SAN FRANCISCO BAY REGION FY 2007-08 SWAMP MONITORING PLAN

Long-term monitoring of water quality for the development of reference conditions and assessment of the effects of urbanization

II. BACKGROUND

Between 2001 and 2005, San Francisco Bay Region SWAMP used a rotating basin sampling design to perform year-long surveys of water quality conditions in a select number of watersheds around the Region. Some of the conclusions of those studies were that, in order to better interpret ambient monitoring data, more information was needed on (1) long-term trends and annual variability, especially the effects of climate change and other regional and local factors affecting minimally disturbed reference sites; and (2) minimally disturbed ("reference") conditions for benthic macroinvertebrates, nutrients, and basic water quality (e.g., dissolved oxygen) (SFBRWQCB 2007a, 2007b, 2008). An additional finding of those studies was that benthic macroinvertebrate assemblages were usually quite degraded in urban areas, raising questions about causes of impairment and the "best attainable conditions" in urban areas. To address the data gaps and questions raised by the initial studies, San Francisco Bay Region SWAMP has developed a new, long-term monitoring plan.

<u>Monitoring Objectives and Questions</u>

Successful environmental monitoring programs are designed around clear and compelling scientific questions. Precise articulation of these scientific questions is crucial because the questions "determine the variables measured, spatial extent of sampling, intensity and duration of the measurements, and, ultimately, the usefulness of the data" (Lovett et al. 2007). As resources are limited, San Francisco Bay Region SWAMP will take a phased approach to implementing a long-term monitoring program design. Listed below are objectives and questions for SWAMP monitoring at the regional level that will be implemented over a 3-5 year period.

FY 2007-08 funds will be used to address objectives I, II.1, and III.1 (shown in bold). Although monitoring to meet these objectives will begin in FY07-08, successful completion of most objectives (i.e., #I and #III) will take many years (i.e., >10 years). Objectives and questions to be addressed in future years are briefly mentioned below and in Figure 1 in order to provide context for the overall monitoring program. Future years' monitoring will depend on funding levels and results of monitoring in previous years. For example, if results from the first year of the reference sites study suggest that nutrient dynamics are very different in large and small streams, additional sites may be added in future years in order to better characterize those conditions.

I. Describe water quality conditions and biotic assemblages, and the spatial and temporal variability of those conditions, at minimally disturbed reference sites.

- **I.1. What are the long-term trends and annual variability in benthic macroinvertebrate assemblages, and how do they vary between perennial and intermittent streams and with annual variability in streamflow?**
- **I.2. What is the seasonal and annual variability in periphyton assemblages, and how do they vary between perennial and intermittent streams?**
- **I.3. What is the seasonal variability and interrelationships among dissolved nutrients,**

periphyton assemblages, primary productivity, dissolved oxygen, and streamflow?

- **I.4. What is the seasonal and annual variability in basic water quality?**
- **I.5. What are the long-term trends in streamflow?**

II. Perform special short-term monitoring studies to answer questions raised by previous ambient monitoring data on the effects of urbanization on water quality conditions.

- **II.1. What water quality and habitat conditions are associated with better-than-expected assemblages of benthic macroinvertebrates in Saratoga Creek (Saratoga), how do they compare to conditions in a more degraded urban watershed, and what are appropriate urban reference conditions?**
- II.2. What are the sources of sediment and water pollution in the Kirker Creek watershed?
- II.3. What are the causes of eutrophication in the Arroyo las Positas watershed?

III. Document pre-project conditions and long-term trends in water quality (e.g., benthic macroinvertebrates, periphyton, basic water quality, and aquatic habitat) in response to large-scale urban development.

- **III.1. Are best management practices (BMPs) of planned urban residential developments successful at preventing water quality degradation in Las Trampas Creek (Moraga)?**
- III.2. Are BMPs of planned urban residential and commercial developments successful at preventing water quality degradation in Mt. Diablo Creek (Concord)?
- III.3. Are BMPs of new urban residential and commercial developments successful at preventing water quality degradation in Coyote Creek (San Jose)?

IV. Monitor water quality conditions in rural watersheds with significant aquatic resources (e.g., Lagunitas Creek, Walker Creek, San Gregorio Creek, Pescadero Creek, Napa River, Sonoma Creek, Suisun Creek).

- IV.1. Are water quality and habitat conditions suitable for salmonid populations, and what are the potential limiting factors for these populations?
- IV.2. What are water quality conditions in tributaries to Tomales Bay?

