SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

BIOLOGICAL OBJECTIVES FOR THE SAN DIEGO REGION

DRAFT STAFF REPORT

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BIOLOGICAL OBJECTIVES FOR THE SAN DIEGO REGION

Staff Report, February 2019

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REGIONAL WATER QUALITY CONTROL BOARD
San Diego REGION

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EXECUTIVE SUMMARY

Periodic review of the Water Quality Control Plan for the San Diego Basin (Basin Plan) is required by State and federal law. California Water Code section 13240 states that Basin Plans "…shall be periodically reviewed and may be revised." Federal Clean Water Act (CWA) section 303(c)(1) states that the Water Boards "…shall from time to time (but at least once each three-year period…) hold public hearings for the purpose of reviewing applicable water quality standards and, as appropriate, modifying and adopting standards." Because federal law requires that water quality standards be reviewed every three years, the periodic review of the Basin Plan is commonly referred to as the "triennial review."

A priority of the California Water Quality Control Board San Diego Region (San Diego Water Board) 2014 triennial review of water quality standards was the amendment of the Basin Plan to incorporate biological water quality objectives in order to protect and restore beneficial uses associated with aquatic and aquatic dependent wildlife. On May 13, 2015, the San Diego Water Board adopted Resolution R9-2015-0043, which directed staff to begin working on the project to amend the Basin Plan to incorporate biological water quality objectives.

A water quality objective for biological condition is critical to restoring and maintaining the biological integrity of the region's waters. Since the development of the CWA and Porter-Cologne Water Quality Control Act (Porter-Cologne) the San Diego Water Board has relied on direct measurements of a waterbody's chemistry to assess if beneficial uses of waters for human health and ecosystems are protected. These beneficial uses center around the objective of the CWA, which is to restore and maintain the chemical, physical, and biological integrity of the Nation's Waters (U.S. Code title 33, chapter 26, subchapter 1, section 1251(a)). Forty years of CWA and Porter-Cologne implementation in the San Diego Region has overwhelmingly focused on management of chemical integrity on a pollutant-by-pollutant and waterbody-by-waterbody basis. While largely appropriate for human health risk, this approach is insufficient to fully protect and restore the biological integrity of waters. Given the scientific advancements in biological metrics for streams, the use of a chemistry-only approach is no longer justified.

Biological assessments provide direct measures of the cumulative and integrated response of the biological community to all sources of stress, as the organisms are exposed to these stresses over time. Through this long-term exposure in their natural setting, biological communities provide the most comprehensive measure of the condition of the beneficial uses related to biological integrity. Biological objectives set the biological quality goal, or target, to which water quality can be managed against, rather than the maximum allowable level of a stressor(s) (pollutant or other water quality condition) that affects the aquatic life in that waterbody.

Evaluating the biological condition of waterbodies allows the San Diego Water Board, other regulatory and regulated agencies, and the community at-large to take a more balanced and holistic approach when identifying priority areas for protection and restoration. This approach is also intended to better integrate ecosystem beneficial uses with other core beneficial uses related to human health for drinking water, recreation, and fish and shellfish consumption.

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List of Acronyms and Abbreviations

ASCI	Algae Stream Condition Index
Basin Plan	Water Quality Control Plan for the San Diego Basin
BMI	Benthic Macro Invertebrates
BMP	Best Management Practice
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
CTR	California Toxics Rule
CWA	Clean Water Act
CADFW	California Department of Fish and Wildlife, formerly Department of Fish and Game (DFG)
DO	Dissolved oxygen
D18	Diatom-based IBI
GIS	Geographic Information System
H20	“Hybrid” algae IBI
HU	Hydrologic Unit
IBI	Index of Biotic Integrity
IPI	Index of Physical Habitat Integrity
Listing Policy	Water Quality Control Policy for Developing California’s Section 303(d) List
LOE	Line of Evidence
MDL	Method Detection Limit
MEP	Maximum Extent Practicable
mg/L	milligrams per liter (parts per million)
MS4	Municipal Separate Storm Sewer System
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Limit
RWB	Reachwide Benthos
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
S2	Soft algae based IBI
SCCWRP	Southern California Coastal Waters Research Program
SMC	Southern California Stormwater Monitoring Coalition
SOP	Standard Operating Procedures
SWAMP	Surface Water Ambient Monitoring Program
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load

TSS	Total Suspended Solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WDR	Waste Discharge Requirement
WLA	Wasteload Allocation
WQBEL	Water Quality Based Effluent Limit
WQIP	Water Quality Improvement Plan
WQO	Water Quality Objective
WQS	Water Quality Standard

1. Introduction and Purpose

1.1. Introduction

The federal Clean Water Act (CWA) gives states the primary responsibility for protecting and restoring surface water quality. In California, the State Water Quality Control Board (State Water Board) and nine Regional Water Quality Control Boards (Regional Water Boards), collectively referred to as the California Water Boards, serve as the agencies with the primary responsibility for implementing CWA requirements. One such responsibility includes the development and adoption of water quality standards. Water quality standards, as defined in CWA section 303(c), consist of designated uses[1] of waterbodies, criteria to protect those uses, and an antidegradation policy. The criteria can be either narrative or numeric. A typical narrative criterion, for example, prohibits "the discharge of toxic pollutants in toxic amounts." Numeric criteria establish pollutant concentrations or levels in water that protect designated uses. An example of a numeric saltwater criterion for copper to protect aquatic life is 3.1 micrograms per liter (µg/l) as a monthly average.

The states are primarily responsible for the adoption of water quality standards, although USEPA has oversight and promulgation authority, as well. In California water quality standards are found in statewide and regional water quality control plans. Water quality control plans contain beneficial use designations, water quality objectives to protect those uses, and a program to implement the objectives. Water quality objectives are the State equivalent of federal criteria under CWA Section 303(c).

1.2. Summary

The San Diego Water Board is proposing an amendment to the Water Quality Control Plan for the San Diego Basin (Basin Plan). The amendment includes the following:

1. Narrative guidance for the development of numeric biological objectives for surface waters in the San Diego Region;
2. A numeric biological objective for perennial and seasonal streams;
3. A program of implementation that contains a description of appropriate monitoring programs for the numeric biological objective; and
4. Actions that shall or should be undertaken when results indicate numeric biological objectives are not being met.

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[1] Known as Beneficial Uses in California. This document uses state terminology throughout for consistency with the Water Quality Control Plan for the San Diego Basin.

1.3. Purpose

The purpose of this staff report is to present the San Diego Water Board's Basin Plan amendment to incorporate narrative guidance for developing biological objectives and a numeric objective for perennial and seasonal streams. This staff report also presents the scientific basis and rationale used to develop the narrative guidance and numeric objective, describes the programs and implementation actions related to the amendment, outlines monitoring program requirements, and includes supplemental environmental documentation pursuant to California Environmental Quality (CEQA) requirements for approved regulatory programs.

2. Project Intent and Applicability

This section provides an overview of the intent and applicability for biological objectives in the San Diego Region.

2.1. Project Goals and Intent

Biological assessment, or bioassessment, is the science of evaluating the health of an ecosystem by assessing the organisms that live within it. The goal and intent of the biological objectives project is to utilize biological assessment ("bioassessment") to better protect and restore waters by facilitating a broader evaluation of the effects of stressors that extends beyond the existing regulatory convention of analyzing for individual chemicals. The amendment of the San Diego Water Board Basin Plan will mirror the goal of the CWA to protect and restore the biological integrity of waters (33 U.S. Code § 1251), and of Porter-Cologne which defines the *Quality of Water* to include chemical, physical, biological, bacteriological, and radiological properties (CWC section 13050). Unlike traditional chemistry-based monitoring, which provides only limited information about a relatively narrow portion of the environment at a discrete point in time, bioassessment can account for living organisms exposed to multiple chemicals and other stressors (such as altered habitats and changes in water-flow patterns) over extended time periods. Consequently, bioassessment has the potential to provide a more integrated reflection of the condition of an aquatic ecosystem; bioassessment also is more closely tied to environmental managers' end-goal focus on ecosystem protection and serves as an important way to monitor and protect the populations of endangered species and fisheries.

2.2. Beneficial Uses

Under Porter-Cologne, specifically Water Code section 13050 (f), beneficial uses of waters of the State may be designated as follows (emphasis added):

> *Beneficial uses of the waters of the State that may be protected against quality degradation include, but are not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and **preservation and enhancement of fish, wildlife, and other aquatic resources or preserves**.*

Of the 23 designated beneficial uses within the San Diego Basin Plan, 10 beneficial uses directly relate to the protection of biological condition, or integrity, of waters within the San Diego Region. These are commonly referred to as "aquatic life" beneficial uses and are outlined in Table 1, below. In addition, attainment for other beneficial uses, such as those related to recreation and fishing, indirectly rely upon the attainment of those beneficial uses in Table 1.

Table 1. Beneficial Uses in the San Diego Water Board Basin Plan related to Biological Objectives and Integrity

Beneficial Use	Abbreviation	Description of Beneficial Use
Warm Freshwater Habitat	WARM	support warm water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates
Cold Freshwater Habitat	COLD	support cold water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates
Inland Saline Water Habitat	SAL	support inland saline water ecosystems, including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates
Estuarine Habitat	EST	support estuarine ecosystems, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g. estuarine mammals), waterfowl, (shorebirds)
Marine Habitat	MAR	support marine ecosystems including, but not limited to, preservation or enhancement or marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g. marine mammals, shorebirds)
Wildlife Habitat	WILD	support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g. mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources
Preservation of Biological Habitats of Special Significance	BIOL	support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance, where the preservation of natural resources requires special protection
Rare, Threatened, or Endangered Species	RARE	support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered
Migration of Aquatic Organisms	MIGR	support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish
Spawning, Reproduction, and/or Early Development	SPWN	support high quality habitats suitable for reproduction, early development and sustenance of marine fish and/or cold freshwater fish

2.3. Applicable Waters

Biological objectives within the San Diego Region may be developed for all surface Waters of the State within the San Diego Region, and specific numeric objectives will be developed and applied by waterbody-type, sub-type, or on a site-specific basis as developed. Surface waterbody types, as defined by the San Diego Water Board Basin Plan, include inland surface waters, coastal waters, and lakes and reservoirs. Waterbody types also include subcategories based on general attributes. As an example, coastal waters include ocean waters, enclosed bays, and estuaries

3. Narrative Guidance for Development of Numeric Biological Objectives

3.1. Introduction – Water Quality Objectives

Along with beneficial uses, Regional Water Boards are required under Porter-Cologne (CWC section 13241) to establish water quality objectives for Waters of the State which are necessary for the reasonable protection of beneficial uses and the prevention of nuisance.

CWC section 13050 defines water quality objectives as:

> *The limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or prevention of nuisance within a specific area.*

As defined in the San Diego Water Board Basin Plan and required under the CWA implementing regulations at 40 CFR 131.11(a)(1): "water quality objectives must protect the most sensitive of the beneficial uses which have been designated for a specific waterbody." While the San Diego Water Board is tasked with protecting the physical, chemical, and biological integrity of surface water beneficial uses, existing water quality objectives in the Basin Plan emphasize the chemical integrity of waters on a pollutant-by-pollutant basis. Doing so assumes that water quality objectives for pollutants will, if attained, result in beneficial use attainment and protection.

However, the use of chemistry-based water quality objectives, alone, is a "bottom-up" paradigm based on laboratory observed effects data and simplistic systems models that rarely scale-up to represent the more complex natural ecosystem (Cairns et al. 1993, Scrimgeour and Wicklum 1996).

Use of water chemistry alone in waterbody assessment does not adequately protect the biological integrity of waters due to the necessarily constrained temporal and spatial extent of chemical monitoring, the limited number of chemicals and matrices that can feasibly be monitored, cumulative and synergistic effects, sublethal effects, and the inability of chemistry-based assessment to detect impairment caused by pollution and not a pollutant (e.g. habitat modification).

Biological objectives are needed, in tandem with chemistry-based water quality objectives and physical assessment, to protect and restore the beneficial uses associated with ecosystem condition (USEPA 1991). For those waterbodies with a designated beneficial use(s) associated with the protection of aquatic ecosystems, chemistry-based water quality objectives alone do not protect the most sensitive beneficial use, nor do they provide accurate assessments of waterbody condition.

As called for in the CWA implementing regulations at 40 CFR 131.11, states should establish water quality objectives as numeric criteria using scientifically defensible methods, or narrative criteria where numeric criteria cannot be established (e.g. due to a lack of scientific development), or to supplement numeric criteria. Both narrative and numeric criteria have been identified by USEPA as a priority for California due to the percentage of impaired stream miles and need to protect existing high-quality waters (USEPA 2009). Given the scope of waterbody types and associated ecological communities in the San Diego Region, it is infeasible at this time to establish numeric biological objectives for all surface waters. Nonetheless, it is reasonable to establish an overarching narrative guidance to guide the current and future development of numeric biological objectives for all of the Region's surface waters.

3.2. Narrative Guidance

This technical report provides the support for the San Diego Water Board Basin Plan's Implementation Chapter to be amended to incorporate the following narrative guidance for development of numeric biological objectives to protect existing beneficial uses:

The development of numeric biological objectives for surface waters within the San Diego Region shall be done to support an ecologically balanced and resilient community of organisms having a native species composition, diversity, abundance, and functional organization commensurate with that of unaltered analogous waters.

This narrative guidance, which is discussed below, was used as the basis for the development of numeric biological objectives for perennial and seasonal streams.

3.3. Discussion Regarding Narrative Guidance

The narrative biological objective development guidance incorporates language that centers on the ecological concept of biological integrity through ecosystem protection. This includes the use of a reference approach as a benchmark to evaluate community condition, as well as maintaining specific ecological characteristics indicative of a balanced and resilient biological community of organisms. This requires that similar habitats be compared using the reference approach, and that the community of organisms within those habitats be composed of native species.

3.3.1 Ecosystem Protection: Biological Integrity

The ten beneficial uses directly related to biological communities in the San Diego Water Board Basin Plan all rely on the protection of ecosystems and subcategories of functions within those ecosystems. This includes habitats necessary to protect rare, threatened, or endangered species, as well as for the protection of specific aquatic-organism life-cycle needs. The Wildlife Habitat beneficial use extends the use of water to that which supports terrestrial ecosystems (e.g. wildlife water and food sources).

As a result, narrative guidance to develop numeric biological water quality objectives must include sufficient language to ensure ecosystem protection and allow for meaningful evaluation of ecosystem condition. The objective of the CWA is clearly to restore and maintain the chemical, physical, and biological **integrity** of the Nation's waters. There can be debate regarding what constitutes ecosystem "condition," usually in the context of requiring an evaluation and definition of ecosystem "health" or "integrity," both of which have vastly different expectations and are thereby fundamentally different (Karr 1995). The use of "health" has been inconsistent in the scientific literature and in a regulatory context, and thus is inappropriate in this evaluation context due to its judgmental nature, inconsistency with the scientific method, and misuse through insertion of personal values under the guise of scientific impartiality (see Scrimgeour and Wicklum 1996, Lackey 2001).

The CWA does not define biological integrity, though it was discussed extensively in committee (Davis and Simon 1995). Dr. James Karr, who coined "index of biotic integrity," defines the integrity of an ecosystem as one that has a "balanced, integrated, adaptive system having the full range of elements (genes, species, assemblages) and processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in areas with minimal influence from modern human society" (Karr 1999). As such, the inclusion of a "top-down" approach that utilizes biological measurements of ecosystem integrity is needed, with specific inclusion of waters subjected to minimal human influence to serve as both a baseline and comparator (see Cairns et al. 1993).

3.3.2 Reference Approach

The proposed narrative guidance relies on the use of *unaltered analogous waters* to define the ecosystem condition that is indicative of attaining biological integrity and thus be able to set targets for maintaining or achieving that condition. This process is referred to as the reference approach.

In order to protect and restore beneficial uses associated with aquatic ecosystems, thus meeting the goal of Porter-Cologne and the CWA, there must be a point of reference for establishing objectively whether beneficial uses have been attained.

Biological data, such as measures of community composition that form the basis for bioassessment, facilitate direct insight into the integrity of facets of an aquatic ecosystem, but they present a challenge. Whereas traditional water-chemistry measures lend themselves to the establishment of empirically derived levels not to be exceeded (in order, for example, to avoid toxic effects on humans and/or wildlife), this paradigm is not well suited to setting objectives in the case of biotic-community measures. Rather, the most tractable means to judge the integrity of ecosystems *vis-à-vis* bioassessment scores, that balances transparency and intuitiveness with practicality, is to compare scores at test sites with those from "reference" sites, where the latter serve to set expectations for what biotic communities *should* look like in the face of minimal human disturbance.

This approach is consistent with the development of the CWA and its goals (USEPA 1991). While the CWA does not define reference, the 1972 House Committee on Public Works and Senate Public Works Committee identified biological integrity as exemplified by systems that existed before perturbations caused by man's activities, and that such systems could be identified with confidence by scientists (Davis and Simon 1995).

While there are many potential ways to define "reference" (reviewed by Stoddard et al. 2006), for the purposes of biological objectives in the San Diego Region, a reference site is considered to be one that is exposed to very low or no anthropogenic stress. This approach allows for the use of contemporary bioassessment scores at minimally disturbed sites throughout the State as a point of reference (rather than guessing, or attempting to reconstruct, what scores might have been during pre-Columbian times), thus reducing uncertainty, limiting assumptions, and promoting defensibility.

3.3.3 Analogous Waters

The concept of "analogous waters" is necessary in order to guarantee that "apples are being compared to apples" in the course of determining whether biological objectives are met. If a test site is an eelgrass bed, its biological condition should be interpreted by comparing it to those of analogous waters, meaning reference-quality *eelgrass beds* (rather than other waterbody types).

In addition, the environmental context within which a test site exists, in terms of the natural gradients (latitude, elevation, etc.) associated with that site, is important to consider. Attainment of biological objectives is determined within the context of expected results at reference sites (i.e., "comparator sites") that occupy *similar environmental contexts* to the test sites.

In the case of stream benthic macroinvertebrates, comparison of a given test site's results to an analogous set of reference sites' results is pre-loaded into the California Stream Condition Index (CSCI) calculation, because of the way in which the CSCI was constructed (Mazor et al. 2016). A statewide algae index (the "ASCI") designed like the CSCI is expected to become available circa 2019.

3.3.4 Ecological Balance and Resiliency

Ecosystems are often challenged by disturbances of natural and/or anthropogenic origin. Under certain circumstances, for example, when crucial thresholds have been crossed (Hilderbrand and Utz 2015), these disturbances can result in temporary or permanent shifts in the nature of the ecosystem, potentially compromising ecosystem services (e.g., primary and secondary productivity, detritus decomposition, pollination, soil formation, and nutrient uptake and fixation; Truchy et al. 2015). Disturbance regimes can vary in duration and severity, and natural disturbance plays a key role in many ecosystems. Disturbances may be episodic and abrupt in nature, such as a 100-year flood in a riparian wetland, or a wildfire leading to sedimentation following subsequent storms, or they may be more gradual and persistent, such as rising temperatures due to global climate change.

In addition to natural disturbances, anthropogenic stressors can also directly disrupt ecosystems and threaten services. The “urban stream syndrome” (i.e., consistently observed ecological degradation of streams draining urban land; Walsh et al. 2005) reflects the effects of the variety and interplay of human-caused stressors to streams. Example stressors include flashy hydrographs, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species. Sources of the stress include urban storm water runoff delivered to streams by hydraulically efficient (engineered) drainage systems, as well as combined or sanitary sewer overflows, wastewater treatment plant effluents, and legacy pollutants (Walsh et al. 2005).

An important goal in protection and restoration of ecological integrity is resilience of the ecosystem, such that disturbances do not permanently curtail the provision of ecosystem services. Ecological resilience is the degree to which an ecosystem can absorb, or withstand, environmental stress or disturbance, and still maintain self-organization (i.e., characteristic structure and function (Holling 1973; Gunderson and Holling 2001)). Resilient ecosystems are those that have the capacity to retain attributes in the face of disturbances.

In a resilient stream ecosystem, key ecological attributes such as species composition, or the range of ecosystem functions performed, remain consistent over long time scales or readily return to pre-disturbance states following perturbations (Hilderbrand and Utz 2015, see Figure 1). Oliver *et al.* (2015) define “resilience” as the degree to which an ecosystem *function* can resist (or recover rapidly from) environmental perturbations, thereby maintaining function above a socially acceptable level.

Figure 1. Upper Boulder Creek in the San Diego River Watershed Pre and Post 2003 *Cedar Fire*. Bottom photo is pre-2003 fire while the top photo is post-2003 fire. This reference quality stream had sufficient resilience to this anthropogenic fire disturbance event and was able to recover after multiple years of rainfall flushed excess sediment from the system (San Diego Water Board 2016b).

Oliver *et al.* (2015) go on to state that attributes at play at the level of the population down to the individual can all influence ecosystem resilience. Population-level examples include the intrinsic rate of population increase (i.e., species with a high intrinsic rate of increase will recover more quickly from environmental perturbations) and genetic variability (which increases the likelihood that genotypes that are tolerant to a given environmental perturbation will be present in a population—this can include epigenetic effects). Adaptive phenotypic plasticity (which encompasses flexible behavioral or physiological strategies that promote survival, such as thermoregulation) plays a role at the species/individual level.

Community-level attributes within a single trophic level are also important for determining ecosystem resiliency. One example relates to the interplay between individual resident species' "response" and "effects" traits, in that a higher correlation between the two results in lower resistance in ecosystem function. Another example is functional redundancy: According to Oliver *et al.* (2015), when multiple species perform similar functions (i.e., they exhibit some redundancy in their contributions to ecosystem processes), the resistance of an ecosystem function will be higher if those species also have differing responses to environmental perturbations; this is further enhanced in the case of negative spatial and/or temporal covariance (asynchrony) between species' population sizes, driven by differing responses to environmental change or competition.

Among trophic levels, interactions between species, such as predation, parasitism, or mutualism, can also have profound effects on ecosystem resilience. For example, extinction cascades can reduce network stability. Highly connected, nested networks dominated by generalized interactions are less susceptible to cascading extinction effects and provide more resistant ecosystem functions in contrast to networks dominated by strong specialized interactions (Oliver *et al.* 2015).

In summary, an ecologically balanced and resilient community of organisms is needed to ensure that an ecosystem can respond to natural disturbance and withstand and recover from anthropogenic disturbance.

3.3.5 Native and Non-native Species

The narrative guidance specifically stipulates that the community of organism have a **native** species composition, diversity, abundance, and functional organization commensurate with that of unaltered analogous waters. As discussed above, ecological balance and resilience are critical for maintenance of ecosystem function and support of aquatic-dependent beneficial uses. Non-native species include those not naturally found within an ecosystem and which have been introduced, intentionally or otherwise, into habitats where they otherwise would be absent (e.g. see Williams and Meffe 1998).

Impacts of non-native species are well documented in the scientific literature, with a multitude of individual and collective species resulting in drastic changes in ecosystem and biological integrity and functional organization, including causing or contributing to declines in native species, and in some cases extinction (Savidge 1987, Vitousek 1990, Ellison et al. 2005).

Common examples of especially destructive non-native species in the United States include the tree snake (*Boiga irregularis*), snakehead (Channidae), quagga and zebra mussels (*Dreissena rostriformis bugensis* and *D. polymorpha*), Caulerpa (*Caulerpa taxifolia*), Asian carp (Cyprinidae), Italian rye grass (*Lolium multiflorum*), and bullfrog (*Rana catesbeiana*, (Lowe et al. 2000, Orlova et al. 2005, Kupferberg 1997, Huenneke et al. 1990, Herborg et al. 2007). Damage from non-natives can be so expansive that on February 03, 1999, Executive Order 13112 was signed by President William Clinton to “minimize the spread of invasive non-native species and… protect the assets and security of the United States.”

The presence of non-native species within an ecosystem can be indicative of a non-reference condition, as ecosystems with high native species diversity and richness have been shown to be invasion resistant (“diversity resistance hypothesis,” Stachowicz et al. 1999, Kennedy et al. 2002, Seabloom et al. 2003). The ability for non-native species to invade an ecosystem and for that invasion to become a success, thus causing subsequent cascading ecosystem impacts, is typically tied to disturbance events (specifically anthropogenic) that reduce native species diversity and competition. In order for a non-native species to survive and exhibit a positive growth rate, there often must be resources available not used by native species. Such a window of opportunity typically occurs as a result of anthropogenic disturbance, such as deforestation, modified fire regimes, excessive grazing, and modification of hydrology.

The impact and influence of non-native species can be site-specific and often co-occurs with disturbance. For example, historic conversion of estuarine mudflat or sandy beach habitat to rocky riprap or hardened structure has allowed for the introduction and proliferation of *Sargassum*, a non-native brown macroalgae dependent on shallow hard habitat in marine locations sheltered from wave action, such as bays and coves. In many shallow quiescent southern California marine areas, such as the leeward side of islands, *Sargassum* outcompetes native algae (Kaplanis et al. 2016).

In the San Diego Region non-native species have the capability of altering or displacing native species and communities through habitat alteration, competitive displacement, and/or direct removal (e.g. Crooks 1998). As an example, in riparian systems throughout the Region the giant reed *Arundo donax* has displaced native riparian vegetation, caused stream hydromodification, increased fire risk, and dewatered streams, all of which have displaced native species and altered the entire ecosystem (Bell 1997). The impacts from this species have such an extensive impact on human health and wildlife that millions of dollars have been allocated through grants within the San Diego Region for restoration. For example, on March 09, 2017, the California Department of Fish and Wildlife's Wildlife Conservation Board granted $2.3 million dollars to the Mission Resource Conservation District for a cooperative project with the La Pata Mitigation Project, Integrated Regional Water Management, U.S. Army Corps of Engineers and local agencies to control 98 acres of *Arundo donax* on 17.8 river miles in the San Juan, Santa Margarita, San Luis Rey, and San Diego watersheds in Orange and San Diego Counties.

4. Numeric Objective for Streams

4.1. Introduction

This section provides support for the use of a numeric objective for perennial and seasonal streams[2] (hereinafter referred to as the *Stream Biological Objective*) in the San Diego Region. The support relies on State of California standardized methods, peer-reviewed assessment tools, and results from two decades of bioassessment evaluation in the Region.

Under the CWA states may establish numeric water quality objectives where scientifically defensible methods are available (see 40 CFR 131.11(b)). While California has historically focused on chemical-specific parameters, other states have included numeric biological criteria to protect the biological integrity of beneficial uses associated with fish, wildlife, and other aquatic resources or preserves. For example, the State of Ohio incorporated biological criteria into Ohio Water Quality Standards in 1990, and North Carolina utilizes both fish and benthic macroinvertebrates as biocriteria for its streams.

Evaluation of the biological integrity of various surface waters using resident organisms is often referred to as "bioassessment." The use of bioassessment can give a better indication of the status of a waterbody and if beneficial uses are being protected or impaired by comparison of site-specific results with those found at defined reference sites. Bioassessment for wadeable streams in California dates back to 1975, when the California Department of Water Resources began sampling sites in its Northern District. In 1992, the United States Geological Survey (USGS) and California Department of Fish and Wildlife[3] (CADFW) began large-scale bioassessment monitoring and method standardization efforts for California. The State of California has been conducting bioassessment monitoring in the San Diego Region using benthic macroinvertebrates for at least twenty years and soft algae and diatoms for over fourteen (Figure 2, Table 2).

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[2] This includes perennial streams that flow year-round and intermittent streams that may flow from a few weeks to months during a typical rainfall year. The definition for covered streams is discussed in section 4.5.
[3] Formerly the California Department of Fish and Game

Figure 2. Long Canyon Creek, San Diego County. Long Canyon Creek is a long-term reference site that has been sampled by the State of California since 2001.

