IDENTIFYING BARRIERS TO TIERED AQUATIC LIFE USES (TALU) IN SOUTHERN CALIFORNIA

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Southern California Coastal Water Research Project

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PREFACE

The goal of this document is to explore the use of a new environmental management tool in southern California known as Tiered Aquatic Life Use or TALU. TALU focuses on the traditionally difficult regulatory problem of maintaining balanced biological communities. The existing California State regulatory framework only lists broad, categorical biological expectations such as warmwater (WARM) or coldwater (COLD) habitat. TALU has the potential to refine the biological expectations within each of these broad categories based on a variety of factors including physical habitat, hydrology, or level of habitat alteration. More detailed expectations tailored to the specific habitat could dramatically improve environmental managers' ability to assess biological impairment and set appropriate benchmarks for improvement.

The goal of this document was to create a workplan for implementing TALU in southern California. We compiled existing information about TALU and, by working with local stakeholders, identified some of the largest technical and potential policy barriers for implementation. This was not an easy task since southern California stakeholder opinions, sensitivities, and personal agendas can dramatically differ. TALU is a powerful tool that can be utilized as a positive step towards conservation and restoration or, alternatively, abused as a means of limiting regulatory oversight. Ultimately, this report lists 13 projects that should be undertaken to help resolve these barriers and develop scientifically defensible tiered aquatic life uses, and integrate these tiered uses into the existing water quality standards program to the betterment of the environment.

This document does not focus on the many non-technical factors that will be fundamental for TALU to be a successful management tool. These factors, which can be political and procedural, are built into the State and Federal regulatory policy development process. Many times, divisive policy issues are a function of perception rather than fact. It is the aim of this document to ensure that the all of the facts are available to evaluate the viability of TALU as a meaningful regulatory tool.

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LIST OF ACRONYMS

ACOE	Army Corps of Engineers
BCG	Biological condition gradient
COLD	coldwater habitat
CSUSM	California State University San Marcos
DWR	Department of Water Resources
EMAP	Environmental monitoring and assessment program
EPA	Environmental Protection Agency
EWH	exceptional warmwater habitat
GSG	Generalized stressor gradient
IBI	Index of biological integrity
MWH	modified warmwater habitat
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PSA	Perennial Stream Assessment
SANDAG	San Diego Association of Governments
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Water Research Project
SFEI	San Francisco Estuary Institute
SMC	Stormwater Monitoring Coalition
SNARL	Sierra Nevada Research Laboratory
SWAMP	Surface water ambient monitoring program
TALU	Tiered aquatic life use
USFS	United Sates Forest Service
WARM	warmwater habitat (California)
WWH	warmwater habitat (Ohio)

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BACKGROUND

What are Tiered Aquatic Life Uses (TALU)?

All states, including California, have designated uses (known as beneficial uses in state terminology) that protect aquatic life. California has several different beneficial uses relevant to protecting aquatic life including warmwater and coldwater habitat, and protection of different life stages such as fish migration and spawning.[1] Most ecosystem managers recognize that the more specific the designated use definition, the clearer it is to describe attainment goals and ensure maintenance and protection of the designated use. EPA also acknowledged this fact and, in response, developed a framework for states to develop Tiered Aquatic Life Uses (TALU).

TALU recognizes different management goals for waterbodies within a given waterbody class and these goals are defined based on detailed information on biological condition and stressor intensity. An example of TALU would be the three tiers of warmwater use defined by the Ohio EPA (OEPA, 2008): exceptional warmwater habitat (EWH), warmwater habitat (WWH), and modified warmwater habitat (MWH). All of these tiers are part of a designated use for warmwater habitat, but each of these tiers is associated with different biological expectations based on detailed knowledge of these systems. EWH has a higher expectation of biological condition (i.e., the types of flora and fauna that should be present represent higher water quality and higher habitat quality) than WWH, which in turn, has a higher biological expectation than MWH.

It is important to recognize that tiered uses are defined based on fundamental differences in structural or hydrological condition, not the current biological or water quality condition. Instead, biological expectations for each tiered use are based on knowledge of what biota is capable of occurring in a waterbody given the fundamental structural or hydrological template that exists. In this way, environmental managers utilize TALU to achieve effective stewardship of beneficial uses by: (1) identifying high quality waterbodies and preventing the gradual degradation of these waterbodies; and (2) identifying restoration benchmarks for degraded biological condition in waterbodies given their structural and hydrologic condition.

Southern California is a tremendously valuable location for examining the application of TALU because of its wide array of biological habitats, extensive structural and hydrologic modification, and regulatory agencies' desire to regulate on biological as well as chemical condition. Streams, coastal lagoons, and bays support sensitive aquatic species, diverse wildlife, and unique habitats. As a result, southern California needs a more refined way of defining Aquatic Life Uses. For example, coastal perennial streams in southern California can range widely in terms of the degree of urbanization, hydrologic regime, and habitat alteration. The TALU framework could be a powerful tool to refine the WARM designated beneficial use and to better reflect attainable aquatic life goals for different stream conditions.

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[1] Categorical aquatic life beneficial uses that are designated for waterbodies in California include: Warm Freshwater Habitat; Cold Freshwater Habitat; Inland Saline Water Habitat; Estuarine Habitat; Wetland Habitat; Marine Habitat; Rare, Threatened, or Endangered Species; Migration of Aquatic Organisms; and Spawning, Reproduction, and/or Early Development.

Initial Steps of the TALU Process in Southern California

There has been some exploration of TALU concepts in southern California. These initial steps have included a pilot study (Tetra Tech, 2005; 2006) and a subsequent public workshop. Between 2005 and 2007, the pilot study gathered a group of experts to discuss the technical underpinnings of a TALU framework for southern California coastal streams. No new data were collected as part of this effort, but relevant available biological data were compiled to conceptualize the two primary components of TALU: (1) the biological condition gradient (BCG); and (2) the generalized stressor gradient (GSG).

