SCOPE OF WORK

Project 2.1: Meeting biological expectations in urban streams (Focused on Water Quality, Flow, and Restoration)

Revised: February 4, 2025

Background

Regulatory agencies are considering water-quality thresholds for stream biointegrity measurements. The San Diego Regional Water Quality Control Board recently became the first in California to propose an objective based on California Stream Condition Index (CSCI) scores – a biological scoring tool that may be applied to other regions in the future. However, past research by the SMC and others have shown that urban streams (particularly those that have undergone channel modification) rarely achieve scores above proposed thresholds. As a result, there is growing interest in understanding the most effective management options that could be implemented to meet any proposed threshold– either through water quality improvements alone, or in combination with stream restoration work.

The SMC is currently finishing a project trying to assess the biological potential in urban streams with modified habitat, flows, and/or water quality. This project has shown that biointegrity scores in urban streams can improve and that there are often a mix of stressors identified that can impact stream biointegrity. What remains unknown, however, is what biointegrity score improvements can be achieved solely through flow management or water quality improvements (i.e., NPDES permit requirements) or solely through physical habitat (i.e., stream restoration) because these biointegrity stressors typically co-occur. The SMC's current project has attempted to tease apart water quality and hydrology from physical habitat, but insufficient synoptic data exists within the current SMC stream monitoring program. The current SMC project has also attempted to compare restored streams reaches to comparable reaches that have not been restored, but finding stream restoration sites that could be sampled has been a challenge.

Getting answers to questions about improvements in stream biointegrity and CSCI scores by improving water quality and hydrology vs habitat remains a fundamental data gap in the SMC region. Without more quantitative information about these two stressors, SMC managers are hamstrung on the most effective and efficient steps to take towards meeting regulatory compliance for stream biointegrity requirements.

Objectives

The objective of this study is to answer two questions:

1. Can biological conditions in urban streams be improved or maintained by water quality improvements or flow management alone?
2. How does restoring urban streams improve biological conditions in urban streams?

General Approach

The first question relating water quality and biointegrity can be answered using two different approaches. The first approach is to continue the methods currently being pursued by the SMC, namely comparing water quality measurements and hydrologic conditions to biointegrity index scores across a range of stream conditions and stressors. Additional effort may be necessary to supplement the data set with new water quality data. The advantage of this approach is that the streams are in a realistic condition, but have so many co-stressors that the effect of improved water quality may be muted.

The second approach for relating water quality, hydrologic conditions and biointegrity is to experimentally test the effects of water quality or flow on biological communities using mesocosms. This will require setting up an outdoor experimental stream mesocosm, which are not easy but have been used in research around the country, including California. Then, the effect of water quality or flow can be directly tested by altering the water quality while holding other factors constant. While less realistic than actual streams, other potential confounding factors are held steady and the effect of water quality or flow can be tested independently from the effects of habitat quality.

The second question relating restoration to biointegrity can also be answered using two different approaches. The first approach is to continue the methods currently being pursued by the SMC, namely analyzing the existing database on stream conditions and stressors to assess possible effects of restoration. The analysis could focus on streams with physical conditions representative of restored sites as a proxy for restoration sites.

The second approach for relating restoration to biointegrity is to sample restored streams before and after restoration to assess the effect(s) of restoration on stream condition. This approach will require identifying sites well ahead of restoration to quantify pre-restoration conditions, and then for several years post-restoration to see if/how stream conditions improve. This is a much more powerful approach compared to the first approach but will take more time and effort.

For this project we recommend a four-phased study design starting with the easier and cheaper approaches first and then progressing through more difficult and expensive approaches as needed.

a) The first phase will create project governance including an Advisory Committee and a Workplan
b) The second phase will focus on analysis of existing data to achieve the answers currently available, while simultaneously gathering more information for later phases so managers can decide whether additional work is advisable.
c) The third phase will focus on collection of new data to support and expand the existing data in the first phase, hopefully filling necessary data gaps to complete the analysis.
d) The fourth phase will implement the most experimental of the study design elements: the mesocosm experiments. These experiments have great potential but are somewhat novel.

Specific Tasks for Phase 1: Project governance

Task 1A. Create an Advisory Committee.

