Assessment of Watershed Assessment Methods

Final Technical Memorandum

Prepared for the
Santa Clara Valley Urban Runoff Pollution Prevention Program

By
Lucy A.J. Buchan
Senior Scientist, EOA, Inc.

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## Acronyms

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<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAMBI</td>
<td>Bay Area Macroinvertebrate Bioassessment Information Network</td>
</tr>
<tr>
<td>CDFG</td>
<td>California Department of Fish and Game</td>
</tr>
<tr>
<td>CSBP</td>
<td>California Stream Bioassessment Procedures</td>
</tr>
<tr>
<td>CWA</td>
<td>Clean Water Act</td>
</tr>
<tr>
<td>FCWA</td>
<td>Framework for Conducting Watershed Assessments</td>
</tr>
<tr>
<td>HGM</td>
<td>Hydrogeomorphic Model</td>
</tr>
<tr>
<td>HMP</td>
<td>Hydromodification Plan</td>
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<tr>
<td>IBI</td>
<td>Index of Biotic Integrity</td>
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<tr>
<td>LFA</td>
<td>Limiting Factors Analysis</td>
</tr>
<tr>
<td>NCWAP</td>
<td>Northern California Watershed Assessment Program</td>
</tr>
<tr>
<td>NPDES</td>
<td>National Pollutant Discharge Elimination System</td>
</tr>
<tr>
<td>NRB</td>
<td>Napa River Basin</td>
</tr>
<tr>
<td>NRC</td>
<td>National Research Council</td>
</tr>
<tr>
<td>OWAM</td>
<td>Oregon Watershed Assessment Manual</td>
</tr>
<tr>
<td>PFC</td>
<td>Proper Functioning Condition</td>
</tr>
<tr>
<td>RBP</td>
<td>Rapid Bioassessment Protocols</td>
</tr>
<tr>
<td>RMAS</td>
<td>Regional Monitoring and Assessment Strategy</td>
</tr>
<tr>
<td>RSAT</td>
<td>Rapid Stream Assessment Technique</td>
</tr>
<tr>
<td>SCBWMII</td>
<td>Santa Clara Basin Watershed Management Initiative</td>
</tr>
<tr>
<td>SCVURPPP</td>
<td>Santa Clara Valley Urban Runoff Pollution Prevention Program</td>
</tr>
<tr>
<td>SEFA</td>
<td>Stream Ecosystem Function Analysis</td>
</tr>
<tr>
<td>SEIDP</td>
<td>Stormwater Environmental Indicators Demonstration Project</td>
</tr>
<tr>
<td>SFRWQCB</td>
<td>San Francisco Regional Water Quality Control Board</td>
</tr>
<tr>
<td>SFC LFA</td>
<td>San Francisquito Creek Limiting Factors Analysis</td>
</tr>
<tr>
<td>SFC SRP</td>
<td>San Francisquito Creek Sediment Reduction Plan</td>
</tr>
<tr>
<td>SWAMP</td>
<td>Surface Water Ambient Monitoring Program</td>
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<tr>
<td>SWRCB</td>
<td>State Water Resources Control Board</td>
</tr>
<tr>
<td>TMDL</td>
<td>Total Maximum Daily Load</td>
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<tr>
<td>UAA</td>
<td>Use Attainability Analysis</td>
</tr>
<tr>
<td>US EPA</td>
<td>United States Environmental Protection Agency</td>
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<tr>
<td>URMP</td>
<td>Urban Runoff Management Plan</td>
</tr>
<tr>
<td>WQC</td>
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Executive Summary

In keeping with the Santa Clara Valley Urban Runoff Pollution Prevention Program’s (SCVURPPP) commitment to continuous improvement of program elements, selected regional and national watershed assessment methods have been evaluated to identify and recommend future direction for SCVURPPP’s monitoring and assessment program. As part of this evaluation, this memorandum identifies SCVURPPP’s monitoring and assessment needs in the context of prior efforts and pilot studies, discusses a framework for linking different types of assessment methodologies to address such needs using an adaptive management approach, and summarizes types of and trends in watershed assessments, focusing on methods utilizing bioassessment and analysis of stream ecosystem functions.

The framework integrates the tiered assessment and rotating basin approaches currently implemented by the San Francisco Regional Water Quality Control Board and SCVURPPP as well as many other agencies involved in water quality and watershed monitoring and assessment. Watershed assessment methods are characterized as either tier I, screening level methods intended to detect Beneficial Use impairment, or tier II, more detailed investigations of causes of degradation and Use impairment. The framework also embraces the practice of integrating biological, chemical and physical indicators using a regional reference framework to establish waterbody condition relative to a benchmark. The ultimate goal of implementing such a framework is to develop a monitoring and assessment program that provides an information base to support SCVURPPP objectives of continuously improving program components, and developing additional ones to support attainment of Beneficial Uses in selected waterbodies (SCVURPPP 1997).

The assessment methods selected for evaluation in this project were selected using the following criteria:

- Methods address at least one type of assessment need as outlined in the framework, e.g., appropriate for tier I screening-level assessment, or tier II analysis of causes of degradation and Use impairment.
- Methods integrate biological, chemical, and physical indicators, and ideally historical information, or at least a means for establishing reference condition.
- For extra-regional methods: tested, proven useful, and demonstrate most recent advances in application of assessment methodologies.
- For intra-regional methods: commonly and recently used.

The tier I assessment methods evaluated included Rapid Bioassessment Protocols, Rapid Stream Assessment Technique, Proper Functioning Condition, Stream Ecosystem Function Assessment, Oregon Watershed Assessment Manual, and the Framework for Conducting Watershed Assessments. These methods were evaluated using the following criteria:

1) Method is reasonably rapid and would allow for assessment of all South Bay Basin watersheds within reasonable timeframe (e.g., 5 – 7 years)
2) Method is appropriate for assessing urbanized watersheds
3) Method includes stressor and response indicators
4) Includes explicit method of data analysis that is repeatable and scientifically robust
5) Method can be used to evaluate stream processes
6) Method allows SCVURPPP to realize benefits of regional coordination to develop assessment tools, including indices of biotic integrity (IBIs), Benthic-IBIs, and reference conditions (currently most relevant for macroinvertebrate monitoring and assessment, being coordinated regionally through the Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI 2003)).

The tier II assessment methods evaluated included the North Coast Watershed Assessment Program Limiting Factors Analysis, the Napa River Basin Limiting Factors Analysis, the San Francisquito Creek
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Sediment Reduction Plan and Aquatic Habitat Assessment and Limiting Factors Analysis, the SCVURPPP Watershed Analysis and Management Practice Assessment in Creeks Potentially Impaired by Sediment from Anthropogenic Activities, the Hydromodification Plan, and the Biological Water Quality Target Approach. The relative strengths and weaknesses of these methods were evaluated using a suite of criteria similar to those used to evaluate tier I methods:

- Method further investigate causes of impairment cost-effectively;
- Data Analysis method is explicit, repeatable, and scientifically robust;
- Method is appropriate for assessing urbanized watersheds;
- Method is useful for investigating causes of existing impairment;
- Method can identify stressors and factors limiting attainment of Uses, management actions to address such factors, and additional information required to test hypotheses regarding causes of impairment.

Recommendations for SCVURPPP’s monitoring and assessment program resulting from this evaluation of watershed assessment methods include the following:

**Tier I Screening Level Assessment Methods:**

1. Use the Stream Ecosystem Function Assessment (SEFA) approach, as recommended by SCVURPPP (2003a), augmented by some aspects of the Rapid Stream Assessment Technique (RSAT), to analyze data generated from an ambient monitoring program based largely on Rapid Bioassessment Protocols (RBPs).

2. Coordinate regionally to develop reference conditions and bioassessment tools to support analysis of macroinvertebrate data.

3. Work towards developing robust numeric biocriteria.

4. Consider pursuing bioassessment of fish assemblages in larger order streams and in streams supporting steelhead trout.

**Tier II Investigative Assessment Methods:**

1. Continue to implement LFA as primary approach to investigating factors potentially limiting attainment of aquatic life Uses and incorporate lessons from other projects implementing LFA.

2. Consider using HMP as tool to address potential Use impairment caused by hydromodification associated with future development;

3. Consider incorporating aspects of the HMP method of geomorphic assessment into a method for classifying Santa Clara Basin streams and to identify and prioritize location(s) of restoration efforts.

4. Incorporate biocriteria into assessments as feasible.

The response to reviewer comments on the draft of this technical memorandum, and the two presentations of this project made jointly to the Ad Hoc Monitoring Committee and the Watershed Assessment Subgroup of the Santa Clara Basin Watershed Management Initiative (April 23, 2003, and July 15, 2003), are included as appendices C, D, and E, respectively.
1.0 Introduction

The purpose of the Assess the Assessments project was to continue the Santa Clara Valley Urban Runoff Pollution Prevention Program’s (hereafter, Program) commitment to improving its monitoring and assessment program by evaluating selected regional and national watershed assessment methods that could address Program needs for environmental monitoring and assessment. For the last decade, the Program has initiated changes in its monitoring and assessment program and undertaken pilot studies to test the ability of different methods to assess the source(s), fate, transport, and effects of urban runoff pollutants, the characteristics of Santa Clara Basin watersheds, the effects of urbanization on watersheds, and the effectiveness of various control measures. This memorandum evaluates selected regional and national watershed assessment efforts in the context of previous Program pilot studies, and recommends future directions for Program monitoring and assessment. The following briefly summarizes the evolution of the Program’s monitoring and assessment program.

2.0 Background

From its inception in 1990 through 1995, the Program’s monitoring activities focused on establishing baseline information through sampling and analysis of runoff from various land uses and ambient waters. Since 1996, at the request of the San Francisco Regional Water Quality Control Board (SFRWQCB), the Program has redirected its monitoring resources and has explored different ways to incorporate biological, chemical and physical indicators into its assessments of watershed health, conditions of designated Beneficial Uses, and Program effectiveness. One approach has been to support the Santa Clara Basin Watershed Management Initiative (SCBWMI) in its efforts to assess attainment of selected Beneficial Uses in the Basin. A second approach has been to initiate pilot studies to test selected watershed assessment methods. Most recently, SCVURPPP implemented the monitoring approach endorsed by the State Water Resources Control Board (SWRCB) (Surface Waters Ambient Monitoring Program (SWAMP)) and by the SFRWQCB (Regional Monitoring and Assessment Strategy (RMAS) (2001). The SWAMP/RMAS approach focuses on strategies for monitoring but does not describe methods to assess monitoring data.

In 1997, the Program initiated the Stormwater Environmental Indicators Demonstration Pilot study (SEIDP) to evaluate the Environmental Indicators approach to assessing stormwater programs and practices (Claytor and Brown 1996). The development of this approach reflected a desire to redirect NPDES-permitted stormwater pollution prevention programs to focus on receiving water body quality and the Beneficial Uses that the community desires for that water body. Claytor and Brown’s methodology included both programmatic indicators that closely related to elements in the Urban Runoff Management Plan (URMP) (SCVURPPP 1997) and indicators of watershed condition. The SEIDP study found many of the programmatic indicators useful to evaluate Program effectiveness and recommended ways to improve relevant Program elements (SCVURPPP 2001a). These recommendations have been subsequently implemented through the Program’s process of continual improvement (URMP 1997) and revisions of Performance Standards (SCVURPPP 2001b). The SEIDP study found that watershed indicators were useful to identify watershed conditions but concluded that the complexity of urban impacts on water bodies cannot be addressed within the limits of an NPDES-permitted program; a watershed management approach is necessary to comprehensively address such impacts. The findings from the SEIDP study resulted in the Program’s two-pronged strategy for monitoring and assessment and a supporting data management strategy (SCVURPPP 2001b):

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1 Loretta K. Barsamian, Executive Officer. August 30, 1996 letter to Frank Maitski.
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1) Development and implementation of programmatic measures – to gauge how well Performance Standards are being met and control measures are being implemented.
2) Development and implementation of environmental measures – to determine if control measures are having the intended effect, and to develop new and improved control measures.
3) Development and implementation of a data management strategy – to enhance the ability to gather, analyze, and share data to improve evaluation of programmatic and environmental measures.

Claytor and Brown’s assessment approach did not identify a framework for integrating results from individual environmental indicators to elucidate relationships between urbanization, stream ecosystem functions and the underlying processes that influence watershed conditions, and Beneficial Uses (SCVURPPP 2001a). To address this need, SCVURPPP developed and tested a method to assess stream ecosystem functions in the Coyote Creek watershed (SCVURPPP 2003a) that integrated hydrogeomorphic models (Brinson et al. 1995, Lee, L.C. et al. 1996, 1997, 2001) and indices of biotic integrity (Karr et al. 1986, Hughes et al. 1998, Harrington and Born, 1999). This method was found useful for evaluating stream ecosystem functions and associated aquatic life Beneficial Uses and for identifying and prioritizing additional management actions that could improve conditions and support Use attainment as well as monitoring activities that could fill existing data gaps (SCVURPPP 2003a). SCVURPPP (2003a) also recommended ways in which the methodology could be improved.

The current multi-year receiving waters monitoring plan submitted to the SFRWQCB (SCVURPPP 2002) describes how the SWAMP/RMAS approach has been implemented in Santa Clara Basin watersheds. It also states the need to both continue efforts to facilitate technical and stakeholder workgroups that will assist SFRWQCB staff to implement the RMAS and develop practical, implementable indicators, including physical and biological, and protocols to assess Beneficial Uses in creeks, wetlands, and the Bay. To this end, the Assess the Assessments project has been undertaken to build upon recent pilot studies and evaluate findings in the context of the Program’s current monitoring and assessment program as well as those implemented by other selected local, regional, and state agencies.

The remainder of this memorandum is organized as follows:
Section 3.0: identify and discuss Program watershed assessment needs and a framework for linking different types of assessment methodologies;
Section 4.0: summarize types of and trends in watershed assessments;
Section 5.0: evaluate recent Program monitoring and assessment efforts in the context of selected regional and national watershed assessment methods in order to recommend future directions;
Section 6.0: identify SCVURPPP data management tools;
Section 7.0: recommend future directions for SCVURPPP’s Monitoring and Assessment Program.

3.0 SCVURPPP Monitoring and Assessment Framework

In order to evaluate assessment methods and identify how they can address SCVURPPP assessment needs, a framework has been developed (Figure 1) that identifies types of assessments, possible outcomes of such assessments, and processes for implementing them via feedback loops to Program elements, e.g., mechanisms for adaptive management. This framework integrates the tiered assessment and rotating basin approaches currently implemented by the SFRWQCB and SCVURPPP as well as many other agencies involved in water quality and watershed monitoring and assessment (NRC 2001). It also embraces the practice of integrating biological, chemical and physical indicators using a regional reference framework to establish water body condition relative to a benchmark. The ultimate goal of implementing such a framework is to develop a monitoring and assessment program that provides an information base to support SCVURPPP objectives of continuously improving Program components and
developing additional ones to support attainment of Beneficial Uses in selected water bodies (SCVURPPP 1997). The following describes the steps outlined in this framework, depicted in Figure 1.

The first step outlined in the framework is to implement ambient, screening-level monitoring and assessment, often referred to as tier I, within each watershed using a rotating basin approach, commonly referred to as a five-year basin approach but the interval can vary (NRC 2001). Preparation for implementing tier I monitoring and assessment includes characterizing and mapping watershed resources, as done by the SCBWMI (2000b). Data generated from tier I, or ambient monitoring are typically used to establish baseline water body conditions, screen and determine whether a waterbody is meeting water quality standards, track status and trends, and evaluate BMP effectiveness towards protecting stream ecosystem integrity. Methods supporting ambient monitoring and assessment are designed to be relatively inexpensive and rapid to allow for broad geographic coverage of all watersheds within a given jurisdiction. A screening-level assessment identifies the relative condition of waterbodies from which a preliminary list of waterbodies that appear to be impaired may be generated. A trend, recently criticized by the National Research Council (2001) is erroneous placement of waterbodies on a 303d list for Total Maximum Daily Load (TMDL) analysis. This study makes the following recommendation:

"Many waters now on state 303d lists were placed there without the benefit of adequate water quality standards, data, or waterbody assessment. These potentially erroneous listings contribute to a very large backlog of TMDL segments and foster the perception of a problem that is larger than it may actually be. States should be allowed to move those waters for which there is a lack of adequate water quality standards of data and analysis from the 303d list back to a preliminary list. This would provide the assurance that listed waters are indeed legitimate and merit the resources required to complete a TMDL." NRC 2001 p 5.