Table 1: Timeline of current and future years' monitoring efforts

Objective/Question		Fiscal years that monitoring will be performed in							
		07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15
I	Reference Sites								
I	Six original sites	■	■	■	■	■	■	■	■
I	Additional reference sites			▒	▒	▒	▒	▒	▒
II	Special studies								
II.1	Urban reference- Saratoga Creek	■							
II.1	Additional urban reference				▒				
II.2	Kirker Creek pollution sources		▒						
II.3	Arroyo Las Positas eutrophication			▒					
III	Urbanization								
III.1	Las Trampas Creek	■	■	■					
III.2	Mt. Diablo Creek			▒	▒	▒	▒	▒	▒
III.3	Coyote Creek				▒	▒	▒	▒	▒
IV	Significant aquatic resources								
IV.1	Salmonid limiting factors			▒	▒	▒	▒	▒	▒
IV.2	Tomales Bay tributaries			▒	▒	▒	▒	▒	▒

Note: black refers to planned monitoring; gray refers to monitoring that may be initiated as resources allow

<u>Overview of FY07-08 Monitoring</u>

FY07-08 monitoring will have two main components: (1) long-term monitoring of water quality, biota, streamflow, and physical habitat at six sites in minimally disturbed reference watersheds (**Objective I**), and (2) a short-term study comparing water quality conditions along urban gradients in Saratoga Creek and Las Trampas Creek (**Objective II.1**). The urban gradient study serves a dual role by also satisfying the first year of data collection (pre-construction) for the urban development study in Las Trampas Creek (**Objective III.1**).

Minimally disturbed reference sites

The focus on long-term trends and temporal variability at minimally disturbed reference sites (i.e., "minimally disturbed condition" of Stoddard et al. 2006) will serve two main purposes: (1) provide a context for existing and future ambient monitoring data, and (2) describe long-term trends due to climate change and other factors. For example, this monitoring plan will produce information on the spatial and temporal variability of benthic macroinvertebrate and periphyton assemblages in minimally disturbed reference streams. This information will be useful for developing numeric biocriteria, which will greatly improve the utility of all bioassessment data collected by ambient monitoring programs. In our Region, ambient monitoring of water quality in watersheds is regularly conducted by a variety of groups, including municipal stormwater programs, research organizations, and citizen watershed groups. A watershed monitoring coalition, made up primarily of municipal stormwater agencies, is currently under development. This group will perform ambient monitoring in Bay Region watersheds. By providing the analytical context for ambient monitoring data collected by the watershed monitoring council, SWAMP will play an integral supporting role for all watershed monitoring in the Region, leveraging resources to maximize the value of all monitoring data. The data collected will be placed in the SWAMP database and will be made available to all agencies, watershed groups and the general public.

The monitoring sites established by this program will serve as important regional benchmark watersheds. Characterization of water quality at these sites will provide a frame of reference for other water quality programs. For example, annual sampling of biological assemblages at minimally disturbed reference sites will enable us to develop reference conditions and biocriteria that reflect the large annual variability of California's climate, and allow us to calibrate ambient bioassessment data collected in any given year. Statewide SWAMP monitoring will use a mixed probabilistic and targeted sampling design principle for reference sites, with an emphasis on understanding geographic and spatial variability. This Region's SWAMP monitoring will complement the statewide reference site study by using a targeted sampling design principle to provide detailed information on long-term, temporal variability at benchmark watersheds representing specific conditions. Given the anticipated effects of climate change on water resources, long-term records of discharge, water quality, and biological assemblages at minimally disturbed reference sites will be important for understanding the effects of climate change and disentangling these effects from the impacts of land use, water withdrawals, and other anthropogenic effects.

Urbanization

Beneficial uses related to aquatic life should be both spatially explicit (distinct for distinct stream segments) and functionally specific (i.e., different water quality expectations for perennial vs.

non-perennial streams). Monitoring of minimally disturbed conditions, as proposed in this monitoring plan, will reflect a wide range of natural conditions in the Bay Area (including perennial and non-perennial streams, forested and grassland watersheds, etc.). The information obtained from this study will result in increased understanding of the spatial and temporal variability in minimally disturbed water quality conditions, allowing for increased specificity in beneficial uses and associated water quality standards. Studies in urbanized creeks will assist in identifying “best attainable conditions” and be useful for developing appropriate aquatic life uses and water quality standards for urban areas. The use of this data for the evaluation and potential development of tiered aquatic life uses (TALU) for urban creeks will assist the region as well as the rest of the state in the development of biocriteria.

