Aquatic Resource Type Conversion Evaluation Framework

Version 2.0

Eric D. Stein

Jeffrey S. Brown

Jennifer D. Siu

Southern California Coastal Water Research Project

Technical Report 1110

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Eric D. Stein[1], Jeffrey S. Brown[1], and Jennifer D. Siu[2]

[1]Southern California Coastal Water Research Project, Costa Mesa, CA

[2]U.S. Environmental Protection Agency, Region 9, San Francisco, CA

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Disclaimer

This report was funded by USEPA, Region 9 pursuant to Contract EP-C-17-001, Task Order #8 and #22. The content and recommendations do not constitute official positions of the US Environmental Protection Agency. None of the suggestions or recommendations in this document are binding, and all final decisions regarding the appropriateness and acceptability of aquatic resources type conversion are at the discretion of the relevant regulatory, grant-funding, or management agencies.

Editorial Note For Regulatory Application Of Framework

Consideration of type conversion from one aquatic resource type to another is one of numerous project elements already accounted for in Clean Water Act regulatory programs. However, as demonstrated in the literature review (Stein et al. 2019), this is usually a subjective analysis by individual staff and no specific guidance exists for how to scientifically evaluate type conversion. Conversion is generally discouraged unless justified based on a watershed approach, regional rarity, etc., but again there is no structured approach for agency determinations and the outcome of type conversion cannot be assumed to result in either a negative or positive impact. A lack of consistent guidance and shared technical basis amongst regulators makes permitting alignment difficult. Further compounding the issue, the increased pace and scale of threats to ecological resiliency require agencies to conduct change analysis under higher levels of risk and uncertainty. This framework highlights type conversion as a critical aspect that will become more prominent over time, and potentially contentious for regulators. The framework is intended to be an analytical structure applied by project proponents and reviewed by regulators (ideally during the pre-application phase) to bring decision efficiency, efficacy, and alignment. It can also be a tool for analysis of alternatives and highlighting areas of incongruency. The analysis should be done as early as possible in the review process and may need to be updated based on changes in the project proposal or design that occur during the evaluation and review process. The framework is not intended to inherently value one type of aquatic resource over another, nor to supersede regulatory mandates. Rather, our intent is to support agencies' technical and regulatory discretion to ensure projects are not only permittable, but environmentally beneficial.

We caution users to carefully consider the threshold of significance for application of this framework. The framework is built to consider all levels of ecological scale, from site-specific to landscape to regional. This holistic context is required to accurately assess inherently complex ecological relationships over both short- and long-term. The framework yields the most value for effort expended when applied to complete ecosystem modifications that address fundamental changes in landscape habitat distribution.

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LIST OF ACRONYMS

AQUARIUS – California Freshwater Species Database

ASCI – Algal Stream Condition Index

BIOS – Biogeographic Information and Observation System

BRRIT – SF Bay Restoration Regulatory Integration Team

CEDEN – California Environmental Data Exchange Network

CNDDB – California Natural Diversity Database

CRAM – California Rapid Assessment Method

CSCI – California Stream Condition Index

CWA – Clean Water Act

ECOS - USFWS Threatened & Endangered Species Active Critical Habitat Report

ESA – Endangered Species Act

GBIF - Global Biodiversity Information Facility

HCP – Habitat Conservation Plan

HGM – Hydrogeomorphic Method

IBI – Index of Biotic Integrity

IPI – Index of Physical Integrity

mAMBI – Multimetric AZTI Marine Biotic Index

NCCP – Natural Communities Conservation Plan

NHD – National Hydrography Dataset

NOAA – National Oceanic and Atmospheric Administration

NWI – National Wetlands Inventory

SCCWRP – Southern California Coastal Water Research Project

SLR – Sea Level Rise

SMC – Stormwater Monitoring Coalition

SWAMP – Surface Water Ambient Monitoring Program

TMDL – Total Maximum Daily Load

USEPA – US Environmental Protection Agency

USFWS – US Fish and Wildlife Service

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- Agnes Farres*, Liz Morrison, and Xavier Fernandez – San Francisco Bay Regional Water Quality Control Board
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- Tami Schane – California Department of Fish and Wildlife*
- Tom Cavanaugh – US Army Corps of Engineers, South Pacific Division

*Members of the BRRIT agency team

The contents of this document do not constitute official policy of any agency.

MOTIVATION AND OBJECTIVES

Wetland and stream restoration projects may sometimes involve converting one “type” of aquatic habitat to another “type” (e.g., managed salt ponds into tidal marshes, depressional wetlands into streams, marsh into transition zone habitat). This “type conversion” may be necessary and beneficial in the context of addressing watershed plans or regional restoration goals, or in achieving resiliency to climatic changes (Goals Project 2015). Conversion can also occur through other large-scale, complex actions (e.g., mitigation banking initiatives). Whether driven by habitat restoration goals or compensatory mitigation needs or both, regulatory oversight typically governs the process. Holistically assessing such conversion through the regulatory lens is challenging for permitting programs, whether it’s a determination pursuant to federal statutes (e.g., CWA Section 404/401, Endangered Species Act, Coastal Zone Management Act) and/or independent state authorities (e.g., California Porter-Cologne Act, California Coastal Act, California Endangered Species Act). The challenge stems from how to accurately determine the overall value of an aquatic resource based on site-specific ecological properties and in the context of larger regional ecosystem management and goals. This is further compounded when assessing aquatic habitats that provide intrinsically different functions and services. Assessments must also account for the fact that wetlands and streams are not static ecosystems, but rather dynamically changing through time due to natural or anthropogenic factors, many of which are difficult to control or even accurately assess (e.g., sea level rise). These challenges are further exacerbated due to urbanization, conflicting human-environment goals, and the evolving state of habitat restoration science.

As resource and regulatory agencies have different mandates and policies regarding aquatic resource protection, complex ecological issues such as type conversion can result in insufficient evaluation, conflicting permit requirements, and uncertainty for the regulated public. Type conversion is recognized by agencies as a “sand in the gears” problem that can stymie permitting because such actions typically require multiple agency authorizations, habitat resource trade-offs, and consensus on ecosystem goals. The lack of consistent, defensible analysis based on transparent evaluation has been shown to impede critically needed habitat restoration.

The overall goal of this project is to develop consistent approaches for assessing the effect of type conversion on aquatic ecosystem function to support decisions made as part of resource management, regional restoration, and regulatory permitting processes. The project intends to provide a framework that can support project planning and inform regulatory evaluation by helping to answer: 1) what loss or gain of function is expected from various aquatic resource type conversions, and 2) how to analyze effectively whether conversion might be appropriate.

The framework is intended to help regulators and project managers address several aspects (i.e., modules) to assess the overall net environmental benefit when considering a project that involves habitat type conversion (Figure 1):

- Feasibility/Suitability
- Site-specific assessment of function and condition
- Regional context

This document looks at each module of the conceptual approach examining four elements:

- Why it is important
- What to measure (critical indicators)
- How to evaluate (interpretation)
- Potential sources of information or data

We envision that project proponents would conduct the analyses outlined in this framework under the direction and review of the relevant regulatory and resource management agencies (although agency staff may choose to conduct the analysis at their discretion). Guiding assumptions made by the analyst should be first vetted with the agencies, including level of project design that is informing the analysis, length of time-period analyzed, identification of data gaps that would severely limit the analysis, and identification of commonly acknowledged areas of technical uncertainty. The intent of the framework is not to generate more field data, but rather to work with a routine level of information that is acceptable and expected by the agencies during pre-application planning and coordination.

The outcomes of the analysis could be used by agency staff to help evaluate project design alternatives relative to existing conditions, restoration objectives, and/or local or regional goals. It is important to note that while the decisions to be made within the framework can build upon each other, the process is not necessarily sequential but rather iterative and parallel. The intent is that all three modules of the framework be applied together to provide a complete analysis. Some factors within the framework will carry more weight than others depending on the regulatory context, the agency mandate, regional goals, etc. Because each agency has its own mandates, priorities, and authorities, a consensus is desirable, but may or may not be possible for each project.

Furthermore, to allow individual agency discretion, we summarize the results of each evaluation module in addition to synthesizing into an overall score. For all three modules, we attempted to provide an inclusive set of criteria. Therefore, we recommend that the framework be used as developed to provide for a standardized analytical approach between projects. However, we recognize that in some cases agencies may want to supplement the framework with additional analysis, at their discretion, to provide more detail or to consider other factors. The intent of this framework is to provide a transparent set of tools and approaches that can inform discussions between agencies and with project proponents during the project evaluation phase.

Impetus for Version 2.0 Revision

In 2021, the version 1.0 framework was tested by EPA and the BRRIT staff on a complex but common San Francisco Bay restoration project proposing large-scale type conversion (McInnis Marsh Restoration Project). In response to that pilot application, it was determined that the second module, Site Specific Assessment of Function and Condition, required elaboration and modification to ensure practical and consistent implementation. Therefore, this version of the framework (v 2.0) supersedes the February 2020 version. We have also added the pilot project as a detailed case study (Appendix A).

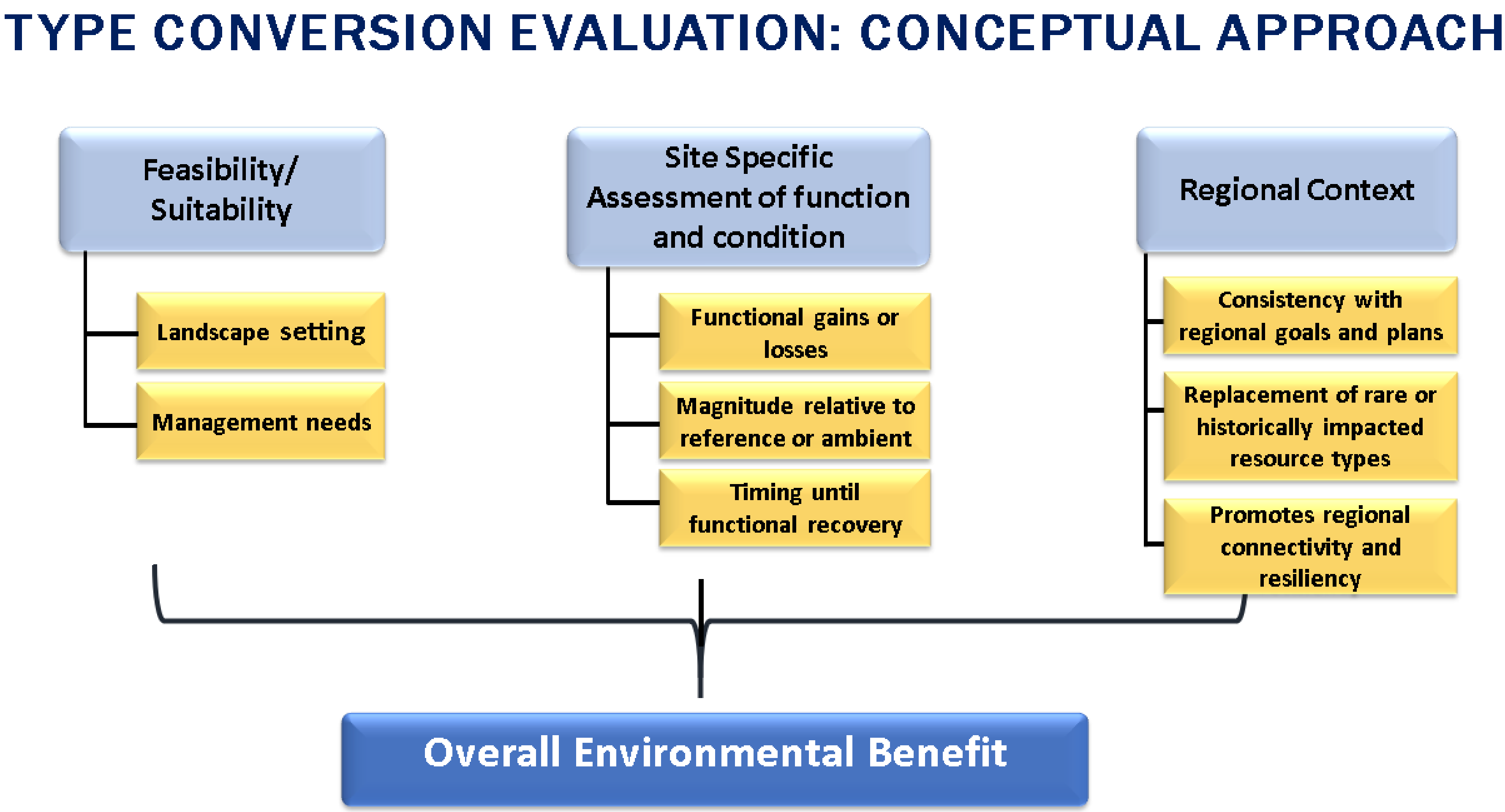


Figure 1. Conceptual approach for evaluating aquatic resource type conversion.

MODULE 1: FEASIBILITY AND SUITABILITY

The desire to restore functioning ecosystems may result in aquatic resource type conversion based on goals of converting a site to match a historically prevalent regional wetland type, increasing habitat for certain threatened/endangered species, providing recreation opportunities, adjusting to new environmental conditions (e.g., resulting from hydromodification or climate change), and increasing specific processes (e.g., water quality improvement, flood attenuation (volume and/or energy), ground water recharge, erosion control). During the planning process, it is important to consider whether the landscape setting meets the requirements to support the intended aquatic resource type.

Why it is important

Wetlands and other aquatic resources have been classified (e.g., depressional, riverine, fringe) based on unique physical characteristics including geomorphic setting, water source and transport, and hydrodynamics (Table 1). Streams and other fluvial feature can be classified based on their flow duration (perennial, intermittent, ephemeral), setting (erosional, transport, depositional), and planform (braided, compound, single thread). Restoring to a new/different aquatic resource type will be successful if the physical requirements of the target aquatic resource type are compatible with the landscape setting. Therefore, it is important to compare the requirements of the target aquatic resource type with existing landscape characteristics. Often, restored wetlands require ongoing management to maintain function over time. The level of intensity (or ease) of necessary ongoing management is also an important feasibility consideration. Wetlands that require more intensive, difficult, frequent, or costly management will be less likely to remain healthy and to perform their expected functions over time. Assessing feasibility also serves as a mechanism for consideration of uncertainty; type conversion plans with more questionable feasibility are inherently more uncertain.

Table 1. Wetland and other aquatic resource types based on landscape setting. Based on the HGM classification (Brinson 1993, Brinson and Rheinhardt 1996) and modified from Hruby et al. 2009.

Landscape setting	Class	Major characteristics of site
Along shores of marine waters and river mouths	Tidal fringe	Site would have water levels controlled by tides
Topographic lows in or adjacent to tidally influenced areas/estuaries	Tidal flat	Intermittent inundation by tides producing emergent or unvegetated flats
Terraces or dry flats where rainfall is the only source of water	Freshwater flat	Topography at the site would be flat and precipitation would be the only source of water. May only be inundated seasonally
Fringe along lakes	Lake fringe	Site is on shores of body of permanent open water that is > 20 acres and at least 30% of the open water area is deeper than 2 meters
Hillside slope or seep	Slope	Site would have water flowing through the wetland in one direction without being impounded. Primary source of water is groundwater discharge.
Areas adjacent to rivers or streams that are periodically flooded or inundated	Riverine	Site would be in a valley or stream channel, periodically inundated by overbank flooding from the stream or river

Topographic depression	Depressional	Site would be in topographic depression where water ponds or is saturated to the surface some time of the year. Primary source of water is groundwater or surface flows from precipitation on the surrounding landscape.

What to measure

Feasibility depends on suitability of the new aquatic resource type for the landscape position where it is being established, major physical drivers, and any needed level of management that may be necessary to sustain the new resource. Ideally, systems would be self-sustaining over the long-term, but that may not always be possible given anthropogenic constraints and climatic fluctuations. Thus, there are numerous design elements to consider when type conversion is anticipated to determine the relative suitability of the landscape to support both the existing and the expected future aquatic resource types:

- Landscape setting
  - Habitat type and position in watershed (marine, estuary, stream, slope, coastal plain, urban, foothill, mountain, alpine), elevation, and slope
- Hydrology
  - Typical amount of water, its frequency and force, retention (amount of draw down by conveyance or infiltration), and source (e.g., ground water, surface flow, precipitation), and how that may change due to changes in lands use and management practices
  - Water quality (e.g., conductivity, eutrophication, turbidity, contaminants), how that may change over time
  - Watershed engineering (pumps, diversions, dams) that alters the hydrology (amount, frequency, quality)
  - Water use practices (e.g., conservation, diversion, recharge) and how they may change over time
  - Changes in sea-level, wave climate, precipitation, flow and evapotranspiration due to climate change or landscape position
  - Modifications of estuarine mouth conditions that affect tidal inflow
- Geomorphic setting (topography, substrate)
  - Correct geologic setting and soil type (i.e., ability to support hydric soils) for desired aquatic resource type
- Sediment sources, supply, and processes [erosion (both natural and as a result of engineering) and aggradation] and typical sediment type (sands, gravels, fines)
  - Hydromodification effects such as channel incision or widening and how that may change over time
- Amount and quality of buffer (invasive plants, roads, agriculture, soil compaction, barriers, other buffer stressors)
- Connectivity (linkages for animal movement or seed dispersal between habitat types)
- Ability to control stressors from the adjacent landscape

How to evaluate

Feasibility is evaluated using a standardized checklist (Table 2) to rate how well various criteria have been met, along with justifications for each assigned rating. The feasibility assessment is comprised of two parts, each of which is scored separately: 1) suitability for the landscape position, and 2) difficulty or intensity of management necessary to support the future aquatic resource type after construction and in perpetuity. Intensity of management should assess the needed frequency and scale of any management interventions. This does not apply to the level of effort required to initial construct the project unless the agencies agree to consider a project with low feasibility. In other words, if the agencies choose to consider a project with low landscape suitability, it would be with the understanding that the necessary management effort, as well as the overall risk and uncertainty of success would be much higher.