The BCG describes how ten general ecological attributes of aquatic ecosystems change in response to increasing levels of stressors. These attributes include several common aspects of community structure (e.g., pollution sensitive species, endemic long-lived species) organism condition, ecosystem function, and biological attributes related to stream connectivity and the larger watershed scale. The gradient can be considered analogous to a field-based dose-response curve where dose (x-axis) = increasing levels of stressors and response (y-axis) = biological condition (Figure 1). The BCG is divided into six levels of biological condition along the stressor-response curve, ranging from observable biological conditions found at no or low levels of stressors (Level 1) to those found at high levels of stressors (Level 6).

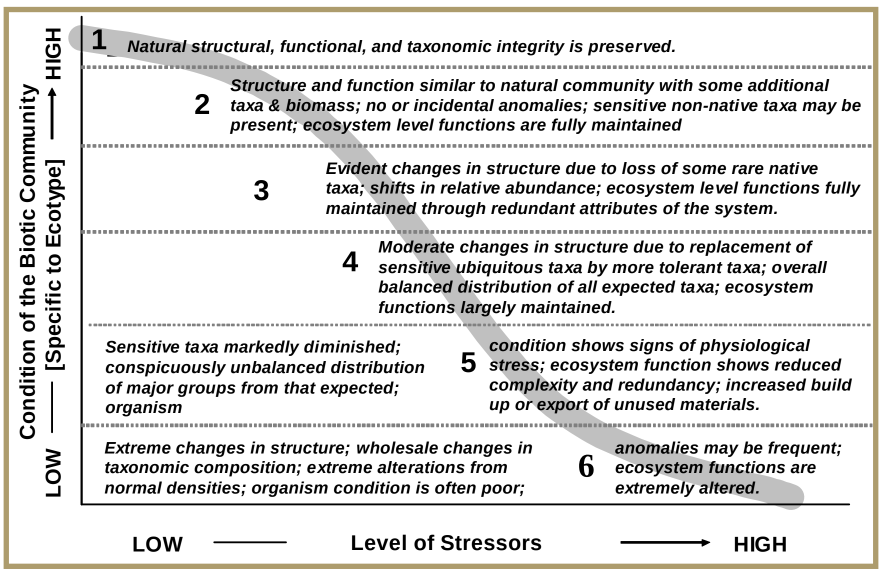

Figure 1. Conceptual model of the Biological Condition Gradient.

The GSG describes the stressor gradient present in the region of interest. Stressors are physical, chemical, or biological factors that adversely affect aquatic biota. Stressors can occur at different scales including instream, within the riparian area and floodplain, or within the watershed. Understanding the linkages between stressors and the response of aquatic biota will help determine existing and potential biological conditions of the aquatic biota. Multiple stressors are usually present and the GSG on the x-axis seeks to represent the cumulative influence of stressors, much as the y-axis generalizes biological condition.

The primary outcome of the pilot study was that TALU could be created in the unique stream environments of southern California. Although much work was left to be accomplished, a BCG and GSG were conceptualized, as well as potential tiered use definitions for perennial streams in the region. The BCG was based largely on the existing Southern California Index of Biological Integrity (IBI; Ode *et al.* 2005) and its associated biological metrics, while the GSG was based primarily on physical habitat measurements and watershed scale disturbance metrics. Relationships were identified between types of coastal perennial streams in southern California, observed aquatic life condition, and preliminary tiered aquatic life uses, along with their corresponding biological expectations.

Several uncertainties were also identified during the pilot study regarding the BCG, GSG, and biological expectations for different tiers. Examples of key uncertainties included defining truly natural conditions in areas where little natural condition remains. Identifying unimpaired sites is vitally important for setting the upper range (i.e. Level 1) of the BCG. Another key uncertainty was the efficacy of additional indicators such as fish or amphibians. One additional uncertainty was optimizing metrics for quantitatively expressing the GSG.

In November, 2007, the Los Angeles Regional Water Quality Control Board sponsored a stakeholder workshop on TALU. The goal of the workshop was two-fold: (1) communicate the findings of the pilot study; and (2) garner input from stakeholders on the viability of TALU as a management tool. Presentations by the US EPA Office of Water and Region IX, the Los Angeles Regional Water Board, and Tetra Tech (US EPA's technical contractor) laid out the rationale, approach, and goals of TALU. The participants were educated about the TALU framework with insight provided by the results of the Southern California pilot study.

The primary outcome of the stakeholder workshop was an earnest interest in TALU. Break-out discussions identified a multitude of issues that were classified into four general areas: (1) determining reference conditions, best attainable conditions, and levels within the BCG; (2) defining stressor gradient metrics; (3) protecting high quality sites and encouraging restoration of degraded sites; and (4) clarifying the regulatory process for developing TALUs.

Identifying Barriers

In June 2008, a second workshop was held to further investigate the specific barriers to implementing TALU in southern California. The workshop was comprised of 12 invited participants representing a cross-section of stakeholders including regulatory, regulated, scientific, and non-governmental sectors (please see Acknowledgements). The group focused on a single goal: design a workplan to overcome the barriers associated with TALU development. Ultimately, the workplan will provide guidance to regulatory and regulated stakeholders that outline the steps necessary to develop TALU in a way that is scientifically defensible and feasible for management. There were three chief considerations asked of participants:

- What are the primary data gaps or information needs?
- How do we combine data gaps into unique project designs?
- What are the factors for prioritizing projects to fill data gaps?