Previous monitoring by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) indicated that benthic macroinvertebrate (BMI) assemblages in urban portions of Saratoga Creek had very high biological integrity relative to other urban watersheds. For example, 8 to 15 EPT (Ephemeroptera, Plecoptera, and Trichoptera; indicators or good water quality) taxa were collected during BMI sampling (at site S-4 in the City of Saratoga between 2004-2005 (SCVURPPP, 2005) using the 2003 CSBP high gradient field protocol and 500 organism laboratory count (Table 2). This site is in an urban area approximately 2.0 miles downstream of the urban-rural boundary, where 18 to 23 EPT taxa were collected. In contrast, few EPT taxa are found in other urban streams. For example, only 2 -5 EPT taxa were collected at site LT-5 in Las Trampas Creek by the Contra Costa Clean Water Program (CCCWP, 2004). These samples were collected in 2003 and 2004 using the 2003 CSBP high gradient field protocol and 500 organism laboratory count. This site is also approximately 2.0 miles downstream of the urban-rural boundary, and has a similar watershed size and level of urbanization as the Saratoga Creek site (Table 2). Above the urban-rural boundary, benthic macroinvertebrate assemblages in Las Trampas Creek were diverse (22 EPT taxa) and similar to minimally disturbed conditions elsewhere in the Bay Area (SFBRWQCB 2007a) .

Table 2: Comparison of two urban bioassessment sites

Stream/Site	EPT Taxa	Watershed area (mi^2)	Percent urban
Saratoga Cr. S-4	8 - 15	9	17
Las Trampas Cr. LT-5	2 - 5	6	15

Why is there this difference in biological integrity between similar urban areas? What water quality or physical habitat conditions in Saratoga Creek support the diverse benthic assemblages? SWAMP will investigate these questions by monitoring biota, water quality and physical habitat at four sites along an urban gradient in both Saratoga Creek and Las Trampas Creek.

<u>Benefits and Outcomes</u>

The proposed monitoring program for FY07-08 (and planned monitoring in future years) will provide the following benefits and outcomes:

- Support the development of reference conditions and numeric biocriteria (e.g., IBIs) for benthic macroinvertebrate and periphyton assemblages;
- Enable the development of reference conditions for nutrients and associated measures of eutrophication (dissolved oxygen, periphyton), to improve the development of nutrient

TMDLs;

- Support the development of "best attainable conditions" (based on Stoddard et al. 2006) for urban areas for benthic macroinvertebrate and periphyton assemblages;
- Further the development of Tiered Aquatic Life Uses (TALU), especially as they relate to urban and intermittent streams;
- Identify the water quality conditions that are associated with good and poor biological integrity in urban streams;
- Provide baseline data prior to the construction of large urban development projects;
- Supplement the statewide reference site study by providing information on annual variability;
- Provide water quality data to the Regional Water Board for the 305(b)/303(d) integrated report;
- Provide context for previously collected SWAMP water quality data;
- Provide timely and relevant water quality data to stormwater programs and over 75 volunteer watershed groups currently operating in the Region.
- Collaborate with monitoring partner organizations (e.g., CCCWP, SCVURPPP, NPS).

III. STUDY METHODS AND MATERIALS

The San Francisco Bay Region SWAMP monitoring program for FY07-08 will have two main components: (1) long-term monitoring of water quality, biota, and streamflow at six sites in minimally disturbed reference watersheds (**Objective I**), and (2) a one-year study comparing water quality conditions along an urban gradient in Saratoga Creek and Las Trampas Creek (**Objective II.1**) (Table 3). The urban gradient study serves a dual role by also satisfying the first year of data collection (pre-construction) for the urban development study in Las Trampas Creek (**Objective III.1**). Both components use a targeted sampling design principle for selecting sampling sites.

Table 3: Overview of FY07-08 monitoring efforts

What	How often	When	Field	Lab
Minimally disturbed reference sites: 6 sites				
BMI	1x / yr	April	R2	DFG-ABL
PHAB	1x / yr	April	R2	R2
Periphyton	3x / yr	Apr., Jun., Aug.	R2	Univ. CO, CSUSM
Nutrients	6x / yr	Feb., Apr. Jun., Aug., Oct., Dec.	R2	DFG-WPCL
Temperature	Continuous	April - October	R2	R2
Basic WQ	Continuous	April - October	R2	R2
Streamflow	Continuous	Year round	R2	R2
Urbanization: 8 sites (Saratoga Cr. and Las Trampas Cr.)				
BMI	1x / yr	April	R2	DFG-ABL
PHAB	1x / yr	June	R2	R2
Periphyton	1x / yr	June	R2	Univ. CO, CSUSM
Nutrients	6x / yr	Feb., Apr. Jun., Aug., Oct., Dec.	R2	DFG-WPCL
Temperature	Continuous	April - October	R2	R2
Basic WQ	Continuous	Four 1-week intervals in Spring and Summer	R2	R2