The State of California's Surface Water Ambient Monitoring Program (SWAMP) has developed standard operating procedures for bioassessment field sampling, laboratory identification of specimens, quality assurance/control, data management, and reporting. The development of biological scoring tools, often referred to as indices or metrics, has been on-going during that time period, with various regional indices developed throughout the State for different organisms such as benthic macroinvertebrates (e.g. Ode et al. 2005, Rehn and Ode 2005, Rehn et al. 2008, Rehn 2010), algae (Blinn and Herbst 2003, Herbst and Blinn 2008, Fetscher et al. 2014), and higher trophic level organisms such as amphibians and/or fish (Moyle and Randall 1996, Moyle and Marchetti 1999). In 2015 the State of California released a peer-reviewed statewide California Stream Condition Index (CSCI, Mazor et al. 2016[4]) for assessing the biological condition of wadeable streams throughout the State based on benthic macroinvertebrates. The CSCI utilizes a combined-reference-site approach to determine the site-specific benthic community expected to be present at any sampled site. The data collected by these programs, and indices developed for benthic macroinvertebrates and algae, serve as the basis for the inclusion of the numeric objective for streams.

Table 2. History of State of California Stream Bioassessment Programs in the San Diego Region

Agency	Program	Time Period
SWAMP	Reference Condition Management Program	2008 - present
SWAMP/USEPA	Perennial Stream Assessment/EMAP/CADFW	1996 - present
San Diego Water Board and SWAMP	Regional Monitoring Programs	1998 - present
State and Local Municipalities	Stormwater Monitoring Coalition	2009 - present

4 See Appendix I for additional documentation details. Note that the CSCI was accepted and published online in 2015.

4.2. Reference Stream Approach for the Stream Biological Objective

The foundation of the proposed Stream Biological Objective relies on the identification of *unaltered analogous waters*, consistent with the proposed narrative guidance, as a reference point for evaluation of condition (see Section 3.3.2). This is known as the reference stream approach.

California's SWAMP has facilitated the reference stream approach by maintaining a long-term data set for benthic macroinvertebrates and benthic algae community composition, in-stream physical habitat, chemistry, and riparian-condition scores based on the California Rapid Assessment Method (CRAM) through the Reference Condition Management Program (RCMP). This program has collected biological data from a network of over 750 reference sites around the State since the program's inception in 2000, with repeat sampling at subsets of sites over time. RCMP sites are distributed across natural gradients representing different latitudes, elevations, geological settings, flow regimes, etc (Figure 3).

Thus, to the extent that natural gradients influence aquatic community structure, the means are available, through the use of "comparator sites" within the RCMP network, to "subtract" the effects of key gradients of natural variation from test-site bioassessment scores, leaving residual variation as a signal reflective of the degree and nature of anthropogenic stress at play. In addition to RCMP, the southern California Stormwater Monitoring Coalition (SMC) conducts bioassessment at trend and probabilistic sites throughout southern California on an annual basis. The SMC program randomly selects a subsample of sites that qualify as reference, collecting benthic macroinvertebrates, benthic algae community, in-stream physical habitat, chemistry, and CRAM data.

Reference sites for the RCMP are designated based on filtering them through a suite of criteria primarily related to surrounding land-uses (i.e. using geographic information system (GIS) data), in order to identify those that are minimally disturbed (described in detail in Ode et al. 2016). For the purposes of the Stream Biological Objective in the San Diego Region, the reference pool will continue to be reevaluated and updated over time, as feasible and necessary, as the applicable science and technological tools available for determining reference continue to evolve.

The concept of reference comes into play in two ways that are relevant to the Stream Biological Objective. First, the two components of the CSCI (taxonomic completeness and predicted multi-metric index, Mazor et al. 2016) were both calibrated based on an understanding of benthic macroinvertebrate community composition within the RCMP network of reference sites throughout the State. Second, the Stream Biological Objective for benthic macroinvertebrates is derived from percentiles of the distributions of scores from reference sites within the RCMP network. Other biological metrics based on stream benthic algae and riparian assessment scores, discussed in Section 4.3 below, also use reference sites and reference site scoring distributions.

Figure 3. Long-term reference stream bioassessment sites sampled under the Surface Water Ambient Monitoring Program's Reference Condition Management Program. Beginning clock-wise from upper left: south coast, central coast, north coast, desert-modoc. Photos: A. Rehn.

4.3. Stream Biological Objective and the Confirmation Approach

This technical report provides the support for the San Diego Water Board Basin Plan to be amended to incorporate the following Stream Biological Objective to protect existing beneficial uses:

> *Perennial and seasonal streams[5] shall support biological conditions consistent with unaltered reference streams. Compliance with this objective is determined using the California Stream Condition Index (CSCI). CSCI scores less than the 10th percentile of the reference calibration sites do not meet the biological objective. However, where the cause of a low CSCI score is natural in origin, compliance with the biological objective may be determined using an alternate analytical method approved by the San Diego Water Board. Alternative analytical methods include, but are not limited to: "Algal Index of Biotic Integrity for Southern California Streams" scores, "Index of Physical Habitat Integrity" scores, "California Rapid Assessment Method" (CRAM) scores, and sediment or water chemistry.*

The Stream Biological Objective uses a single threshold for the CSCI. As the CSCI is a predictive index based on reference condition, thresholds have been set in accordance with the likelihood, or risk, that sites are not reference. The threshold is set at the 10th percentile, with scores above meeting the Stream Biological Objective. Scores below the 10th percentile show a condition of "likely to be altered" or "very likely altered." Such sites are considered not in attainment of the objective unless the San Diego Water Board determines that site-specific information shows the stream is indeed attaining expected reference condition and low CSCI scores are due to natural factors. This site-specific reference confirmation will rely on additional physical, chemical, and biological scientific information for the stream, as well as substantial evidence on the naturally occurring factors influencing the CSCI score.

Multiple existing beneficial uses are directly and indirectly protected by the Stream Biological Objective (Table 3). The use of the CSCI as a Stream Biological Objective directly protects the WARM and COLD beneficial uses, which specifically include invertebrates. The Stream Biological Objective also indirectly protects the WILD, BIOL, RARE, MIGR, and SPWN beneficial uses as benthic macroinvertebrates are a critical component of supporting the species or habitats these beneficial uses encompass.

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[5] For the purpose of this objective, "seasonal streams" means freshwater streams that are expected to be inundated with flowing water for at least four weeks between the months of February and October, except during periods of atypical or extreme drought. Seasonal streams have sufficient flows to conduct bioassessment sampling for stream aquatic benthic macroinvertebrates in most years. Seasonal streams do not include those streams that only exhibit ephemeral flow, which is flow that occurs only during or immediately following (e.g. 24-48 hours) rainfall events.

Table 3. Beneficial Uses Directly and Indirectly Protected by the Stream Biological Objective

Beneficial Use	Abbreviation	Description of Beneficial Use
Warm Freshwater Habitat	WARM	support warm water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, **including invertebrates**
Cold Freshwater Habitat	COLD	support cold water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, **including invertebrates**
Wildlife Habitat	WILD	support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g. mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources
Preservation of Biological Habitats of Special Significance	BIOL	support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance, where the preservation of natural resources requires special protection
Rare, Threatened, or Endangered Species	RARE	support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered
Migration of Aquatic Organisms	MIGR	support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish
Spawning, Reproduction, and/or Early Development	SPWN	support high quality habitats suitable for reproduction, early development and sustenance of marine fish and/or cold freshwater fish

4.4. Discussion Regarding the Stream Biological Objective

This section discusses the selection of the CSCI, selection of CSCI thresholds based on the concept of reference quality and risk, and the use of additional scientific results where the cause of a low CSCI score is natural in origin.

4.4.1 California Stream Condition Index (CSCI)

The CSCI has been selected as the appropriate index for use as an objective over regionalized indices (e.g. southern California IBI) for benthic macroinvertebrates due to its use of reference as a benchmark, incorporation of natural gradients, allowance for incorporation of new site data over time and space, and use of both species composition and functional organization in determining stream condition. Utilization of the CSCI as a basis for the Stream Biological Objective to determine condition is consistent with the proposed narrative guidance, the intent of the CWA, and Porter-Cologne.

Unlike prior indices of biotic integrity for benthic macroinvertebrates, which rely on evaluation of the community structure based on reference streams in fixed locations at a fixed point in time, the CSCI utilizes a predictive framework to identify reference sites across the State that show similar abiotic properties (e.g. precipitation, elevation, temperature) and thus more similar biological communities. This predictive approach is used to determine the community of organisms that would be expected to be present (i.e. “taxonomic completeness”), as well as the functional organization of the community, under the assumption of minimal anthropogenic stress.

The pool of reference sites can be augmented by the State or other interested entities (e.g. Stormwater Monitoring Coalition, NGOs), and can include repeated sampling over time at selected sites, which will both increase precision and allow for incorporation of predicted reference condition change over time if influenced by external factors, such as climate change. The State of California also maintains a stream bioassessment Reference Condition Management Program that annually monitors qualifying reference sites, including in the San Diego Region.

4.4.2 CSCI Reference Quality

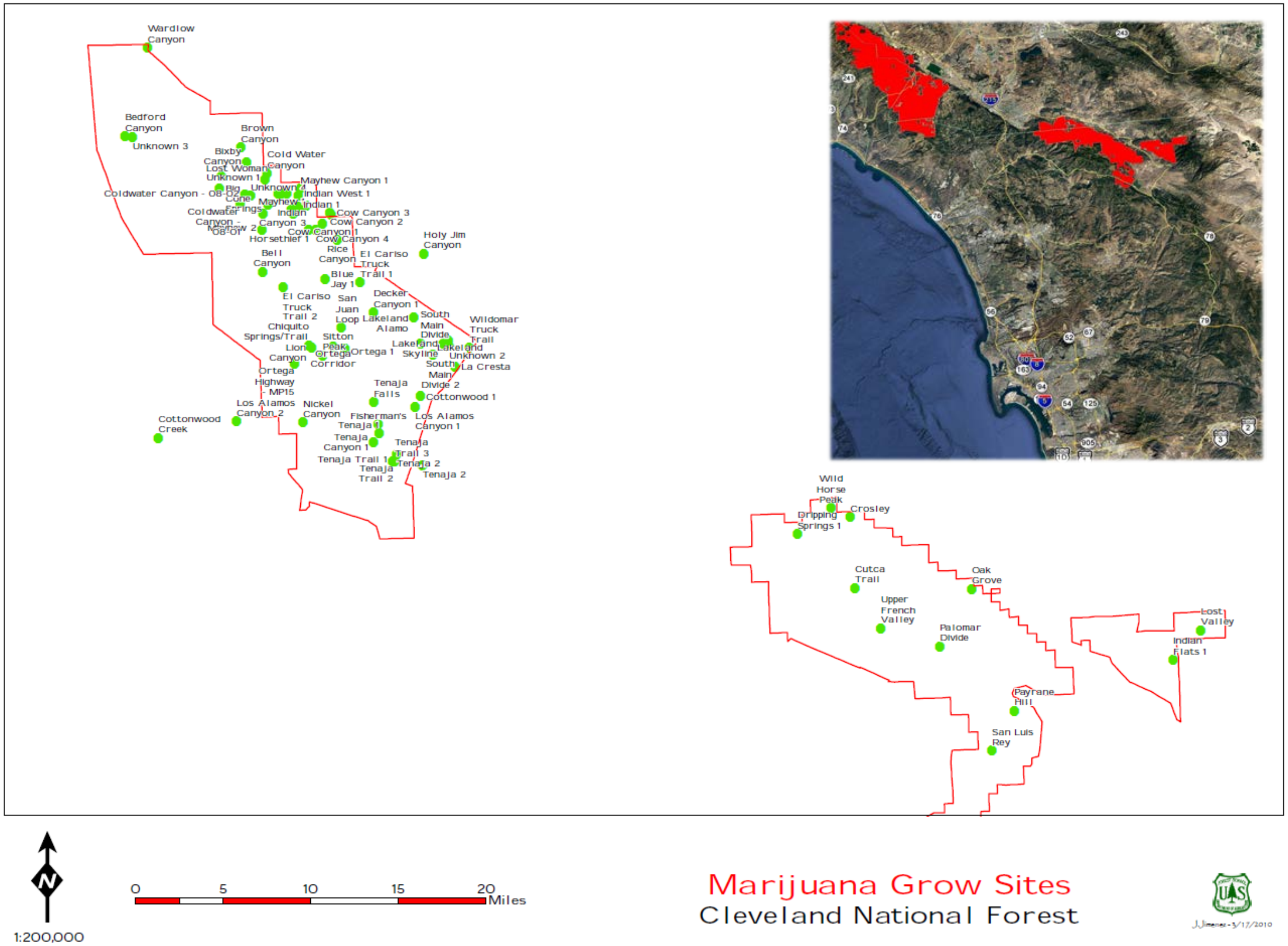
As discussed previously (section 3.3.2), the definition of "reference" and identification of reference stream reaches by the State are critical components in beneficial use evaluation using the Stream Biological Objective. The miss-identification of sites as reference and their inclusion within the CSCI development process would theoretically result in reference site score distributions not as indicative of a condition of "true reference." The CSCI development process defined specific criteria for selection of sampling reaches that met the reference definition (see Ode et al. 2016), which was based on high-resolution ad-hoc land-use and attribute mapping in GIS and screening in order to achieve a balance "between environmental representativeness and biological integrity…sufficient to support robust regulatory applications" (Ode et al. 2016). The metric screens used in the CSCI development and by the RCMP are intended to ensure that most types of anthropogenic activity that could impact stream condition are kept to a minimal level, though some activities are not captured by land-use geographic metrics and are therefore not included in screening. These include discrete activities not captured at larger scales (discussed below) and some larger anthropogenic impacts, such as atmospheric deposition, that can impact sensitive species and beneficial uses (e.g. Fellers et al. 2004, Smalling et al. 2013).

Larger-scale reference screening for CSCI development sites and continued RCMP monitoring is followed by an "on-the-ground" post-hoc validation conducted by trained sampling crews. A trained crew can flag a sampling reach in a database as *not* meeting reference criteria based on field observations. Sampling reaches that have passed through the GIS screens for reference can still be excluded from reference for a variety of reasons, including, but not limited to, flow diversions, unmapped roads and crossings, mining operations, and fire events, as flagged and documented by sampling crews. However, there are smaller unmapped anthropogenic alterations that may occur in a stream's tributary watershed that may not be reliably excluded from reference by either the GIS mapping or the field crew observations. These include activities such as illegal grazing, unauthorized marijuana cultivation, unpermitted upstream crossings, and illegal mining. These activities can, unknowing to scientists or the sampling crew, impact the benthic community sampled which results in that site's incorrect inclusion within the "reference" pool of sites.

As an example, long-term flow monitoring of streams has revealed the presence of otherwise undocumented flow diversions, including in reaches that would otherwise qualify as reference based on GIS land use mapping (Mazor et al. 2014). In addition, information provided by law enforcement agencies have identified potential impacts associated with illegal marijuana cultivation in otherwise reference-quality watersheds, including wilderness areas in the San Diego Region (Figure 4). Such anthropogenic activities, if known, would result in these streams potentially not being treated as reference due to possible sources of pollution and flow modification associated with these activities. In some cases, however, such non-reference reaches are sampled and unwittingly included in the reference pool. When available, additional information, even if acquired post-sampling, should be considered for possible reclassification of reference sites for future sampling.

It is important to note that the step-wise approach for identifying reference sites results in potential unidirectional bias, with some reference sites potentially included in metric development (e.g. CSCI) that are non-reference. It is also possible for some potential reference sites to be erroneously excluded from the State reference pool by inaccurate screening. While the existing statewide reference network has a robust sample size and replication maintained by the State and cooperative agencies, the exclusion of sites can un-necessarily limit the size of the reference pool, and future site reference screening and updates to the CSCI by the State will likely include consideration of sites that may be erroneously screened out on a site-by-site basis due to incorrect or outdated land use data. This can increase CSCI score confidence and precision ever further over time, further improving the threshold identified for the Stream Biological Objective, which can be updated in future Basin Plan amendments (see Section 4.4.3 below for additional discussion on CSCI threshold selection).

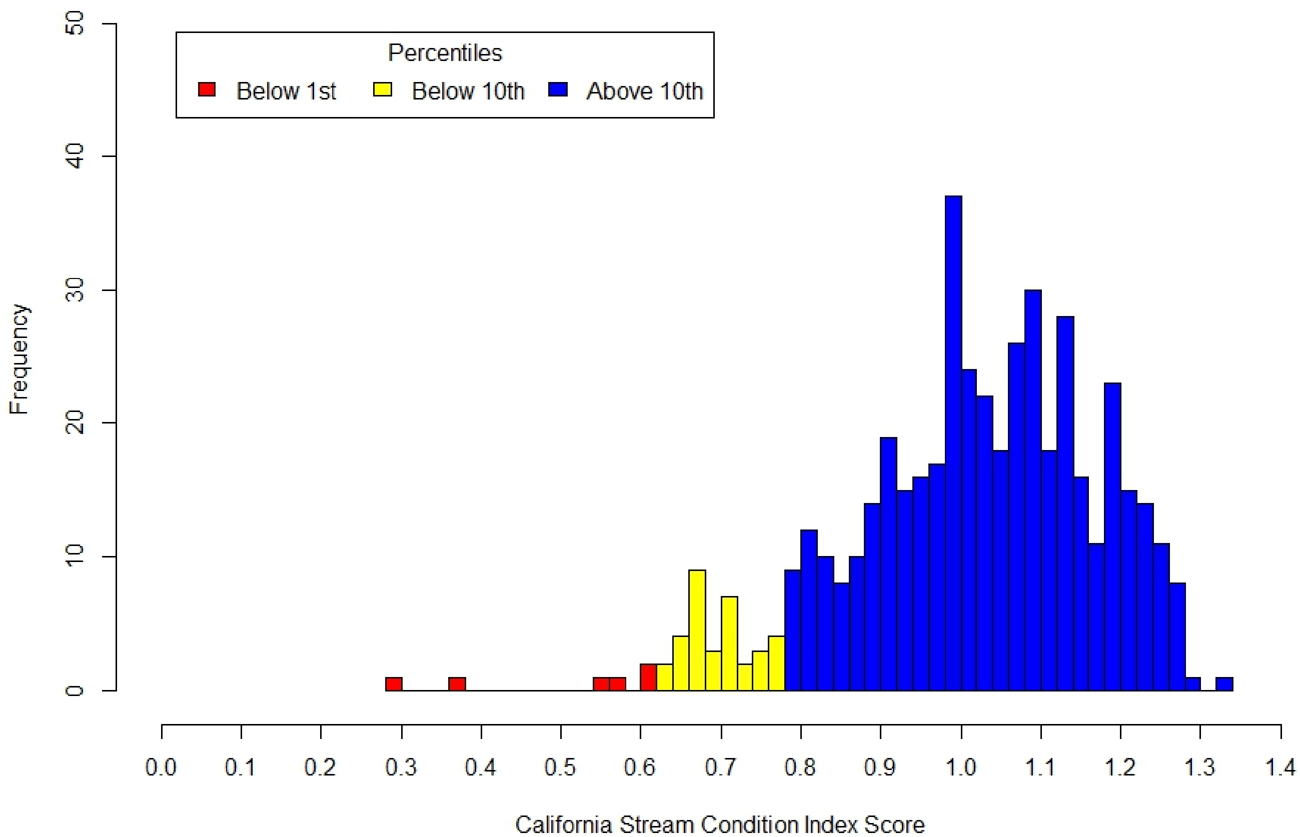
Figure 4. Map of Illegal Marijuana Grow Sites in Cleveland National Forest, including the San Mateo Wilderness (2010). Location of National Forest lands denoted by red areas within inset map.



4.4.3 Selection of the CSCI Threshold

The selection of index scoring thresholds to identify impacts associated with natural and/or anthropogenic disturbance is an important component of the use of any conditional index. As the CSCI is a predictive index based on reference condition, the threshold has been set in accordance with the likelihood, or risk, that sites are not reference. As discussed in section 4.4.2 above, reaches identified as reference-quality for the CSCI meet a **minimum level** of screening for anthropogenic alteration; however, due to imperfect knowledge about all stressors potentially at play, some seemingly reference reaches may actually be more than just minimally disturbed, and may not truly qualify as reference for the purposes of setting a numeric biological objective. In addition, some site-specific naturally occurring stressors may not be wholly represented in the reference dataset. Due to this uncertainty, the 10th percentile is used as a threshold for the CSCI, with the inclusion of evaluation of compliance, at the discretion of the San Diego Water Board, where naturally occurring factors may suppress a stream's CSCI score (Mazor et al. 2016, Figure 5).

Figure 5. Distribution of California Stream Condition Index scores at reference calibration sites used to set thresholds in Mazor et al. 2016. Colors denote thresholds at the 1st and 10th percentiles (0.63 and 0.79, respectively).



The 10th percentile was selected as a threshold to add certainty, incorporate a margin of safety, and reduce risk associated with miss-identification of stream reaches as being of “reference” quality given the uncertainty around the miss-identification of sites in the reference pool. The 10th percentile is the threshold designated by the creators of the CSCI (Mazor et al. 2016) as indicative of a threshold state that, when scoring below, is “likely to be altered” or “very likely to be altered,” implying relatively low confidence that reaches with such scores below 0.79 qualify as reference quality condition. In addition, analysis of statewide CSCI results by CSCI authors have identified sites below the 10th percentile threshold as being in “poor” condition (Rehn 2016). For the Stream Biological Objective, the selection of the 10th percentile as the threshold, with a limited site-specific caveat for a further reference “likeness” determination, was based on this designation by the CSCI authors, combined with the likelihood that the reach does not represent comparability to a “true” minimally disturbed reference condition.

The use of the 10th percentile (vis-a-vis 90th percentile) is common throughout the literature and across ecosystem types for data standardization, index development, ecological condition evaluations, setting standards, and environmental risk assessment (USEPA 1992a, Van Dolah 1999, Snyder et al. 2003, Hawkins 2006, Borja et al. 2008) including for existing numeric objectives in the San Diego Water Board Basin Plan (San Diego Water Board 2016c). For example, when updating human health criteria for drinking water and fish consumption in 2015, USEPA used the upper 90th percentile consumption rate for drinking water and fish tissue to represent the general U.S. adult population (USEPA 2015).

Scores used for integrity evaluations associated with other biological condition indices are also classified as “degraded” based on the quality of reference sites, with the 25th or 10th percentile (as a wide margin of safety) used in states and regions with greater anthropogenic stressors and fewer minimally disturbed reference reaches, or the 1st or 5th percentile where higher-quality and higher-confidence reference reaches are available for index development (see discussion in Pont et al. 2009).

The CSCI Stream Biological Objective has been set at the 10th percentile of the reference distribution, based on the rationale that, for reaches scoring below the 10th percentile, there is estimated to be 10 percent chance or less that they are *truly* representative of reference condition **<u>if, and only if,</u>** every single one of the reference sites in the CSCI development dataset themselves were 100 percent *truly* representative of reference condition. However, the current reference screening in Ode et al. 2016 does not provide 100 percent assurance that all sites sampled as reference and used in CSCI development were truly representative of reference. Thus, the Stream Biological Objective uses the 10th percentile to incorporate a margin of safety and as an estimated evaluation of risk. This is also consistent with recommendations for ecological risk assessments (see USEPA 1992b).

Setting the 10th percentile as a threshold provides for a margin of safety that the Stream Biological Objective is protective of reference biological condition. However, as discussed above, there is a low probability that sites scoring below the 10th percentiles are indeed scoring similar to reference, except for in very rare cases where streams may have naturally occurring stressors that are not well represented in the reference pool. Thus, for those reaches that score below the 10th percentile of the CSCI reference distribution, the San Diego Water Board may, at its discretion, utilize site-specific additional physical, chemical, and biological information on the stream (described below) to assess if the stream is truly like reference, thus preventing a "false positive" that a stream is unlike reference.

4.4.4 Scientific Reference Confirmation Approach

If the CSCI score for a given sampling reach is greater than the 10th percentile of the distribution of scores among reference sites, then no other information is needed in order for the reach to be considered "not degraded" (i.e., attaining the Stream Biological Objective). Likewise, if the CSCI score is less than the 10th percentile, it is considered degraded.

However, for those stream segments with CSCI scores below the 10th percentile of the reference distribution, the San Diego Water Board may, when given significant reason, consider other scientific results for a stream's biological, physical, and chemical condition as an alternative analytical method to show, to the satisfaction of the San Diego Water Board, that the site is truly similar to reference. This consideration is done at the discretion of the San Diego Water Board, and will be specific to where evidence is presented, to the satisfaction of the San Diego Water Board, that "*the cause of a low CSCI score is natural in origin*." Thus, conducting the determination will first be predicated on evidence that natural factors have suppressed the CSCI score, and that these natural factors thus preclude the accuracy of the CSCI in predicting reference condition.

Where the San Diego Water Board conducts this determination, the San Diego Water Board will use all relevant and scientifically valid physical, chemical, and biological condition information (discussed below) for the stream. This can include, but may not be limited to, indices of biotic integrity (or equivalent) for benthic algae, results from water column and sediment acute and chronic toxicity assays, chemical-based water quality objectives related to aquatic life, and physical habitat condition, such as using the Index of Physical Habitat Integrity (IPI, Rehn et al. 2018) or CRAM Scores (Physical and Biotic Structure) as discussed below. Examples of sites evaluated using such relevant and scientifically valid information are included as Figures 7 and 8.

This approach is consistent with the recommendations of USEPA, which considers toxicity, chemistry, and biology as independently applicable when evaluating if water quality standards are met, and states that “appropriate action should be taken when any of the three types of assessment determines that the standard is not attained” (USEPA 1991). USEPA also “encourages States to implement and integrate all three approaches into their water quality control programs and apply them in combination or independently as site-specific conditions and assessment objectives dictate” and also include considerations for habitat condition (USEPA 1991).

As further scientific biological, physical, and chemical science is developed, the San Diego Water Board may consider using such methods, tools, and results when making a determination of similarity to reference condition (e.g. Goldberg et al. 2011, Maruya et al. 2013, Mehinto et al. 2016, Macher et al. 2016, Hering et al. 2018).

Naturally Occurring Factors

Consideration of other scientific results to determine attainment of the Stream Biological Objective may be conducted when evidence is presented, to the satisfaction of the San Diego Water Board, that “*the cause of a low CSCI score is natural in origin*.” The San Diego Water Board does not expect to conduct this evaluation at every site that does not meet the Stream Biological Objective. The reason for this is two-fold:

1) The majority of streams subject to the Stream Biological Objective are well represented by reference sites in the CSCI’s reference data pool.

2) There are a limited number of natural disturbance events that may suppress CSCI scores.

The CSCI incorporates a wide range of reference sites that incorporate wide environmental gradients, including site elevation, ecoregion, slope, and other natural factors (see Olson and Hawkins, Mazor et al. 2016). This provides a reasonable level of assurance that a sampled stream is well represented by the CSCI due to the inclusion and evaluation of natural factors in the CSCI’s development. However, it is possible that a sampled site has site-specific natural stressors that are not well represented in the CSCI reference pool, and theoretically this *may* have the potential to result in suppressed CSCI scores. In addition, sites that are well represented in the reference pool *may* experience natural disturbance that results in suppressed CSCI scores (e.g. Hawkins and Sedell 1990). In such cases, the resulting CSCI score may not be representative of the reference-quality condition of a stream due to naturally occurring factors.

As an example, in the County of San Diego some groundwater contains naturally high levels of radionuclides and total dissolved solids (County of San Diego 2010, City of San Diego 2015a), and these naturally occurring factors *may* impact benthic macroinvertebrate communities where *they naturally occur* in streams through unaltered ground-surface water interactions. Anthropogenic modification that results in the unnatural presence of an otherwise naturally occurring factor or stressor that impacts CSCI scores will not be considered "natural in origin." Where significant scientific evidence is submitted to the San Diego Water Board in this regard then the San Diego Water Board may, at its discretion, conduct an evaluation and determination for applicable sites that do not meeting the 10th percentile threshold. The compliance implementation of this aspect of the objective is discussed in Section 5 of this report.

Scientific Biological Condition Information

Scientific biological condition information may be used by the San Diego Water Board, to determine if stream segments scoring below 10th percentile are truly representative of expected reference condition and thus are in compliance with the objective. Biological condition information for other organisms can provide degradation information that is directly or indirectly linked to benthic macroinvertebrates, thus providing information that can be used for either confirming attainment or non-attainment of the the Stream Biological Objective.