Routine adaptive management is not considered a management intervention in the framework. After construction, all projects have an initial phase of active management that involves fine-tuning the design (i.e., initial post-construction years when the system is establishing and equilibrating). Likewise, any management actions needed to account for unanticipated or uncontrollable events are not considered as part of the evaluation in the framework.

Risk and uncertainty associated with project actions are addressed in this module by incorporating a qualitative assessment of direct, indirect, and cumulative impacts. For instance, if an experimental construction method is proposed then uncertainty and risk would be higher and scoring for intensity of management should reflect a likely moderate to high level of necessary management. Risks can also be characterized in the context of the "no-project" action if there is reasonable scientific information available to outline the risk; for example, risks of tidal marsh drowning from SLR resiliency if the proposed action is not taken. The rationale for such conclusions should be clearly articulated in the uncertainty assessment.

Feasibility should be assessed using the following steps:

1-1. Evaluate the suitability of the new aquatic resource type for the intended landscape position based on whether the future aquatic resource type will be able to meet each criterion.

- 1 = No
- 2 = Yes

1-2. Qualitatively estimate the feasibility/ease of management necessary to meet that criterion.

- 1 = extremely difficult to meet without extensive management intervention or criterion cannot be met
- 2 = criterion can be met with moderate amount of management intervention
- 3 = criterion can easily be met with little need for management intervention

1-3. Add up scores for landscape suitability.

- The new aquatic resource type should generally be considered suitable for the landscape position (i.e., "positive") if the landscape suitability score is 17 or higher (greater than 75% of the maximum possible score).

1-4. Add up scores for the management feasibility/ease.

- Management intensity should be considered "positive" if the ease of management score is 25- 33.
- Management intensity should be considered "negative" if the ease of management score is 11-19.
- Management intensity should be considered "indeterminate" if the ease of management score is 20-24. For these cases, additional investigation may be necessary.

An example feasibility assessment is shown in the checklist in Table 2. Criteria related to the physical landscape setting are evaluated for the level of suitability and the level of difficulty required to adapt the current site to the target aquatic resource type. The scores in each column are then summed and evaluated.

Table 2. Hypothetical application of the feasibility check list/rating system. For this example, landscape suitability would be considered "positive" (score of 17 or higher) and the management intensity score would be considered "indeterminate" (score between 20 and 24).

Criteria	Question/Consideration	Landscape Suitability (1, 2)	Ease of Management (1 – 3)
Landscape Setting	Will watershed processes be adversely altered for the intended aquatic resource type.	2 (Yes)	3 (Little adaptation needed)
	Will the conversion result in an aquatic resource of the appropriate class in that landscape setting?	2 (Yes)	3 (Little adaptation needed)
Hydrology[1]	Will the primary source of water and timing, frequency and duration of flow to the site be appropriate for the new aquatic resource type without engineering a delivery system that requires long-term control or maintenance?	1 (No)	1 (Difficult)
	Does the site have the ability to adapt to accommodate future hydrologic conditions associated with climate change or expected change in water use practices?	2 (Yes)	2 (Moderate management needed)
Geomorphology	Does the site have the appropriate underlying geology, and will the site maintain hydric soils (if appropriate)?	2 (Yes)	3 (Little adaptation needed)
	Is the anticipated sediment supply to the site appropriate to maintain geomorphic stability for the new aquatic resource type?	1 (No)	1 (Difficult)

[1] hydrology should consider surface flows, groundwater discharges, and tidal flows

Sediment	Will anticipated sediment processes (e.g., accretion, scour) provide appropriate elevations for the new aquatic resource type?	1 (No)	1 (Difficult)
Connectivity	Is the site connected or in close proximity to other aquatic resources or uplands that will support species and habitats for the new aquatic resource type?	2 (Yes)	3 (Little adaptation needed)
	Does the site have adequate buffers to help reduce effects of stressors from the adjacent landscape?	2 (Yes)	2 (Moderate management needed)
Stressor control	Can the site be designed to control aggressive plant species and/or reduce invasion by feral or non-native predators?	1 (No)	1 (Difficult)
	Will the site be designed to minimize effects of excessive human impacts, grazing, or other source of persistent disturbance?	2 (Yes)	1 (Difficult)
Total Score		***17 Positive***	***21 Indeterminate***

Potential sources of information or data

- Projected land use change (local planning documents)
- Projected changes in water management practices (municipal water districts)
- Sea level rise (SLR) projections (Our Coast Our Future, Sea Level Rise Viewer)
- Typology/Current and historic wetland/stream mapping (NHD, NWI, delineations, topographic sheets)
- California Rapid Assessment Method (CRAM) for stressors, sediment processes, hydrologic connectivity
- Species databases for occurrence, critical habitat constituents (CNDDB, BIOS, AQUARIUS, ECOS, species lists from resource agencies)
- Water Quality databases (e.g., CEDEN), established TMDLs
- Existing monitoring programs (e.g., SWAMP, SMC) or information collected as part of planning process

Module 2: Site-Specific Assessment Of Function And Condition

Wetlands and other aquatic habitats perform a variety of functions and services (Table 3); however, these functions may occur to different levels depending on the wetland type and condition. For example, wet meadows generally have higher primary productivity than sandy fringe habitat, but lower function as fish nurseries. Consequently, type conversion has the potential to result in both a change in the level of function and shift in the types of functions that are performed. This portion of the framework provides an approach for evaluating the relative change in function between the original and ultimate wetland type to support an evaluation of whether such a change is acceptable and/or desirable. Unlike the previous module, Module 2 does not address likelihood of success but focuses on potential implications of type conversion on wetland functions.

Why it is important

As part of the planning and decision process, it will be important to identify the types of functions that will be gained, lost or neutral through type conversion, as well as the magnitude and timing of those changes. Loss of certain aquatic habitat functions may help determine whether type conversion is desirable or help determine the proportional make up of each habitat type planned for conversion.

What to measure

Functions are usually long-term processes but are often measured through surrogate field indicators (i.e., environmental proxies). For example, concentration of chlorophyll-a has been used as an indicator of primary production (Sullivan and Moncreiff 1988), oyster biomass has been used as a surrogate for secondary productivity (Wong et al. 2011), and high-water marks have been used as indicators for some functions of hydrology (Wohl et al. 2016). Existing functional assessment methods can be used to assess wetland functions by class.

For some aquatic habitat types (e.g., riverine, depressional wetlands, estuaries) bioassessment or condition assessment methods (e.g., CRAM) may be available from existing monitoring programs, such as the State of California’s SWAMP or from watershed-based monitoring programs. These tools do not directly measure function but do provide a surrogate way to measure condition/health for different habitat types and compare likely changes associated with type conversion.

The intent of this section of the framework is not to facilitate “trading” of functions between different aquatic habitat types. Change in function can be assessed relative to ambient or reference data for the same wetland type, based on what is available. A relative comparison allows agency staff to evaluate relative gains and losses of different functions associated with type conversion and avoids direct functional comparisons by evaluating where along the gradient of function (or condition) each wetland type exists.

When comparing relative gains and losses between aquatic resource types, it is important to identify the functions that are most susceptible or environmentally relevant, as well as the indicators or assessment tools that can be used to measure their gains and losses. Table 3 contains examples of common functions relevant to various aquatic resource types, and example indicators that can be used to assess them.

Table 3. Aquatic resource functions, services, benefits and example assessment tools/indicators.

Function	Category of Benefit	Example Indicators
Wholly aquatic habitat and species support (e.g., fish, amphibians)	habitat/ecology	wildlife surveys, CRAM, HGM, bioassessment
Partially aquatic habitat and species support (e.g., birds, mammals)	habitat/ecology	wildlife surveys, CRAM, HGM, bioassessment
Biodiversity support	landscape or regional ecology	habitat surveys, bioassessment, CRAM
Surface water storage	water quality/hydrology	mapping and surveys, HGM, CRAM
Organic matter/nutrient cycling	water quality/habitat	dissolved organic carbon, biomass, chlorophyll a, HGM
Removal of elements and compounds	water quality	water quality measures, soil properties, sediment quality, HGM
Sediment/particulate retention	water quality/habitat	geomorphic surveys, CRAM, HGM
Groundwater recharge	hydrology/water supply/habitat	monitoring wells, soil profiles
Carbon sequestration	water quality/climate change/resiliency	biomass, carbon flux
Shoreline stabilization/energy dissipation	hydrology/social/climate resiliency	mapping, HGM, CRAM
Recreation and aesthetics	social	surveys of use

How to evaluate

2-1. Identify functions associated with current aquatic resource type (see Table 3)

2-2. Identify functions expected to occur at proposed future aquatic resource type (this is assuming the proposed project is completely successful at providing the intended functions)

2-3. Identify functions that may be affected by the proposed type conversion, along with the rationale for the assumed effects and the assumed level of function.

- Outline proposed changes and describe conceptual effects on functions
- Functions should be binned into those with low, moderate, and high priority (see section below)
- Wildlife support functions can be subdivided based on species or assemblage based on management objectives

2-4. Identify available assessment tools

- Table 4 provides examples of direct and indirect measurement approaches for each function, as well as typical maturation times for each function (i.e., the time necessary to fully achieve the function).

2-5. Identify available data

- Data from the current aquatic resource being evaluated
- Data from analogue sites for the proposed future aquatic resource type
- Reference or ambient data that can be used to help contextualize the assessment

2-6. Evaluate current and expected future functions using assessment tools, conceptual models, or consultation with technical experts

- Relate functions to reference, ambient conditions, or known standards and thresholds (see example evaluation approaches A and B below)
- Clearly document the rationale behind the assessment and include relevant data sources and citations

2-7. Account for time necessary for new functions to accrue/mature

- Do not consider short-term, construction related effects
- Assign weighting based on priority of functions and confidence (or uncertainty) in the assessment tools and available data (see section below)

2-8. Compile results of relative change in function analysis to determine if the proposed change is positive, negative, or indeterminate

Further details for the steps in the evaluation are provided in the following sections.

Table 4. Examples of direct and indirect measures for each function to be considered in a type conversion analysis and expected maturation time for functions to accrue.

Function	Direct Measure	Indirect Measure	Typical Maturation time[2]
Wholly aquatic habitat and species support (e.g., fish, amphibians)	biological or species surveys	habitat extent and condition	fast
Partially aquatic habitat and species support (e.g., birds, mammals)	biological or species surveys	habitat extent and condition	moderate
Biodiversity support	biological surveys, eDNA	CRAM	moderate – slow
Surface water storage	duration and frequency of inundation	area and depth, topographic complexity	fast
Organic matter/nutrient cycling	primary producer surveys, sediment carbon and nitrogen	duration of inundation, vegetation cover and density	slow
Removal of elements and compounds	redox, below ground biomass, sediment nitrogen and phosphorous	plant cover, litter cover, area and depth	moderate
Sediment/particulate retention	accretion rates, estimates of inundation extent and duration	surface roughness and plant density, area	fast – moderate
Groundwater recharge	well-level data, soil water balance (precipitation, runoff, ET, and soil water storage)	area, soil texture	fast
Carbon sequestration	biomass accumulation (above and below ground), inundation, soil depth and organic matter	saturated area, plant density, soil texture	slow
Shoreline stabilization/energy dissipation	accretion rates, inundation extent	vegetation density or roughness and width from water's edge	moderate
Recreation and aesthetics	recreational use surveys	general features of site (e.g., trails, access points, proximity to local communities)	fast

[2] slow is considered greater than 5 years, moderate is 3-5 years, fast is 0-2 years

Steps 2-1 through 2-3, Grouping and Prioritizing Functions

- Group functions from Table 3 into low, moderate, and high priority based on their association with each wetland type using the following steps:
    A. Is the function typically considered a primary (or principal) function of both the pre AND post project wetland type?
        - If YES, proceed to question C. If NO, proceed to question B
    B. Is the function typically considered a primary (or principal) function of EITHER the pre- OR the post-project wetland type?
        - If YES, proceed to question C. If NO, this is a LOW PRIORITY function and can be qualitatively assessed
    C. Can this function be quantified using a standardized assessment tool (either direct or indirect measurement)?
        - If YES, proceed to question D. If NO, this is a MODERATE PRIORITY function and can be qualitatively assessed
    D. Is contextual information available for this function (e.g., threshold values, reference sites, ambient data)?
        - This is a HIGH PRIORITY function. If YES, evaluate relative to contextual information. If NO, evaluate relative to range of possible scores from the assessment tool

- Wildlife support functions can be subdivided based on species or assemblage based on management objectives – this is an optional step.
    - The default approach is to use the two major categories of wildlife assessment (i.e., wholly and partially aquatic); they should only be split if ecologically necessary
    - Splits should be based on species or assemblages of management concern (e.g., endangered or threatened species)
    - Discrete assessment tools should be available for each species or assemblage
    - Relative change scores for each species or assemblage should be averaged without weighting and rolled up to one of the two wildlife function categories

Steps 2-4 and 2-5, Identify Assessment Tools and Available Data

Table 4 provides a list of potential direct and indirect measures for each function. This is not an exhaustive list, but rather provides representative examples. Direct measures of function can quantify processes or structural elements of the wetland or can be multi-functional indices, such as indices of biotic integrity (e.g., IBI, CSCI, ASCI, mAMBI). Indirect measures of function often consist of surrogates or proxies associated with certain functions or can be EPA Level 2 (rapid) assessment tools (e.g., CRAM). Some functional assessment tools, such as the Hydrogeomorphic Method (HGM) can provide both direct and indirect measures of function depending on the specific metrics used. In general, indirect measures are less intensive, but provide lower levels of certainty on the level of function being performed or expected.

Data to support functional assessments can come from the wetland being evaluated or from analogue wetlands in the region (see Appendix C for potential data sources). The actual functional assessment approach used will be partially predicated on the availability of reference or ambient that can be used to provide comparisons to the project site. Examples of these two approaches are provided in Step 2-6 below.

Step 2-6, Relate Functions Using Example Approach A or B

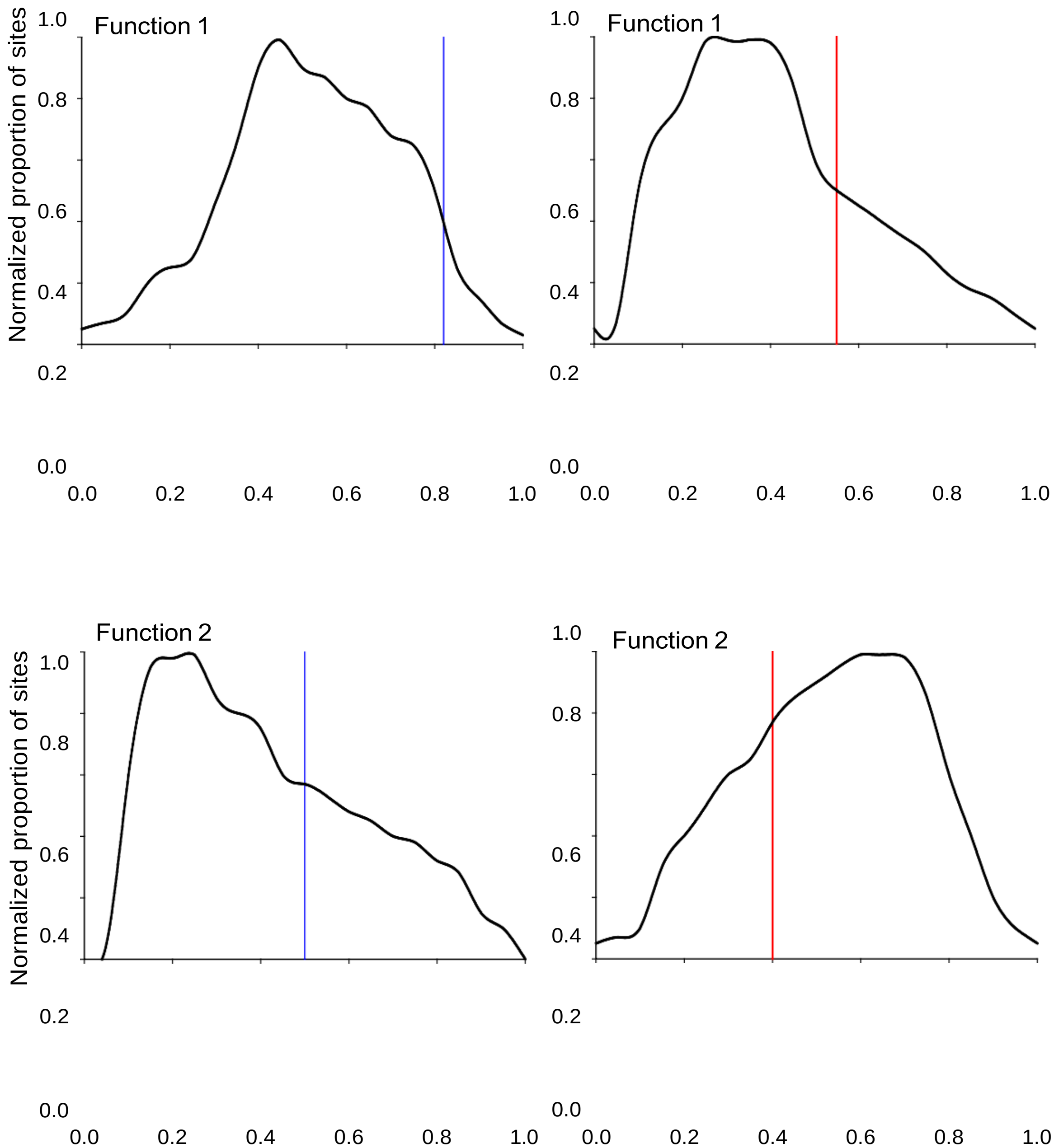
Approach A – Ambient or Reference Data is Available

Potential changes in function resulting from type conversion can be assessed relative to the range of functions in similar aquatic resource types in the region (i.e., ambient) (Figure 2) or to a distribution of reference sites. This allows a more direct comparison of the relative change in function in moving from one aquatic resource type to another. For example, surface water storage functions may be improved during the conversion of an incised stream to a depressional wetland. The level of function in the original aquatic resource type (e.g., incised stream) would be evaluated relative to either reference streams in the region or, if reference data is not available, to the distribution of function at streams in the region (e.g., the current level of function might be at the lower 20% of all streams in the region). A similar evaluation would be done for the new aquatic resource type (e.g., depressional wetland) to determine if the expected level of function would be higher relative to reference depressional wetlands or to the distribution in the region (e.g., expected function would be in the upper 80% of all depressional wetlands). Approach A comparison is contextual and visually accomplished in a step-wise fashion:

- Generate distribution plots for both the original and new aquatic resource type based on available reference or ambient data, for every function where data is available. This relies on the availability of ambient monitoring and/or reference data for each wetland type[3].
- Plot the functional score (for all possible functions) of the original aquatic resource type on the distribution curves for that aquatic resource type to determine its current relative function.
- Plot the expected future functional score (for all possible functions) of the proposed future aquatic resource type on the distribution curves for the new aquatic resource type to determine its expected future relative function.
- Compare the relative function of the existing to the proposed new aquatic resource type for every function.