Note: R2 = SFBRWQCB SWAMP staff; DFG-ABL = Department of Fish and Game Aquatic Bioassessment Laboratory; Univ. CO = University of Colorado; CSUSM = California State University San Marcos; DFG-WPCL = Department of Fish and Game Water Pollution Control Laboratory.

a. Monitoring design

Minimally disturbed reference sites

The minimally disturbed reference sites study uses a targeted sampling design. Six minimally disturbed reference sites have been selected that reflect a range of flow types (i.e., perennial and intermittent), watershed size, ecoregions, vegetation types, and geographic distribution throughout the Region (Table 4). Criteria for identifying minimally disturbed sites included: (1) minimal upstream human land use (no urban land use and light grazing or timber harvest limited to less than 25% of the watershed area) based upon semi-quantitative assessments of watershed land use from land use maps, aerial photos, and field reconnaissance; (2) minimal local habitat disturbance based upon previous PHAB assessments and field reconnaissance; and (3) excellent water quality based upon existing water quality and bioassessment data. The sites represent both EPA Level III ecoregions that are found in the Region, and all four of the major USFS Ecological Subregion Sections found in the region (Table 4). Channel slopes range from approximately 0.1% to 5%, and riffles are present at all six sites. One perennial and one intermittent stream were selected for each of three watershed sizes (small, medium, large).

Table 4: Minimally Disturbed Reference Sites

Stream	SWAMP Site	County	Landowner	Flow status	Vegetation	Watershed size	EPA Level III Ecoregions/ USFS Ecological Sections
Ritchey Creek	N/A	Napa	Bothe-Napa State Park	P	Redwood/ Mixed hardwood	Small (<5 mi^2)	6/ NCC
Mitchell Canyon	MTD120	Contra Costa	Mt. Diablo State Park	I	Oak/ Chaparral	Small (<5 mi^2)	6/ CCC
Redwood Creek	RDW100	Marin	Mt. Tamalpais State Park	P	Redwood/ chaparral uplands, willow/ alder riparian veg.	Medium (5-10 mi^2)	6/ NCC
Indian Creek	IND100	Alameda	San Francisco Public Utilities Commission	I	Oak/mixed evergreen forest	Medium (5-10 mi^2)	6/ CCCR
Pescadero Creek	PES160	San Mateo	Memorial County Park	P	Redwood forest	Large (>20 mi^2)	1/ CCC
Coyote Creek	COY###	Santa Clara	Henry Coe State Park	I	Oak/ Chaparral	Large (>20 mi^2)	6/ CCCR

Note: P = perennial flow in most years; I = intermittent flow in most years (no flow, discontinuously wet or completely dry channel for some amount of time); 6 = Southern/Central California Chapparal and Oak Woodland; 1 = Coast Range; NCC = Northern California Coast; CCC = Central California Coast; CCCR = Central California Coast Range.

The upstream watersheds of these sites have no urban land use, little or moderate grazing or timber harvest activities, and are permanently protected as open space. Three upstream watersheds are 100% undeveloped open space; Pescadero Creek has some upstream private timber land and Coyote Creek and Indian Creek have some upstream land used for grazing. Five of these sites have been sampled previously by San Francisco Bay Region SWAMP, and are known to be some of the least disturbed watersheds in the Bay Area. One site (Ritchey Creek) has been sampled previously by Friends of the Napa River. In the event that any of the reference sites are impacted in the future by natural disasters (e.g., fire, flood) or other impacts (e.g., exotic species), monitoring should continue at the site(s) in order to document the effects of these processes.

In order to document and examine annual variability in benthic macroinvertebrate assemblages, we plan on monitoring benthic macroinvertebrates during the April/May index period for at least the next 10 years, if funding allows. Benthic macroinvertebrate assemblages can have significant year-to-year variability, depending on climatic patterns, flow conditions and other factors. Because water quality conditions are often inferred from a single collection (during the index period) of benthic macroinvertebrates, the range in annual variability in benthic assemblages needs to be known in order to understand the representativeness of a single sample. Data collected over multiple years at the same reference sites will allow for an assessment of annual variability, as well as provide a way to calibrate biological expectations based on climate conditions in the winter and spring prior to sampling new sites. From existing data, we have observed considerable variability in benthic macroinvertebrate assemblages among reference streams, most likely caused by the combined effects of summer-flow status (perennial vs. intermittent) and ecoregion. Long-term monitoring of reference sites will provide additional information on the relative importance of climate, flow conditions, and other ecological factors that affect the composition and structure of benthic macroinvertebrate assemblages.

