Building State Capacity For Wetland Monitoring, Assessment, and Tracking: Pilot Demonstration Report

Sarah Lowe, Sarah Pearce, and Josh Collins
(SFEI-ASC)

December 30, 2017

State Water Board Project 8414
Task 1.E

This report is formatted for two-sided printing.
This page is intentionally blank

Table of Contents

This report is formatted for two-sided printing.
This page is intentionally blank

Wetland Beneficial Use Protection:
Pilot Demonstration Project

A. Introduction

This memorandum presents technical recommendations to the 401 Certification and Waste Discharge Program (401 Program) of the State Water Resources Control Board (State Board) for a coherent, scientifically sound, repeatable, watershed approach to wetland restoration site evaluation, compliance monitoring and assessment, and Tracking. The recommendations are drawn from the previous four memoranda produced for the Pilot Demonstration Project (project) that address the following subjects: project work plan and information flow diagram; scientific literature review; landscape scenario planning (to map and prioritize restoration opportunities); and a framework for a watershed-approach to evaluate and report the capacity of a wetland restoration site to protect wetland beneficial uses.

This Project focused on a sub-watershed of the Santa Rosa Plain, in Sonoma County, California. The area was chosen for the Project for three reasons: (1) it is integral to an existing nutrient TMDL and therefore is supported relatively well with hydrological and nutrient data; (2) the historical and existing wetlands and streams of the area were mapped recently in sufficient detail to inform landscape planning; and (3) implementation of the TMDL will involve wetland restoration to reduce downstream nutrient loads, and therefore the Project may help implement the TMDL.

The primary overall purpose of this Project was to explore how numerical simulation and statistical modeling could be combined with existing wetland assessment and reporting tools to create a coherent, watershed-based approach to wetland beneficial use protection. Any relevance to the existing nutrient TMDL for the demonstration area is an intentional, but secondary benefit of this Project.

We wish to thank staff and management of the 401 Program of the State Board and of the North Coast Regional Water Quality Control Board (Regional Board) for their advice and review for this Project.

B. Project Information Flow

Relationships among the outputs of the Project are illustrated in the diagram of the Project's information flow (Figure 1), culminating in this summary of technical recommendations (Technical Memorandum 5).

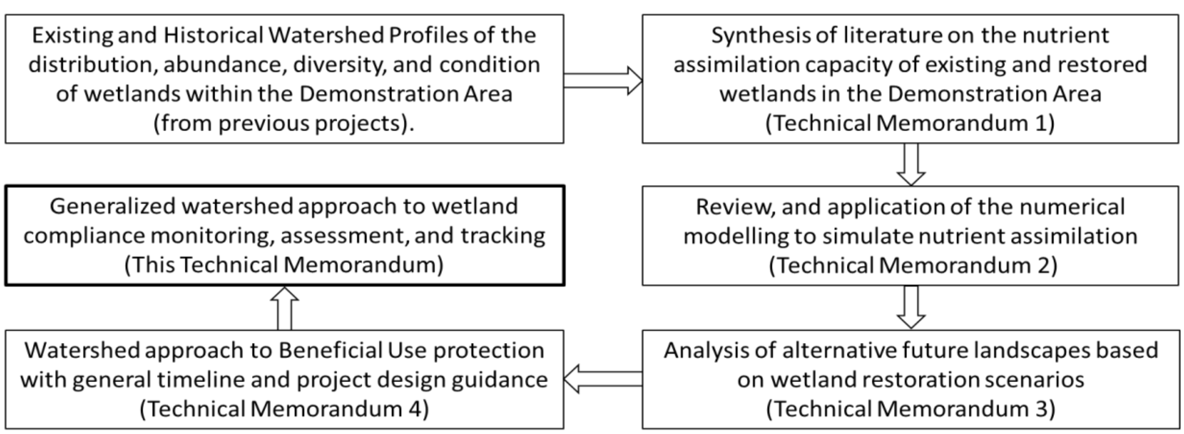

Figure 1. Information flow diagram for this demonstration project.

