with the 24-h average criteria, samples collected near the surface will be considered representative of the mixed surface layer. In deep streams, reservoirs, and tidally influenced water bodies, automated equipment is positioned between 1 foot (from the surface) to one-half the depth of the mixed surface layer. At least 10 24-h monitoring events (using the 24-h criteria and/or absolute minimum criteria) at each site within a 5-year period are recommended to provide adequate data for assessment.

When to Collect Other Routine Samples, if doing 24-hour D.O. measurements

Other routine field measurements and water samples should be collect at either the time of deployment, at the reference check, or when the multi-probe recording 24-h data is retrieved. When ever possible, flow must be measured at the 24-h site.

Priority for Scheduling 24-Hour Sampling Events

- < 303d listed waterbodies
- < Waterbodies with Concerns for DO problems (too few samples available for full use assessment).
- < Occurrence of low D.O. concentrations observed during the day
- < Waterbodies with trends indicating declining D.O. concentrations
- < Waterbodies which would contribute to an Eco-region data set

Data Reporting for 24-hour D.O. measurements

Dissolved oxygen values recorded over the 24-h period are summed and divided by the number of measurements to determine the average concentration, which is compared to the 24-h criterion. The lowest D.O. value from each 24-h set is compared to the minimum criterion. There will be occasions when a complete 24-h data set won't be possible. For example, if there are 18 measurements instead of 24, a time weighted diurnal average needs to be calculated. This can be easily done using GW Basic.

Support of assigned aquatic life use is based on 24-h D.O. average and minimum criteria for each monitoring event. Report the 24-h average D.O. value, number of measurements over a 24-h period, and the minimum, and maximum values. Report data as a time composite sample with a beginning and ending date and time, covering the 24-h period measured.

Specific Conductance (µS/cm)

Specific conductance should be recorded for each SWAMP visit in final form on a Field Data Sheet and submitted to the SWAMP data management staff.
See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Specific Conductance Sampling Equipment

The conductivity meter should be calibrated according to the recommended procedures for calibration and maintenance of SWAMP field equipment. Calibration directions are listed in the manufactures field equipment operations manual.

Specific Conductance Sampling Procedure

Preferably, conductivity is measured directly in-stream at the depth(s) specified earlier in this document. Allow the conductivity probe to equilibrate for at least one minute before specific conductance is recorded to three significant figures (if the value exceeds 100). The primary physical problem in using a specific conductance meter is entrapment of air in the conductivity probe chambers. The presence of air in the probe is indicated by unstable specific conductance values fluctuating up to +/-100 µS/cm. The entrainment of air can be minimized by slowly, carefully placing the probe into the water; and when the probe is completely submerged, quickly move it through the water to release any air bubbles.

If specific conductance cannot be measured in-stream, it should be measured in the container it can be measured in a bucket-Nalgene or plastic container. The following precautions are outlined above; “Temperature Measurement from a Bucket”.

Salinity (parts per thousand--ppt, or ‰)

The value for salinity is computed from chloride concentration or specific conductance. The calculation assumes a nearly constant ratio for major ions in an estuary when seawater is diluted by river water. This assumption does not hold for cases where salinity is less than about three parts per thousand. Salinity determinations at such low values are only approximate. In estuarine waters, salinity is a relevant and meaningful parameter. Often the salinity may be low, approaching that of freshwater. Nevertheless, this is useful information. Determine if a station is estuarine from historical records (i.e., experiences cases where salinity is >2.0 ppt) and always report salinity at this station, regardless of the salinity during periods of high flow.

Salinity is measured directly in-stream at the depth(s) specified earlier in this document. Salinity data should be recorded for each SWAMP visit in final form on a Field Data Sheet and submitted to the SWAMP data management staff. See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Values between 2.0 ppt and 1.0 ppt should be reported as <2.0 ppt rather than the actual value and values <1.0 ppt should be reported as <1.0 ppt. The field instruments compute salinity from specific conductance and temperature, and display the value in parts per thousand. Report salinity values above 2.0 ppt to the nearest 0.1 ppt.

Secchi Disc Transparency (meters)--if requested in special study

Secchi disk transparency should be recorded for each SWAMP visit in final form on a Field Data Sheet and submitted to the SWAMP data management staff. See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Secchi Disk Sampling Equipment

- Secchi disk, 20 cm in diameter
- Measuring tape

Secchi Disk Transparency Sampling Procedures

Preferably, Secchi disk transparency is measured directly in-stream wherever conditions allow. The Secchi disk should be clean, weighted and suspended with chain, wire, or Dacron line (the line used to suspend the Secchi disk should not be nylon or cotton; stretching may cause erroneous readings). Another option is to attach the Secchi disk to a metal rod calibrated in metric units.

Average Turbidity

The Secchi disk should be lowered vertically in a location shielded from direct sunlight. Glare from the water's surface will affect the accuracy of the measurement. Don't wear sunglasses.

Slowly lower the disk until it disappears from view. The person viewing the disk should maintain an eye level of less than two meters above the water's surface. Note the depth at which the disk disappears from view.

Slowly raise the disk until it becomes visible. Note the depth at which the disk reappears.

Compute the mathematical average of the two depths noted and record the average value to two significant figures on the field data sheet. The recorded average value is the Secchi disk transparency.

High Turbidity (Muddy Water)

In streams with very high turbidity, high velocity, and/or poor access, it may be necessary to measure Secchi disk transparency in a bucket. Fill the bucket from the centroid of flow being careful not to disturb the substrate.

Follow steps above for measuring the Secchi disk depth within 30 s after raising the filled bucket from the water's surface. Or, re-suspend the solids by stirring, then quickly make the measurement.

Record Secchi disk transparency to two significant figures.

Low Turbidity (Clear Water)

Some bodies of water will be so clear and shallow that it will not be possible to lower the Secchi disk until it disappears from view.

Measure and record the depth at the deepest point accessible. Report Secchi disk transparency as greater than the deepest depth measured.

Example (Low Turbidity): South Fork Rocky Creek is a small (<1 ft^3/s) clear stream. The stream in the vicinity of the sampling site was less than 1 m deep and the bottom was clearly visible everywhere. However, a pool was located in the stream next to a bridge. The maximum depth of the pool was 2.6 m at which depth the Secchi disk was still visible. Therefore, Secchi disk transparency for South Fork Rocky Creek was recorded as > 2.6 m.

Importance of Secchi Disk Data

Eutrophication, the natural aging process in reservoirs and lakes is accelerated by human activities which add nutrients to lakes, reservoirs, and the surrounding watersheds. Section 314 of the Clean Water Act (CWA) of 1987 requires all states to classify lakes and reservoirs according to trophic state. Although chlorophyll a is the most direct measure of algal biomass, other indices and programs utilize Secchi disk depth as the primary factor.

Turbidity Measurement with Turbidity Meter

Nephelometric Turbidity (turbidity standard unit is called Nephelometric Turbidity Units (NTU)) can be determined by measuring the amount of scatter when light is passed through a sample using a turbidity meter. The LaMotte 2020 Turbidity meter is a suitable instrument for example. There are also turbid-ometers attached to multi-probe instruments like YSI or Hydro-Lab.

Turbidity meters should be calibrated using a standard close to the expected sample value. Calibration standards should be used that are relative to the suspended sediment particles in the sampleable water column. Typical calibration standard values are 1, 10, 100, and 1000 NTU's.

For instructions on how to operate the instruments refer to the manufacturer's manual. Turbidity measurements can be executed together with water sampling. The turbidity sample has to be representative for the sampled water mass. Make sure that no gas bubbles are trapped in the vial for the reading and that the outside of the vial is wiped completely clean (i.e., meaning free of moisture, lint and fingerprints). Take several measurements to assure an accurate reading. Do not record values that vary greatly. If variations are small, record an average. If settling particles are present, record a reading before and one after settling. The meter might have to be recalibrated with a different standard, if the sample water readings are outside of the calibration standard limits.

Flow

Sampling crews should be notified on reconnaissance forms if it is known that there is an operational United States Geological Survey (USGS) gage located at or nearby a sampling site. If there is a USGS gage nearby, a gage height in feet is recorded and later converted to an instantaneous flow value and recorded on the field data sheet. The gage height is always to be reported to the USGS for conversion to flow. If a USGS gage is not available, a flow measurement should be taken, if requested. See Instantaneous Flow Measurement information starting on page 13 in this document. Centroid velocity measurements may also be taken as a minimum acceptable rough characterization of the stream flow as requested, although this measurement is not to be recorded as a flow, since it is only a velocity measurement
Flow information for over 200 USGS sites is available on the Internet. The address is **http://water.usgs.gov/index.html**. This is useful information in determining flow conditions prior to sampling. This information may be included in general observations.

Flow Measurement Method (Reporting)

The method used to measure flow is noted by reporting which instrument or gage is used. Examples are, Flow Gage Station (USGS/IBWC), Electric Marsh-McBirney flo mate 4000, Mechanical (ex. Pigmy meter), Weir/Flume, Other (orange peel, etc.) Flow data transformers are used to enter flow data into the SWAMP database. Please contact the SWAMP data management team to obtain the flow data transformer.

Flow (ft^3/s)

If requested, flow data should be recorded for each monitoring visit to non-tidal, flowing streams. Flow data should be recorded in final form on a Field Data Sheet and submitted to the SWAMP data management staff. See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting. The following are two exceptions to the flow reporting requirement:

No Flow/ Pools — If there is no flow at a stream site and accessible, isolated pools remain in the stream bed, collect and report the required field data and laboratory samples from the pools and report instantaneous flow. Under these conditions, flow (ft^3/s) should be reported as zero. Pools may represent natural low-flow conditions in some streams and the chemistry of these pools will reveal natural background conditions.

Dry — If the stream bed holds no water, the sampling visit is finished. Report that the stream was "dry" in the observations. No value is reported for flow since there is no water.

Flow Measurement

If a flow measurement is required at a site, measure and record flow after recording visual observations. The intent of measuring flow first is to delay collection of chemical and biological water samples with limited holding times. Care must be taken not to collect water samples in the area disturbed during flow measurement. There are several acceptable flow measurement methods that can be used.

U.S. Geological Survey (USGS) Gaging Station

Some SWAMP Stations are sampled at sites where the USGS maintains flow gaging equipment. On any type of sampling visit to a site that has a USGS flow gage, observe and record the gage height to the nearest hundredth of a foot in the field logbook. Upon return to the office, contact the USGS office responsible for maintaining the gage. USGS personnel can provide the flow value in cubic feet per second (ft^3/s) that corresponds to the gage height. Although SWAMP personnel may have a rating curve available to them, shifts associated with changes in the stream bed may occur over time. Always call the USGS to determine the shift. At some sites the shift changes frequently. At others, the relation between stream flow and gage height is almost unchanging. If a gage is no longer maintained by USGS, cross out the recorded gage height and be prepared to measure flow by another method on the return visit to that site.

Several factors may influence the accuracy of the USGS rating curves that are used to convert gage height to flow. If there is any doubt about the accuracy of a USGS gage height reading or flow rating curve, sampling personnel should measure the flow if possible.

Gage height may be indicated at a USGS gage by one of three methods:

Staff Gage

Staff gages are enameled steel plates (with the appearance of large measuring tapes) bolted to some stable structure. For example, staff gages may be bolted to concrete bridge abutments, pillars, or docks. The staff gage face is white with black lettering and gradations. The gradations shown are feet, tenths of a foot, and 0.02 of a foot. The point at which the water level crosses the staff gage should be recorded to the nearest hundredth of a foot.

Wire Weight Gage

Wire weight gages are locked, metal boxes with approximate dimensions of 15 in. long x 12 in. tall x 12 in. deep. Wire weight gages are usually affixed to bridge rails near mid-stream. They must be unlocked with a USGS key. The wire weight gages house a weight attached by wire cable to a graduated reel (gradations are tenths and hundredths of feet) with a counter at one end.

When the reel is released the weight can be gradually lowered until the bottom of the weight contacts the water surface. At the point of contact, the weight causes the water surface to ripple slightly. Maintaining the weight in that position, record the counter value to the nearest whole number and the point indicated by the stylus on the graduated reel to the nearest hundredth of a foot. Determine if the gage is the movable type that can be moved to multiple

locations on the bridge. This type is common on braided streams. A correction value is stamped on the bridge near each point that the gage can be attached. Record the corrected value as the gage height in feet.

Bubble Gage

Bubble gages are locked in metal sheds that are approximately 4 ft wide x 4 ft deep x 6.5 ft tall. The gage houses are most frequently located on the shore near a bridge but sometimes are attached to bridge pillars near mid-stream or established on the stream bank far from any bridge. The gage house must be unlocked with a USGS key. Bubble gages in gage houses usually indicate the gage height in two or three locations. A counter attached to the manometer system indicates gage height in feet. Some gage houses have stilling wells that can be entered. Often there is a staff gage on the inside wall.

Most bubble gages are also equipped with digital recorders. Digital recorders consist of two white, coded discs, approximately 4 in. in diameter with a punch tape overlapping a portion of each disc. The discs are marked with 100 gradations. As the front of the digital recorder is viewed, the stylus at the disc on the left indicates height in feet. The stylus at the disc on the right indicates gage height in hundredths of feet. The gage height from both discs should be added and the number recorded in the field logbook as gage height to the nearest hundredth of a foot.

Many USGS metal sheds also contain a surface level recorder. This devise can be opened to determine how stable stream flow has been prior to the sampling event. Record observations concerning the flow hydrograph.

Instantaneous Flow Measurement

Water quality monitoring visits to sites where there are no nearby USGS flow gauges will require water quality monitoring personnel to measure flow, when requested by Regional Water Quality Control Boards (Regional Boards).

Flow Measurement Equipment

Flow meter

One of the following or an equivalent:

- < Marsh-McBirney Electronic meter
- < Montedoro-Whitney Electronic meter
- < Price Pigmy meter (with timer and beeper)
- < Price meter, Type AA (with Columbus weight)

Additional Equipment

- < Top-setting wading rod (preferably measured in tenths of feet)(see Figure 1).
- < Tape measure (with gradations every tenth of a foot or every centimeter).

Flow Measurement Procedure (USGS, 1969)

Select a stream reach with the following characteristics:

- < Straight reach with laminar flow (threads of velocity parallel to each other) and bank to bank. These conditions are typically found immediately upstream of riffle areas or places where the stream channel is constricted.
- < The site should have an even streambed free of large rocks, weeds, and protruding obstructions that create turbulence. The site should not have dead water areas near the banks, and a minimum amount of turbulence or back eddies.