In an effort to constrain the scope of the workplan, the workshop participants immediately decided to limit the scope to perennial wadeable streams in the southern California region.

The workshop ideas and concerns fell into one of three areas including biological, stressor, and implementation related data gaps. The biological-related data gaps included identifying appropriate indicators, adequate representation of reference conditions and range of impact (for defining the BCG scale), capturing natural temporal variation (seasonal/interannual), and specific biological responses to changes in flow (hydromodification).

The stressor related data gaps included improving the understanding and quantification of the human disturbance gradient (to build the GSG), improving the information for quantifying and defining stressor gradients at both the local and watershed scales (e.g., physical habitat and GIS/land use, respectively), and identifying site specific factors that influence stressor impact on aquatic life (e.g., best management practices).

The implementation related issues included identifying appropriate habitat breaks for TALU application, development of appropriate criteria, setting tiers, determining values for nonbiological indicators (i.e. water quality objectives) for the tiers, and integrating TALU with other state or federal regulatory programs.

There were several factors the workshop participants utilized for prioritizing project concepts. These included availability of data/information for compilation as opposed to new data collection, estimated cost, time for completion, and perceived importance in providing defensibility of TALU structure. Ultimately, 14 projects were derived for the workplan based on these criteria.

Table 1. Summary of data gaps or information needs identified at the June 19, 2008 technical meeting regarding the advancement of Tiered Aquatic Life Uses (TALU) in southern California coastal perennial streams and proposed projects that address these gaps.

DATA GAP	PROPOSED PROJECTS
Biology-related	
• The BCG needs to include more than one type of indicator, so that expected responses to human development are accurately evaluated	• Project #1: Develop algal indicators of biological condition for perennial coastal California streams; • Project #2: Develop riparian vegetation and habitat indicators suitable for BCG development
• Natural condition needs to be defined for each stream classifications to determine Level 1 for the BCG	• Project #3: Define minimally impacted (natural) biological condition for coastal perennial streams and determine appropriate stream classification factors
• Temporal variability needs to be captured in the BCG	• Project # 4: Determine seasonal and interannual variability for relevant biological indicators and identify appropriate ranges of indicators for BCG development
• Representation of biological sites needs to be broad and complete enough to ensure accurate BCG development	• Project #5: Characterize range of available biological indicator information and identify gaps in BCG
• Biological expectations for hydrologically modified streams need to be defined	• Project #6: Determine appropriate BCG for different degrees of hydrologic modification
Stressor-related	
• Need to evaluate if recent changes in physical habitat sampling methods provide useful information for quantifying the GSG	• Project #7: Evaluate and develop a refined set of physical habitat measures that help develop the GSG
• Better base maps are needed for quantifying stressor information	• Project #8: Develop refined base maps of stressor information
• Need to better define and integrate landscape and reach scale stressors to quantify the human disturbance gradient	• Project #9: Research and evaluate different indices of human disturbance as GSG surrogates
• Need to understand why individual outlier sites have unpredictably good or bad biological condition	• Project #10: Examine BMP effects on biological condition
Implementation-related	
• Need to translate science to policy when setting stream classifications and tiered uses	• Project #11: Determine appropriate implementation criteria for identifying stream classes and tiered uses
• Consider biocriteria as a means to evaluate whether tiered uses are being achieved	• Project #12: Integrate BCG development and TALU with potential biocriteria
• Examine how other water quality objectives should be tiered along with biological uses (e.g., DO, temperature)?	• Project #13: Determine potential tiered water quality objectives
• Need to link TALU with other regulatory programs (TMDL, 401/404, stormwater) • State-wide implementation vs. region-specific approaches need to be evaluated	• Project #14: Link TALU with other regulatory programs

SPECIFIC PROJECTS

Project 1:	**Develop algal indicators of biological condition for perennial coastal California streams**
Issue:	Previous BCG development efforts were based primarily on macroinvertebrate data and assessment tools. However, macroinvertebrate data and assessment tools alone may not be sufficiently sensitive and robust to characterize perennial coastal California streams. Several examples exist including low gradient streams. Therefore, BCG development should include more than one type of indicator so that expected responses to human disturbance are accurately evaluated. Algae often respond differently to stressors, particularly nutrients, than macroinvertebrates. Therefore, inclusion of algal indicators will provide a more comprehensive BCG.
Tasks:	1. Compile existing algal data for southern California. 2. Segregate algal data and related assessment tools into various habitat types, including consideration of elevation, stream gradient, and degree of channelization. 3. Identify whether sufficient algal data is available for reference sites in southern California to develop an algal indicator. If not, identify sites and collect data as needed. 4. Correlate algal data and related assessment tools with physical or chemical stressors, land use, etc. Other stream systems can provide insight into these relationships. 5. Determine if algal data show sufficient sensitivity to stressors in southern California to serve as useful indicators of human impacts. 6. If algal indicators are sufficiently sensitive to act as useful indicators of biological condition in perennial southern California streams, select an indicator, or suite of indicators, to develop the BCG for algae. This process should be reviewed using an expert panel to verify BCG attributes for algae. 7. Set detection, precision, and accuracy estimates for the algal index developed.
Product:	Identification of algal indicators and expected changes with increasing stress. Detailed description of BCG for algal indicators.
Information Available:	Algal bioassessment methods and data collection are currently underway as part of SWAMP program. Some data is available through Western EMAP. A South Coast periphyton IBI is currently under development at SCCWRP. Additional sampling could be conducted to fill in gaps or verify correlations, as needed.
Estimated Cost:	$ 100,000 to 500,000, depending upon whether sufficient data are available
Schedule:	Two to three years, depending on availability of data
Potential Collaborators:	SCCWRP, EMAP, SWAMP, SNARL, CSUSM