For example, other portions of the State of California, and other states, have developed specific metrics and indices of biotic integrity for other organisms, such as amphibians and fish, which are often used with or in addition to benthic macroinvertebrates to assess biological integrity (e.g. Moyle and Randall 1996, Hughes et al. 1998, Klauda et al. 1998, Moyle and Marchetti 1999, Nerbonne and Vondracek 2001, Marzin et al. 2014). For streams covered by the Stream Biological Objective in the San Diego Region, stream benthic algae are a primary example of relevant and scientifically valid information available for consideration when confirming the attainment or non-attainment of the biological uses.

Stream benthic algae ("algae") provide strong confirmation information for attainment or non-attainment of the Stream Biological Objective as algae community structure reflects impacts to a stream over time, are sensitive to changes in water chemistry (e.g. nutrients; Rehn 2016), and may provide a faster response to anthropogenic alteration and restoration than benthic macroinvertebrates (Parkyn et al. 2010). However, benthic algae may be less responsive to anthropogenic stressors associated with in-stream physical habitat degradation, which can limit their independent use to confirm beneficial use attainment (Rehn 2016). Peer-reviewed published indices of biotic integrity are available and used for assessment purposes in southern California for diatoms and soft algae, including cyanobacteria (Fetscher et al. 2014, e.g. Table 1-1 in SMC 2015). While not a predictive index akin to the CSCI, the indices utilize the same reference pool used for CSCI development, plus an additional number of non-perennial stream reaches. An algae stream condition index ("ASCI") is currently under development statewide and is expected to be available to supplement or replace the existing indices if needed. In addition, a State of California Standard Operating Procedure (SOP) has been written for collection of algae alongside benthic macroinvertebrates (Ode et al. 2016b).

Scientific Physical Habitat Condition Information

Scientific stream physical condition information may be used by the San Diego Water Board to determine if stream segments scoring below the 10th percentile are truly representative of expected reference condition and thus attaining the beneficial use. The physical condition of streams is directly linked to beneficial uses and benthic macroinvertebrates, as the physical habitat is the living space, and often food source, for living biota (Wallace et al. 1997, Kaufmann et al. 1999, Maddock 1999, Herbst et al. 2012, Herbst et al. 2016). As a result, habitat alteration may result in significantly higher impacts on benthic community condition than using chemical water quality objectives alone (see Hall et al. 2013). A stream's overall physical habitat integrity and alteration is directly linked to attainment of the Stream Biological Objective and is an important component of waterbody assessment for regulatory purposes (e.g. Integrated Reporting under the CWA, see section 5.4, San Diego Water Board 2016). For the Stream Biological Objective, physical habitat metrics associated with the stream, such as those in CRAM, are an example of relevant and scientifically valid physical information for consideration.

Multiple physical habitat metrics and assessment tools are available for streams, including assessment tools like the Hydrogeomorphic Approach (HGM, Brinson et al. 1995). More recent habitat metrics include CRAM and a physical habitat index of physical habitat integrity ("IPI", Rehn et al. 2018). CRAM is a USEPA Level 2 tool that involves a semi-quantitative assessment of multiple attributes of habitat condition for streams and other types of wetlands (Sutula et al. 2006, Stein et al. 2009, CWMW 2013). These include an overall score, a buffer and landscape score, a hydrologic connectivity score, a physical structure score, and a biotic structure score. For CRAM the stream reach's hydrologic, physical, and biotic structure attributes may be used (e.g. Rehn 2016) to determine a stream's likelihood of degraded conditions and thus confirmation of the attainment or non-attainment of the Stream Biological Objective. The IPI is a more prescriptive USEPA Level 3 tool that uses quantitative habitat protocol data collected as part of stream bioassessment to assess the in-stream physical habitat condition. Akin to the CSCI, the IPI uses a predictive approach to assess how similar the physical habitat in a stream is to reference-quality streams. IPI scores incorporate multiple physical habitat metrics and thus can be used to determine a stream's likelihood of degraded conditions and thus confirmation of the attainment or non-attainment of the Stream Biological Objective.

Additional metrics to assess physical stream condition, such as for hydrologic alteration (or "hydromodification") are in various phases of scientific research, development, and metric tool use availability (Stein et al. 2017a), with general assessment tools available, as well as guidance on conducting watershed-specific assessment. These additional metrics would be appropriate for use in place of or in conjunction with CRAM and the IPI to confirm attainment or non-attainment of the Stream Biological Objective. Sites with no evidence of degraded conditions as confirmed by benthic algae, toxicity, and water chemistry results, but with evidence of physical habitat alteration that is impacting benthic macroinvertebrates are good candidates for physical habitat restoration.

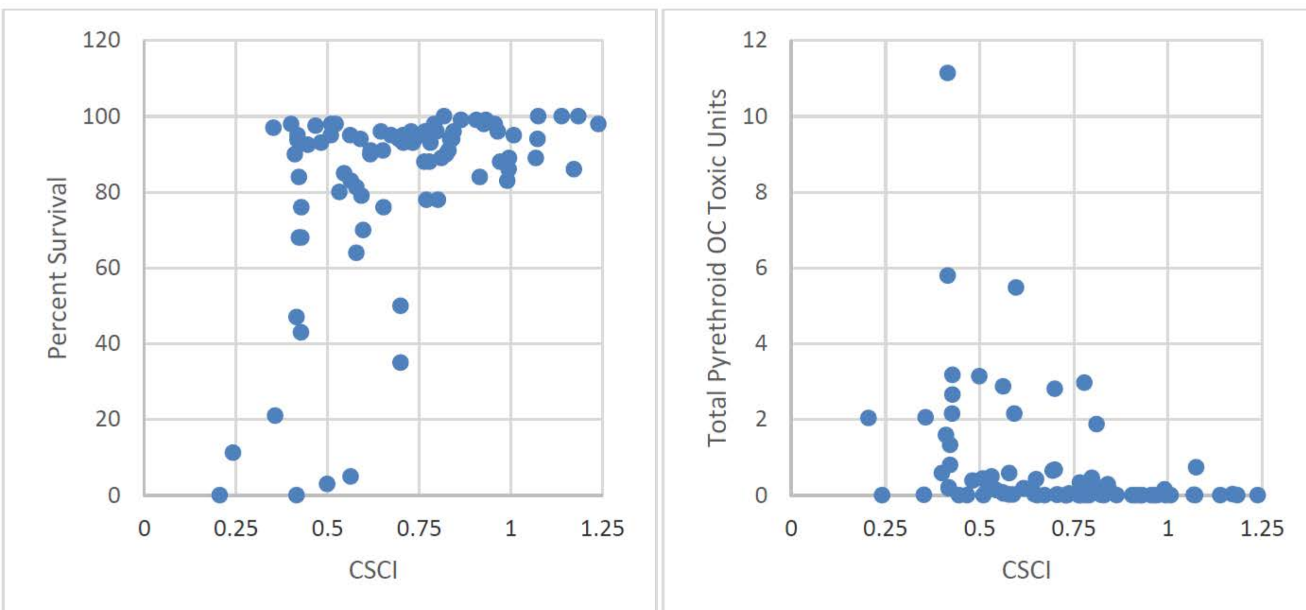
Scientific Chemical Condition Information

Scientific chemical condition information may be used by the San Diego Water Board to determine if stream segments scoring below the 10^{th} percentile are truly representative of expected reference condition and thus attaining the beneficial use.

Standardized lab toxicity testing using test organisms representative of stream systems provides additional evidence regarding the attainment or non-attainment of the beneficial use. Toxicity testing can provide a high confidence of non-attainment, thus confirming non-attainment, as it is a more direct measurement of the acute and chronic impact from the chemical conditions present in a stream system and their impacts on resident benthic macroinvertebrates (Weston et al. 2014, Phillips et al. 2016). Furthermore, evaluation of statewide site-specific toxicity data relative to CSCI scores shows the utility of toxicity testing to determine beneficial use attainment (Phillips et al. 2016, Figure 6).

Whereas a positive toxicity result can be a robust indication that beneficial uses are not being attained, a failure to detect toxicity is less definitive. Lab-based toxicity testing can take multiple forms (chronic, acute), in multiple matrices (sediment, water), and on multiple organism types (invertebrates, vertebrates). Thus, while observed significant toxicity in a sample provides confirmation of non-attainment, observed failure to detect toxicity may occur due to an incorrect test, test organism, matrix, or use of culture conditions that are not representative of field conditions. For example, toxicity testing should be conducted at representative stream temperatures using organism(s) sensitive to the toxicants expected to be present to prevent potential toxicity from being undetected (Anderson et al. 2012, Weston et al. 2009). In addition, sampling the wrong matrix (e.g. water column instead of sediment) can "miss" the presence of certain pollutants and toxicity effects, such as pyrethroid pesticides (Gillet et al. *in preparation*, City of San Diego 2015b). Lastly, toxicity testing does not test for longer-term sublethal impacts on stream biota.

Figure 6. From Phillips et al. 2016. ***Relationship between the percent survival of amphipods in laboratory sediment toxicity tests and sediment concentrations of total pyrethroids compared to measures of CSCI at sites at or within 500 meters of sediment collection.*** **Sites with observed toxicity below 80 percent survival or with elevated toxic units were found to have poor benthic community scores.**



Relevant aquatic-life-associated water quality objectives for conventional and toxicant pollutants may also be used as information to evaluate the attainment or non-attainment of beneficial uses. Water or sediment samples taken over multiple years, or multiple samples taken during a single bioassessment sampling index period that exceed water quality objectives for one or more parameters potentially impacting the benthic macroinvertebrate community[6] provide strong evidence for non-attainment of the beneficial use (unless such parameters are determined by the San Diego Water Board to be natural).

Like toxicity testing, water quality objectives for conventional and toxicant pollutants may provide a more robust confirmation of non-attainment. However, the testing and comparison of individual chemical parameters to water quality objectives may not detect cumulative effects from chemical mixtures, impacts from mass loading of a pollutant, or may simply "miss" or misrepresent the presence of pollutants due to the ephemeral nature of collecting water samples in flowing streams (Vighi et al. 2003, Skeffington et al. 2015). There also may be pollutants for which no water quality objectives or other criteria are available. In addition, water quality objectives may be overly or under-protective of the beneficial uses they are intending to protect, and site-specific natural factors may influence perceived impacts (e.g. USEPA 1997a). It is expected that biological objectives will, over time, provide a basis for the updating of relevant chemistry-based water quality objectives on a site-specific, watershed, or regional scale.

[6] Water quality objectives based upon the protection of aquatic life. Not water quality objectives established to protect human health (e.g. maximum contaminant levels, indicator bacteria).

Figure 7. Upper San Juan Creek (Status: non-reference, CSCI: 0.69). This site's CSCI score places it below the 10th percentile of the reference distribution, which does not meet the Stream Biological Objective. The San Diego Water Board may, at its discretion, consider additional biological, physical, and chemical relevant scientific information to determine if this stream is similar to reference. Sampling results show the site scores similar to reference for algal IBIs (Fetscher et al. 2014, SMC 2015), the IPI (Rehn et al. 2018), and CRAM, with a combined diatom and soft algal hybrid ("H20") score of 72, IPI score of 1.08, and CRAM scores of 92/88/100. No evidence of toxicity was present, with 100 percent survival of *Ceriodaphnia dubia*. Chemistry water quality objectives were not exceeded at this site. There is evidence this site meets the Stream Biological Objective as scientific information on the biological, physical, and chemical condition of the stream show attainment of the beneficial use. Photo: SMC.

Figure 8. Lower Forrester Creek (Status: non-reference, CSCI: 0.72). This site's CSCI score places it within the below the 10th percentile of the reference distribution, which does not meet the Stream Biological Objective. The San Diego Water Board may, at its discretion, consider additional biological, physical, and chemical relevant scientific information to determine if this stream is similar to reference. Sampling results for algae were very poor with scores of 36/100 for diatoms and 3/100 for soft algae (Fetscher et al. 2014, SMC 2015). Sediment toxicity results were significantly positive for toxicity, with 0-10 percent 10-day survival rates for *Hyalella azteca*. CRAM results were within reference expectations with Hydrologic/Physical/Biotic attributes scoring 75/69/75, all above the 10th percentile of reference (SMC 2015). Despite scientific information (CRAM results) on the physical condition showing the site to be similar to reference, biological and chemical information shows the stream is in non-attainment. Chemistry results point to elevated nutrients and pyrethroid pesticides as pollutants of concern. Photo: C. Turpe.

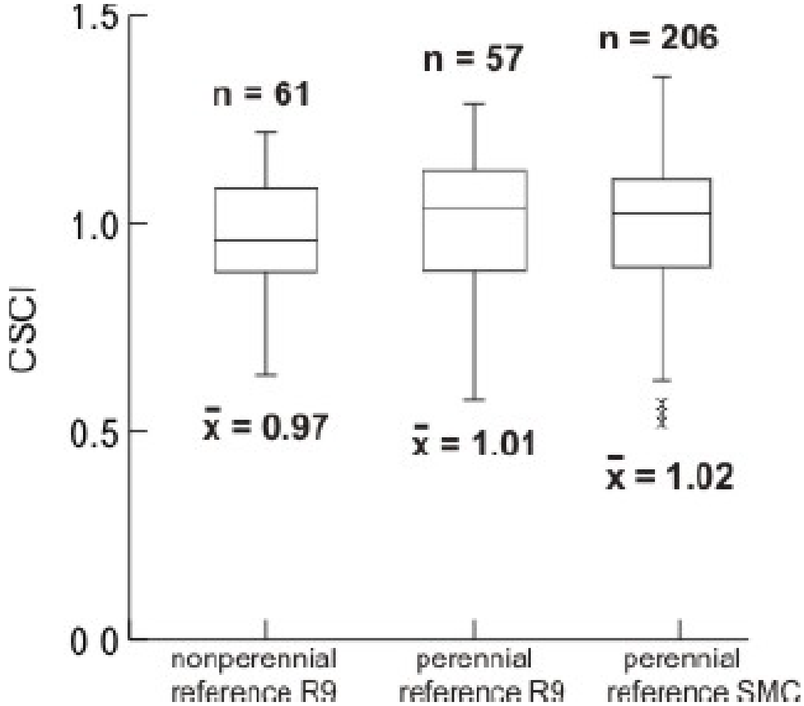
4.5. Applicable Waterbodies

The Stream Biological Objective includes a definition for streams, for the purpose of objective applicability, as follows:

> *For the purpose of this objective, "seasonal streams" means freshwater streams that are expected to be inundated with flowing water for at least four weeks between the months of February and October, except during periods of atypical or extreme drought. Seasonal streams have sufficient flows to conduct bioassessment sampling for stream aquatic benthic macroinvertebrates in most years. Seasonal streams do not include those streams that only exhibit ephemeral flow, which is flow that occurs only during or immediately following (e.g. 24-48 hours) rainfall events.*

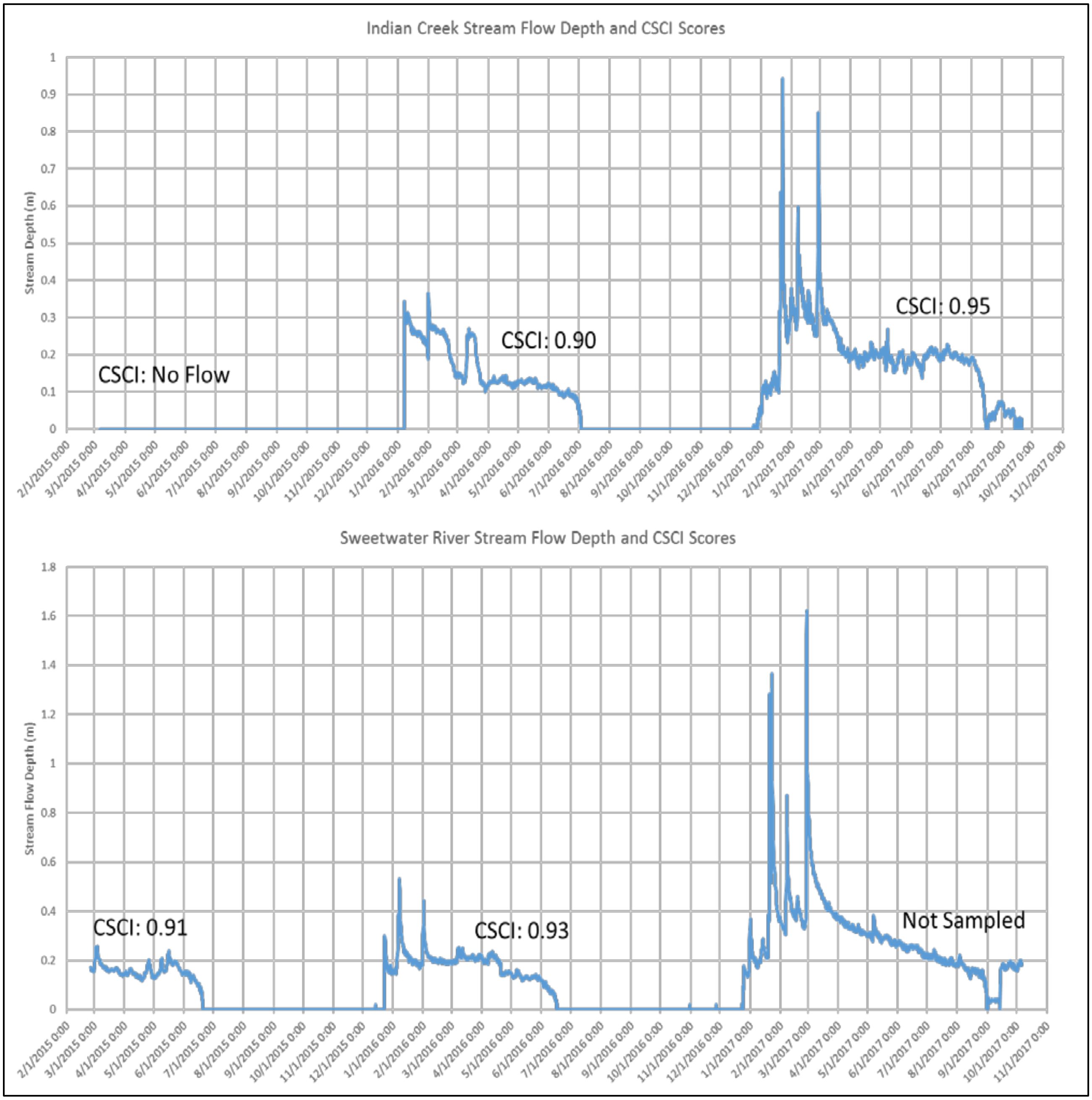
Research by the CSCI's authors (Mazor et al. 2014, Mazor, Rehn, and Stein in Mazor et al. 2015, Figure 9, Figure 10) that occurred up to and simultaneous to the CSCI's publication found that the CSCI and sampling protocols overwhelmingly work for seasonally intermittent streams in the San Diego Region. The authors found that "as long as a stream can be successfully sampled with standard protocols, it can be successfully assessed with standard indices" (the CSCI, Mazor et al. 2015). Thus, both perennial and regularly seasonal intermittent streams can be sampled for the CSCI. The CSCI scores represent biological integrity in perennial and seasonal streams.

Figure 9 (from Mazor et al. 2015). Comparison of CSCI distributions at perennial and intermittent (nonperennial) reference sites in the San Diego Region (R9) and for perennial reference sites across southern California. CSCI scores showed no bias against intermittent streams.



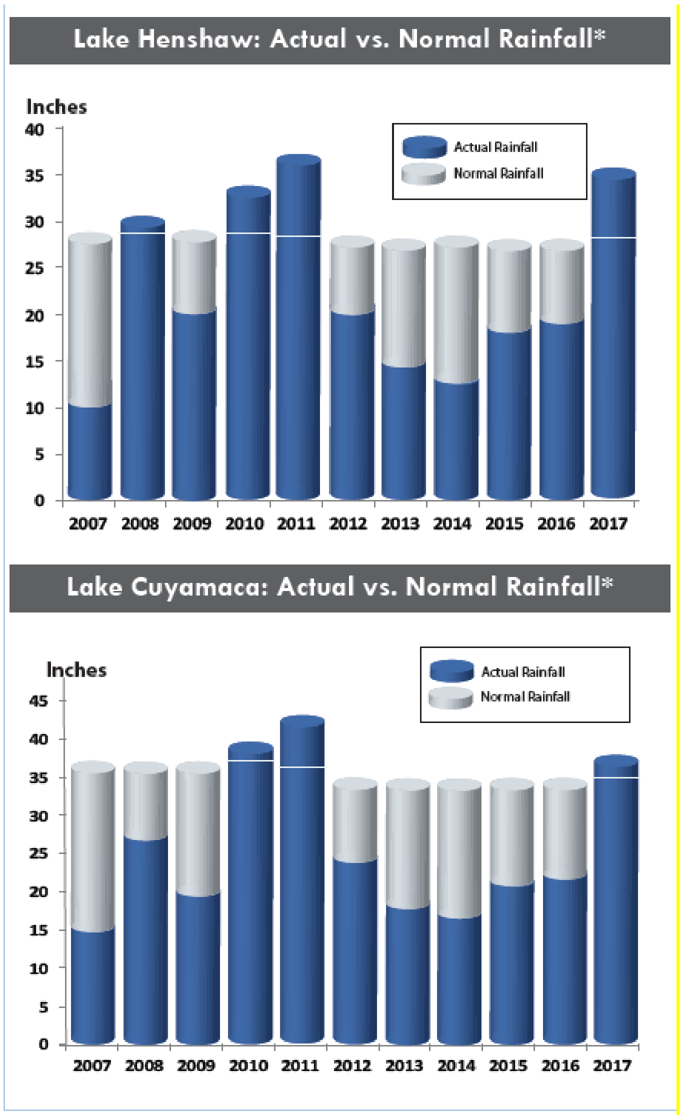
Distribution of CSCI scores in nonperennial reference sites compared to perennial sites in the San Diego region and the larger SMC region. Sample sizes and means are shown above and below box plots, respectively.

Figure 10. Examples of intermittent stream flow regimes at reference (Ode et al. 2016) streams used for the development of the CSCI (Mazor et al. 2016) and sampled by the State of California's Surface Water Ambient Monitoring Program. Indian Creek and Sweetwater River are located in the San Diego Region and both exhibit seasonal flows during drought (2015, 2016) and elevated (2017) rainfall years. Indian Creek lacked surface flows during 2015, which was the second straight year of exceptional drought for the Region. Note 2017 was an atypically high rainfall year that brought the region out of drought status.



This result is consistent with the findings from on-going stream bioassessment work associated with Mazor et al. 2015, which has found that while the CSCI was developed for so-called “perennial” streams, the majority of streams used for index development were not monitored to confirm the assumed perennial hydrologic condition. Instead, streams were sampled if they had sufficient flow to meet State of California SOPs for conducting bioassessment during the site visit, with sampling occurring between the months of March and October, though typically between May and July (see Appendix I). In addition, the CSCI developmental dataset includes data from San Diego Region reference sites that spans drought years (e.g. 2002, 2007, Figure 11), when streams were likely seasonal.

Figure 11. From SDCWA 2018. Rainfall records from the San Diego Region near reference sites used in CSCI development.



*Based on “Water Year” 2017 (Oct. 2016 - Sept. 2017)

As shown in Figure 10 and Figure 12, more recent flow sampling of reference bioassessment sites by the State of SWAMP, including those used in CSCI development and calibration, has documented that many streams used in development were, in fact, not perennial but seasonally intermittent streams that flow for short durations during spring and early summer on an annual basis. Some streams had a complete lack of flow due to extreme drought years (e.g. 2013-2015, Figure 10 and Figure 13), though this did not preclude the accurate use of the CSCI in prior or following years to predict similarity to reference. Thus, the definition of seasonal streams also includes those streams that may not naturally flow during atypical or extreme drought.

As a result, the Stream Biological Objective is suitable to apply to streams that are perennial or seasonally intermittent, using a minimum expected flow requirement for sampling. Mazor et al. 2015 used and recommends a minimum 4-week sampling delay period from the onset of stream flow and/or from the last major storm “re-setting” event. This 4-week flow requirement has been combined with the CSCI development reference site sampling period of March to October to insure the objective (CSCI) applies to representative streams from Mazor et al. 2015 and 2016. On-going research into the suitability of the CSCI to accurately predict reference condition at so-called “sporadically intermittent” or “atypically intermittent” stream sites is underway in the San Diego Region, and is targeting streams that lack surface flows except during years with above to well above average rainfall (e.g. 2011, 2017, see Figure 13). Initial results indicate the CSCI may work for such streams (Loflen, *unpublished data*), but potential limitations on feasible regulatory implementation associated with a limited sampleability period needs to be resolved.

The term “expected to be inundated” means that the objective applies to streams that are expected to be flowing absent anthropogenic alteration (e.g. flow diversions). The de-watering of a stream does not preclude the applicability of the Stream Biological Objective.

For the Stream Biological Objective, samples should be collected when streams are at or near base flow (i.e., not influenced by storm runoff), as sudden flow increases can displace benthic organisms from the stream bottom and dramatically alter local community composition (Ode et al. 2016b). State of California methods require sampling be carried out at least two, and preferably, three weeks after any storm event that has generated enough stream power to mobilize cobbles and sand/silt capable of scouring stream substrates (Ode et al. 2016b). Section 1.4 in Ode et al. (2016b) provides tips on how to evaluate a sampling reach for recent scour. Two to three weeks will usually allow time for benthic fauna and algae to recolonize scoured surfaces (Kelly et al. 1998; Stevenson and Bahls in Barbour et al. 1999). Ultimately, the time of delay from a scouring event to the acceptable window for sampling will depend on a stream’s environmental setting, time of year, and that season’s timing of storm events. Mazor et al. 2015 also provides additional recommendations for stream flow assessment (e.g. see Table 4).

A reach is also considered sampleable per Ode et al. (2016b) if at least half of the reach has a wetted width of at least 0.3 m (the width of a D-frame net) and there are no more than three transects that are completely dry within the monitoring reach at the time of assessment. If more than three transects are completely dry, then the stream reach should not be sampled; however, if the monitoring program allows it, the reach may be shifted in order to reduce the number of dry transects, thus allowing the shifted reach to be sampled. The wadeability limitation is determined by the practical ability to safely obtain a consistent sample of the benthic community from a reach. In general, a reach is considered wadeable if the thalweg is less than one-meter-deep for at least half the length of the reach. While largely not applicable in the San Diego Region, the wadeability limitation can exclude portions of large rivers in certain parts of the state (e.g. American, Sacramento, and Owens River).

Table 4 (from Mazor et al. 2015). Typical sampling periods at different types of streams.[7]

Scenario	Typical sampling period
Nonperennial stream in a typical year	March 1 through May 1
Nonperennial stream in a dry year	February 15 through April 15
Nonperennial stream in a wet year	April 15 through July 15
Perennial stream in a typical year	May 15 through July 15
Perennial stream in a dry year	April 15 through June 15
Perennial or high-elevation stream in wet year*	June 15 through August 15

* (where snow or meltwater is a concern)

[7] For the purposes of the Stream Biological Objective non-perennial and perennial streams are wadeable streams.

Figure 12. Stream flows and CSCI Scores at Upper Bell Creek, Orange County. Upper Bell Creek was sampled as part of the State of California's Surface Water Ambient Monitoring Program, passes State of California reference screens (Ode et al. 2016), has a seasonally intermittent flow regime, and consistently scores as reference-condition using the CSCI. Note that drought conditions in 2014 and 2015 reduced the duration of baseflows but did not impact the ability to sample or reduce the CSCI score. Note 2017 was an atypically high rainfall year.