We will convene a Technical Advisory Committee comprised of stream restoration experts from agencies that oversee restoration programs. Potential members may include experts from the Regional Water Quality Control Board 401/404 programs, the Department of Fish and Wildlife Habitat Conservation Branch program, mitigation/conservation bank curators, restoration funding agencies (i.e., State Coastal Conservancy, Rivers and Mountain Conservancies), restoration practitioners, and/or academics focused on restoration research. The exact agencies needed for the Advisory Committee, and potential persons to fill these positions, will be reviewed and approved by the SMC Steering Committee.

Products:

- *Creation of Technical Advisory Committee.*

Task 1B. Create a Project Workplan.

This Technical Advisory Committee will help the SMC develop a workplan that includes a list of candidate sites for sampling and a classification system to support analyses of different types of restorations. As part of developing the workplan, we will conduct reconnaissance and site visits to evaluate the suitability of sites for sampling and obtain additional information about restoration activities. The Workplan will be reviewed and approved by the SMC Steering Committee.

- *Project Workplan*
- *Database of past restoration sites (including both natural and modified channels).*
- *List of sites with planned restorations for sampling to address question #2.*

Specific Tasks for Phase 2: Analysis of existing data and preparing for later phases

Task 2A. Analysis of existing data.

We will analyze existing data from the SMC regional stream monitoring program to explore the relationship between water quality and CSCI scores along gradients of habitat condition. We will explore a variety of methods, which may include quantile regressions within classes of modified channels, structural equation models, and other suitable methods. We will explore relationships between water quality, hydrologic conditions, and biointegrity index scores. We will also identify gaps where additional data collection could improve these models.

Products:

- *Model or computer algorithm for the SMC region that can predict improved biointegrity index scores based on water quality improvements in modified channels to help answer question #1.*

Task 2B. Review of mesocosm feasibility

We will review scientific and technical literature on stream mesocosm studies investigating the relationship between water quality and benthic organisms, focusing on studies in California. We will identify facilities in California where experiments could be run (e.g., the Experimental Stream Channels at the Sierra Nevada Aquatic Research Lab [SNARL]; see picture). We will also explore options for creating a new facility.

Figure 1. SNARL facilities in Mono County, CA.

Products:

- *Literature review summarizing stream mesocosm studies conducted in urban streams, with a focus on California.*
- *A recommendation where such studies should be conducted to address question #1.*

Specific Tasks for Phase 3: Collection of new data

Task 3A. Collection of new water quality data

Because the SMC's regional stream monitoring program collects data largely at randomly selected sites – which is the appropriate design for that project - it is likely that data gaps will appear in the gradient of impact due to water quality needed for this proposed project. After conducting the data analysis in Phase 1, it will become clear where these data gaps occur between water quality and CSCI scores. We will identify the sites that will likely fill the data gaps identified in Phase 1. Then, SMC members will collect data at 12 to 24 priority sites, and we will re-calibrate and validate the models developed in Task 1A.

Products:

- *Candidate sampling sites with potential to fill data gaps.*
- *Updated models relating water quality to index scores.*
- *Journal article or technical report summarizing the updated model relating water quality to index scores along gradients of habitat quality, providing an answer for question #1.*

Task 3B. Collection and analysis of data at restored sites

We will assess whether restorations that have already taken place by analyzing existing data, and collecting additional data at suitable restored sites. We will match locations of existing restoration sites in the workplan to sites with existing bioassessment data in CEDEN or the SMC data portal. We will compare conditions at these sites to conditions at comparably urbanized but unrestored sites.

We will also identify a list of restored sites where bioassessment sampling could occur. By repurposing sites in the SMC regional stream bioassessment program, data will be collected at an additional 20 restored sites, targeting priority restoration types identified by the project Technical Advisory Committee. Conditions at these sites will be compared to 20+ unrestored comparator sites and to 20+ urban "benchmark" sites (i.e., urban sites that represent goals for restoration projects).

Products:

- *Water quality, physical habitat, and biointegrity data at 20 restored sites.*
- *Technical report comparing conditions at restored sites to unrestored comparators and to urban benchmark sites to address question #2.*

Task 3C. Establish baseline at sites where restoration is planned.