Project 2:	**Develop riparian vegetation and habitat indicators suitable for BCG development**
Issue:	During the BCG Pilot Study for southern California coastal streams, the Technical Advisory Committee clearly recognized that riparian vegetation/habitat is a useful indicator of biological condition. However, use of riparian vegetation/habitat as an indicator of biological condition must be approached cautiously, as lack of vegetation/habitat can also be considered part of the stressor gradient. Preliminary work using the California Rapid Assessment Method (CRAM) was used as a placeholder absent any other standardized riparian quantification method. However, more work is needed to refine the usefulness of riparian vegetation and habitat indicators in TALU development, including identifying reference conditions and determining whether quantifiable metrics can be developed that characterize the condition gradient in response to stressor intensity.
Tasks:	1. Examine current status of CRAM to see if quantitative metrics of disturbance have been assessed. 2. If not, collate existing CRAM information along with metrics of stress or disturbance level. 3. Determine appropriate riparian/waterbody classifications (habitats) for which individual natural conditions will be defined. These could include high elevations streams, low elevation/high gradient streams, and low elevation/low gradient streams. 4. Identify specific changes in riparian indicators with stressor intensity, characterizing natural conditions as well as conditions under various levels of stress. During this process, develop a means to consider lack of vegetation due to hydrologic modification as a stressor. Identify BCG thresholds for riparian condition using CRAM. 5. Assess whether CRAM serves as an appropriate and sufficiently sensitive metric for riparian vegetation/habitat in southern California perennial coastal streams. If CRAM does not appear to be a good metric, assess whether other metrics should be used instead.
Product:	Identification of riparian indicators and expected condition gradient with increasing stress. Detailed BCG for riparian indicators.
Information Available:	Current on-going work on CRAM, including the State's Wetland Monitoring Program; 404/401 monitoring for restoration/mitigation projects. SWAMP/Perennial Stream Assessment monitoring.
Estimated Cost:	$100,000 to 500,000, depending upon whether sufficient data are available
Schedule:	Two to three years, depending upon availability of data
Potential Collaborators:	SCCWRP, SFEI, CA Coastal Conservancy, US ACOE, Southern CA Wetland Recovery Project

Project 3:	**Define minimally impacted (natural) biological condition for coastal perennial streams and determine appropriate stream classification factors.**
Issue:	BCG development depends on having Level 1 (natural condition) defined, even if it is not represented in the region at present. The Pilot Study suggested that high elevation streams were a different class from low elevation streams, but this may not be the case and the exact elevation cutoff is unknown. The separation of stream classifications is driven largely by ecotonal gradients of physical factors and biological assemblages in the absence of stressors, i.e. a comparison of reference conditions. Identifying different classes of streams is critical because this is what determines ultimate biological expectations (i.e., low elevation or low gradient stream biological assemblages may never look like those of a high elevation or high gradient stream, even with outstanding habitat and water quality).
Tasks:	1. Compile biological indicator data, water quality data, pertinent classification metadata (elevation, gradient, geology, etc.), and stressor data. 2. Identify sites and data that are believed to represent natural conditions (Level 1) using the stressor data. If unstressed sites are unavailable, then alternative approaches can be evaluated including using sites outside of the Southern California Bight, historical information, museum archives, etc. 3. Evaluate the degree to which biological expectations differ between different coastal streams in southern California and determine classes. This is typically accomplished using multivariate statistical techniques. 4. Verify stream class determination and Level 1 attribute conditions using expert opinion.
Product:	Database of macrobenthos, other biological indicators, and pertinent physical and stressor information. Statistical analysis of biological assemblages sufficient to delineate stream classes. List and range of data for biological metrics, physical, and stressor information that characterizes Level 1 of the BCG for different classes of streams in the region.
Information Available:	Macroinvertebrate data are available from a wide range of sources including SWAMP, EMAP, SMC, NPDES monitoring, amongst others. Sufficient data may also be available for other indicators such as algae, riparian condition, and fish. (See projects 1 and 2.) SWAMP is also creating a Reference Condition Management Plan that will directly address this issue in future years.
Estimated Cost:	$150,000 - $250,000
Schedule:	One to two years.
Potential Collaborators:	SWAMP, SMC, USFS, EMAP

Project 4:	**Determine Seasonal and Interannual Variability for Relevant Biological Indicators and Identify Appropriate Ranges of Indicators for BCG Development**
Issue:	A comprehensive and accurate BCG depends, in part, on understanding and incorporating natural variability in the biological condition of the indicators. All biological indicators have some variability between seasons and between years resulting from differences in hydrological or climate regime, or innate differences in population recruitment or mortality rates. To a large extent, this type of variability has not been evaluated, creating an information gap in terms of uncertainty in biological indicator thresholds for different levels of the BCG.
Tasks:	1. Compile biological indicator data for individual sites over time. Preferably, each site will have multiple seasons and/or multiple years of record. 2. Characterize and quantify the variability of biological data, including individual metrics and composite metrics for various indicators. 3. Identify multi-year variability for given index periods and evaluate the need for a single index period in BCG development for a given indicator. Quantify appropriate ranges for individual indicators under natural conditions (Level 1 of the BCG) as well as for various stress levels.
Product:	Time-series data for specific biological indicators and sites, and statistics for seasonal and inter-annual variability based on different classes of streams. Identification of appropriate ranges of indicators to be used in setting Level 1 of the BCG.
Information Available:	Multi-year site data for macrobenthic assemblages are collected largely by NPDES permittees, although the data for reference sites may be limited. EMAP has revisited a subset of sites. The USFS has revisited some sites, but many are not in the southern California region.
Estimated Cost:	$100,000-$200,000 if data are available
Schedule:	One year
Potential Collaborators:	SWAMP, EMAP, USFS, NPDES permittees