In the monitoring and assessment framework outlined in Figure 1, the concept of a preliminary list is integrated as an outcome of ambient monitoring and assessment. In addition to listing which waterbodies may be impaired, this list can serve as an early warning mechanism for identifying and prioritizing management actions that may be implemented to prevent further degradation and improve waterbody conditions. The State of California has embraced this concept in the recently approved 2002 303(d) list by establishing a preliminary list (a.k.a. monitoring list) of water bodies (SWRCB 2003a), and in recently published draft guidance on assessing surface waters (SWRCB 2003b).

Waterbodies on the preliminary list that are considered high priorities for improvement may be subsequently investigated further using tier II monitoring and assessment methods that are more data intensive and driven by specific hypotheses generated from a preceding tier I assessment (Figure 1). It is difficult to be prescriptive about a specific method to use at this level of investigation due to the range and complexity of questions that may need to be addressed. A common assessment method employed to investigate potential water body impairment is a limiting factors approach. Using this method or another comparable, could result in several possible outcomes (Figure 1):

- No management actions are required because assessment determines that errors in data collection or data analysis occurred in the tier I assessment;
- Identification of management actions designed to improve water body conditions and attain Use support, incorporated into Program elements through adaptive management;
- Revision of water quality standard(s), either by developing site-specific water quality criteria or by assessing Use designations;
- Assignment to the 303d List of Impaired Water bodies and subsequent development of a TMDL.
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Tiered Assessment Strategy

Tier I Screening
Watershed Assessment

Preliminary* List
Impaired Waterbodies

Tier II Investigative
Watershed Assessment

No Action; data error
Mgmt Actions
Revise WQS
303d List

Site-specific WQC; UAA
TMDL
Mgmt Actions

SCVURPPP
Program Elements
Programmatic Indicators


Figure 1: Assessment Framework for SCVURPPP.
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As reflected in the frequent reference made above to a monitoring and assessment program, monitoring design (location and frequency of sampling) is intimately linked to assessment methods and has a large impact on assessment results. Discussion of monitoring design is beyond the scope of this memorandum but it is important to note that monitoring plan design will significantly influence the ability of an assessment to provide meaningful results for an agency/organization. Several common monitoring designs are: ambient, point source, and nonpoint source. All designs may have a role in tier I and II assessments, though a point source design will be more common in a tier II assessment where monitoring is designed to answer specific questions. Because watersheds have developed differently and have different histories of data collection efforts, monitoring and assessment methods may need to be tailored to each watershed, this is particularly true for tier II level assessments, and attendant monitoring.

Stream channel classification is an important tool for stratifying data related to physical habitat features of streams. Although discussion of classification methods is beyond the scope of this memorandum, it is mentioned here because it is a component of an overall monitoring and assessment strategy. Stream classifications have been developed and applied to several watersheds in the Santa Clara Basin (SCBWMI 2002, SCVURPPP 2003a). Stream classification facilitates an understanding of the variables that affect sensitive or important aquatic resources, and leads to a more meaningful evaluation of the factors affecting Beneficial Uses. Classifying stream reaches also provides a mechanism for extrapolating site-specific data to other stream reaches that have similar characteristics. In addition, classification serves as a tool for predicting future stream responses to perturbations, and as a basis for selecting future sampling sites and methodologies for field monitoring.

4.0 Watershed Assessment: Types and Trends
The following describes two common types of methods used to assess water bodies and highlights current trends in monitoring and assessment frameworks.

4.1 Types of Watershed Assessment

4.1.1 Emergence of Bioassessment as a Principal Tool for Watershed and Water Quality Management
Until the mid-1990s, regulatory programs, including NPDES permitting, concentrated almost exclusively on controlling toxic chemicals in the water column and ignored other factors that affect the U.S. Clean Water Act (CWA) mandate to protect ecological integrity. However, the underlying presumption that improvements in chemical water quality would be followed by a restoration of biological integrity has been increasingly questioned. A growing body of information has shown that in addition to chemical water quality, factors related to habitat structure, flow regime, biotic interactions, and the available energy base are responsible for the condition of surface water resources (Karr et al. 1986, Davis and Simon 1995, Karr and Chu 1998).

Biological assessment (bioassessment) has become an increasingly popular method used in tier I and tier II water quality management and constitutes a large proportion of many state and other monitoring programs (Table 1) (Davis and Simon 1995, US EPA 2003), while preserving roles of traditional chemical/physical and toxicological approaches that have been developed and implemented for several decades. Bioassessments consist of surveys and other direct measurements of aquatic life. Part of the popularity of bioassessment stems from a high level of support by the U.S. EPA to develop this tool. The ecological rationale is that biological measures integrate the effects of multiple physical and chemical stressors such as excess nutrients and sediment, toxic chemicals, increased temperature, hydromodification, and habitat degradation, and thereby provide an overall measure of the short and long-term, aggregate/cumulative impact of such stressors that otherwise might not be obtained with episodic
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water chemical measurements or discrete toxicity tests. Biological assemblages such as fish and insects consist of a variety of species with different life histories, sensitivity to degradation, and function in the ecosystem, and respond to a range of urbanization effects. The economic and social rationales are that bioassessment is a relatively inexpensive tool to implement, and provides a measure of water resource condition that can be relatively well-understood by citizens, thereby fostering public education and support for monitoring and assessment programs.

Table 1: Number of Biological Assessment Programs and Biocriteria Development for States, Tribes, Territories, and Interstate Commissions. Adapted from U.S. EPA 2002.

<table>
<thead>
<tr>
<th>Program Elements</th>
<th>1989</th>
<th>2001</th>
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<tbody>
<tr>
<td>Use of Bioassessments</td>
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<tr>
<td>Water Resource Mngmt</td>
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<td>11</td>
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<tr>
<td>Interpret Aquatic Life Use Attainment</td>
<td>&lt;&lt; 31</td>
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<td>Fish</td>
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<td>Benthic Macroinvertebrates</td>
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<td>Reference Conditions</td>
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<td>Multiple Metrics for Data Analysis</td>
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<tr>
<td>Biological</td>
<td>3</td>
<td>50</td>
<td>47</td>
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</table>

Bioassessment data can be used for a variety of purposes in water quality programs including assessment of aquatic life Uses and appropriateness of Use designations, setting protection and restoration goals, and evaluating the effectiveness of management actions including best management practices. Bioassessment is used to address the following CWA requirements (US EPA 2000a):

- Aquatic Life Use Attainment (section 305b): bioassessments determine if a waterbody has healthy aquatic life
- Nonpoint Source (section 319): bioassessments are the most effective way to evaluate cumulative impacts from nonpoint sources (both chemical and non-chemical stressors)
- TMDLs (section 303d): bioassessments help provide an ecologically based assessment of the status of a waterbody and help prioritize waterbodies for TMDLs based on the severity of biological damage.
- NPDES (section 402): bioassessments directly measure the combined impacts of any and all stressors on the resident aquatic biota and can be used to determine the effectiveness of permit controls.

An area of active research is the development of biological signatures using biological metrics and indices to identify consistent patterns that correlate with different types of stressors. This has been particularly useful to date for identifying complex toxic stressors (Yoder and DeShon 2003) and dose-response linkages associated with sediment stress (Herbst 2002).

Although bioassessment is clearly becoming an increasingly effective water quality management tool, chemical and physical monitoring still plays an important role. No single monitoring component is sufficient to indicate where and how ecosystem integrity is being affected, particularly where multiple stressors are impacting stream reaches. Relying on a single component may result in environmental regulation that is less accurate and potentially underprotective of the water resource. For example, Ohio EPA found that 49.8% of streams assessed as impaired were detected by bioindicators but not by chemical indicators; chemical indicators revealed exceedences of chemical criteria in 2.8% of cases where biocriteria were fully attained (Yoder et al. 1999). A robust and cost-effective approach to water quality
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management should include an appropriate mix of all monitoring components that is prioritized based on experience, existing information, and best professional judgement (Yoder 1995).

Table 2. Strengths and Limitations of Chemical and Biological Assessments (Source NRC 2001)

<table>
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<th>Attribute</th>
<th>Chemical-based</th>
<th>Bioassessment-Based</th>
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<tbody>
<tr>
<td>Expressed in WQS as</td>
<td>Parameter-specific criteria</td>
<td>Biological criteria</td>
</tr>
<tr>
<td>Representation of biointegrity</td>
<td>Surrogate measure</td>
<td>Direct measure</td>
</tr>
<tr>
<td>Principal Focus</td>
<td>Pollutant focused</td>
<td>Resource focused</td>
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<tr>
<td>Breadth of coverage</td>
<td>Partial</td>
<td>Complete</td>
</tr>
<tr>
<td>Operative directiona</td>
<td>Bottom-up approach</td>
<td>Top-down approach</td>
</tr>
<tr>
<td>Effect Properties</td>
<td>Individual effects</td>
<td>Cumulative effects</td>
</tr>
<tr>
<td>Indicator role</td>
<td>Stressor/exposure</td>
<td>Response</td>
</tr>
<tr>
<td>Best strength</td>
<td>Design criteria</td>
<td>Impact assessment criteria</td>
</tr>
</tbody>
</table>

*a Biological criteria represent a top-down evaluation of waterbody condition, where the end product (biological community performance) is used to characterize the integrated result of chemical, physical, and biological processes that affect biological performance. In contrast, the traditional chemical/toxicity approach represents a bottom-up evaluation where only some of the stressors are used to predict or explain complex processes using surrogate end points (Yoder 1995).

4.1.2 Assessment of Stream Ecosystem Functions

Another type of watershed assessment includes analysis of processes that maintain stream ecosystem structure and functions, e.g., hydrologic, biogeochemical, plant community/habitat, and faunal community/habitat (Brinson 1995). This approach reflects the importance of analyzing how natural and human factors influence the processes that shape stream structure and function over time, e.g., how streams “work” to move water and sediment though a watershed. It explicitly reflects the concept of streams operating as a continuum (Vannote et al. 1980) in which headwater reaches typically deliver sediment to a stream, lower-elevation and lower-gradient reaches typically transport sediment, and reaches traversing relatively flat valley floors typically receive sediment and act as zones of deposition. Vegetation, landforms, and large woody debris dissipate energy associated with high flows and result in physical changes such as reduced erosion, sediment filtering, and improved flood-water retention. As such physical aspects of the stream system function, they support development of channel characteristics that provide habitat for aquatic organisms.

The stream function approach incorporates assessment of biological resources in a broad ecosystem context. It emerged in response to a need for assessing changes, both gains and losses, in ecosystem functions in the context of regulatory requirements, specifically U.S. CWA Section 404 process, CEQA, NEPA, and other state and local equivalents. Also, former President Clinton’s 1993 Wetlands Plan called for improving techniques to assess water/wetland ecosystem functions in regulatory contexts. Therefore, it has not been developed to focus on assessment of water quality standard attainment. Methods have been developed that are relatively rapid and reference-based to assess the types of functions present, and the level at which they function, e.g., their functional capacity. These methods may be applied at both a tier I and tier II level depending on the resolution of data and models developed for a given area.

4.2 Trends in Watershed Assessment

4.2.1 Regional Reference.

The issue of reference conditions is critical to interpreting monitoring data. A reference condition establishes the basis for making comparisons and for detecting Use impairment. Reference conditions are typically established in two ways: 1) as site-specific measurements of conditions upstream of a point...
source discharge, or from a “paired” watershed that is classified similarly; 2) based on measurements taken from a population of relatively unimpaired or least-impacted sites throughout a relatively homogenous region and habitat type. Identifying reference conditions in urbanized areas is challenging due to the extent of landscape alteration and its impact on stream ecosystem processes. This is especially true for stream segments traversing the urbanized valley floor and alluvial plains of the Santa Clara Basin. It is particularly difficult to identify sites at which reference data may be collected for large order streams because in the Santa Clara Basin they all traverse the urbanized valley floor. Alternatives to establishing reference conditions based on recent data collected from least-impacted sites include using historical information and modeling approaches such as statistical inference from existing data. These approaches have been implemented in the Coyote Creek watershed (SCVURPPP 2003a. The historical approach has also been demonstrated in several other Bay Area creeks including Sulfer and Carneros Creeks (Napa River watershed), Crow Creek (San Lorenzo watershed), and Wildcat Creek (Wildcat Creek watershed) (Grossinger 2001).

Due to the extensive sampling requirements, establishing regional reference conditions is most feasibly done when monitoring agencies coordinate. A current example is the Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI) which is a group of scientists, agency representatives and community-based monitors interested in promoting the use of benthic macroinvertebrate bioassessment. BAMBI participants implement individual monitoring efforts and share experiences and information to improve components of bioassessment, including identification and monitoring of potential reference sites. Other issues they are addressing include development of statistical data analysis techniques and metric selection, refinement of rapid habitat assessment protocols, standardization of data management formats and quality control practices to facilitate analysis of regional data, support stream classification, and guidance on using BMI data for addressing watershed management questions (BAMBI 2003).

4.2.2 Stressor, Exposure, Response Indicators

In order to detect and evaluate waterbody impairment and respond with effective management actions it is important to incorporate indicators that reflect sources of stress, and responses to and exposure to stress over time. Indicators included in monitoring and assessment programs are typically categorized as either stressor, exposure, or response indicators. Appendix A provides an example developed through the SWAMP program. Stressor indicators are characteristics that are expected to change the condition of a resource if the intensity or magnitude is altered. Exposure indicators measure the initial effects of stressors and can include concentrations of toxic chemicals, bioassay endpoints, tissue residues, and biomarkers, each of which can provide evidence of biological exposure to a stressor-caused agent. Response indicators are generally composite measures of the cumulative effects of stress and exposure and include the direct measures of biological community and population response. Stressor indicators derived from physical habitat quality data can help explain or diagnose stream condition relative to response indicators. Stressor and Response indicators are frequently used in screening level assessments. Exposure indicators are more commonly used in investigative tier-II assessments.

5.0 Evaluation of Watershed Assessment Methods

The assessment methods selected for evaluation in this project were selected using the following criteria:

- Methods address at least one type of assessment need as outlined in Figure 1, e.g., appropriate for tier I screening-level assessment, or tier II investigative analysis of causes of degradation and Use impairment.
- Methods integrate biological, chemical, and physical indicators and ideally historical information or at least a means for establishing reference condition.
Assessment of Watershed Assessment Methods

- For extra-regional methods: tested, proven useful, and demonstrate most recent advances in application of assessment methodologies.
- For intra-regional methods: commonly and recently used.

5.1 Tier I Assessment Methods

As discussed, the purpose of a Tier I assessment is to provide a screening-level evaluation of waterbody condition based on ambient monitoring of general physical, chemical, and biological parameters/indicators. Selection of environmental indicators should be based on scientific, practical, and programmatic considerations. Of primary importance is the ability of an indicator to address the question posed by the ambient monitoring program. At a tier I level, the primary questions being addressed, are 1) are designated Beneficial Uses attained, if not, what are the factors most likely causing impairment and limiting attainment, and 2) what do ambient monitoring data tell us about effectiveness of BMPs?

5.1.1 Evaluation Criteria

To provide a basis for comparison among tier I assessment methods, the following criteria were applied:

- Method is reasonably rapid and would allow for assessment of all South Bay Basin watersheds within reasonable timeframe (e.g., 5 – 7 years)
- Method is appropriate for assessing urbanized watersheds
- Method includes stressor and response indicators
- Includes explicit method of data analysis that is repeatable and scientifically robust
- Method can be used to evaluate stream processes
- Method allows the Program to realize benefits of regional coordination of certain monitoring methods to develop assessment tools including IBIs, B-IBIs, and reference conditions. This is currently most relevant for macroinvertebrate monitoring and assessment which is being coordinated regionally through the Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI 2003).