[3] Programs should endeavor to generate ambient or reference data over time and make it readily available to the user community, and/or to partner with programs that generate such data.

Original Aquatic Resource Type | Proposed Aquatic Resource Type



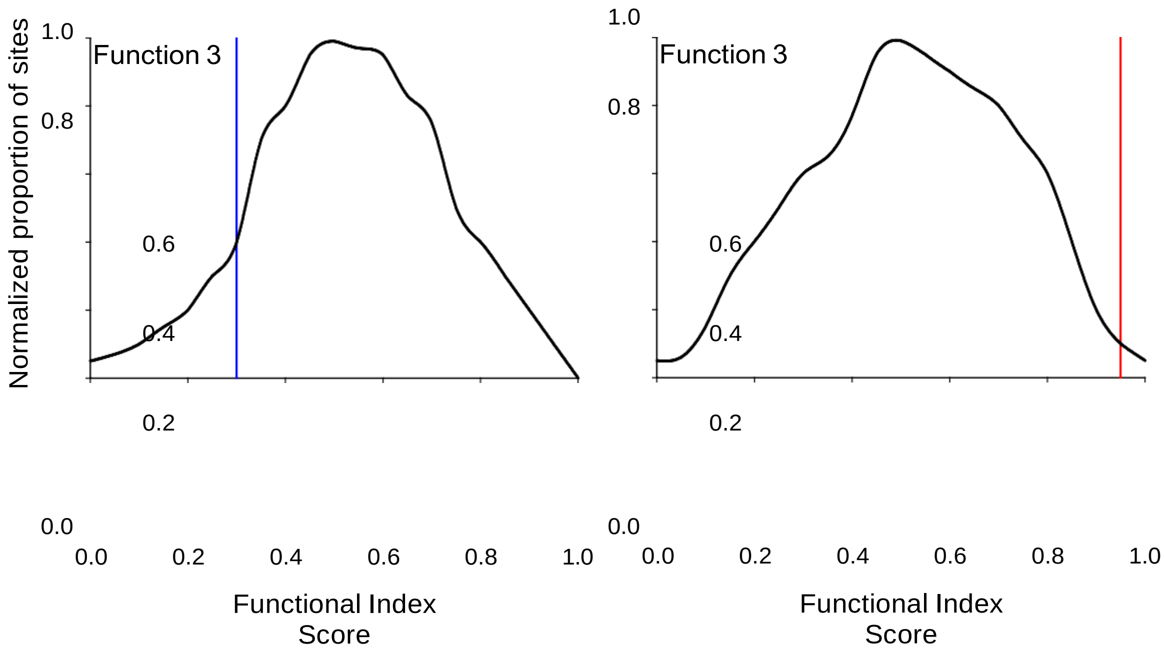


Figure 2. Example comparing relative loss in function at original aquatic resource type to relative gain at new aquatic resource type for three functions. Distribution curves are based on normalized measures of function at reference or ambient sites (y-axis) for both the original and proposed aquatic resource types. The blue lines indicate the functional score of the original aquatic resource type, and the red lines indicate the functional score after converting to the proposed aquatic resource type (x-axis).

When using indirect measures or qualitative assessments, relative change in function can be evaluated based on the change in "functional categories" between the current and expected future wetland types (e.g., high, medium, low). An increase in functional category (e.g., low to medium or high) would be considered positive, a decrease would be considered negative, and no change would be considered indeterminate (Figure 3).

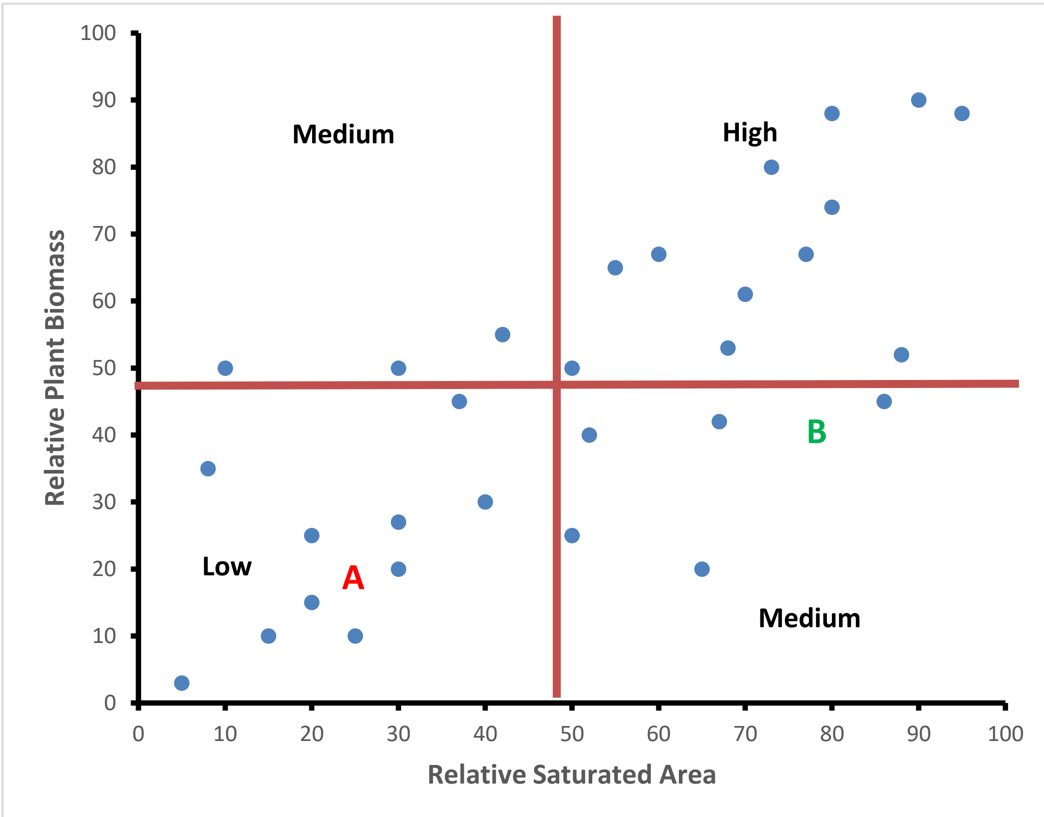


Figure 3. Example assessment of relative function based on an indirect measure. In this example, relative biomass and saturated area are used as an indirect measure of carbon sequestration. Regional observations were used to generate the overall plot and the functional category for the current wetland type (A) is compared to the functional category for the expected future wetland type (B).

Figure 4 illustrates another way to utilize reference condition data by direct evaluation of relative functional gains and losses: plotting the ratio of observed function to reference expectations for the current wetland type against the ratio of expected function to reference expectations for the proposed future wetland type (Figure 4). This approach allows for a simple evaluation of whether the relative difference is positive, negative, or indeterminate.

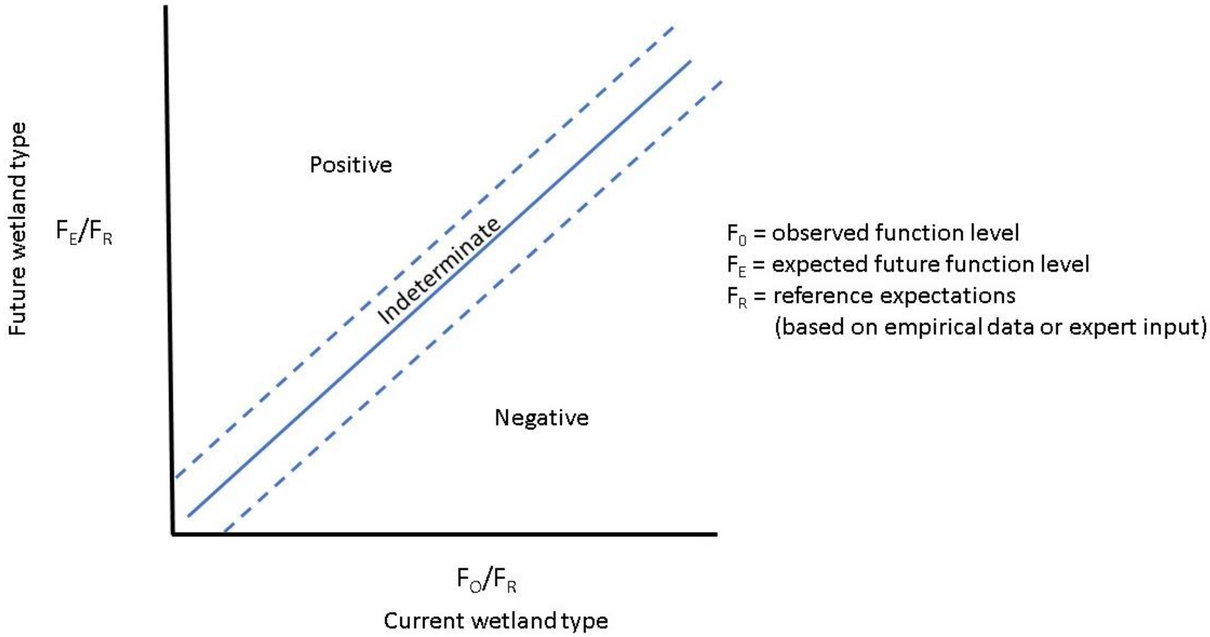


Figure 4. Example comparison of relative function based on ratios of observed and expected function to reference expectations. If the current vs. future relative function point falls above the upper dashed line it would be considered positive, if it falls below the lower dashed line, it would be considered negative, and if it falls between the two, it would be considered indeterminate.

Approach B – Ambient or Reference Data Not Readily Available

Comparison of functional change relative to reference or ambient conditions is always the recommended approach. However, reference or ambient data may not always be available. In these cases, assessment tools (or indices) with internal scales that allow direct comparison of functions for aquatic resource types can be used. For example, Functional Capacity Units calculated based on HGM assessments are already scored relative to regional reference; therefore, direct comparison of functional change between aquatic resource types would be acceptable because the relative comparison is embedded in the assessment method (Figure 5).

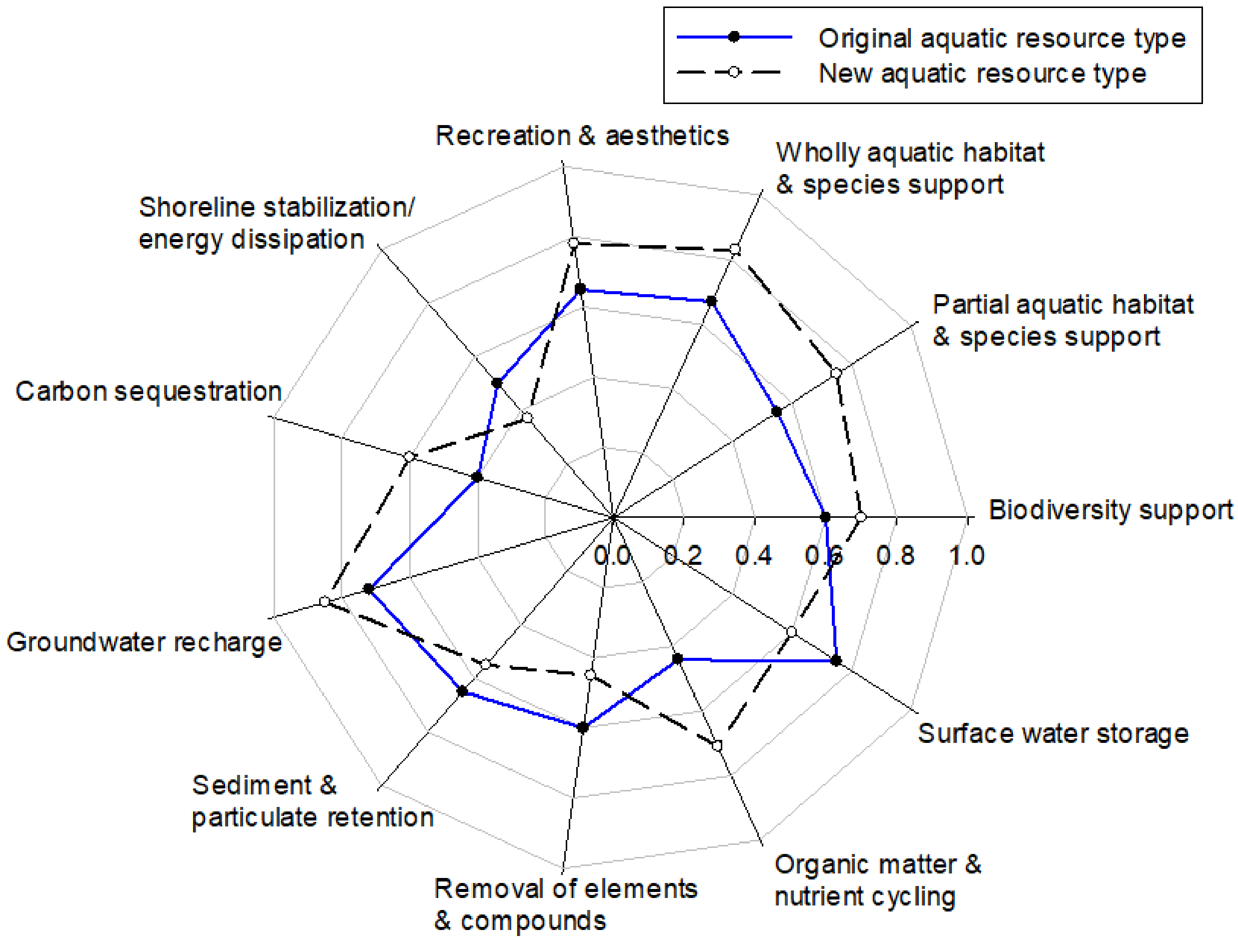


Figure 5. Example radial diagram showing functional changes in original vs. new aquatic resource type. This example is based on the HGM approach where the scoring of Functional Capacity Units (FCUs) is based on a regional reference standard that is incorporated into the scoring for each metric.

Step 2-7, Assessing Temporal Development and Weighting

Functions develop over different time scales (some on the order of decades) to reach conditions similar to those found at reference sites (Steyer et al. 2003) (Table 4). Type conversion may result in temporary loss of functions due to site disturbance (e.g., earth moving, vegetation removal), with recovery happening over a period of years following restoration. The time required for a site to reach maturity can lead to functions increasing or decreasing over different timeframes. Temporal differences in development of functional maturity may or may not be problematic depending on the importance of the function from a site-specific and regional context. The goal of the framework is to document temporal factors so they can be considered when an agency determines if type conversion is acceptable or desirable. Including a consideration of temporal loss also provides a way to account for uncertainty in proposed type conversion because that uncertainty increases with the time necessary for those functions to develop (see Tables 7 and 8). For some aquatic resource types, performance curves may be available (from the literature or on EcoAtlas) that can help estimate the time necessary for specific functions to develop (Figure 6; Fong et al. 2017). These curves are useful in estimating potential temporal losses associated with type conversion. Agencies, at their discretion, may decide to weight the comparison of relative functional gains and losses by the time necessary to achieve the desired functions (see above section on step 2-3).

Functions may also be weighted in consultation with the agencies. Weighting should reflect a combination of priority of the function (low, moderate, or high) and the level of confidence in the assessment method (Table 5). Qualitative assessments are generally assigned a lower level of confidence.