Nutrients (nitrate/nitrite, TKN, ammonia, orthophosphate, total phosphorus) and suspended sediment concentrations (SSC) will be monitored bimonthly from February to December. Although many waterbodies in the Region are on the U.S. EPA 303(d) list as impaired for nutrients, there have been no detailed studies of nutrient levels in reference streams or the relationships between nutrient levels, periphyton growth, dissolved oxygen, physical habitat, and flow conditions. Relevant nutrient standards for the Region are lacking. Information on seasonal and geographic variation in nutrient concentrations would be useful to compare to existing SWAMP data and disturbed systems, and provide perspective when developing impairment assessments.

In order to document seasonal variability in periphyon assemblages and to relate nutrient concentrations to periphyton biomass, periphyton will be sampled concurrent with nutrient sampling in April, June, and August. Little or no information is available on periphyton assemblages in streams of the Region. There are current statewide and regional efforts to develop periphyton as a bioassessment tool. Before beginning a comprehensive monitoring program, however, some baseline data on seasonal, annual, and geographic variability in periphyton assemblages needs to be collected. Logistically, it is convenient to perform ambient monitoring of periphyton at the same time benthic macroinvertebrates are collected during the index period in April or May. However, periphyton assemblages may exhibit much more seasonal variability than benthic macroinvertebrates. For example, high flows in March and April can remove periphyton and reduce biomass, while low flow and warm temperatures during the summer months can cause large algae blooms with high biomass. Data on seasonal variability in periphyton during the spring and summer season will improve our understanding of the role of climate and flow conditions on periphyton assemblages, which will help guide future monitoring plans and data analysis. In addition, examining the relationship between nutrient concentrations and periphyton biomass will assist in the development of nutrient criteria.

Basic water quality parameters (dissolved oxygen, temperature, pH, conductivity and turbidity) will be monitored continuously (15 minute intervals) from April to October using YSI 6600 sondes. Temperature will also be measured continuously, from April to October, using Hobo temperature loggers. Temperature loggers will be placed in reaches where bioassessment data is collected but where the water level is too shallow for sondes, as well as in pools that act as refugia for fish. Detailed measurement of basic water quality parameters is critical to the understanding of water quality conditions as they relate to aquatic life. Extreme diel fluctuations in dissolved oxygen (DO) or prolonged periods with low DO can be evaluated with continuous monitoring probes, providing a more comprehensive picture of potential impacts to aquatic life. Continuous temperature and dissolved oxygen data, collected by SWAMP in 37 watersheds, have proven to be very useful in evaluating beneficial use impairment for 303d/305b reporting. Questions concerning the natural variability of basic water quality parameters, especially during the summer months in intermittent streams, necessitate continuous time-series monitoring at these reference sites. These data will be especially useful in combination with continuous streamflow data (see below), and will allow for a better assessment of potential causes of impairment.

Continuous, long-term measurements of stream flow will be collected by accessing data from existing USGS flow gauges (Redwood, Coyote and Pescadero creeks) or installing simple, permanent depth sensors (pressure transducers) at reference sites without gauges. Available streamflow data in the Region is mostly limited to USGS maintained gages. There is little streamflow information for small streams, where much of the water quality monitoring occurs. Flow data for these smaller streams will be very valuable in interpreting water quality data measured at reference sites, including benthic macroinvertebrates, periphyton, nutrients, and basic water quality parameters. Just as importantly, long-term data on flow in small streams with natural hydrographs will enable us to assess the effects of climate change on streamflow patterns in the Bay Area.

Urbanization

The urbanization study also uses a targeted sampling design. Four sampling sites will be selected in both Saratoga Creek and Las Trampas Creek, in consultation with partner agencies (SCVURPPP and CCCCWP). The sites will be located close together (0.25 – 0.5 miles apart), near the urban boundary, in order to assess the downstream changes in biota and water quality with urbanization. The same suite of indicators (BMI, periphyton, nutrients, physical habitat, and basic water quality) will be collected (some at lower frequencies) at these sites as at the minimally disturbed reference sites, facilitating comparison between the urban and minimally disturbed sites.