We will quantify the biointegrity improvements due to restoration using a before-after-control-impact (BACI) or similar study design. We will identify 10+ sites where restoration is likely to occur within the next 5-10 years and begin baseline data collection at these sites. In addition, we will identify 10+ unrestored comparator sites where no major interventions are planned, and 10 "benchmark" sites that represent the target condition for the restoration projects. Sampling is intended to collect at least 3 pre-restoration samples and 3 post-restoration samples. Sampling will be conducted through the SMC regional stream survey.

Data will be analyzed using statistical tests appropriate for BACI designs (e.g., repeated measures ANOVA). However, data analysis and reporting will not occur until after sufficient data have been collected (e.g., 5+ sites with 3+ years of post-restoration data). We assume that this will not occur within the intended timeframe of the project.

Products:

- *Data at 10+ sites where restorations are planned.*
- *Data summaries to address question #2 (full data analysis and reporting not expected during this phase of the study; analyses will take place after restorations are completed).*

Specific Tasks for Phase 4: Mesocosm experiments

Task 4A: Develop a mesocosm workplan

The Technical Advisory Committee will be amended with at least one external person with expertise in running mesocosm experiments. The Technical Advisory Committee will assist with the development of a workplan for a mesocosm study, including selection of a facility, priority stressors, and key endpoints to examine.

Products:

- *A workplan for the mesocosm study.*

Task 4B: Conduct mesocosm study

A mesocosm study consistent with the workplan designed in Task 3A will be conducted. This task will likely employ a factorial design with two levels of habitat quality (e.g., simplified vs. complex channel forms) and three levels of two water quality parameters (e.g., high, medium, and low concentrations), each with 3 levels of replication for a total of 54 experimental units. Limiting the scope to a single water quality parameter may reduce the cost of by a factor of ~3. The study will likely take place over multiple years.

Products:

- *A report or journal article summarizing the impacts of two water quality parameters and habitat quality on biological endpoints within a stream mesocosm answering question #1.*
- *A database of mesocosm data linked to the SMC website.*

Schedule

The schedule is focused on Phases 1 and 2. Phase 3 details should wait until it is needed and the Technical Advisory Committee has provided input on study design.

Phase	Task	Notes	Start Date	End Date
1	1A	Restoration focused Tech Adv Comm,	Jul 2025	Sep 2025
	1B	Project Workplan, database of past restoration sites, list of recommended monitoring sites for quantifying restoration improvements in CSCI	Sep 2025	Dec 2025
2	2A	Analysis of existing data for CSCI – water quality relationships	Jul 2025	Jun 2026
	2B	Review of mesocosm feasibility including literature review and recommendations	TBD	TBD
3	3A	Data from new sites to fill data gaps, final model of water quality-CSCI relationships, technical report/journal article	Mar 2026	Jun 2027

	3B	Data from new sites to fill data gaps in restoration vs non-restoration comparisons, technical report/journal article	Mar 2026	Jun 2027
	3C	Data from new sites where restoration is planned (i.e., pre-restoration data)	Mar 2026	Jun 2028
4	4A	Workplan for mesocosm study	TBD	TBD
	4B	Mesocosm study	TBD	TBD

Budget

The budget is focused on Phases 1 and 2. Phase 3 details should wait until it is needed and the Technical Advisory Committee has provided input on study design.

Phase	Task	Notes	FY 2025/26	FY 2026/27	FY 2027/28	FY 2028/29	TOTAL
1	1A	Project Advisory Committee	49,000 [c]				49,000
	1B	Project Workplan	25,000 [c]				25,000
2	2A	Analysis of existing data for CSCI – water quality relationships	52,000				52,000
	2B	Review of mesocosm feasibility including literature review and recommendations					TBD
3	3A	Data from new sites to fill data gaps, final model of water quality-CSCI relationships, technical report/journal article [a]		47,000			47,000
	3B	Data from new sites to fill data gaps in restoration vs non-restoration comparisons, technical report/journal article [a]		43,000	44,500	47,000	134,500
	3C	Data from new sites where restoration is planned (i.e., pre-restoration data) [a, b]		60,000	21,500	22,500	104,000
4	4A	Workplan for mesocosm study					TBD
	4B	Mesocosm study					TBD
		TOTAL	126,000	150,000	66,000	69,500	411,500

[a] assumes data collection and analysis is embedded within the existing regional stream bioassessment program.

[b] future funding will be required to complete this task once restoration is completed.

[c] These funds cover all four Fiscal Years.