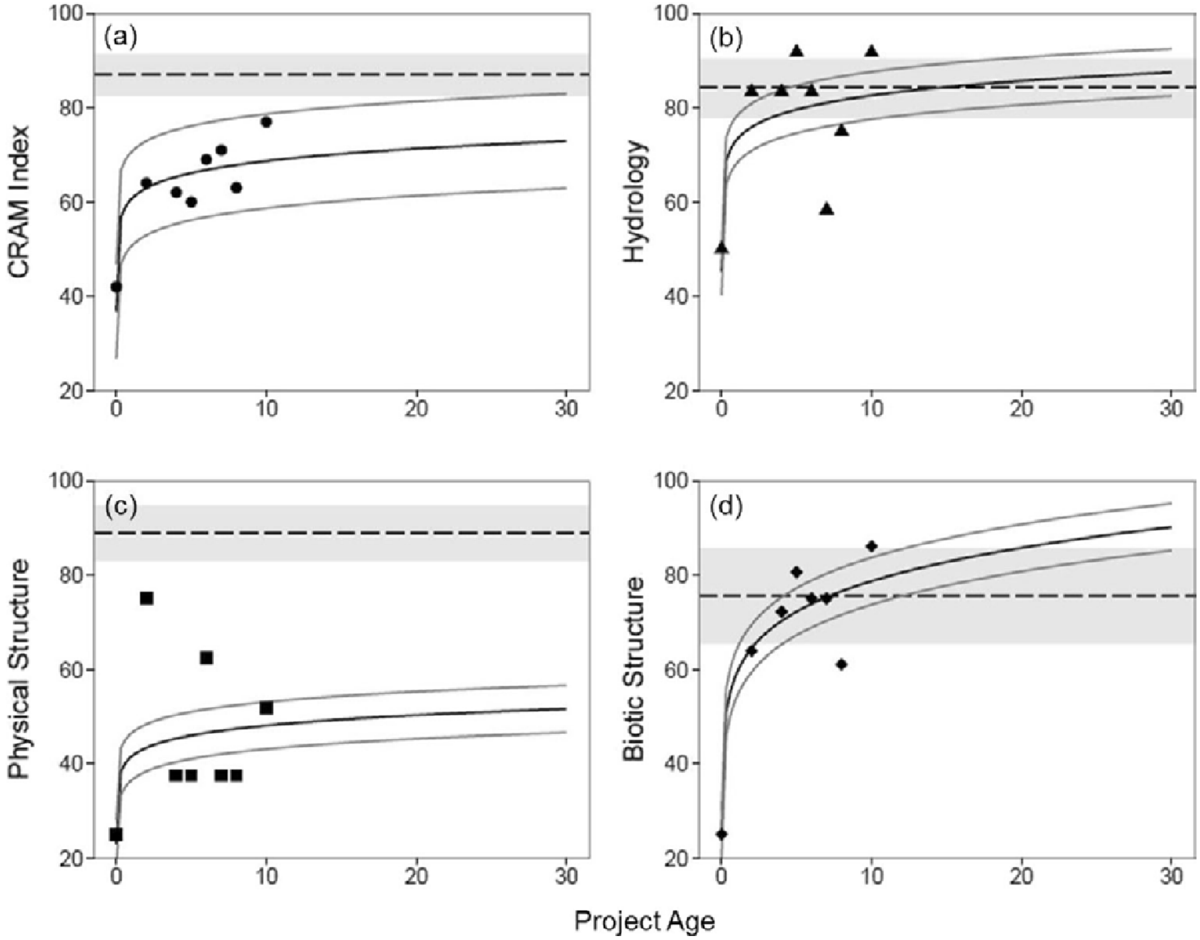


Figure 6. Stream restoration performance curves for CRAM; (a) Overall index score (black circle), (b) Hydrology (black triangle), (c) Physical Structure (black square), and (d) Biotic Structure (black diamond). The curve error band (bounded by gray lines) is ± 10% error. Reference envelopes (shaded gray) are comprised of the 95% confidence intervals around mean reference values, indicated by dashed lines. Figure from Fong et al. 2017.

Table 5. Guidance on how to assign weighting to functions. Priority is based on Step 2-3 of the process and confidence is based on the level of confidence reported or associated with the specific assessment method.

Weighting Guidance				
		Priority		
		Low	Moderate	High
confidence	Low	1.00	1.25	1.50
	Moderate	1.00	1.50	1.75
	High	1.00	1.75	2.00

Step 2-8, Compile Results of Relative Change in Function

Whether using Approach A or B, the rationale for all decisions should be clearly documented using the template provided in Appendix B, Table B-2. Determinations resulting from the analysis can be documented using a simple summary table (Table 6). A blank template for summarizing decisions is provided in Appendix B, Table B-3. The following general rules for filling out Table 6 are provided to facilitate synthesis of the functional evaluation into a semi-quantitative determination:

1. Once functions are identified and prioritized, assess the direction and magnitude of change based on the evaluation of each function. Change assessments should include clear rationale or justification, particularly for qualitative assessments. Functional changes can be binned based on relative magnitude and are applied to both positive and negative changes in relative function:

    - 0 = changes of less than 15% or no change in the qualitative (H, M, L) category. A change of less than 15% is generally within the uncertainty associated with most functional assessment methods, and should be considered "inconclusive"
    - +1 or (-1) = moderate effect; changes of between 15% and 50% or change of one qualitative category (e.g., L to M or M to H)
    - +2 or (-2) = substantial effect; changes of 50% or greater or change in of two qualitative categories (e.g., H to L or L to H)

2. Per step 2-7, estimate the timeframe necessary for functions to accrue in the new aquatic resource type. For summary purposes, timeframes for functional accrual can be binned based on the time it takes for a function to fully develop or fully degrade[4]:

    - 1 = slow, greater than 5 years
    - 2 = moderate, 3-5 years
    - 3 = fast, 0-2 years

    If an overall score is desired, multiply the relative functional change bin score (0, -1, -2, +1, +2) by the timeframe bin score (1, 2, 3) to get a net change score for each function.

3. Add up all the net change scores (negative scores should be subtracted). The maximum possible unweighted score is 66 (11 functions x 2 [substantial effect] x 3 [fast accrual time]). The minimum possible score is -66. Overall functional change should be evaluated using the following criteria:

    - Type conversion function gain should generally be considered "positive" if the functional change is 25% of the maximum score or greater, which equates

[4] Some wetland types may take longer than 5 years to fully mature; however, a five-year period is appropriate for most wetland types and is consistent with typical permit compliance review periods

to a score of 17 or greater if all functions are evaluated.

- Type conversion function gain should generally be considered "negative" if the functional change results in any negative score.

- Type conversion function gain should generally be considered "indeterminate" if the functional change is between 1 and 25% of the maximum score; between 1 and 16.5 if all functions are evaluated.

4. If using weighted functions, the maximum possible weighted score is 132 (11 functions x 2 [substantial effect] x 3 [fast accrual time] x 2 [max possible weighting]). The minimum possible score is -132. Overall functional change should be evaluated using the following criteria:

   - Type conversion function gain should generally be considered "positive" if the functional change is 25% of the maximum score or greater, which equates to a score of 33 or greater if all functions are evaluated.

   - Type conversion function gain should generally be considered "negative" if the functional change results in any negative score.

   - Type conversion function gain should generally be considered "indeterminate" if the functional change is between 1 and 25% of the maximum score; between 1 and 32.5 if all functions are evaluated.

Table 6. Example functional evaluation of type conversion. The net unweighted functional gain is +35, while the weighted score is +43.5; this would be considered a positive outcome.

Function	Priority	Method	Pre Conversion	Post Conversion	Relative Change	Timeframe	Net Change	Weighting	Weighted Score
Wholly aquatic habitat and species support	High	fish surveys	up to 20% increase in sensitive fish species		20% (1)	2 years (3)	**3**	2	**6**
Partially aquatic habitat and species support	High	bird surveys	approx 10 special status bird spp	up to 40% increase in special status bird spp	40%(1)	3-4 years (2)	**2**	1.5	**3**
Biodiversity support	High	CRAM	65%	78%	20% (1)	> 5 years (1)	**1**	1.5	**1.5**
Surface water storage	Low	qualitative	low due low residence time in the flood channels	High due to large area accessible for open water or saturated conditions	(2)	1-2 years (3)	**6**	1	**6**
Organic matter/nutrient cycling	Low	qualitative	low due to lotic nature and relatively low organic matter in the substrate	high due to long residence times, high organic matter, and hig biomass	(2)	4-5 years (2)	**4**	1	**4**
Removal of elements and compounds	Low	qualitative	moderate due to velocities and size of channel	high due to longer residence times and more area for inundation	(1)	3-4 years (2)	**2**	1	**2**
Sediment/particulate retention	Moderate	inundation, plant density	<10 acreas of tidally inundated marsh	120 acres of tidally inundated marsh	> 50% (2)	4 years (2)	**4**	1.25	**5**
Groundwater recharge	Low	qualitative	low due low residence time in the flood channels	low due to mainly tidal influence with little freshwater input	0	N/A	**0**	1	**0**
Carbon sequestration	Low	area x biomass	Low	Medium	(1)	> 5 years (1)	**1**	1	**1**
Shoreline stabilization/energy dissipation	Moderate	dimensions (width) and vegetation density	levee slope provides 75 ft. of trangressions space, minimal vegetation density	wider, horizontal leveels to provide approximatley 1,000 ft. of trangression space with high density vegetation	> 50% (2)	2 years (3)	**6**	1.25	**7.5**
Recreation and aesthetics	Moderate	recreational use surveys	currently <10,000 visitors/year	expect 30,000 visitor/year @ post restoration	> 50% (2)	0-2 years (3)	**6**	1.25	**7.5**
Total							**35**		**43.5**
Normalized total (relative to max possible)							**0.53**		**0.33**

Potential sources of information or data

- Local functional or condition assessments, e.g., CRAM, HGM, CSCI, ASCI, IPI, mAMBI
- Regional reference sites selected to represent the highest level of functioning within the geographic region
- Regional or statewide ambient monitoring programs
- Habitat data from BIOS, EcoAtlas or other databases
- Species information from CNDDB, AQUARIUS, iNaturalist, eBird, GBIF
- Water quality or bioassessment data from SWAMP/CEDEN database
- Site-specific historical records and monitoring data

MODULE 3: REGIONAL CONTEXT

Aquatic resources do not occur in isolation but exist as an integrated set of systems that collectively perform greater functions than what occurs at each individual site. For example, aquatic-dependent species may rely on different types of systems for different aspects of their life history; such as depressional wetlands for breeding and riverine wetlands for foraging and cover. Similarly, energy dissipation, organic matter cycling and sediment processes, rely on combinations of aquatic resources that are distributed, yet connected through the landscape. This section of the framework provides approaches to consider how type conversion may support or detract from the larger regional functions and connections that individual aquatic resources contribute to.

Why it is important

Proposed type conversion should be considered in the context of landscape-scale functions. Converting from one aquatic resource type to another should promote larger landscape functions by increasing diversity and complexity of the landscape, promoting physical, biogeochemical or hydrologic connection, and facilitating migration or biological linkages. Type conversion should also support (and be consistent with) watershed or regional goals where they have been established.

What to measure

Contribution to regional condition can be assessed using statewide, regional, or watershed plans and associate data and/or by review of regional maps and aerial photographs. Effects of type conversion to regional goals and function should be assessed based on:

- Consistency with regional or watershed goals
- Replacement of regional rare aquatic resource types
- Progress toward replacement of historical losses
- Regional connectivity of habitats and overall landscape complexity
- Regional water quality, recharge, recreation, or other social benefits
- Resiliency relative to landscape constraints and stressors

How to evaluate

Evaluating regional context can be the most challenging element of the framework and will likely require compilation of information from a variety of sources. Contribution to regional function or condition is based on a qualitative evaluation of increases or decreases for a series of landscape criteria based on available reports, plans and data (Table 7; a blank template form is provided in Appendix B, Table B-4). Each rating should be accompanied by a rationale or justification based on the source of the information used to assign the rating; examples are provided below:

- Consistency with regional goals – can be evaluated based on regional or watershed plans, such as the *Bayland's Goals* Project or the *Wetland*

Recovery Project's Regional Strategy, or *Recovery Plan for Tidal March Ecosystems of Northern and Central California*. Local watershed plans or habitat conservation plans can also be consulted. Type conversions should be considered positive if they contribute toward achieving the regional or watershed goals.

- Replacement of regionally rare resource types – can be based on review of landscape profiles and state or local mapping and inventory projects that catalogue the distribution of aquatic resource types. Type conversion should be considered negative if replacing a regionally rare resource with a more common resource type, positive if it restores an aquatic resource type that is underrepresented in the landscape or considered rare by public agencies, and neutral if it does neither.

- Replacement of historical losses – will be possible in areas where historical ecology analysis has been conducted. Historical analyses are available through EcoAtlas, CalTsheets.org, the San Francisco Estuary Institute, and the Southern California Coastal Water Research Project, or local studies (Figure 7). Type conversion should be considered positive if it replaces resource types that have been disproportionately impacted compared to historical condition.

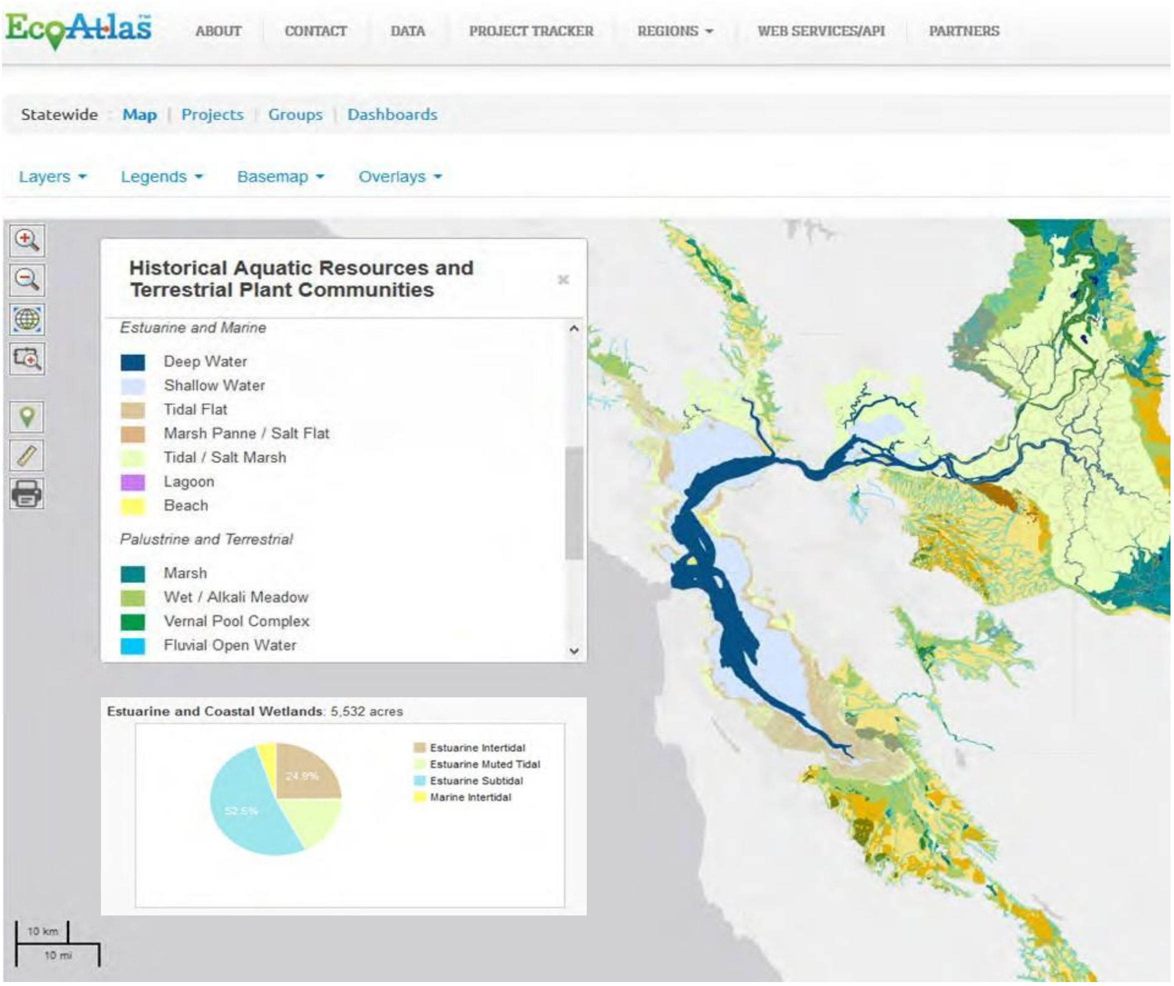


Figure 7. Historic aquatic resources and terrestrial plant communities in the Bay Area, from the EcoAtlas landscape profile tool.

- Regional connectivity and complexity of habitats – can be evaluated based on regional conservation or recovery plans, habitat conservation plans (e.g., NCCP, HCP), or watershed plans that identify opportunities to restore key linkages (Figure 8). In the absence of such reports/plans, regional monitoring program data and review of historic and contemporary aerial photographs can provide insight into opportunities to restore connectivity or complexity. Projects that involve type conversion should aim to improve regional or landscape connectivity and complexity of habitats.

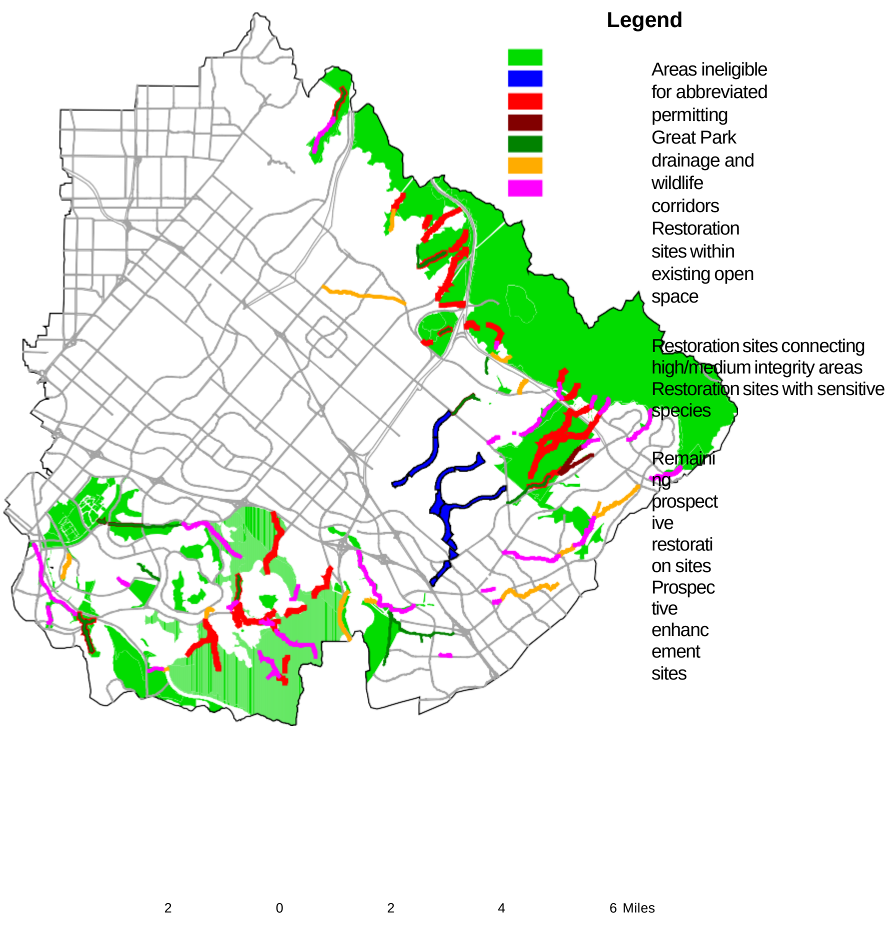


Figure 8. Example of priorities for restoring landscape linkages from the San Diego Creek Special Area Management Plan (SAMP).