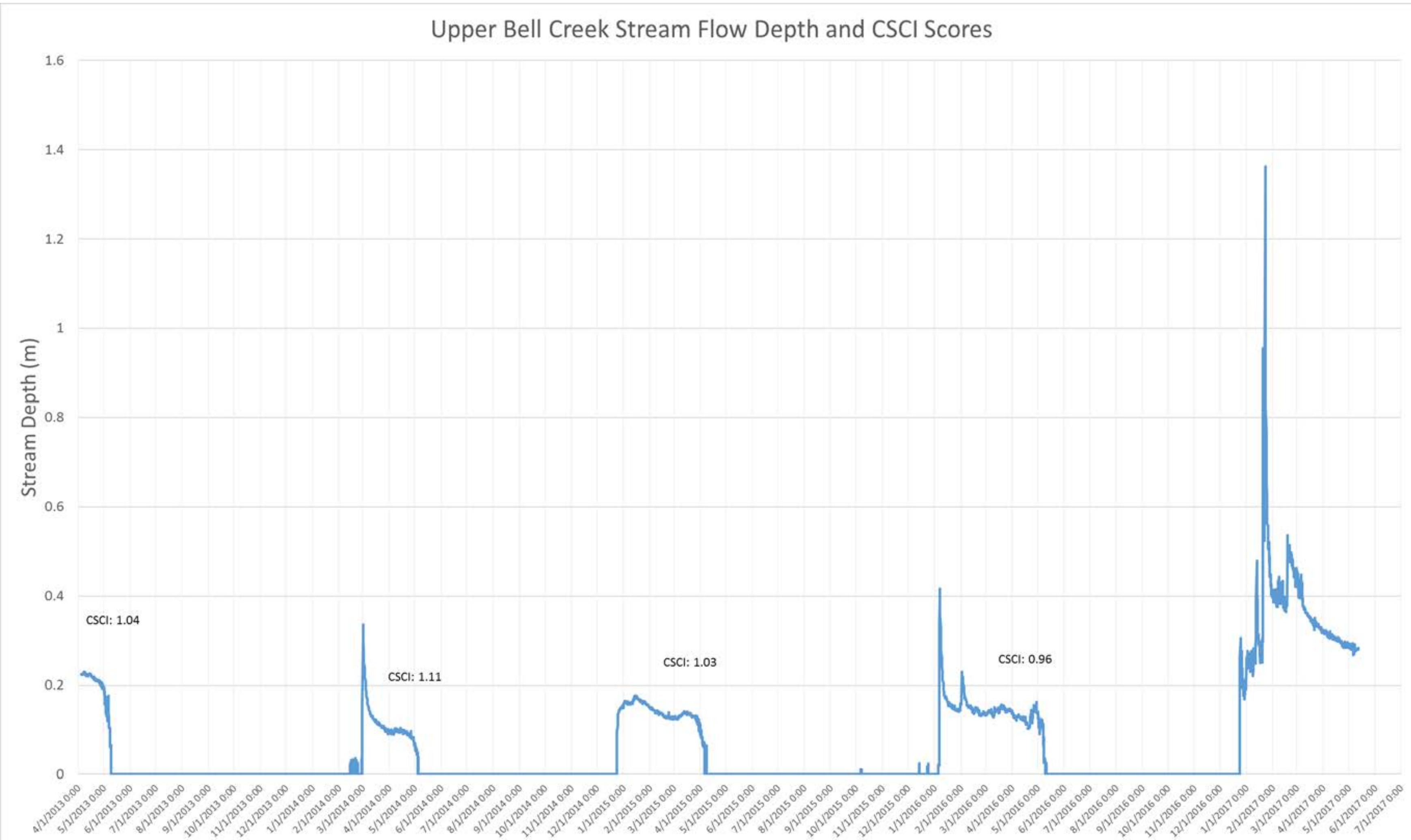
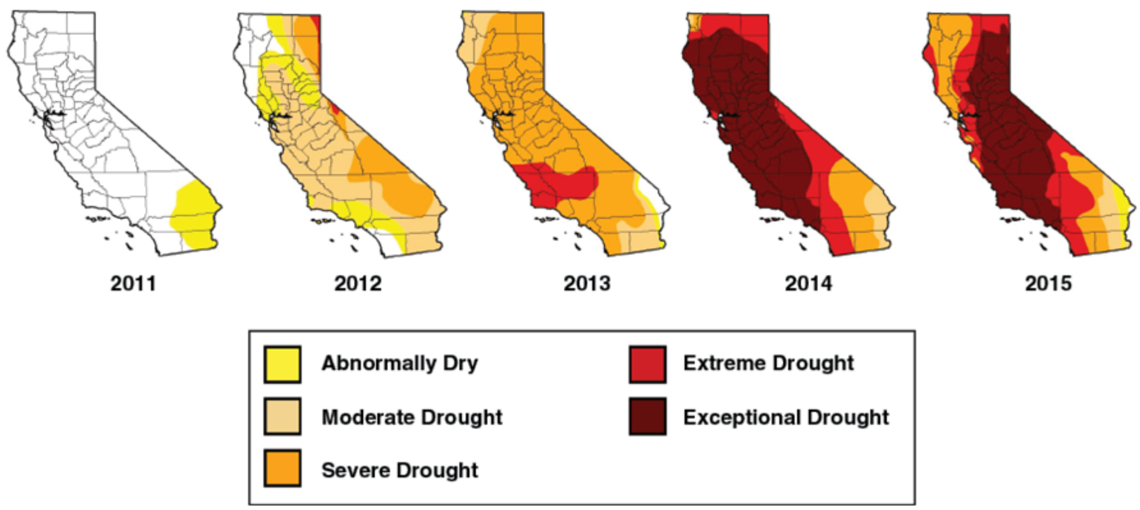


Figure 13. From: State of California 2016-2017 Budget. Drought rating intensity from 2011 to 2015. The San Diego Region underwent severe and extreme drought from 2013-2015, which reduced many stream baseflows (see Figures 10 and 11).

Figure 2

Drought Has Expanded, Intensified Across State

Statewide Drought Measurements From U.S. Drought Monitor, Taken Around October 1 Each Year[a]



[a] The U.S. Drought Monitor estimates drought intensity based on several indicators, including soil moisture, streamflow, and precipitation. October 1 is the beginning of the state's "water year" for annual precipitation calculations.

The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln (NDMC-UNL), the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Maps courtesy of NDMC-UNL.

4.6. Climate Change Considerations

The use of bioassessment and setting of the Stream Biological Objective includes considerations regarding potential impacts associated with climate change. The two primary concerns related to climate change and regulatory setting of objectives include 1) the ability of the objective(s) to detect changes due to climate change and 2) the ability to distinguish between climate change related impacts vs. other anthropogenic stressors (e.g. see discussion of bioassessment in USEPA 2012). The combined use of the CSCI and continued San Diego Water Board and Statewide support of the SWAMP Reference Condition Management Program address these two concerns.

The primary route to detect changes in stream systems due to climate change is through the Reference Condition Management Program with support from the Stormwater Monitoring Coalition, together which encompass a long-term reference condition monitoring program statewide. USEPA has identified the “long-term monitoring of high-quality, generally undisturbed rivers and streams” using a “comprehensive monitoring design” as needed to document climate change impacts (USEPA 2012). Detected changes in benthic macroinvertebrate communities in response to climate change at otherwise un-impacted reference sites can then be compared to CSCI taxa metrics and sub-metrics to determine if the CSCI requires modification.

The CSCI is a predictive index whose predictive portion relies on samples collected from the statewide network of reference sites. Unlike past regional indices, the CSCI will be updated if needed and warranted to include more recent sampling of reference sites, specifically if long-term monitoring by the State or other agencies indicates climate change is depressing or increasing scores independent of local or regional stressors. The updating of the CSCI shall occur as warranted through the Basin Plan amendment process.

4.7. Bioassessment Field Sampling

This section summarizes the field protocols required for conducting bioassessment sampling, as well as sampling for additional lines of evidence. Field sampling for bioassessment requires properly trained personnel and adherence to the latest State of California Standard Operating Procedures (SOPs) in an unbiased manner representative of stream reach condition. Field sampling also requires consistency with the SWAMP Quality Assurance Program Plan (SWAMPP QAPP) guidelines and requirements or having a project-specific QAPP that meets these minimum guidelines and requirements, such as the *Southern California Regional Watershed Monitoring Program Bioassessment Quality Assurance Project Plan, 2009*.

4.7.1 Benthic Macroinvertebrates

The sampling of benthic macroinvertebrates is conducted in accordance with the latest State of California SWAMP SOP for wadeable streams developed for California's SWAMP (Ode et al. 2016b). Sampling of benthic macroinvertebrates in the SOP is conducted on a fixed transect basis, with eleven samples taken along a 150-meter stream reach (Figure 14). Sampling is conducted utilizing the reachwide benthos method (RWB), which, unlike other methods, does not target specific habitat types (e.g. riffles). Instead, different stream habitat types are sampled according to transect location. This results in sampling of habitats, such as pools and glides, which are representative of overall stream condition. SWAMP requires that duplicate sampling of benthic macroinvertebrates and benthic algae occur at 10 percent of study sites (preferably at the same set of sites, when both assemblages are being sampled together). The recommended location for collecting duplicates is at adjacent positions along the sampling transects. In addition, regular (e.g., yearly) field audits of sampling crews should be conducted by an authorized individual (e.g., qualified personnel of CADFW).

Figure 14. From Ode et al. 2016b. Reach layout for sampling of benthic macroinvertebrates, algae, and physical habitat.

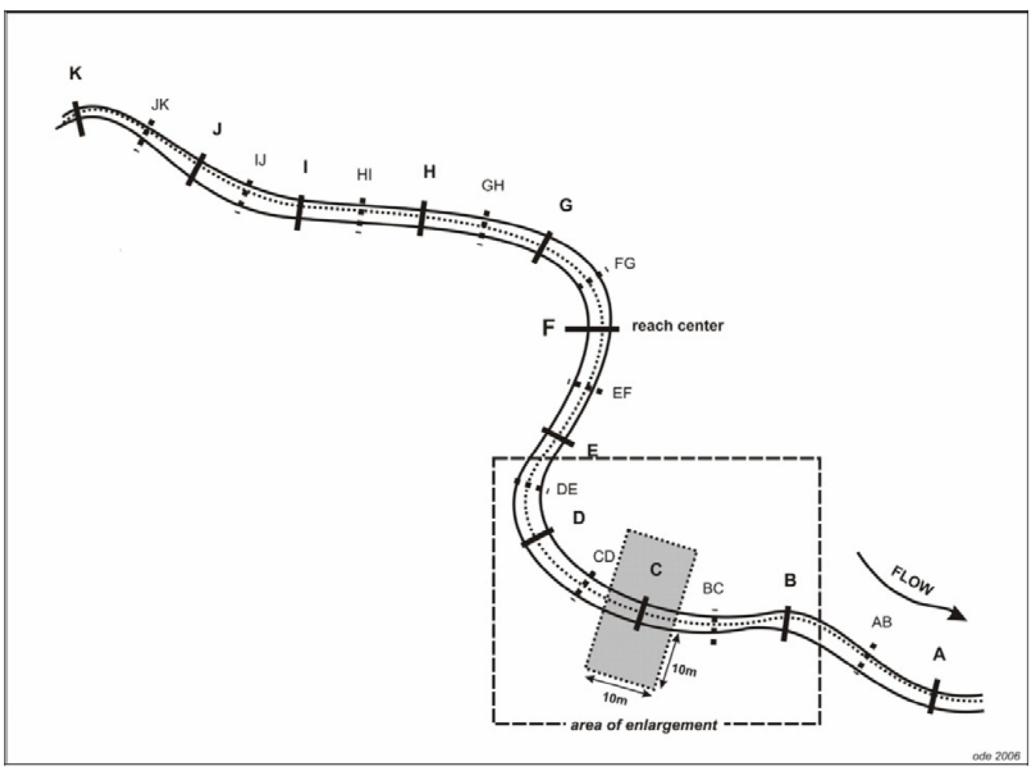


Figure 3. Reach layout geometry for physical habitat (PHab) and biotic sampling showing positions of 11 main transects (A-K) and the 10 inter-transects (AB-JK). The "area of enlargement" highlighted in the figure is expanded in Figure 17. Reach length = 150 m for streams ≤ 10 m average wetted width,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

Use of the RWB method for sampling benthic macroinvertebrates representative of stream condition requires sufficient baseflow conditions and depends on streamflow duration (see guidance in Mazor et al. 2015 for intermittent streams, also Table 4).

Sampling at or near stream flow cessation (e.g. oligorheic period, Gallart et al. 2012) may result in biased sample results due to the proportional loss of select habitat types (riffles, glides) as flows cease and stream water levels drop (Herbst 2016, see Figure 15). Likewise, sampling too soon following high scour events should be avoided (Ode et al. 2016b, see also Section 4.5). Sampling benthic macroinvertebrates during periods of no measurable flow should be avoided (or documented in field sheets if unavoidable).

Figure 15. Example of sampling during stream flow cessation period, or *oligorheic* aquatic state (Gallart et al. 2012). Note exposed active bed material and low flow condition. Site: Boden Canyon Creek (Status: Reference, CSCI at time of photo: 0.82 = 14th percentile of reference distribution). Note that the sampling did not meet the requirements of the California SOP (Ode et al. 2016b) due to a lack of sufficient stream width, flow condition, and dry transects. However, this site score would still meet the Stream Biological Objective as it scores > 0.79. This site was resampled the following year during regular baseflow condition in accordance with the SOP and received a CSCI score of 1.06.

4.7.2 Algae and Cyanobacteria

As with benthic macroinvertebrates, field sampling for benthic algae requires sampling crews follow the methods described in the SOP for wadeable streams developed for SWAMP (Ode et al. 2016b). Field sampling for benthic algae is typically conducted during the benthic macroinvertebrate sampling event, but may occur independently if needed.

This ‘‘multi-habitat method’’ involves objectively collecting eleven fixed-area samples of benthic algae along a pre-determined grid overlain on a 150-m-long stream segment comprising the sampling site (Figure 14). Under this method, “quantitative” algae samples are collected by isolating benthic specimens from a known, fixed surface area on stream substrata (e.g., silt, sand, gravel, cobbles, bedrock, concrete) in proportion to their relative abundances in the stream, and combining them into a “composite.” In addition, a fresh, ‘‘qualitative’’ sample is also collected by gathering an intact sample of all macroalgal types observed within the sampling reach. The qualitative sample provides important data that are used in calculating algal IBI (Fetscher et al. 2014) scores, and aids in laboratory identification of specimens in the quantitative sample that may have been fragmented in the course of collection (Stancheva et al., 2012). In addition, it can be used, as needed, for isolation and culturing of specimens of interest.

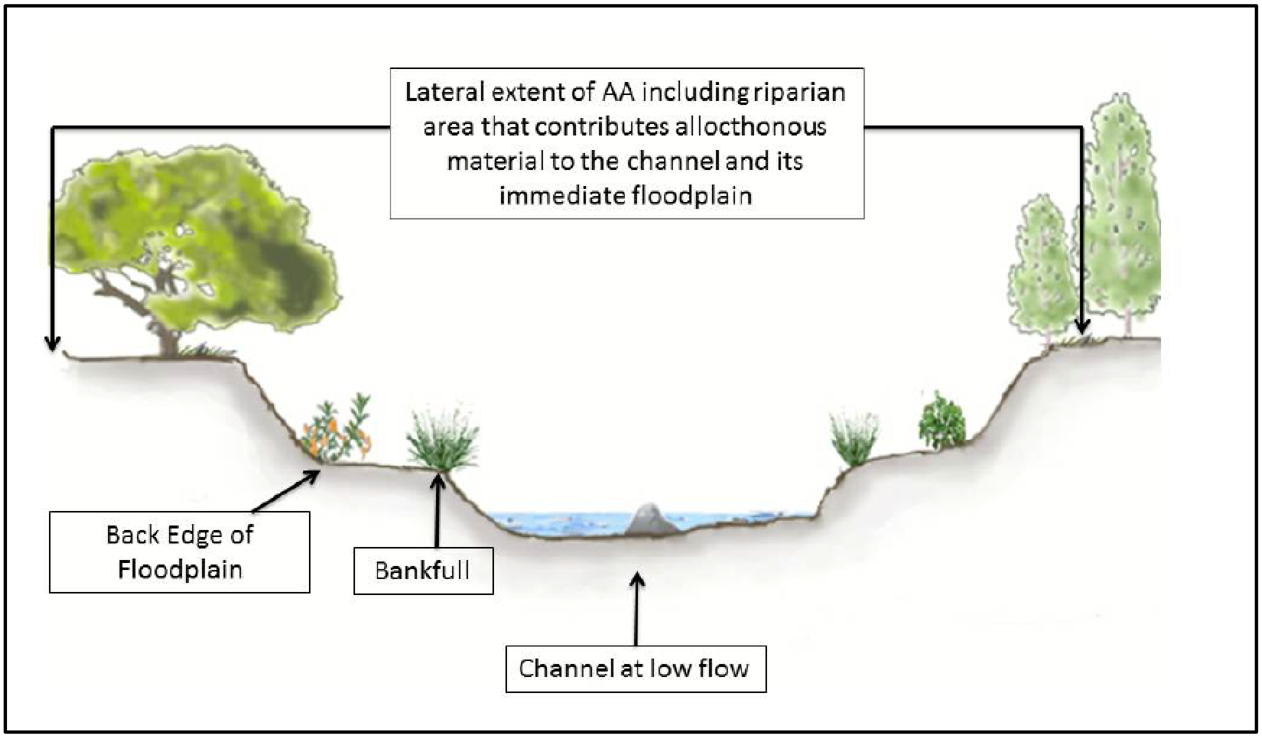
4.7.3 Physical Habitat and California Rapid Assessment Method (CRAM)

As with benthic macroinvertebrates and algae, field sampling for in-stream physical habitat and associated riparian habitat (“Physical Habitat”) requires sampling crews follow the methods described in the SOP for wadeable streams developed for SWAMP (Ode et al. 2016b). Field sampling for Physical Habitat is typically conducted during the benthic macroinvertebrate sampling event, but may occur independently.

Sampling of Physical Habitat in the SOP is conducted on a fixed transect basis, with various quantitative samples of physical habitat taken across 21 transects along a 150-meter stream reach (Figure 14). Measurements include, but are not limited to, water depth, substrate type, flow habitats, canopy cover, and stream width. Results from the Physical Habitat sampling can be used to calculate the stream segment’s IPI score (Rehn et al. 2018)

CRAM is a field sampling method used to assess riparian condition (CWMW 2013, Figure 16). CRAM uses “guided, best-professional judgment” for determining the health of wetlands, including stream riparian habitat. Practitioners collect observational data along the stream reach of concern and its adjacent floodplain, based on a number of metrics, such as landscape buffer and channel stability, with narrative condition categories ranging from “A” to “D,” like a report card. Metric scores are aggregated into four “attributes:” 1) habitat buffer/landscape context, 2) hydrology, 3) physical structure, and 4) biotic structure. The resulting attribute scores are then combined to generate a single, overall CRAM score. In addition, several types of stressors that the practitioner observes to be potentially impacting the site are tallied in order to document likely factors that could explain why stream/wetland condition might be subpar.

Figure 16. Stream riparian assessment area (AA) for the California Rapid Assessment Method (CWMW 2013).



4.7.4 Chemistry

The sampling of stream chemistry for regulatory purposes in receiving waters, including for lab toxicity evaluation, requires adherence with the most recent State of California SWAMP SOP for the *Collection of Field Data for Bioassessments of California Wadeable Streams* (Ode et al. 2016b) and, at a minimum, the most recent State of California SOP *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California* (March 2014). Standard parameters monitored per the SWAMP SOP for bioassessment (Ode et al. 2016b) include turbidity (NTU), water temperature (°C), specific conductivity (µS/cm), salinity (ppt), alkalinity (mg/L), pH, and dissolved oxygen (mg/L and % saturation). When algae is collected, this also includes total nitrogen (TN) and total phosphorus (TP) as well as nitrate-nitrite and orthophosphate.

Sampling of water and sediment chemistry (including for toxicity testing) is described in the bioassessment SOP, and occurs prior to bioassessment sampling, and at a location immediately downstream of what will be the first bioassessment transect, so as not to disturb benthic communities and potentially compromise benthic macroinvertebrate and algae data. Sampling of water chemistry occurs within a non-depositional area subject to stream flows (e.g. run), while sediment sampling occurs in depositional areas. Field crews avoid sampling water from an area where they have just disturbed the sediment, which would otherwise contaminate the water sample.

4.8. Laboratory Analysis

This section summarizes the laboratory analysis protocols required for analyzing bioassessment samples for the Stream Biological Objective, as well as samples for additional lines of evidence.

4.8.1 Benthic Macroinvertebrates

Laboratory analysis of benthic macroinvertebrates for CSCI calculation requires taxonomic identifications be conducted at a Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) level of II or IIa level (midges to subfamily) in accordance with the most recent State of California *Standard Operating Procedures for Laboratory Processing and Identification of Benthic Macroinvertebrates in California* (Woodward et al. 2012).

External laboratory quality control is conducted in accordance with State of California guidelines and the most recent *Standard Operating Procedures for External Quality Control of Benthic Macroinvertebrate Taxonomy Data Collected for Stream Bioassessment in California* (July 2015). Though not developed at this time, future laboratory identification using genetic methods may be used if consistent with laboratory results and conducted using methods approved by the State of California SWAMP and San Diego Water Board Executive Officer.

4.8.2 Soft Algae, Diatoms, and Cyanobacteria

Laboratory identification and quantification of specimens in the benthic stream algal communities sampled for IBI calculations follow the SOP developed for California's SWAMP Program (Stancheva et al. 2015), which prescribes methods for separate analysis of 1) diatoms and 2) soft algae (including cyanobacteria).

Diatom samples are cleaned of organic matter via boiling in nitric acid. The cleaned sample is then mounted on a microscope slide with appropriate mounting medium. Slides are viewed under a compound microscope along a series of optical "transects," and the taxonomic IDs of the diatom valves traversed by the transects are recorded, for a total of 600 IDs.

Soft algae *quantitative* samples undergo separate processing for the “macroalgae fraction” and the “microalgae fraction.” For the former, all macroscopic algae from the sample tube are isolated, identified taxonomically under a microscope, and their biovolume determined. For the latter, the remaining liquid in the sample tube (i.e., after all visible macroalgae have been removed) is gently homogenized and quantitatively subsampled, then 300 soft algal “natural entities” (defined in Stancheva et al. 2015) are identified along transects on a microscope slide, as viewed under a compound microscope. Dimensions of specimens are recorded for calculations to estimate biovolumes. Recordkeeping of original sample volume, subsample volume, and number of transects allows the calculation of total biovolume of each taxon in the sample. Results for both macro- and micro-algal fractions of the quantitative sample are reported in terms of total biovolume estimated for the stream reach. Epiphytes are identified on the macroalgal specimens and enumerated to a total of 100. Qualitative samples undergo an exhaustive tally of all macroalgal taxa in the sample. Both the epiphytes and specimens in the qualitative sample are reported as tallies.

Nomenclatural conventions of the SWAMP program (i.e., the most current version of the “Master Taxa List”) is used for naming the algae specimens encountered (https://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/), and taxonomic resolution of the specimens identified follows that prescribed by the California Freshwater Algae Work Group. External laboratory quality control for identification is conducted in accordance with State of California guidelines and Stancheva et al. (2015).

As of spring 2017, work is underway to develop and test molecular tools for inferring algal community composition, which may eventually be useful in addition, or as an alternative, to current algae taxonomy data based on morphology. Depending on the outcome of this development, molecular algae data may eventually replace and/or supplement the morphology-based data discussed here when approved by the State of California’s SWAMP as a Standard Operating Procedure.

4.8.3 Chemistry

For chemistry monitoring, including toxicity testing, analyses and determinations are performed by qualified personnel using USEPA or California Department of Public Health (CDPH) approved test procedures described in the following references:

- USEPA CFR, Title 40, Part 136, “Guidelines Establishing Test Procedures for the Analysis of Pollutants, Standard Methods for Examination of Water and Wastewater”
- USEPA publication SW-846 entitled “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods;” CDPH approved test procedures
- California Code of Regulations (CCR), Title 22, Division 4.5, Chapter 11, “Identification and Listing of Hazardous Waste,” as appropriate.

Chemistry lab analysis and determinations are conducted consistent with the requirements found in the SWAMP QAPP and its specifications for laboratory procedures, sample analysis, and reporting.

Reporting limits associated with analysis are included within the State Water Board's SWAMP QAPP. At a minimum, samples analyzed according to the SWAMP QAPP should achieve Reporting Limits (RLs) for SWAMP analytical procedures as listed in Appendix C of the SWAMP QAPP, and report the method number, MDL, and RL with each constituent analyzed. RLs for chemical constituents, or contaminants are at least as sensitive as the more restrictive of those required for analysis of pollutants under CFR, Title 40, Part 136, or analysis of drinking water under CCR, Title 22, Division 4, Chapter 15, or CFR, Title 40, Part 141.

4.9. Reporting and Interpretation of Biological Index Scores

This section summarizes the reporting protocols required for calculating CSCI scores, as well as scoring and evaluating additional scientific biological information for the Stream Biological Objective.

4.9.1 Benthic Macroinvertebrates

Benthic macroinvertebrate data collected and identified to SAFIT Level II or IIa in accordance with the most recent State of California SOPs are used for calculating California Stream Condition Index scores on a per sample basis (one reach, one sampling event). Scores are calculated using the most recent version of *The California Stream Condition Index (CSCI): Guidance for calculating scores using GIS and R* (current version: Mazor et al. 2018). The State of California intends to release a web-based calculation tool for CSCI scores using taxonomy data entered into State of California databases.

There are scoring limitations for CSCI scores calculated with certain data types or sources. These are discussed in the Mazor et al. (2018) guidance document for score calculation. Samples where benthic macroinvertebrates were identified to a lower level of taxonomic level effort cannot be used to calculate accurate CSCI scores in all cases. Data based on lower level taxonomic effort may be used in a qualitative purpose using CSCI sub-metrics or as prescribed specifically in the implementation section to calculate a "best-case scenario score" (Section 5). Samples where portions of the watershed are within other nations (e.g. Mexico) should be interpreted with caution as select GIS predictive metrics may be missing data from Mexico (see Section 5).

4.9.2 Soft Algae, Diatoms, and Cyanobacteria

Following algae bioassessment sampling and sample analysis per the SWAMP methods (Ode et al., 2016b, Stancheva et al. 2015), the following benthic algae data types will be available: 1) identifications of 600 diatom valves, 2) identifications and total biovolumes of 300 microalgal entities from the quantitative sample, 3) identifications and total biovolume of all macroalgal specimens from the quantitative sample, 4) identifications of 100 epiphytes, 5) identifications of all macroalgae in the qualitative sample. These data are used to calculate at least three types of index scores (Fetscher et al. 2014): 1) the diatom index, D18, 2) the soft-algae index, S2, and 3) the "hybrid" index, H20, which incorporates metrics from both the diatom and soft-algae assemblages. Eventually (circa 2019), the ASCI will be available to be calculated.

Two methods are available for calculating D18, S2, and H20. The SWAMP database includes a reporting module for automatically producing the metric and index scores. The only requirement is that the data be entered into the SWAMP database beforehand. If the option to upload the data to SWAMP is unavailable, an online calculator is available at http://sccwrp.org/Data/DataTools/algaeIBI.aspx. To use this tool, data must be formatted according to instructions on the website. Score output includes raw and scaled metric scores, as well as all index scores and information about data completeness as it relates to reliability of the metric scores.

The resulting index scores could be compared to the 10th percentiles from the distributions of appropriate sets of reference sites in order to assist the San Diego Water Board determination of whether beneficial uses are being attained (e.g. see Table 1-1, SMC 2015, see Section 4.4.4).

4.9.3 Physical Habitat Index and California Rapid Assessment Method

Physical habitat data collected using the “full” physical habitat method with the most recent State of California SOP (Ode et al. 2016b) is used for calculating Index of Physical Habitat Integrity scores on a per sample basis (one reach, one sampling event, Rehn et al. 2018). Scores are calculated using the most recent version of *The Physical Habitat (PHAB) Index of Physical Integrity (IPI): Interim instructions for calculating scores using GIS and R* (current version: Rehn et al. 2018b).

CRAM results can be calculated by hand or entered into EcoAtlas, at

http://www.cramwetlands.org/dataentry

The resulting CRAM scores could be compared to percentiles from the distributions of appropriate sets of reference sites in order to assist in the San Diego Water Board determination of whether beneficial uses are being attained (e.g. see Table 1-1, SMC 2015, see Section 4.4.4).