5.1.2 Tier I Method Evaluation

The following screening level assessment methods are described and evaluated in terms of their relative strengths and weaknesses using the above criteria: Rapid Bioassessment Protocols (Barbour et al. 1999), Rapid Stream Assessment Technique (Galli 1997), Stream Ecosystem Function Assessment (SCVURPPP 2003a), Proper Functioning Condition (Prichard et al., 1998), the Oregon Watershed Assessment Manual (Watershed Professionals Network 1999), and the Framework for Conducting Watershed Assessments (Santa Clara Basin Watershed Management Initiative 2000a).

Rapid Bioassessment Protocols (RBPs)

The RBPs are a synthesis of existing methods employed by various State Water Resource Agencies that were designed as inexpensive screening tools to determine whether a stream is supporting a designated aquatic life Use and the relative severity of any impairment detected. The RBPs have been developed over a twenty year period, and were most recently refined in 1999 (Barbour et al.). They include quantitative techniques to evaluate general physicochemical water quality constituents, habitat parameters, and biological assemblages (most commonly macroinvertebrates and fish) using the regional reference concept. The first step is to implement biosurveys to assess aquatic life impairment using stressor and response indicators. Data are scored and calculated as indices of relative condition that may be related to possible causes of impairment (Table 3). Once an impairment is detected, additional
Assessment of Watershed Assessment Methods

ecological data, including exposure indicators, are collected and analyzed in a tier-II level assessment to identify causes, sources, and to identify appropriate management actions.

Table 3. Generalized Relationships between Indices of Biological Integrity and Habitat Condition, and Possible Causes of Impairment (Barbour et al. 1999).

<table>
<thead>
<tr>
<th>IBI Score</th>
<th>Habitat Score</th>
<th>Possible Cause of Impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>No Impairment</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>Chemical/Altered Flow</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>Habitat</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>Nutrient Enrichment</td>
</tr>
</tbody>
</table>

RBP are by far one of the most commonly implemented bioassessment methods. They are prevalent at the state level, including in California. California’s Department of Fish and Game’s (CDFG) Water Pollution Control Laboratory and its Aquatic Biological Assessment Laboratory (ABAL) developed a set of standard protocols for assessing biological and physicochemical conditions of wadeable streams, the California Stream Bioassessment Procedures (CSBP), that are regional adaptations of the national USEPA RBPs. Standard field data sheets are used to record data as they are collected for general physical characterization of stream, water quality, habitat assessment, and macroinvertebrate assessment. Fish assemblages are not included in the CSBP due to difficulties often associated with collecting and analyzing fish communities in Western streams, including low species richness, high endemism and numbers of introduced species, and obtaining necessary permits to sample (Moyle and Marchetti 1999). Parameters collected to assess habitat include epifaunal substrate/cover, embeddedness, velocity/depth regime, sediment deposition, channel flow, channel alteration, riffle frequency, bank stability, streambank vegetation disturbance, riparian width and contiguity. The ABAL is working in coordination with RWQCBs in California and groups such as BAMBI to develop reference conditions and select appropriate metrics to be used in the evaluation of macroinvertebrate data (CDFG 2002). Regional coordination is important to effectively develop such robust bioassessment tools.

Many Bay Area stormwater agencies, including SCVURPPP (2001b), implement the CSBP as the primary screening-level component of their monitoring and assessment program plans (Alameda County Clean Water Program 2002, Contra Costa Clean Water Program 2002, Marin County Stormwater Pollution Prevention Program 2003, San Mateo Countywide Stormwater Pollution Prevention Program 2002). As well, at least three regional water quality control boards implement the CSBP as their primary screening-level assessment tool (Central Coast RWQCB 2003, CDFG 2002, SFRWQCB 2001). The US EPA Environmental Monitoring and Assessment Program Western Pilot Study also implements the RBP habitat and visual stream assessment protocols as a means quickly providing a cross-check to data collected using more detailed and intensive sampling methods (US EPA 2001).

Evaluation of RBPs

Strengths: RBPs are rapid, well-defined, and robust methods that include both stressor and response indicators (Appendix B) and can be used to evaluate stream conditions in urbanized watersheds. The parameters assessed strongly correlate with some, but not all stream functions and could be used to assess them. RBP protocols for macroinvertebrates are commonly implemented by a wide variety of organizations and agencies nationwide and within the Bay Area Region. As discussed, efforts to develop bioassessment tools in California and the Bay Area are based on these protocols. Therefore, implementing RBPs as a component of a monitoring and assessment strategy provides a direct means of benefiting from regional efforts to coordinate bioassessment protocols and tools. Such coordination is important since development of bioassessment tools requires sampling streams across urban and
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environmental gradients over time, which can be achieved most effectively by coordination amongst resource management agencies.

Weaknesses: RBPs are not sufficient as a stand-alone method because they do not address the full suite of parameters required to evaluate stream ecosystem functions, but they are suitable as a component of a more comprehensive monitoring and assessment program.

Rapid Stream Assessment Technique (RSAT)
RSAT was developed by the Metropolitan Washington Council of Governments in 1992 to provide a method that could quickly identify channel erosion problem areas and characterize stream quality conditions. RSAT is a synthesis of several stream survey techniques, including U.S. EPA’s RBPs, the Izaak Walton League and Save Our Streams stream survey techniques, and the US Department of Agriculture Water Quality Indicators Guide for Surface Waters (Galli 1997). It uses both a reference stream and an integrated numerical scoring and verbal ranking approach. Over 30 biotic and abiotic parameters are measured and weighted differently in the following six evaluation categories:

- Channel Stability
- Channel scouring/sediment deposition
- Physical Instream Habitat
- Water Quality
- Riparian habitat Conditions
- Biological Condition

The RSAT method surveys the entire stream sampling at riffle transects at 400-foot intervals. Under normal field conditions a two-person monitoring team can survey 1.0 – 1.25 stream miles/day. Although a two-person team is strongly recommended to implement RSAT, the approach can be implemented by a single person. Streams are classified into segments and stream parameters/conditions measured at transects are averaged over the respective stream segment. For each segment, investigators develop a summary condition score for each of the six RSAT evaluation categories based on the averaged results of field measurements, additional general stream characteristics (including presence of storm drain outfalls, fish barriers, amount of trash) noted during surveys, as well as conditions observed between transect station locations. This process of developing a final score involves applying some professional judgement; based on the averaged field measurement score, an investigator adds or subtracts points based on his/her opinion of the relative influence of the additionally noted stream characteristics.

RSAT data is useful for generating representative channel cross-sections, calculating average cross-sectional channel area, determining the gross level of channel widening, degradation, and impacts related to flow-regime, and for creating a historical reference baseline for future follow-up surveys. Baseflow water quality grab sampling provides a snap-shot of stream water quality conditions that can be used to interpret biological data. Ten parameters are measured but only two (substrate fouling and total dissolved solids) are used to directly compare streams because 1) they provide a good indirect measure of overall long-term water quality condition, 2) they are not greatly influenced by prevailing daily or seasonal meteorological/climatological conditions, and 3) they are strongly correlated with percent imperviousness, macroinvertebrate community condition, and overall stream condition (Galli 1997).

The stormwater control program in Montgomery County, Maryland, has utilized the RSAT approach to address the following assessment needs (US EPA 2003):

- Identification of baseline stream conditions
Assessment of Watershed Assessment Methods

- Screening tool to evaluate cumulative watershed impacts
- Identification of causes of biological impairment
- Assessment of effectiveness of innovative BMP and development designs
- Establishment of goals for stream conditions for Countywide Stream Protection Strategy

**Evaluation of RSAT**

**Strengths:** RSAT provides a quantifiable, rapid method to evaluate stressor and response indicators (Appendix B) and has been tested in urbanized watersheds. The six evaluation categories included in the assessment strongly correlate with stream processes. Most of the physical habitat and macroinvertebrates parameters are similar to those sampled using the RBPs, but RSAT includes more parameters related to channel condition and stressor indicators than either the RBP or the Stream Ecosystem Function (SEF) method (see below).

**Weaknesses:** The biggest weakness in the RSAT method is its employment of professional judgement to score existing conditions, which reduces the ability of this method to be repeatedly implemented reliably. While it likely would be feasible to develop a protocol for including such influence on the scores, for example, an index that assigns the number of points to be added or subtracted for each degree of influence, the existing method description (Galli 1997) does not include this. Furthermore, Galli (1997) does not describe the models for evaluating stream conditions with enough detail for others to implement them. For example, he does not list the parameters included in each evaluation category, and an unstated assumption is that they are weighted equally in each category. Despite repeated attempts at contacting staff from the Montgomery County Monitoring Program, none were available for comment.

A minor drawback to RSAT is its use of a level I RBP protocol for sampling macroinvertebrates; the CSBP uses a level III which provides a higher level of detail and potential to identify factors causing impairments. This weakness could be overcome by implementing the level III protocol and revising the scoring to accommodate the finer resolution data.

In summary, some of the parameters measured by RSAT could contribute to other methods such as RBP and SEFA, and to regional efforts to improve and standardize methods of habitat and macroinvertebrate sampling and data analysis (see Section 7.0). The lack of clarity in the model mechanisms as discussed above are a significant weakness. If this issue were addressed then the RSAT model could be considered quite comparable to the SEFA approach.

**Stream Ecosystem Function Assessment (SEFA)**

The Assessment of stream ecosystem functions is a synthesis of two methods (SCURPPP 2003a). Physical stream ecosystem functions are assessed based on the Hydrogeomorphic Approach (HGM) that was developed to assess riverine (water and wetland) functions (Brinson et al. 1993) and has been applied in Central and Northern California (Lee, L.C. et al., 1996, 1997, 2001), and locally (Buchan et al., 1999). Biological stream ecosystem functions are assessed using a multimetric approach to calculate an Index of Biological Integrity based on Hughes et al. (1998) for fishes, and Harrington and Born (1999) for macroinvertebrates.

HGM is a relatively rapid and reference-based method that can be used to assess the type of functions present and the level at which they function, e.g., their functional capacity. The HGM approach is designed to measure change at a scale large enough to capture ecosystem functions. Therefore, it is
Assessment of Watershed Assessment Methods

appropriate for assessing entire watersheds. HGM assessments have been found useful for the following activities (Lee et al. 2001, SCVURPPP 2003a):

- Identifying potential waterbody impairment, causes of impairment, and management actions to restore functionality
- Planning, reconnaissance-level inventories
- Prioritizing sites for protection or restoration
- Analyzing project alternatives to minimize impacts
- Assessing project impacts for permitting and enforcement
- Developing restoration project targets or performance standards
- Triggering contingency measures when project targets are not being met
- Identifying specific areas of concern in an impact assessment process

The HGM approach to assessing stream ecosystem functions has four essential elements (Brinson 1995): 1) stream classification based on hydrogeomorphic factors; 2) identification, definition, and description of the functions for the stream classes under consideration; 3) development of a reference system that includes descriptive information about the stream classes and associated range of variation in structure and function; 4) development of an assessment model, associated protocols, and definition of functional indices that establish criteria for the background information necessary to perform a functional assessment.

The SEFA approach (a combination of HGM and IBI approaches) has been tested in the Coyote Creek watershed of the Santa Clara Basin (SCVURPPP 2003a) using clearly defined models to evaluate a suite of physical and biological parameters related to the following functions:

- Hydrologic Processes and Channel Dynamics
- Riparian Habitat Variation and Richness
- Aquatic Habitat Variation and Richness
- Landscape-Level Aquatic Habitat Connectivity
- Aquatic Vertebrate Community
- Aquatic Invertebrate Community

The SEFA approach as implemented in the Coyote Creek watershed included analysis of historic fisheries data to establish reference conditions. Reference conditions for other stream functions were developed using a statistical approach (SCVURPPP 2003a). SCVURPPP (2003a) recommended including analysis of historic geomorphic conditions to assist in developing representative reference conditions.

The SEFA approach evaluates both the existing, future, and potential capacity of stream ecosystem functions. The existing conditions are evaluated using explicitly defined, quantitative models. The future and potential capacities of physical and biological stream ecosystem functions are evaluated by applying best professional judgement to the baseline existing condition established using the quantitative models. Future capacities of physical and biological stream ecosystem functions are evaluated by considering the relative positive or negative impacts of existing and near-term factors that may continue or soon influence the distribution and viability of fish and macroinvertebrate assemblages, their habitats, and the functional capacities of supporting stream processes. The potential capacities of physical and biological stream ecosystem functions are evaluated by identifying where existing and future stream ecosystem functional capacities could be maintained or improved by practicable strategic actions that have not been planned yet. SCVURPPP (2003a) discuss how assessments of future and potential stream ecosystem functional
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capacities could be conducted using a more quantifiable approach to improve the repeatability of methods to evaluate future and potential conditions.

**Evaluation of SEFA**

**Strengths:** Implementation of SEFA, as was done in the local, urbanized Coyote Creek watershed (SCVURPPP 2003a), is a rapid assessment process that includes both stressor and response indicators (Appendix B). Unlike any of the other methods evaluated here, the SEFA method assesses not only existing, but also future and potential conditions, thereby explicitly defining, prioritizing, and evaluating the impacts of future and potential management actions. As implemented in the Coyote Creek watershed, the SEFA method for evaluating existing conditions was based on well-defined, quantitative models, however, evaluation of future and potential conditions relied on best professional judgement. To address this issue, the authors discuss how methods for evaluating future and potential conditions could be further quantified to provide reproducible results.

SCVURPPP (2003a) relied on existing data and therefore did not recommend data sampling methods. The SEFA models, however, can accommodate data of different resolution. The important issue in designing a monitoring plan to use the SEFA model is to select sampling sites that provide data that are representative of each reach and that include data that are relevant to model parameters. The assessment of macroinvertebrates, and aquatic and riparian habitat can utilize data collected using protocols that are planned to be developed regionally through BAMBI.

**Weaknesses:** The hydrogeomorphic assessment of existing conditions could be strengthened. Recommended changes to improve model performance should be implemented (SCVURPPP 2003a).

**Proper Functioning Condition (PFC)**

PFC was developed over several years beginning in 1988 by the Bureau of Land Management, the Fish and Wildlife Service, and the Natural Resources Conservation Service to address management of lands under their jurisdiction (Prichard et al., 1998). PFC is a qualitative method for assessing the condition of riparian-wetland areas. The product of a PFC assessment is a checklist describing the presence/absence of functions related to hydrology, vegetation, and soil erosion/deposition. The assessment is intended to be implemented by an interdisciplinary team whose members have local field experience using quantitative sampling techniques that support the checklist functions. The method is intentionally qualitative to provide a rapid means of identifying functional capacity and prioritizing the type and location of additional quantitative monitoring. The developing agencies consider the PFC as a minimum level of assessment for riparian-wetland areas. They have also developed a more scientifically rigorous quantitative method to classify riparian-wetland sites called the Ecological Site Inventory (ESI).

In the PFC, a riparian-wetland area is considered to be in proper functioning condition when adequate vegetation, landform, or large woody debris is present to:

- Dissipate stream energy associated with high waterflow, thereby reducing erosion and improving water quality;
- Filter sediment, capture bedload, and aid floodplain development;
- Improve flood-water retention and ground-water recharge;
- Develop root masses that stabilize streambanks against current action;
- Develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other Uses;
- Support greater biodiversity.
The steps in the PFC method are
1) Stratify riparian-wetland areas into aquatic ecological units using factors such as climate, physiography, soils, and hydrology.
2) Identify and understand the attributes and processes occurring in a riparian-wetland area
3) Identify an area’s capability and potential
   • Potential is defined as the highest ecological status a riparian-wetland area can attain given no political, social, or economical constraints, and is referred to as the potential natural community (PNC).
   • Capability is defined as the highest ecological status a riparian-wetland area can attain given political, social, or economical constraints which a resource manager cannot eliminate or change through management actions.
   • Comparison to the capability of the site is more appropriate in an urbanized context because so much of the landscape has been permanently altered from its natural state.
4) Rate the functional capacity of an area in accordance with its capability and potential.

**Evaluation of PFC**

**Strengths:** This method can be used to rapidly assess stream functions.

**Weaknesses:** PFC has several significant shortcomings. It includes only physical (no biological) response variables that are oriented towards evaluation of rural, relatively non-urbanized, riparian areas. It does not clearly identify methods for collecting and evaluating data. Rather, it relies on the training and experience of an interdisciplinary field crew to visually assess functions in the field and use best professional judgement to rate functional capacity. This approach does not provide a baseline database that could be useful for future monitoring and assessment and makes repeatability impossible.