Flat Streambed Profile (cross section)

Stretch the measuring tape across the stream at right angles to the direction of flow. When using an electronic flow meter, the tape does not have to be exactly perpendicular to the bank (direction of flow). When using a propeller or pigmy type meter, however, corrections for deviation from perpendicular must be made.

If necessary and possible, modify the measuring cross section to provide acceptable conditions by building dikes to cut off dead water and shallow flows, remove rocks, weeds, and debris in the reach of stream one or two meters upstream from the measurement cross section. After modifying a streambed, allow the flow to stabilize before starting the flow measurement.

Record the following information on the flow measurement form (see example Flow Measurement Forms at end of this document):

- < Station Location and Station ID
- < Date
- < Time measurement is initiated and ended
- < Name of person(s) measuring flow
- < Note if measurements are in feet or meters
- < Total stream width and width of each measurement section
- < For each cross section, record the mid-point, section depth and flow velocity

Measuring the Stream Width

Measure and record the stream width between the points where the tape is stretched (waters edge to waters edge).

Determining the Number of Flow Cross Sections

Determine the spacing and location of flow measurement sections. Some judgment is required depending on the shape of the stream bed. Measurements must be representative of the velocity within the cross-section. If the stream banks are straight and the depth is nearly constant and the bottom is free of large obstructions, fewer measurements are needed, because the flow is homogeneous over a large section. Flow measurement sections do not have to be equal width. However, they should be unless an obstacle or other obstruction prevents an accurate velocity measurement at that point. ***No flow measurement section should have greater than 10% of the total flow.***

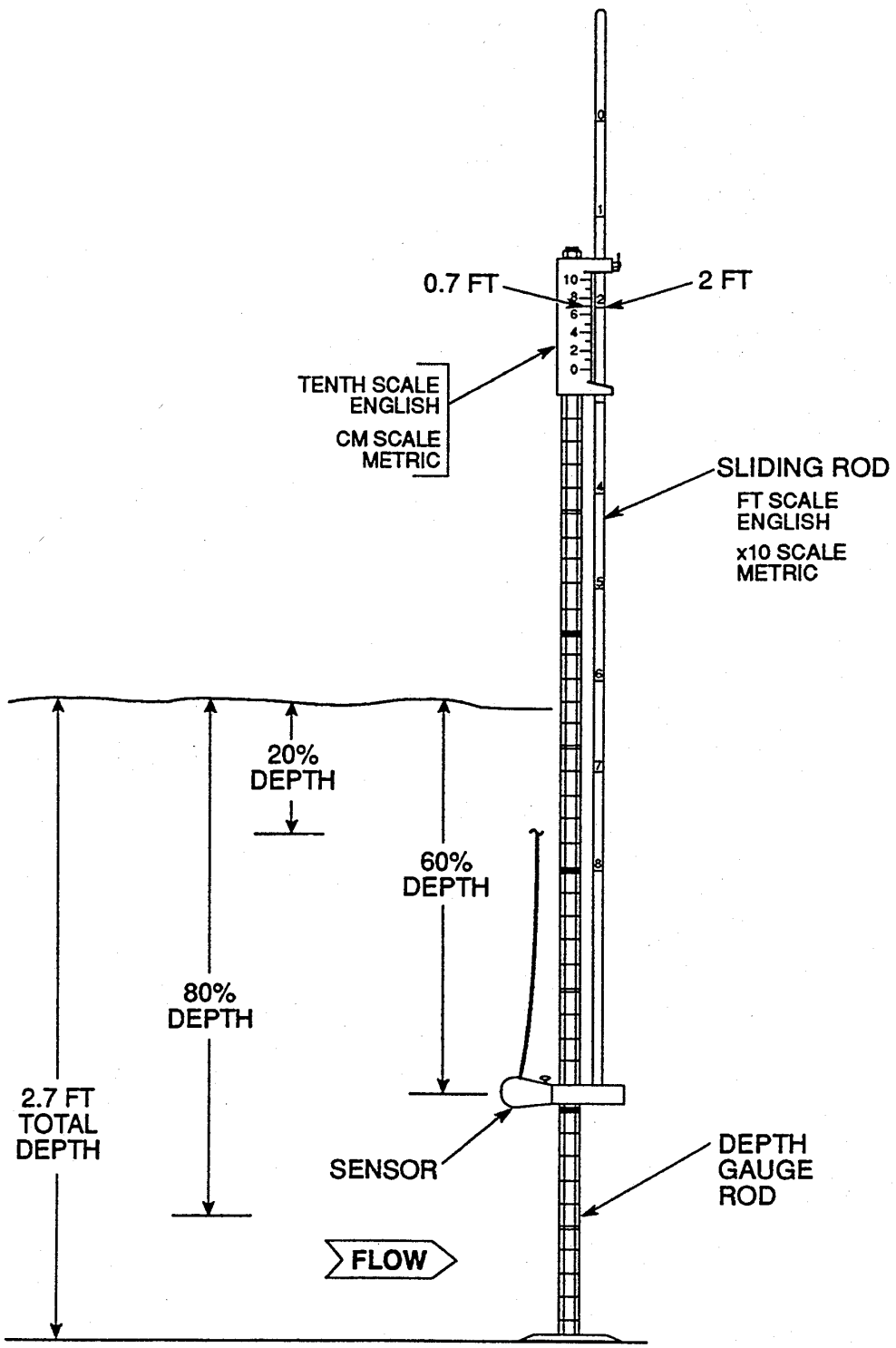
If the *stream width is less than 5 ft*, use flow sections with a width of 0.5 ft (See example 1 on page 23 of this document). If the *stream width is greater than 5 ft*, the minimum number of flow measurements is 10. The preferred number of flow measurement cross sections is 20-30 (See Example 2 on page 24 on this document). The total stream width is 26 ft with 20 measurements, section widths will be 1.3 ft (26/20 = 1.3).

Determining the Mid-Point of the Cross Section

To find the mid-point of a cross section, divide the cross section width in half. Using Example 2 (see forms at end of document);

- The total stream width is 26 ft with 20 cross sections and each cross section width is equal to 1.3 ft.
- Divide 1.3 ft in half and the mid-point of the first section is 0.65 ft. In this example the tape at waters edge is set at zero (0) ft.
- By adding 0.65 to zero the mid-point of the first section is 0.65 ft.
- Each subsequent mid-point is found by adding the section width (1.3 ft) to the previous mid-point. For example; MIDPOINT #1 is 0.65 + 0.0 = 0.65; MIDPOINT #2 is 0.65 + 1.3= 1.95 ft; MIDPOINT #3 is 1.95 + 1.3 = 3.25 ft and ....MIDPOINT # 20 is 24.05 +1.3.
- Place the top setting wading rod at 0.65 ft for the first measurement.
- Using a top setting wading rod, measure the depth at the mid-point of the first flow measurement section and record to the nearest 0.01 ft.

Figure 1. Top-Setting Wading Rod (Marsh-McBirney)



Adjusting the Sensor Depth at a Cross Section

Adjust the position of the sensor to the correct depth at each mid-point. The purpose of the top setting wading rod is to allow the user to easily set the sensor at 20%, 60%, and 80% of the total depth. The total depth can be measured with the *depth gage rod*. Each single mark represents 0.10 foot, each double mark represents 0.50 foot, and each triple mark represents 1.00 foot (see Figure 2).

For Depths < 2.5 Ft	If the depth is less than 2.5 ft, only one measurement is required at each measurement section. To set the sensor at 60% of the depth, line up the foot scale on the *sliding rod* with the *tenth scale*, located on top of the depth gage rod. If, for example, the total depth is 2.7 ft (as shown on Figure 2), then line up the 2 on the foot scale with the 7 on the tenth scale (Marsh-McBirney 1990).
For Depths > 2.5 Ft	If the depth is greater than 2.5 ft, measurements should be taken at 20% and 80% of the total depth.

Measuring Velocity (this has typically been measured at 6/10 of the total depth, for velocity-only measurements)

- Position the meter at the correct depth and place at the mid-point of the flow measurement section. Measure and record the velocity and depth. The wading rod is kept vertical and the flow sensor kept perpendicular to the tape rather than perpendicular to the flow while measuring velocity with an electronic flow meter. When using a propeller or pigmy-type meter, however, the instrument should be perpendicular to the flow.
- Permit the meter to adjust to the current for a few seconds. Measure the velocity for a minimum of 20 s with the Marsh-McBirney and Montedoro-Whitney meters. Measure velocity for a minimum of 40 s (preferably 2 min with the Price and pigmy meters).
- When measuring the flow by wading, stand in the position that least affects the velocity of the water passing the current meter. The person wading stands a minimum of 1.5 ft downstream and off to the side of the flow sensor.
- A flow sensor, equipped with cable and weight may be used to measure flows where the water is too deep to wade. Follow the procedure involving meters attached to wading rods.
- Report flow values less than 10 ft^2/s to two significant figures. Report flow values greater than 10 ft^3/s to the nearest whole number, but no more than three significant figures.
- In cases where the flow is low and falling over an obstruction, it may be possible to measure the flow by timing how long it takes to fill a bucket of known volume.

Avoid measuring flow in areas with back eddies. The first choice would be to select a site with no back eddy development. However, this can not be avoided in certain situations. Measure the

negative flows in the areas with back eddies. These negative values will be included in the final flow calculation.

Calculating Flow

To calculate flow, multiply the width x depth (ft^2) to derive the area of the flow measurement section. The area of the section is then multiplied by the velocity (ft/s) to calculate the flow in cubic feet per second (cfs or ft^3/sec) for that flow measurement section. When flow is calculated for all of the measurement sections, they are added together for the total stream flow (see Figure 2). Flow data transformers are also provided by the SWAMP data management team. The transformer provides the calculations needed to obtain a final flow value in cubic feet per second.

Q=Total Flow (or discharge), W=Width, D=Depth, V=Velocity.

$Q = (W_1 * D_1 * V_1) + (W_2 * D_2 * V_2) + ... (W_n * D_n * V_n)$

What to Do with Negative Values

Do not treat cross sections with negative flow values as zero. Negative values obtained from areas with back eddies should be subtracted during the summation of the flow for a site.

Flow Estimate (ft^3/s)

Flow estimate data may be recorded for a non-tidally influenced stream when it is not possible to measure flows by one of the methods described above. Flow estimates are subjective measures based on field personnel's experience and ability to estimate distances, depths, and velocities. If flow can not be measured at a routine non-tidal station, a new site should be selected where flow can be measured.

Flow Estimate Procedure

- Observe the stream and choose a reach of the stream where it is possible to estimate the stream cross section and velocity.
- Estimate stream width (ft) at that reach and record.
- Estimate average stream depth (ft) at that reach and record. Estimate stream velocity (ft/s) at that reach and record. A good way to do this is to time the travel of a piece of floating debris. If doing this method from a bridge, measure the width of the bridge. Have one person drop a floating object (something that can be distinguished from other floating material) at the upstream side of the bridge and say start. The person on the downstream side of the bridge will stop the clock when the floating object reaches the downstream side of the bridge. Divide the bridge width by the number of seconds to calculate the velocity. The velocity can be measured at multiple locations along the bridge. These velocities are averaged. If this is done alone, watch for road traffic.
- Multiply stream width (ft) time's average stream depth (ft) to determine the cross sectional area (in ft^2) which when multiplied by the stream velocity (in ft/s) and a correction constant, gives an estimated flow (ft^3/s).

***Example**:* A stream sampler conducted a sampling visit to a stream while the flow meter was being repaired. The sampler looked at the creek downstream from the bridge and saw a good place to estimate flow. The stream width was around 15 ft. It appeared the average depth on this reach was about 0.75 ft. The sampler timed a piece of floating debris as it moved a distance of 10 ft in 25 s downstream over the reach. An estimated flow with a smooth bottom was calculated using the following formula.

Width x Depth x Velocity x A (correction factor)= estimated flow
15 ft (width) x 0.75 ft (depth) x 2.5 ft/s (velocity) x A =25 ft^3/s (cfs)

A is a correction constant: 0.8 for rough bottom and 0.9 for smooth bottom

Estimated flow should be reported to one or two significant figures.

Experienced field personnel are able to estimate flow to within 20% of actual flow for total flows less than 50 ft^3/s. The best way to develop this skill is to practice estimating flow before making measurements at all monitoring visits to non-tidally influenced flowing streams and then compare estimated flows with those obtained from USGS gages or from instantaneous flow measurements

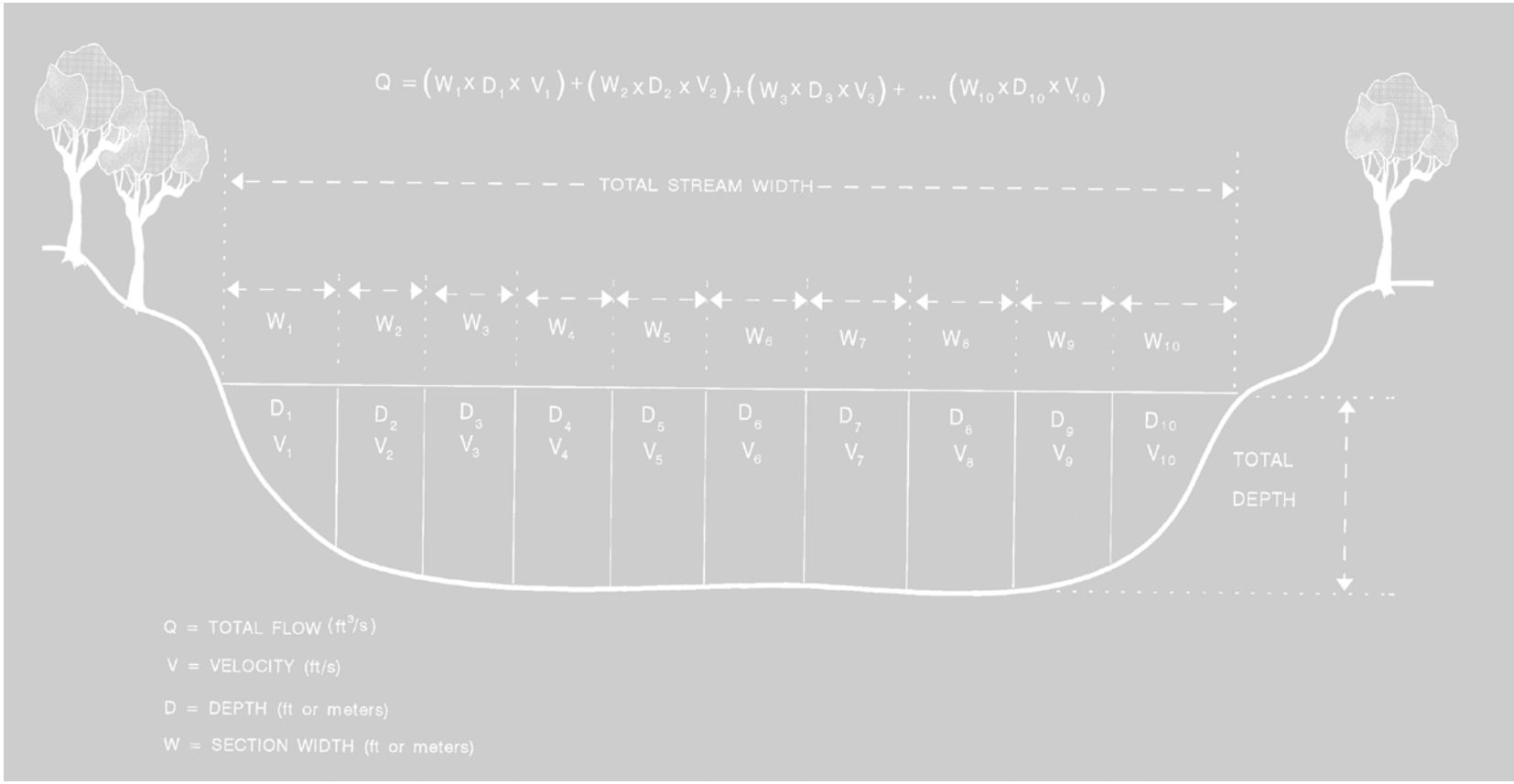


Figure 2. Stream Flow (Discharge) Measurement

Example 1.
Stream Flow (Discharge) Measurement
Small Stream < 5 Ft Wide and #2.5 Ft Deep