C. Literature Search and Evaluation of Simulation Models

The literature review covered world-wide, refereed scientific publications in English, and reports produced by U.S. Federal and State agencies, focused on (1) nutrient assimilation capacities for the common wetland types of the Santa Rosa Plain; (2) existing models and tools that can be used to simulate wetland assimilation of pollutants, especially nutrients; and (3) previous local studies and modeling efforts on hydrology and loading pathways for nutrients and sediment.

Wetland can effectively remove or assimilate many pollutants, including organic matter, suspended solids, metals, and excessive nutrients, to reduce their environmental impacts. The beneficial hydrogeological and hydrochemical processes include water and sediment, infiltration, denitrification, absorption, and plant uptake. These processes can be highly efficient, up to a threshold of loading rates. An overabundance of nutrients due to inputs of agricultural runoff or sewage effluent will cause eutrophication and habitat degradation. The capacity of wetland vegetation to store heavy metals is affected by climate, water residence time, wetland size, and plant species composition.

Intensive local modeling has demonstrated that useful, site-specific models can be developed to estimate nutrient and sediment loading through local storm drains and stream systems. Wetlands were not explicitly incorporated into this modeling, however. Furthermore, the existing wetlands have not been individually characterized with regard to all of the various factors affecting their assimilation capacities. This significantly constrained the inclusion of wetlands into the local, site-specific modeling efforts.

A more general approach to estimating the effects of wetlands on downstream sediment and nutrient loading is facilitated by recent advances in the Hydrological Simulation Program – FORTRAN (HSPF). HSPF is the only comprehensive model of watershed hydrology and water quality that allows the integrated simulation of land and soil runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of model simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at any point in a watershed. Beginning with the 2014 update to EPA BASINS 4.1, a wetlands module became available for HSPF. This module uses a DEM grid and a wetlands map layer to determine the amount of land area draining to and from a wetland, and to simulate the effect of wetlands and riparian areas on downstream hydrology and pollutant loading.

The wetlands module of HSPF proved to have limited applicability to arid and semi-arid climates, however, especially for seasonal wetlands. Pollutant loads into a wetlands from the first major rain storm after a prolonged dry period spike artificially and erratically due to numerical instability caused by initial very flow values. This problem was evident for the demonstration area, where most streams are ephemeral and the wetlands are seasonal. The wetland module of HSPF is not generally applicable to reaches of seasonal drainage systems and wetlands subject to very low flow or desiccation. For these systems, further development of the module is needed. Nevertheless, the simulation of nutrient and sediment load reduction for three different amounts of wetland restoration within the demonstration area provided some useful insights for wetland planning in the watershed context:

- Larger wetland located downstream appear more effective than smaller upstream wetlands in reducing stormwater runoff and pollutant loads.
- A general simulation model can be useful for coarse, landscape–scale estimates of pollutant load reduction by wetlands.
- HSPF shows promise with its comprehensive capacities to simulate hydrology and water quality processes as well as wetland hydrological functions, but has problems simulating load reductions

through ephemeral streams and season wetlands typical of arid and semi-arid climates, due to model instability when inflows approach zero.

- Adding wetlands to arid or semi-arid landscapes can helps reduce pollutant loads but may also decrease the amount of perennial stream habitat, which should be considered when deciding the net increase in wetland abundance.

D. Analysis of Future Landscapes

To proceed with the analysis of alternative wetland restoration plans, the well-established hydrological module of HSPF was used in conjunction with modelling system called Green Plan-IT. Green Plan-IT is an example of models used to optimize the location and amount of Green Infrastructure (GIS) to meet target reductions in stormwater flow and contaminant reductions.