This method might be more useful if the checklist form was further developed to accommodate the data that provides the basis of the assessment and if stressor indicators were included along the lines of those indicated in Appendix B. However, this would require significant effort to develop this method in a direction that has already been done (e.g., SEFA).

**Oregon Watershed Assessment Manual (OWAM)**

The State of Oregon published the Oregon Watershed Assessment Manual in 1999 to help watershed councils, particularly those participating in the Oregon Plan for Salmon and Watersheds, to evaluate their watersheds. The manual is intended to be used as a broad-scale screening tool to identify potential problems that need further investigation (Watershed Professionals Network 1999). The manual is organized into the following 11 components to assist councils with planning and allocating their resources and to provide flexibility in deciding which components met their assessment needs and resource limitations:

- **Component 1, Start-up and Identification of Watershed Issues,** defines a process to identify an assessment team and compile background information to create a basemap.
- **Components 2-3, Historical Conditions and Channel habitat Type Classification,** involve compiling information and developing basemaps.
- **Components 4-9 define the factors assessed:** Hydrology and Water Use, Riparian-Wetland Functionality, Sediment Sources, Channel Modification, Water Quality, and Fish and Fish Habitat.
- **Components 10-11, Watershed Condition Evaluation and Monitoring Plan,**
Each component begins with a set of standard topics that include critical questions to guide the approach, assumptions behind the component and its procedures, and the skill set needed to complete the component. Each component includes forms and worksheets to summarize and assess compiled data, and evaluate confidence in assessment. Also included are relevant reference tables, resources for data acquisition, and background information on the assessment component.

While OWAM does an excellent job of describing types and sources of information needed to assess watershed condition, it falls short of defining a mechanistic method for integrating the component assessments, let alone a method using standardized scoring. The OWAM method for watershed condition evaluation includes 5 general steps to summarize key historical and current factors that influence fish habitat and water quality:
1) Review summary data
2) Gather products from assessment components
3) Organize meetings with assessment team and key stakeholders to discuss and summarize products from assessment components
4) Summarize historical and current watershed conditions and data gaps in narrative format
5) Identify protection and restoration opportunities

**Evaluation of OWAM**

**Strengths:** OWAM does a good job of including a suite of response and stressor indicators that can be integrated to identify sources and processes impacting stream conditions and Uses. It also includes methods for stream classification and assessment of historical geomorphic conditions as well as a form that is useful to support the identification of watershed management actions to protect and restore stream conditions.

**Weaknesses:** OWAM does not provide a clear mechanistic method to integrate information from the assessment components, nor a method of standardized scoring to provide a means for comparing between similar stream segments or over time in the same segment. Because OWAM is focused on assessment of fish community and habitat, it does not provide a clear means of coordinating with regional efforts to develop bioassessment tools. However, a macroinvertebrate component could be added to address this shortcoming. A potential benefit of using OWAM that cannot be realized in the Santa Clara Basin because it is geared towards Oregon’s ecoregions, is the compendium of reference tables, and resources for data acquisition.

**Framework for Conducting Watershed Assessment (FCWA)**

The Framework for Conducting Watershed Assessments (FCWA) (SCBWI 2000a) was developed by the Santa Clara Basin Watershed Management Initiative (2000a) to provide a comprehensive watershed management program to address water quality problems and quality of life issues for people, animals, and plants that live in watersheds (SCBWI 2000b). The SCBWI was initiated in 1996 by the U.S. Environmental Protection Agency, the State Water Resources Control Board, and the San Francisco Bay Regional Water Quality Control Board. In addition to such federal, state, and local regulators, stakeholders involved in the SCBWI include representatives from business and industrial sectors, professional and trade organizations, environmental, resource conservation, and agricultural groups, and local public agencies. The SCBWI has completed pilot assessments for the Upper Penitencia Creek, Guadalupe River and San Francisquito Creek watersheds.
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The FCWA is designed to assess the level of support (e.g., supported, not supported or support unknown due to insufficient data) for five primary Beneficial Uses/interests:

- Cold Freshwater Habitat (COLD);
- Municipal and Domestic Water Supply (MUN);
- Water Contact Recreation (REC-1);
- Preservation of Rare and Endangered Species (RARE);
- Protection from Flooding (PFF).

Each Use/interest is evaluated by following a series of sequential steps outlined in logic diagrams in which existing data are compared to threshold values identified for “preferred or alternative”, quantifiable indicators. Support status is assessed using a weight of evidence approach. Selection of quantifiable parameters for indicators and threshold criteria were developed through a stakeholder process. Wherever a Use/interest is not fully supported within a stream reach, assessment results identify factors limiting support in the form of indicators and criteria that were not met. Uncertainty associated with each support status assessment is evaluated.

Evaluation of FCWA

Strengths: The FCWA is an explicit, quantitative, peer-reviewed method specifically designed to evaluated Beneficial Uses and stakeholder interests in the urbanized watersheds of the Santa Clara Basin. The SCBWMI identified a number of methodological issues associated with the FCWA that could improve its ability to be implemented rapidly (URS Greiner et al., 2002). Benefits of regional coordination to improve bioassessment tools can be realized using this method.

Weaknesses: The FCWA includes mostly response, and few stressor indicators. Assessment results do not include a numerically standardized gradient of response indicator condition, such as those produced by the RBP, RSAT, and SEFA methods, making it difficult to compare the relative condition of indicators in different stream segments or across watersheds. Selection of the primary Beneficial Uses used in the assessment was intended to address other relevant Uses, but the selected Uses may not always be sufficient surrogates. The FCWA is designed to assess Uses/interests and not stream functions per se, (however, a geomorphic characterization has been recommended (URS Greiner et al., 2002)), nor does it provide a mechanism for identifying management actions to address impairments.

5.1.3 Summary Evaluation of Tier I Assessment Methods

Table 4 summarizes the evaluations of the tier-I assessment methods selected for comparison in this project. The SEFA method was the only one that met all of the evaluation criteria. The RBP method met all but one criterion, however, this method can be incorporated as a component of a more encompassing assessment method, e.g., such as RSAT or SEFA. Most problematical were the failures of the RSAT and PFC methods to meet the criteria for providing a method of data analysis that is explicit and repeatable. For RSAT, this issue might be addressed through correspondence with knowledgeable staff from the Montgomery County Monitoring Program. The FCWA method, while meeting all but one criteria, (e.g., does not lend itself to evaluating stream processes), had some shortcomings that are not reflected in the summary table but are discussed in the text.

2 The SCBWMI has conducted a more in-depth evaluation of its pilot assessment methodology (URS Greiner et al., 2002), and the FCWA has been compared to the SEFA (SCVURPPP 2003a).
Table 4. Evaluation of Assessment Methods Suitable for Screening-Level, Tier I Assessments

<table>
<thead>
<tr>
<th>Assessment Method</th>
<th>Rapid to Implement</th>
<th>Appropriate for Local Urban Watersheds</th>
<th>Stressor and Response Indicators</th>
<th>Explicit and Repeatable Method of Data Analysis</th>
<th>Can be Used to Evaluate Stream Processes</th>
<th>Realize Benefits of Regional Coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid Bioassessment Protocols</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No¹</td>
<td>Yes</td>
</tr>
<tr>
<td>Rapid Stream Assessment Technique</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No² – somewhat qualitative</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Stream Ecosystem Functions</td>
<td>Yes³</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Proper Functioning Condition</td>
<td>Yes</td>
<td>No⁴ – just response indicators</td>
<td>No – just response indicators</td>
<td>No⁵ – qualitative using BPJ</td>
<td>Yes - qualitatively</td>
<td>No</td>
</tr>
<tr>
<td>Oregon Watershed Assessment Manual</td>
<td>Yes</td>
<td>Yes⁶ – with adaptation</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Framework for Conducting Watershed Assessments</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes – but mostly response indicators</td>
<td>Yes⁸</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

¹ Not alone but can be used as a component of bioassessment in other assessment methods.
² Assessment method is largely mechanistic and based on reference framework, however, involves some application of best professional judgement to evaluate stream functions.
³ Approach was tested using existing, available data that was not collected using rapid monitoring techniques. However, this method can accommodate data of different resolution, including data collected using rapid techniques.
⁴ Selection of variables in this method is oriented towards evaluation of rural, relatively non-urbanized riparian areas.
⁵ No standardized framework in which to assess components nor mechanistic methods to integrate data summarized for each component.
⁶ Method is focused on evaluating salmonids and their habitat and does not include a benthic macroinvertebrate component. Use of method requires identification of appropriate data sources (cannot use same recommended in manual due to ecoregional differences).
⁷ No standardized framework in which to assess components nor mechanistic methods to integrate data summarized for each component.
⁸ Although explicit, method does not employ the reference concept, nor a numerically standardized scale to compare the relative condition of stream function responses across stream reaches.

Appendix B lists the parameters included in each of the tier I assessment methods with the exception of PFC, and categorizes them as either response or stressor indicators. The PFC protocol is not included in Appendix B because it is a visual assessment that requires an experienced field crew to assess a suite of variables and report a presence/absence of a function, therefore, it is difficult to evaluate it in the format of a table comparing individual habitat parameters to be assessed.

5.2 Evaluation of Tier II Assessment Methods

As discussed, the purpose of a Tier II assessment is to conduct a more detailed analysis of potential causes of impairment for highest-priority waterbodies placed on a preliminary list of impaired
Assessment of Watershed Assessment Methods

waterbodies. Tier II monitoring and assessment methods are more data intensive than tier I and are driven by specific hypotheses generated from a preceding tier I assessment (Figure 1) regarding likely causes of impairment, relative contributions, and sources.

A limiting factors analysis (LFA) approach is commonly implemented to investigate sources and degrees of impairment. The concept that aquatic species production is limited by a single factor or by interactions between discrete factors is fundamental to stream habitat management (Meehan 1991). A limiting factor can be anything that constrains, impedes, or limits the growth and survival of a population. For example, factors considered to limit anadromous fish production include deficient stream flow, lack of shade canopy, excessive sediment yield, high water temperature, excessive turbidity, lack of instream cover (California Resources Agency 2001). US EPA recently published (2000a) the Stressor Identification (SI) method as a companion for bioassessment methods to both identify stressors causing biological impairment in aquatic ecosystems, and provide a structure for organizing the scientific evidence supporting the conclusions.

Due to the range and complexity of questions that may need to be addressed by a LFA or SI investigation, it is difficult to be prescriptive about how to implement them. Therefore, the following outlines their general approaches. Implementation of LFA is discussed in several Northern California examples. SI implementation is not discussed in this memorandum because examples were not identified within the timeframe of this project; the US EPA Guidance Manual (2000a) only provides two retrospective examples of how this method could have been used to determine causes of non-attainment of aquatic life Use.

5.2.1 Tier II Methods Overview

A level-II LFA process typically follows the following steps:

1. **Identifying factors most likely limiting waterbody condition.** Potential causes of impairment should be identified by developing a complete list of all stressors known to occur in the waterbody of concern or in others similar. This list may subsequently be parsed to a shorter list of the stressors most likely impacting a waterbody by examining existing data and those compiled through ambient monitoring. Locations of stressors must be identified and mapped and prioritized.

2. **Develop Conceptual Models, Select Target Species.** Based on the prioritized list of potential stressors and their sources, a conceptual model should be developed to describe hypotheses that may be investigated regarding how and why impairments are occurring. Typically LFAs select target species for analysis, using either species that whose life history requirements cover a broader spectrum of other species present in the aquatic system, and/or sensitive species whose life history requirements are the most stringent and require the highest level of ecological integrity. Such models can demonstrate where multiple causes may interact and where additional data collection may provide useful information for the assessment.

3. **Conduct Focused Studies.** After analyzing available information to the extent possible and identifying critical data gaps, fieldwork is conducted to validate existing data, and collect new data required to test hypotheses.

4. **Conduct Analysis to Identify Factors Limiting Beneficial Use Attainment.** Review and synthesize existing and newly collected data to test hypotheses about limiting factors.

5. **Develop and Prioritize Management Actions.** The extent of actions defined in this step depends on how well hypotheses have been tested using available and newly gathered data. If all data gaps have been filled, and hypotheses tested, then a well-defined set of prioritized management actions to address limiting factors and restore stream functions may be produced at this step. However, testing of initial hypotheses frequently leads to formulation of additional hypotheses that require testing. In
Assessment of Watershed Assessment Methods

some cases, budget limitations may have only allowed data collection to support the testing of a single highest-priority hypotheses while others remain untested. As a result, actions may include recommendations for future studies, either to test additional factors, and/or to establish cause-effect relationships between limiting factors and human land use activities.

The steps in the SI process closely follow those outlined above for a LFA:

1. **List candidate causes of impairment**
2. **Develop conceptual models for the candidate causes** that link the cause with the effect to explain how a stressor could have caused the observed impairment.
3. **Analyze new and previously existing data to generate evidence for each candidate cause.** The SI process does not require a minimum data set. Existing data may be sufficient to determine the cause of impairment but investigators must evaluate the quality of such data. Data are analyzed and converted into causal evidence that falls into four general categories of relationships:
   3.1 Associations between measurements of the candidate causes and effects;
   3.2 Associations between measures of exposure at the site and measures of effects from laboratory studies;
   3.3 Associations between site measurements with intermediate steps in a chain of causal processes;
   3.4 Associations between causes and effects in deliberate manipulations of field situations or media.
4. **Produce a causal characterization using the evidence generated in step 2** to draw conclusions about the stressors that are most likely to have caused the impairment by using either one or a combination of the following methods:
   4.1 Eliminating alternatives;
   4.2 Using diagnostic protocols;
   4.3 Weighing the strength of evidence supporting each candidate cause.
5. **Translate conclusions into management actions and monitor effectiveness of management actions.**

5.2.2 **Total Maximum Daily Load (TMDL) Assessment Methods**

TMDLs specifically respond to a regulatory requirement of the CWA (section 303d) and fall under the auspices of a tier-II level investigation of impairment. The TMDL program defines a process for meeting water quality standards for waterbodies in which technology-based limits alone do not ensure attainment. TMDL development is pollutant- and site-specific. Specifically, a TMDL is the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background (40 CVF 130.2) with a margin of safety (CWA Section 303(d)).

TMDL development is described generally by the following steps/components which may be completed concurrently or iteratively depending on the site-specific situation:

1. Problem identification
2. Identification of Water Quality Indicators and Target Values
3. Source Assessment
4. Linkage between Water Quality Targets and Sources
5. Allocations
6. Follow-up Monitoring and Evaluation Plan
7. Assembling the TMDL

The SWRCB recently published draft guidance (2003c) that describes the above steps, summarizes the sequences of analyses typically implemented to address prevalent types of impairments, and references relevant case studies.
TMDLs may be expressed through appropriate measures other than mass loads per time (40 CFR 130.2, SWRCB 2002). For example, alternative measures for sediment TMDLs include (US EPA 1999):

- Expression of numeric targets in terms of substrate or channel condition, aquatic biological indicators, or hillslope indicators such as road stream crossings with diversion potential or road culvert sizing. The hillslope indicators and targets should complement in-stream indicators and targets.
- Expression of numeric targets and source allocations in terms of time steps different from daily loadings and as functions of other watershed processes such as precipitation or runoff.
- Expression of allocations in terms other than loads or load reductions (e.g., specific actions shown to be adequate to result in attainment of TMDL numeric targets and water quality standards).

The National Research Council’s study (2001) of the TMDL process included the following recommendations which are reflected both in the proposed monitoring and assessment framework for SCVURPPP as well as in the approach being implemented to address potential sediment impairment in Santa Clara Basin streams (see below):

- States should develop appropriate Use designations for waterbodies in advance of assessment and refine these Use designations prior to TMDL development.
- EPA should approve the use of both a preliminary list and an action list instead of one 303d list.
- The TMDL program should encompass all stressors and models should more effectively link environmental stressors and control actions to biological responses.
- Biological criteria should be used in conjunction with physical and chemical criteria to determine whether a waterbody is meeting its designated Use because biocriteria are a better indicator of designated Uses than are chemical criteria.
- TMDL plans should employ adaptive implementation.

5.2.3 Sediment Investigations and TMDLs

Sediment is the leading pollutant affecting the health of waterbodies in the U.S. (US EPA 2000b). Investigations of anthropogenic-related sediment impacts to water quality and Beneficial Uses are increasingly being implemented in the Bay Area region and in the Santa Clara Basin. This section discusses background information about sediment investigations and TMDLs.