5. Program Implementation

5.1. Introduction

The incorporation of water quality objectives requires the implementation of those objectives within existing San Diego Water Board programs pursuant to the CWA and Porter-Cologne. These programs include:

5.2 Anti-Degradation
5.3 National Pollution Discharge Elimination System
5.4 Integrated Reporting
5.5 Total Maximum Daily Load
5.6 CWA Section 401 Water Quality Certifications
5.7 Waste Discharge Requirements
5.8 Non-point Source Pollution Control Program
5.9 Grant Program
5.10 Monitoring and Reporting

The incorporation of the Stream Biological Objective into the San Diego Water Board Basin Plan will result in implementation consistent with existing language in Chapter 4 of the Basin Plan, with the Stream Biological Objective generally implemented as receiving water limitations in applicable waterbodies or waterbody types. When included as receiving water limitations, permitting programs will focus on the discharger and/or San Diego Water Board determination that the discharge(s) does not cause or contribute to an exceedance of the Stream Biological Objective in receiving waters. Determination of if a discharge causes or contributes to degradation will consider the pollutants, magnitude, and duration of the discharge in relation to the physical, chemical and biological condition of the receiving water. In many cases, there may be historic discharges (e.g. stream fill) or land use practices that have directly caused existing degraded biological conditions in receiving waters. In addition, as specified in the objective, natural site-specific factors may preclude compliance with the 10^{th} percentile objective.

The inclusion of water quality objectives for biological condition works to insure implementation will meet aquatic life beneficial uses in receiving waters. The incorporation of biological objectives for specific surface water types (the Stream Biological Objective) or locations does not preclude the assessment of the physical and chemical condition of those same waterbodies (USEPA 1991 and 2002a). Biological objectives are intended to provide a more accurate and direct assessment of aquatic-life beneficial uses, and work with existing chemical water quality objectives and assessments of physical waterbody condition (USEPA 1991 and 2002a). Implementation actions that include the chemical and physical conditions, and the potential impacts of those conditions on the biological condition of surface waters allows for better protection and meaningful restoration (e.g. Herbst et al. 2018).

For the Stream Biological Objective, the co-evaluation of stream physical habitat and hydrology, in addition to chemistry and toxicity water quality objectives, provides the needed information for the San Diego Water Board to guide appropriate program implementation actions and document success. Conducting bioassessment includes a minimum level of evaluation of stream hydrology, physical habitat, and water quality objectives. San Diego Water Board evaluation of streams for protection or restoration through program implementation using the Stream Biological Objective may include assessment of physical habitat and hydrology metrics, including an evaluation of the deviation from natural flow condition (e.g. see Zimmerman et al. 2017), using metrics such as duration, magnitude, variability and frequency for hydrology (Stein et al. 2017a and 2017b) and flow habitat, substrate type, riparian cover and channel cover for habitat (Rehn et al. 2018). Other physical habitat and hydrologic metrics may be evaluated as applicable given site and landscape characteristics (e.g. Mazor et al. 2018b, Sengupta et al. 2018). Combining the evaluation of physical and chemical components of stream integrity when implementing programs for the Stream Biological Objective is expected to result in successful protection and meaningful restoration of stream beneficial uses.

Regulatory permitting for the Stream Biological Objective as a receiving water standard requires that, for discharges that represent a probable threat to the Stream Biological Objective, the discharge conduct monitoring of receiving waters to ensure the discharge does not cause or contribute to an exceedance. Where the discharge is determined, by the San Diego Water Board or discharger, to have caused or contributed to an exceedance of the Stream Biological Objective, appropriate permit and discharge follow-up actions would be required. For those discharges to receiving waters where other sources, such as in-stream channel hardening, already cause and/or contribute to an exceedance, the permitted discharge is largely not required to remedy existing in-stream physical habitat condition in order to discharge (see discussion in Section 5.5) unless a condition of proposed mitigation associated with a site-specific project (e.g. Section 5.6), or as a matter of enforcement (e.g. illegal fill). Instead, the discharger would be, consistent with existing water quality objectives, required to ensure its discharge does not contribute to the continued degradation or increase the level of degradation, resulting in additional Beneficial Use loss (e.g. Section 5.2).

While insuring that a discharger does not contribute to existing degradation may not resolve existing degradation from other historic sources in the short term, degraded waters will still be assessed and restored over time by a combination of the CWA Integrated Reporting process (Section 5.4) and Total Maximum Daily Loads (Section 5.5), through continued measured improvement within the existing regulatory framework (e.g. Section 5.3.4 *Phase I Storm Water*), and via other Regional Board programs, such as grants (Section 5.9). This general implementation approach is consistent with the goals and intent of the project for the following reasons:

1) The goals and intent of the project are to protect and restore the biological condition of receiving waters. Protection includes 1) ensuring those waters that are meeting objectives not degrade, resulting in loss of Beneficial Use(s) and impairment, and 2) ensuring those waters with some form of existing impairment do not further degrade and lose **additional** Beneficial Use(s).

2) Where existing historic activities, such as stream channel hardening, may already cause degradation of the biological condition of receiving waters subject to a discharge(s) today, these historic activities do not preclude discharges from meeting other water quality objectives for chemistry and toxicity. This consideration is important as discharges do extend downstream beyond the initial discharge point to other waterbodies, such as estuaries, bays, reservoirs, and the ocean.

3) Restoration of waters where long-term historic land-use decisions have restricted the ability for current discharges to meet the Stream Biological Objective will require long-term incremental improvement through existing implementation programs (e.g. Section 5.3.3 *Phase I Storm Water*, Section 5.5).

5.2. Antidegradation Policies

Title 40, Section 131.12 of the Code of Federal Regulations requires that the state water quality standards include an antidegradation policy consistent with the federal policy (Federal Antidegradation Policy). The State Water Board established California's antidegradation policy in State Water Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California" (State Antidegradation Policy). The State Antidegradation Policy incorporates the Federal Antidegradation Policy where the federal policy applies under federal law. The San Diego Water Board's Basin Plan implements, and incorporates by reference, both the State and Federal Antidegradation Policies.

The Federal Antidegradation Policy applies to surface water, regardless of quality. (40 CFR 131.12.) It establishes three tiers of waters. Tier 1 maintains and protects existing uses and water quality conditions to support such uses. (40 CFR 131.12(a)(1).) Tier 2 is comprised of "High Quality Waters." Tier 2 waters have higher water quality than those required to support designated uses. (40 CFR 131.12(a)(2).) Tier 3 is comprised of Outstanding National Resource Waters. (40 CFR 131.12(a)(3).) Some degradation may be allowed in Tier 1 and Tier 2 waters provided that certain findings are met. If degradation is allowed in a high quality water, the state must determine, after a consideration of alternatives, that the degradation is necessary to accommodate important economic or social development in the area in which the waters are located. (40 CFR 131.12(a)(2)(ii).) No water quality degradation is allowed in Tier 3 waters. (40 CFR 131.12(a)(3).)

The State Antidegradation Policy protects high quality waters of the state, including groundwater. High quality waters are waters where existing water quality is better than required by water quality control plans or policies. The State Antidegradation Policy requires that any discharge to a high quality water must use the best practicable treatment and control necessary to maintain the highest water quality possible consistent with the maximum benefit to the state.

The San Diego Water Board will consider the potential for degradation of biological conditions when issuing or modifying waste discharge requirements (including NPDES permits) and 401 certifications. In conducting an antidegradation analysis the San Diego Water Board must compare baseline water quality to the water quality objective. Baseline water quality is the best water quality that has existed since 1968, when considering the State Antidegradation Policy, or 1975 when considering the Federal Antidegradation Policy, unless subsequent lowering was due to regulatory action consistent with State and federal antidegradation policies. (See State Antidegradation Policy Resolve 1 and APU 90-004.) Where a water quality objective is adopted after 1968, or 1975, the baseline for that water quality objective is determined as of the date the new objective takes effect. (State Antidegradation Policy, Resolve 1.) Therefore, any antidegradation analysis with respect to the Stream Biological Objective will consider baseline water quality as of the effective date of the Stream Biological Objective.

5.3. National Pollutant Discharge Elimination System (NPDES)

CWA section 402 establishes the NPDES Program to regulate the ''discharge of a pollutant,'' other than dredged or fill materials, from a ''point source'' into ''waters of the U.S." (CWA §§ 1342(a) & 1362(12)). The NPDES Permitting Program is a federal program that has been delegated to the State of California for implementation through the State Water Board and the nine Regional Water Boards (CWC § 13370 et seq.). Under section 402, discharges of pollutants to waters of the U.S. must obtain and comply with NPDES permits issued by the Water Boards. In California, NPDES permits are also Waste Discharge Requirements (WDRs). (CWC § 13374).

NPDES permits control water pollution by regulating point sources with Best Management Practices (BMPs), Technology Based Effluent Limitations (TBELs) and Water Quality Based Effluent Limitations (WQBELs). TBELs control pollution by requiring discharges to achieve the minimum level of effluent quality attainable using demonstrated treatment technologies. TBELs may not be stringent enough to ensure that water quality standards will be attained in receiving waters. In such cases, NPDES regulations require the San Diego Water Board to develop WQBELs for pollutants at the levels needed to apply and ensure compliance with applicable state water quality standards. WQBELs must be consistent with the assumptions and requirements of any wasteload allocation assigned to a water through an adopted TMDL. (40 CFR § 122.44(d)(1)(vii)(B)). NPDES permits may also include Receiving Water Limits. Receiving Water Limits prohibit discharges that cause or contribute to an exceedance of an applicable water quality standard in the surface water that receives the discharge.

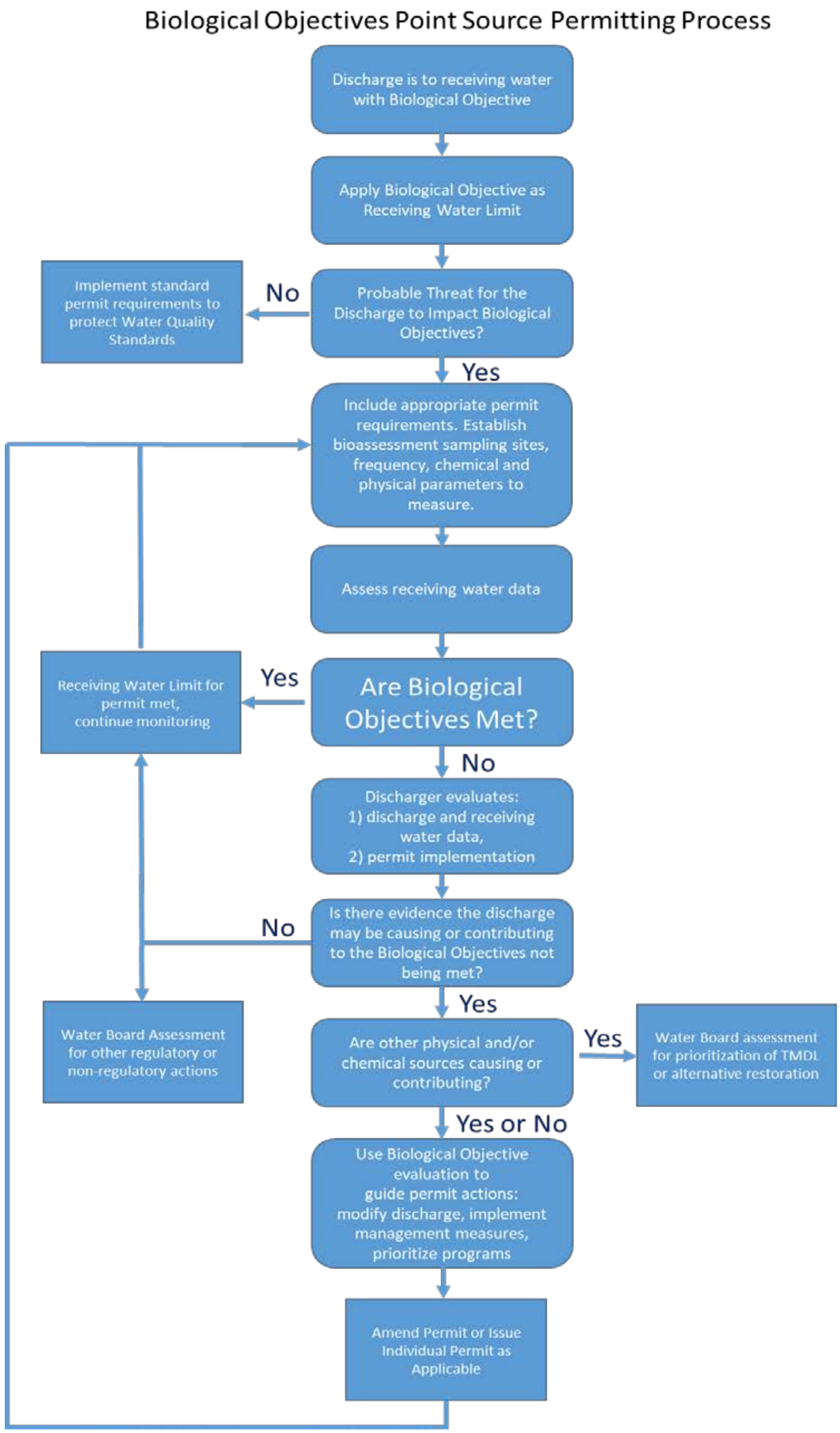
5.3.1 Implementation of Biological Objectives in NDPES Permits

Biological objectives are potentially applicable to all point source discharges in the San Diego Region. The San Diego Water Board currently regulates point source discharges from a variety of sources, including but not limited to: wastewater treatment plants, municipal storm water systems (MS4s), shipbuilding, and groundwater extraction. The State Water Board also issues general statewide NDPES permits to cover certain types of discharges in the San Diego Region, such as industrial storm water, construction storm water, California Department of Transportation (CalTrans) storm water, and pesticides. The proposed Basin Plan Amendment implements the Stream Biological Objective in NPDES permits affecting the San Diego Region as discussed below. An outline of the process is also included as Figure 17, below.

Where incorporated as receiving water limits, permit requirements will include Stream Biological Objective monitoring and assessment where the discharge presents a probable threat to the Stream Biological Objective.[8] Where a discharge is determined by the San Diego Water Board to not present a probable threat to the Stream Biological Objective, receiving water monitoring for the Stream Biological Objective will not be required as implementation of permit requirements is expected to be sufficient to meet water quality standards. For dischargers that are determined to present a probable threat, bioassessment will be required in surface waters subject to the discharge. Stream Biological Objective monitoring and reporting for receiving waters will be required to be conducted in accordance with State of California Standard Operating Procedures (SOPs). Permits with bioassessment monitoring may also require receiving water chemistry and toxicity monitoring, which will be determined on a case-by-case basis in the permitting process based upon the pollutant(s) of concern associated with the discharge. For permit renewals, the San Diego Water Board will evaluate prior monitoring requirements to determine if any can be reduced to help off-set costs of new biological monitoring and assessment.

[8] Note that Statewide General NPDES Permits undergo a different process than as described and presented in Figure 17. See further discussion in Section in 5.3.3

Figure 17. Process of Implementation for Point Source Discharges



5.3.2. Receiving Water Limits for Biological Objectives in NDPES Permits

Biological objectives will be applied as a receiving water limit in all permits where there is a biological objective for the receiving water subject to the discharge. Receiving water monitoring and reporting will be required where the San Diego Water Board has determined the discharge is or will represent a probable threat to biological objectives.

The amendment of the San Diego Water Board Basin Plan to include the Stream Biological Objective would require some new, amended, and reissued individual NPDES permits to include an assessment of the regulated discharge(s) related to the Stream Biological Objective. The required assessment would be related to the biological condition of the receiving waters and not an individual pollutant or toxicity, the latter of which can be monitored directly in the proposed discharge. Existing reasonable potential analysis is focused on the pollutants in the discharge and the potential for the pollutants to cause or contribute to an exceedance of applicable water quality objectives in the Basin Plan, which are presumed to be protective of receiving waters. With the adoption of the Stream Biological Objective, dischargers to streams may be required to, as part of their ROWD, submit an assessment of the condition of the receiving water for the Stream Biological Objective related to the discharge, including the proposed discharge's magnitude and duration spatially and temporally, constituents expected to present and potentially associated with biological impacts, and current documentation, if any, of existing degradation and attributed potential sources.

5.3.3 San Diego Water Board Determination of Probable Threat to the Stream Biological Objective

For NPDES permits, the San Diego Water Board will determine where Stream Biological Objective receiving water monitoring and reporting will be required based upon the probable threat of the discharge to cause or contribute to degradation of the Stream Biological Objective. In some cases, existing permits may have already identified a discharge as presenting a probable threat to the Stream Biological Objective. Applicants for discharges to surface waters where the San Diego Water Board determines the discharge may present a probable threat to the Stream Biological Objective may be required to submit, as part of their ROWD, an assessment of receiving water condition for the Stream Biological Objective (Receiving Water Biological Assessment).

This assessment must include a discussion of the biological condition of receiving waters relative to their existing and/or proposed discharge as well as the management measures proposed to protect receiving water condition. This assessment must also evaluate whether flow from the discharge is likely to cause a condition of erosion or the need for engineered stream channel modifications because both are significant threats to aquatic life beneficial uses and the ability of waterbodies to meet the Stream Biological Objective. The Receiving Water Biological Assessment may include data collected by the applicant, SWAMP data, data from the most recent Integrated Report, or data from other agencies and sources.

General Regional Phase I MS4 Permits

The San Diego Water Board presently has findings and a fact sheet that documents the impact of Phase I MS4 discharges on benthic macroinvertebrates (see R9-2013-0001). The Phase I MS4 permit currently requires bioassessment monitoring and reporting, and the use of receiving water data, including bioassessment, to guide permit implementation actions. As such, implementation of Stream Biological Objective monitoring and reporting will occur in general regional Phase I permits because Phase 1 discharges have already been determined by the San Diego Water Board to represent a probable threat to the Stream Biological Objective.

Individual NPDES Permits

The San Diego Water Board currently issues individual project or facility specific NPDES permits for point sources discharges throughout the region. The San Diego Water Board will require applicants, as part of their ROWD, submit a Receiving Water Biological Assessment if the discharge meets the following criteria:

- Discharge to a seasonal stream, and
- Discharge duration period greater than 2 months, and
- Discharge outside the rainy season (rainy season is Oct 1st to May 30th), or
- Discharge to a high quality waterbody

While stream systems have a high degree of intra and inter-annual flow variability, increasing the duration of baseflows in naturally intermittent streams may contribute to the establishment and spread of non-native species dependent on sustained perennial flow (e.g. New Zealand mud snail (*Potamopyrgus antipodarum*), NZMMCPWG 2007). In addition, discharges that do not match natural stream hydrologic regimes may cause excessive scour and sedimentation, which can impact benthic macroinvertebrate communities (Stein et al. 2017a) and cause or contribute to an excursion of the Stream Biological Objective and/or other receiving water quality objectives (e.g. nutrients, turbidity).

San Diego Water Board staff may, upon review of a ROWD, determine a discharge presents a probable threat to the Stream Biological Objective and require Stream Biological Objective monitoring and reporting requirements. The above criteria represents an expected level of potential applicability of the Stream Biological Objective associated with the assessment of probable threat. However, staff may also request the submittal of a Receiving Water Biological Assessment to determine if the discharge may present a probable threat to the Stream Biological Objective on a case-by-case basis.

The Receiving Water Biological Assessment must include an assessment of the Stream Biological Objective (in applicable receiving waters), which would be upstream and downstream of the discharge for wadeable streams. The assessment must include traditional evaluations (chemistry and toxicity), and an evaluation of existing conditions upstream and downstream (in applicable receiving waters) to assess if the magnitude, scope, and duration of the discharge may cause or contribute to an excursion above the biological water quality standard using the Stream Biological Objective. Consideration must include the existing physical and biological condition of the receiving water(s) impacted by the proposed discharge and the potential for the discharge to cause or contribute to the alteration of the chemical, physical, and thus biological, condition of the receiving water(s).

General Statewide NPDES Permits

General Statewide NPDES Permits are issued on a statewide basis by the State Water Board, and generally include all water quality objectives as receiving water limits. The San Diego Water Board expects that the vast majority of enrollees under statewide general NPDES permits will not require additional implementation measures, including Stream Biological Objective monitoring and reporting, as existing BMP-based permit requirements and implementation will be sufficient to meet the Stream Biological Objective (see 40 CFR 122.44(k)).

The implementation of BMPs and compliance with statewide general permit conditions is expected to be sufficient to protect Beneficial Uses and meet the Stream Biological Objective. Projects or facilities enrolled under statewide general permits are required to develop extensive project or site-specific plans for BMP implementation, including site evaluation and design, assessment, structural and non-structural BMP selection, BMP monitoring and inspections, and plan implementation requirements (e.g. see USEPA 2003, SWRCB 2014). Statewide general permits encompass projects and facilities that are spatially or temporally limited and are expected to have reduced discharge magnitudes and pollutant loading compared to projects or facilities required to obtain individual permits. General permits contain thresholds of applicability associated with site activities (e.g. industrial), size (e.g. acres), or production (e.g. number of animals), thus limiting general permit applicability to those where BMPs are reasonably expected to achieve water quality standards (see 40 CFR 122.44(k)), while also reducing risk of potential pollutant loading to receiving waters when in compliance with permit requirements. In addition, BMP permit requirements, in addition to structural BMP design and technologies, have improved over time (e.g. Currier et al. 2006). Many recommendations for BMP improvements have been incorporated into general statewide permits (e.g. 2009-009-DWQ, 2014-0057-DWQ). Lastly, many projects or facilities are regulated at both the state and local level, providing multiple layers of project or facility oversight for BMP implementation.

However, the San Diego Water Board will, upon adoption of the Stream Biological Objective, review enrollments under statewide general NPDES permits to assess if current implementation requirements within the various statewide general NPDES permits are sufficient for the protection of the Stream Biological Objective, or if additional implementation measures for permits, enrollee types or categories, or waterbodies may be needed to protect beneficial uses associated with the Stream Biological Objective. When evaluating statewide general permits, the San Diego Water Board will consider the magnitude and duration of covered discharges, the spatial and temporal variability of covered discharges, constituents expected to be present in various covered discharge types, and documentation, if any, of existing degradation and attributed potential sources. The San Diego Water Board will also consider the locations of covered discharges (e.g. to an MS4, directly to a receiving water) and the biological condition of downstream receiving waters.

The San Diego Water Board may, on a case-by-case basis, determine if an individual enrollee or proposed enrollee has a discharge that presents a probable threat or directly causes or contributes to an exceedance of the Stream Biological Objective. The San Diego Water Board may require such dischargers to obtain an individual NPDES permit for their discharges, implement additional other control measures or BMPs to meet the Stream Biological Objective, and/or require receiving water monitoring and reporting. In addition, many statewide general permits require that, where a Regional Water Board determines the discharge is causing or contributing to an exceedance of a water quality standard, the discharger must take corrective actions under the general permit (e.g. 2014-0057-DWQ). The San Diego Water Board will consider the magnitude and duration of the discharge spatially and temporally, constituents expected to present and potentially associated with biological impacts, and current documentation, if any, of existing degradation and attributed potential sources for the downstream receiving waters. The San Diego Water Board will also consider the location of the proposed discharge (e.g. to an MS4, directly to a receiving water) and the biological condition of downstream receiving waters.

The San Diego Water Board may also issue regional general NPDES permits for discharges otherwise covered under statewide general NPDES permits. Regional general permits may include more specific implementation measures, such as focused BMPs or additional monitoring and reporting requirements.

Lastly, the San Diego Water Board may, in response to documented impacts to the Stream Biological Objective by similar projects or facilities under statewide general permits, request that State Board provide additional requirements or limitations to protect the Stream Biological Objective during subsequent general permit reissuance processes.

General Regional Board NPDES Permits

For Regional General NPDES permits (excluding Phase I MS4), the San Diego Water Board will evaluate the probable threat to the Stream Biological Objective associated with the discharge to determine if Stream Biological Objective monitoring and reporting implementation requirements will be incorporated as permit requirements.

As with individually issued permits, the San Diego Water Board will require applicants, as part of their ROWD, submit a Receiving Water Biological Assessment if the discharge meets the following criteria:

- Discharge to a seasonal stream, and
- Discharge duration period greater than 2 months, and
- Discharge outside the rainy season (rainy season is Oct 1st to May 30th), or
- Discharge to a high quality waterbody

For temporary discharges under San Diego Water Board general NPDES permits, the San Diego Water Board will, as is currently done, assess a proposed discharge's applicability for enrollment under the general order and may require additional BMPs, effluent limitations, and/or the discharger to obtain an individual NPDES permit.

Applicants for permanent and temporary discharges to wadeable streams under San Diego Water Board NPDES permits that meet the above criteria may be required to include a Receiving Water Biological Assessment in their ROWD. The Receiving Water Biological Assessment will evaluate bioassessment and invasive species data, channel morphology and the potential for scour, and evaluation of regional models relative to the discharge in order to determine if the discharge will match naturally occurring flow magnitudes and duration (see Stein et al. 2017a). Receiving water data for the Receiving Water Biological Assessment may include data collected by the applicant, Surface Water Ambient Monitoring Program (SWAMP) data, data from the most recent Integrated Report, or data from other agencies and sources.

For permits that require a consideration of discharge alternatives, the Receiving Water Biological Assessment must be included in the alternatives consideration by the applicant/permittee. The biological assessment must be included in the alternatives consideration. Should information submitted to the San Diego Water Board indicate that the discharge may cause or contribute to an excursion above the Stream Biological Objective, additional WQBELs, BMPs, monitoring, and/or the issuance of an individual NPDES permit may be required to ensure the discharge would not cause or contribute to an excursion above a water quality standard.

5.3.4 Permit Implementation for Permits with Receiving Water Limitations for the Stream Biological Objective

Standard Permit Implementation

The inclusion of the Stream Biological Objective as a receiving water limit in specific permits is intended to be used as a priority consideration when determining program implementation effectiveness. As described above, Stream Biological Objective data in receiving waters subject to a discharge are expected to be used to assess the success of a permittees BMPs, TBELs, and WQBELs while guiding what additional implementation actions, if any, are needed.

Where conditions in the receiving waters subject to a discharge do not meet the Stream Biological Objective, **that result in itself does not produce a condition of permit noncompliance**. Permits are issued to ensure that a discharge does not cause or contribute to an exceedance of water quality standards, including the Stream Biological Objective. It is possible that factors external of the permitted discharge result in the Stream Biological Objective not being met in a receiving water, such as illicit discharges, illegal dredge or fill activities, noncompliance by other permitted dischargers, or natural factors.

Results from permit-based Stream Biological Objective monitoring are expected to be assessed by the discharger to determine if the permitted discharge caused or contributed (or may have caused or contributed) to an exceedance of the Stream Biological Objective. However, implementation of the Stream Biological Objective in NPDES permits is not intended or expected to require permittees to conduct traditional USEPA causal assessments in response to degraded conditions or exceedance of the Stream Biological Objective ("CADDIS" USEPA 2010). These may be required when conducting TMDL development (see Section 5.5). Instead, regulated permittees will be highly encouraged to utilize rapid causal assessment methods when assessing impacts associated with their discharge as part of their existing implementation of BMPs, TBELs, and WQBELs.

San Diego Water Board Permits for Phase I Municipal Storm Water

As Phase I MS4 discharges have been identified by the San Diego Water Board as presenting a probable threat to the Stream Biological Objective, the Stream Biological Objective will be incorporated as a receiving water limit with associated Stream Biological Objective monitoring and reporting unless a permittee or permittees choose to select an alternative compliance pathway. Where an alternative compliance pathway is selected, the permittee must notify the San Diego Water Board prior to the submittal of their ROWD.

For San Diego Water Board issued individual or regional permits for Phase I MS4 discharges, the San Diego Water Board will require permittees conduct receiving water bioassessment in locations representative of the discharge(s).