Project 5:	**Characterize range of available biological indicator information and identify gaps in biological condition gradient**
Issue:	BCG development depends on having a complete understanding of how various biological indicators change with increasing stressor intensity. While the character of natural conditions and extremely stressed conditions is often known with some precision, changes in biological condition with intermediate levels of stress are not often as well characterized, yet this information is crucial to having a useful BCG for TALU development. Without sufficiently represented gradients of biological condition, inappropriate thresholds for BCG levels may be established. Therefore, it is critical that datasets of appropriate indicators cover the entire range of biological conditions in response to stressors. If gaps are present in the data (i.e., not enough intermediate-stressed sites), additional sampling will be needed.
Tasks:	1. Compile data sets for biological indicators, physical habitat, and stressor data. This may coordinate well with Projects 1-3. 2. Characterize the distribution of data for biological indicators and determine potential breaks or groups that may define thresholds for BCG levels, based on response of the data to stressors. Identify areas of the distribution in which there are relatively few sites represented or parts of the distribution in which there are sharp changes in indicator condition. 3. Determine if locations of missing data represent areas where thresholds will be placed. These areas of the gradient would be the prioritized data gaps for additional sampling.
Product:	Compiled data set of biological, physical habitat, and stressor information. Graphs and tables describing the distributions of each indicator. Prioritized list of data gaps requiring additional sampling.
Information Available:	For a focus on macroinvertebrates, spatially distributed data sets are preferred such as SWAMP, EMAP, PSA, SMC, USFS and others.
Estimated Cost:	\$50,000 to \$150,000; perhaps >\$500,000 if additional sampling is included.
Schedule:	One year for data compilation and analysis
Potential Collaborators:	SWAMP, EMAP, PSA, SMC, USFS and others

Project 6:	**Determine appropriate BCG for different degrees of hydrologic modification**
Issue:	Hydromodification is one of many potential stressors. However, the pervasiveness of hydrologic modification in southern California and the significant degree to which it can impact biota makes it a particularly important stressor. Since hydrologic modification represents a stressor condition that is difficult to reverse in the short- to medium-term, this may be one basis upon which TALU is considered for southern California coastal streams (i.e., for low gradient/low elevation streams, assign tiers based on degree of hydromodification such as full channelization, concrete sides with soft botton, and unchannelized). Therefore, understanding how biological expectations change with hydrologic modification is an essential step towards refining the BCG and developing TALU in the region.
Tasks:	1. Compile biological, physical habitat, stressor condition, and water quality data as well as hydromodification attributes from existing data. This can include various biological indicators (benthic macroinvertebrates, algae, riparian vegetation, fish, amphibians, etc.) and could be done in coordination with Projects 7, 8, and 9. Develop metrics of hydrologic modification that can be scaled from natural (no modification) to extreme modification. 2. Develop a relationship between biological metrics or IBI and hydromodification metrics. 3. Verify relationships and identify a refined and comprehensive BCG that takes these relationships into account, using an expert review panel. The expert panel should help derive decision rules for weighting different data and determining BCG level based on various biological datasets (i.e., macroinvertebrates, algae, riparian vegetation, fish, amphibian, etc.).
Product:	A refined BCG based on level of hydrologic modification. Proposed tiered aquatic life uses based on varying levels of hydrologic modification.
Information Available:	SCCWRP, Counties of Ventura and Los Angeles, and the SMC are currently working on hydrologic modification projects related to erosion. For a focus on macroinvertebrates, spatially distributed data sets are preferred such as SWAMP, EMAP, PSA, SMC, USFS and others
Estimated Cost:	$50,000 to $150,000; perhaps >$500,000 if additional sampling is included.
Schedule:	Two to three years. One and one half years for data compilation and the remainder for developing the BCG
Potential Collaborators:	SWAMP, EMAP, PSA, SMC, USFS and others

Project 7:	**Evaluate and develop a refined set of physical habitat measures that help develop the GSG.**
Issue:	Physical habitat quality should be an important factor in determining biological condition expectations. Until recently, most physical habitat sampling followed protocols that were semi-quantitative and subject to large sampler-to-sampler variance. The Pilot Study showed that these highly variable, semi-quantitative physical habitat measurements were insufficiently robust for developing a predictable GSG. More quantitative, less variable, physical habitat protocols have recently been developed and are now being implemented throughout the region. These new protocols may be more useful in developing the GSG since they are more quantitative, but no one has examined their results critically for this type of TALU application.
Tasks:	1. Compile physical habitat data for sites using the new protocols along with biological data, as available. 2. Characterize the statistical distribution of various physical habitat measures. It may be useful to examine multi-metric indices of physical habitat condition. It may also be useful to differentiate the data by stream classification and degree of hydromodification. 3. Determine relationships between physical habitat metrics and biological measures. Recommend the physical habitat metrics that best predict biological responses. 4. Pilot test recommended metrics at a range of sites to evaluate the utility of the proposed physical habitat metrics.
Product:	Series of correlation plots or matrices of physical habitat metrics and biological responses. Recommend validated physical habitat metrics for use in developing the GSG.
Information Available:	EMAP has the most quantitative physical habitat measurements. SWAMP and the Perennial Stream Assessment have developed new methods for physical habitat that are derived from the EMAP protocols. The SMC will be using the SWAMP protocols in the upcoming years and the data generated could serve as the validation data set.
Estimated Cost:	$200,000 - $500,000, not including additional data collection
Schedule:	Two to three years
Potential Collaborators:	EMAP, SWAMP, PSA, SMC