Background

The general goal of sediment investigation and TMDL analysis is to protect designated Uses by characterizing existing and desired watershed condition, evaluating the degree of impairment to the existing (and future) conditions, and identifying land management and restoration actions needed to attain desired conditions (US EPA 1999). The degree of analysis required for each of the components of a sediment investigation or TMDL can range from simple, screening-level approaches based on limited data to detailed investigations that might take several months to years to complete. Sediment investigations and TMDLs are problem-solving processes to which no prescribed “cookbook” approach can be applied. That said, it can be very useful to learn from past and ongoing examples. A number of interrelated factors will affect the level of analysis for each step. Such factors include: the type of impairment (e.g., violation of a numeric criterion versus designated or existing Use impairment); the physical, biological, and chemical processes occurring in the waterbody and its watershed; watershed size; the number of sources; the available resources and data; and the types and costs of actions necessary to implement the analysis.

US EPA (1999) discusses the relative benefits of implementing simple screening-level approaches versus more detailed approaches. Simple approaches may afford cost and time savings and may be applied by a wide range of personnel and result in analyses that are easier to understand than more detailed analyses.
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The trade-offs include a potential decrease in predictive accuracy and often an inability to make predictions at fine geographic and time scales (e.g., watershed-scale source predictions versus parcel-based predictions and annual estimates versus seasonal estimates). Detailed approaches may increase predictive accuracy and spatial and temporal resolution. These may translate into greater stakeholder support and smaller margins of safety which usually reduce source management costs. Detailed approaches may be necessary when the screening-level approaches have been proven ineffective, or in situations where improvement in waterbody condition is critical, e.g., where endangered species are at high risk. Additionally, detailed approaches may be warranted if it is uncertain whether sediment discharges are attributable to human or to natural sources and the anticipated cost of controls is high. Detailed approaches may be implemented as follow-up to a screening-level approach that indicates a need to reduce uncertainties resulting from such simple analysis. The trade-offs include higher costs, greater data requirements, and longer time to completion.

5.2.4 Tier-II Investigative Methods Evaluation

The following LFA methods are reviewed and evaluated: the North Coast Watershed Assessment Program Limiting Factors Analysis, the Napa River Basin Limiting Factors Analysis, the San Francisquito Creek Sediment Reduction Plan and Aquatic Habitat Assessment and Limiting Factors Analysis, and the SCVURPPP Watershed Analysis and Management Practice Assessment in Creeks Potentially Impaired by Sediment from Anthropogenic Activities. Other examples of tier II level approaches to investigating Use impairments reviewed and evaluated in this memorandum include the Hydromodification Plan, and the Biological Water Quality Target Approach.

The relative strengths and weaknesses of each tier II investigative method are evaluated using a suite of criteria similar to those used to evaluate tier I methods:

- Method further investigates causes of impairment cost-effectively;
- Data Analysis method is explicit, repeatable, and scientifically robust;
- Method is appropriate for assessing urbanized watersheds;
- Method is useful for investigating causes of existing impairment;
- Method can identify stressors and factors limiting attainment of Uses, management actions to address such factors, and additional information required to test hypotheses regarding causes of impairment.

North Coast Watershed Assessment Program (NCWAP) Limiting Factors Analysis

The NCWAP is a multi-agency effort focused on assessing conditions that affect anadromous fisheries, particularly on lands affected by Timber Harvest Plans. NCWAP is led by the California Resources Agency and includes the California Departments of Fish and Game, Forestry and Fire Protection, Conservation-Division of Mines and Geology, Water Resources, as well as the North Coast Regional Water Quality Control Board and the Institute for Fisheries Resources. The NCWAP’s goals (California Resources Agency 2001) are to:

- Provide a baseline of data for evaluating the effectiveness of various resource protection programs over time;
- Guide watershed restoration programs;
- Guide cooperative interagency, nonprofit, and private sector approaches to “protect the best” through stewardship, easement, and other incentive programs;
- Help landowners and agencies implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Act.
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The NCWAP Draft Manual outlines a six-step process for watershed assessment:
1) Assessment start-up with agencies, landowners, and stakeholders
2) Data Compilation and Review
3) Initial Analysis and Preliminary LFA - analyze existing data and identify data gaps
4) Fieldwork to address critical data gaps
5) Data Analysis and Final LFA – run model again using existing and newly collected data
6) Development of Final Products for Each Basin

To implement a LFA, NCWAP plans to employ a knowledge-base/expert-system modeling approach using a computer-based decision support system (Ecological Management Decision Support, EMDS and Netweaver). These software models allow “experts” to construct models using their expert opinion so that it is formalized, quantified, and can be applied systematically throughout all the watershed assessments. The models can be used to assess alternative management scenarios, to test the sensitivity of the model’s assumptions, and to facilitate public communication and understanding of the LFA approach.

Evaluation of NCWAP LFA

Strengths: LFA is a useful approach to investigate sources and degrees of impairment. The NCWAP approach of implementing a preliminary and final LFA is similar to the cost-effective, two-tier assessment approach implemented by NRB and proposed for SCVURPPP (see below). Although not proven in this case, the LFA method can potentially provide information to support scientifically-based recommendations to restore stream functions and support Use attainment.

Weaknesses: The NCWAP manual does not present a specific assessment model. Until experts have developed a knowledge base, no explicit method exists, therefore, it is difficult to evaluate. Their approach is useful in the high-level multi-agency level at which they are operating, in which numerous scientific experts need to contribute to conducting assessments, but SCVURPPP does not have the same need of coordinating multiple expert’s opinions, nor would the parameters developed for a North Coast model apply directly to streams in the Santa Clara Basin; they would need to be adapted to reflect local conditions and processes. Comments from a scientific peer review of the NCWAP manual may be downloaded from the NCWAP website.

Napa River Basin Limiting Factors Analysis (NRB LFA)

The SFRWQCB and the California State Coastal Conservancy funded researchers to conduct a limiting factors analysis in the Napa River Basin (Stillwater Sciences and W. Dietrich 2002). The NRB LFA was prompted by a listing of sediment impairment under section 303(d) of the CWA and the need to provide information for a TMDL assessment. The LFA approach was chosen to provide such information in a broader context of factors most likely limiting target analysis species and to provide information to support scientifically-based restoration recommendations.

The LFA was designed in two phases. Phase I involved a basin-wide assessment of current conditions to identify factors most likely limiting three target species: chinook salmon (Oncorhynchus tshawytscha), steelhead (O. mykiss), and California freshwater shrimp (Syncaris pacifica). Phase II will be conducted pending available funding, and is intended to further address issues identified during Phase I and examine new hypotheses generated during Phase I. Specifically, Phase II is intended to support a more intensive sampling effort to quantify sediment inputs and develop a mechanistic understanding of the linkages between land use practices, sediment delivery to channels and channel conditions.
The following steps were implemented in the Phase I LFA:
1) Assemble and review available information, characterize watershed.
2) Select Target Species, develop initial hypotheses and work plan for focused studies. Studies included turbidity impacts to juvenile feeding and growth, spawning gravel permeability study, bed mobility and redd scour, and pool filling and juvenile rearing habitat.
3) Conduct focused studies to test most likely hypotheses and assess uncertainty associated with model results. Further develop and refine hypotheses.
4) Conduct Limiting Factors Analysis. Further develop and refine hypotheses.
5) Develop recommendations for restoration actions, and future studies to establish cause-effect relationships between limiting factors and human land use activities.

Studies in step two included analysis of historical photographs and fish survey data to compare to recent data, field measurement of general habitat conditions for target species, water temperature, turbidity, pool filling, spawning gravel, and a study to determine summer growth rates of juvenile steelhead. Studies in step three included sediment-related factors (turbidity, pool filling, gravel permeability, and bed mobility), water temperature, fish passage barriers, patterns of dry season surface flow, juvenile steelhead growth rates, and distribution and abundance of potential freshwater shrimp habitat.

**Evaluation of Napa River Basin LFA**

**Strengths:** The use of a phased framework in the NRB LFA is similar to the tiered approach outlined for SCVURPPP’s investigation of potential sediment impairment and the NCWAP LFA approach, and is useful because it helps define data needs cost-effectively through an iterative process of hypothesis development, testing, and refinement.

Implementation of the NRB LFA has demonstrated that is it a useful, well-defined approach to 1) investigate sources and degrees of impairment in local urbanized watersheds, and 2) clearly identify management actions to address stressors and improve stream conditions, as well as additional information and studies required to address information gaps. Of the three target species analyzed in the NRB LFA, steelhead trout is present in several Santa Clara Basin streams and is identified in the SCVURPPP work plan (2002) as the primary target species to use in an LFA based on the method used in the NRB LFA (see below).

**San Francisquito Creek Sediment Reduction Plan and the Aquatic Habitat Assessment and Limiting Factors Analysis**

In response to a listing of sediment impairment under section 303(d) of the CWA, and a need to provide information for a TMDL assessment, *two separate but coordinated projects* have been developed: the San Francisquito Creek Sediment Reduction Plan (SFC SRP) (SFC Joint Powers Authority 2001) and the Aquatic Habitat Assessment and Limiting Factors Analysis (SFC LFA) (Santa Clara Valley Water District 2003). Though separately funded, both projects are being implemented through a stakeholder process that includes representatives from the Joint Powers Authority, US Geologic Survey, Santa Clara Valley Water District, San Francisquito Creek Coordinated Resources Management and Planning group, San Mateo County, San Mateo Countywide Stormwater Pollution Prevention Program, the cities of East Palo Alto, Palo Alto, Menlo Park, Portola Valley, Woodside, and Stanford University.

The primary issues driving the TMDL are flooding and degradation of steelhead trout, other threatened aquatic species, and their habitats. The approach adopted by these projects is to assess factors limiting the threatened aquatic species, including but not confined to those related to excessive sedimentation caused by human land use activities. Project products are intended to produce information that will assist the
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SFRWQCB to confirm or reject the validity of the sediment impairment listing and help identify other causes of impairment to aquatic species and their habitat.

The draft SFC LFA scope of work follows the approach outlined for the Napa River Basin LFA described above. Additionally, the SFC SRP scope of work includes the following elements to be implemented in parallel to the LFA:

1) Historical and Existing Conditions Analysis
2) Watershed Sediment Analysis using Rapid Sediment Budget to determine significant active processes delivering sediment from upslope areas to channels.
3) Assess effectiveness of existing policies, regulations, and land management practices to minimize sediment inputs
4) Make recommendations to improve existing management practices and to identify new ones

Evaluation of SFC SRP and LFA

Strengths: Considering all phases and components of the SFC and the NRB projects, they reflect similar approaches to analyzing potential sediment impairment prompted by a 303(d) listing, namely, a holistic watershed assessment of factors limiting threatened and sensitive species through a stakeholder process. Using a LFA approach in conjunction with efforts to estimate sediment sources, production, and delivery provides a broad context in which all potential factors limiting sensitive and threatened species may be identified and their relative importance established. By focusing on all potential limiting factors it addresses uncertainty that may have been associated with the data used to list the respective creek for sediment impairment. An assessment approach that focused solely on estimating sediment sources, production, and delivery might overlook additional factors that alone, or in conjunction with sediment, limit the capacity of target species in watersheds. Although SFC was listed for sediment-impairment prior to conducting a LFA, the proposed LFA may provide critical information to put this listing in appropriate ecological perspective and support scientifically-based recommendations to restore stream functions and support Use attainment.

Weaknesses: Parallel implementation of a LFA and analysis of sediment production and delivery is less cost-effective than sequential implementation (as proposed in the NRB LFA and SCVURPPP workplans), in which sediment budget is only developed for areas where a LFA has demonstrated sediment as a limiting factor. The difference (e.g., the move from parallel to sequential implementation) reflects the evolution of the SFRWQCB’s approach sediment TMDLs over the last few years3. The NPDES Permit4 for SFC required a sediment study to develop a TMDL regardless of whether a LFA demonstrated sediment impairment. To the extent possible, field work and tasks similar to both studies are being coordinated to achieve feasible cost effectiveness.

SCVURPPP Workplan to Conduct Watershed Analysis and Management Practice Assessment in Creeks Potentially Impaired by Sediment from Anthropogenic Activities

SCVURPPP has developed a workplan (SCVURPPP 2002) to fulfill NPDES Permit Order No. 01-024 Provision C.9.f.iii, and assess creeks other than San Francisquito (SCVURPPP 2003b) which may be impaired by excessive sediment production from erosion due to anthropogenic activities. This workplan is modeled on the NRB LFA and includes elements of the approach used in the San Francisquito Creek

3 Comment from Geoff Brosseau on the change in SFRQCB’s approach to sediment TMDLs following SFC’s, e.g., in NRB and other watersheds identified in the SCVURPPP workplan (2002).
4 San Francisquito Creek was listed by the SFRWQCB as impaired for sediment in 1995. The associated requirement to develop a TMDL within a time schedule resulted in parallel development of a LFA and sediment study (personal communication, Laura Young, SCVWD, July 2003 WAS meeting, also one of her review comments).
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LFA. It includes three major components with several elements identified to address SFRWQCB concerns.

Component 1 - Conduct limiting factors analysis that is largely based on the approach used in the Napa River watershed assessment. This component includes collecting available existing data to characterize the watersheds and identify issues of concern; develop hypotheses to understand potential impacts of sediment to species that are sensitive to excess sediment; conduct focused studies to test hypotheses; implement a limiting factors analysis to determine to what degree sediment impacts are key factors.

Component 2 - Conduct rapid sediment budget when necessary, using approach implemented in San Francisquito Creek and proposed for Napa River (e.g., Rapid Evaluation of Sediment Budgets (Reid and Dunne, 1996)). The schedule of this component is based on the Napa River watershed assessment approach and the sediment TMDL process. Similar to the phased approach used in Napa, a rapid sediment budget will be completed after the limiting factors analysis if sediment is shown to be the limiting factor or a rapid sediment budget is recommended based on the analysis.

Component 3 – Conduct sediment management practice assessment. This is also based on the San Francisquito Creek watershed assessment approach. The schedule of this component is designed so the start of the project is not based on the completion of the other two components; however, the final assessment and recommendations use the results of the completed limiting factors analysis and rapid sediment budget.

Evaluation of SCVURPPP Watershed Analysis and Management Practice Assessment for Sediment

Strengths: SCVURPPP’s approach synthesizes the LFA approaches in the NRB and the SFC and reflects the intention to learn from these efforts by explicitly scheduling components to follow completion of corollary assessment components from these other projects. The sequence in which assessment components are implemented in the SCVURPPP workplan is intended to be cost-effective and follows that of the NRB LFA, e.g., the rapid sediment budget is proposed following the LFA where the LFA has demonstrated that sediment is a limiting factor, in contrast to the SFC approach which conducts the LFA and rapid sediment budget in parallel (see footnote 2). Although not yet demonstrated, implementation of this approach should be able to support scientifically-based recommendations that are appropriate to restore stream functions and support Use attainment in local urbanized watersheds.

Hydromodification Plan

Another example of a tier-II investigative approach being implemented in the Bay Area Region is the Hydromodification Management Plan (HMP). The HMP (Geosyntec Consultants HMP Project Team 2003a), currently under development with SCVWD, City of San Jose, and SCVURPPP funding, is an example, of what could be implemented as a followup assessment approach to a tier I problem identification or LFA that identifies changes in hydromodification and/or sediment as a stressor impacting a waterbody.

HMP is being developed as a tool to evaluate changes in hydrology and associated stream channel conditions, predict the potential for erosion and deposition or other impacts attributed to hydromodification from future urban development, and recommend management strategies. The HMP method is subdivided into three major elements:

1) Problem Area and Reach Characterization using geomorphic assessment to identify stream segments that are currently subject to erosion and/or deposition that could be affected by future development.
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2) Hydrologic/hydraulic modeling using long-term, historic time series of precipitation data and continuous simulation modeling to analyze the frequency, duration, and timing of geomorphically significant flows.

3) Channel stability assessment using time series stream flow data generated from the hydrologic/hydraulic models.