Large-scale residential and commercial developments are continuing to be built throughout the Bay Area. These projects can have large impacts on water and sediment quality conditions. Anticipated land-use changes from these developments present unique opportunities to document responses in stream conditions to watershed disturbances, and examine whether current best management practices (CASQA 2003) are sufficient to protect aquatic resources. The monitoring in Las Trampas Creek will also serve the role of collecting baseline data on water quality conditions prior to the construction of three large residential development projects in the upper watershed. Existing bioassessment data collected by CCCWP will supplement this baseline data collection effort. The three planned projects will include a total of ~300 homes. Construction is projected to begin in 2009.

b. Indicators and measurement parameters

All sites

- Benthic macroinvertebrates and physical habitat will be sampled and measured using the 2007 SWAMP Bioassessment Procedures (Ode 2007) and SAFIT Level II taxonomy.
- Periphyton biomass (chlorophyll a and AFDM) and taxonomy of diatoms and soft algae will be sampled and analyzed using methods to be recommended by the SWAMP Periphyton Committee.
- Nitrate/nitrite, ammonia, TKN, total phosphorus, orthophosphate, and suspended sediment concentration (SSC) will be sampled and analyzed using standard SWAMP protocols (Puckett 2002, Ode 2007).
- Basic water quality parameters (pH, dissolved oxygen, temperature, conductivity, and turbidity) will be measured and recorded with YSI 6600 sondes.
- Temperature will be measured and recorded with Hobo temperature loggers.
- Discharge data will be calculated from velocities measured with a pygmy meter.

Minimally disturbed reference sites only:

- Flow data will be accessed at 3 USGS stations on Redwood, Coyote and Pescadero creeks. For the other reference creeks, depth will be measured with in-situ pressure transducers. Transducers will be installed for long-term monitoring. Discharge data will be calculated from velocities measured with a pygmy meter and will be used to develop rating curves for each site.

c. Data analysis and assessment

Minimally disturbed reference sites

Data analysis and assessment for Objective I will focus on long-term trends, annual and seasonal variability, and relationships among factors affecting algae growth. Monitoring data will be used to develop and improve upon existing water quality guidelines for the Region, especially in circumstances when guidelines are unavailable or not specific to the Region (e.g., benthic macroinvertebrates, periphyton, nutrients). For example, examination of the relationships between observed seasonal trends in nutrients (e.g., declines in concentrations over the summer season) and temperature, pH, DO and periphyton biomass will be used to improve nutrient TMDL development. Annual variability in benthic macroinvertebrate assemblages among minimally disturbed reference sites will be useful for characterizing the variability of reference conditions for biocriteria development and evaluating the potential effects of climate change. Benthic macroinvertebrate communities will be assessed using multivariate methods, as well as by calculating assessment metrics or indices. Interrelationships among factors affecting periphyton growth and eutrophication will be examined for the spring and summer periods. Continuously measured dissolved oxygen data will be used to infer primary productivity, and characteristics of diel dissolved oxygen curves (e.g., daily range, minima, maxima) will be used as measures of eutrophication. These measures will be compared to continuously measured conditions (i.e., stream flow, temperature) and bi-monthly samples (nutrients, periphyton) in order to understand patterns of algae growth in reference systems.

Urban development

Data analysis and assessment for Objective II.1 will involve comparison of water quality and physical habitat conditions and biota along urban gradients and between watersheds. Urban gradients will be established based on the relative contribution of urban and rural land use to each sampling site, obtained from storm drain maps. Based on previously collected data, it is expected that benthic macroinvertebrate assemblages will exhibit minor changes along the rural-urban gradient in Saratoga Creek, but large changes along Las Trampas Creek. We will then assess whether periphyton, nutrients, basic water quality, and physical habitat (PHAB) exhibit these same patterns, in order to develop hypotheses about the potential causes of poor biological integrity. For example, if dissolved oxygen patterns are similar along the urban gradient in Saratoga Creek but indicate severe eutrophication at the lower sites in Las Trampas Creek, this pattern could be responsible for the observed changes in BMI assemblages. If, on the other hand, basic water quality, nutrients, and physical habitat do not show any downstream trends in either watershed, other factors that were not measured may be responsible. If periphyton does not exhibit the same trends as BMI assemblages, the observed changes must be a result of water quality or habitat factors that only strongly affect BMIs. This data will also be used to identify "best attainable conditions" in urban creeks for the evaluation and potential development of TALU.

Data analysis and assessment for Objective III.1 will take the form of a Before-After-Control-Impact (BACI) design. At least one year of pre-construction data will serve to characterize baseline conditions prior to development. Because the sampling sites on Las Trampas Creek are situated along a gradient of increasing urbanization, it is expected that water quality at the downstream site will be more impacted relative to the upstream site, even prior to the new development projects. Monitoring data in the years following construction will be used to assess the impact of the development project. The upstream site, which is not expected to be influenced by any upstream development, should serve as a project-specific control site for the duration of the study.