For San Diego Water Board regional municipal storm water permits, dischargers are currently required to evaluate if their discharges cause or contribute to an exceedance of water quality standards in receiving waters. Tools are available to evaluate the storm and non-storm water hydrologic (see Stein et al. 2017a and 2017b) and chemical quality of discharges from their MS4 in relation to observed receiving water chemical, physical habitat and biological condition (e.g. USEPA 2015b, City of San Diego 2015c). This process is already in place and being used for existing water quality objectives. In addition, current Regional MS4 Permit dischargers have already conducted receiving water condition assessments and included bioassessment, as seen in the approved Water Quality Improvement Plan (WQIP) for the San Juan Hydrologic Unit (Orange County 2017), or are developing rapid casual assessment stressor identification methods for larger scale MS4 systems that incorporate both physical and chemical alteration components (e.g. City of San Diego 2015b, 2015c, Gillet et al. *under review*). The San Diego Water Board expects this process to continue, with the Stream Biological Objective added as a water quality objective driver for stream integrity.

The San Diego Water Board will require permittees to assess and prioritize program implementation based on the biological condition of waters subject to a discharge(s). Permits will require permittees use CSCI scores to guide program implementation (e.g. in permittee development of WQIPs). Consistent with the general steps for implementation of the Stream Biological Objective, this process may prioritize implementation actions for discharges to:

- Protect high quality sites that meet or exceed the biological objective.
- Protect sites that meet the biological objective but are vulnerable.
- Restore sites that do not meet the biological objective.

Prioritization of implementation actions must investigate if the observed condition is or could be threatened, vulnerable, or impacted relative to a storm water discharge(s) and/or an external factor(s) that caused or contributed to the observed condition. Rapid causal assessment, physical in-stream habitat assessment, biological condition modeling, and traditional stressor identification methods may be utilized for the evaluation and prioritization. Formal USEPA causal assessment (e.g. “CADDIS” USEPA 2010) is not appropriate for use in this application. While this prioritization may identify other core beneficial uses as a priority for implementation actions (e.g. human health related beneficial uses), this does not preclude the evaluation of the Stream Biological Objective in the assessment process.

Permit writers will require permittees use CSCI results as part of the process to evaluate program effectiveness, and to prioritize storm water program implementation actions to protect and/or restore aquatic life Beneficial Uses. CSCI results shall be used to target management measures and/or best management practices that prevent or minimize the discharge of pollutants that impact aquatic habitat.

5.3.5 Effluent Limits for the Stream Biological Objective in NPDES Permits

Technology and chemistry-based effluent limitations, as well as BMPs, are expected to protect water quality standards, including the Stream Biological Objective (40 CFR 144(k)). Water quality monitoring of discharges and receiving waters will be required to be assessed in permits to guide the implementation of best management practices. Effluent limitations for the Stream Biological Objective in NPDES permits will be established where a causal assessment has been conducted, the Total Maximum Daily Load (TMDL, see Section 5.5 below) development process has identified sources and parameters, and wasteload allocations have been established. The Stream Biological Objective may be translated into effluent limits established to protect or restore the biological integrity of surface waters after:

- A clear causal relationship has been established linking the discharge to the degradation,
- The pollutants causing or contributing to the degradation have been identified, and
- Appropriate loading studies have been completed to estimate the reductions in pollutant loading for the discharge that will protect Beneficial Uses.

5.4. Integrated Reporting

Section 305(b) of the CWA requires each state to report biennially to USEPA on the water quality conditions of its surface waters. USEPA compiles these assessments into a biennial "National Water Quality Inventory Report" to Congress. CWA Section 303(d) requires each state to develop, update, and submit to the USEPA for approval, a list of waterbody segments not meeting water quality standards. Federal regulations at 40 CFR Section 130.7(d)(1) require each state to submit the list biennially. This list is commonly referred to as the "303(d) List" or the "List of Impaired Waters." Waterbody segments placed on the 303(d) list must be addressed through the development of Total Maximum Daily Loads (TMDLs, see below), or an existing regulatory program that is reasonably expected to result in the attainment of the water quality standard within a specified timeframe.

In conformance with USEPA guidance (USEPA 2005), the State and Regional Water Boards prepare a single Integrated Report that meets the reporting requirements of CWA sections 303(d) and 305(b). The San Diego Water Board is responsible for developing and adopting the Integrated Report for waters within the San Diego Region. Following adoption by the San Diego Water Board, the Integrated Report is transmitted to the State Water Board, where it is considered for approval.

The Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (Listing Policy) (SWRCB 2015), provides guidelines for the water quality assessment process and establishes a standardized approach for developing California's 303(d) list. The Listing Policy outlines an approach for making listing decisions based upon different types of data and establishes a systematic framework for statistical analysis of water quality data. The Listing Policy also establishes requirements for data quality, data quantity, and administration of the listing process. Listing and delisting factors are provided for chemical-specific water quality standards; bacterial water quality standards; health advisories; bioaccumulation of chemicals in aquatic animal tissues; defining "nuisance" such as trash, odor, and foam; nutrients; water and sediment toxicity; adverse biological response; degradation of aquatic animal populations and communities; trends in water quality; and weight of evidence.

The San Diego Water Board has previously used the CSCI in the Integrated Reporting process (San Diego Water Board 2016) in accordance with the Listing Policy and USEPA recommendations for incorporation of biological data (USEPA 2002a and 2002b). The addition of the Stream Biological Objective to the Board Basin Plan is consistent with the recommendations for benthic community effects determination in the Listing Policy and by USEPA, which includes using physical and chemical data when conducting assessments, including assessment of hydrologic alteration and physical habitat condition (see USEPA 2015b, Listing Policy §§ 6.1.5.8).

Under the Listing Policy, a water segment may be on the 303(d) list for biological impairments if it exhibits significant degradation in biological populations as compared to a reference site or if there is an adverse biological response (e.g. fish or bird kills) in the water segment. (Listing Policy §§ 3.8 and 3.9.) However, prior to listing the biological degradation or adverse response must first be associated with a potential pollutant (e.g. temperature, dissolved oxygen, trash) or type of pollution (e.g. hydromodification). This step is important, as the 303(d) List (Category 5 waterbodies) identifies those waterbodies for which **pollutants** are impairing beneficial uses. Category 4 identifies those waterbodies where beneficial uses are impaired due wholly or in part to non-pollutant factors (it also identifies waters impaired but with an approved TMDL).

While the Stream Biological Objective is a water quality objective, it is not a pollutant. Thus, failure to meet a biological water quality objective simply means there is an overall beneficial use impairment. Consistent with USEPA recommendations (2015b), the San Diego Water Board will continue to place waterbodies identified as impaired for biological condition into multiple Integrated Reporting Categories, as applicable depending on the impairment sources (pollutant or pollution) identified in lines of evidence for stream segments and as applicable using the current Listing Policy (see Figure 18.

Upon adoption of the Stream Biological Objective, a water segment may be considered impaired based on exceedances of the Stream Biological Objective consistent with section 3.9 and 6.1.5.8 of the Listing Policy[9]. However, pollutant and pollution information will not be disregarded, and will be critical for the identification of potential sources and subsequent placement into proper Integrated Reporting Categories for impairment, as specific categories are specific to pollutants or pollution (see Chapter 3 in San Diego Water Board 2016). These sources can include chemical, physical, and biological pollutants/pollution, especially with respect to current, proposed, and historic discharges. The degree of habitat and/or hydrologic alteration is a critical consideration in the assessment of biological integrity, and tools are currently developed or under development to better assess degrees of alteration on various scales, from site-specific to the watershed level (e.g. City of San Diego 2015c, Stein et al. 2017a and 2017b, Mazor et al. 2018b, Rehn et al. 2018, Sengupta et al. 2018).

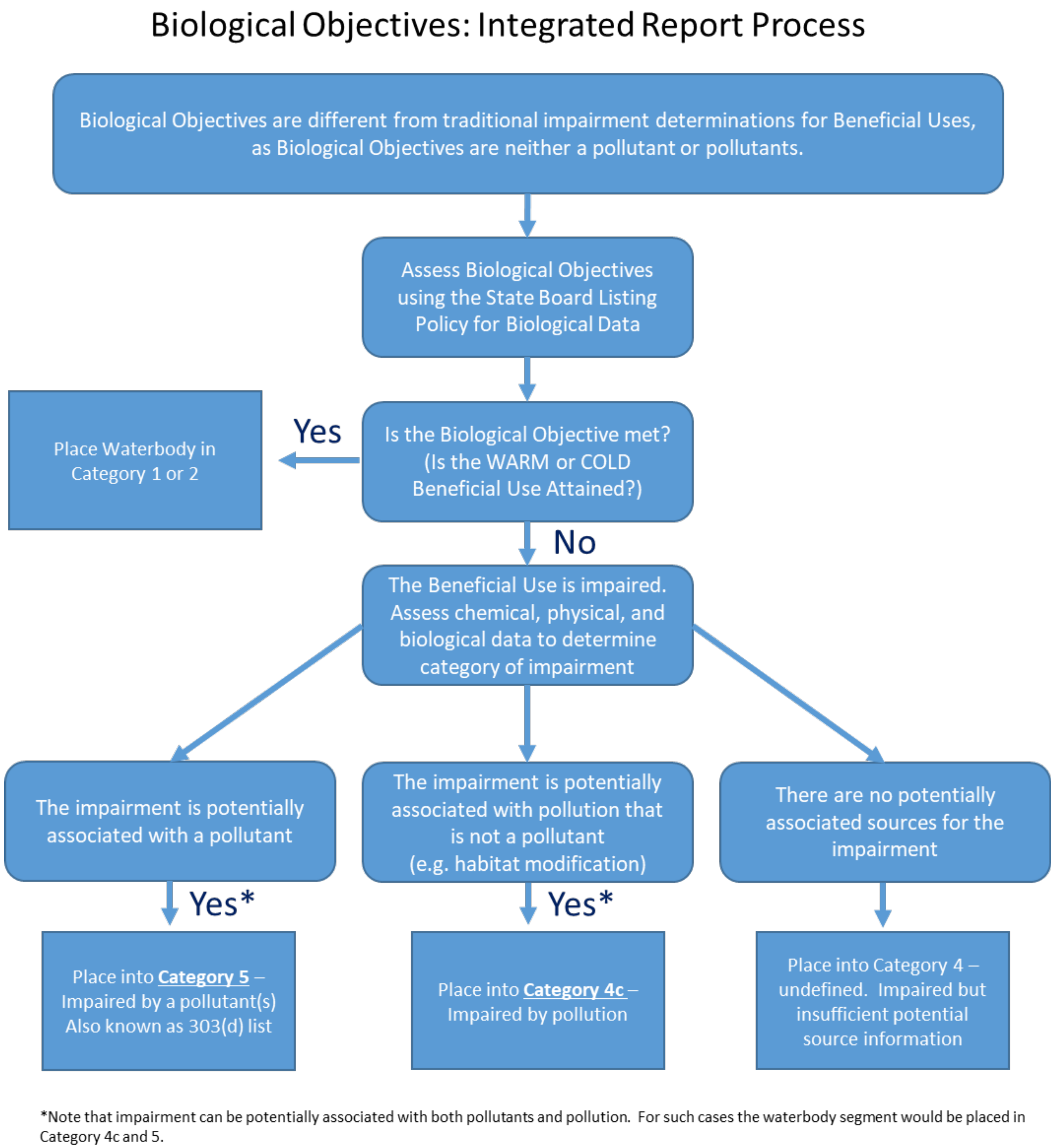
The tools available may be used by the San Diego Water Board as part of the source identification and listing/delisting process, which will also provide dischargers with information regarding a discharge's potential to cause or contribute to exceedance of the Stream Biological Objective. Rapid causal assessment methods, when automated, could also be used by the San Diego Water Board during the listing and delisting process to assess potential sources and guide TMDL and/or TMDL alternative development.

The listing and delisting of waterbodies for biological degradation will be conducted consistent with the Listing Policy (Listing Policy §§ 4.9, 4.10, 4.11) regarding assessment of degradation, trends, and site-specific weight-of-evidence factors.

As specified in the Stream Biological Objective, the objective may be determined to be met by the San Diego Water Board where natural factors are resulting in low CSCI scores for a waterbody. Some waterbodies may have disturbance or chemistry that mirrors anthropogenic impacts but occurs naturally, warranting a case-by-case site-specific assessment of whether the water quality objective is met for that particular waterbody. At the discretion of the San Diego Water Board, the integrated reporting process will incorporate this assessment when determining if water quality objectives for specific waterbodies are met.

[9] Tables 3.1, 3.2, 4.1, and 4.2 in the Listing Policy apply to pollutants. They do not apply to the assessment of biological population and community data.

Figure 18. Flow chart of Stream Biological Objective assessment process and categorization for the Clean Water Act Sections 305(b) and 303(d) Integrated Report.



5.5. Total Maximum Daily Load

The Total Maximum Daily Load (TMDL) program is required under CWA Section 303(d). Where CWA Section 303(d) requires states to identify where surface waters are not meeting water quality standards, states restore those water quality standards that are impaired, either through a TMDL, an existing regulatory program, or other pollution control programs (SWRCB 2005, USEPA 2013).

A TMDL is a quantitative assessment of water quality problems, contributing sources, and load reductions or control actions needed to restore and protect a waterbody's water quality standards. The TMDL approach does not replace existing water pollution control programs. It provides a framework for evaluating pollution control efforts and for coordination between federal, state and local efforts to meet water quality standards where existing programs are insufficient. TMDLs typically include an implementation plan, including a schedule for achieving the water quality standards in the receiving waters and monitoring and assessment to evaluate compliance. The majority of TMDLs are adopted as amendments to the Basin Plan. Under some circumstances, TMDLs may be established through non-regulatory tools such as permitting and enforcement actions (see SWRCB Resolution 2005-0050, Water Quality Control Policy for Addressing Impaired Waters: Regulatory Structure and Options § I.D.2.)

The San Diego Water Board utilizes waterbodies identified in the Integrated Report as impaired as a basis for beginning the TMDL process. While the Integrated Report also includes TMDL scheduling, the 2014 Integrated Report adopted by the San Diego Water Board has at least 166 impaired waterbodies, typically for multiple pollutants. Thus, the implementation of the TMDL program must consider additional factors when prioritizing waterbodies for implementation, including availability of alternative restoration approaches, spatial and temporal applicability, key beneficial uses and areas, environmental justice, and progress made in existing permits to restore beneficial uses relative to TMDL timeframes (USEPA 1997b, USEPA 2015b). The 2014 Integrated Report includes impairment listings for benthic community degradation, and amendment of the Basin Plan to include exceedances of the Stream Biological Objective would continue the practice of waterbody assessments for impairment listings and subsequent evaluation of priority for TMDL development.

If a waterbody is selected for formal TMDL development, the numeric (if applicable) objectives would likely be included in the TMDL impairment and source assessment process, which evaluates the magnitude of the impairment spatially and temporally, as well as historic, existing, and potential sources of impairment. For the Stream Biological Objective, this evaluation is expected to include an assessment of the biological condition of receiving waters to confirm the magnitude of the listed impairment and include a causal assessment component where warranted to determine the physical (see USEPA 2015b) and/or chemical causes of impaired biological condition, if and where observed.

As described in the NPDES implementation section above, causal assessment is not limited to the TMDL process, but when used by the TMDL program it is expected to be done in accordance with San Diego Water Board and USEPA guidance, recommendations, and requirements on a TMDL-by-TMDL basis. Extensive research and piloting of the USEPA causal assessment has occurred in California and other states (see Schiff et al. 2015), with extensive improvements identified for the traditional CADDIS causal assessment method (USEPA 2010). For TMDLs in the San Diego Region, the causal assessment process is expected to include recommendations from Schiff et al. 2015, including expansion of comparator sites (consistent with predictive index tools, Gillet et al. *under review*) and incorporation of new assessment tools (e.g. flow ecology, Stein et al. 2017a and 2017b).

For the Stream Biological Objective, the TMDL development process needs to differentiate between impairment caused by pollutants, pollution, or a combination of both. Impairment caused by pollutants are differentiated in Integrated Reporting from those caused by pollution. In USEPA 2015b, clarification was provided on the assessment and assignment of waters whose impairment is caused wholly or in part by pollution. Such pollution includes hydrologic or habitat alteration, which USEPA suggests States can assess using biological or flow criteria. Thus, “data and/or information documenting significant hydrologic or habitat alteration could be used to make a use attainment decision for an impairment due to pollution not caused by a pollutant and should be collected, evaluated, and reported as appropriate” (USEPA 2015b). Furthermore, USEPA 2015b states:

> *If States have data and/or information that a water is impaired due to pollution not caused by a pollutant (e.g., aquatic life use is not supported due to hydrologic alteration or habitat alteration), those causes should be identified and that water should be assigned to Category 4C. Examples of hydrologic alteration include: a perennial water is dry; no longer has flow; has low flow; has stand-alone pools; has extreme high flows; or has other significant alteration of the frequency, magnitude, duration or rate-of-change of natural flows in a water; or a water is characterized by entrenchment, bank destabilization, or channelization. Where circumstances such as unnatural low flow, no flow or stand-alone pools prevent sampling, it may be appropriate to place that water in Category 4C for impairment due to pollution not caused by a pollutant. In order to simplify and clarify the identification of waters impaired by pollution not caused by a pollutant, States may create further sub-categories to distinguish such waters. While TMDLs are not required for waterbody impairments assigned to Category 4C, States can employ a variety of watershed restoration tools and approaches to address the source(s) of the impairment.*

Thus, for TMDL development related to the Stream Biological Objective, the TMDL will by necessity identify those pollutants and/or pollution that is causing or contributing to the impairment, with appropriate regulatory and/or non-regulatory actions for pollutants and pollution. This is consistent with existing TMDL requirements, which require pollutants be addressed within a set time period though incorporation into relevant permits. However, for impairment due to pollution, such as channel modification via hardening, longer-term restoration of the watershed's hydrologic regime is needed in order to provide for in-stream habitat restoration (see Bernhardt and Palmer 2011, Hughes et al. 2014, Loflen et al. 2016, Stein et al. 2017a and 2017b). The existing San Diego Regional Municipal Storm Water permit (R9-2013-0001) includes requirements for redevelopment activities to mitigate for changes in hydrology associated with redevelopment projects. In addition, Section E.5.e of R9-2013-0001 requires Copermittees have a program to retrofit areas of existing development within its jurisdiction to address identified stressors, including pollutants and pollution, and to have a program for the rehabilitation of streams, channels, and habitats within areas of existing development in consideration of pollutants and pollution. These existing requirements are expected to gradually address pollution over time and allow for in-stream habitat restoration to occur at various time scales, due to difference in existing stream condition, independent of the traditional TMDL process.

Selection of biological targets in TMDLs would be consistent with the narrative guidance and the Stream Biological Objective, and is expected to be conducted on a TMDL-by-TMDL basis, allowing for site-specific expectations over select time periods in comparison to reference, consistent with the guidance and Stream Biological Objective. This would also include consideration as to if impairments are due to pollutants and/or pollution. The Stream Biological Objective will, in most cases, guide restoration of water quality standards for chemistry-based water quality objectives, which is the goal of the TMDL process, and may take precedent when considering compliance with WLAs and conducting Basin Plan modifications, as the development of WLAs is a modeling exercise with assumptions and levels of uncertainty. For example, the Lahontan Region Squaw Creek TMDL 2006 includes benthic invertebrate biological metrics to guide stream sediment restoration activities and Beneficial Use attainment, which guides overall TMDL compliance with WLAs in the TMDL (e.g. the restoration of the stream takes precedence over compliance with chemistry-based WLAs).

Lastly, the TMDL development process may identify that a specific waterbody that was 303(d) listed as impaired is impaired due to naturally occurring pollutants (e.g. not present due to anthropogenic activities). For such cases, the TMDL development process may identify that site-specific waterbodies are, in fact, similar to reference expectations and are thus meeting the Stream Biological Objective. In such cases, this determination may be used in the Integrated Reporting process (described above) for de-listing purposes.

5.6. Clean Water Act Section 401 Water Quality Certifications

Under section 401 of the CWA, any applicant for a federal license or permit which may result in any discharge into navigable waters must obtain a CWA Section 401 Water Quality Certification (Certification) from the Water Boards verifying that the project will comply with state water quality standards and other appropriate requirements of state law.[10] State water quality standards include designated beneficial uses of the receiving water, water quality objectives, and the federal and state antidegradation policies. Certifications may also have to comply with other state requirements, such as the California Environmental Quality Act.

The Certification issued by the State may establish relevant effluent limitations, monitoring requirements, and performance standards that then become conditions of the federal license or permit. The Certification ensures that beneficial uses for waterbodies subject to the discharge will be protected. In California, the responsibility for Certifications is assigned to the State Water Board and the nine Regional Water Boards. The Water Board may opt to:

- Recommend Certification with or without conditions
- Deny Certification
- Adopt or deny WDRs

The federal license or permit may not be issued if a Certification is denied.

The federal licenses and permits that are most frequently subject to §401 water quality certification are CWA §404 (dredge and fill) permits. However, other federal licenses and permits may be subject to Section 401, such as NPDES permits issued by EPA and Rivers and Harbors Act §9 and §10 permits issued by the Corps.

The San Diego Water Board reviews Certification applications for impacts to water quality and the designated beneficial uses for receiving water(s). Certifications involve activities that vary in scope, magnitude, and duration, and may often impact multiple habitats types. In cases where there will be impacts to waters of the United States attributable to the project, the Certification applicant must show that a sequence of actions has been taken to first avoid, then minimize, and lastly mitigate for the impacts. The Certification may include appropriate conditions to offset any unavoidable impacts through compensatory mitigation. Upon adoption of the Stream Biological Objective, the San Diego Water Board will consider impacts to the Stream Biological Objective in its review of Certification applications. If the activity has the potential to impact a biological resource, the San Diego Water Board may impose additional conditions on the activity or the compensatory mitigation as discussed below.

[10] Discharges to waters of the state that are not regulated under the CWA, including discharges are of dredge and fill material, are regulated through the issuance of WDRs under Porter-Cologne.

The 401 Certification has special emphasis on activities affecting wetlands, riparian areas, and headwaters. These valuable waters have high resource value and are vulnerable to dredge and fill activities. The Basin Plan includes a discussion on the degradation of biological communities associated with dredge and fill activities (4-62, 4-98). Research to date in the San Diego Region has demonstrated that the 404 permit program/401 Certification Program has resulted in the loss of beneficial uses, and recommends incorporation of "performance standards based on habitat function" (Sudol and Ambrose 2002).

The Stream Biological Objective established through this Basin Plan amendment will be incorporated into the San Diego Water Board's Certification application review and issuance process. Certification applications will be reviewed for a project relative to water quality standards, including the Stream Biological Objective. Projects that are small in scale and having temporary-only impacts to aquatic resources will be evaluated for Certification with the inclusion of existing Basin Plan prohibitions and BMPs to ensure the Stream Biological Objective is protected. These projects are expected to not require further evaluation for the protection of the Stream Biological Objective, such as the inclusion of pre-project stream bioassessment monitoring or setting of biological objective performance standards.

Project applications proposing permanent impacts to aquatic resources in receiving waters with the Stream Biological Objective will be assessed for adverse effects to water quality standards through the priority of first avoiding, and then minimizing adverse effects of the project on aquatic life Beneficial Uses. Project applicants will be required to offset any remaining unavoidable adverse impacts to Beneficial Uses by compensatory mitigation requirements, which may include restoration, enhancement, establishment, and/or preservation of Beneficial Uses. Depending on the project conditions, the condition of Beneficial Uses may be evaluated using the Stream Biological Objective under both pre-project and post-project conditions in order to assess if Beneficial Uses have been lost due to the project, and said losses require additional mitigation. This may require pre-project evaluations including biological monitoring and bioassessment for wadeable streams, to determine the condition of Beneficial Uses on site relative to proposed avoidance, minimization, and compensatory mitigation measures, and to set biological objective performance criteria. Projects subject to CWA 404b requirements, which are required by the U.S. Army Corps of Engineers to consider project alternatives in the 404 process, may be required to include bioassessment in their evaluation of project alternatives for Certification.

For those projects with unavoidable permanent impacts to Beneficial Uses, measurable biological performance criteria may be required to ensure water quality standards are met and restored post-project at compensatory mitigation site(s). If required, this will include site-specific numeric criteria consistent with the Stream Biological Objective in the Basin Plan and Executive Order W-59-3, commonly referred to as California's No Net Loss of Wetlands policy (No Net Loss Policy State of CA 1993). The Basin Plan amendment is consistent with and supports the No Net Loss Policy by incorporating the Stream Biological Objective for the assessment of habitat quality and values as outlined in the Executive Order. Assessment of potential compensatory mitigation site(s) to offset loss associated with permanent impacts is expected to consider the quantity and quality of loss at the permanent impact site (using biological monitoring). Furthermore, selection of compensatory mitigation site may be required to evaluate mitigation activities expected to achieve defined biological improvements for Beneficial Uses as a result of the restorative actions of the permittee applicant, independent of other external factors that may impact a mitigation site (e.g. upstream storm water discharges, see Loflen et al. 2016). This monitoring and assessment approach is currently used in some existing Certifications in the San Diego Region, but would now require enforceable Stream Biological Objective performance standards to protect and restore Beneficial Uses (e.g. R9-2015-0127[11], 11C-058[11]). Tools such as rapid causal assessment may be used to identify potential mitigation sites where specific restoration/establishment activities will meet performance metrics.

Where required, biological monitoring for assessment related to criteria, including the Stream Biological Objective, must also occur for a time period sufficient to demonstrate improvement and sustained performance (e.g. Parkyn et al. 2010, Loflen et al. 2016, Fong et al. 2017), including to meet biological objective performance metrics, but not less than five years as currently specified in current Certifications.

401 Certification applicants may propose to mitigate for unavoidable impacts to Beneficial Uses through the purchase of credits at mitigation banks or via payment of fees into in-lieu fee programs. Thus, the use of mitigation banks and in-lieu fee programs are included within the 401 Certification Program to compensate for impacts to aquatic resources authorized by general permits and individual permits. Mitigation banks and in-lieu fee programs are constructed/developed for the creation, restoration, enhancement, and/or preservation of aquatic resources that can be used, at a monetary cost, to offset unavoidable impacts to aquatic resources by individual projects seeking 401 Certification from Water Boards. As mitigation banks and in-lieu fee programs offset impacts to water quality standards, those offsets relative to impacts must be quantified in regard to establishment, restoration, and/or enhancement of water quality standards lost (permanently or temporarily) as a result of a project's impacts.

[11] https://www.waterboards.ca.gov/sandiego/water_issues/programs/401_certification/

The historic basis for assessment of Beneficial Uses lost and gained relied on a geographical assessment of acreage and/or linear feet of aquatic resources, with quantitative measurements of plant-based metrics to determine condition and guide the purchase of credits or payment of fees. In order for project applicants to utilize mitigation bank or in-lieu fee programs, the San Diego must assess the success of the bank or program at provided compensation for lost Beneficial Uses. The San Diego Water Board currently requires assessment consistent with this amendment of the Basin Plan, which would require more ecologically-based assessment of pre and post bank/program implementation using comparator sites and/or upstream/downstream sites to quantify water quality standards and meet the Policy (Executive Order W-59-93). For the Stream Biological Objective, this process will now likely include conducting bioassessment pre and post bank establishment and the setting of biological objective performance metrics to document bank establishment and fee payment program success and thus suitability for use by project applicants.

5.7. Waste Discharge Requirements (WDRs)

The San Diego Water Board regulates discharges of waste that may affect the quality of waters of the state, other than discharges to a community sewer system, through the issuance of WDRs or conditional waivers of WDRs. (Water Code §§ 13263, 13269). WDRs impose limits on the quality and quantity of waste discharges and specify conditions to be maintained in the receiving waters. This section focuses on WDRs imposed for discharges not covered by the CWA. These include WDRs for nonpoint sources (e.g. agriculture), for discharges of dredge and fill to waters of the State not considered waters of the United States (e.g. isolated wetlands), and for discharges to land that have the potential to impact groundwater (e.g. landfills). (See Sections 5.3 for NPDES and Section 5.6 for 401 Certifications for discussion of WDRs issued concurrently under the CWA).