These elements will be applied to all stream segments in the Santa Clara Basin that are at risk of erosion due to future development. The HMP conducted a geomorphic/historic assessment and sediment transport modeling on a test watershed (Thompson Creek) but is not implementing this component in other streams in the Basin.

Evaluation of HMP

Strengths: Because the focus of the HMP is to identify stream segments at risk of erosion from future development, it is appropriate as a component of assessing future stream conditions. Preliminary analysis has indicated that relatively few stream segments in the Santa Clara Basin are at risk from future development because most development will occur in areas that are significantly urbanized where hydromodification impacts have already occurred. The increase in imperviousness associated with future development in these areas will not significantly increase impacts associated with hydromodification. The Coyote Valley is the exception, because it is virtually undeveloped. Changes in stream conditions caused by hydromodification associated with urban development are greatest in watersheds that are undeveloped or have very low levels of development (Wang and Lyons 2003).

Although the HMP is not intended to assess impacts caused by hydromodification associated with existing development, nor to identify management actions to address existing problems, aspects of the methodology and work being done to develop this plan may be useful to assessments of existing conditions and development of management actions to address existing problems. The purpose of The Problem Area and Reach Characterization element of the HMP is to characterize features of the watershed and stream channels in order to elucidate the nature and extent of problem areas and stream reaches. This element provides the foundation for evaluating the trajectory of hydrogeomorphic change in watersheds and the modification of flow pathways affecting channel form and stability. Therefore, it can contribute to an understanding of existing stream conditions and the requirements for managing the stream system to create an ultimately stable channel. Specifically, a geomorphic assessment could contribute to development of stream classification methods and provide information about stability of stream sections useful for identifying and prioritizing where restoration efforts could occur.

Weaknesses: Although the HMP recognizes that water quality and ecology are critical to the health of stream ecosystem functions, it focuses primarily on the physical characteristics of stream systems and not the biological or chemical. Therefore, it is not sufficient as a stand-alone watershed assessment method. It is suitable as a component of a broader watershed assessment that seeks to address factors limiting for example, biological assemblages. It is not designed to identify management actions to address existing problems, although as mentioned above, it may be useful in this context.

Biological Water Quality Targets (BWQT) Approach

Researchers from the University of California Sierra Nevada Aquatic Research Laboratory used bioassessment data to contribute to development of a sediment TMDL for the Squaw Creek watershed (Herbst 2002). They used macroinvertebrates as indicators of biological integrity and sampled over a range of sediment loading exposures to establish a dose-response linkage between sediment stress and biological signals. They defined biological criteria based on site-specific reference stream sampling and
used these criteria to establish whether and how much the streams were impaired and to designate a water quality targets for attaining biological integrity. By examining the biological response over a dose range they identified a load level threshold at which impairment was considered to occur. This threshold was used as a guide to identify a specific TMDL, in this case annualized or event-related load reduction needed to attain the reference condition for biological health.

The Squaw Creek study defined load reductions to respond to the impairment, but as discussed in 5.2.4, allocations may also be expressed in terms other than loads or load reductions, for example, specific actions shown to be adequate to result in attainment of TMDL numeric targets and water quality standards. Although not implemented in the context of a TMDL, this approach of identifying management actions to improve waterbody conditions has been implemented in the Coyote Creek watershed (SCVURPPP 2003a).

**Evaluation of Biological Water Quality Target Approach to TMDL Development**

**Strengths:** Using bioassessment to develop a TMDL is a relatively new approach that is endorsed by US EPA (2000a) and the NRC (2001). Biological water quality criteria have been shown to indicate Use impairment in many instances where traditional chemical-only criteria have not (Yoder et al., 1999). Monitoring to support the use of biocriteria has been shown to be more cost-effective than traditional chemical water quality monitoring (Yoder and Rankin 1995).

The method, as implemented in the Squaw Creek watershed, is appropriate when a stressor, such as sediment, has been clearly identified, and a TMDL is required, e.g., a limiting factors analysis was not deemed necessary. The BWQT approach for Squaw Creek was explicitly defined and could be similarly applied in local, urban watersheds. Scientists established a dose-response model to describe the relationship between the stressor (sediment) and the response target (macroinvertebrate assemblages). Key to the Squaw Creek process was the ability to identify reference sites in comparable streams. As discussed in section 4.2.1, this is difficult to achieve in many urbanized areas, especially for larger order streams that traverse alluvial plains and valley floors. Rather than use site-specific reference conditions, a regional reference and/or historical reference approach will likely need to be implemented to establish reference conditions for larger order streams in the Santa Clara Basin.

**Weaknesses:** The use of biological water quality criteria requires further development of bioassessment tools, including development of reference conditions and appropriate metrics to include in indices of biological integrity, by SCVURPPP and other agencies in the Bay Area Region. In watersheds in which factors causing impairment are not clearly understood, a LFA should be implemented first. A BWQT approach is useful for identifying impairment; researchers are working on refining this type of method to identify specific causes of impairment (Yoder and DeShon 2003).

**5.2.5 Summary Evaluation of Tier II Investigative Assessment Methods**

Table 5 summarizes the evaluation of the tier II investigative watershed assessment methods included in this project. Both the Napa River LFA and the SCVURPPP LFA met all of the evaluation criteria. Specific recommendations for SCVURPPP tier II assessments are included in Section 7.0.
Table 5. Evaluation of Assessment Methods Suitable for Investigative, Tier II Assessments (LFA refers to Limiting Factors Analysis).

<table>
<thead>
<tr>
<th>Assessment Method</th>
<th>Cost-Effective</th>
<th>Explicit and Repeatable Data Analysis Method</th>
<th>Appropriate for Local, Urban Watersheds</th>
<th>Useful to Investigate Causes of Existing Impairment</th>
<th>Identify Management Actions and Additional Information Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Coast LFA</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Napa River LFA</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>San Francisquito LFA</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SCVURPPP LFA</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Oregon Watershed Assessment</td>
<td>No</td>
<td>No</td>
<td>Somewhat(^1)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Hydromodification Plan</td>
<td>NA(^2)</td>
<td>Yes</td>
<td>Yes</td>
<td>Somewhat(^3)</td>
<td>Yes</td>
</tr>
<tr>
<td>Biological Water Quality Targets</td>
<td>Yes(^4)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

\(^1\) In general, this method supports identification of urban stressors and provides a form to facilitate identification of appropriate management actions to address impairment. However, because it is designed to support watershed assessments in Oregon, the resources referenced in the guidebook are not useful for Santa Clara watershed assessments.

\(^2\) Cannot evaluate until project is completed.

\(^3\) The geomorphic assessment included in the HMP could assist evaluate existing conditions, but in general, this method is designed to assess future impacts associated with hydromodification.

\(^4\) Method requires the use of reference conditions and is cost-effective once these are established. Because regional reference conditions for macroinvertebrates can be developed, even this aspect of project cost is relatively cost-effective.

### 5.3 Assessment of Water Quality Standards

A water quality standard\(^5\) defines the water quality goals for a water body, or portion thereof, by designating the Use or Uses to be made of the water, by setting criteria necessary to protect the Uses, and by protecting water quality through antidegradation provisions. The Water Quality Standards Regulations (40CFR 131) describes the federal requirements and procedures for developing, reviewing, revising, and adopting water quality standards as authorized by section 303(c) of the CWA. States adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. The CWA act goals are:

- wherever attainable, achieve a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water; and
- restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.

\(^5\) In California, the California Water Code (Porter-Cologne Water Quality Control Act) defines a water quality standard as a water quality objective (section 13241). Consistent with Section 13000 of the CWC, section 13241 specifically identifies the key environmental, social and economic factors that must be considered as part of developing water quality objectives to ensure the reasonable protection of Uses and prevention of nuisance.
Methods to assess water quality standards and designated Uses are not tier II investigative watershed assessment methods per se, therefore, rather than evaluating them, they are briefly summarized here to complete the overview of assessment methods potentially relevant to SCVURPPP’s monitoring and assessment program.

Assessment of Water Quality Standards

The report of the National Research Council (2001) on the scientific basis of the TMDL program provided some key observations and insights relative to the importance of setting appropriate water quality standards as the foundation of an ambient monitoring program. The NRC report recommended that States focus on the following water quality standard issues:

- Whether the designated Uses assigned to particular waters are appropriate and scientifically valid. (This issue is discussed in the next section).
- Whether the criteria established to support those designated Uses are attainable. (This issue is discussed in this section).
- Whether compliance with the water quality criteria can be accurately assessed.
- Whether appropriate numeric translators for narrative criteria have been promulgated.

Assessment of Water Quality Criteria:

State water quality criteria are typically based on national water quality criteria developed by US EPA under the CWA. Thus, the criteria often do not take into consideration unique characteristics of specific waters. Site-specific criteria are appropriate in the following situations:

- When species in a particular waterbody are more or less sensitive than those species used to develop the national or State criteria.
- When physical or chemical characteristics of the waterbody alter the toxicity or biological availability of a chemical.
- When natural or local hydrology, land use, climate, nutrient species, or other localized factors would justify criteria other than those derived from national guidance.

Existing EPA water quality regulations provide specific guidance for States to investigate the use of developing site-specific criteria. The three available approaches to modify the water quality criteria include: 1) recalculation procedure, 2) indicator species procedure, and 3) resident species procedure. The recent investigation in the Lower South San Francisco Bay on copper and nickel (SFRWQCB 2002) is an excellent example of the use of the above noted approaches. The indicator species approach coupled with derivation of a water effect ratio was used to develop a site-specific water quality criterion for copper. The combination of the recalculation and indicator species approaches was used to update the national data-set and calculate a site-specific Final Acute-to Chronic ratio and ultimately a site-specific water quality criterion for nickel.

Assessment of Designated Uses

EPA regulations contain a Use Attainable Analysis process (UAA) to revise designated Uses where appropriate. The UAA is a structured scientific assessment of factors affecting the attainment of designated Uses. The CWA requires that a UAA be conducted when a State considers designation of a Use less stringent than the fishable swimmable goals of the CWA⁶. States may remove or create subcategories of a designated Use, including a seasonal Use, that is not an existing Use if it can

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⁶ UAA’s are not necessary when removing or revising Uses not related to the fishable and swimmable goal.
demonstrate that attaining the designated Use is not feasible due to one of several specific factors (see 40 CFR 131.10). Further, a UAA can be used to help designate Uses consistent with the CWA.

6.0 Data Management
Identifying a data management strategy and developing data management tools to store and retrieve monitoring data are critical aspects to implementing an effective monitoring and assessment program. SCVURPPP has developed several tools that track progress of ongoing projects and studies (Stream Studies Inventory (SSI)) and archive metadata related to historic and current projects and studies (Metadata Database (MDDB)) in Santa Clara Basin watersheds. Continuous development and improvement of such tools facilitates the efficiency and effectiveness of efforts to compile, collect, and analyze data through monitoring and assessment programs.

7.0 Recommendations for SCVURPPP
The following recommendations summarize evaluations made previously in this memorandum for both screening level tier I and investigative tier II types of assessments. The SCVURPPP Multi-year Monitoring Plan (SCVURPPP 2001b) and the pending Fiscal Year 2004-05 Monitoring Plan should be modified to integrate these recommendations.

Tier I:
1. Use the Stream Ecosystem Function Assessment (SEFA) approach, as recommended by SCVURPPP (2003a), augmented by some aspects of the Rapid Stream Assessment Technique (RSAT)\(^7\), to analyze data generated from an ambient monitoring program based largely on Rapid Bioassessment Protocols (RBPs).

The SEFA approach provides several advantages over RSAT. SEFA provides standardized, explicitly defined models for evaluating stream functions using stressor and response indicators. A weakness in the RSAT method is its employment of professional judgment to score existing conditions, which reduces the ability of this method to be repeatedly implemented reliably. While it likely would be feasible to develop a protocol for including such influence on the scores, the existing method description (Galli 1997) does not include this. Furthermore, Galli (1997) does not describe the models for evaluating stream conditions with enough detail for others to implement them. For example, he does not list the parameters included in each evaluation category, and an unstated assumption is that they are weighted equally in each category. Another weakness of RSAT is its use of a level I RBP protocol for sampling macroinvertebrates; the CSBP uses a level III which provides a higher level of detail and potential to identify factors causing impairments.

Both SEFA and RSAT can be implemented rapidly depending on the resolution of field sampling units. SEFA can accommodate different types and resolution of data. As implemented in Coyote Creek watershed, relatively fine resolution data from continuous habitat surveys were used. However, coarser resolution data collected at intervals along a stream could also be used in SEF, the difference lies in the accuracy of estimates to represent conditions in respective stream segments. RSAT specifies 400-foot intervals for the streams in which it was developed, however that is not necessarily appropriate for Santa Clara Streams; sampling intervals will largely depend on the resolution of the stream classification method applied to streams as well as sampling design (e.g., point or nonpoint).

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\(^7\) Prior to incorporating changes to SEFA, SCVURPPP staff should again attempt to contact staff from Montgomery County’s monitoring program to discuss their experience with implementing RSAT.
Assessment of Watershed Assessment Methods

The RBPs provide a rapid, widely accepted, standardized method for collecting data on habitat and water quality and biological assemblages. The CSBP is a modified version of the RBP intended to address conditions in California streams, with particular focus on macroinvertebrates. Compared to the RBP, as well as RSAT and SEFA, the CSBP habitat assessment protocol includes fewer parameters related to stressors. The recommendation here is to continue implementing the CSBP macroinvertebrate protocols as part of the ambient monitoring program to provide data for the SEFA model. The protocol for collecting habitat data for use in SEFA, however, should include all of the stressor indicators listed in Appendix B for all of the screening level methods. SEFA models should be modified to include these parameters. Additionally, the following response indicators included in RSAT should be incorporated into SEFA models: flow and velocity, bank stability, and bank material. These correspond with recommendations included in the final report on implementation of SEFA in the Coyote Creek watershed (SCVURPPP 2003a).

2. Coordinate regionally to develop reference conditions and bioassessment tools to support analysis of macroinvertebrate data.

Establishing reference conditions to provide a benchmark for comparing existing data and rating existing stream conditions is critical for all assessment methods; without representative benchmarks, it is difficult to provide an ecologically meaningful and defensible evaluation of existing conditions. The Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI) is planning to facilitate the coordination of regional efforts to develop reference conditions and bioassessment tools to support analysis of macroinvertebrate data collected using the California revised RBP protocol (CSBP). SCVURPPP staff should continue to participate in BAMBI. Staff should actively participate in discussions to revise the physical habitat protocol of CSBP and introduce the recommendations made above. The SCVURPPP monitoring program should include sampling of potential reference sites to contribute to development of regional reference conditions. Staff should consider conducting a workshop for decision maker/managers on the uses of reference conditions to evaluate stream conditions and Program improvements.

3. Work towards developing robust numeric biocriteria.

As regional reference conditions are established, and robust indices are developed and tested it will be feasible to develop robust numeric biocriteria that can be used in assessments. Developing biological criteria, as discussed, is an extremely active area of current research with significant agency support, particularly from US EPA. Such development occurs incrementally as ambient monitoring programs develop and refine analytical tools such as invertebrate IBIs and reference conditions.

4. Consider pursuing bioassessment of fish assemblages in larger order streams and in streams supporting steelhead trout.

EPA guidance for implementing bioassessment in water resource management supports the use of more than one biological assemblage in large order streams. Using the SEFA approach, SCVURPPP (2003a) developed and tested an index of biological integrity (IBI) for fish assemblages in the Coyote Creek watershed and addressed some of the issues identified as difficulties in implementing an IBI in Western streams (Moyle and Marchetti 1999, Hughes et al. 1998). The final report included recommendations for further development of an IBI. The IBI can be a useful bioassessment tool in streams known to currently support or which until recently supported sensitive species such as steelhead and/or relatively rare warmwater assemblages. Permit requirements for sampling in streams supporting sensitive species, however, can complicate the process of data collection required to support an IBI.
Assessment of Watershed Assessment Methods

**Tier II:**

1. **Continue to implement LFA as primary approach to investigating factors potentially limiting attainment of aquatic life Uses and incorporate lessons from other projects implementing LFA.**
   LFA is a useful approach because it provides an opportunity to investigate a potentially impairing pollutant in a broader context of other factors influencing a Use possibly independently or synergistically. By default, a LFA approach also provides a means of addressing uncertainty in a listing. SCVURPPP has proposed to implement LFA to assess potential sediment impairment. The workplan proposes LFA as the initial analysis to be followed by estimate of a rapid sediment budget where necessary. This sequence of components ensures that Program resources are used most efficiently where warranted. As the NRB and SFC projects implementing the LFA approach proceed, it will be feasible to incorporate lessons learned from these projects.