<u>d. Data collection and frequency of sampling</u>

All sampling, unless otherwise indicated, will target non-flood base flows (i.e., at least 24 hours following significant precipitation events). Nutrient sampling will be performed in the morning hours (9-12 a.m.). The timing of all other monitoring will occur depending upon field logistics.

- Benthic macroinvertebrates and physical habitat will be sampled once per year in April (the index period) at all sites.
- Periphyton communities and biomass will be sampled three times during the spring/summer season (April, June, August) for the minimally disturbed reference site study. In subsequent years the frequency may be reduced to once per year if the data indicate that one sample per year is sufficient to use periphyton for bioassessment. For the urbanization study, periphyton will be sampled once per year in June.
- Temperature will be monitored continuously, From April to October, at all of the sites using

Hobo temperature loggers. At the minimally disturbed reference sites, basic water quality (dissolved oxygen, pH, conductivity, temperature and turbidity) will be monitored continuously (15-minute intervals) from April through October with 6 YSI 6600 sondes dedicated to these sites. YSI sondes and temperature loggers will not be deployed during the wet season because (1) dissolved oxygen is primarily of concern during the spring and summer (sondes) and (2) there is the potential for instrument loss during winter high flows. YSI sondes will be maintained bimonthly, during the same site visits as other sampling is performed. Maintenance includes retrieval, accuracy checks with standards, probe cleaning, calibration, and re-deployment. An additional two sondes will be dedicated to the eight urban gradient sites. The two sondes will be rotated among the eight sites, for 1-week intervals, during the period from April to October. This plan will allow each site to be monitored at least 3-4 times (weeks) during this period.

- Nutrients and SSC will be sampled bimonthly (February, April, June, August, October, December) at all of the sites.
- Depth will be measured continuously (15 minute intervals) year-round at the minimally disturbed reference sites. Discharge will be measured during bimonthly site visits. Occasional discharge measurements may also be made during high flow events during the wet season, in order to develop a site specific rating curve (depth-discharge relationship). Continuous depth measurements will not be made at the urbanization study sites because the limited timeframe of the study will prevent the development of discharge rating curves.

<u>e. Spatial and temporal scale</u>

Minimally disturbed reference sites

The scope of the spatial scale of the study design for Objective I is the range of minimally disturbed stream ecosystems in the Region. The six sites reflect a range of flow types (i.e., perennial and intermittent), ecoregion, vegetation type, and geographic distribution throughout the Region (see Table 2). The primary focus of the study design is long-term trends, although seasonal and annual variability will also be examined. Although not planned for FY07-08, in future years SWAMP may also investigate the short-term dynamics of nutrient concentrations during single storm events during the wet season in order to better understand variation over short time scales in reference streams.

Urbanization

Monitoring for Objective II.1 will focus on four sites along an urban gradient in each of two watersheds. The Saratoga Creek watershed drains the Santa Cruz Mountains before the creek flows into the Santa Clara Valley. Las Trampas Creek is a tributary to Walnut Creek, east of the Oakland hills. This monitoring component will last for one year.

Objective III of this monitoring program is focused on individual watersheds in the Region with planned urban developments. In 2007-08, four sampling sites in the Las Trampas Creek watershed will be sampled. At least three large developments are planned on the outskirts of the town of Moraga in the Las Trampas Creek watershed over the next several years. These developments could potentially cause water and sediment quality impacts in upper Las Trampas Creek, a relatively intact watershed with good water quality and habitat conditions. SWAMP monitoring will collect at least one year of pre-construction data, and up to 5 years or post-construction data. Two other watersheds with very large planned developments (>10,000 residential units), Mt. Diablo Creek (Concord) and Coyote Creek (San Jose), will be added in later years.

f. Data management

All nutrient and SSC monitoring data collected for this project will be entered directly into the SWAMP database by the Moss Landing Marine Lab. Continuous basic water quality data will be entered by SWAMP staff into the Bay Delta and Tributaries (BDAT)[1] time series database linked to the SWAMP database through the California Environmental Data Exchange network (CEDEN). Bioassessment (benthic macroinvertebrate and periphyton) data will be directly entered into the Aquatic Bioassessment Laboratory (ABL) database by ABL staff. The SWAMP physical habitat (PHAB) database is currently under development, but it is expected that the database will be available for data entry by summer 2008. All data will be directly accessible by all agencies, watershed groups and the general public.

IV. COORDINATION AND REVIEW STRATEGY

This plan has been reviewed internally by SWAMP staff, by one representative of a county stormwater program, and by a contractor involved with SWAMP data analysis and report writing. This coordination is necessary to establish a framework for a watershed monitoring coalition in the Region. Peer review, using the State Water Board's peer review process, will be completed before implementation.