For WDRs, the San Diego Water Board where the Stream Biological Objective will apply as a receiving water limit, Stream Biological Objective monitoring and reporting will be required based upon the probable threat of the discharge to cause or contribute to degradation of the Stream Biological Objective. The San Diego Water Board presently has findings and a fact sheet that documents the impact of discharges from commercial agricultural operations on benthic macroinvertebrates (see R9-2013-0001, R9-2016-004 and 005). These discharge permits currently require bioassessment monitoring and reporting, and the use of receiving water data, including bioassessment, to guide permit implementation. As such, implementation of the Stream Biological Objective monitoring and reporting will occur in these permits as they have already been determined by the San Diego Water Board to represent a probable threat to the Stream Biological Objective.

For other individual or general WDRs, the San Diego Water Board will rely on the permit implementation process as described in section 5.3, above.

WDRs need not contain numeric effluent limits and generally rely on best management practices to reduce pollution. The following sections discuss how the Stream Biological Objective will be implemented in WDRs issued in the San Diego Region.

5.7.1 Commercial Agriculture

The San Diego Water Board has issued WDRs for discharges associated with commercial agriculture operations. In 2016, the San Diego Water Board adopted Order No. R9-2016-0004, *General WDRs for Discharges from Commercial Agricultural Operations for Dischargers that are Members of a Third-Party Group in the San Diego Region* (Third-Party General Order), and Order No. R9-2016-2005, *General Waste Discharge Requirements for Discharges from Commercial Agricultural Operations for Dischargers Not Participating in a Third-Party Group in the San Diego Region* (Individual General Order). Collectively, the Third-Party General Order and the Individual General Order are referred to as the General Agricultural Orders.

The General Agricultural Orders requires Agricultural Operations to implement effective management practices to minimize or eliminate the discharge of pollutants that may adversely impact the Beneficial Uses of waters of the State, conduct routine monitoring and reporting activities, complete yearly water quality management training, and prepare and implement Water Quality Protection Plans and Water Quality Restoration Plans. The Third-Party General Order also includes requirements for approved Third-Party Groups. The General Agricultural Orders contain water quality monitoring “benchmarks” to assess the adequacy of implementation of management practices to protect water quality standards. When monitoring benchmarks are exceeded affected dischargers are required to update their Water Quality Protection Plans and develop and implement Water Quality Restoration Plans. The Stream Biological Objective would be included as an additional monitoring “benchmark.”

Water Quality Protection Plans identify the type and location of management measures, based on agricultural operations, to minimize or prevent the discharge of waste to waters of the State via sources such as storm water runoff and irrigation water runoff. Quarterly monitoring and assessment of these management measures is required. As stated above, when receiving water quality “benchmarks” are exceeded, dischargers are required to develop Water Quality Restoration (Program) Plans. Water Quality Restoration Plans must include the following:

- A description of the actual or suspected waste sources that may be causing or contributing to the exceedance or trend of water quality degradation that threatens a beneficial use(s)
- Additional or improved management practices that will be implemented to minimize or prevent discharges causing or contributing to the exceedance or trend
- A schedule for implementation
- A monitoring and reporting plan to provide feedback on progress

The 3rd Party General Agricultural Order already includes monitoring requirements to conduct bioassessment at selected trend sites in the San Diego Region. The amendment of the San Diego Water Board Basin Plan would require the inclusion of the Stream Biological Objective as a receiving water limit and thus the use of the Stream Biological Objective as an additional "benchmark" under the General Orders during the next WDR renewal. Individual enrollees would be required to conduct an assessment of receiving water condition the Stream Biological Objective relative to their existing and/or proposed discharge. Compliance with the Stream Biological Objective is expected to be consistent with the existing response required for exceeding benchmarks, as described above.

The San Diego Water Board may also direct a discharger(s) to prepare a Water Quality Restoration Plan if a discharger(s) are determined to present an elevated risk or are found to be causing or contributing to an exceedance. Traditional causal assessment would not be required where receiving water limits are exceeded. However, rapid causal assessment could be used to assess the sources relative to discharges associated with agricultural activities.

The San Diego Water Board expects that the use of the Stream Biological Objective as an additional or priority benchmark to provide for more effective and efficient Water Quality Restoration Plans over time, as the Stream Biological Objective benchmark can:

1) Better assess the condition of receiving waters that receive agricultural dischargers than relying on chemistry-based monitoring results, and
2) Better pinpoint specific pollutants that are impacting receiving waters, allowing for better focus on implementing measures that will yield results.

5.7.2 Dredge and Fill Material Discharged to Non-federal Waters

The San Diego Water Board may issue general or individual WDRs for discharges of dredge and/or fill material to waters of the State that are not waters of the United States. The implementation for such discharges mirrors the 401 Certification implementation discussed in section 5.6 above.

5.7.3 Discharges to Land

The San Diego Water Board may issue WDRs to waste discharges to land that may affect ground water quality and beneficial uses. Examples of such waste discharges include:

- Sewage treatment plants with discharges to land
- On-site wastewater treatment systems, or "OWTS" (septic tanks and advanced treatment systems)
- Class III (nonhazardous waste) and Class I (hazardous waste) landfills
- Industrial discharges
- Land treatment units (bioremediation)
- Dairies

For WDRs for discharges to land, treatment is required to protect beneficial uses associated with groundwater. The proposed Stream Biological Objective is not applicable to groundwater and generally would not be incorporated into WDRS as a receiving water limit. However, where discharges to land may impact surface waters via an interconnected groundwater pathway, the San Diego Water Board may adopt WDRs that that include the Stream Biological Objective as a receiving water limit in the affected surface water with permit-specific groundwater and receiving water monitoring to determine if an interconnected groundwater pathway exists. Should the discharge to land be determined by the San Diego Water Board to reach surface waters with the Stream Biological Objective, the objective will be applied in the WDRs as a receiving water limit and contain receiving water monitoring and reporting requirements consistent with Section 5.3.

5.8. Nonpoint Source (NPS) Pollution Control Program

NPS pollution comes from many diffuse sources. NPS pollution occurs when rainfall flows off the land, roads, buildings, and other features of the landscape. This diffuse runoff carries pollutants into drainage ditches, lakes, rivers, wetlands, bays, and aquifers. NPS discharges are not subject to the NDPES permitting program, but the CWA requires states to develop a program to protect the quality of water resources from the adverse effects of NPS water pollution. The NPS Program aims to minimize NPS pollution from land use activities in agriculture, urban development, forestry, recreational boating and marinas, hydromodification, and wetlands. The NPS Program goal is to achieve water quality goals and maintain beneficial uses. The NPS Program also provides financial support and condition reporting (CWA section 319) for those waterbodies that are determined to be impaired and whose sources include NPS.

The San Diego Water Board regulates NPS pollution through WDRs as discussed in Section 5.7. The proposed amendments to the Basin Plan to the Stream Biological Objective may result in identification of waters where the Stream Biological Objective is met as discussed in Section 5.4. Waterbodies identified in the Integrated Report process as a priority based on biological condition are expected to be included as a San Diego Water Board priority for NPS reporting under the State of California's Nonpoint Source Management Plan, which is required to measurably improve water quality via the addition of management practices. The San Diego Water Board also may include the measurable protection of high quality waters in existing Nonpoint Source areas as a priority.

5.9. Grant Program

The San Diego Water Board periodically administers grants issued from various funding sources (e.g. legislative funds). Grants administered by the San Diego Water Board will require, as appropriate, the use of the Stream Biological Objective to provide an assessment of their proposed project on receiving water conditions and to assess the effectiveness of attaining the proposed improvements to water quality. This should include utilization of existing biological data relative to the proposed project, and a discussion of how the project relates to observed conditions and targeted improvements. Evaluation and recommendations by San Diego Water Board staff will be made on a case-by-case basis, consistent with the existing grant program process.

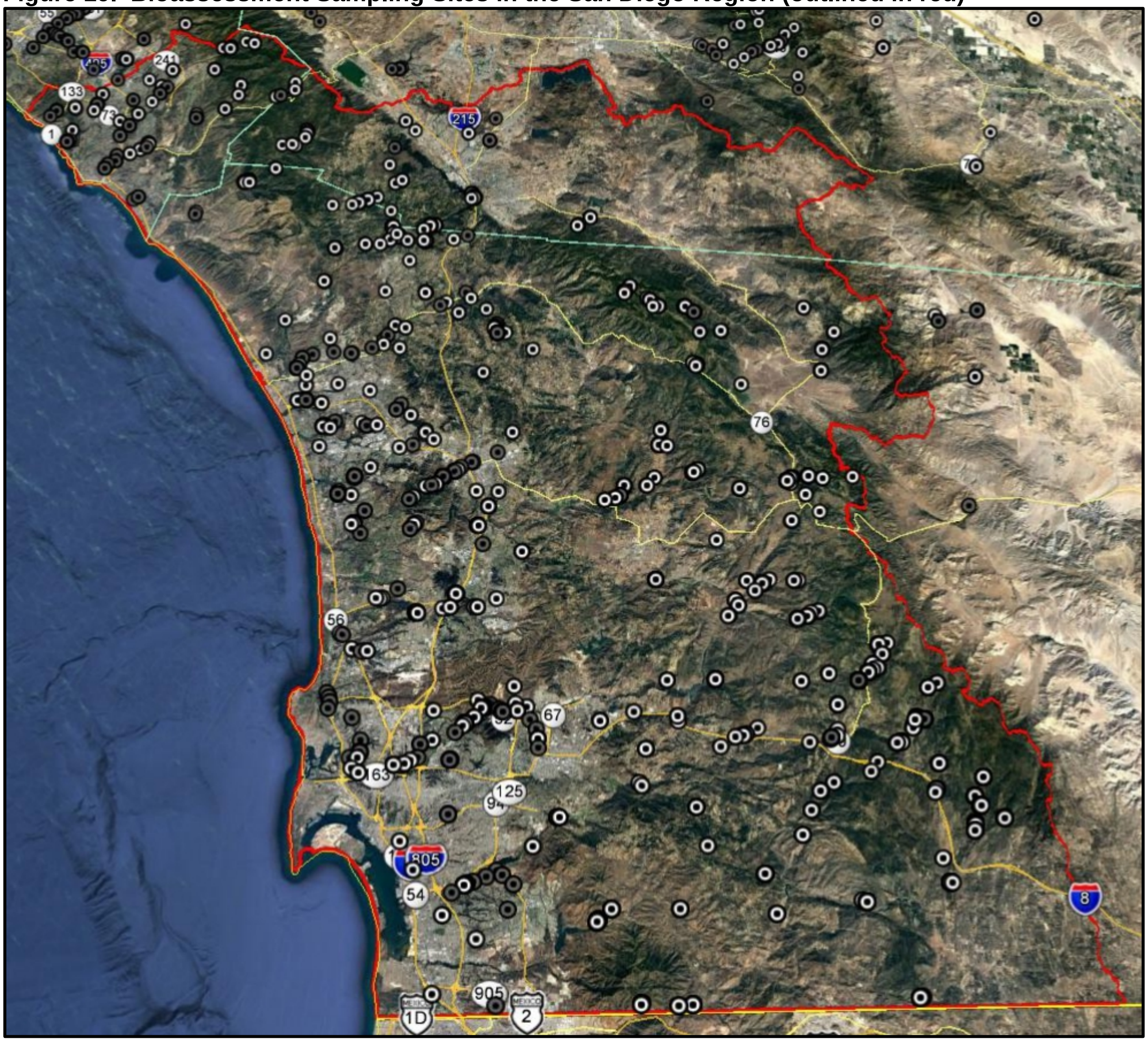
5.10. Monitoring and Reporting Requirements

Monitoring guidance, goals, and strategies for the San Diego Water Board are presented in the "Surveillance, Monitoring and Assessment" Chapter of the San Diego Basin Plan, as well as in the Framework for Monitoring and Assessment in the San Diego Region (Busse and Posthumus 2012). Surface water monitoring in the San Diego Region is conducted by a multitude of entities including, but not limited to, federal, state, local, research institutions, and citizen monitoring groups. In addition, entities regulated by the San Diego Water Board are required to conduct effluent and receiving water monitoring to measure compliance with applicable water quality standards. Monitoring may include: effluent monitoring and receiving water monitoring, including water column, sediment, and tissue monitoring, as well as conducting bioassessment.

The amendment of the Basin Plan to include the Stream Biological Objective may require San Diego Water Board permitting programs to incorporate biological monitoring (or bioassessment) to determine compliance with the Stream Biological Objective. Some permitting programs have already incorporated bioassessment into existing monitoring and reporting programs. In these cases, existing bioassessment requirements may need to be modified to provide the appropriate data and documentation to evaluate compliance with the proposed Stream Biological Objective as discussed below. In addition, the proposed amendment to the Basin Plan requires biological monitoring programs for receiving waters to be conducted in accordance with the State of California's most recent SOPs. The SOPs and provide guidance on the minimum requirements for sample collection and analysis (e.g. reach delineation, sampleability criteria, sampling protocol, etc.) Existing bioassessment requirements may be modified or supplemented to ensure consistency with the SOPs. For the Stream Biological Objective, this includes SOPs for sampling and analysis of benthic macroinvertebrates, algae, and chemistry as defined in the most recent SWAMP stream bioassessment SOP.

It is important to note that bioassessment monitoring data available for use in program implementation is not limited to the bioassessment activities conducted by individual dischargers. Within the San Diego Region, over 300 bioassessment sites have been sampled by various regulatory, regulated, and not-for-profit entities (Figure 19). Many of these sites have trend information, with some having been sampled periodically for 15 years or more.

Figure 19. Bioassessment Sampling Sites in the San Diego Region (outlined in red)



Municipal Storm Water

Phase I municipal storm water permittees in the San Diego Region are currently regulated under a region-wide permit which requires monitoring and reporting on receiving water conditions for a variety of surface waters, including conducting targeted bioassessment for wadeable streams on a watershed basis as part of their WQIPs (R9-2013-0001, Section II.D.1). In addition, permittees participate in region-wide probabilistic and trend stream bioassessment sampling as part of the SMC bioassessment program, which provides for an offset from other permit requirements (R9-2013-001, Section II.D.1.e). The level of monitoring and reporting that has occurred in the current Regional Phase I permit and past Phase I permits in the San Diego Region is expected to continue with the amendment of the Basin Plan to include the Stream Biological Objective. Existing permitting requirements under the region-wide permit require the Copermittees to evaluate data collected by all monitoring efforts (outfall monitoring, receiving water monitoring, and special studies) to assess program strategies in the WQIP towards achieving compliance with receiving water limitations and discharge prohibitions (Section II.D.4 of R9-2013-0001, as amended.). Copermittees are also required to re-evaluate the priority waterbody conditions for their watershed management area(s) as needed and as part of their ROWD. As part of this assessment, the Copermittees must consider the biological monitoring data (Section II.D.1.c.(5).). The incorporation of the Stream Biological Objective as a receiving water limit in the Phase I MS4 permit would thus require the Copermittees to assess if their discharge(s) are causing or contributing to an exceedance of the Stream Biological Objective receiving water limit and, based on that evaluation, adjust their BMPs in accordance with permit requirements.

Caltrans and Phase II storm water discharges are covered under General NPDES permits adopted by the State Water Board. The Phase II permit (2013-0001-DWQ, Section E.13) requires that monitoring occur for discharges to ASBS, TMDL, or 303(d) impaired waterbodies for Traditional Phase II enrollees, and includes required receiving water monitoring based on Phase II thresholds. Phase II permittees are also required to consult with the Regional Water Board on their receiving water monitoring programs, subject to Executive Officer approval. While there are not currently any Traditional Phase II enrollees in the San Diego Region, should any Traditional Phase II enrollees emerge, the Stream Biological Objective would be incorporated as a receiving water limit and bioassessment monitoring conducted consistent with the permit requirements.

For current or new small Phase II enrollees, no receiving water monitoring is required under the Phase II permit. The Caltrans permit (2012-0011-DWQ) does not require bioassessment monitoring. While the amendment of the Basin Plan to incorporate the Stream Biological Objective does not require Caltrans or Phase II facilities to conduct additional monitoring, the San Diego Water Board may exercise its authority under the CWA section 13383 or Porter-Cologne to require enrollees to conduct bioassessment within the San Diego Region to determine if their discharge(s) cause or contribute to an exceedance of water quality standards and submit reports commensurate with regulatory requirements. This may occur if the San Diego Water determines there is or may be a relationship between discharges from enrollees relative to the biological degradation in a specific receiving water, or if a discharge presents a high likelihood that the discharge will result in degradation of a high quality water.

Construction Storm Water

Enrollees under the current Statewide General NPDES construction storm water permit, 2009-0009-DWQ as amended, are required to conduct bioassessment of receiving waters only if the discharger is classified as a Risk 3 or LUP Type 3 construction site and the project is equal to or larger than 30 acres with direct discharges into receiving waters. While the amendment of the Basin Plan to incorporate the Stream Biological Objective does not require construction permit enrollees to conduct additional monitoring, the San Diego Water Board may exercise its authority under the CWA section 13383 or Porter-Cologne to require enrollees to conduct bioassessment within the San Diego Region to determine if their discharge(s) cause or contribute to an exceedance of water quality standards and submit reports commensurate with regulatory requirements. This may occur if the San Diego Water determines there is or may be a relationship between discharges from enrollees relative to the biological degradation in a specific receiving water, or if a discharge presents a high likelihood that the discharge will result in degradation of a high quality water.

Industrial Storm Water
Enrollees under the Statewide General NPDES industrial storm water permit in the San Diego Region are currently not required to conduct bioassessment of receiving waters within the San Diego Region. While the amendment of the Basin Plan to incorporate the Stream Biological Objective does not require enrollees to conduct additional monitoring, the San Diego Water Board may exercise its authority under the CWA section 13383 or Porter-Cologne to require enrollees to conduct bioassessment within the San Diego Region to determine if their discharge(s) cause or contribute to an exceedance of water quality standards and submit reports commensurate with regulatory requirements. This may occur if the San Diego Water determines there is or may be a relationship between discharges from enrollees relative to the biological degradation in a specific receiving water, or if a discharge presents a high likelihood that the discharge will result in degradation of a high quality water. NPDES permits issued to individual industrial facilities for storm water discharges generally require receiving water monitoring, including for biological condition. While no permits are in place in the San Diego Region, the inclusion of the Stream Biological Objective may require additional biological monitoring if permits are issued to individual facilities that discharge to receiving waters with the Stream Biological Objective to determine if their discharge(s) cause or contribute to an exceedance of water quality standards.

NPDES permitting
The San Diego Water Board has issues individual and general NPDES permits for discharges of wastewater to surface waters. Individual permits currently contain receiving water chemical, physical, and biological monitoring that is largely consistent with the amendment to the Basin Plan to incorporate the Stream Biological Objective (e.g. R9-2016-0099). In some cases, individual permits may need to be modified to ensure sampling and analysis methods are consistent with the State SOPs needed for the Stream Biological Objective. Existing individual permits (e.g. R9-2016-0099) already require biological monitoring, including bioassessment, for receiving waters subject to the discharge and include monitoring of analogous comparator sites (upstream in wadeable streams).

For individual non-storm water discharge permits with a discrete discharge point receiving water monitoring will occur upstream and downstream of the proposed or current discharge location for wadeable streams, or by the use of appropriate comparator sites for other waterbody types. If receiving water monitoring data indicates the downstream receiving water site is impacted relative to the upstream receiving site the discharger will be required to evaluate their discharge monitoring data and the observed downstream receiving water conditions (e.g. physical habitat, invasive species, illegal discharges) to investigate the observed impact. This investigation into the observed impacted condition is meant to determine if the impact may be due to the discharge and/or an external factor that caused or contributed to the observed condition. This can then be used to address any needed discharge modifications or through conveyance of external factors to the San Diego Water Board.

Monitoring and reporting for individual dischargers may also require additional source identification monitoring and assessment if receiving water monitoring continuously indicates a discharge may be causing or contributing to an exceedance of the Stream Biological Objective when compared to upstream (or otherwise appropriate comparator site) monitoring results beyond the initial investigation and response. Source identification monitoring may include rapid causal assessment or confirmation monitoring, which may include additional chemistry, physical habitat, and toxicity monitoring (e.g. at different temperatures using different species and endpoints).

For general statewide NPDES permit, enrollees are currently not required to conduct bioassessment of receiving waters within the San Diego Region. While the amendment of the Basin Plan to incorporate the Stream Biological Objective does not require enrollees to conduct additional monitoring, the San Diego Water Board may exercise its authority under the CWA section 13383 or Porter-Cologne to require enrollees to conduct bioassessment within the San Diego Region to determine if their discharge(s) cause or contribute to an exceedance of water quality standards and submit reports commensurate with regulatory requirements. This may occur if the San Diego Water determines there is or may be a relationship between discharges from enrollees relative to the biological degradation in a specific receiving water, or if a discharge presents a high likelihood that the discharge will result in degradation of a high quality water. Locations required for sampling would likely include stations upstream and downstream to ensure that permanent or extended duration discharges are not causing or contributing to an exceedance of water quality standards. This is consistent with current permitting for monitoring and reporting for discharges in the San Diego Region that are permanent or of extended duration (e.g. R9-2011-0052[12], R9-2016-0099[12]).

It is important to note that, consistent with current permitting requirements, the San Diego Water Board assessment of individual and/or general enrollee permit conditions, compliance, and monitoring results may result in additional monitoring and special studies requirements, including biological monitoring to assess if a discharge causes or contributes to an exceedance of water quality standards.

CWA Section 401 Water Quality Certifications

Monitoring and reporting for CWA 401 Water Quality Certifications are discussed in the prior implementation section.

[12] https://www.waterboards.ca.gov/sandiego/board_decisions/adopted_orders/

Waste Discharge Requirements

Applicable WDRs within the San Diego Region include those for commercial agricultural operations, for discharges of dredge and fill to waters of the State of California not considered waters of the United States, and in discharges to land that have the potential to impact groundwater via interconnected ground-surface waters. Existing WDRs for commercial agricultural for dischargers enrolled in a Third-Party Group require receiving water monitoring requirements, including regional stream bioassessment consistent with the latest SWAMP SOPs. The WDRs for commercial agricultural operations also require coordination in sampling with the SMC to prevent duplicative efforts and provide for resource efficiency. The Water Quality Protection Plan and Water Quality Restoration Plan process and use of the Stream Biological Objective in goal setting processes may result in additional targeted sampling efforts by some permittees or Third-Party Groups.

Monitoring and reporting for WDRs for discharges of dredge and/or fill to waters of the State that are not waters of the United States are covered under the CWA 401 Certification discussion in the prior implementation sections.

For WDRs for discharges to land, treatment is required to protect beneficial uses associated with groundwater, and thus the amendment of the Basin Plan to include the Stream Biological Objective will have low applicability to monitoring and reporting except in those cases where potential discharges to surface waters may exist via the groundwater pathway. As discussed above, for these cases the Regional Water Board may impose WDRs requiring a reduced concentration in the proposed discharge effluent, reduction in total nitrogen loads, and/or compliance with more stringent water quality objectives in receiving surface waters for the protection of beneficial uses. Such scenarios may include biological monitoring to ensure the discharge is not causing or contributing to an exceedance of the Stream Biological Objective, including using bioassessment for wadeable streams. These monitoring requirements would be consistent with those for individual NPDES permits.

NPS Program and CWA section 319(h) Grants

NPS Program and CWA section 319(h) grants shall, as appropriate, include bioassessment monitoring for NPS Program and Grant projects associated with wadeable streams, to assess project implementation success, depending on the scale and scope of the project on a case by case basis. Monitoring for restoration projects shall, as appropriate, take into account the magnitude and scope of the proposal related to receiving waters (see Loflen et al. 2016).

San Diego Water Board SWAMP Program

The State of California SWAMP was created to fulfill the State Legislature's mandate for a unifying program that would coordinate all water quality monitoring conducted by the Water Boards (see Assembly Bill 982, 1999). Each Regional Water Board implements its own individual program through annual funding for personnel and monitoring purposes. The amendment of the Basin Plan to include the Stream Biological Objective will not have a direct regulatory impact on the San Diego Region SWAMP. However, the San Diego Region SWAMP will continue to conduct and participate in biological monitoring and assessment in the region to support the Stream Biological Objective, including reference condition monitoring and assessment to support the CSCI. In addition, the State Water Board bioassessment program, which utilizes USEPA funds, conducts probabilistic and reference site sampling throughout California, including in the San Diego Region. This monitoring will be used to support development of additional biological objectives and the continued support of the CSCI.

6. References

Anderson, B.S., Phillips, B.M., Siegler, K., Voorhees, J.P., 2012. Initial Trends in Chemical Contamination, Toxicity and Land Use in California Watersheds: Stream Pollution Trends (SPoT) Monitoring Program. Second Technical Report - Field Years 2009-2010.

Bell, G.P. 1997. Ecology and Management of *Arundo donax*, and approaches to riparian habitat restoration in Southern California. *Plant Invasions: Studies from North America and Europe:* pp. 103-113. Backhuys Publishers, The Netherlands.

Bernhardt, E.S. and M.A. Palmer. 2011. River restoration: The fuzzy logic of repairing reaches to reverse catchment scale degradation. *Ecological Applications* 21:1926–1932.

Blinn, D.W. and D.B. Herbst. 2003. Use of Diatoms and Soft Algae as Indicators of Stream Abiotic Determinants in the Lahonton Basin, USA. Final Report to the California Water Quality Control Board, Lahonton Region and the California State Water Resources Control Board.

Borja, A., Bricker, S.B., Dauer, D.M., Demetriades, N.T., Ferreira, J.G., Forbes, A.T., Hutchings, P., Jia, X., Kenchington, R., Marques, J.C. and C. Zhu. 2008. Overview of integrative tools and methods in assessing ecological integrity in estuarine and coastal systems worldwide. *Marine Pollution Bulletin* 56: 1519-1537.

Brinson, M.M., Rheinhardt, R.D., Hauer, F.F., Lee, L.C., Nutter, W.L., Smith, D.R. and D. Whigham. A Guidebook for Application of Hydrogeomorphic Assessments to Riverine Wetlands. U.S. Army Corps of Engineers Wetland Research Program Technical Report WRP-DE-11.

Busse, L. and B. Posthumus. 2012. A Framework for Monitoring and Assessment in the San Diego Region. San Diego Water Board Staff Report.

Cairns, J.C., McCormick, P.V. and B.R. Niederlehner. 1993. A proposed framework for developing indicators of ecosystem health. *Hydrobiologia* 263: 1-44.

CWMW (California Wetland Monitoring Workgroup). 2013. California Rapid Assessment Method for Wetlands Riverine Wetlands Field Book. ver. 6.1 January 2013.

City of San Diego. 2015a. Investigation of Total Dissolved Solids Impacts on Freshwater Benthic Macroinvertebrate Communities in the San Diego Region. Amec Foster Wheeler Project No. 5025141095.

City of San Diego. 2015b. Synthetic Pyrethroids Causal Assessment for the San Diego River. Tetra Tech, Inc.

City of San Diego. 2015c. Identifying Modified Streams in Southern California. Tetra Tech, Inc.

County of San Diego. 2010. County of San Diego Department of Planning and Land Use General Plan Update Groundwater Study. April 2010.

Crooks, J.A. 1998. Habitat alteration and community-level effects of an exotic mussel, *Musculista senhousia*. *Marine Ecology Progress Series* 162: 137-152.
CWMW (California Wetlands Monitoring Workgroup). 2013. California Rapid Assessment Method (CRAM) for Wetlands, Version 6.1 pp. 67.

Currier, B., Minton, G., Pitt, R., Roesner, L.A., Schiff, K., Strenstrom, M., Strassler, E. and E. Strecker. 2006. Storm Water Panel Recommendations to the California State Water Resources Control Board: The Feasibility of Numeric Effluent Limits Applicable to Discharges of Storm Water Associated with Municipal, Industrial and Construction Activities. June 19, 2006.

Davis, W.S. and T.P. Simon. 1995. Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers.