Project 8:	**Develop refined base maps of stressor information**
Issue:	Development of a reliable GSG is dependent upon having accurate stressor information. Moreover, this information will help define the tiers for TALU implementation. Currently, insufficient stressor information exists with which to draw relationships with existing biological indicators. For example, macroinvertebrate data are available for many sites in the region, but associated stressor information is not complete. This stressor information comes in many varieties, but can be broken into two types: watershed scale and reach scale. Watershed stressors focus on large-scale cumulative impacts such as upstream land use. Reach stressors focus on local impacts such as physical habitat, flow, or water quality.
Tasks:	1. Compile data on watershed scale stressors. This may include, but is not limited to, land use, imperviousness, flow augmentation or diversions as well as associated structures (i.e., dams, reservoirs, etc.), and point source discharges. 2. Compile data on reach scale stressors. This may include, but is not limited to, stream bed material (i.e., fully channelized, concrete-lined with soft bottom, unchannelized), nonpoint source inputs, road crossings and associated structures (i.e., bridges, culverts, Arizona crossings). 3. Place all of this information into a GIS platform for use in future projects. Use the GIS to create maps of the stressor distributions. 4. Evaluate maps to ensure they are using the most up-to-date information and identify sites needing follow-up reconnaissance to ensure desired accuracy.
Product:	GIS layers and base maps of watershed and reach scale stressors.
Information Available:	Much of the watershed scale stressor information is currently available and compiled. Less information has been compiled for reach scale stressors.
Estimated Cost:	$250,000 to $500,000
Schedule:	One to three years, depending on number of stressors and scale.
Potential Collaborators:	DWR, SCAG/SANDAG, most public works and flood control agencies, NOAA.

Project 9:	**Research and evaluate different indices of human disturbance as GSG surrogates**
Issue:	There are myriad of biological stressors, which often have cumulative impacts on southern California streams. Successful TALU delineations depend on having a clear understanding of these stressors and their gradations (i.e., the GSG). Through the process of defining GSG attributes, stakeholders can determine which stressors are controllable (and therefore, not an appropriate aspect of tiered uses) and which are not readily controllable (and might make for good attributes to use in defining tiers). Previously, only landscape scale stressors were evaluated. However, these large-scale stressor evaluations were incomplete and virtually no reach-scale stressors appeared adequate for describing biological response in the biological indices examined to date (i.e., macroinvertebrates). The goal of this project is to improve the GSG for developing TALU.
Tasks:	1. Compile the existing knowledge of stressor indices from the literature, particularly those used in other water programs. 2. Use the existing knowledge from task 1 to create metrics to characterize stressors. This may include multi-metric approaches. 3. Evaluate the biological responses along each stressor metric gradient to identify the best (most predictive) approach. Conduct this process with several types of biological responses to determine the most sensitive biological response to stress. 4. Verify the pros and cons of potential stressor metrics and select preferred approach using an expert review panel. 5. Create a GIS map of stressor metrics for perennial streams region wide.
Information Available:	There are a number of stressor metrics recently developed and published in the literature. Land cover data are readily available, but should be checked for currency and accuracy (see Project 8). Hydrologic as well as physiochemical data are available from several sites and time periods. Where data do not exist, a targeted sampling program may be required.
Product:	Literature review of existing approaches to stressor identification. Series of correlation plots or matrices of stressor metrics and biological responses. Recommended GSG options for use in developing TALU.
Estimated Cost:	$200,000 - $400,000
Schedule:	Two to three years
Potential Collaborators:	SWAMP, NPDES permittees, USGS, DWR

Project 10:	**Examine BMP effects on biological condition**
Issue:	Condition assessments from the Pilot Study indicated that some sites had relatively "good" biological condition considering the level of stressors such as surrounding land use. Similarly, some sites had relatively "poor" biological condition despite an apparent lack of significant stressor sources. The initial assumption has been that unique, site-specific circumstances help dictate the outlier conditions of these sites. To determine whether site-specific circumstances are the cause of the outlier conditions, sites that are uncharacteristically "good" or "bad" should be examined to determine if this is a result of specific practices, such as BMPs or the presence of industrial discharges. This analysis can help determine whether the indicators are appropriate, and potentially identify the key physical and/or hydrologic factors that can help improve degraded sites.
Tasks:	1. Using the compiled data set from Projects 6, 8, and 9, look for anomalous sites that do not fit the BCG/GSG relationship. 2. Conduct site reconnaissance to determine site-specific factors, including BMPs or specific discharges, if any. 3. Based on BMPs or other factors that yielded better than expected biological condition, recommend approaches that may help improve other lower quality sites (e.g., BCG Level 5 or 6). An alternative is to work with agencies that are preparing to install BMPs to test BMP effectiveness. 4. Recommend procedures for handling outlier or anomalous sites within a TALU framework.
Product:	Report with maps showing outlier sites and evaluation of factors causing site-specific condition. Create a list of BMPs that will improve biological condition at these sites. Guidelines for dealing with outlier sites in TALU implementation where site-specific factors need to be accounted for.
Information Available:	SWAMP and the Perennial Stream Assessment have a large number of sites that can contain outliers for investigation. SCCWRP has just completed an assessment of BMPs for habitat restoration.
Estimated Cost:	$100,000 to $200,000, more if sampling or BMP construction is required.
Schedule:	One to two years
Potential Collaborators:	SWAMP, EMAP, PSA