2. **Consider using HMP as tool to address potential Use impairment caused by hydromodification associated with future development;**
   Once the HMP project has been completed it will be feasible to evaluate its utility for assessing future stream conditions.

3. **Consider incorporating aspects of the HMP method of geomorphic assessment into a method for classifying Santa Clara Basin streams and to identify and prioritize location(s) of restoration efforts.**
   A historic geomorphic assessment describes the geologic and geomorphic characteristics of a watershed and stream network, the dominant physical processes that appear to be controlling stream attributes and erosion historically and at present, and the extent and modes of failure for observed eroding channel banks and beds (Geosyntec Consultants HMP Project Team 2003b). Therefore, it can contribute to an understanding of existing stream conditions and implications for managing the stream system to create an ultimately stable channel.

4. **Incorporate biocriteria into assessments as feasible.**
   As biocriteria are developed for the Bay Area Region, consider conducting (where applicable) pilot tier-II assessments that include them, for example, as components of a sediment investigation or TMDL as done in Squaw Creek (Herbst 2001).
Assessment of Watershed Assessment Methods

8.0 Literature Cited


Bay Area Macroinvertebrate Bioassessment Information Network. 2003. Bay Area macroinvertebrates: improving tools for stream assessment and management. A Draft concept proposal for CALFED Watershed (Proposition 50) funding by the Association of Bay Area Governments, acting for the Bay Area Macroinvertebrate Bioassessment Information Network.


California Department of Fish and Game. 2002. California Regional Water Quality Control Board, San Diego Region 2002 Biological Assessment Report: Results of May 2001 Reference Site Study and Preliminary Index of Biotic Integrity. California Department of Fish and Game Water Pollution Control Laboratory, Aquatic Bioassessment Laboratory. Rancho Cordova, CA.


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Harrington, J. M.  1999. Biological and Physical/Habitat Assessment of California Water Bodies, Russian River Index of Biological Integrity (RRBI) for First to Third Order Tributary Streams. California Department of Fish and Game Office of Spill Prevention and Response Water Pollution Control Laboratory. Rancho Cordova, California. 20pp.


Marin County Stormwater Pollution Prevention Program.  2003. Aquatic Macroinvertebrate Sampling Program. Marin County Stormwater Pollution Prevention Program, Marin County, California.


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San Francisco Regional Water Quality Control Board. 2002. Resolution R2-2002-0061 Amending the Water Quality Control Plan For the San Francisco Bay Region to Adopt Site-Specific Objectives for Copper and Nickel in the Lower South San Francisco Bay and an Implementation Plan. 4 pp.


Santa Clara Valley Urban Runoff Pollution Prevention Program. 2002. Workplan for conducting watershed analysis and management practice assessment in other creeks potentially impaired by sediment
Assessment of Watershed Assessment Methods


Assessment of Watershed Assessment Methods


### Appendix A. List of Response, Stressor, and Exposure Indicators
(Source: SWAMP [http://www.swrcb.ca.gov/swamp/wqindicators.html])

<table>
<thead>
<tr>
<th>Question</th>
<th>Beneficial Use</th>
<th>Category</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the water safe to swim?</td>
<td>Water Contact Recreation</td>
<td>Contaminant exposure</td>
<td>Total coliform bacteria, Fecal coliform bacteria, Enterococcus bacteria, Enteric viruses</td>
</tr>
<tr>
<td>Is the water safe to drink?</td>
<td>Municipal and Domestic Water Supply</td>
<td>Contaminant exposure</td>
<td>Inorganic water chemistry, Nutrients, Organic water chemistry, Total coliform bacteria, Cryptosporidium, Giardia</td>
</tr>
<tr>
<td>Is it safe to eat fish and other aquatic resources?</td>
<td>Commercial and Sport Fishing, Shellfish Harvesting</td>
<td>Contaminant exposure</td>
<td>Fish tissue chemistry, Shellfish tissue chemistry, Coliform bacteria in shellfish, Fecal coliform bacteria in water</td>
</tr>
<tr>
<td>Is aquatic life protected?</td>
<td>Aquatic Life</td>
<td>Biological Response</td>
<td>Phytoplankton, Chlorophyll-a, Benthic infauna, Fish assemblage, Fish pathology, Recruitment of sensitive life stages, Interstitial water toxicity, Macroinvertebrate assemblage, Periphyton, Sediment toxicity, Water toxicity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pollutant exposure</td>
<td>Acid volatile sulfides/simultaneously extracted metals, Debris, Intersitial water metal chemistry, Reporter Gene System (RGS 450), Organic and inorganic sediment chemistry, Total organic carbon, Shellfish or fish tissue chemistry, Nutrients, Turbidity, Inorganic and organic water chemistry</td>
</tr>
</tbody>
</table>
### Assessment of Watershed Assessment Methods

<table>
<thead>
<tr>
<th>Question</th>
<th>Category</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is water flow sufficient to protect fisheries?</td>
<td>Sufficient Flow Habitat</td>
<td>Water flow, Suspended solids, Channel morphology, Water temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Biological response Fish assemblage and populations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Macroinvertebrate assemblage and populations Periphyton</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wetland habitat, Riparian habitat</td>
</tr>
<tr>
<td>Is the water safe for agriculture use?</td>
<td>Agricultural Supply</td>
<td>Pollutant Exposure Organic and inorganic chemistry</td>
</tr>
<tr>
<td>Is the water safe for industrial use</td>
<td>Industrial Supply</td>
<td>Pollutant Exposure Organic and inorganic chemistry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total organic carbon Temperature Electrical conductivity</td>
</tr>
<tr>
<td>Are aesthetics conditions of water protected?</td>
<td>Non-contact Water</td>
<td>Pollutant Exposure Taste and odor Debris and trash</td>
</tr>
<tr>
<td></td>
<td>Recreation</td>
<td></td>
</tr>
</tbody>
</table>
Appendix B. Comparison of Habitat Parameters Included in Selected Tier I Screening-Level Watershed Assessments.

<table>
<thead>
<tr>
<th>Indicator Type</th>
<th>Category Type</th>
<th>Parameter</th>
<th>RBP</th>
<th>RSAT</th>
<th>SEFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat Unit Descriptn.</td>
<td>Reach Length</td>
<td>estimate</td>
<td></td>
<td></td>
<td>Measure^g</td>
</tr>
<tr>
<td></td>
<td>Stream Width</td>
<td>estimate</td>
<td></td>
<td></td>
<td>Measure^g</td>
</tr>
<tr>
<td></td>
<td>Reach Area</td>
<td>estimate</td>
<td></td>
<td></td>
<td>Measure^g</td>
</tr>
<tr>
<td></td>
<td>Stream Depth</td>
<td>estimate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent Gradient:</td>
<td>Ea. riffle</td>
<td>For Stream</td>
<td></td>
<td>Measure^g</td>
</tr>
<tr>
<td></td>
<td>Peak Flows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riffle Charactzn.</td>
<td>Riffle Length</td>
<td>Ea. riffle</td>
<td></td>
<td>Measure^g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avg. Riffle Width</td>
<td>Ea. riffle</td>
<td></td>
<td>Measure^g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avg. Riffle Depth</td>
<td>Ea. riffle</td>
<td></td>
<td>Measure^g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Riffle Velocity</td>
<td>measure at thalweg</td>
<td>Measure baseflow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate</td>
<td>Embeddedness</td>
<td>Ea. riffle</td>
<td>Ea transect</td>
<td>Pool tail channel bed;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Substrate Composition (inorganic)</td>
<td>% bedrock, boulder, cobble, gravel, sand, silt, clay</td>
<td>Type</td>
<td>% boulder-cobble, %fines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Substrate Composition (organic)</td>
<td>% CPOM, %FPOM, %Marl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Substrate Fouling</td>
<td>Type^g</td>
<td>Measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riparian Habitat</td>
<td>Riparian vegetation type, dominant species</td>
<td>Yes</td>
<td>Type – R and L bank</td>
<td>Yes^g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Riparian buffer width</td>
<td>measure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Riparian buffer condition</td>
<td></td>
<td></td>
<td>Contiguity and disturbance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% Canopy Cover</td>
<td>Estimate</td>
<td>Measure</td>
<td>Measure^g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% Bank vegetation</td>
<td></td>
<td></td>
<td>Measure^g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large Woody Debris</td>
<td>% area</td>
<td>Tot # tree falls; # recent treefalls</td>
<td>Measure^g % in-channel coarse WD</td>
<td></td>
</tr>
<tr>
<td>Aquatic Habitat</td>
<td>Aquatic Vegetation:</td>
<td>Dominant type, species, area of reach</td>
<td></td>
<td>See below</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instream Cover</td>
<td>Estimate % epifaunal substrate and available cover</td>
<td></td>
<td>Measure^g % rootwad, terrestrial veg, aquatic veg, undercut banks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% Connected floodplain</td>
<td></td>
<td></td>
<td>Measure^g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bankfull depth</td>
<td>High water mark^h</td>
<td>Avg bank height, R &amp; L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Condition</td>
<td>Top Channel Width</td>
<td></td>
<td>Measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottom Channel Width</td>
<td></td>
<td>measure</td>
<td></td>
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</table>
## Assessment of Watershed Assessment Methods

<table>
<thead>
<tr>
<th>Indicator Type</th>
<th>Parameter</th>
<th>RBP</th>
<th>RSAT</th>
<th>SEFA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Channel Condition</strong></td>
<td>Wetted Perimeter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank Stability</td>
<td>Type erosion&lt;sup&gt;h&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank Material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Riffle/Pool Ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fish Habitat</strong></td>
<td><em>Pool habitat – depth</em></td>
<td>measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Pool habitat - quality</em></td>
<td>measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Salmonid Spawning Habitat&lt;sup&gt;8&lt;/sup&gt;</td>
<td></td>
<td>Gravel amount embeddedness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Juvenile salmonid rearing habitat&lt;sup&gt;9&lt;/sup&gt;</td>
<td></td>
<td>% rearing area</td>
<td></td>
</tr>
<tr>
<td><strong>Salmonid Habitat</strong></td>
<td>Fish Barriers</td>
<td></td>
<td>partial or complete</td>
<td>#, type barriers</td>
</tr>
</tbody>
</table>

### Stressor Indicators

<table>
<thead>
<tr>
<th>Stressor Indicators</th>
<th>Physical</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS pollution present</td>
<td>Checkboxes&lt;sup&gt;h&lt;/sup&gt;</td>
<td>Type and % drainage</td>
</tr>
<tr>
<td>Surrounding landuse</td>
<td>Checkboxes&lt;sup&gt;h&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>% Imperviousness</td>
<td></td>
<td>Measure % measure&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hydromodification</td>
<td></td>
<td>Type, location, # stormdrain outfalls</td>
</tr>
<tr>
<td>Channel modification</td>
<td></td>
<td>Type and % reach</td>
</tr>
<tr>
<td>Trash**</td>
<td></td>
<td>Type and % reach</td>
</tr>
<tr>
<td>Substrate odors, oils, deposits, color</td>
<td>Checkboxes&lt;sup&gt;h&lt;/sup&gt;</td>
<td>type</td>
</tr>
<tr>
<td># Exposed Sewer Lines</td>
<td>count</td>
<td></td>
</tr>
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<td>Accessibility**</td>
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<td></td>
</tr>
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<td>Last Precipitation Event</td>
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<td>date</td>
</tr>
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<td>Water Temperature</td>
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<td>yes</td>
</tr>
<tr>
<td>Conductivity</td>
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<td>yes</td>
</tr>
<tr>
<td>pH</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Yes&lt;sup&gt;a&lt;/sup&gt;</td>
<td>yes</td>
</tr>
<tr>
<td>TDS</td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>Water odors, oils</td>
<td>Yes&lt;sup&gt;a&lt;/sup&gt;</td>
<td>yes</td>
</tr>
<tr>
<td>DO</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Nutrients</td>
<td></td>
<td>yes&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

(a) each sampling point out of 5 composited from a sampled riffle  
(b) *relevant for fish  
(c) **REC uses  
(d) or land use types  
(e) yes, where available  
(f) CPOM = coarse plant organic material; FPOM = fine plant organic material  
(g) Used existing GIS data that recorded field measurement, however, field estimates could also be used for these parameters. The implication of doing this is to reduce the accuracy of the measurement.  
(h) Not included due to uncertainty of accuracy of available data  
(i) Included in RBP but not in CSBP Field Worksheets.

<sup>8</sup> Included b/c data from FAHCE available. However, perhaps more appropriate for tier II than tier I  
<sup>9</sup> ditto
## Appendix C

Response to reviewer’s comments of SCVURPPP’s Assessment of Watershed Assessment Methods.

Two presentations of SCVURPPP’s Assessment of Watershed Assessment Methods were made to a joint meeting of the SCBWMI Watershed Assessment Group (WAS) and the SCVURPPP Ad Hoc Monitoring Committee (April 23, 2003, and July 15, 2003). The mid-project April presentation focused on discussing types of Assessments and the methods that were selected for review. The final-project July presentation focused on discussing results of the assessment. Prior to the July meeting a draft technical memorandum summarizing the project approach and results was distributed for comment to WAS and the Ad Hoc Monitoring Committee (comment period July 9 – 22, 2003). At the request of those attending the July presentation, a table has been developed to identify how comments have been responded too. Specifically, the following table lists all comments received from reviewers, the respective reviewer’s name, and how and where in the final technical memorandum comments have been addressed. Comments are organized by topic.