Stream:___**OAK CREEK**_____Date:__**5/29/91**___
Station Description:_____**at US Hwy 90A**_____
Time Begin:__**1545**_____Time End:__**1630**_____Meter Type:__**Marsh-McBirney**_____
Observers:_____**BK/MK**_____Stream Width*:____**5 ft**_____ Section Width:____**0.5 ft**_____
Observations:_____

Section Midpoint (ft)	Section Depth (ft)	Observational Depth** Ft	Velocity		Area W x D (ft^2)	Discharge (Q) V x A (ft^3/s)
			At Point (ft/s)	Average (ft/s)		
0.25	**0.55**			**0.05**		**0.01375**
0.75	**0.80**			**0.11**		**0.044**
1.25	**0.85**			**0.27**		**0.42635**
1.75	**0.90**			**0.49**		**0.2205**
2.25	**1.10**			**0.58**		**0.275**
2.75	**1.50**			**0.72**		**0.540**
3.25	**1.20**			**0.76**		**0.456**
3.75	**0.90**			**0.76**		**0.342**
4.25	**0.75**			**0.44**		**0.165**
4.75	**0.30**			**0.00**		**0.00**

m^3/s x 35.3 = ft^3/s

Total Discharge (3Q) (ft^3/s)	**2.4826**

Example 2: Stream Discharge Measurement Example (Larger Stream > 5 Ft and #2.5 Ft Deep)

Stream:___**RED RIVER**_____Date:__**5/28/91**___
Station Description:_____**Post Oak Creek 40 m Below Sherman WWTP Outfall**_____
Time Begin:__**1542**_____Time End:__**1601**_____Meter Type:_**Marsh-McBirney**_____
Observers:_____**CM, EW, DO**_____Stream Width*:____**26 ft**___ Section Width:___**1.3 ft**_____
Observations:

Section Midpoint (ft)	Section Depth (ft)	Observational Depth** ft	Velocity		Area W x D (ft^2)	Discharge (Q) V x A (ft^3/s)
			At Point (ft/s)	Average (ft/s)		
0.65	0.55			2.03	0.715	1.451
1.95	0.40			2.04	0.520	1.061
3.25	0.42			2.02	0.546	1.103
4.55	0.38			1.77	0.494	0.874
5.25	0.40			1.75	0.520	0.910
7.15	0.42			1.93	0.546	1.054
8.45	0.40			1.99	0.52	1.035
9.75	0.37			1.92	0.481	0.924
11.05	0.37			1.56	0.481	0.750
12.35	0.43			1.32	0.559	0.738
13.65	0.40			1.36	0.520	0.707
14.95	0.42			1.33	0.546	0.726
16.25	0.40			1.35	0.520	0.702
17.55	0.45			1.64	0.585	0.959
18.85	0.48			1.70	0.624	1.061
20.15	0.48			2.00	0.624	1.248
21.45	0.50			1.95	0.650	1.268
22.75	0.40			2.18	0.520	1.134
24.05	0.48			1.71	0.624	1.067
25.35	0.50			0.60	0.650	0.390
				Total Discharge (3Q) (ft^3/s)		**19.162**

m^3/s x 35.3 = ft^3/s

Example 3: Stream Flow (Discharge) Measurement (Larger Stream > 5 Ft and >2.5 Ft Deep)

Stream:____ARROYO COLORADO_____Date:__**6/16/98**__

Station Description:_____Downstream of Harlingen WWTP_____

Time Begin:__**1400**_____Time End:__**1445**_____Meter Type:__**Marsh-McBirney**_____

Observers:_____**JD, CK**_____Stream Width*:___**47.5 ft**___ Section Width:___**2.375 ft**_____

Observations: *Note that the starting point is at 4.7 ft on the measuring tape and not zero.

Section Midpoint (ft)	Section Depth (ft)	Observational Depth** ft	Velocity		Area W x D (ft^2)	Discharge (Q) V x A (ft^3/s)
			At Point (ft/sec)	Average (ft/sec)		
4.70	0.73			0.65	1.73	1.127
7.08	1.10			1.08	2.61	2.822
9.45	1.85			0.90	4.39	3.954
11.83	2.20			1.05	5.23	5.486
14.20	2.20			1.44	5.23	7.531
16.58	2.45			1.09	5.82	6.342
18.95	2.55	0.20	1.75	1.76	6.06	10.659
		0.80	1.76			
21.33	2.60	0.20	1.79	1.56	6.18	9.633
		0.80	1.32			
23.70	2.70	0.20	1.63	1.45	6.41	9.298
		0.80	1.26			
26.10	3.05	0.20	1.68	1.42	7.24	10.286
		0.80	1.15			
28.48	3.10	0.20	1.23	0.96	7.36	7.068
		0.80	0.69			
30.85	2.90	0.20	1.22	1.06	6.89	7.301
		0.80	0.89			
33.23	2.84	0.20	0.60	0.49	6.75	3.305
		0.80	0.37			
35.60	2.65	0.20	0.80	0.51	6.29	3.210
		0.80	0.21			
37.98	2.65	0.20	0.85	0.91	6.29	5.727
		0.80	0.96			
40.35	2.20			0.28	5.23	1.464
42.73	2.30			0.16	5.46	0.874
45.10	2.05			0.51	4.87	2.483
47.48	1.10			0.49	2.61	1.280
49.86	0.65			0.62	1.54	0.957

m^3/s x 35.3 = ft^3/s **Total Discharge (3Q) (ft^3/s)**

Stream Flow (Discharge) Measurement Form

Stream:____Date:_______________

Station Description:____

Time Begin:___________ Time End:_____________ Meter Type:__________________________

Observers:____________________ Stream Width*:______________ Section Width:___________

Observations:____

Section Midpoint (ft) (m)	Section Depth (ft) (m) (cm)	Observational Depth** ft-m-cm	Velocity		Area W x D (ft^2) (m^2)	Flow (Q) V x A (m^3/s) (ft^3/s)
			At Point (ft/s) (m/s)	Average (ft/s)(m/s)		

$m^3/s \times 35.3 = ft^3/s$

Total Flow (Discharge) (3Q) (ft^3/s)	

Make a minimum of 10 measurements when the total width is > 5.0 ft, 20 measurements preferred.

If the depth is less than 2.5 ft, only one measurement is required at each measurement section. To set the sensor at 60% of the depth, line up the foot scale on the *sliding rod* with the *tenth scale*, located on top of the depth gage rod. If, for example, the total depth is 2.7 ft (as shown on Figure 2), then line up the 2 on the foot scale with the 7 on the tenth scale (Marsh-McBirney 1990). If the depth is greater than 2.5 ft, measurements should be taken at 20% and 80% of the total depth.

Summary of Significant Figures for Reporting Field Parameters

Parameter	Field Data Reporting Requirements
Water Temperature (^{o}C)	Report temperature to the nearest tenth of a degree. Round insignificant figures 0 through 4 down and 5 thru 9 up.
pH (s.u.)	Report pH to the nearest tenth of a pH standard unit.
D.O. mg/L **D.O.** (% saturation)	Report dissolved oxygen to the nearest tenth of a mg/L. Report % saturation to the nearest tenth of a percent
Specific Conductance (micro siemens/cm)	Report specific conductance to only three significant figures if the value exceeds 100. Do not report ORP which is displayed by some multi-probes.
Salinity (ppt)	Report salinity values above 2.0 ppt to the nearest tenth of a part per thousand. In estuarine waters report the actual values displayed by the multi-probe above 2.0 ppt and values less than 2.0 as <2.0 or <1.0 only. Determine if a station is estuarine (i.e., experiences cases where salinity is >2.0 ppt) and always report salinity at this station, regardless of the salinity during periods of high flow.
Secchi Disk (meters)	Report Secchi depth transparency in meters to two significant figures.
Flow (ft^3/s)	Report instantaneous flow values less than 10 ft^3/s to two significant figures. Report flow values greater than 10 ft^3/s to the nearest whole number, but no more than three significant figures. When there is no flow (pools), report as 0.0. When there is no water, don't report a value, but report as "dry" in the observations.

BEAUFORT SCALE: Specifications and equivalent speeds for use at sea

FORCE	EQUIVALEN SPEED 10 m above ground		DESCRIPTION	SPECIFICATIONS FOR USE AT SEA
	Miles/hour	knots		
0	0-1	0-1	Calm	Sea like a mirror
1	1-3	1-3	Light air	Ripples with the appearance of scales are formed, but without foam crests.
2	4-7	4-6	Light Breeze	Small wavelets, still short, but more pronounced. Crests have a glassy appearance and do not break.
3	8-12	7-10	Gentle Breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.
4	13-18	11-16	Moderate Breeze	Small waves, becoming larger; fairly frequent white horses.
5	19-24	17-21	Fresh Breeze	Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.
6	25-31	22-27	Strong Breeze	Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray.
7	32-38	28-33	Near Gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	39-46	34-40	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks along the direction of the wind.
9	47-54	41-47	Severe Gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble, and roll over. Spray may affect visibility.
10	55-63	48-55	Storm	Very high waves with long over- hanging crests. he resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On he whole the surface of the sea takes on a white appearance. The 'tumbling' of the sea becomes heavy and shock-like. Visibility affected.

Last edited on 09 January, 1999 Dave Wheeler weatherman@zetnet.co.uk
Web Space kindly provided by Zetnet Services Ltd, Lerwick, Shetland.
http://www.zetnet.co.uk/sigs/weather/Met_Codes/beaufort.htm

Field Collection Procedures for Water Samples

Scope and Application

This protocol describes the techniques used to collect water samples in the field in a way that neither contaminates, loses, or changes the chemical form of the analytes of interest. The samples are collected in the field into previously cleaned and tested (if necessary) sample bottles of a material appropriate to the analysis to be conducted. Pre-cleaned sampling equipment is used for each site, whenever possible and/or when necessary. Appropriate sampling technique and measuring equipment may vary depending on the location, sample type, sampling objective, and weather. Trade names used in connection with equipment or supplies do not constitute an endorsement of the product. Safety equipment is always used while water sampling including gloves, waders and eye protection. Safety equipment helps to protect the sampler from potential contaminants and to prevent sample contamination.

Summary of Method

Appropriate sample containers and field measurement gear as well as sampling gear are transported to the site where samples are collected according to each sample's protocol. Water velocity, turbidity, temperature, pH, conductivity, dissolved oxygen as well as other field data are measured and recorded using the appropriate equipment. These field data measurement protocols are provided in this Field Measurement SOP. Samples are immediately put on ice and appropriately shipped to the authorized laboratories. This procedure has been modified from the Texas Natural Resources Conservation Commission's Procedure Manual for Surface Water Quality Monitoring, with major input from the United State's Geological Survey's (USGS's) National Water Quality Assessment (NAWQA) Protocol for Collection of Stream Water Samples.

WATER SAMPLE COLLECTION

Water chemistry and bacteriological samples, as requested, are collected at the same location. *Water samples are best collected before any other work is done at the site*. If other work (e.g., sediment sample collection, flow measurement or biological/habitat sample collection or assessment) is done after or downstream of the collection of water samples, it might be difficult to collect representative samples for water chemistry and bacteriology from the disturbed stream. Care must be taken, though, to not disturb sediment collection sites when taking water samples. Don't be trampling where you are sampling.

The following general information applies to all types of water samples, unless noted otherwise:

Sample Collection Depth

Sub-Surface Grab Sample Samples are collected at 0.1 m below the water surface. Containers should be opened and re-capped under water in most cases.

Depth-integrated Sample If a depth-integrated sample is taken, the sample is pumped from discrete intervals within the entire water column.

Surface Grab Sample Samples are collected at the surface when water depth is <0.1 m. Since there is a difference in water chemistry on the surface, compared to subsurface, surface water should be noted on the field data sheet as 0 m.

Where to Collect Samples

Water samples are collected from a location in the stream where the stream visually appears to be completely mixed. Ideally this would be at the centroid of the flow (*Centroid* is defined as the midpoint of that portion of the stream width, which contains 50% of the total flow), but depth and flow do not always allow centroid collection. For stream samples, the sampling spot must be accessible for sampling physicochemical parameters, either by bridge, boat or wading. Sampling from the shoreline of any water body (meaning standing on shore and sampling from there) is the least acceptable method, but in some cases is necessary.

In reservoirs, lakes, rivers, and coastal bays, samples are collected from boats at designated locations provided by Regional Water Quality Control Boards (Regional Boards). Samples from boats should be collected where the vessel does not interfere with the water being collected.

Sampling Order if Multiple Media are Requested to be Collected

The order of events at every site has to be carefully planned. For example, if sediment is to be collected, the substrate can not be disturbed by stepping over or on it; water samples can not be collected where disturbed sediment would lead to a higher content of suspended matter in the sample. *For the most part, water samples are best collected before any other work is done at the site*. This information pertains to walk-in sampling.