Project 11:	**Determine appropriate implementation criteria for identifying stream classes and tiered uses**
Issue:	BCG and GSG-related projects will determine appropriate classes of perennial streams in Southern California, within which more specific aquatic life uses can be defined. To implement this classification, there needs to be objective science-based criteria for distinguishing classes so that water quality standards can clearly identify to which class a given segment belongs. However, there are policy implications for how stream classifications are attributed. It is this intersection of science and policy that requires thoughtful implementation to ensure equity, effectiveness, and cost efficiency. Several questions need to be answered such as, if classification is based on elevation (or gradient), what is the specific cutoff for high vs. low elevation streams (or high vs. low gradient); are there exceptions to this classification; and how is this classification scheme best applied to ensure efficient implementation of TALU? Similarly, TALU tier thresholds are derived from application of scientific information, but these thresholds need to be re-evaluated once they are applied to actual stream reaches to ensure the biological expectations are appropriate.
Tasks:	1. Compile, summarize, and analyze statistically the database from Projects 3, 4, 6, 8, and 9 will be to identify stream classes that should be considered for separate TALU "regions". This will be done in a pilot watershed. 2. Conduct GIS analysis and create a map of stream classification assignments and proposed tiered uses in the pilot watershed. 3. Evaluate the stream assignments to confirm appropriate classes and tiered uses within each class using a task force of scientists, regulatory and regulated agency staff, as well as nongovernmental organizations. While the goal is not to agree on every stream reach assignment, this project will help to define a framework for conducting the public process in the remainder of the region.
Product:	Framework document detailing the criteria and process for assigning stream classifications and tiered uses.
Information Available:	Results of Projects 3, 4, 6, 8, and 9
Estimated Cost:	$75,000 – 150,000
Schedule:	One year
Potential Collaborators:	Regulatory agencies and regulated stakeholders

Project 12:	**Integrate BCG and TALU development with potential biocriteria**
Issue:	Formulation of tiered aquatic life uses will be most useful if there are appropriate criteria available to ensure protection of waterbodies within each tier. Currently, no biocriteria have been established as regulatory water quality standards for southern California streams although the Southern California IBI for macroinvertebrates has been suggested. On-going algae work, including that proposed in Project 1, could provide information with which to develop biocriteria for algae, if algae criteria can be developed that serve as good indicators of biological condition. If appropriate biocriteria can be formulated, they could be used as measurement benchmarks with which to evaluate impairments and restoration progress as well as document protection of different aquatic life uses.
Tasks:	1. Establish a task force consisting of regulatory, regulated, and nongovernmental agencies to provide a context for biocriteria interpretation. This group may best be served by using a regulatory agency as the lead. 2. Create a framework that maps the relationship between beneficial uses in basin plans, biocriteria, use attainability analysis, and antidegradation policies. Data compiled and used as part of this workplan should help immensely. 3. Write a consensus-based white paper outlining the regulatory model that can be used as the basis for integrated policy development.
Product:	White paper outlining the regulatory model that can be used as the basis for integrated policy development
Estimated Cost:	$75,000-$150,000
Schedule:	One to two years
Potential Collaborators:	Regulatory agencies and regulated stakeholders

Project 13:	**Determine potential tiered water quality objectives**
Issue:	In developing tiered aquatic life uses, it may be appropriate to modify water quality objectives to reflect what is necessary to obtain and maintain aquatic life uses for that tier. For example, if a high quality tiered aquatic life use is identified (and supported by both BCG and available biological condition data), it may be critical to have more stringent water quality objectives for certain parameters, such as oxygen, temperature, sediment, and possibly certain chemical pollutants, than are necessary for more standard aquatic life uses. Likewise, if a tiered use is identified for highly modified waterbodies, it may be desirable to modify objectives in cases where a less stringent objective may be adequately protective. Tiered or modified water quality objectives may not be appropriate for certain types of parameters. While there have been some evaluations of this issue at the national level, no guidance has been developed. If and how objectives are modified in concert with TALU will have a direct bearing on how TALU is implemented.
Tasks:	1. Convene a workshop consisting of regulatory agencies, resource agencies, and invited scientists to discuss appropriate actions in tasks 2-3 below. 2. Evaluate what EPA and others have considered, and list the pros and cons of different strategies for dealing with tiered water quality objectives. 3. Identify a preliminary list of parameters for possible tiering, as well as a list of parameters for which tiered objectives would be inappropriate. 4. Identify a pilot study to test the feasibility of tiered water quality objectives. Where possible, actual data for parameters should be examined from segments representing all tiers.
Product:	Topical Workshop. Position paper recommending results of evaluation and parameters potentially subject to tiering, if any. Design for Pilot Study.
Estimated Cost:	$50,000 to $75,000
Schedule:	Six months to one year
Potential Collaborators:	Regulatory and regulated entities.

Project 14:	**Link TALU with other regulatory programs**
Issue:	Local, State, and Federal regulatory programs do not operate in isolation from one another. Water quality standards, biocriteria, total maximum daily loads (TMDLs), NPDES permitting, 401/404 certification for streambed alteration are just a few examples. Optimizing the interplay between regulatory programs and regulatory agencies will help reduce redundancy and increase effectiveness of the regulatory framework. This will be particularly important in determining if TALU should be initiated at the local, regional, or statewide level.
Tasks:	This project will require two tasks. First, a policy committee should be gathered to help evaluate optimal implementation strategies. This policy committee should contain representatives from regulatory, regulated, and environmental advocacy organizations. Regulatory program representation should include RWQCB, SWRCB, and EPA. Second, the committee should draft an implementation workplan to coordinate efforts.
Product:	Implementation strategy workplan.
Information Available:	There are other examples that can serve as a model for this Committee including the State's Sediment Quality Objectives.
Estimated Cost:	$100,000 to $200,000
Schedule:	Two years
Potential Collaborators:	Regulatory and regulated entities

PROJECT INTEGRATION AND SYNTHESIS

The projects outlined in the previous section are designed to address major data gaps in our understanding of biological responses to stressors in southern California perennial streams and how the stressor axis of the BCG should be constructed and applied. These projects are necessary to formulate a scientifically defensible framework upon which tiered aquatic life uses can be developed and implemented. To make the most efficient use of available resources, certain projects should be completed or at least largely completed prior to others. Ideally, regulators and stakeholders would cooperatively lay out the TALU development framework in order to make the process efficient, effective, and transparent. To that end, we see projects being conducted in four phases, understanding that there will be (and should be) some overlap in the timing of different phases so that the process is as efficient as possible.