- Contribution to regional water quality and regional groundwater recharge – can be evaluated through review of regional stormwater, watershed, or water resources management plans. Many watersheds in the state have developed such plans to help prioritize water quality and water resource management projects. Type conversion should be considered positive if it is consistent with these plans, but not at the expense of inherent aquatic resource functions. For example, a natural wetland in its appropriate landscape position should not be converted to a treatment wetland solely to support regional water quality improvement plans. Similarly, conversion of groundwater dependent ecosystems to other wetland types should generally be avoided.

- Contribution to recreational or social benefits – Aquatic resources can be important regional opportunities for recreation, education, or other social benefits. The State of California Office of Environmental Health Hazard Assessment (OEHHA) California Communities Environmental Health Screening Tool (CalEnviroScreen) is a screening tool that can be used to help identify California communities that are disproportionately burdened by multiple sources of pollution. In addition, local general plans, specific plans, park plans, or other land use planning documents can provide insight as to how aquatic resources can provide social benefits. Projects that involve type conversion that enhances these social values should be considered positive to the extent that they do not compromise inherent ecological functions.

- Resiliency relative to landscape constraints and stressors – Long term sustainability of a restored site may be affected by landscape-scale stressors. Landscape factors should be evaluated in the feasibility module of the framework. Regional analyses and watershed monitoring programs (e.g., California's SWAMP) provide information on landscape stressors. Statewide assessments, such as the Healthy Watershed Initiative, Statewide Watershed Prioritization, and the State Water Board's Healthy Watershed Partnership can also provide information on landscape-scale stressors (Figure 9). The USEPA StreamCat and LakeCat data systems also provide information on landscape stressors and constraints. Finally, review of aerial photographs can provide some insight for this evaluation. Type conversion should be considered positive if it results in an aquatic resource type that is less sensitive or less vulnerable to landscape-scale stressors, in consideration of the rarity of the wetland type (i.e., rare wetlands may be more sensitive, but more desirable from a restoration perspective).

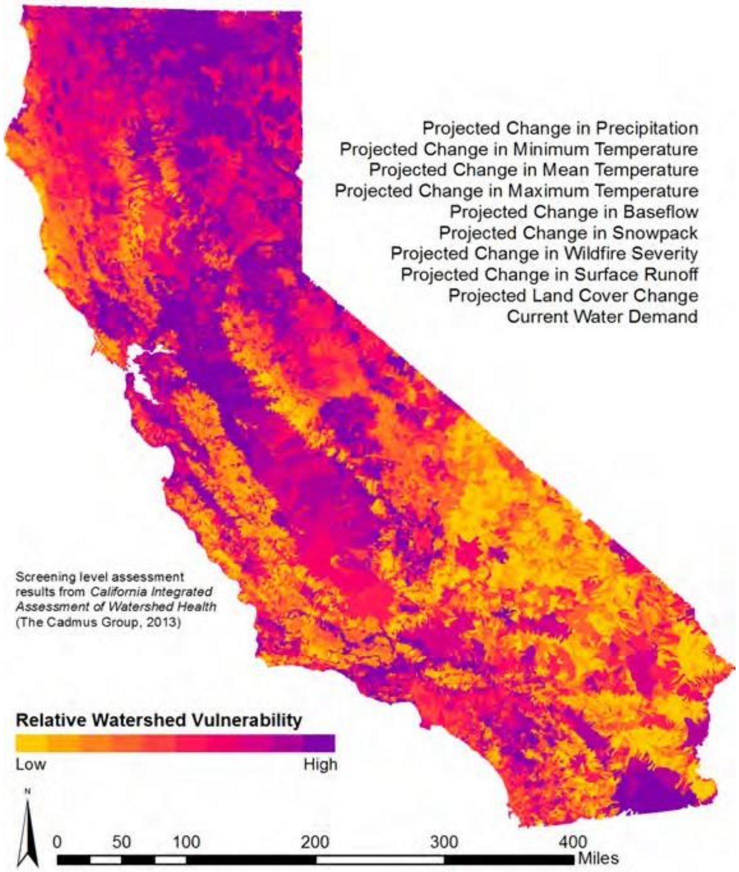


Figure 7. Watershed vulnerability assessed at the HUC 12 level provides information on a range of landscape-scale stressors. Data and maps from USEPA 2013.

Regional context considerations can be synthesized by tallying the relative direction of change between the original and ultimate aquatic resource types (Table 7). Acceptability can be qualitatively assessed for each criterion and an ultimate decision can be made based on the proportion of criteria that show a net improvement associated with the type conversion. As a general rule:

- Support of regional context should generally be considered "positive" if four or more regional criteria are met (i.e., 50% or greater are positive).
- Support of regional context should generally be considered "indeterminate" if two or three regional criteria are met.
- Support of regional context should generally be considered "negative" if less than two regional criteria are met (i.e., less than 25% are positive) or if more than two criteria are expected to change in a negative direction

These bins/categories should be considered general guidelines, but there may be projects that are determined to be positive or negative when they don't fall into these bins or based on the magnitude of change in certain criteria (at the discretion of the agencies). In all cases, the rationale for a determination should be clearly documented.

An example comparison of relative functional effects of a type conversion can be found in Table 7. For this example, a depressional wetland formed by impounding a historical stream course is being converted to a riverine wetland. In this case, four regional criteria would be met; therefore, the type conversion would be a net positive in terms of regional context. The example provided is hypothetical and does not represent an actual project but is solely to demonstrate how an assessment would be scored.

Table 7. An example synthesis of evaluation of regional considerations.

Criterion	Direction of Change	Explanation	Source/Justification
Consistency with regional goals	positive	consistent with regional goals	WRP Regional Wetland Goals
Replacement of regional rare resource types	neutral	new resource type is not "rare"	Historical ecology reports
Replacement of historical losses	positive	shifts landscape profile closer to historical condition	EcoAtlas
Regional connectivity and complexity of habitats	positive	connects currently fragmented habitats	Missing Linkages Report, Aerial photograph analysis
Contribution to regional water quality	negative	replaces emergent wetland with stream; less water quality benefits	Regional Water Quality Improvement Plan
Contribution to regional groundwater recharge	neutral	no apparent difference between old and new resource type	Integrated Regional Watershed Management Plan
Contribution to recreational or social benefits	negative	does not contribute to regional recreation plans	City General Plan
Resiliency relative to landscape constraints and stressors	positive	can be incorporated into regional management program	Healthy Watersheds Plan, Regional monitoring data

Potential sources of information or data

Information may or may not be available to evaluate all regional considerations for all aquatic resource types in all areas.

- Regional inventory of current and historical wetland makeup
- Watershed or regional goals assessments
- Local watershed plans, Special Area Management Plans, Habitat Conservation Plans (e.g., NCCP, HCP), water quality improvement plans, Integrated Water Resource Management Plans, etc.
- Historical aerial photography (e.g., UCSB Framefinder, USGS Earth Explorer, local collections)
- EcoAtlas
- State Healthy Watersheds Partnership
- EPA StreamCat and LakeCat systems

- Knowledge/history on past projects with comparable wetland projects
- Predictions of future conditions
    - Climate change
    - Land use
    - Water use/supply

OVERALL ENVIRONMENTAL BENEFIT

An ultimate determination on the expected environmental outcome should be based on a review of all three modules: feasibility, site-specific function, and regional context. The overall assessment can be done by reviewing the specific factors that contribute to each module through a lollipop graph (Figure 10) and/or by summarizing in tabular form (Table 8; a blank template form is available in Appendix B, Table B-5). The table should be annotated with key summary statements from the analysis for why a determination of positive, negative, or indeterminate is given. Documenting the rationale behind these decisions will increase transparency and interpretability of the overall outcome of the typeconversion evaluation.

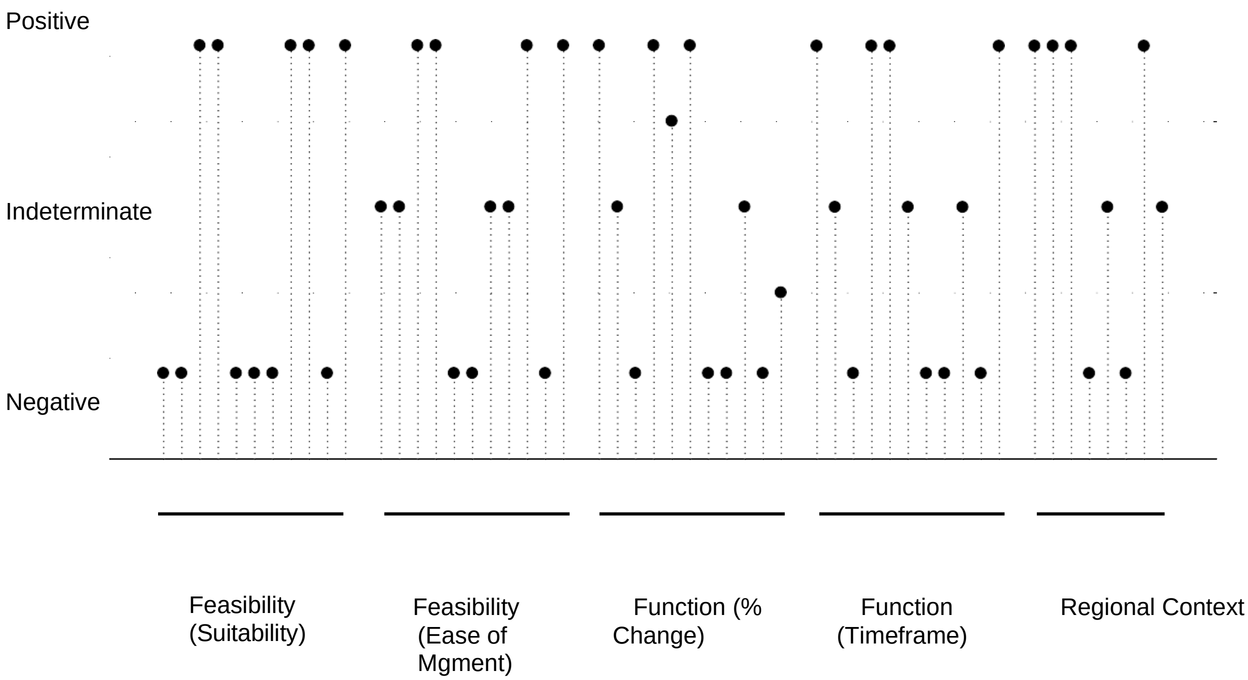


Figure 8. Summary of all factors for each module used in the type conversion assessment framework.

Table 8. Summary table to compile results from all three assessment modules.

	Positive	Indeterminate	Negative	Rationale
Feasibility – landscape suitability				
Feasibility – ease of management				
Site-specific Function				
Regional Context				

As a general rule, the following decision tree can be used to help make a determination of "Overall Environmental Benefit":

A. If either of the feasibility criteria are negative, the type conversion should be considered **undesirable/negative**

B. If neither of the feasibility consideration is negative, then:

    a. If both site-specific function and regional context are positive → **net benefit**

    b. If either site-specific function or regional context are positive and the other is indeterminate → **net benefit**

    c. If either site-specific function or regional context are positive and the other is negative → **indeterminate**

    d. If either site-specific function or regional context are negative and the other is indeterminate → **undesirable/negative**

    e. If both site-specific function and regional context are negative → **undesirable/negative**

    f. If both site-specific function and regional context are indeterminate → **default to the result of the feasibility analysis**

As an option, agencies could rank modules in the final overall determination, based on their policies, priorities, and the levels of uncertainty in the assessments. However, the intent is for the framework to be applied in totality through coordinated discussions that lead to agreement on the appropriateness and desirability of a type conversion proposal. Further, uncertainty is partially accounted for in the feasibility module, through consideration of temporal loss factors (in the functional assessment module) and by the ability to weight (or bin) functions based on importance and confidence in the assessments. This step is to ensure that the underlying assumptions guiding the analysis have been clearly documented throughout.

IMPLEMENTATION GUIDANCE

The type conversion assessment framework is intended to improve coordination among agencies in the decision-making process by providing a tool based on shared technical information. The goal is to reduce disparate determinations regarding the effect of type conversion by providing best practices to ensure successful application of the assessment framework.

First, there must be a clear determination of who will be conducting the analysis. The general expectation is that the applicant will complete the assessment and submit to the agencies for review. In some instances, the agencies themselves may choose to conduct the assessment after receiving a permit application. If the applicant conducts the analysis, they should first provide a checklist to the agencies of the data they intend to use and ascertain if they need further agency guidance on specific desired datasets (e.g., species occurrence data). If the agencies conduct the analysis, this should ideally be done as a coordinated effort, whereby the agencies agree upfront to conduct a single analysis by assigning permitting staff from multiple agencies to complete the analysis. This would provide quality control to generate consistent analysis output for use in each agencies' final decision-making.

Second, the rationale and basis for all decisions should be clearly documented. Data sources, citations, or other references used to justify decisions should be listed (and provided where possible). All assumptions and rationale behind scoring decisions should be documented sufficiently so that someone not involved in the original analysis can clearly understand the basis for decisions made in application of the framework. This will aid in future performance reviews, which will likely be conducted by individuals not involved in the original analysis.

Third, optimum coordination relies on the ability for agencies to share information, data, and documentation used to support the framework. Although agencies typically each have their own data management systems, advances in open source analytical tools, web services, and cloud storage have improved the ability to share information across platforms and agencies. However, there are still barriers to data sharing among agencies, which will ultimately require commitment to open data practices and investment of staff resources for implementation of these practices and for ongoing data management. In the short-term, agencies should share, closely track, and confirm the datasets to be used in type conversion analysis prior to conducting (i.e., a data checklist). Data management for type-conversion evaluation should be fully integrated with existing or newly developed systems for tracking compensatory mitigation and restoration projects. The ability to track and share information will also facilitate compilation of regional reference and ambient data on condition or function, temporal loss data and restoration trajectories, and performance of restoration projects involving type conversion relative to expectations. Performance data will be critical for not only tracking success, but for adaptive management and improving the type conversion assessment framework over time based on experience.

We recommend the following general data management considerations and practices:

- Strive for an integrated, electronic data flow through all steps of the data management process from data collection, organization, visualization, and interpretation.

- Manage data in a geospatial format to enhance data visualization and interpretation and facilitate data integration across programs; and

- Use an open data format, which may include web services and application program interfaces (APIs), to facilitate data access and sharing (EcoAtlas is one example of a web-based data service).

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APPENDIX A: MCINNIS MARSH CASE STUDIES APPENDIX

Version 1.0 of this framework included three case studies based on reviews of project files and discussions with agency staff:

- Case Study #1. PG Creek Watershed Enhancement Project
- Case Study #2. Stream Realignment and Creation of Broader Floodplain and Ponds
- Case Study #3. Sonoma County Watershed Restoration Project

These case studies are not repeated in Version 2.0. Instead, we provide a more detailed case study of the McInnis Marsh project in the San Francisco Bay Region. We encourage the development of additional case studies that provide examples of application of the framework to other wetland types or other circumstances. These can be provided to developers of the framework for future dissemination.

Project Overview

The vision for the McInnis Marsh restoration project is to restore tidal exchange to the 180-acre McInnis Marsh parcel, expanding contiguous high marsh habitat in the western and eastern marsh, increasing tidal prism to Gallinas Creek, and reducing the need for downstream dredging. The project would also reconnect Miller Creek to the Gallinas Baylands increasing connectivity between the baylands, the adjacent upland riparian corridor, and its alluvial sediment. Hydraulic connections will be made via levee breach, channel construction, and creek levee removal. Restoring connectivity between tidal baylands, adjacent upslope lands and alluvial sediments provide opportunity for natural adaption (upslope movement) of wetland ecotones in response to rising tides and increasing storm magnitude and frequency (Figure 1).