Sample Container Labels

Label each container with the station ID, sample code, matrix type, analysis type, project ID, and date and time of collection (in most cases, containers will be pre-labeled). After sampling, secure the label by taping around the bottle with clear packaging tape.

Procedural Notes

For inorganic and organic water samples, bottles do not have to be rinsed if they are I-Chem 200 series or higher or ESS PC grade or higher. This means that the sample bottles are analyzed for contamination, and a certification of analysis is included with the bottles. Other sample containers are usually rinsed at least three times if the bottles do not meet these requirements. See filling instruction for each type of analyses if there is uncertainty. If applicable to the sample and analysis type, the sample container should be opened and re-capped under water.

Sample Short-term Storage and Preservation

Properly store and preserve samples as soon as possible. Usually this is done immediately after returning from the collection by placing the containers on bagged, crushed or cube ice in an ice chest. Sufficient ice will be needed to lower the sample temperature to at least 6 ° □(time of collection. Sample temperature will be maintained at 6 °□C until delivered to the laboratory. Care is taken at all times during sample collection, handling and transport to prevent exposure of the sample to direct sunlight. Samples are preserved in the laboratory, if necessary, according to protocol for specific analysis (acidification in most cases).

Field Safety Issues

Proper gloves must be worn to prevent contamination of the sample and to protect the sampler from environmental hazards (disposable polyethylene, nitrile, or non-talc latex gloves are recommended, **however, metals and mercury sample containers can only be sampled and handled using clean polyethylene gloves as the outer layer**). Wear at least one layer of gloves, but two layers help protect against leaks. One layer of shoulder high gloves worn as a first (inside) layer is recommended to have the best protection for the sampler. Safety precautions are needed when collecting samples, especially samples that are suspected to contain hazardous substances, bacteria, or viruses.

Sample Handling and Shipping

Due to increased shipping restrictions, samples being sent via a freight carrier require additional packing. Although care is taken in sealing the ice chest, leaks can and do occur. Samples and ice should be bagged placed inside a large trash bag inside the ice chest for shipping. Ice should be double bagged to prevent melted ice water from leaking into the sample. The large trash bag can be sealed by simply twisting the bag closed (while removing excess air) and taping the tail down. Prior to shipping the drain plug of the ice chests have to be taped shut. Leaking ice chests can cause samples to be returned or arrive at the lab beyond the holding time.

Although glass containers are acceptable for sample collection, bubble wrap must be used when shipping glass.

Chain of Custody (COC) Forms

Every shipment must contain a complete Chain of Custody (COC) Form that lists all samples collected and the analyses to be performed on these samples.

Make sure a COC is included for every laboratory, every time you send a shipment of samples. Electronic COC's can also be emailed to the various laboratories but must be sent before the samples arrive at their destinations.
Include region and trip information as well as any special instructions to the laboratory on the COC.

The original COC sheet (not the copies) is included with the shipment (insert into ziplock bag) One copy goes to the sampling coordinator, and the sampling crew keeps one copy.

Samples collected should have the salinity (in parts per thousand) or specific conductivity (**µS/cm),** depth of collection, and date/time collected for each station on every COC.

Write a comment on this form, if you want to warn the laboratory personnel about possibly hazardous samples that contain high bacteria, chlorine or organic levels.

Field QC Samples for Water Analyses

Field duplicates are currently submitted at an annual rate of 5%. Field travel blanks are required for volatile organic compounds at a rate of one per cooler shipped. Field blanks are required for trace metals (including mercury and methyl mercury), DOC, and volatile organic compounds in water at a

project rate of 5%. See the SWAMP Quality Control and Sample Handling Guidelines for information regarding frequency and types of field QC samples.

SWAMP Field Data Sheets

Each visited field site requires a field observation completed SWAMP Field Data Sheet, even if no samples are collected (i.e. at a site which is found to be dry). If water and/or sediment samples are collected, all elements of the SWAMP Field Data Sheet must be completely filled out. Data sheets are provided from the SWAMP Data Management Resources website at: **Water Quality Field Data Sheet** *(updated 12/18/12)*

General Pre-Sampling Procedures

Instruments. All instruments must be in proper working condition. Make sure all calibrations are current. Multi-probe sondes should be pre-calibrated every morning prior to sampling and post-calibrated within 24 h of the original calibration. Conductivity should also be calibrated between stations if there is a significant change in salinity. Dissolved oxygen sensors should be re-calibrated if there is a 500 ft change in elevation.

Calibration Standards. Pack all needed calibration standards.

Sample Storage Preparations. A sufficient amount of cube ice, blue ice and dry ice as well as enough coolers of the appropriate type/size must be brought into the field, or sources for purchasing these supplies identified in advance.

Sample Container Preparation. After arriving at the sample station, pack all needed sample containers for carriage to the actual collection site, and label them with a pre-printed label containing Station ID, Sample Code, Matrix info, Analysis Type info, Project ID and blank fields for date and time (if not already pre-labeled).
Safety Gear. Pack all necessary safety gear like waders, protective gloves and safety vests.

Walk to the site. For longer hikes to reach a sample collection

site, large hiking backpacks are recommended for transport of gear, instruments and containers. Tote bins can be used, if the sampling site can be accessed reasonably close to the vehicle.

GPS. At the sampling site, compare/record reconnaissance GPS reading with current site reading and note differences. GPS coordinates should be in Decimal Degrees (e.g. 38.12345 -117.12345).

COLLECTION OF WATER SAMPLES FOR ANALYSIS OF CONVENTIONAL CONSTITUENTS

In most streams, sub-surface (0.1 m below surface) water is representative of the water mass. A water sample for analysis of conventional constituents is collected by the grab method in most cases, immersing the container beneath the water surface with the cap on to a depth of 0.1 m. Remove cap and fill container replacing the cap before removing the container from the water. Sites accessed by bridge can be sampled with a sample container-suspending device. Extreme care must be taken to avoid contaminating the sample with debris from the rope and bridge. Care must also be taken to rinse the device between stations. If the centroid of the stream cannot be sampled by wading, sampling devices can be attached to an extendable sampling pole. It should be noted on the field data sheet if using a bucket sampler that surface water is entering the sample bottle.

In some cases, depth-integrated sampling is required, as requested by Regional Boards. This is useful when lakes or rivers are stratified and a sample is wanted that represents the entire water column. Depth-integrated sample collection is explained later in this document.

Conventional Water Constituents, Routinely Requested in SWAMP

Chloride (Cl-), Sulfate ($SO4^{2-}$), Nitrite ($NO2^{-}$), Nitrate ($NO3^{-}$) (or Nitrate + Nitrite ($NO_3 + NO_2$)), Ortho-phosphate, Fluoride (F-), Total Phosphorus (TPO_4), Ammonia (NH3), Total Nitrogen (TN), Alkalinity, Chlorophyll a.

Conventional Water Constituents, Occasionally Requested in SWAMP

Total Suspended Solids (TSS) or Suspended Sediment Concentration (SSC), Total Dissolved Solids (TDS--especially if total metals requested), Total Kjeldahl Nitrogen (TKN), Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC), hardness (if trace metals analysis is requested).

Conventional Water Constituents Sample Volume

Due to the potential for vastly different arrays of requested analyses for conventional constituents, please refer to table at the end of this document, as well as the Quality Control and Sample Handling Guidelines for Conventional Parameters, for

information on the proper volume to collect for the various types of analyses.

Conventional Water Constituents Sample Container Type

Due to the potential for vastly different arrays of requested analyses for conventional constituents, please refer to table at the end of this document, as well as the Quality Control and Sample Handling Guidelines for Conventional Parameters, for information on the proper type of sample containers.

Chlorophyll a Syringe Sample Method

Chlorophyll a syringe method: Chlorophyll a is sampled by forcing water with a 60-mL syringe through a filter holder containing a 25-mm glass microfiber filter. The 60-mL syringe and an in-line filter holder are rinsed three times with the ambient water before filtration. The syringe is then filled with 60 mL of ambient water. The filter holder is then removed and a 25-mm glass microfiber filter is placed inside. The filter holder is then screwed onto the syringe and the ambient water is then flushed through the filter. The filter holder is removed every time more water needs to be drawn into the syringe. The process is then repeated until the desired amount of Chlorophyll a is present (usually 60 to 360 mL depending on the water clarity). When filtering is complete the filter holder is opened and the filter is removed with tweezers without touching the Chlorophyll a. The filter is then folded in half, then again, in half with the Chlorophyll a inside the folds. The folded filter is then wrapped in aluminum foil and placed in an envelope labeled with the site information and the volume filtered. The envelope is then immediately placed on dry ice until transferred to the lab.

Collection of Water Samples for Analysis of Trace Metals (Including Mercury)

When deciding to measure total and dissolved metals in water the purpose of the sampling must be considered. Water quality standards for the protection of aquatic life are determined for the dissolved form of heavy metals in most cases, although this, too, can vary within different Basin Plans for different regions. The exception to routinely conducting dissolved metals analyses is usually mercury (and often selenium). Water quality standards usually apply to the total form of mercury (and often selenium), and not the dissolved form of these elements. Several regions are interested in conducting total metals analyses, in order to address specific issues. In order to budget inputs, transport, and accumulation of metals, it is necessary to know the concentration of total metals in the water column, sediments, effluent, etc. Sample collection for trace metals and mercury in water requires "Clean Hands/Dirty Hands" methodology.

Metals-in-water: General Information

Unless otherwise requested to collect for total metals analysis, dissolved metals are collected for all elements with the exception of mercury. Metals-in-water samples should **not** be collected during periods of abnormally high turbidity if at all possible. Samples with high turbidity are unstable in terms of soluble metals, and it is difficult to collect a representative grab sample. Special study sampling, however, may be an exception. For example, wet weather sampling is likely to include some samples with high turbidity.

Metals-in-water: Sample Collection Depth

Collect a metals sample from a depth of 0.1 m using a sub - surface grab method, or at discrete depths using a depth-integrated sampling method with a peristaltic pump (described further down). In most streams, sub-surface water is representative of the water mass. For the purpose of determining compliance with numerical toxic substance standards, a sample taken at the surface is adequate.

Metals-in-water: Sample Volume

Refer to table at end of this document for specific information on the proper volume to collect for trace metals analyses. Generally, for procedures most commonly used for analysis of metals in water (total or dissolved metals); one 60-mL polyethylene container is filled with the salinity recorded on the field data sheet and COC. Generally, for the procedures most commonly used for analysis of mercury in water (whether total or dissolved), one 250-mL glass or teflon container is filled, regardless of the salinity. All containers are pre-cleaned in the lab using HNO_3.

Metals-in-water:

Sampling Equipment

The method of choice for the collection of water samples for trace metals analysis in small, wadeable streams is the grab method, where the sampler submerges the sample bottle or syringe beneath the surface of the water until filled. The procedure for filtration of water samples for trace metals analysis must be performed within 15 minutes of collection to meet the required filtration holding time. For Mercury(Hg) samples, preservation may take place in the field or at the laboratory within 48 hours of collection. Extreme care must be taken to avoid contamination of the water sample. Considering these factors, it is best to use a **field** filtration system, such as a set-up with peristaltic pump with in-line filter, or a set-up with a syringe filter, if filtered water is required. Samples are pumped and/or filtered directly into the sample container. This minimizes contamination by using no intermediate sampling device. Samples can also be filtered in lab if need be Un-powdered (no-talc) polyethylene gloves are always worn during sampling for metals-in-water.

Depth-integrated sampling is useful when lakes or rivers are stratified and a representative sample is wanted which represents the entire water column. The method involves a peristaltic pump system with enough Teflon tubing to pump at the desired depth with an inline filter. Filter equipment blanks are analyzed for five percent of all cleaned equipment.

Equipment Preparation

It is best if the metals-in-water sampling materials are prepared by a laboratory that can guarantee contamination-free sampling supplies. If a laboratory assembles a Metals-in-Water Sample Collection Kit, it should contain the following items packaged together **for each sample**:

- Tubing with an in-line filter (disposable, 0.45 μm) attached for dissolved metals-in-water sampling. This same tubing is used for total metals-in-water samples without filter. If an in-line pumping system is not used, an acid cleaned syringe and filter are packed.
- Sample containers- polyethylene for total and dissolved samples and blanks; Glass or Teflon for total and dissolved mercury.
- Acid preservation is performed in the laboratory.
- Metals-free DI water (for blanks).
- Powder-free polyethylene gloves

If a laboratory is not assembling collection kits, individuals should take care to keep containers in the original packaging. When removed from the box, sample containers are placed in clean plastic bags (zipper closure bags). Although filters come individually wrapped, they should also be stored in new zipper closure bags to avoid possible contamination.

The filtering equipment is pre-cleaned according to laboratory protocol. Clean tubing is put into clean containers, such as large zipper closure bags. Metals-free filter cartridges with the capacity to filter several liters are commercially available. Equipment blanks are run at the laboratory on batches of metals-in-water sampling equipment prior to their distribution to field staff. One to two liter containers with metals-free deionized water are taken into the field for travel blanks. Metals-free deionized water is supplied by the laboratory performing metals analysis. The deionized water containers are kept clean and dust-free on the outside by wrapping in two plastic bags.

Dissolved and Total Metals-in-Water: Detailed Collection Techniques

- ***Sub-Surface Grab Method***
- ***Syringe Filtration Method (for sub- surface collection)***
- ***Peristaltic Pumping Method (Using Tubing/In-line Cartridge Filters)for sub- surface collection or for depth-integrated collection***

Metals-in-water Sample Collection:

Sub-Surface Grab Method

Clean Hands/Dirty Hands Technique

Unfiltered Samples (for total metals analysis, if requested, and for mercury almost always, unless otherwise requested): Some samples can be sampled directly from the ambient water either by wading into the stream and dipping bottles under the surface of the water until filled, or by sampling from a boat and dipping the bottle under the surface of the water until it is filled. The bottles are cleaned according to laboratory protocol. It is very critical that all the acid is rinsed out of the bottles before the samples are collected. Personnel involved in field sample collection/processing wear polyethylene gloves. The laboratory pre-cleaned glass or Teflon™ 250 mL (for mercury) or polyethylene 60 mL (for metals) sample bottles are taken from the double-wrapped

zipper closure plastic bags using "Clean Hands/Dirty Hands" techniques. The dirty hands collector opens the first outer bag, and the clean hands collector opens the inner bag around the bottle. The clean hands collector then removes the bottle from the inner bag. Clean hands collector then places the inner bag back inside the outer bag while sampling occurs. The clean hands collector dips the bottle into the ambient water, with the cap on, to approximately 0.1 m (avoiding disturbing surface scums), placing the cap back on the bottle before being removed from the water, rinses the bottle five times with ambient water, making sure the threads of the bottle get rinsed as well, and fills the bottle to the top. The lid is secured under the water surface and the bottle is put back into the inner clean bag and sealed by the clean hand collector. The sealed clean bag is then placed back inside the outer bag by the clean hands collector. The dirty hands collector then seals the outer bag.