Ellison, A.M., Bank, M.S., Clinton, B.D., Colburn, E.A., Elliot, K., Ford, C.R., Foster, D.R., Kloeppel, B.D., Knoepp, J.D., Lovett, G.M., Mohan, J., Orwig, D.A., Rodenhouse, N.L., Sobczak, W.V., Stinson, K.A., Stone, J.K., Swan, C.M., Thompson, J. Von Holle, B.V. and J.R. Webster. 2005. Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. *Frontiers in Ecology* 3(9): 479-486.

Fellers, G.M., McConnell, L.L., Pratt, D. and S, Datta. 2004. Pesticides in Mountain Yellow-legged Frogs (*Rana muscosa*) from the Sierra Nevada Mountains of California, USA. *Environmental Toxicology and Chemistry* 23(9): 2170-2177.

Fetscher, A.E., Stancheva, R., Kociolek, J.P., Sheath, R.G., Stein, E.D., Mazor, R.D., Ode, P.R. and L.B. Busse. 2014. Development and comparison of stream indices of biotic integrity using diatoms vs. non-diatom algae vs. a combination. *Journal of Applied Phycology* 26:443-450.

Fong, L.S., Stein, E.D. & R.F. Ambrose. 2017. Development of Restoration Performance Curves for Streams in Southern California Using an Interactive Condition Index. *Wetlands* 37: 289.

Gallart, F., Prat, N., García-Roger, E. M., Latron, J., Rieradevall, M., Llorens, P., Barberá, G. G., Brito, D., De Girolamo, A. M., Lo Porto, A., Buffagni, A., Erba, S., Neves, R., Nikolaidis, N. P., Perrin, J. L., Querner, E. P., Quiñonero, J. M., Tournoud, M. G., Tzoraki, O., Skoulikidis, N., Gómez, R., Sánchez-Montoya, M. M., and J. Froebrich. 2012. A novel approach to analyzing the regimes of temporary streams in relation to their controls on the composition and structure of aquatic biota, *Hydrology and Earth System Sciences* (16): 3165-3182.

Goldberg, C.S., Pilliod, D.S., Arkle, R.S. and L.P. Waits. 2011. Molecular Detection of Vertebrates in Stream Water: A Demonstration Using Rocky Mountain Tailed Frogs and Idaho Giant Salamanders. *PLoS One* 6(7).

Gunderson L., Holling C.S. (eds). 2001. Panarchy: understanding transformations in human and natural systems. Island Press, Washington, DC.

Hall, L.W., Killen, D.W., Anderson, R.D. and R.W. Alden. 2013. A three year assessment of the influence of physical habitat, pyrethroids and metals on benthic communities in two urban California streams. *Journal of Ecosystem & Ecography* 3: 133.

Hawkins, C.P. and J.R. Sedell. 1990. The Role of Refugia in the Recolonization of Streams Devasted by the 1980 Eruption of Mount St. Helens. *Northwest Science* 64(5):271-274.

Hawkins, C.P. 2006. Quantifying Biological Integrity by Taxonomic Completeness: Its Utility in Regional and Global Assessments. *Ecological Applications* 16(4): 1277-1294.

Herborg, L., Mandrak, N.E., Cudmore, B.C. and H.J. MacIssac. 2007. Comparative distribution and invasion risk of snakehead (Channidae) and Asian carp (Cyprinidae) species in North America. *Canadian Journal of Fisheries and Aquatic Sciences* 64: 1723:1735.

Herbst, D.B. and D.W. Blinn. 2008. Preliminary Index of Biological Integrity (IBI) for Periphyton in the Eastern Sierra Nevada, California: Draft Report. Surface Water Ambient Monitoring Program.

Herbst, D.B., Bogan, M.T., Roll, S.K. and H.D. Safford. 2012. Effects of livestock exclusion on in-stream habitat and benthic invertebrate assemblages in montane streams. *Freshwater Biology* 75: 204-217.

Herbst, D.B. 2016. Reach-Scale Riffle and Pool Habitat Vary with Stream Flow, Altering Benthic Community Structure in Reachwide Benthos Samples. Presentation at 2016 California Aquatic Bioassessment Workgroup.

Herbst, D.B., Medhurst, B.R. Medurst and I.D. Bell. 2016. Benthic invertebrate and Deposited Sediment TMDL Guidance for the Pajaro River Watershed. Final SWAMP Technical Report SWAP-MR-RB3-2016-0001.

Herbst, D.B., Medhurst, R.B. and N.J.P. Black. 2018. Long-Term Effects and Recovery of Streams from Acid Mine Drainage and Evaluation of Toxic Metal Threshold Ranges for Macroinvertebrate Community Reassembly. *Environmental Toxicology* 37(10): 2575-2592.

Hering, D., Borja, A., Jones, J.I., Pont, D., Boets, P., Bouchez, A., Bruce, K., Drakare, S., Hänfling, B., Kahlert, M., Leese, F., Meissner, K., Mergen, P., Reyjol, Y., Segurado, P., Vogler, A. and M. Kelly. 2018. Implementation options for DNA-based identification into ecological status assessment under the European Water Framework Directive. Water Research 138: 192-205.

Hilderbrand, R.H. and R.M. Utz. 2015. Ecological Thresholds and Resilience in Streams *in* Eds., Paweł Rowiński, Artur Radecki-Pawlik, Rivers – Physical, Fluvial and Environmental Processes, Springer, Berlin. pp 461-478.

Holling, C.S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology, Evolution, and Systematics* 4:1-23.

Huenneke, L.F., Hamburg, S.P., Koide, R., Mooney, H.A. and P.M. Vitousek. 1990. Effects of Soil Resources on Plant Invasion and Community Structure in Californian Serpentine Grassland. *Ecology* 71(2): 478-491.

Hughes, R.M., Kaufmann, P.R., Herlihy, A.T., Kincaid, T.M., Reynolds, L. and D.P. Larsen. 1998. A process for developing and evaluating indices of fish assemblage integrity. *Canadian Journal of Fisheries and Aquatic Science* 55(7):1618-1631.

Hughes, R.M., Dunham, S., Maas-Hebner, K.G., Yeakley, J.A., Schreck, C., Harte, M., Molina, N., Shock, C.C., Kaczynski, V.W. and J. Schaeffer. 2014. A Review of Urban Water Body Challenges and Approaches: Rehabilitation and Remediation. *Fisheries* 39(1): 18-29.

Kaplanis, N.J., Harris, J.L. and J.E. Smith. 2016. Distribution patterns of the non-native seaweeds *Sargassum horneri* (Turner) C. Agardh and *Undaria pinnatifida* (Harvey) Suringar on the San Diego and Pacific coast of North America. *Aquatic Invasions* 11(2): 111-124.

Karr, J.R. 1995. Using Biological Criteria to Protect Ecological Health. In: Rapport D.J., Gaudet C.L., Calow P. (eds) Evaluating and Monitoring the Health of Large-Scale Ecosystems. NATO ASI Series (Series I: Global Environmental Change), vol 28. Springer, Berlin, Heidelberg.

Karr, J.R. 1999. Defining and measuring river health. *Freshwater Biology* 41: 221-234.

Kaufmann, P. R., P. Levine, E. G. Robinson, C. Seeliger, and D. V. Peck. 1999. Surface waters: quantifying physical habitat in wadeable streams. EPA/620/R-99/003. Office of Research and Development, US Environmental Protection Agency, Washington, DC.

Kelly, M.G., A. Cazaubon, E. Coring, A. Dell'Uomo, L. Ector, B. Goldsmith, H. Guasch, J. Hürlimann, A. Jarlman, B. Kawecka, J. Kwandrans, R. Laugaste, E.-A. Lindstrøm12, M. Leitao, P. Marvan, J. Padis´ak, E. Pipp, J. Prygie, E. Rott, S. Sabater, H. van Dam, and J. Vizinet. 1998. Recommendations for the routine sampling of diatoms for water quality assessments in Europe. *Journal of Applied Phycology* 10: 215–224.

Kennedy, T.A., Naeem, S., Howe, K.M., Knops, J.M.H., Tilman, D. and P. Reich. 2002. Biodiversity as a barrier to ecological invasion. *Nature* 417: 636-638.

Klauda, R., Kazyak, P., Stranko, S., Southerland, M., Roth, N. and J. Chaillou. 1998. Maryland Biological Stream Survey: A State Agency Program to Assess the Impact of Anthropogenic Stresses on Stream Habitat Quality and Biota. *Environmental Monitoring and Assessment* 51: 299-316.

Kupferberg, S. 1997. Bullfrog (*Rana Catesbeiana*) Invasion of a California River: The Role of Larval Competition. *Ecology* 78(6): 1736-1751.

Lackey, R.T. 2001. Values, Policy, and Ecosystem Health: Options for resolving the many ecological policy issues we face depend on the concept of ecosystem health, but ecosystem health is based on controversial, value-based assumptions that masquerade as science. *Bioscience* 51(6): 437-443.

Loflen, C., Hettesheimer, H., Busse, L.B., Watababe, K., Gersberg, R.M., and V. Luderitz. 2016. Inadequate Monitoring and Inappropriate Project Goals: A Case Study on the Determination of Success for the Forester Creek Improvement Project. *Ecological Restoration* 34(2): 124-134.

Lowe, S., Browne, M., Boudjelas, S. and M. De Poorter. 2000. 100 of the World's Worst Invasive Alien Species A selection from the Global Invasive Species Database. Published by The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN).

Macher, J.N., Salis, R.K., Blakemore, K.S., Tollrian, R., Matthaei, C.D. and F. Leese. Multiple-stressor effects on stream invertebrates: DNA barcoding reveals contrasting responses of cryptic mayfly species. *Ecological Indicators* 61: 159-169.

Maddock, I. 1999. The importance of physical habitat assessment for evaluating river health. *Freshwater Biology* 41: 373-391.

Marzin, A., Delaigue, O., Logez, M., Belliard, J. and D. Pont. 2014. Uncertainty associated with river health assessment in a varying environment: The case of a predictive fish-based index in France. *Ecological Indicators* 43: 195-204.

Mayura, K.A., Schlenk, D., Anderson, P.D., Denslow, N.D., Drewes, J.E., Olivieri, A.W., Scott, G.I. and S.A. Snyder. 2013. An Adaptive, Comprehensive Monitoring Strategy for Chemicals of Emerging Concern (CECs) in California's Aquatic Ecosystems. *Integrated Environmental Assessment and Management* 10(1): 69-77.

Mazor, R., Schiff, K., Ode, P. and E.D. Stein. 2014. Final Report on Bioassessment in Nonperennial Streams. Report to the State Water Resources Control Board. SCCWRP Technical Report 695.

Mazor, R., Rehn, A., Pendelton, P., Dark, S., Giraldo, M., Stein, E. and C. Loflen. 2015. Final Report on Assessment of Nonperennial Streams. SCCWRP Report to San Diego Regional Water Quality Control Board.

Mazor, R.D., Rehn, A.C., Ode, P.R., Engeln, M., Schiff, K.C., Stein, E.D., Gillett, D.J., Herbst, D.B. and C.P. Hawkins. 2016. Bioassessment in complex environments: designing an index for consistent meaning in different settings. *Freshwater Science* 35(1): 249-271.

Mazor, R.M., Ode, P.R., Rehn, A.C., Engeln, M., Beck, M., Boyle, T., Fintel, E. and C. Yang. 2018. The California Stream Condition Index (CSCI): Interim instructions for calculating scores using GIS and R. SWAMP SOP-2015-0004. Revision Update August 01, 2018.

Mazor, R.M., May, J.T., Sengupta, A., McCune, K.S., Bledsoe, B. and E.D. Stein. 2018(b). Tools for managing hydrologic alteration on a regional scale: Setting targets to protect stream health. *Freshwater Biology* 00: 1-18.

Mehinto, A.C., Jayasinghe, B.S., Vandervort, D.R., Denslow, N.D. and K.A. Maruya. 2016. Screening for Endocrine Activity in Water Using Commercially-available *In Vitro* Transactivation Bioassays. *Journal of Visualized Experiments http://www.jove.com/video/54725*

Moyle, P.B. and P.J. Randall. 1996. Biotic Integrity of Watersheds. In Sierra Nevada Ecosystem Project: Final report to Congress, vol. II, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources.

Moyle, P. B., and M. P. Marchetti. 1999. Putah Creek IBI. In: Assessing the sustainability and biological integrity of water resources using fish communities.

Simon, T.P. Pages 367-380.

Nerbonne, B.A. and B. Vondracek. 2001. Effects of Local Land Use on Physical Habitat, Benthic Macroinvertebrates, and Fish in the Whitewater River, Minnesota, USA. *Environmental Management* 28(1): 87-99.

NZMMCPWG (New Zealand Mudsnail Management and Control Plan Working Group). 2007. National management and control plan for the New Zealand Mudsnail. Aquatic Nuisance Species Task Force, May 2007. Available at http://www.anstaskforce.gov/Documents/NZMS_MgmtControl_Final.pdf

Ode, P.R., Rehn, A.C. and J.T. May. 2005. A Quantitative Tool for Assessing the Integrity of Southern Coastal California Streams. *Environmental Management* 35(4): 493-504.

Ode, P.R., Rehn, A.C., Mazor, R.D., Schiff, K.C., Stein, E.D., May, J.T., Brown, L.R., Herbst, D.B., Gillett, D., Lunde, K. and C.P. Hawkins. 2016. Evaluating the adequacy of a reference-site pool for ecological assessments in environmentally complex regions. *Freshwater Science* 35(1): 237-248.

Ode, P.R., A.E., Fetscher, and L.B. Busse. 2016(b). Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 004.

Oliver, T.H., Heard, M.S., Isaac, N.J., Roy D.B., Procter D., Eigenbrod F., Freckleton R., Hector A., Orme C.D., Petchey O.L., Proença V., Raffaelli D., Suttle K.B., Mace G.M., Martín-López B., Woodcock B.A., and J.M. Bullock. 2015. Biodiversity and Resilience of Ecosystem Functions. *Trends in Ecology and Evolution* 30(11):673-684.

Olson, J. R., and C. P. Hawkins. 2012. Predicting natural baseflow stream water chemistry in the western United States. *Water Resources Research* 48: W02504.

Orange County. 2017. South Orange County (San Juan Hydrologic Unit) Water Quality Improvement Plan and BMP Design Manual. Orange County Public Works.

Orlova, M.I., Therriault, T.W., Antonov, P.I. and G.K. Shcherbina. 2005. Invasion ecology of quagga mussels (*Dreissena rostriformis bugensis*): a review of evolutionary and phylogenetic impacts. *Aquatic Ecology* 39: 401-418.

Parkyn, S., Collier, K., Clapcott, J., David, B., Davies-Colley, R., Matheson, F., Quinn, J., Shaw, W. and R. Storey. 2010. The restoration indicator toolkit: Indicators for monitoring the ecological success of stream restoration. National Institute of Water & Atmospheric Research Ltd, Hamilton, New Zealand. 134pp.

Phillips, B.M., B.S. Anderson, K. Siegler, J.P. Voorheers, D. Tadesse, L. Webber and R. Breur. 2016. Stream Pollution Trends (SPoT) Monitoring Program Fourth Report — Seven-Year Trends 2008-2014. SWAMP-MR-SB-2016-0008.

Pont, D, Hughes, R.M., Whittier, T. and S. Schmutz. 2009. A Predictive Index of Biotic Integrity Model for Aquatic-Vertebrate Assemblages of Western U.S. Streams. *Transactions of the American Fisheries Society* 138: 292-305.

Rehn, A.C. and P.R. Ode. 2005. Development of a Benthic Index of Biotic Integrity (B-IBI) for Wadeable Streams in Northern Coastal California and its Application to Regional 305(b) Assessment. Surface Water Ambient Monitoring Program Technical Report.

Rehn, A. C., May, J. T. and P.R. Ode. 2008. An index of biotic integrity (IBI) for perennial streams in California's Central Valley.

Rehn, A.C. 2010. Benthic Macroinvertebrates as Indicators of Biological Condition Below Hydropower Dams. PIER Final Project Report. California Department of Fish and Game. CEC-500-2009-060. Surface Water Ambient Monitoring Program Technical Report.

Rehn, A.C., R.D. Mazor and P.R. Ode. 2015. The California Stream Condition Index (CSCI): A New Statewide Biological Scoring Tool for Assessing the Health of Freshwater Streams. Swamp Technical Memorandum SWAMP-TM-2015-0002.

Rehn, A.C. 2016. Using Multiple Biological and Habitat Condition Indices for Bioassessment of California Streams. Surface Water Ambient Monitoring Program Technical Memorandum. SWAMP-TM-SB-2016-0003.

Rehn, A.C., Mazor, R.D. and P.R. Ode. 2018. An Index to Measure the Quality of Physical Habitat in California Wadeable Streams. SWAMP Technical Memorandum SWAMP-TM-2018-0005.

Rehn, A.C., Mazor, R.D., Ode P.R., Beck. M., Boyle, T., Fintel, E. and C. Yang. 2018(b). The Physical Habitat (PHAB) Index of Physical Integrity (IPI): Interim instructions for calculating scores using GIS and R. SWAMP SOP 2018-0006.

SDCWA (San Diego County Water Authority). 2018. Local Rainfall and Reservoirs. February 2018.

San Diego Water Board (San Diego Regional Water Quality Control Board). 2016. San Diego Regional Water Quality Control Board Clean Water Act Sections 305(B) and 303(D) Integrated Report for the San Diego Region. Staff Report. October 12, 2016.

San Diego Water Board. 2016b. Assessing Ecological Health of the San Diego River Watershed. Watershed Status Sheet. June 2016.

San Diego Water Board. 2016c. Water Quality Control Plan for the San Diego Basin. Available online at: https://www.waterboards.ca.gov/sandiego/water_issues/programs/basin_plan/

Savidge, J.A. 1987. Extinction of an Island Forest Avifauna by an Introduced Snake. *Ecology* 68(3): 660-668.

Schiff, K., Gillet, G., Rehn, A. and M. Paul. 2015. Causal Assessment Evaluation and Guidance for California. SCCWRP Technical Report 750.

Scrimgeour G.J. and D. Wicklum 1996. Aquatic ecosystem health and integrity: problems and potential solutions. *Journal North American Benthological Society* 15(2): 254-261.

Seabloom, E.W., Harpole, W.S., Reichman, O.J. and D. Tilman. 2003. Invasion, competitive dominance, and resource use by exotic and native California grassland species. PNAS 100(23): 13384-13389.

Sengupta, A., Adams, S.K., Bledsoe, B.P., Stein, E.D., McCune, K.S. and R.D. Mazor. 2018. Tools for managing hydrologic alteration on a regional scale: Estimating changes in flow characteristics at ungauged sites. *Freshwater Biology* 00:1-17

Skeffington, R.A., Halliday, S.J., Wade, A.J., Bowes, M.J. and M. Loewenthal. 2015. Using high-frequency water quality data to assess sampling strategies for the EU Water Framework Directive. *Hydrology and Earth System Sciences* 19: 2491-2504.

Smalling, K.L., Fellers, G.M., Kleeman, P.M. and K.M. Kuivila. 2013. Accumulation of Pesticides in Pacific Chorus Frogs (*Pseudacris regilla*) from California's Sierra Nevada Mountains, USA. *Environmental Toxicology and Chemistry* 32(9): 2026-2034.

SMC (Stormwater Monitoring Coalition). 2015. Bioassessment of Perennial Streams in Southern California: A Report on the First Five Years of the Stormwater Monitoring Coalition. SCCWRP Technical Report 844.

Snyder, C.D., Young, J.A., Villella, R. and D.P. Lemarie. 2003. Influences of upland and riparian land use patterns on stream biotic integrity. *Landscape Ecology* 18: 647-664.

Stachowicz, J.J., Whitlatch, R.B. and R.W. Osman. 1999. Species Diversity and Invasion Resistance in a Marine Ecosystem. *Science* 286: 1577-1579.

Stancheva, R., Fetscher, A.E., Sheath, R.G., 2012. A novel quantification method for stream-inhabiting, non-diatom benthic algae, and its application in bioassessment. *Hydrobiologia* 684 (1), 225–239.

Stancheva, R., Busse, L., Kociolek, J. P., and Sheath, R. G., 2015. Standard Operating Procedures for Laboratory Processing and Identification of Stream Algae. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 0003.

State of California. 1993. Executive Department State of California Order W-59-93.

State of California. 2016. California Budget 2016-2017. Available online at: http://www.ebudget.ca.gov/home.php?selectedYear=2016-17

Stein, E.D., Fetscher, A.E., Clark, R.P., Wiskind, A., Grenier J.L., Sutula, M., Collins, J.N. and C. Grosso. 2009. Validation of a Wetland Rapid Assessment Method: Use of EPA's Level 1-2-3 Framework for Method Testing and Refinement. *Wetlands* 29(2): 648-665.

Stein, E.D., Mazor, R.D., Sengupta, A., McCune, K., Bledsoe, B., Adams, S., Eberhart, S., Pyne, M., Ode, P. and A. Rehn. 2017a. Development of Recommended Flow Targets to Support Biological Integrity Based on Regional Flow-ecology Relationships for Benthic Macroinvertebrates in Southern California Streams. SCCWRP Technical Report 974.

Stein, E.D., Sengupta, A., Mazor, R.D., McCune, K., Bledsoe, B.P. and S. Adams. 2017b. Application of regional flow-ecology relationships to inform watershed management decisions: Application of the ELOHA framework in the San Diego River watershed, California, USA. *Ecohydrology* 10(7).

Stevenson, R.J. and L.L. Bahls. 1999. Periphyton protocols. Chapter 6 in: M.T. Barbour, J. Gerritsen, B.D. Snyder, and J.B. Stribling (eds.), Rapid Bioassessment Protocols for use in Streams and Wadeable Rivers. Second Edition. EPA/841-B-99-002. US Environmental Protection Agency, Office of Water. Washington, DC.

Stoddard J.L., Larsen D.P., Hawkins C.P., Johnson R.K., R.H. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. *Ecological Applications* 16:1267–1276.

Sudol, M.F. and R.F. Ambrose. 2002. The US Clean Water Act and Habitat Replacement: Evaluation of Mitigation Site in Orange County, California, USA. *Environmental Management* 30(5): 727-734.

Sutula, M.A., Stein, E.D., Collins, J.N., Fetscher, A.E. and R. Clark. 2006. A Practical Guide for the Development of a Wetland Assessment Method: The California Experience. *Journal of the American Water Resources Association* 157-175.

SWAMP (Surface Water Ambient Monitoring Program) QAPP. 2008. The State of California's Surface Water Ambient Monitoring Program Quality Assurance Program Plan.

SWRCB (State Water Resources Control Board). 2005. State of California State Water Resources Control Board S.B. 469 TMDL Guidance A Process for Addressing Impaired Waters in California.

SWRCB. 2014. General Permit Fact Sheet for Storm Water Discharges Associated with Industrial Activities. NPDES No. CAS000001.

SWRCB. 2015. Water Quality Control Policy of Addressing Impaired Waters. State Water Resources Control Board Resolution No. 2005-0050. SWRCB. Sacramento, CA. Amendment approved by Office of Administrative Law 05/15/2015.

Truchy, A., Angeler, D.G., Sponseller, R.A., Johnson, R.K. and B.G. McKie. 2015. Linking Biodiversity, Ecosystem Functioning and Services, and Ecological Resilience: Towards an Integrative Framework for Improved Management Advances in Ecological Research *In*: Ecosystem Services: From Biodiversity to Society, Part 1 / [ed] Bohan, D; Pocock, Michael J.O; Woodward, G;, Elsevier, 2015, 55-96 p.

USEPA (United States Environmental Protection Agency). 1991. Final Policy on Biological Assessments and Criteria.

USEPA. 1992a. Guidelines for Exposure Assessment. EPA/600/Z-92/001.

USEPA. 1992b. Framework for Ecological Risk Assessment. EPA/630/R-92/001.

USEPA 1997a. Memorandum from Tudor T. Davies, Director, Office of Science and Technology. Establishing Site Specific Aquatic Life Criteria Equal to Natural Background. November 5, 1997.

USEPA. 1997b. Memorandum from Robert Perciasepe, Assistant Administrator, to Regional Administrators and Regional Water Division Directors Regarding New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs). U.S. EPA Washington, D.C.

USEPA 2002a. Biological Assessments and Criteria: Crucial Components of Water Quality Programs. EPA 822-F-02-006.

USEPA. 2002b. Memorandum from Robert Wayland, Director, to Regional Administrators and Regional Water Division Directors Regarding Clarification of the use of Biological Data and Information in the 2002 Integrated Water Quality Monitoring and Assessment Report Guidance. U.S. EPA Washington, D.C.

USEPA 2003. Stormwater and the Construction Industry: Planning and Implementing Erosion and Sediment Control Practices. EPA 833-H-03-001.

USEPA. 2005. Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b), and 314 of the Clean Water Act. U.S. EPA. Washington, D.C.

USEPA. 2009. Development and Implementation of Biological Objectives for California. Presentation at the State of California 2009 California Aquatic Bioassessment Workgroup.

USEPA. 2010. Causal Analysis/Diagnosis Decision Information System (CADDIS). Originally released in 2010. Available online at: https://www.epa.gov/caddis

USEPA. 2012. Implications of Climate Change for Bioassessment Programs and Approaches to Account for Effects. PA/600/R-11/036F.

USEPA. 2013. A Long-term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program. December 2013.

USEPA. 2015. Human Health Ambient Water Quality Criteria: 2015 Update. USEPA Office of Water EPA 820-F-15-001.

USEPA. 2015(b). Memorandum from Robert Perciasepe, Assistant Administrator, to Regional Administrators and Regional Water Division Directors Regarding Information Concerning 2016 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions. U.S. EPA Washington, D.C.

Van Dolah, R.F., Hyland, J.L., Holland, A.F., Rosen, J.S. and T.R. Snoots. 1999. A benthic index of biological integrity for assessing habitat quality in estuaries of the southeastern USA. *Marine Environmental Research* 48: 269-283.

Vighi, M., Altenburger, R., Arrhenius, A., Backhaus, T., Bödecker, W., Blanck, H., Consolaro, F., Faust, M., Finizio, A., Froehner, K., Gramatica, P., Grimme, L.H., Grönvall, F., Hamer, V., Scholze, M. and H. Walter. Water quality objectives for mixtures of chemicals: problems and perspectives. *Ecotoxicology and Environmental Safety* 54: 139-150.

Vitousek, P.M. 1990. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. *Oikos* 57: 7-13.

Wallace, J.B., Eggert, S.L., Meyer, J.L. and J.R. Webster. 1997. Multiple Trophic Levels of a Forest Stream Linked to Terrestrial Litter Inputs. *Science* 277: 102-104.

Walsh, C.J., Roy, A.H., Feminella, J.W., Cottingham, P.D., Groffman, P.M. and R.P. Morgan. 2005. The urban stream syndrome: current knowledge and the search for a cure. *Journal North American Benthological Society* 24(3): 706-723.

Weston, D., You, J., Harwood, A. and M.J. Lydy. 2009. Whole sediment toxicity identification evaluation tools for pyrethroid insecticides: III. Temperature manipulation. *Environmental Toxicology and Chemistry* 28, 173-180.

Weston, D.P. and M.J. Lydy. 2014. Toxicity of the Insecticide Fipronil and Its Degradates to Benthic Macroinvertebrates of Urban Streams. *Environmental Science and Technology* 48, 1290-1297.

Williams, J.D. and G.K. Meffe. 1998. Nonindigenous species. In: Mac, M.J. P.A. Opler, C.E. Puckett Haecker, and P.D. Doran. 1998. Status and trends of the nation's biological resources, Vol.1. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

Woodard, M.E., J. Slusark, and P.R. Ode. 2012. Standard Operating Procedures for Laboratory Processing and Identification of Benthic Macroinvertebrates in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 003.

Zimmerman, J.K.H., Carlisle, D.M., May, J.T., Klausmeyer, K.R., Grantham, T.E., Brown, L.R., and J.K. Howard. 2017. Patterns and magnitude of flow alteration in California, USA. *Freshwater Biol*ogy 00:1–15.

7. Appendices

7.1. Appendix I: Stream Biological Objective CSCI Documentation

Included as an Attachment

7.2. Appendix II: Substitute Environmental Document

Included as an Attachment