GreenPlan-IT consists of four standalone tools: (1) a GIS-based Site Locator Tool to identify and rank potential GI sites; (2) a Modeling Tool that quantifies anticipated watershed-scale runoff and pollutant load reduction from GI sites; (3) an Optimization Tool that uses a cost-benefit analysis to identify the best combinations of GI within a watershed to achieve flow and/or load reduction goals; and (4) a Tracker tool that records and displays information about GI implementation for individual sites, and assesses and reports their effectiveness in relation to regulatory compliance and other communication needs. This demonstration project only utilized the Site Locator Tool and the Optimization Tool.

The Site Locator is a screening tool used to identify and rank potential GI locations based on criteria developed and weighted by the user. Running the Site Locator Tool is typically an iterative and interactive process. The user can add data layers to further identify and rank potential GI locations. The weights of ranking criteria can be changed, and the Tool can be rerun by including or excluding any of the data layers associated with the ranking criteria.

The GreenPlan-IT Optimization Tool uses an optimization technique adopted from evolutionary biology to evaluate the benefits (i.e., runoff and pollutant load reductions) and financial costs associated with various GI implementation scenarios (e.g., GI type, location, number) and identify the most cost-effective options that satisfy user-defined goals. The Optimization Tool requires both site information generated from the GIS Site Locator tool and time-series estimates of flow and pollutant inputs from a hydrologic model.

For the demonstration project, the cost-benefit analysis focused on identifying the best combinations of depressional wetland restoration projects within the study area to achieve various flow and load reduction goals. The GreenPlan-IT Optimization Tool was used to carry out the analysis.

The optimization process generates a range of optimal watershed planning solutions along a cost-effectiveness curve. The curve relates the levels of flow or pollutant reduction to various combinations of wetland restoration projects (i.e., total number and type) throughout the watershed and their associated, combined cost. The slope of the curve represents the marginal value of wetland projects.

In this case, the optimization indicated a diminishing marginal return on restoration investments greater than $10 million. For example, a 40% flow reduction might be achieved with a $10 million investment, but only 20% additional flow reduction can be expected for a $20 million investment. This was because runoff is not uniform across the landscape. After restoring or creating wetlands in the highest ranked areas, subsequent wetland projects are less efficient, resulting in higher cost per unit water volume treated. Assuming the goal is a 40% reduction in flow and nitrogen, and a 60% reduction in phosphorus, the optimal solution consisted of 519 wetland enhancement projects and 487 creation projects.

As illustrated by this demonstration project, the Optimization Tool can be very powerful when combined with hydrologic modeling and cost analysis. Successful and meaningful application of the Optimization Tool largely depends on accurate representation of the watershed baseline condition, wetland configurations, and the associated wetland restoration costs. As such, it is important to emphasize that the optimization results must be interpreted in the context of specific problem formulation, assumptions, constraints, and optimization goals unique to the landscape of interest.

E. Evaluation of Beneficial Uses

The California State Water Resources Control Board (State Water Board) is proposing Draft Procedures for Discharges of Dredged or Fill Material to Waters of the State (proposed Procedures) for inclusion in the Water Quality Control Plan for Inland Surface Waters and Enclosed Bays and Estuaries and Ocean Waters of California. It is the State Water Board's intent to be consistent with the U.S. Amy Corps of Engineers (USACE) procedures where feasible, to bring uniformity to Federal and State regulation of discharges of dredged or fill material to all waters of the state.

In addition to the Supplemental Dredged or Fill Guidelines, the Regional Water Boards are examining the feasibility of preparing a Water Quality Control Plan for Wetlands ("Wetlands Plan"). The Wetlands Plan describes a set of beneficial uses (BUs) attributed to all wetlands and is supported by four narrative wetland water quality objectives (WWQOs), intended to protect the BUs.

Under the Wetlands Plan, all wetlands have three designated BUs, habitat support, water quality enhancement, and hydrology support. There are four narrative Wetland Water Quality Objectives (WWQOs) that apply to each designated BU.