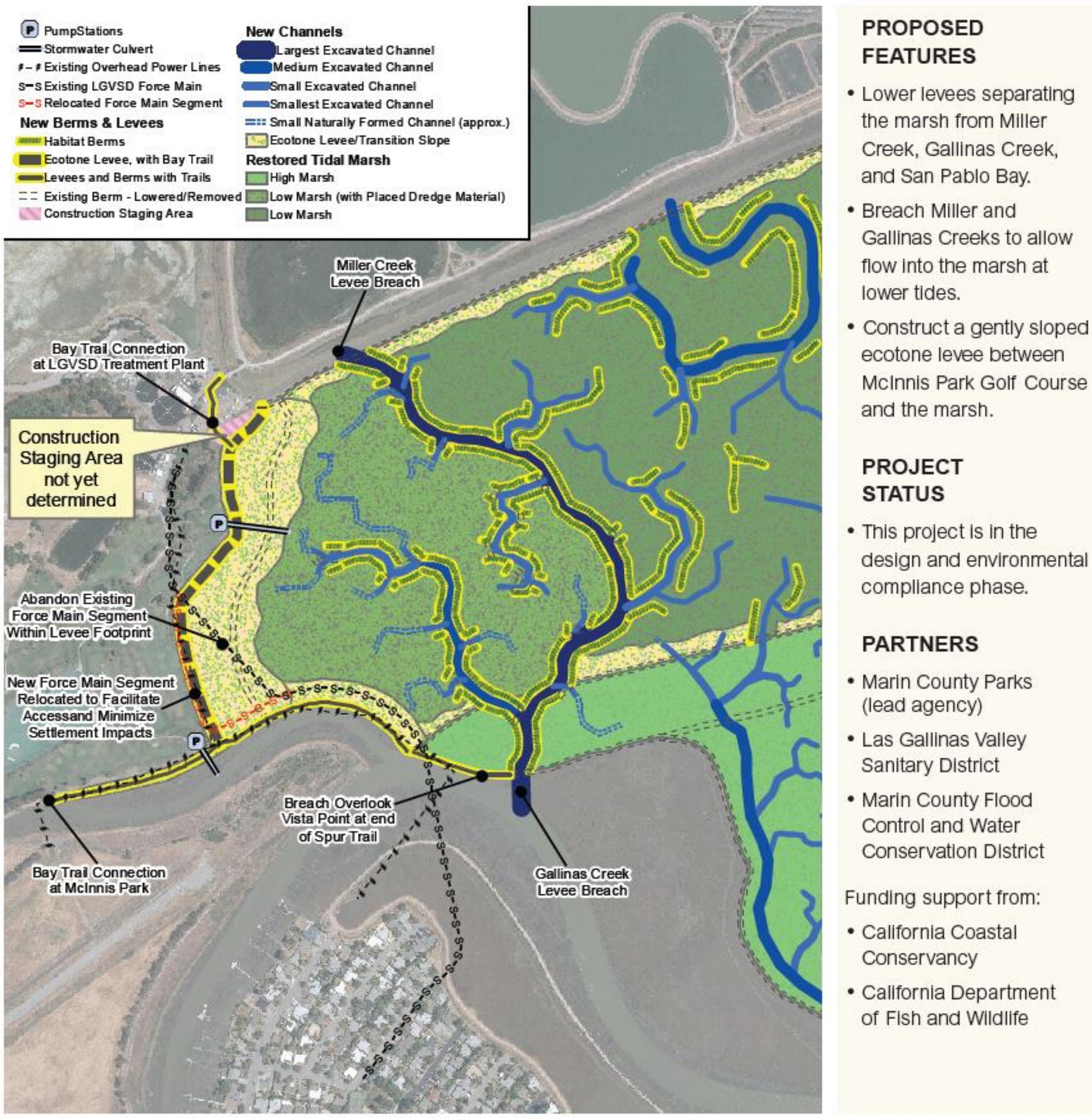

Figure 1. Proposed McInnis Marsh restoration project.

In additional to sustaining critical habitat for endangered wetland wildlife, the restoration project integrates infrastructure modifications to levees, trails, storm water, and treated wastewater outfalls. If a South Fork Gallinas Creek dredge project is implemented in the near future, opportunity may also exist to place sediment at McInnis Marsh. As conceived, this project facilitates bayland management that seeks to improve both ecological functions and community infrastructure; in addition, the restored site will be more responsive to sea-level rise and extreme climate events by providing transitional marsh ecotone (upland to high marsh) as habitat refuge.

The McInnis Marsh project was specifically chosen to pilot the type conversion framework due to the commonality of the Bayland habitat restoration needed, significant SLR resiliency aspects, wildlife tradeoffs, and construction of a habitat transition zone requiring fill into existing wetland features. Transitional ecotone habitats (a.k.a. horizontal levees) are of particularly interest to the design of this project, and in the larger context of habitat conversion and valuation in the regulatory context. The placement of sediment into heavily subsided marshes and adjacent uplands can be a significant long-term resiliency measure against SLR, and results in short-term opportunity costs to ensure the larger ecosystem success. Many restoration projects around the bay are incorporating these 'living shorelines' for several purposes (SLR adaptation, creating marsh migration space in a constrained landscape, flood attenuation, etc.). Agencies must assess when and where incorporating these ecotones is appropriate to protect and restore Bayland processes now and into the future. This pilot analysis addresses ecotone habitat throughout the three modules as a critical component of future wetlands (i.e., the slopes of the ecotone are considered marsh rather than upland to reflect future expected conditions). The fill of open water or existing marsh for wetland transition habitat is encapsulated in the scoring under the "Feasibility and Suitability" module given the increase in hydrologic and habitat connectivity and SLR resilience. In the "Site Assessment of Function/Condition" module, the ecotone is scored as wetland with higher functions related to sediment retention, shoreline stabilization, and support for partially aquatic species. The "Regional" module reflects the reality of the need for complex ecotones in areas around the Bay to accomplish greater marsh outcomes.

Project Summary Statistics

Project Name: McInnis Marsh Restoration Project, Phase II

Project Proponent: Marin County Parks, Las Gallinas Sanitary District

Site: McInnis Marsh, City of San Rafael and unincorporated Marin County

Size: 180-acres

Operational Landscape Unit (OLU) (see https://www.sfei.org/adaptationatlas): Gallinas
Watershed: San Francisco Bay Basin, Gallinas Creek (GC), Miller Creek (MC)

Main Goals: enhance & restore wetlands, restore estuarine habitat for steelhead, protect public recreational access and infrastructure facilities from flooding

Aquatic Resource Conversion: seasonal mixed, non-tidal wetlands and open water (stream habitat) associated with Gallinas and Miller Creeks to tidal marsh wetlands and high marsh transitional habitat (ecotone)

ESA Focal Species: Ridgeway's Clapper Rail, CA Black Rail, Salt Marsh Harvest Mouse, Central CA Coast Steelhead, Longfin Smelt

Priority Issues: Potential for flooding of adjacent neighborhoods, ESA impacts ST (during construction) and LT (predator access from trail, potential loss of existing high-quality marsh), Loss of existing high-quality outboard tidal marsh ST (breached by construction) and LT (SLR impacts)

Specific Actions: (1) lower levees that isolate the historic marsh from San Pablo Bay, Miller Creek, and Las Gallinas Creek; (2) construct breaches into both Miller Creek and Gallinas Creek; (3) construct interior marsh channels connecting the two creeks and connecting marsh to outboard marsh; (4) construct other channels and berms to provide habitat diversity and high-tide refugia; (5) Use dredged material from Gallinas Creek geomorphic dredging to raise internal site grades; (6) install a flood protection levee with an ecotone slope; and (7) construction of new public access trails.

Critical Assumptions

1. The Framework pilot took place during pre-application coordination and planning with the BRRIT members. Analysis is based on preliminary design drawings and basic habitat mapping. No formal jurisdictional delineation has been conducted and limited species surveys have been performed.

2. Additional information would be helpful in several areas. Results could be revisited if/when this information becomes available:

    a) Anticipated level of future onsite O&M actions? For instance, rate of internal berm subsidence and need for augmentation.

    b) After construction breaches, what may be the longer-term ecological effects to outboard fringing marsh with this action? Short-term monitoring data from the nearby Hamilton Wetlands Restoration Project (USACE 2021) indicates that erosion rates are constant with historic trends indicating no adverse effect as a result of the restoration. The initial five years of monitoring show climatic-induced patterns with the greatest levels of erosion occurring during drought years and lowest levels during wet years.

    c) Confirmation of onsite tidal circulation analysis after construction to determine adaptive management needs.

3. Local watershed analysis is made at the HUC 12 local sub-watershed level:180500020801. Regional watershed analysis is at HUC 8 San Pablo Bay and HUC 10 San Pablo Bay and Petaluma River Frontal San Pablo Bay Estuaries levels.

4. The analysis timeframe for consideration is from present to 2100, in line with current SLR predictions.

Analysis Summary

Feasibility and Suitability

Table 1. Feasibility check list/rating system *(Time to complete 2hrs)*.

Criteria	Question/Consideration	Landscape Suitability (1= No not suitable, 2= Yes suitable)	Ease of Management (1= High Level of Management to sustain system, 2= Moderate Level, 3= Low Level)
Landscape Setting	Watershed processes are not adversely altered for the intended aquatic resource type within the hydrologic unit. Recreation of tidal marsh from diked wetlands in same historic landscape setting; reconnection of the marsh with upper watershed via creeks would restore historic process. Natural historic hydraulics & elevation are highly modified, & subject to current land-use constraints (primarily residential housing, infrastructure) – restoring tidal hydraulics will require levee breaching & berms placement, which may require ongoing maintenance (sediment redistribution & augmentation due to subsidence). Tidal flow & circulation will increase with action. Adjacent southern areas currently receive 0-2ft flooding on King tides; med-high SLR predictions (2100: 42" + 100yr storm surge) will result in 6-10ft flooding for these southerly areas – analysis did not specifically look at adjacent flood risk w/project, but peak water elevations only expected to increase slightly [@10 & 100yr tidal & fluvial floods: Miller Crk reduced by 0.1-1ft, N & S Forks GC increase by 0.1ft]. Fluvial upstream effects up to 1.5RM. No sig fluvial influence on peak water levels during 100yr tidal flood. Modeled increase of GC due to scour from the project may have indirect LT impacts to southern GC levee that currently protects infrastructure. Establishment of ecotone will provide necessary migration space, biodiversity, refugia, and adaptability.	2 Rationale: restoration of tidal marsh in original landscape setting	2 Rationale: Internal berms require potential LT management due to subsidence. Both a reduction (less creek dredging, tidal gates removed) & potential increase (offsite levee scour in Gallinas Creek) in maintenance of proposed watershed processes
	Will the conversion result in an aquatic resource of the appropriate class in that landscape setting? Current wetland classes are depressional/slope & high tidal marsh. Restoration of complex tidal marsh would occur in historic landscape setting with suitable source water (riverine and tidal).	2 Rationale: restoration of historic class - complex tidal marsh	3 Rationale: low level of management to maintain tidal marsh complex - quality of that marsh will depend on other factors
Hydrology	Will the primary source of water to the site be appropriate for the new aquatic resource type without engineering a delivery system that requires long-term control or maintenance? Reconnection of tidal and fluvial flows via breaching. Removal of current tidal gates. 90% MC flow re-routed to site and GC (similar to historic). Tidal flow & circulation will increase – will increase quality and balanced retention.	2 Rationale: reconnection of historic tidal & fluvial flows	3 Rationale: once constructed, passive delivery system of tidal & fluvial flows

	Does the site have the ability to adapt to accommodate future hydrologic conditions associated with climate change or expected change in water use practices? Muted tidal action (70%) for first few decades after construction until outboard marsh breach scouring can increase to 100%. *[remaining uncertainty associated with this muted tidal action – what does this mean from impact standpoint?]* Will eventually double the tidal prism in the creeks. Stormwater culverts (2) will be relocated & one will be attenuated through the ecotone; operating pumps will be needed. Fluvial scour on MC elbow – will require design consideration for O&M needs. Offsite GC levee may need further adaptation design for SLR resiliency. Without habitat ecotone & room for migration, high future risk of conversion of outboard mature marsh to subtidal habitat by 2100, and submergence of internal wetlands**.**	2 Rationale: breaching and scouring processes will adapt over time	2 Rationale: appropriate reuse/finishing/flow attenuation of stormwater to marsh, but pumps needed. Scour processes may cause indirect impacts that need management. Mature marsh cannot accommodate SLR changes w/o project.
Geomorphology	Does the site have the appropriate underlying geology, and will the site maintain hydric soils (if appropriate)? Restoring downstream connections will reduce frequency of dredging due to scour processes. Within the Gallinas OLU, project and adjacent areas have physically similar characteristics (tidal range, geology, habitat types) and land-use pressures. Underlying geology of project area is filled & subsided hydric soils, so should develop easily once flows reintroduced. GC & MC would increase in width by 60%. Transitional ecotone will provide stability and adaptability for SLR pressure.	2 Rationale: occurring in historic geomorphic setting, already has hydric soils	3 Rationale: breaching will re-engage natural geomorphic processes; already has hydric soils; no active management for geomorphology factors
Sediment	Is the anticipated sediment supply to the site appropriate to maintain geomorphic stability for the new aquatic resource type? Reconnection of floodplain will allow marshes to receive coarse sediment from Miller & Gallinas Creeks, as well as receive suspended sediment (SSC) from tidal action. Polder area is 3-5ft subsided as compared to adjacent marshes; requires fill to initially increase elevation in some portions of the site (from onsite cut & fill, maybe reuse of dredged material from creeks to fill area west of the new main channel – uncertainty of volume available & needed). Eastern marsh elevations are higher & will need less. Some onsite & offsite adjacent areas may need LT augmentation (e.g., MC elbow, habitat berms, southern flood protection levee on GC) as scouring increases over time due to project. Ecotone will provide upland-marsh transition stability and adaptability for SLR pressure.	2 Rationale: reconnection of more natural, historic sed sources (tidal, fluvial); ecotone, tidal channels, & berms provide stability	2 Rationale: moderate uncertainty for ongoing fill amount to maintain elevations, particularly berms & levees.
	Will anticipated sediment processes (e.g., accretion, scour) provide appropriate elevations for the new aquatic resource type? 80% site subsided to 1-2ft NAVD. Moderately favorable conditions for marsh accretion - estimated at 3mm/yr w/200mg/L SSC as based on north Bay reference sites [muted tidal will take longer to accrete]; this will yield mix of low and mid-marsh system. Time to reach tidal marsh elevation estimated at 10-20yrs. Some levees may need LT management as scouring increases in creeks to reach equilibrium. Subsidence of internal habitat berms possible.	2 Rationale: reconnecting systems to allow natural sediment processes in the project areas.	2 Rationale: Modeling indicates marsh elevations should maintain pace w/SLR depending on other factors with moderate to high uncertainty (exact SLR heights, SSC changing in Bay). Moderate

			frequency of LT interventions may be needed, although this is ameliorated by the more natural project design connecting sedimentary processes.
Connectedness	Is the site connected or in close proximity to other aquatic resources or uplands that will support species and habitats for the new aquatic resource type? Portions w/in San Pablo Bay Wildlife Area; Located adjacent to Gallinas Crk Baylands – support high quality habitat for tidal marsh obligate birds; outboard mature marsh; regionally significant ESA populations nearby; Bayside linkage with other green spaces (China Camp, San Pedro Mtn, Sears Point, Hamilton Wetlands, San Pablo Bay National Wildlife Refuge). McInnis Park is a protected area. MC supports critical steelhead population & would benefit from estuarine habitat restoration.	2 Rationale: site located w/in & adjacent to protected habitats that support desired focal species	3 Rationale: no management actions needed to improve location
	Does the site have adequate buffers to help reduce effects of stressors from the adjacent landscape? Design includes increasing spatial & elevational buffers (ecotone) and reducing the perimeter-area ratio which results in more robust natural buffers (dense, complex, native vegetation, tidal channels). Adjacent to lower-impact land-uses: open space golf course, Bay Trail, wastewater treatment facility. Will still have WQ impact pressures and proximity to urban landscape. Focusing on relocating the main trial (Bay Trail) to upland/high-marsh elevation to avoid low-marsh impacts; however, there are many informal trails in area that may persist.	1 Rationale: Somewhat increasing buffer capacity through actions, but not much room to substantially increase.	2 Rationale: moderate management needed to maintain buffers (veg management on ecotone, human use of trails).
Stressor control	Can the site be designed to control aggressive plant species and/or reduce invasion by feral or non-native predators? Reconnection of hydrology and natural processes should help reduce invasive veg species. Ecotone maintenance will include reclaimed water to potentially reduce drought-tolerant upland veg nuisance species. Reducing perimeter-area ratio & disconnecting levees should reduce access points into marsh proper. High efforts needed to control feral predators due to high proximity to urban landscape (cats, racoons, raven/crow, etc).	2 Rationale: designed to reduce invasion (ecotone, removing levees, building appropriate elevations & complexity)	1 Rationale: will need high level of management to control predators; moderate level to control invasive veg until marsh veg is established
	Will the site be designed to minimize effects of excessive human visitation, grazing, or other source of persistent disturbance? Moving Bay Trail and onsite infrastructure to reduce human disturbance; but still have many informal trails – will need to discuss further from design perspective. Ecotone width will provide high tide refugia for species; tidal marsh habitat is a deterrent. No grazing on site.	2 Rationale: designed to reduce anthropogenic disturbance (ecotone, creating large marsh, moving trails)	2 Rationale: will need moderate level of management to control off-trail human visitation & indirect effects from trash, etc. of an urban marsh
Total Score		21	25

Feasibility Data Sources

- Hamilton Wetlands Restoration Project Year 5 – 2019/20 Monitoring Report (Draft), January 2021
- Marin County Park Memorandum to BRRIT, November 22, 2019
- McInnis Marsh Conceptual Design, February 2019
- McInnis Marsh Restoration Project: Feasibility Study and Alternatives Analysis, February 2016
- McInnis Marsh Hydraulic Modeling Report, September 2019
- Point Blue, 2019 California Ridgeway's Rail Summary Report to County of Marin, October 31, 2019
- EcoAtlas Landscape Profiles
- SF Bay Shoreline Adaptation Atlas
- Marin Watershed Program
- ART Bay Shoreline Flood Explorer
- CNDDB in BIOS
- Mead & Hunt, Aeronautical Analysis of Levee Options Adjacent to the San Rafael Airport, prepared for Marin County Department of Public Works, August 8, 2018

Function and Condition

Table 2. Functional evaluation rating table. (Time to complete is highly variable & dependent on available data, 8-16hrs). ***Note that tables in this module look different as they were populated during the pilot stage, which resulted in subsequent revisions to final tables presented in V2.0 of the framework.***

Function	Priority	Method	Pre Conversion	Post Conversion	Relative Change	Time	Net Change	Project Reference	Weight	Weight Score
Wholly aquatic habitat and species support (e.g., fish, amphibians)	High	fish surveys		up to 20% increase in sensitive fish species	20% (1)	2yrs (3)	3	based on BA report, insufficient information to fully evaluate; see analysis notes below	2	6
Partially aquatic habitat and species support-birds	High	bird surveys	approx 10 special status bird spp	up to 50% increase in special status bird spp	50% (2)	3-4 yrs (2)	4	based on BA report and estimated changes in species expectations	1.75	5.75
Partially aquatic habitat and species support-mammals	High	mammal surveys	mammal usage expected to be relatively comparable; however, ecotone and berms will provide uplift in available refugia		20% (1)	> 5 yrs (1)	1	based on BA report, insufficient information to fully evaluate	1.5	2.5
Biodiversity support	High	CRAM	65%	78%	20% (1)	> 5 yrs (1)	1	see analysis notes below for details	1.5	1.5
Surface water storage	Low	qualitative	Low due to low residence time in the flood channels	High due to large area accessible for open water or saturated conditions	(2)	1-2 yrs (3)	6	qualitative/subjective evaluation	1	6
Organic matter/nutrient cycling	Low	qualitative	low due to lotic nature and relatively low organic matter in the substrate	high due to long residence times, & high organic matter and biomass	(2)	4-5 yrs (2)	4	qualitative/subjective evaluation	1	4

Removal of elements and compounds	Low	qualitative	moderate due to velocities and size of channel	high due to longer residence times and more area for inundation	(1)	3-4 yrs (2)	2	qualitative/subjective evaluation	1	2
Sediment/particulate retention	Mod	inundation, plant density	<10 acres of tidally inundated marsh	120 acres of tidally inundated marsh	> 50% (2)	4 yrs (2)	4	hypothetical numbers based on McInnis feasibility report	1.25	5.25
Groundwater recharge	Low	qualitative	low due low residence time in the flood channels	low due to mainly tidal influence with little freshwater input	0	N/A	0	qualitative/subjective evaluation	1	0
Carbon sequestration	Low	area x biomass	Low	Medium	(1)	> 5 yrs (1)	1	see analysis notes below for details	1	1
Shoreline stabilization/energy dissipation	Mod	Dimension (width) and vegetation density	levee slope provides 75 ft. of transgression space, minimal vegetation density	wider, horizontal levees to provide approx 1,000 ft. of transgression space with high density vegetation	> 50% (2)	2 yrs (3)	6	hypothetical numbers based on McInnis feasibility report	1.5	7.5
Recreation and aesthetics	Mod	recreational use surveys	currently <10,000 visitors/year	expect 30,000 visitor/year @ post restoration	> 50% (2)	0-2 yrs (3)	6	hypothetical numbers based on feasibility report	1.25	7.25
Total							38			48.75
CONCLUSION							Positive			Positive

Table 2A. McInnis Marsh Decision Tracker.