<table>
<thead>
<tr>
<th>Reviewer</th>
<th>Comment</th>
<th>Response; Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laura Young, SCVWD</td>
<td>1. Include an assessment of the WMI Pilot Assessment Framework in the Tier II discussion; the comparison found in the Coyote Integrated Assessment report could be used here too.</td>
<td>SCBWMI is now included in response to interest. It’s included in Tier I asmt b/c it is a screening level method to identify impairment. Originally this method was not included in this project because it had previously been assessed in the Coyote Creek Watershed Integrated Pilot Assessment.</td>
</tr>
<tr>
<td>Kristy McCumby, City Sunnyvale</td>
<td>I have just one comment/suggestion. I couldn't find any mention of the WMI's pilot watershed assessment approach draft. I know we had difficulties with the framework and actual results of the studies, but since it was such a big local effort, perhaps it should be mentioned and not left out as an omission. It would be useful to say why you did not select it to go with further investigations and at least recognize that this effort was made locally.</td>
<td>Ditto</td>
</tr>
<tr>
<td>Geoff Brosseau, BAASMA</td>
<td>P 6. 1st Paragraph: Not sure this explains why Tier II methods were not also evaluated using most if not all of Tier I criteria, which weren't related to the complexity of questions but rather basic attributes of the methods (e.g., reasonably rapid, explicit, usable for stream processes...) Seems users would want to know that the Tier II methods also met these criteria (as applicable). Of course, I wouldn't remove the strength/weakness analysis -- just address the criteria issue as well.</td>
<td>Included explicit evaluation criteria similar to those used for Tier I method evaluation, and included a summary table of evaluation (table 5, pp 35).</td>
</tr>
<tr>
<td>Geoff Brosseau, BAASMA</td>
<td>P. 31, 5.2.5 See note on top of page 6.</td>
<td>Ditto</td>
</tr>
<tr>
<td>Laura Young, SCVWD</td>
<td>2. Page 31 – Section 5.2.5 - Summary Evaluation of Tier II An evaluation of comparison table of the Tier II assessments would be helpful for Section 5.2.5, presenting main elements, strengths, weaknesses, general data types used (e.g. biological, chemical, physical, ecological function), qualitative vs. quantitative, etc.; and would support recommendations for SCVURPPP in Section 7.0. This could be</td>
<td>Ditto</td>
</tr>
<tr>
<td>Author</td>
<td>Page</td>
<td>Comment</td>
</tr>
<tr>
<td>-------------------</td>
<td>------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Laura Young, SCVWD</td>
<td></td>
<td>3. Page 32 – SFC LFA and SRP “...Conducting a LFA and analysis of sediment production and delivery in parallel, rather than in sequential phases...is potentially less cost-effective.” Not exactly true; Please rewrite this statement as was discussed at the WAS presentation. This is an artifact of the 1995 listing of the creek as impaired with out benefit of supporting data, and the Regional Board’s NPDES permit requirements on the urban runoff program to conduct a sediment study within a certain time period and schedule. Note that it’s due to San Franciscquito Creek listing as impaired and requirement of TMDL development that the LFA and sediment study are being conducted in parallel. In this case there was no choice whether or not to conduct a sediment study; it was required whether a LFA demonstrated impairment or not. So in this case, conducting the LFA and sediment study in parallel becomes most cost effective, by allowing coordination of tasks and field work similar to both studies. It is cost effective to do the LFA before the sediment study when impairment has not been determined yet, and the LFA serves as the tool for doing this, as is the case with SCVURPPP LFA (other urban creeks potentially impaired by sediment). Rewritten to reflect this comment: Pp 31 Evaluation section, and footnote #4.</td>
</tr>
<tr>
<td>Geoff Brosseau, BAASMA</td>
<td></td>
<td>P 27, last paragraph – Evaltn SFC: Inserted explanatory sentence: The difference reflects an approach to sediment TMDLs by the SFBRWQCB that has evolved over the last few years. Ditto</td>
</tr>
<tr>
<td>Laura Young, SCVWD</td>
<td></td>
<td>4. Page 17 – Evaluation of RSAT Perhaps comment on modification of RSAT method to incorporate/use quantifiable, field measurements for chemical and physical, to determine quality and verification of professional judgment, as you did for using a level III bioassessment (and as you did for the SEFA in SCVURPPP (2003a)). Although this might be cleared up after you talk to Montgomery County. P 18 – Evaltn Section. Rewrote sentence to reflect possible changes.</td>
</tr>
<tr>
<td>Laura Young, SCVWD</td>
<td></td>
<td>5. Page 34 – Assessment of Water Quality Standards. A review of the State’s draft guidance documents on ‘TMDL process for impaired waters’ and ‘Assessing Surface Waters’ might also add additional information, ideas, and recommendations. See two links for State’s A review of the referenced guidance document did not provide further insight into specific methods to evaluate water quality standards than already included in the Assess the Assessments Technical Memo; rather, the reference describes a process for addressing impaired waters. However, it is now</td>
</tr>
<tr>
<td>Laura Young, SCVWD</td>
<td>6. Page 36 – Section 7.0 Recommendations for SCVURPPP #2 Reference conditions</td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As part of Programs monitoring plan, consider including a recommendation for the Program to develop decision maker/manager education and outreach on use of reference condition and its application, how reference conditions are applied to define targets, successes of BMPs, and success and improvement of Program. Also, how can historical ecology and information be used to develop reference.</td>
<td></td>
</tr>
<tr>
<td>Laura Young, SCVWD</td>
<td>7. Editorial comments Parent 13 – Section 4.1.2 – 1st Paragraph - “This approach reflects an understanding of the importance of analyzing how natural and human factors influence…..”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rewrite sentence, too wordy and confusing use of lots of qualifying descriptors</td>
<td></td>
</tr>
</tbody>
</table>

| Laura Young, SCVWD | 52 |
Appendix D

April 23, 2003 Presentation of the Assess Watershed Assessment Project to the Santa Clara Valley Urban Runoff Pollution Prevention Program Ad Hoc Monitoring Committee, and the Watershed Assessment Subgroup of the Santa Clara Valley Watershed Management Initiative

Assessment of Watershed Assessment Methods

Santa Clara Valley Urban Runoff Pollution Prevention Program

April 23, 2003
Lucy Buchan
Assessment of Watershed Assessment Methods

Santa Clara Valley Urban Runoff Pollution Prevention Program

April 23, 2003
Lucy Buchan
Objectives

- Evaluate selected regional and national watershed assessment methodologies relevant to SCVURPPP assessment needs
- Recommend possible future directions for SCVURPPP monitoring and assessment program
- Summarize in Technical Memorandum
Evolution of SCVURPPP Monitoring Approach

- **1990-1995**: Baseline water quality
- **1996**: New approach
  - Continuous improvement ⇒ URMP
  - Pilot studies testing watershed assessment approaches ⇒ SEIDP, Stream Function Pilot
- **2002**: Multi-year monitoring plan
  - Implementation & effectiveness of Program elements
  - Identify impairment
Trends in Watershed Assessment

- Emphasize **bioassessment** and include chemical, physical measurements
  - Detect Use Impairment
  - Evaluate Use designation (Use Attainability Analysis)
- Develop **biocriteria**
- Develop **biological response signatures** for individual stressors
State Bioassessment Program Summary

<table>
<thead>
<tr>
<th>Program Elements</th>
<th>1989</th>
<th>2001</th>
<th>Net Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use of Bioassessments</strong></td>
<td></td>
<td></td>
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<tr>
<td>Water Resource Mngmt</td>
<td>41</td>
<td>52</td>
<td>11</td>
</tr>
<tr>
<td>Interpret Aquatic Life Use Attainment</td>
<td>&lt;&lt; 31</td>
<td>39</td>
<td>&gt;&gt; 8</td>
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<tr>
<td><strong>Organism Group Used</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>22</td>
<td>37</td>
<td>15</td>
</tr>
<tr>
<td>Benthic Macroinvertebrates</td>
<td>39</td>
<td>51</td>
<td>12</td>
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<tr>
<td><strong>Reference Conditions</strong></td>
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<td></td>
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<tr>
<td>Ecoregional</td>
<td>4</td>
<td>39</td>
<td>35</td>
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<tr>
<td>Site-specific</td>
<td>&lt;&lt; 31</td>
<td>19</td>
<td>-12</td>
</tr>
<tr>
<td><strong>Multiple Metrics for Data Analysis</strong></td>
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</tr>
<tr>
<td>Biological</td>
<td>3</td>
<td>50</td>
<td>47</td>
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</tbody>
</table>

Source: Summary of Current Biological Assessment Programs and Biocriteria Development. United States Environmental Protection Agency 2003.
Why Bioassessment

- Reflect Cumulative Effects; ecological integrity
  - 50% impaired streams in Ohio detected by only biological indicators; chemical indicators indicated no impairment in same streams

- $$$
  - Maryland DEP monitored 346 sites covering 1,500 stream miles and operated 2 automated storm event sampling stations for equivalent cost to conduct runoff event chemical sampling at 4 - 8 stations.

- Educational Value
  - promote community support and funds for programs
STRATEGY:
Integrated, Tiered Assessments

- Integrate biological assessment with physical and chemical; Integrate historical conditions
- Tier I **Screening level**: methods to identify impairment
- Tier II **Analytical level**: methods to identify and investigate causes of impairment
Tiered Assessment Strategy

Tier I Screening
Watershed Assessment

Preliminary* List
Impaired Waterbodies

Tier II Investigative
Watershed Assessment

Adaptive Management

SCVURPPP
Program Elements
Programmatic Indicators

No Action; data
Mgmt Actions
Revise WQS

303d List
TMDL

UAA

Mgmt Actions

*Source: National Research Council 2001: Assessing the TMDL Approach to WQ Management
State Level, Tier I: Ohio, Oregon

- **OH: EPA Rapid Bioassessment Protocols** - bio, chem, phys monitoring and assessment
  - Determine Use attainment
  - Evaluate Use designations; UAAs
  - Evaluate controls for point sources and BMPs for nonpoint sources
  - Developing stressor-response relationships

- **OR: Watershed Assessment Manual**
  - Determine Use attainment
  - Identify management actions to protect and restore watersheds
County Level, Tier I: Montgomery County, MD Stormwater Program

- EPA Rapid Bioassessment Protocols
- Rapid Stream Assessment Techniques
  - Synthesis of methods: EPA RBP, Izaak Walton League and Save Our Streams, USDA Water Quality Indicators Guide
  - Evaluation 30 parameters for the following categories:
    - channel stability
    - channel scouring/deposition
    - physical instream habitat
    - water quality
    - riparian habitat
    - biological indicators
California, Tier I:

- Relatively slow development bioassessment:
  - Tremendous ecological diversity,
  - Complex history land and water use,
  - 9 independent regulatory entities in SWRCB

- CDFG revised EPA RBPs: California Stream Bioassessment Procedures (CSBP) using benthic macroinvertebrates

- Most Bay Area Stormwater Agencies and CA RWQCBs are using CSBP for screening level watershed assessment
Watershed Function Approach

- USDA (FS & NRCS), USDI (BLM)
  - Tier I rapid Process for Assessing Proper Functioning Condition
  - Tier II Ecological Site Inventory

- Stream Ecosystem Function Approach
  Coyote Creek Watershed Pilot, Tier I
  - Multimetric Indices of Biological Integrity (Hughes et al. 1998, Harrington and Born, 1999)
Limiting Factors Approach (LFA), Tier II, TMDL: CA Region

- North Coast Watershed Assessment Program (multiple state and regional partners)
  - Preliminary LFA for salmonids
  - Fieldwork to verify existing data and address data gaps
  - Final LFA for salmonids
- Napa and San Francisquito Watersheds
  - LFA, Sediment TMDL
- Truckee River Basin Sediment TMDL
  - Follows EPA protocols, incorporates biocriteria
Summary

- 2 tiers of monitoring and assessment
- Emphasize integrating bioassessment (esp. macroinvertebrate), chem., phys., and historical
- Coordinate regionally to develop reference conditions and IBIs
  - CABW: California Bioassessment Workgroup
  - BAMBI: Bay Area Macroinvertebrate Bioassessment Information Network
Assessment of Watershed Assessment Methods

Appendix E

July 15, 2003 Presentation of the Assess Watershed Assessment Project to the Santa Clara Valley Urban Runoff Pollution Prevention Program Ad Hoc Monitoring Committee, and the Watershed Assessment Subgroup of the Santa Clara Valley Watershed Management Initiative

Assessment of Watershed Assessment Methods

Santa Clara Valley Urban Runoff Pollution Prevention Program

July 15, 2003
Lucy Buchan
Assessment of Watershed Assessment Methods

Santa Clara Valley Urban Runoff Pollution Prevention Program

July 15, 2003
Lucy Buchan
Objectives

- Evaluate selected regional and national watershed assessment methodologies relevant to SCVURPPP assessment needs

- Recommend possible future directions for SCVURPPP monitoring and assessment program

- Summarize evaluation in Technical Memorandum
  - SCVURPPP monitoring and assessment background
  - discuss types of and trends in watershed assessments
  - identify a framework to link different assessment methodologies using an adaptive management approach
  - identify criteria to select methods
  - Identify evaluation criteria and implement evaluation
  - provide recommendations
Tiered Assessment Strategy

Tier I Screening
Watershed Assessment

Preliminary* List
Impaired Waterbodies

Tier II Investigative
Watershed Assessment

No Action; data error
Mngmt Actions
Revise WQS
303d List

SCVURPPPP
Program Elements
Programmatic Indicators

Mngmt Actions

*National Research Council 2001; SWRCB 2003
Selection of Methods for Evaluation

Criteria for selecting assessment methods:

- Methods address at least one type of assessment need as outlined in the framework, e.g., appropriate for tier I screening-level assessment, or tier II investigative analysis of causes of degradation and Use impairment.

- Methods integrate biological, chemical, and physical indicators and ideally historical information or at least a means for establishing reference condition.

- For extra-regional methods: tested, proven useful, and demonstrate most recent advances in application of assessment methodologies.

- For intra-regional methods: commonly and recently used.
Tier I Screening Assessment Evaluation

- **Methods:**
  - Rapid Bioassessment Protocols (US EPA)
  - Rapid Stream Assessment Technique (Montgomery County, MD)
  - Proper Functioning Condition (USDI, NRCS)
  - Stream Ecosystem Function Assessment (USACE, SCVURPPP)

- **Evaluation Criteria:**
  - reasonably rapid
  - appropriate for assessing urbanized watersheds
  - include stressor and response indicators
  - Include explicit method of data analysis that is repeatable and scientifically robust
  - can be used to evaluate stream processes
  - allows SCVURPPP to realize benefits of regional coordination to develop assessment tools
## Tier I Evaluation Results

<table>
<thead>
<tr>
<th>Assessment Method</th>
<th>Rapid to Implement</th>
<th>Stressor and Response Indicators</th>
<th>Explicit and Repeatable Method of Data Analysis</th>
<th>Can be Used to Evaluate Stream Processes</th>
<th>Realize Benefits of Regional Coordination of Assmts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid Bioassessment Protocols</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Yes</td>
</tr>
<tr>
<td>Rapid Stream Assessment Technique</td>
<td>Yes</td>
<td>Yes</td>
<td>No – somewhat qualitative</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Stream Ecosystem Function Assmt</td>
<td>Yes&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Proper Functioning Condition</td>
<td>Yes</td>
<td>No – just response</td>
<td>No&lt;sup&gt;3&lt;/sup&gt; – qualitative using BPJ</td>
<td>Yes, qualitatively</td>
<td>No</td>
</tr>
</tbody>
</table>

<sup>1</sup> Not alone but can be used as a component of bioassessment in other assessment methods.

<sup>2</sup> Approach was tested using existing, available data that was not collected using rapid monitoring techniques. However, this method can accommodate data of different resolution, including data collected using rapid techniques.

<sup>3</sup> No standardized framework in which to assess components nor mechanistic methods to integrate data summarized for each component.
Recommendations for Tier I Assessment

- Use the Stream Ecosystem Function Assessment (SEFA) approach as recommended by SCVURPPP (2003), augmented by aspects of the Rapid Stream Assessment Technique (RSAT), to analyze data generated from an ambient monitoring program based largely on Rapid Bioassessment Protocols (RBPs).

- Coordinate regionally to develop reference conditions and bioassessment tools to support analysis of macroinvertebrate data.

- Work towards developing robust numeric biocriteria.

- Consider pursuing bioassessment of fish assemblages in larger order streams and in streams supporting steelhead trout.
Tier II Investigative Assessment Evaluation

Methods

- North Coast Watershed Assessment Program Limiting Factors Analysis (LFA)
- Napa River Basin LFA
- San Francisquito Creek Sediment Reduction Plan and LFA
- SCVURPPP LFA for Creeks Potentially Sediment-Impaired
- Oregon Watershed Assessment Manual
- Hydromodification Plan
- Biological Water Quality Target Approach

Evaluation Criteria

- relative strengths and weaknesses discussed
  - Investigate impairment cost-effectively
  - Identify stressors/limiting factors, appropriate management actions, additional information to test hypotheses regarding causes of impairment
## Tier II Evaluation Results

<table>
<thead>
<tr>
<th>Method</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Coast LFA</td>
<td>Tiered: prelim, final</td>
<td>No explicit method</td>
</tr>
<tr>
<td>Napa River LFA</td>
<td>Tiered: LFA, Sed Bdgt</td>
<td></td>
</tr>
<tr>
<td>San Francisquito LFA</td>
<td>LFA and Sed Bdgt</td>
<td>Parallel implementation.</td>
</tr>
<tr>
<td>SCVURPPP LFA</td>
<td>Tiered: LFA, Sed Bdgt</td>
<td></td>
</tr>
<tr>
<td>Oregon Wshd Assmt</td>
<td>Suite of indicators</td>
<td>No explicit method</td>
</tr>
<tr>
<td></td>
<td>Resources, Forms</td>
<td></td>
</tr>
<tr>
<td>Hydromodification Plan</td>
<td>Geomorphic Assmt</td>
<td>Physical focus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Future conditions</td>
</tr>
<tr>
<td>Biological WQ Target</td>
<td>Dose-response linkage</td>
<td>Site-specific reference, Tool development</td>
</tr>
</tbody>
</table>
Recommendation for Tier II Assessment

- Continue to implement LFA as primary approach to investigating factors potentially limiting attainment of aquatic life Uses and incorporate lessons from other projects implementing LFA.

- Consider using HMP as tool to identify potential Use impairment caused by hydromodification associated with future development;

- Consider incorporating aspects of the HMP method of geomorphic assessment into a method for classifying Santa Clara Basin streams and to identify and prioritize where restoration efforts could occur.

- Incorporate biocriteria into assessments as feasible.