Metals-in-water Sample Collection:

Syringe Filtration Method (for sub-surface collection)

Filtered Samples (for dissolved metals analyses): Sub-surface water samples are filtered for dissolved trace metals analysis (not for mercury, however, in almost all cases) using the following syringe filtration method.

The syringe (60 cc size, pre-cleaned in the laboratory) and in-line filter are pre-packed in two zipper closure bags. The syringe and filter are taken out of the bags using "Clean Hands/Dirty Hands" technique, as previously described. The sub-surface water sample is collected by 1) wading out into the centroid portion of the stream, or by leaning over the edge of the boat, and aspirating water into the syringe, filling and rinsing the syringe five times with ambient water; 2) attaching the filter onto the syringe and filling the syringe body; 3) rinsing the filter with a few milliliters of the sample; 4) rinsing the sample bottle five times with the filtered ambient water; and 5) extruding the sample through the syringe filter and completely filling each bottle. The bottles are taken out of and put back into their bags using "Clean Hands/Dirty Hands".

Metals-in-water Sample Collection--

Peristaltic Pump

The basic "Clean Hands/Dirty Hands" technique is also applied in the use of a peristaltic pump with an in-line filter cartridge for metals-in-water sample collection. Dirty Hands removes the plastic cover from the end of the pump tubing and inserts the tubing into the sampling container. Dirty Hands holds the tubing in place. The in-line cartridge filter is attached to the outlet end of the tubing.

Clean Hands takes the plastic cover off the other end of the tubing. Dirty Hands turns on the pump and flushes lL of ambient water through the tubing to purge it for dissolved metals.

Clean Hands removes the cap from the sample bottle and uses the pump to fill it with ambient water. Clean Hands puts the cap back on the bottle and places it in the plastic bag.

Metals-in-water Sample Collection:

Depth-Integrated Sampling, using In-line Cartridge Filter and Peristaltic Pump

Preparation for Depth-integrated sample collection:
Depth-integrated sampling is useful when lakes or rivers are stratified, and a representative sample is wanted that represents the entire water column to the extent possible. The method utilized to date for SWAMP involves a peristaltic pump system with enough Teflon tubing to pump from the desired depth. Regional Boards must request depth-integrated sampling.

The tubing set consists of a small length of CFLEX tubing that fits in the peristaltic pump, with an appropriate length of Teflon tubing on the suction side of the pump and a 3-ft section of Teflon tubing on the discharge side of the pump.

The tubing set is pre-cleaned in 10% reagent grade HCL at the laboratory, and to date in SWAMP, a new pre-cleaned tubing set is used for each site. However, the same peristaltic tubing set can be used at multiple sites, as long as it has been cleaned in the field between stations, according to protocol as outlined below. If this is to be done, however, and Dissolved or Total Organic Carbon samples are collected, equipment blanks should be collected at each site until it is determined that the blanks are acceptably low.

The field cleaning procedure for tubing that is to be re-used is:

- Pump phosphate free detergent through tubing.
- Pump 10% HCL through tubing.
- Pump methanol through tubing.
- Pump 1 l of blank water (Milli-Q) through.

All reagents must be collected in appropriate hazardous waste containers (separated by chemical), and transport, as well as

disposal, must follow appropriate local, state, and federal regulations.

If a field blank is needed, collect it after the 1 L of blank water is pumped through. Pump the amount of ambient water equivalent to 3 times the volume of the tubing before sampling the next site.

Filtered and Unfiltered Samples, Depth-integrated:
It is recommended to attach the tubing to a line with depth measurement markers (preferably in meters). At the end of this line should be a trace metal-safe weight, which hangs about one meter below the tubing end, avoiding any sediment intake from the bottom of the water column with the pump tubing.

At the site, Dirty Hands sets up the pump, while Clean Hands takes a bottle from the plastic bag and places it in a container holder or on a clean surface. A container holder can be anything trace metal clean that supports the bottle, freeing up the collector's hands. Clean Hands takes the outlet-end of the tubing (with the in-line filter cartridge attached) out of the bag, and places it in the peristaltic pump head. The outlet end is long enough to allow easy bottle filling; the other end is long enough to easily reach beneath the water surface and to the desired depth. Dirty Hands closes the pump head, locking the tubing in place.

Make sure that all bottles are filled with a depth-integrated water sample. This can be accomplished by dividing the total vertical length of the water column into 2 to 10 equal intervals, and sampling each interval equally, filling the bottles at each depth proportional to the number of intervals sampled. For example, if 10 intervals are sampled, every bottle is filled $1/10^{th}$ full at each depth sampled. A very common method of dividing the water column is by first determining the depth of the thermo-cline. Samples are taken at the midpoint between the surface and the thermo-cline, at the midpoint between the top of the thermo-cline and the bottom of thermo-cline, and at the midpoint between the bottom of the thermo-cline and just above the bottom of the water column. For these methods, all containers have to be filled at the same time. Note the number of intervals sampled on the data sheet.

When filling bottles, Clean Hands immerses the intake tube directly into the water at the appropriate depth, and Dirty Hands operates the pump to flush the tubing with a minimum of 1L of ambient water through the tubing and filter.

Clean Hands removes the cap from the sample bottle, holds the tubing outlet with the in-line filter cartridge over the container opening (without touching the container), and allows the container to fill. The container is filled and rinsed five times with ambient water, and is then filled to the top for the actual sample. Clean Hands puts the cap back on the bottle, and places the bottle back it in the zipper closure plastic bag. Whenever Clean Hands touches the boat or equipment, which may be contaminated, gloves should be changed immediately.

(Note for Unfiltered samples: *If an unfiltered sample is required for total metals, total mercury, conventional constituents, toxicity, or synthetic organics, the same procedure is used as described above, except the filter is detached from the end of the tubing before filling the bottles.)*

When sampling is finished, the tubing is brought to the surface, clean water (Milli-Q or deionized) is pumped through system, and the tubing is stored in a polyethylene bag.

The tubing set can be used at multiple sites, as long as it has been cleaned in the field between stations (see field cleaning procedure above). However, if Dissolved or Total Organic Carbon samples (in water) are collected, equipment blanks should be collected at enough sites until it is determined the blanks are appropriate.

Metals-in-water Sample Collection:

Collecting the Sample:

Composite Bottle

The sample collection methodologies are identical to those described above except the sample is collected first into a composite bottle(s). The sample is collected in an amber glass 4-L bottle for mercury and methyl mercury, and a 4-L polyethylene bottle for other trace metals. The compositing bottle is cleaned according to SWAMP SOP.SC.G.1. It is very critical that all the acid is rinsed out of the bottle and that the bottle is rinsed with sample water (five times) before the

sample is taken. The sample is collected by the grab or pumping method after being rinsed five times with ambient water and is brought inside the water quality vehicle or sampling box for processing. Personnel involved in sample processing don polyethylene gloves. During sampling the dirty hands person opens the bag holding the composite bottle and opens the outer plastic bag. The clean hands person opens the inner plastic bag, removes the bottle and holds the bottle while the Dirty Hands sampler controls the flow of water through the pump into the bottle.

Preparing sample aliquots from a composite bottle into smaller sample bottles using an inline pump and filter:

The dirty hands person opens the first bag, and the clean hands person opens the inner bag around the composite bottle. The clean hands person then removes the bottle from the inner bag and places the bags and the bottle in a designated clean place.

This process is repeated until all sample bottles are lined up on the clean bench with their tops still on.

The top of the bottles are loosened so that they fit very loosely on top of the bottles so the clean hands person can remove the caps and pour or pump water into the bottles easier.

The clean hands person shakes the 4-L sample in a steady and slow up and down motion for two full minutes.

Samples that are not to be filtered (including TSS/SSC) are sub-sampled out of the bottle by pouring out of the large compositing bottle into the sample bottles. The compositing bottle is shaken for 15 s between these subsamples.

Each sample bottle is rinsed five times with ambient water before filling.

For the clean pumping system setup procedure, see above.

(The equipment or field blank is processed exactly like a sample following the same steps.)

The clean end of the tubing used for suction is placed into 1 L bottle. Approximately 750 mL of Milli-Q are then pumped through the system to purge any residual contamination.

The 250-mL sample bottles are then filled to the neck and capped as soon as possible.

Note: if volatile organics are to be collected they should be pumped directly into the sample containers before the compositing procedure.

Metals-in-water: Short-term Sample Preservation

After collecting the sample, the double-bagged container is placed in another plastic bag for shipping, and placed on ice in the ice chest, cooled to 6 °C. This is to prevent possible contamination from other samples in the ice chest. Metals-in-water samples are acid-preserved in the lab.

Metals-in-water: Sample Container Label

Label each outer sample-bag with the station ID, sample code, matrix type, analysis type, project ID, and date and time of collection.

Metals-in-water: Field Equipment Blank

Pumping Method. If required, field blanks are collected at the last site of a sampling trip, with the same tube and filter used to collect the last dissolved metals-in-water sample of the day (before the ambient sample is collected); and with the tube used for the last total metals-in-water sample of the day. If each sample is taken using a new set of tubing, a separate tubing-set should be used for the blank.

The same Clean Hands/Dirty Hands collection techniques are followed for the field blank as the samples, pumping trace metal-free water from a clean container supplied by the laboratory.

Syringe Method. If required, field blanks are collected in much the same way as in the pumping method. "Clean Hands/ Dirty Hands" techniques are used. The syringe is taken out of the double bags, deionized water is aspirated into the syringe, syringe is rinsed five times with ambient water, the filter is attached, and the blank water is extruded into a sample bottle. A minimum of one blank per trip is taken, if required.

Grab Method. Bottles full of deionized water or Milli-Q are opened at the site for the same length of time the sample bottles are open.

COMPANION SAMPLES FOR METALS-IN-WATER

A hardness analysis should be requested by the Regional Water Control Board whenever metals-in-water are to be analyzed from an inland (freshwater) site. Estuarine/marine sites do not require hardness analysis.
If a total metals sample is collected, it is recommended to submit a sample for total suspended solids/suspended sediment concentration (TSS/SSC) in a companion sample for "conventionals in water".

Hexavalent Chromium

Very rarely, a request may be made for conducting hexavalent chromium analysis in water samples. Acidification alters the hexavalent form of chromium. A separate (un-acidified) sample must be submitted if hexavalent chromium is to be analyzed. Filter and submit a minimum of 500 mL water. The sample is collected in a DI-water-rinsed polyethylene or glass container, placed on ice, and shipped to the lab in time for analysis to begin within 24 h of collection. The lab must be notified when a hexavalent chromium sample will arrive. Hexavalent chromium is not usually analyzed on unfiltered samples.

FIELD QC SAMPLE COLLECTION REQUIREMENTS FOR METALS-IN-WATER

In order to assess contamination, "blanks" are submitted for analysis. Special projects may have other requirements for blanks. The same group of metals requested for the ambient samples are requested for the blank(s). Run a blank for each type of metal sample collected. Blanks results are evaluated (as soon as available) along with the ambient sample results to determine if there was contamination or not. See the Quality Control and Sample Handling Guidelines for Inorganic Analytes for information regarding frequency and types of field QC samples.

Field Equipment Blank (Ambient Blank) Submit an equal volume (equal to the ambient sample) of metals-free deionized water that has been treated exactly as the sample at the same location and during the same time period. Use the same methods as described above (Grab sample, pumping method, syringe method). At least one ambient blank per field trip is required each for trace metal and Mercury samples in water. *If contamination is detected in field equipment blanks, blanks are required for every metals-in-water sample until the problem is resolved.*

Laboratory Equipment Blank

Laboratory Equipment Blanks for pumping and sampling equipment (Metals-in-Water Sample Collection Kits and Syringe Filtration Kits) are run by the laboratory that cleans and distributes the collection materials. It documents that the materials provided by the laboratory are free of contamination. When each batch of tubes, filters, bottles, acid and deionized water are prepared for a sampling trip, about five percent of the Mercury sampling materials are chosen for QC checks. Trace metal equipment needs to be subjected to an initial blank testing series. If these blanks are acceptable only occasional re-testing is required for TM equipment. The QC checks are accomplished by analyzing metals-free water which has been pumped through the filter and tube; collected in a sample container; and preserved.

Field Duplicates

Five percent Field Duplicates are submitted every year. (If fewer than 20 samples are collected during an event, submit one set of duplicates per event.)

Collection of Water Samples for Analysis of Synthetic Organic Compounds

Collect organic samples at a depth of 0.1 m by submerging the sample container by hand. If depth-integrated sampling is required, use the in-line peristaltic pump methodology described previously. Since organic compounds tend to concentrate on the surface of the sampling device or container, the sampling device and sample container are ***not*** to be rinsed with ambient water before being filled.

Sample Containers and Collection

Also refer the Quality Control and Sample Handling Guidelines for Synthetic Organic Compounds in Fresh and Marine Water for a list of recommended container types.