Decision				
1		Which functions should be prioritized for analysis?	Priority	Rationale
	A	aquatic habitat and species support	HIGH	type conversion will affect habitat type and amount, shifting from seasonal wetlands to tidal marsh habitat, function can be evaluated quantitatively using a standardized approach
	B	partially aquatic species support - birds	HIGH	function provided at different levels and for different species in pre and post project wetland types, can be evaluated quantitatively using a standard approach. Evaluated separately from mammals due to management importance (e.g., sensitive spp)
	C	partially aquatic species support - mammals	HIGH	post-project wetland type may support sensitive mammal spp, can be evaluated quantitively using standard approach. Evaluated separately from birds due to management importance (e.g., sensitive spp). Ecotone will be important for providing refugia.
	D	biodiversity support	HIGH	both pre and post project wetland types will support biodiversity, but level of support may differ. CRAM can be used as proxy for biodiversity support in absence of full biological surveys and provides a standard assessment method
	E	sediment/particulate retention	MODERATE	sediment retention is expected to occur at different levels in the pre vs. post project wetland type. This function can be assessed quantitatively, but there is no standard index or assessment approach available
	F	shoreline stabilization/energy dissipation	MODERATE	proposed changes to the site are expected to affect this function – the ecotone will stabilize and protect transitional margins; the strategic breaches will allow for flow energy stabilization. It can be quantitatively assessed based on detailed modeling or by using vegetation density as a proxy. However, there is no standard index or assessment approach available
	G	recreation and aesthetics	MODERATE	The post-project condition aims to enhance recreational opportunities- trails and ecotone. This function can be evaluated quantitatively, but standardized tools may not be readily available
2		Choice of assessment method use for each function	Data Needs	Direct Measure/Proxy
	A	aquatic habitat and species support	Fish seine, trawls, cores/grabs	indices of fish or invertebrate abundance, richness and diversity
	B	partially aquatic species support - birds	bird survey, habitat mapping	bird abundance, richness, composition. Extent of key habitat based on vegetation, elevation, etc.

	C	partially aquatic species support - mammals	mammal surveys, habitat maps	mammal richness and composition. Extent of key habitat for target sensitive mammal species.
	D	biodiversity support	CRAM	CRAM assessment as a proxy for biodiversity
	E	sediment/particulate retention	accretion rates, estimates of inundation extent & duration	inundation extent and frequency, plant density, sediment accretion
	F	shoreline stabilization/energy dissipation	vegetation density, shoreline modeling	model wave energy and runup. Vegetation structure and density can be used as proxy
	G	recreation and aesthetics	recreational use surveys	tally of recreational use by season and based on different demographics
3		How each assessment is contextualized	Method	Approach
	A	aquatic habitat and species support	bio index	relative to range of values observed at other similar sites in the region OR relative to max observed regional value
	B	partially aquatic species support - birds	bio index	relative to range of values observed at other similar sites in the region OR relative to max observed regional value
	C	partially aquatic species support - mammals	bio index	relative to range of values observed at other similar sites in the region OR relative to max observed regional value
	D	biodiversity support	CRAM	relative to range of values observed at regional reference sites OR relative to ambient range
	E	sediment/particulate retention	accretion, inundation	no standard approach, simply compare values
	F	shoreline stabilization/energy dissipation	veg. density	no standard approach, simply compare values
	G	recreation and aesthetics	rec. surveys	no standard approach, simply compare values
4		What timeframe is necessary for each function to mature	Maturation Time	Rationale or Citation
	A	aquatic habitat and species support	0 - 2 years	once hydrology is restored, aquatic species support should resume quickly
	B	partially aquatic species support - birds	3-5 years	salt marsh habitat typically takes several years to mature and be able to provide this function
	C	partially aquatic species support - mammals	> 5 years	salt marsh habitat typically takes several years to mature and be able to provide this function; ecotone as refugia habitat will also need time to develop.
	D	biodiversity support	> 5 years	full maturity of salt marsh is required to support broad assemblages of species and diversity of

				habitats
	E	sediment/particulate retention	> 5 years	accretion and retention accrue slowly over time as biomass accumulates. May also only occur following episodic events
	F	shoreline stabilization/energy dissipation	> 5 years	physical structure and biological communities must mature before this function can be fully supported
	G	recreation and aesthetics	0-2 years	once site is constructed, recreation opportunities are available, will increase over time
5		what additional weighting is assigned to each function	Priority	Weighting
	A	aquatic habitat and species support	HIGH	2.0 times weighting due to high priority and high confidence in assessment data
	B	partially aquatic species support - birds	HIGH	1.75 times weighting due to high priority and moderate confidence in assessment data
	C	partially aquatic species support - mammals	HIGH	1.5 times weighting due to high priority, but relatively higher uncertainty in the data
	D	biodiversity support	HIGH	1.5 times weighting due to high priority, but data gaps that prevent a comprehensive assessment
	E	sediment/particulate retention	MODERATE	1.25 times weighting due to moderate priority and high uncertainty in assessment due to lack of data
	F	shoreline stabilization/energy dissipation	MODERATE	1.5 times weighting due to moderate priority, and moderate uncertainty in assessment. Anecdotally know that ecotone, berms, and channel breaches will provide uplift in these functions.
	G	recreation and aesthetics	MODERATE	1.25 times weighting due to moderate priority and high uncertainty in assessment due to lack of data

Analysis Notes

Several functions were identified as critical, high priority related to the project: wholly and partially aquatic habitat and species support, and biodiversity support. This section illustrates the analysis completed for the biodiversity, wholly aquatic habitat and species support, and carbon sequestration functions.

Biodiversity

Biodiversity functionality was assessed using a CRAM Index score as a surrogate indicator to determine relative change in biodiversity. The analysis required determination of ambient population for SF Bay freshwater and tidal resources, and appropriate subsets, to represent both current (seasonal mixed depressional) and future (fully tidal marsh) condition.

Brief background on CRAM (CWMW 2019): CRAM Index is a measure of overall conditional capacity of a wetland system based on four attributes (hydrology, biotic structure, physical structure, and buffer/landscape). Confidence intervals for CRAM Index is a spread of 7 points, which verifies that one score is statistically different from another. Further, CRAM Index is assigned condition of poor (≤ 50), fair (51-75), good (> 75) based on statewide probabilities.

Steps:

1. EcoAtlas was queried within a user-defined area for all freshwater wetland data (Cram Index and Metric scores) in the 9 Bay area counties to establish ambient condition (total of 94 sites). Then 59 sites were culled from that total of 94 (approximately 63%) to represent similar characteristics of the current wetland condition (since no CRAM data was collected on McInnis Marsh itself).

2. EcoAtlas was queried within a user-defined area for all estuarine wetlands in the 9 Bay area counties to establish ambient condition (total of 165 sites). Then 48 sites were culled from that total (approximately 29%) to represent similar characteristics of the future wetland condition.

3. The next step was to determine the value (poor, fair, good) in terms of the CRAM scores, for both the current and future condition, in comparison to the gradient of the ambient populations. Scores for CRAM Index and individual metric scores were averaged, and then determined if the subsets were different from ambient (Table 2B).

4. We then compared the relative change in value between current condition and future condition (Table 2B).

Table 2B. Average CRAM Index and Metric scores for both current and future type conditions compared to ambient populations. Significance is defined as a minimum 7-pt difference in scores.

Average Value	Current condition (n=59)	Ambient Seasonal (n=94)	Significant from ambient	Future Condition (n=48)	Ambient Tidal (165)	Significant from ambient	**Sig Relative Change Current to Future (positive or negative)?**
CRAM Index	65	61	N	78	72	N	Y+
Buffer/Landscape	80	60	Y	89	80	Y	Y+
Hydrology	64	71	N	81	75	N	Y+
Physical Structure	53	52	N	71	63	N	Y+
Biotic Structure	62	61	N	71	69	N	N

Results

1. Index Score: Current condition of the seasonal wetlands is considered Fair; proposed future condition of tidal marsh is Good. The difference in Index scores indicates that the relative change between current and future condition is positive and significant from current (65) to proposed condition (78). In other words, the future condition will provide higher functional capacity than the current condition, and overall condition will go from Fair to Good.

2. Individual Metric Attributes: Buffer/Landscape and Hydrology would be expected to shift positively from fair to good with the type conversion. Physical Structure would shift positively but remain in fair condition. Biotic Structure would not shift and remain in fair condition.

Wholly Aquatic Species

Fish species richness, as an indicator of aquatic species support, was evaluated relative to expected reference conditions for rivers (existing type) and connected riverine-tidal marsh (proposed future type) using local data sources. Existing conditions were based on observed fish species richness in Miller and Gallinas Creek. Expected future conditions were based on the proposed restoration design in comparison to both marsh and river 'reference' condition (Table 2C). The results of the analysis suggest that relative fish richness will improve following conversion to the new wetland type (Figure 2). This conclusion is likely due to a combination of both improved habitat and increased wetland size (vs. current conditions), both of which would contribute to higher richness.

Figure 2. Comparison of relative richness of fish species. The point above the red line indicates a net benefit of relative richness associated with the type conversion.

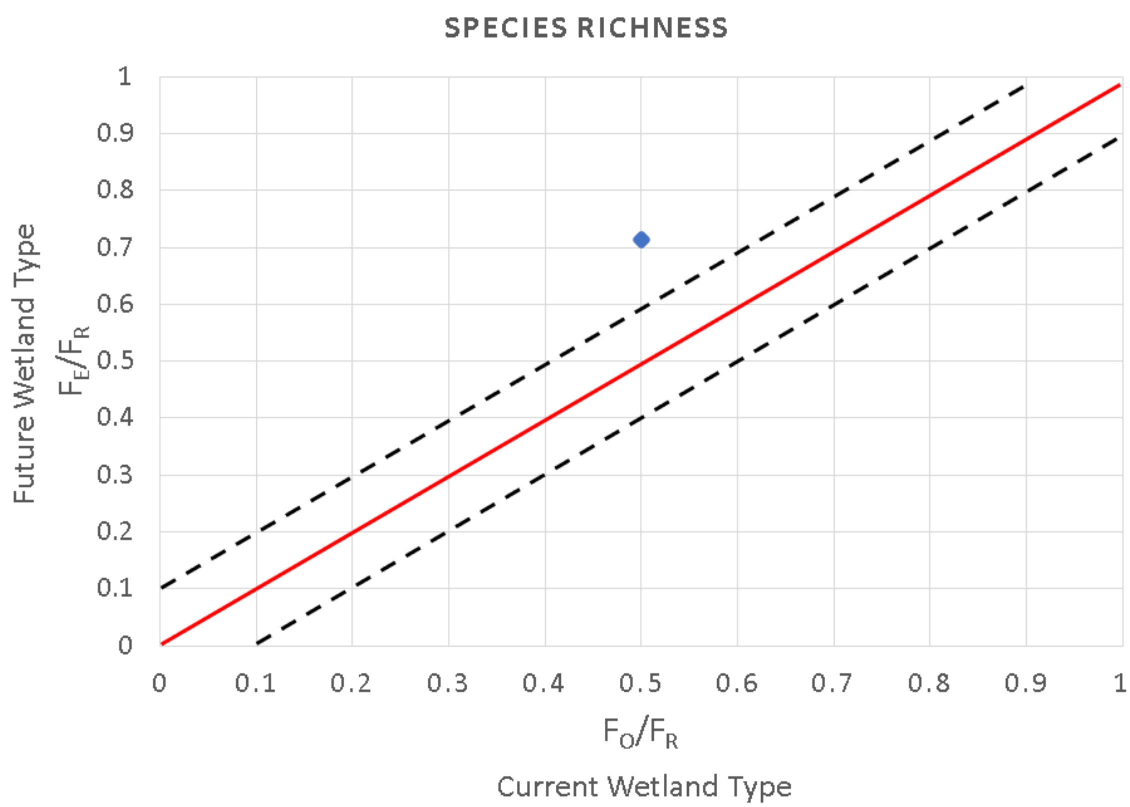

Table 2C. Relative fish richness in existing and proposed future wetland type.

		Fish Species Richness
McInnis Marsh	F_O	7
McInnis Marsh (future)	F_E	21 (Mean of River & Marsh Reference)
Napa River	F_R River	14
Hamilton	F_R Wetland	28

Carbon Sequestration

The relative ability of the existing and proposed future wetland type to sequester carbon was based on a comparison of estimated relative plant biomass and relative saturation area (Figure 3). Based on this analysis, the proposed type conversion would increase expected carbon sequestration from Low to Moderate/Medium.

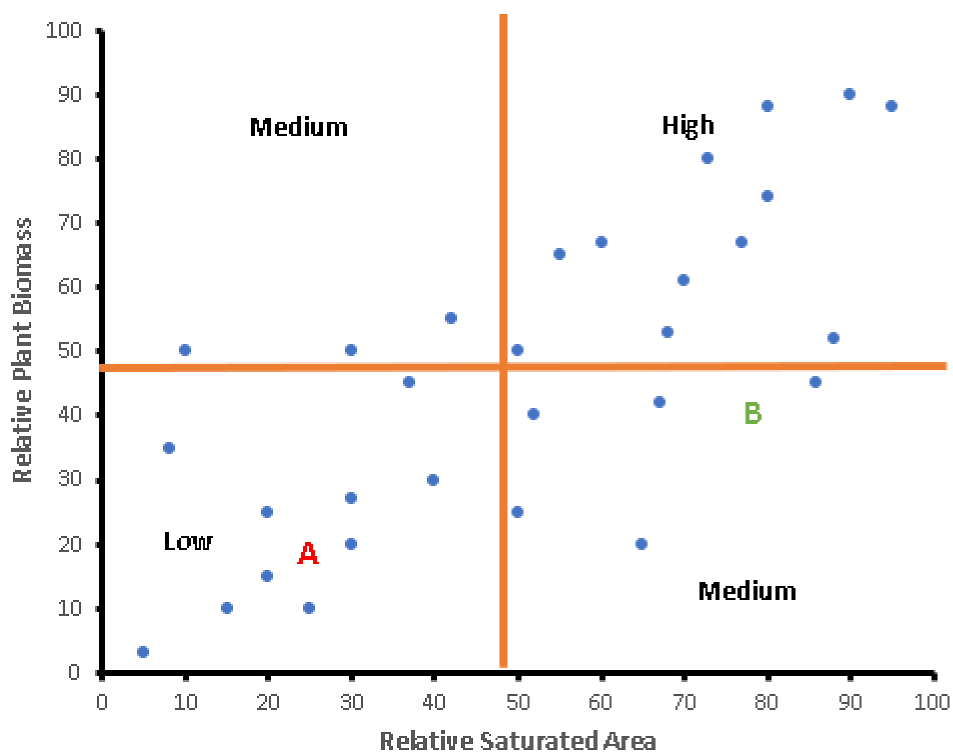

Figure 3. Estimate of change in carbon sequestration capacity between current and expected future wetland type. Estimates are based on a combination of relative plant biomass and saturated area as a proxy for carbon sequestration.