This project will be managed and implemented by the Region 2 SWAMP Program. It is expected that all field sampling will be completed by Region 2 staff. Laboratory analyses will be performed by partner agencies in SWAMP (i.e., DFG Aquatic Bioassessment Laboratory, DFG Water Pollution Control Lab, and DFG Marine Pollution Studies Laboratory).

SWAMP is coordinating site selection and monitoring efforts with the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPPP), the Contra Costa Clean Water Program, the San Francisco Public Utilities Commission (SFPUC) and the National Park Services (NPS). SCVURPPP has done previous sampling at multiple sites in the Saratoga Creek watershed in 2004 and 2005. CCCWP has done previous sampling at multiple sites in the Las Trampas Creek watershed in 2003, 2004, and 2007. Based on this monitoring, CCCWP has identified the need to further investigate water quality conditions between sites LT-6 and LT-5. NPS plans to monitor water quality in Redwood Creek on a monthly basis starting in October 2008. By partnering with SCVURPPP, CCCCWP and NPS, SWAMP will be able to enhance our dataset and develop positive relationships with clients and stakeholders. SWAMP is also coordinating monitoring efforts with the Bay Area Bioassessment Macroinvertebrate Information Network (BAMBINet), an organization made up of representatives of numerous agencies including municipal stormwater agencies, environmental consulting firms, research scientists, land management agencies, and citizen monitoring groups, with the goal of developing biocriteria for the Region. Additionally, SWAMP is collaborating with an environmental science class at the University of California, Berkeley (UCB), taught by Professor Vincent Resh. This class will conduct watershed assessments in Las Trampas Creek at the study sites selected by SWAMP and CCCWP, providing data on habitat conditions and channel morphology that will be useful for

[1] http://bdat.ca.gov/index.html

assessing long-term changes in channel conditions following urban development. Streamflow monitoring will be coordinated with the United States Geological Survey (USGS). The long-term monitoring of minimally disturbed reference sites is being coordinated with scientists from the Sierra Nevada Aquatic Research Laboratory (SNARL), who are initiating similar monitoring studies in the Sierra Nevada to understand the effects of climate change on aquatic resources.

V. QUALITY ASSURANCE

This monitoring study will be consistent with the SWAMP Quality Assurance Management Plan (Puckett 2002).

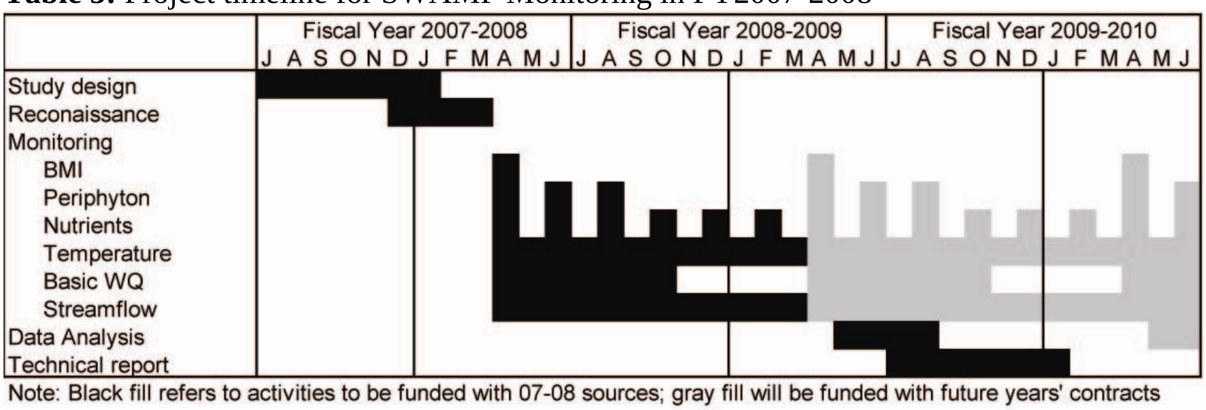
VI. REPORTING

Technical reports summarizing the findings of each objective will be produced by R2 SWAMP staff and the contractor who has led previous reporting efforts for R2 SWAMP. Reports will be made available on the Region's SWAMP website.[2]

VII. PROJECT SCHEDULE

Monitoring will begin in April 2008. Pending availability of data, data analysis will be performed during May-August 2009. A technical report on monitoring performed with FY2007-2008 funds will be completed by February 1, 2010 (Table 5).

Table 5: Project timeline for SWAMP Monitoring in FY2007-2008



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[2] http://www.swrcb.ca.gov/swamp/qapp.html

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