Pesticides/ Herbicides	The sample container for pesticides and herbicides is a new, clean, unused amber glass jar with a Teflon-liner inside the cap. Collect one liter of water for each of the three sample types (Organophosphorus Pesticides, Organochlorine Pesticides and Chlorinated Herbicides). **EACH ANALYSIS TYPE REQUIRES A SEPARATE JAR**. Minimize the air space in the top of the jar. Preserve immediately after collection by placing on ice out of the sunlight.
Semi-volatile Organics	The sample container for semi-volatile organics must also be new, clean, unused amber glass bottles with a Teflon-liner inside the cap, and pre-rinsed with pesticide-grade hexane, acetone, or methylene chloride. Fill jars to the top and place on ice in the dark. In addition to other sample information, label the jar Semi-volatiles.
Volatile Organics: **Volatile Organic Carbon (VOC), Methyl-Tert Butyl Ether (MTBE) and (BTEX)**	The sample containers for volatiles are VOA vials. Fill the 40-mL VOA vials to the top and cap without trapping any air bubbles. If possible, collect directly from the water, keeping the vial under water during the entire collection process. To keep the vial full while reducing the chance for air bubbles, cap the vials under the water surface. Fill one vial at a time and preserve on ice. The vials are submitted as a set. If the vial has been pre-acidified for preservation, fill the vial quickly, without shaking using a separate clean glass jar. Fill the vial till the surface tension builds a meniscus, which extends over the top end of the vial, then cap tightly and check for bubbles by turning the vial on its head. Ensure that the pH is less than 2. If the water may be alkaline or have a significant buffering capacity, or if there is concern that pre-acidified samples may have the acid wash out, take a few practice vials to test with pH paper. It may take more than two

	drops, and it will then be known how to preserve the other samples that are being submitted to the lab. If an alternative method has proven successful, continue with that method. **Note**: If vigorous foaming is observed following acidification, discard that sample and collect another set. Do not acidify the second set. Mark the sample clearly "not acidified" and the lab will run them immediately. Holding time is 14 days with acid, 7 days without acid. Collect three VOA vials, if VOC, MTBE and BTEX are required, two vials, if only VOC is required and two vials, if only MTBE and BTEX are require. The vials may be taped together to keep them together.
Perchlorate	Surface water samples for perchlorate should be collected in a new unused polyethylene or glass container. Perchlorate samples should be placed immediately on ice to maintain temperature at 6 ^{o}C. The sample holding time is 28 days, under refrigeration.
Sample Treatment in Presence of Chlorine	If in stream chlorine residual is suspected, measure the chlorine residual using a separate water subsample. Free chlorine will oxidize organic compounds in the water sample even after it is collected. If chlorine residual is above a detectable level, (i.e., the pink color is observed upon adding the reagents) immediately add 100 mg of sodium thiosulfate to the pesticides, herbicides, semi-volatiles and VOA samples; invert until sodium thiosulfate is dissolved. Record the chlorine residual concentration in field logbook. If chlorine residual is below detectable levels, no further sample treatment necessary.
VOA Trip Blank	Submit one Trip Blank for VOA samples (2- 40 mL VOA vials) for each sampling event. Trip Blanks are prepared in advance just before the sampling trip and transported to the field. Ask the laboratory for DI water and specify that it is for a VOA trip blank. VOA blanks require special purged water. Trip blanks demonstrate that the containers and sample handling did not introduce contamination. The trip blank vials are never opened during the trip.
Field QC Samples	If required, field Duplicates and field blanks are submitted at a rate subject to the discretion of the project manager. Refer to the SWAMP Quality Control and Sample Handling Guidelines for details on required blanks and duplicates.

BACTERIA AND PATHOGENS IN WATER SAMPLES

Summary of Collection Procedure (Based on EPA water quality monitoring procedures)

Make sure the containers are sterilized; either factory-sealed or labeled.

Whirl-pak® bags

- Label the bottle as previously described for SWAMP.
- Tear off the top of the bag along the perforation above the wire tab just prior to sampling. Avoid touching the inside of the bag. If you accidentally touch the inside of the bag, use another one.
- If wading into the stream, try to disturb as little bottom sediment as possible. Be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you.
- If taking sample from a boat, carefully reach over the side and collect the water sample on the upstream side of the boat.
- Hold the two white pull-tabs in each hand and lower the bag into the water on your upstream side with the opening facing upstream. Open the bag midway between the surface and the bottom by pulling the white pull-tabs. The bag should begin to fill with water. You may need to "scoop" water into the bag by drawing it through the water upstream and away from you. Fill the bag no more than 3/4 full.
- Lift the bag out of the water. Pour out excess water. Pull on the wire tabs to close the bag. Continue holding the wire tabs and flip the bag over at least 4-5 times quickly to seal the bag. Don't try to squeeze the air out of the top of the bag. Fold the ends of the wire tabs together at the top of the bag, being careful not to puncture the bag. Twist them together, forming a loop.
- If the samples are to be analyzed in the lab, place them in a cooler with ice or cold packs for transport to the lab.

Screw cap containers

- Label the bottle as previously described for SWAMP.
- Remove the plastic seal from the bottle’s cap just before sampling. Avoid touching the inside of the bottle or cap. If you accidentally touch the inside, use another bottle.

- If wading into the stream, try to disturb as little bottom sediment as possible. Be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you.
- If taking sample from a boat, carefully reach over the side and collect the water sample on the upstream side of the boat.
- Hold the bottle near its base with polyethylene gloves and submerge the bottle in the water with the cap on. Open the bottle collecting the water sample 0.1m beneath the surface. When the bottle is filled to the desired level recap the bottle and remove from water. You can only use this method if the sample bottles do not contain sodium thiosulfate.
- Turn the bottle underwater into the current and away from you. In slow moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction.
- Alternative sampling method: In case the sample bottle contains preservatives/chlorine removers (i.e. Sodium-Thiosulfate), it cannot be plunged opening down. In this case hold the bottle upright under the surface while it is still capped. Open the lid carefully just a little to let water run in. Fill the bottle to the fill mark and screw the lid tight while the bottle is still underneath the surface.
- Leave a 1-in. air space so that the sample can be shaken just before analysis. Recap the bottle carefully, remembering not to touch the inside.
- If the samples are to be analyzed in the lab, place them in a cooler with ice or cold packs for transport to the lab. Samples should be placed immediately on ice to maintain temperature at 6 ^{o}C

Pouring from another clean bottle

- Due to different sampling conditions (high turbidity, rough water etc.) it is sometimes easy to pour water from another clean bottle into the bacteria bottle. This helps to make sure that the sample water is only being filled to the desired line and no overfilling occurs.

TOXICITY IN WATER

Sample Collection

Using the standard grab sample collection method described previously for water samples, fill (for typical suite of water toxicity tests conducted) the required amount of 2.25-L amber glass bottles with sub surface water. Since the size of the 2.25-L amber bottle is bigger than your average sample bottle, find a spot in the centroid of the stream to completely submerge the toxicity bottle if possible. A clean water organics(1-L glass amber) bottle can be used if there is no sampling point deep enough to submerge a large toxicity bottle. If the stream is not deep enough to submerge any bottle, then comments should be made on the field data sheets that surface water was collected. Depth should also equal 0 for the sampling depth. All toxicity samples should be. put on ice, and cooled to 4 °C. Label the containers as described above and notify the laboratory of the impending sample delivery, since there is a 48-hr maximum sample hold time. Sample collection must be coordinated with the laboratory to guarantee appropriate scheduling.

Summary of Sample Container, Volume, Initial Preservation, and Holding Time Recommendations for Water Samples

Parameters for Analysis in WATER Samples	Recommended Containers (all containers pre-cleaned)	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time (analysis must start by end of max)
Conventional Constituents in Water				
Alkalinity	Polyethylene bottles (see **NOTE(1)** below)	950 mL	Cool to ≤ 6 °C, dark	14 days at ≤ 6 °C, dark
Chloride (Cl), Sulfate (SO_4) and Fluoride (F)	Polyethylene bottles (see **NOTE(1)** below)	950 mL	Cool to ≤ 6 °C, dark	28 days at ≤ 6 °C, dark
Ortho-phosphate (OPO_4)	Field filtered during collection into a 125 mL polyethylene bottle	60 mL	Filter within 15 minutes; Cool to ≤ 6 °C, dark	48 h at ≤ 6 °C, dark
Nitrate + Nitrite (00630) ($NO_3 + NO_2$)	Clear polyethylene 500 mL with 0.4mL concentrate H_2SO_4 Preservative.	500 mL	Cool to ≤ 6 °C, dark	48 h at ≤ 6 °C, dark
Total Keldjahl Nitrogen (TKN)	Clear polyethylene 500 mL with 0.4mL concentrate H_2SO_4 Preservative.	500 mL	Cool to ≤ 6 °C, dark; H_2SO_4 to pH<2	Unacidified: 7 days Acidified: 28 days Either one at ≤ 6 °C, dark
Total Dissolved Solids (TDS)	Polyethylene bottles (see **NOTE(1)** below)	950 mL	Cool to ≤ 6 °C, dark Cool to 4°C, dark	7 days at ≤ 6 °C, dark
Ammonia (NH_3)	Clear polyethylene 500 mL with 0.4mL concentrate H_2SO_4 Preservative.	500 mL	Cool to ≤6 °C; samples may be preserved with 2 mL of H_2SO_4 per L	Unacidified: 48 h Acidified: 28 days Either one at ≤ 6 °C, dark
Total Phosphorus (TPO_4) and Total Nitrogen (TN)	Clear polyethylene 500 mL with 0.4mL concentrate H_2SO_4 Preservative.	500 mL	Cool to ≤ 6 °C, dark	Unacidified: 48 h Acidified: 28 days Either one at ≤ 6 °C, dark
(1)NOTE: The volume of water necessary to collect in order to analyze for the above constituents is typically combined in 1 950mL polyethylene bottle. More water volume might be needed for possible re-analysis and for conducting lab spike duplicates. This is possible since the same laboratory is conducting all of the above analyses; otherwise, individual volumes apply.				
Total Organic Carbon (TOC),	125 mL amber glass PC with 1ml 1:1 H_2SO_4 preservative.	125 mL for TOC	Cool to ≤6 °C; acidify to pH<2 with HCl, H_3PO_4, or H_2SO_4 within 2 hrs	28 days
Dissolved Organic Carbon (DOC)	Field filtered 125 mL amber glass PC with 1ml 1:1 H_2SO_4 preservative.	125 mL for DOC	Filter and preserve to pH<2 within 48 hours of collection; cool to ≤6 °C	28 days
Total Suspended Solids (TSS)	Clear HDPE 2000 mL narrow mouth bottle	2000 mL	Cool to ≤6 °C, dark	7 days at ≤6 °C, dark
Suspended Sediment Concentration (SSC)	Amber 950 mL HDPE wide mouth bottle.	Up to 950 ml depending on turbidity of water	Cool to ≤6 °C, dark	7 days at ≤6 °C, dark

Parameters for Analysis in WATER Samples	Recommended Containers (all containers pre-cleaned)	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time (analysis must start by end of max)
Chlorophyll *a* **Pheophytin *a*** **Chlorophyll a** **Pheophytin *a***	1-L amber polyethylene bottle Aluminum Foil, GFC Filters	1000 mL (one bottle) 20-420 mL	Centrifuge or filter as soon as possible after collection; if processing must be delayed, keep samples on ice or at ≤6 °C; store in the dark	Samples must be frozen or analyzed within 4 hours of collection; filters can be stored frozen for 28 days
Non-Routine Compounds in Water Samples				
OIL AND GREASE	1-L glass jar with Teflon lid-liner, rinsed with hexane or methylene chloride	1000 mL (one jar)	Cool to ≤6 °C; HNO_3 or H_2SO_4 to pH<2	28 days at ≤6 °C, dark
PHENOLS	1-L glass jar with Teflon lid-liner	1000 mL (one jar)	Cool to ≤6 °C; H_2SO_4 to pH<2	28 days at ≤6 °C, dark
CYANIDE	1-L cubitainer	1000 mL (one cubitainer)	Cool to ≤6 °C; NaOH to pH>10; add 0.6 g $C_6H_8O_6$ if residual chlorine is present	14 days at ≤6 °C, dark
BIOCHEMICAL OXYGEN DEMAND (BOD)	4-L cubitainer	4000 mL (one cubitainer)	Cool to ≤6 °C; add 1 g FAS crystals per liter if residual chlorine is present	48 h at ≤6 °C, dark
CHEMICAL OXYGEN DEMAND (COD)	1-L cubitainer	110 mL (one cubitainer)	Cool to ≤6 °C; H_2SO_4 to pH<2	28 days at ≤6 °C, dark; biologically active samples should be tested as soon as possible
Trace Metals in Water Samples				
DISSOLVED METALS (except Dissolved Mercury)	60 mL polyethylene bottle, pre-cleaned in lab using HNO_3	60 mL (one bottle)	Filter at sample site using 0.45 micron in-line filter, or syringe filter (within 15 minutes of collection). Cool to 6°C, dark. Acidify in lab, within 48 hrs, using pre-acidified container (ultra-pure HNO_3) for pH<2.	Once sample is filtered and acidified, can store up to 6 months at room temperature

Parameters for Analysis in WATER Samples	Recommended Containers (all containers pre-cleaned)	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time (analysis must start by end of max)
DISSOLVED MERCURY	250 mL glass or Teflon bottle, pre-cleaned in lab using HNO_3	250 mL (one bottle)	Filter within 15 minutes of collection. Cool to 6°C, dark. Acidify in lab within 48 hrs, with pre-tested HCL to 0.5%.	Once sample is filtered and acidified, can store up to 90 days at room temperature
TOTAL METALS (except Total Mercury)	60 mL polyethylene bottle, pre-cleaned in lab using HNO_3	60 mL (one bottle)	Cool to ≤6 °C, dark. Acidify in lab within 48 hrs, with pre-acidified container (ultra-pure HNO_3), for pH<2.	Once sample is acidified, can store up to 6 months at room temperature
TOTAL MERCURY	250 mL glass or Teflon bottle, pre-cleaned in lab using HNO_3	250 mL (one bottle)	Cool to ≤6 °C, dark. Acidify in lab within 48 hrs, with pre-tested HCL to 0.5%.	Once sample is acidified, can store up to 90 days at room temperature.
HEXAVALENT CHROMIUM (filtered)	600 mL plastic or glass bottle	600 mL (one bottle)	Cool to ≤6 °C, dark No acid	Keep at ≤6 °C, dark for up to 24 h; must notify lab in advance.
HARDNESS	200 mL polyethylene bottle	200 mL (one bottle)	Cool to 6°C, dark OR Cool to ≤6 °C; HNO_3 or H_2SO_4 to pH<2	48 h at 6°C, dark 6 months at ≤6 °C, dark
Synthetic Organic Compounds in Water Samples				
VOLATILE ORGANIC ANALYTES (VOA's) including VOC, MTBE and BTEX	40 mL VOA vials	120 mL (three VOA vials)	All vials are pre-acidified (50% HCl or H_2SO_4) at lab before sampling. Cool to 6°C, dark	unacidified: 7 days acidified: 14 days Both at 6°C, dark
PESTICIDES & HERBICIDES* ☐Organophosphate Pesticides ☐Organochlorine Pesticides ☐Chlorinated Herbicides **SEMI-VOLATILE ORGANICS*** **POLYCHLORINATED* BIPHEYNYL AND AROCHLOR COMPOUNDS** **TPH, PAH, PCP/TCP***	1-L I-Chem 200-series amber glass bottle, with Teflon lid-liner (per each sample type)	1000 mL (one container) ***Each sample type requires 1000 mL in a separate container**	Cool to 6°C, dark If chlorine is present, add 0.1g sodium thiosulfate	Keep at 6°C, dark, up to 7 days. Extraction must be performed within the 7 days; analysis must be conducted within 40 days.