Function and Condition Assessment Data Sources

- McInnis Marsh Restoration Project: Feasibility Study and Alternatives Analysis, February 2016
- California Wetland Monitoring Workgroup (CWMW). 2019. Using the California Rapid Assessment Method (CRAM) for Project Assessment as an Element of Regulatory, Grant, and other Management Programs. Technical Bulletin – Version 2.0, 85 pp
- EcoAtlas CRAM
- Hamilton Wetlands Restoration Project Year 5 – 2019/20 Monitoring Report (Draft), January 2021
- Napa River Fish Monitoring Program: 2019-2020 Report

Regional Context

Table 3. Evaluation of regional considerations table *(Time to complete: 2-4hrs).*

Criterion	Direction of Change	Explanation	Source/Justification
1. Consistency with regional goals	Positive	Identified as high priority for conservation (high value habitat for marsh bird species particularly rails that require patch sizes of >247ac, potential species extirpation w/higher SLR predictions), meets regional tidal marsh restoration goals, Priority Conservation Area (MTC/ABAG), ID'd as potential future tidal restoration in SPB. Ecotone levees identified as high potential to provide migration space for this site per Adaptation Atlas.	North Bay Watersheds Assoc, PRBO Future Marshes Report, Baylands Ecosystem Habitat Goals Project (BEGHU), Conservation Lands Network 2.0, USFWS Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (SPB Unit), SFEI Adaptation Atlas
2. Replacement of regional rare resource types	Neutral	Current resource type (seasonally ponded, diked Baylands) is not 'rare'. New resource is not necessarily rare. No rare resources are impacted by substantive sediment placement of ecotone and berms.	Historical ecology (SFEI, EcoAtlas); BEGHU
3. Replacement of historical losses	Positive	Shifts landscape profile closer to historical condition (at present, only 34% of historic tidal marsh abundance in North Bay exists)	EcoAtlas Landscape Profile, HUC 10 San Pablo Bay, BEGHU
4. Regional connectivity and complexity of habitats	Positive	Would connect fragmented watershed habitat along shoreline, increase patch size, and restore tidal marsh complexity (increase tidal channels, veg cover & structure); MC is a top stream goal for area, Priority 2 & 3 stream conservation goal.	BEHGU, Conservation Lands Network 2.0, TNC OmniScape Explorer, USFWS Recovery Plan
5.Contribution to regional water quality	Positive	Miller Creek is a 303(d) impaired waterway, restoring complex marshes will capture sediment & urban COCs in Gallinas & Miller Creeks, & allow for WQ finishing treatment for San Pablo Bay as well. Methyl mercury may result in the ST and is a bay-wide issue for wetland restoration.	EPA, SF Basin Plan, Mercury TMDL
6.Contribution to regional groundwater recharge	Neutral	Novato Valley Groundwater Sub-basin is one of 2 GW basins in MMWD that supplies limited GW for community supply – basin is listed as low to very low priority to develop LT sustainability plans (SGMA); saline intrusion in this region is an issue in areas bordering San Pablo Bay. No apparent difference w/current and proposed habitat.	North Bay Water Recycling Program DEIR/EIS, CA DWR
7.Contribution to recreational or social benefits	Neutral	Current open space that will remain open with appropriate restrictions to not compromise ecological functions; will help with completing a segment of the Bay Trail (complementary mission goals with wetland restoration – public support for wildlife oriented public access). Loss of direct connection to Bay edge due to removal of existing public and informal	Conservation Lands Network 2.0; ABAG Senate Bill 100, Bay Trail Design Guidelines (Compatibility with Wildlife); SF Bay Plan; San Rafael General Plan 2040

		access trails on the outboard bayward levee.	
8. Resiliency relative to landscape constraints and stressors	Positive	Classified as moderate watershed vulnerability w/less than 45% urban/industrial: several factors improve the site's resiliency to SLR and current habitat stressors: ecotone design (buffer), return to natural wetland/stream processes in appropriate landscape, increased habitat connectivity in watershed for wildlife (migration potential). Current CRAM scores generally in good category for estuarine wetlands, so likely no relative change but likely increase over time (if can keep up w/SSC). Stream health is given as very likely altered condition (i.e., lower stream health) so will be positive relative change w/project. High suitability for polder/diked Baylands management & migration space; less density urban along shoreline.	SWRQCB - CA Integrated Assessment of Watershed Health; EcoAtlas Landscape Profile CRAM & CSCI; Adaptation Atlas (Gallinas); ART Bay Shoreline
Total Positive	5		

Regional Considerations Data Sources

- EcoAtlas
- ABAG Bay Trail, https://baytrail.org/, https://baytrail.org/pdfs/BayTrailDGTK_082616_Web.pdf
- Baylands Ecosystem Habitat Goals Science Update 2015 (including Appendix B & C)
- ART Bay Shoreline Flood Explorer
- SF Bay Shoreline Adaptation Atlas
- Conservation Lands Network 2.0, https://www.bayarealands.org/explorer-v2/?z=8&y=37.88159&x=-122.37000&l=counties%2Ccln2018essential%2Ccln2018important%2Ccln2018connector%2Ccln2018contributing&b=map&localdev=
- The Nature Conservancy OmniScape Explorer, https://omniscape.codefornature.org/#/analysis-tour
- PRBO, Veloz, S., N. Elliott, D. Jongsomjit. 2013. Adapting to sea level rise along the north bay shoreline. A report to the North Bay Watershed Association.
- PRBO, SF Bay Future Tidal Marsh, https://data.pointblue.org/apps/sfbslr_map/sfbmap_html.php

- North Bay Watershed Association, https://www.nbwatershed.org/about-us/watershed-map/
- McInnis Marsh Restoration Feasibility Study (2016)
- North San Pablo Bay Restoration & Reuse Project (North Bay Water Recycling Program) DEIR/EIS, https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=3819
- CA DWR Basin Prioritization, https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization
- CA Integrated Assessment of Watershed Health (2013), https://www.mywaterquality.ca.gov/monitoring_council/healthy_streams/docs/ca_hw_report_111213.pdf

Overall Environmental Benefit

Table 4. Summary table to compile results from all three assessment modules.

	Positive	Indeterminate	Negative	Rationale
Feasibility – landscape suitability	X			Historic Tidal Marsh setting that was diked off; will restore high connectivity for restoration components and tidal marsh goals; high adaption strategy to SLR with substantial ecotone and strategic breaching
Feasibility – ease of management	X			Moderate amount of adaptive, ongoing sediment augmentation/manipulation may be needed after initial construction; lack of control over some stressors
Site-specific Function	X			Top high priority functions show an increase over time; weighted functions also show increase in functions. No negative net changes.
Regional Context	X			Overall support for the regional context with change from current to proposed type

Based on this analysis, type conversion from seasonal, mixed wetlands to fully tidal marsh-connected riverine complex is deemed to be overall positive and a net benefit to the environment with regard to numerous ecological functions and values. Additionally, the proposed substantial sediment placement and redistribution to construct the ecotone and internal berms are shown to be a net gain overall. Recommend approval of the type conversion action with no required offset mitigation required for CWA 404/401 impacts.

Complete analysis took between 12 and 22 hours depending on whether direct or proxy assessment methods were used, availability and accessibility of data sources, and familiarity of the analyst with the assessment framework. The feasibility and regional context assessments took less time, whereas the more detail and complex function and condition analysis took longer. Depending on where in the project process the framework is deployed, there will be less or more data, although we restate that the intent is to utilize existing data and not generate new data per se.

APPENDIX B: SCORING SHEETS

Table B-1. Feasibility check list/rating system.

Criteria	**Question/Consideration**	**Landscape Suitability (1, 2)**	**Ease of Management (1 – 3)**
Landscape Setting	Watershed processes are not adversely altered for the intended aquatic resource type within the hydrologic unit.		
	Will the conversion result in an aquatic resource of the appropriate class in that landscape setting?		
Hydrology	Will the primary source of water to the site be appropriate for the new aquatic resource type without engineering a delivery system that requires long-term control or maintenance?		
	Does the site have the ability to adapt to accommodate future hydrologic conditions associated with climate change or expected change in water use practices?		
Geomorphology	Does the site have the appropriate underlying geology, and will the site maintain hydric soils (if appropriate)?		
Sediment	Is the anticipated sediment supply to the site appropriate to maintain geomorphic stability for the new aquatic resource type?		
	Will anticipated sediment processes (e.g., accretion, scour) provide appropriate elevations for the new aquatic resource type?		
Connectedness	Is the site connected or in close proximity to other aquatic resources or uplands that will support species and habitats for the new aquatic resource type?		
	Does the site have adequate buffers to help reduce effects of stressors from the adjacent landscape?		
Stressor control	Can the site be designed to control aggressive plant species and/or reduce invasion by feral or non-native predators?		
	Will the site be designed to minimize effects of excessive human visitation, grazing, or other source of persistent disturbance?		
Total Score			

Table B-2. Template worksheet for documenting decisions and rationale associate with each step of the functional evaluation process.

Decision Worksheet			
	How should functions be prioritized for analysis?	**Priority**	**Rationale/Citation/Source**
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			
	Choice of assessment method use for each function	**Data Needs**	**Direct or Indirect Measure Used**
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			

	How each assessment is contextualized[5]	Method	Approach
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			
	What timeframe is necessary for each function to mature	**Maturation Time**	**Rationale or Citation**
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			
	What additional weighting is assigned to each function	**Priority**	**Weighting**
A			

[5] assessments can be contextualized by comparison to reference conditions, ambient, or an established threshold or standard

B			
C			
D			
E			
F			
G			
H			
I			
J			
K			

Table B-3. Functional evaluation rating table.

Function	Priority	Evaluation Method	Function relative to ambient/reference		Direction and Relative magnitudeof change	Timeframe of change	Net Change (unweighted)	Weighting	Weighted Score
			Pre-conversion	Post-conversion					
Wholly aquatic habitat and speciessupport (e.g., fish, amphibians)									
Partially aquatic habitat and speciessupport (e.g., birds, mammals)									
Biodiversity support									
Surface water storage									
Organic matter/nutrient cycling									
Removal of elements and compounds									
Sediment/particulate retention									
Groundwater recharge									
Carbon sequestration									
Shoreline stabilization/energy dissipation									
Recreation and aesthetics									

Table B-4. Evaluation of regional considerations table.

Criterion	Direction of Change	Explanation	Source/Citation/Justification
Consistency with regional goals			
Replacement of regional rare resource types			
Replacement of historical losses			
Regional connectivity and complexity of habitats			
Contribution to regional water quality			
Contribution to regional groundwater recharge			
Contribution to recreational or social benefits			
Resiliency relative to landscape constraints and stressors			

Table B-5. Summary table to compile results from all three assessment modules.

	Positive	Indeterminate	Negative	Rationale
Feasibility – landscape suitability				
Feasibility – ease of management				
Site-specific Function				
Regional Context				

Table B-6 Summary scoring table.

Module	Number of Criteria	Scoring of each Criterion	Threshold(s)	Categories
Feasibility Landscape Suitability	11	No = 1 Yes = 2	Sum 17	Suitable ≥ 17 Unsuitable <17
Feasibility Management Intensity	11	Difficult = 1 Moderate = 2 None needed = 3	Sum 25 Sum 20	Positive ≥ 25 Indeterminate 20-24 Negative < 20
Site Specific Function	11	% Change ≤ -50% = -2 -50% to -15% = -1 -15% - +15% = 0 15 to 50% = 1 ≥ 50% = 2 Timeframe > 5 yr = 1 3-5 yr = 2 0-2 yr = 3 Unweighted Combined Scoring =Change score x Time score Weighted Combined Scoring =Change score x Time score x Weight	 Sum 66 Sum 132	 Positive ≥ 17 Indeterminate 1-16.5 Negative – any neg. score Positive ≥ 33 Indeterminate 1-32.5 Negative – any neg. score
Regional Context	8	Negative or Neutral = 0 Meets Goal = 1	Sum 4 Sum 2	Positive ≥ 4 Indeterminate 2-3 Negative < 2

APPENDIX C: COMMON DATALINKS FOR WETLAND AND ECOLOGICAL DATA RESOURCES

- NOAA
  - Species Directory https://www.fisheries.noaa.gov/species-directory
  - Critical Habitat Mapper https://www.fisheries.noaa.gov/resources/maps?title=critical+habitat&field_management_area_value%5BWest+Coast%5D=West+Coast&field_species_vocab_target_id=&sort_by=created
  - Historical Surveys (T-Sheets) https://shoreline.noaa.gov/data/datasheets/t-sheets.html
  - CA-NV Weather Forecast Center https://www.cnrfc.noaa.gov/ol.php?type=precip
  - Recovery Plans https://www.fisheries.noaa.gov/resource/document/recovery-plan-evolutionarily-significant-units-sacramento-river-winter-run

    https://www.fisheries.noaa.gov/resource/document/final-coastal-multispecies-recovery-plan-california-coastal-chinook-salmon

    https://www.fisheries.noaa.gov/resource/document/final-recovery-plan-southern-distinct-population-segment-north-american-green
  - Essential Fish Habitat Mapper https://www.habitat.noaa.gov/apps/efhmapper/
- USFWS
  - National Wetlands Inventory https://www.fws.gov/wetlands/
  - ECOS, Generate Listed Species List https://ecos.fws.gov/ecp0/reports/ad-hoc-species-report-input
  - ECOS, Threatened & Endangered Species Active Critical Habitat Report https://ecos.fws.gov/ecp/report/table/critical-habitat.html
- EcoAtlas
  - https://www.ecoatlas.org/about/
  - https://maps.ecoatlas.org/?customview=hpfilter
- The Nature Conservancy
  - Coastal Conservation Strategy and Map https://coastalresilience.org/project/conservation-assessment/
  - California Freshwater Species Database https://www.scienceforconservation.org/products/california-freshwater-species-database
  - Groundwater Dependent Ecosystems https://www.scienceforconservation.org/products/groundwater-dependent-ecosystems-data
- CDFW
  - California Natural Diversity Database (CNDDB) ***the public version of CNDDB is included in the EcoAtlas Landscape Profile Tool*
  - Species of Special Concern https://wildlife.ca.gov/Conservation/SSC
  - Areas of Conservation Emphasis https://wildlife.ca.gov/Data/Analysis/Ace

- Vegetation Classification and Mapping Program (VegCAMP) https://wildlife.ca.gov/Data/VegCAMP California Essential Habitat Connectivity Project https://wildlife.ca.gov/Conservation/Planning/Connectivity/CEHC
    - Natural Community Conservation Planning (NCCP) https://wildlife.ca.gov/Conservation/Planning/NCCP
    - California Salmonid Recovery Plans https://www.calfish.org/fisheriesmanagement/recoveryplans.aspx
- USEPA
    - StreamCat Dataset https://www.epa.gov/national-aquatic-resource-surveys/streamcat-dataset-0
    - LakeCat Dataset https://www.epa.gov/national-aquatic-resource-surveys/lakecat-dataset-0
    - National Wetland Condition Assessment - https://www.epa.gov/national-aquatic-resource-surveys/nwca
- OEHHA
    - California EnviroScreen Tool https://oehha.ca.gov/calenviroscreen
- SWRCB
    - My Water Quality Portals https://mywaterquality.ca.gov/index.html
    - Surface Water Ambient Monitoring Program https://www.waterboards.ca.gov/water_issues/programs/swamp/
    - California Environmental Data Exchange Network http://ceden.org/index.shtml
- USGS
    - Water Quality Data https://www.usgs.gov/mission-areas/water-resources/data-tools
    - National Mapper (variety of data) https://viewer.nationalmap.gov/advanced-viewer/
- PRISM Climate Group
    - Computational models of precipitation, including last 30-yr Normals http://prism.oregonstate.edu/
- FEMA
    - Flood Zone Maps https://msc.fema.gov/portal/home
- Healthy Watersheds Partnership
    - Watershed Prioritization Mapper: https://gamma-data-portal-sccwrp.hub.arcgis.com/datasets/watershed-prioritization-recommended-actions-2021-raw-data

      https://gamma-data-portal-sccwrp.hub.arcgis.com/maps/watershed-prioritization-recommended-actions-2021-summary

San Francisco Bay Area Resources

- Bay Shoreline
    - Adaptation Atlas (Operational Landscape Units Watershed Boundaries) https://www.sfei.org/adaptationatlas

      https://www.sfei.org/sites/default/files/toolbox/SFEI%20SF%20Bay%20Shoreline%20Adaptation%20Atlas%20April%202019_medres.pdf

- Adapting to Rising Tides Shoreline Flood Explorer (various scenarios include SLR + storm surge; models surface/groundwater and overtopping mechanisms) https://explorer.adaptingtorisingtides.org/home
- Bay Area Greenprint
  - https://www.bayareagreenprint.org/dashboard/#!?tabid=Overview&title=Percent%20of%20Land%20Protected
- Watershed Plans for SF Bay Estuary
  - Baylands Ecosystem Habitat Goals Project https://baylandsgoals.org/
  - SFEP Comprehensive Conservation and Management Plan (Estuary Blueprint) https://www.sfestuary.org/ccmp/
  - San Francisco Basin Plan www.swrcb.ca.gov/rwqcb2/water_issues/programs/basin_plan/docs/basin_plan07.pdf
  - San Francisco Bay Plan www.bcdc.ca.gov/plans/sfbay_plan.html
  - Watershed Management Initiative (2005) www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/watershed/WMI/WMI_2004_Regionwide_Activities04-12-05.pdf
- Tidal Marsh Ecological Recovery Plan https://www.fws.gov/sacramento/es/Recovery-Planning/Tidal-Marsh/
- ABAG Flooding & Hazard Maps http://resilience.abag.ca.gov/floods/
- Flood Control 2.0 http://www.sfei.org/projects/flood-control-20#content-8-region

Other Regional Resources

- Central Coast Wetlands Workgroup
  - Bar Built Estuaries of California https://mlml.sjsu.edu/ccwg/estuary-map/
  - Central Valley Wetlands and Riparian Areas https://databasin.org/datasets/d998b8cf8d624434909c93f868cf4a41/
- Southern California Wetlands Recovery Project
  - Marsh Adaptation Planning Tool https://scwrp.databasin.org/
  - Southern California Regional Strategy Report https://scwrp.databasin.org/pages/regional-strategy-report/
  - Assessment of Sea Level Rise Vulnerability for Coastal Wetlands https://scwrp.org/wp-content/uploads/2017/12/Doughty_USCSeaGrantReport_090216_SUBMITTED-1.pdf
  - Wetlands of the S. CA Coast – Change over Time http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/826_WetlandsHistory.pdf

US Coast Survey Maps of California (Historical) https://www.caltsheets.org/