In the first phase, basic information is needed regarding biological responses to stressors, characterizing the stressor gradient, and the types of data available for BCG analyses. Therefore, Project #3 (natural condition definition and appropriate classification) and Project #5 (characterize range of biological condition data available) should be initial priorities. Unless these projects are addressed, subsequent BCG or GSG-related projects may be flawed or incomplete. Simultaneously, Project #7 (improve physical habitat measures to develop the GSG), Project #8 (improved base maps for stressors), and Project #9 (evaluate indices of human disturbance) should also be first phase projects of high priority. Results of Projects 7, 8, and 9 will be instrumental in developing a sound GSG axis with which subsequent BCG development can occur. The outcome of the first phase of projects will be:

- A better understanding of how natural condition should be described biologically
- Available data or information to characterize Level 1 of the BCG (at least for macroinvertebrates)
- Degree to which the full range of biological condition is represented using available site data for the southern California
- Preferred ways to characterize the stressor gradient and data refinements needed to define and quantify the GSG
- Refinements to physical habitat metrics and results that will feed into the GSG characterization and provide useful information for other programs and applications
- More informative base maps to allow better characterization of the range of stressor intensity represented using current biological sites

A second phase of projects would build on the ones noted above, refining the BCG further using other assemblage data (algae, Project #1, and riparian vegetation, Project #2). The inclusion of algae and riparian vegetation condition attributes is considered key to making the BCG more robust and scientifically defensible. The inclusion of these assemblages, as well as macroinvertebrates (and fish or other vertebrates to the extent possible), will ensure that a broader range of effects of stressors are included in the BCG and properly interpreted. The timing of these projects would also allow completion of current algal and CRAM data collection efforts, which will be instrumental in completing Projects 1 and 2. Results of Phase 2 would be a more comprehensive BCG that can now be refined in Phase 3 using expert consensus and site-specific information.

The third phase of projects would further refine and ultimately complete previous work in the form of more complete, robust BCG characterization (Project #6), and consideration of ways that may be effective in restoring certain tiers of aquatic life uses in some cases (Project #10, evaluate effects of BMPs and other site-specific factors on biological condition). The analysis of more site-specific biological-stressor relationships (Project #10) is neither necessary, nor desirable when formulating the BCG for a region (Phases 1 and 2) but is useful once a regional BCG is developed and the beginnings of implementation are being considered. Site-specific relationships can also be helpful in validating the BCG and determining the types of stream conditions that may be highest priority for restoration efforts.

The fourth and final phase of projects addresses TALU implementation issues (Projects 11, 12, and 13). In order to develop appropriate implementation criteria for stream classification, tiered uses, biocriteria, and appropriateness of tiered water quality objectives, a well-characterized and accepted BCG (including a robust GSG) is critical. The science provided in the first 3 phases will help guide appropriate implementation strategies. While biocriteria can be developed without TALU, implementation of biocriteria in the context of TALU is likely to have greater environmental benefits, be easier for regulatory agencies to implement in the long run, and be more defensible to stakeholders. Phase 4 projects could start as Phase 2 projects are being completed, once better information becomes available to characterize the BCG and GSG. However, Phase 4 implementation projects are not likely to be completed until after BCG development is complete (Phase 3).

While approximate costs are provided in the project descriptions, the estimates are by no means rigorous and there are many opportunities for cost savings by leveraging among projects and outside studies. For example, there are at least eight projects that rely on compiled databases of biological condition, hydrology, physical habitat, and stressor information. Obviously, this needs only to be done once and, even then, portions will be done in individual project development (i.e., stressor specific information, Project 8). Another example would be the formation of expert panels and task force committees. Virtually every project would benefit from the use of independent, multi-sector review as a means for oversight, validation, and transparency. These committees are crucial to success, but a new committee is not needed for every study. One committee could take on the challenge of several projects, especially if the projects are similar in nature such as those described within each of the implementation phases. Finally, the potential collaborators for these projects were repeated over and over again. An integrated approach with multiple agencies attacking these data gaps will increase the cost leveraging necessary to overcome the hurdles to achieving TALU.

REFERENCES

Ode, P.R., A.C. Rehn and J.T. May. 2005. A quantitative tool for assessing the integrity of southern California coastal streams. *Environmental Management* 35:493-504.

OEPA. 2008. State of Ohio Water Quality Standards. Chapter 3745-1 of the Administrative Code. Effective April 23, 2008. Ohio Environmental Protection Agency, Division of Surface Water, Standards and Technical Support Section. Columbus, OH.

Tetra Tech. 2005. Evaluation of Tiered Aquatic Life Uses (TALU) for Southern California Coastal Streams. Draft Summary Report. Prepared for: EPA Region 9 and California Los Angeles Regional Water Quality Board. Tetra Tech, Inc. Owings Mills, MD.

Tetra Tech. 2006. Revised Analyses of Biological Data to Evaluate Tiered Aquatic Life Uses (TALU) for Southern California Coastal Streams. Prepared for: EPA Region 9 and California Los Angeles Regional Water Quality Board. Tetra Tech, Inc. Owings Mills, MD.