Parameters for Analysis in WATER Samples	Recommended Containers (all containers pre-cleaned)	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time (analysis must start by end of max)
Toxicity Testing Water Samples				
TOXICITY IN WATER	Four 2.25 L amber glass bottles	9000 mL	Cool to 4°C, dark	48 hrs at 4°C, dark
Bacteria and Pathogens in Water Samples				
E. Coli	Factory-sealed, pre-sterilized, disposable Whirl-pak® bags or 125 mL sterile plastic (high density polyethylene or polypropylene) container	100 mL volume sufficient for both E. coli and Enterococcus analyses	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to ≤ 10°C; dark.	STAT: 8 hrs at ≤ 10°C, dark if data for regulatory purposes; otherwise, 24 hrs at ≤ 10°C, dark if non-regulatory purpose.
Enterococcus	Factory-sealed, pre-sterilized, disposable Whirl-pak® bags or 125 mL sterile plastic (high density polyethylene or polypropylene) container	100 mL volume sufficient for both E. coli and Enterococcus analyses	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to ≤ 10°C ; dark.	STAT: 8 hrs at ≤ 10°C, dark if data for regulatory purposes; otherwise, 24 hrs at ≤ 10°C, dark if non-regulatory purpose.
FECAL COLIFORM	Factory-sealed, pre-sterilized, disposable Whirl-pak® bags or 125 mL sterile plastic (high density polyethylene or polypropylene) container	100 mL volume sufficient for both fecal and total coliform analyses	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to ≤ 10°C; dark.	STAT: 8 hrs at ≤ 10°C, dark if data for regulatory purposes; otherwise, 24 hrs at ≤ 10°C, dark if non-regulatory purpose.
TOTAL COLIFORM	Factory-sealed, pre-sterilized, disposable Whirl-pak® bags or 125 mL sterile plastic (high density polyethylene or polypropylene) container	100 mL volume sufficient for both fecal and total coliform analyses	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to ≤ 10°C; dark.	STAT: 8 hrs at ≤ 10°C, dark if data for regulatory purposes; otherwise, 24 hrs at ≤ 10°C, dark if non-regulatory purpose.

Field Collection Procedures for Bed Sediment Samples

Bed sediment (hereafter termed "sediment") samples are collected after any water samples are collected where water and sediment are taken in the same reach. Care must be taken not to sample sediments that have been walked on or disturbed in any manner by field personnel collecting water samples. Sediment samples are collected into a composite jar, where they are thoroughly homogenized in the field, and then aliquoted into separate jars for chemical or toxicological analysis. Sediment samples for metals and organics are submitted to the respective analytical laboratories in separate glass jars, which have been pre-cleaned according to laboratory protocol.

Sediment chemistry samples give information regarding both trends in contaminant loading and the potential for adverse effects on sediment and aquatic biota. In order to compare samples over time and from site to site, they must be collected in a consistent manner. Recently deposited fine grain sediments (see attached table) are the target for sediment collection. If a suitable site for collecting sediments cannot be found at a station (it only contains larger grain material), sampling personnel should not collect the sediment sample, and should instead attempt to reschedule the sample collection or move to a different area that has more recently deposited fine sediment. If this is not possible, make a note so that the missing sample is accounted for in the reconciliation of monitoring events during preparation of sample collection "cruise reports". Sites that are routinely difficult to collect should be considered for elimination or relocation from the sample schedule, if appropriate.

Characteristics of Ideal Sediment Material to be Collected

Many of the chemical constituents of concern are adsorbed onto fine particles. One of the major objectives in selecting a sample site, and in actually collecting the sample while on site, is to obtain recently deposited fine sediment, to the extent possible. Avoid hard clay, bank deposits, gravel, disturbed and/or filled areas. Any sediment that resists being scooped by a dredge is probably not recently deposited fine sediment material. In following this guidance, the collection of sediment is purposefully being biased for fine materials, which must be discussed thoroughly in any subsequent interpretive reporting of the data, in regards to representation of the collected sample to the environment from which it was collected.

Characteristics of an Ideal Site

Quiescent areas are conducive to the settling of finer materials (EPA/USACOE, 1981).
Choose a sampling site with lower hydrologic energy, such as the inner (depositional) side of bends or eddies where the water movement may be slower. Reservoirs and estuaries are generally

depositional environments, also.

Selecting the Appropriate Sediment Type for Analysis

Sediment will vary from site to site and can vary between sample events at a particular site.

Streams and Rivers: Sediment collection in flowing streams is often a challenge. In areas of frequent scouring there may not be sufficient sediment for collection during or following periods of high flow. Sediment collection during these times may prove unsuccessful and may have to be rescheduled or cancelled.

When the suspended load in rivers and streams precipitates due to reduction of velocity, most of the resulting sediment will be fine-grained. More often than not, a dredge or mechanical grab device does not function well for collection of sediment in smaller streams. In many cases, sediment will have to be collected using a pre-cleaned polyethylene scoop. Collect the top 2 cm for analysis. Five or more (depending on the volume of sediment needed for conducting analyses) fine-sediment sub-sites within a 100-m reach are sampled into the composite jar.

Reservoirs and Estuaries: Collect the top 2 cm for analysis. Grabs are composited for the sediment sample, depending on the volume of sediment needed for conducting analyses.

GENERAL PROCEDURE FOR COLLECTION OF BED SEDIMENT

After choosing an appropriate site, and identifying appropriate fine-grained sediment areas within the general reach, collect the sample using one or more of the following procedures, depending on the setting:

A. <u>Sediment Scoop Method—Primary Method for Wadeable, Shallow Streams</u>

- The goal is to collect the top 2 cm of recently-deposited fine sediment only.
- Wear gloves and protective gear, in areas of potential exposure hazards, per appropriate protocol (make sure gloves are long enough to prevent water from overflowing gloves while submerging scoop).
- Survey the sampling area for appropriate fine-sediment depositional areas before stepping into the stream, to avoid disturbing possible sediment collection sub-sites.
- Carefully enter the stream and start sampling at the closest appropriate reach, then continue sampling UPSTREAM. Never advance downstream, as this could lead to sampling

disturbed sediment.

- Stir, do not shake, collected sediment with a polyethylene scoop for at least 5 min making sure all sediment is completely homogenized.
- Quickly scoop sediment out of the homogenizing jar into desired sampling jars making sure to stir the sediment in the homogenizing jar in between each aliquot.
- Inspect each individual sediment jar making sure of consistent grain size throughout the entire sample collection.
- Single bag all sediment containers to prevent cross contamination.
- Make sure all containers are capped tightly and stored in a cooler on cube ice at 6 °C.

B. Hand Core Method-Alternate method for wadeable shallow streams with fine sediment

- A hand core is used in wadeable streams where there is very fine sediment.
- The hand core sampler consists of a 3-in. diameter polycarbonate core that is 8 inches long. Samplers push the core into the sediment to the desired depth, pull the core out of the sediment, and cap the bottom with a polyethylene core cap or by placing their hand underneath the cap to hold the sediment in place.
- Hand cores are usually measured and marked at 2 cm length so the sampler knows how far to deploy the core into the sediment.
- Sediment is then emptied into a homogenizing jug and aliquoted accordingly.

C. Sediment Grab Method—Primarily for Lake, River, Bridge, and Estuarine Settings (or deeper streams)

Description of sediment grab equipment:

- A mechanical sediment grab is used for the SWAMP bed sediment collection field effort for lake, river, bridge, and estuarine/coastal settings (or deeper, non-wadeable streams).
- The mechanical grab is a stainless steel “Young-modified Van Veen Grab", and is 0.5 m^2 in size.
- The mechanical grab is deployed primarily from a boat, and is used in deeper, non-wadeable waters, such as lakes, rivers, estuaries, and coastal areas.
- It is also deployed by field personnel from land in settings which allow its use: primarily from bridges; from smaller vessels in streams or drainage channels too deep or steep to wade into, but too shallow for a larger boat.

Deploying and retrieving the grab:

- Slowly lower the grab to the bottom with a minimum of substrate disturbance.
- Retrieve the closed dredge at a moderate speed (e.g., less than two feet per second).
- Upon retrieval, open the lids of the sediment grab, examine the sample to ensure that the

sediment surface is undisturbed and that the grab sample should not be rejected.

Rejection Criteria—reject the sample if the following are not met:

- Mud surface must not be pressing out of the top of the sampler. If it is, lower the grab more slowly.
- Overlying water must not be leaking out along the sides of the sediment in the grab. This ensures the surficial sediment is not washed out.
- Sediment surface is flat and level in the sampler. If it is not level, the grab has tilted over before closing.

Processing the sediment sample from the grab equipment:

- The water overlying the sediment in the grab is very gently decanted by slightly tipping the grab with the lid closed until the water runs out the top.
- The decanting process should remove all of the overlying water but not remove the surficial sediments. The laboratory reports percent water for the sample, so overlying water is not included in the sample container.
- The sediment is examined for depth of penetration, color and thickness of top aerobic zone, and texture. These observations are recorded on the field data sheet.
- Collect the top 2 cm from at least five sub samples, and otherwise, exclude the bottom-most layer and composite.
- In streams or other settings with excessive bottom debris (e.g., rocks, sticks, leaves) where the use of a grab is determined to be ineffective (e.g., dredge does not close, causing loss of sediment), samples may be collected by hand using a clean plastic scoop, or by a variety of coring methods, if appropriate for the situation.
- Sediment is handled as described below in the metals and organic sections.

Cleaning the Grab Equipment and Protection from Potential Contaminating Sources:

- The sediment sampler will be cleaned prior to sampling EACH site by: rinsing all surfaces with ambient water, scrubbing all sediment sample contact surfaces with Micro™ or equivalent detergent, rinsing all surfaces with ambient water, rinsing sediment sample contact surfaces with 5% HCl, and rinsing all sediment sample contact surfaces with methanol.
- The sediment grab will be scrubbed with ambient water between successive deployments at ONE site, in order to remove adhering sediments from contact surfaces possibly originating below the sampled layer, thus preventing contamination from areas beyond target sampling area.
- Sampling procedures will attempt to avoid exhaust from any engine aboard any vessel involved in sample collection. An engine will be turned off when possible during portions of the sampling process where contamination from engine exhaust may occur. It is critical that sample contamination be avoided during sample collection. All sampling equipment (e.g., siphon hoses, scoops, containers) will be made of non-contaminating material and will be appropriately cleaned before use. Samples will not be touched with un-gloved fingers. In addition, potential airborne contamination (e.g., from engine exhaust, cigarette smoke) will be avoided.

D. Core Method--alternative for fast-moving, wadeable streams

The core method is used in soft sediments when it is difficult to use the other methodologies. The cores can be used in depths of water from 0 to 10 ft by using a pole deployment device or in deeper water using SCUBA divers. The pole deployment device consists of a pole that attaches to the top of the core. The top of the core is fitted with a one-way valve, which allows the core to be filled with sediment, but when pulled from the sediment catches the sediment within the core. The core is then brought to the surface and the sediments within the core are extruded out the top of the core so that 2 cm of sediment is above the top of the plastic core. The 2 cm of sediment is then sliced off and placed in the homogenizing jar. A new core, homogenizing jar, and device used to slice off the top two cm. are used at each station unless the equipment is cleaned using laboratory protocols.

E. Sediment Grab Method – Primarily used from bridges or for streams with restricted bank access.

Description and sampling procedure for the Eckman sediment grab

- The Eckman grab is 0.2 m^2 in size with a lead "messenger" that triggers the spring loaded doors.
- The primary use is for sampling from bridges or from small vessels in streams or drainage channels too deep or steep to wade into, but too shallow for a larger boat.
- The grab must be cleaned with a Micro™ and tap water rinse before sampling and in-between sample stations.
- To deploy the grab, pull the spring loaded doors open and hook the cables on the actuator plate.
- With a rope, lower the grab to the desired sample reach making sure that the grab has penetrated the sediment. Clip the "messenger" on the rope and release it while maintaining tension on the rope. Pull up the grab once the "messenger" has activated the doors.
- While wearing clean poly gloves, open the top hatch and remove the top 2 cm of sediment with a clean polyethylene scoop. Place the sediment into the homogenizing jug and repeat the sampling process until there is enough desired sediment. See general procedures for processing of bed sediment samples, once they are collected for sediment homogenization and aliquoting into sample jars.

GENERAL PROCEDURE FOR PROCESSING OF BED SEDIMENT SAMPLES, ONCE THEY ARE COLLECTED

Sediment Homogenization, Aliquoting and Transport

For the collection of bed sediment samples, the top 2 cm is removed from the scoop, or the grab, or the core, and placed in the 4-L glass compositing/homogenizing container. The composited

sediment in the container is homogenized and aliquoted on-site in the field. The sample is stirred with a polyethylene scoop until sediment/mud appears homogeneous. All sample identification information (stations numbers, etc.) will be recorded prior to homogenizing and aliquoting. Sediment samples will immediately then be cooled to 6 °□C and separated for preservation according to the: Summary of Sample Container, Volume, Preservation, and Storage Requirements for SWAMP Bed Sediment, Biota, and Tissue Samples (for contaminant analysis).Each container will be sealed in one large plastic bag to prevent contact with other samples or ice or water.

Metals and Semi-volatile Organics in Sediment	For trace metals and semi-volatile organics, a minimum of three grabs is distributed to the composite bottle and/or sample containers. Mixing is generally done with a polyethylene scoop. Make sure the sample volume is adequate, but the containers do not need to be filled to the top. Seal the jars with the Teflon liner in the lids.
Sediment Conventionals	Sediment conventionals are sometimes requested when sediment organics, sediment metals, and/or sediment toxicity tests are requested for analysis of samples. The collection method is the same as that for metals, semi-volatile organics, and pesticides. Sediment conventionals include: grain size analysis and total organic carbon. These are used in the interpretation of metals and organics in sediment data.
Sample Containers	See "Sediment Sample Handling Requirements" table at end of this document.
Sediment Sample Size	Must collect sufficient volume of sediment to allow for proper analysis, including possible repeats, as well as any requested archiving of samples for possible later analysis. See "Sediment Sample Handling Requirements" Table at end of this document.
Labeling	Label the jars with the station ID, sample code, matrix type, project ID, time, and date of collection, as well as the type of analysis requested (e.g., metals, conventionals, organics, or archives).
Short-term Field Preservation	Immediately place the labeled jar on ice, cool to 6 °□C, and keep in the dark at 4 °□C until delivery to the laboratory.
Field Notes	Fill out the SWAMP Sediment Data Sheet. Make sure to record any field notes that are not listed on the provided data sheets. This information can be reported as comments with the sediment analytical results.

Summary of Sample Container, Volume, Preservation, and Storage Requirements for SWAMP Bed Sediment, Biota, and Tissue Samples (for contaminant analysis)

Parameters for Analysis	Recommended Containers	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time
Bed Sediment Samples				
Trace Metals, including Hg and As (except for Se--see below)	60-mL I-Chem 300- series clear glass jar with Teflon lid-liner; Pre-cleaned	60 mL (one jar)	Cool to ≤6 °C within 24 hours, then freeze to ≤-20 °C	12 months(1) (-20 °C)
Methylmercury	60-mL I-Chem 300- series clear glass jar with Teflon lid-liner; Pre-cleaned	60 mL (one jar)	Freeze to ≤-20 °C immediately	12 months(1) (-20 °C)
Selenium (separate container required)	60-mL I-Chem 300- series clear glass jar with Teflon lid-liner; Pre-cleaned	60 mL (one jar)	Cool to ≤6 °C within 24 hours, then freeze to ≤-20 °C	12 months(1) (-20 °C)
Synthetic Organic Compounds	250-mL I-Chem 300-series amber glass jar with Teflon lid-liner; Pre-cleaned	500 mL (two jars)	Cool to ≤6 °C within 24 hours, then freeze to ≤-20 °C	12 months(1) (-20 °C)
Sediment TOC	250-mL(3) clear glass jar; Pre-cleaned	125 mL (one jar)	Cool to ≤6 ˚C or freeze to ≤-20 ˚C	28 days at ≤6 ˚C; 1 year at ≤-20 ˚C (2)
Sediment Grain Size	250-mL(3) clear glass jar; Pre-cleaned	125 mL (one jar)	Wet ice to ≤6 ˚C in the field, then refrigerate at ≤6 ˚C	1 year (≤6 ˚C) ***Do not freeze***
Sediment Toxicity Testing	1-L I-Chem wide-mouth polyethylene jar with Teflon lid-liner; Pre-cleaned	2 (two jars filled completely)	Cool to 4 °C, dark, up to 14 days	14 days (4 °C) ***Do not freeze***

(1) Sediment samples for parameters noted with one asterisk (*) may be refrigerated at 6 °C for up to 14 days maximum, but analysis must start within the 14-day period of collection or thawing, or the sediment sample must be stored frozen at minus (-) 20 °C for up to 12 months.

(2) Sediment samples for sediment TOC analysis can be held at 4°C for up to 28 days, and should be analyzed within this 28-day period, but can be frozen at any time during the initial 28 days, for up to 12 months at minus (-) 20 °C.

(3) Sediment samples for TOC AND grain size analysis can be combined in one 250 mL clear glass jar, and sub-sampled at the laboratory in order to utilize holding time differences for the two analyses. If this is done, the 250 mL combined sediment sample must be refrigerated only (not frozen) at 4 °C for up to 28 days, during which time the sub-samples must be aliquoted in order to comply with separate storage requirements (as shown above).

Attachment C

Rapid Trash Assessment Field Form (San Francisco Regional Water Quality Control Board 2004)

RAPID TRASH ASSESSMENT WORKSHEET

Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board

WATERSHED/STREAM: _____ DATE/TIME: _____
MONITORING GROUP, STAFF: _____ SAMPLE ID NO. _____
SITE DESCRIPTION (Station Name, No., etc.): _____

	CONDITION CATEGORY			
Trash Assessment Parameter	**Optimal**	**Sub optimal**	**Marginal**	**Poor**
1. Level of Trash	On first glance, no trash visible; little or no trash evident when streambed and streambanks are closely examined for litter and debris, for instance by looking under leaves.	On first glance, little or no trash visible; after close inspection small levels of trash evident in streambank and streambed.	Trash is evident in low to medium levels on first glance. Stream-bank surfaces and immediate riparian zone contain litter and debris. Evidence of site being used by people: scattered cans, bottles, blankets, and/or clothing.	Trash distracts the eye on first glance. Streambank surfaces and immediate riparian zone contain substantial levels of litter and debris. Evidence of site being used frequently by people: many cans & bottles, food wrappers, manmade shelters, blankets, and/or piles of clothing.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Actual Number of Trash Items Found	0 to 5 trash items based on a rapid survey of a 100-foot stream reach.	6 to 25 trash items based on a rapid survey of a 100-foot stream reach.	26 to 50 trash items based on a rapid survey of a 100-foot stream reach.	Over 50 trash items based on a rapid survey of a 100-foot stream reach.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Threat to Aquatic Life	Trash, if any, is mostly paper or wood products or other biodegradable materials. Note: A large amount of rapidly biodegradable material like food waste creates high oxygen demand, and should not be scored as optimal.	Little or no persistent, buoyant, and small litter or debris. Presence of settleable, degradable, and non-toxic debris such as wood, glass, metal, and degradable plastics such as foamed plastics.	Medium prevalence of persistent (plastic, synthetic rubber or cloth), toxic, buoyant, and small litter such as: plastic bags; pellets; cigarette butts; large deposits of settleable debris such as glass or metal; and any evidence of small clumps of deposited yard waste or leaf litter.	Large amount of persistent (plastic, synthetic rubber or cloth), toxic, buoyant, and small (transportable) trash such as: cigarette butts; plastic bags; plastic pellets; batteries or other toxic substances; and large clumps of yard waste or dumped leaf litter.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Threat to Human Health	Observable trash contains no evidence of bacteria or virus hazards such as medical waste, diapers, pet or human waste, no evidence of toxic substances such as pesticides or batteries, no ponded water for mosquito production & no evidence of puncture or laceration hazards associated with the observed litter or debris.	No medical waste or sources of toxic substances, but any presence of puncture or laceration hazards such as broken glass and metal debris. Or presence of ponded water in trash items such as tires or containers that could facilitate mosquito production.	Presence of **one** of the following: hypodermic needles, pipettes, or other medical waste ; any used diapers or pet waste within the stream channel or where runoff could carry materials to waterbody; any toxic substance such as pesticides, batteries, or fluorescent light bulbs (mercury).	Presence of **more than one** of the following: any hypodermic needles, pipettes, or other medical waste; used diapers or pet waste within the stream channel or where runoff could carry materials to waterbody; any toxic substances such as pesticides, batteries, or fluorescent light bulbs (mercury); ponded water in trash items.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

RAPID TRASH ASSESSMENT WORKSHEET

Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board

	CONDITION CATEGORY			
Trash Assessment Parameter	**Optimal**	**Sub optimal**	**Marginal**	**Poor**
5. Illegal Dumping and Littering	Any observed trash is incidental litter (less than 5 items) or carried downstream from another location. No evidence of illegal dumping.	Some evidence of in-stream or shoreline littering; and/or some evidence of illegal dumping, such as a sign prohibiting dumping along with observed garbage bags of material. Limited vehicular access limits the amount of potential dumping, or material dumped is diffuse paper-based debris (e.g., convenience stores or fast food).	Prevalent in-stream or shoreline littering; and/or the presence of **one** of the following: furniture, appliances, or bags of garbage or yard waste, coupled with vehicular access that facilitates in-and-out dumping of materials to avoid landfill costs.	Significant litter on shoreline or stream banks and streambed; and/or evidence of chronic dumping, with **more than one** of the following items: furniture, appliances, shopping carts, garbage bags, or yard waste. Easy vehicular access for in-and-out dumping of materials to avoid landfill costs.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Accum-ulation of Trash	There does not appear to be a problem with trash accumulation from downstream transport. Observable trash, if any, appears to have been directly deposited at the stream location.	Some evidence that litter and debris have been transported from upstream areas to the location. Less than 5 trash items have been transported from upstream locations, based on evidence such as silt marks, faded colors or location near high water marks.	5 to 20 items of observable trash are carried to the location from upstream, as evidenced by its location near high water marks and siltation marks on the debris.	Trash appears to have accumulated in substantial quantities at the location based on delivery from upstream areas, and is in various states of degradation based on its persistence in the waterbody. Over 20 items of observable trash have been carried to the location from upstream.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Total Score _____

SITE DEFINITION:
UPPER/LOWER BOUNDARIES OF REACH: _____
HIGH WATER LINE: _____
UPPER EXTENT OF BANKS OR SHORE: _____
_____

NOTES:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

RAPID TRASH ASSESSMENT WORKSHEET

Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board

TRASH ITEM TALLY (Tally with (|) if found below high water line, and (•) if above)

PLASTIC	**METAL**
Plastic Bags	Aluminum Foil
Plastic Bottles	Aluminum or Steel Cans
Plastic Bottle Caps	Bottle Caps
Plastic Cup Lid/Straw	Metal Pipe Segments
Plastic Pipe Segments	Auto Parts (specify below)
Plastic Six-Pack Rings	Wire (barb, chicken wire etc.)
Plastic Wrapper	Metal Object
Soft Plastic Pieces	**LARGE (specify below)**
Hard Plastic Pieces	Appliances
Styrofoam cups pieces	Furniture
Styrofoam Pellets	Garbage Bags of Trash
Fishing Line	Tires
Tarp	Shopping Carts
Other (write-in)	Other (write-in)
BIOHAZARD	**TOXIC**
Human Waste/Diapers	Chemical Containers
Pet Waste	Oil/Surfactant on Water
Syringes or Pipettes	Spray Paint Cans
Dead Animals	Lighters
Other (write-in)	Small Batteries
CONSTRUCTION DEBRIS	Vehicle Batteries Cigarette Butts
Concrete (not placed)	Other (write-in)
Rebar	**BIODEGRADABLE**
Bricks	Paper
Wood Debris	Cardboard
Other (write-in)	Food Waste
MISCELLANEOUS	Yard Waste (incl. trees)
Synthetic Rubber	Leaf Litter Piles
Foam Rubber	Other (write-in)
Balloons	**GLASS**
Ceramic pots/shards	Glass bottles
Hose Pieces	Glass pieces
Golf Balls	**FABRIC AND CLOTH**
Tennis Balls	Synthetic Fabric
Other (write-in)	Natural Fabric (cotton, wool)
Other (write-in)	Other (write-in)

SPECIFIC DESCRIPTION OF ITEMS FOUND (if any):

_____

_____

_____

_____

_____

_____

Attachment D

Example Field Forms and Chain-of-Custody

Field Monitoring Form

MONITORING PROGRAM / MAINTENANCE

☐ Dry-Weather Monitoring ☐ Wet-Weather Monitoring

GENERAL SITE DESCRIPTION

Site Id ____ Discharge Area ____ Intersection/Location ____

Field Crew ____ Date ____ Time ____ Photo Taken ☐ Yes # ____ ☐ No

Conveyance ☐ Manhole ☐ Catch Basin ☐ Outlet ☐ Concrete Channel ☐ Natural Creek ☐ Earthen Channel ☐ Curb/Gutter
(Check one only)

ATMOSPHERIC CONDITIONS

Weather ☐ Sunny ☐ Partly Cloudy ☐ Overcast ☐ Fog ☐ Raining

Last Rain ☐ > 72 hours ☐ < 72 hours **Rainfall** ☐ None ☐ < 0.1" ☐ > 0.1"

RUNOFF CHARACTERISTICS

Odor	☐ None	☐ Musty	☐ Rotten Eggs	☐ Chemicals	☐ Sewage	☐ Other ____
Color	☐ None	☐ Yellow	☐ Brown	☐ White	☐ Gray	☐ Other ____
Clarity	☐ None	☐ Slightly Cloudy	☐ Opaque	☐ Other ____		
Floatables	☐ None	☐ Trash	☐ Bubbles/Foam	☐ Sheen	☐ Fecal Matter	☐ Other ____
Deposits	☐ None	☐ Sediment/Gravel	☐ Fine Particles	☐ Stains	☐ Oily Deposits	☐ Other ____
Vegetation	☐ None	☐ Limited	☐ Normal	☐ Excessive	☐ Other ____	
Water Flow	☐ Flowing	☐ Ponded	☐ Moist	☐ Dry	☐ Tidal – Cond (mS/cm) ____	

DRY-WEATHER ONLY

FLOW ESTIMATION WORKSHEETS ☐ N/A

Flowing Creek, Box Culvert, Gutter		Field Measurement		Field Measurement	
Width (ft.)		pH		Turbidity (NTU)	
Depth (ft.)		Temp (°C)		Other	
Velocity (ft/sec)		SpCond (µS)			
Flow (gpm)		DO (mg/l)			

Evidence of Overland Flow? ☐ Yes ☐ No ☐ Irrigation Runoff Other ____

LAND USE ONLY

Land Use ☐ Residential ☐ Commercial ☐ Industrial ☐ Agricultural ☐ Park ☐ Open
(Check all that apply)

POST-STORM DATA

Total Flow Volume ____ Composite Sample Aliquot Count ____

Total Rain (in) ____ Total Sample Volume (L) ____

Pollutagraph Sample Times and Flow

Sample#	Time	Flow (cfs)

EQUIPMENT CONDITION ☐ Good ☐ Maintenance/Calibration Required

Samples Collected

☐ Water Sample
☐ Water Field Duplicate
☐ Water Field Blank

Site Observations / External Factors not including Homelessness

HOMELESSNESS OBSERVATIONS

REC-1 Activities:

Types of Litter/Trash (Indicate Increase/Decrease Since Last Visit):

Number and Location of Encampments (Indicate Increase/Decrease Since Last Visit):

Damaged Riparian Vegetation (Indicate Increase/Decrease Since Last Visit):

Modified Aquatic Habitat (Indicate New Changes Since Last Visit):

Evidence of Damaged Habitat by Fire:

Other Impacts Caused by Homelessness:

CHAIN OF CUSTODY RECORD

Company:				Phone:				Job No.														Page _____ of _____	
Project Manager:				Email:				Analysis Requested														**Test Instruction & Comments**	
Project Name:				Project #																			
Site Name: & Address:																							
Sample ID		**Lab ID**	**Date**	**Time**	**Matrix**	**Container Number/Size**	**Pres.**																
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							
13																							
14																							
15																							

Sample Receipt: To Be Filled By Lab	**Turn Around Time**	Relinquished By: 1	Relinquished By: 2	Relinquished By: 3
Total Number of Containers	Normal	Signature	Signature	Signature
Custody Seals Yes No N/A	Rush	Printed Name		Printed Name
Received in Good Condition Yes No	Same Day	Date Time	Date Time	Date Time
Properly Cooled Yes No N/A	24 Hrs	Received By 1	Received By 2	Received By 3
Samples Intact Yes No N/A	48 Hrs	Signature	Signature	Signature
Samples Accepted Yes No	72 Hrs	Printed Name	Printed Name	Printed Name
		Date Time	Date Time	Date Time