Biological Objective: The biological integrity of wetlands shall be protected, and the occurrence of flora and fauna shall be comparable to that naturally present in wetlands of similar type. Wetlands shall be protected to prevent conditions that cause the establishment or proliferation nuisance organisms.

Physical Objective: The physical structure shall be protected, and be comparable to that naturally present in wetlands of similar type.

Chemical Objective: Wetlands shall be free from substances attributed to waste discharges that would substantially degrade biological communities associated with those wetlands. The chemical constituents in water and the substrate within wetlands shall be comparable to that naturally present in wetlands of similar type.

Hydrological Objective: The hydrology of wetlands, including the extent, duration and frequency of saturated or ponded conditions, and water flow, shall be comparable to that naturally present in wetlands of similar type.

For this demonstration project, the ability of a wetland site to support the BUs was assessed using the Wetland and Riparian Area Monitoring Plan (WRAMP) produced by the California Wetland Monitoring Workgroup (CWMW), of the California Water Quality Monitoring Council (CWQMC). WRAMP consists of a framework and standardized monitoring and assessment tools to support wetland regulation; including permitting decisions and monitoring and tracking of wetland projects, to ensure that wetland BUs are protected. The primary WRAMP tools used in this case were the California Rapid Assessment Method for wetlands (CRAM), the California Aquatic Resources Inventory (CARI) and EcoAtlas.

CARI is an SOP and online editing tool for mapping wetlands and related aquatic features to the standards of accuracy and resolution needed to support local wetland planning, protection, and restoration. CARI is consistent with federal standards and datasets of the National Wetland Inventory (NWI) and the National Hydrographic Dataset (NHD) for mapping aquatic habitats and surface waters of the U.S., but provides more local detail than these Federal programs can provide statewide.

CRAM is the best, currently available, field method for assessing wetland condition, relative to the standard WWQOs. CRAM metrics were designed to directly measure the biological, physical, and hydrological aspects of wetland condition. Individual CRAM metrics and attributes pertain directly to each to the narrative criteria of the WWQOs. The numeric CRAM scores can be used to assess how well a wetland is functioning compared to reference conditions, and relative to other wetlands, and therefore can be used to determine whether or not a wetland is meeting the WWQOs. CRAM is a *numeric translation* of the narrative Wetland water Quality Objectives.

EcoAtlas is a set of interactive, map-based online tools for standardized wetland and project mapping, rapid wetland condition assessment (CRAM), and web-based data management, visualization, and sharing. It includes ways to map and otherwise document impact sites and the associate mitigation areas, and it includes a file archive system for wetland project tracking over time. Data can be accessed and summarized for any user-defined area of the State. CARI serves as the base map for EcoAtlas.

The State Water Board's concept of a Project Evaluation Area (PEA) was adopted as the spatial template for the evaluation of BUs. The PEA approach recognizes that individual wetlands are integral components of ecological and hydrological systems, and that individual wetlands must be assessed in the context of these systems, to protect their BUs. The proposed Procedures suggest that the PEA demarcates the boundaries of the systems, and that the PEA is therefore the spatial template for the assessments of whether or not the WWQO are being met.

The South Pacific Division (SPD) of the USACE has adopted CRAM as an acceptable Functional or Condition Assessment Method (FCAM) for assessing wetland impacts and compensatory mitigation. The Los Angeles District of the USCAE (LA USACE) has developed a procedure based on the SPD guidance that features a site evaluation checklist. The USACE checklist was adapted to assess the ability of a proposed wetland project to meet the WWQOs and thus support the BUs. This demonstration project includes a recommended State Water Board Checklist.

The State Water Board's concept of a watershed or PEA profile is foundational to the assessment of wetland WWQOs in the watershed context. The profile consists of a quantitative survey of the distribution, abundance, diversity, and condition of wetlands and associated aquatic resources within the PEA. Ideally, the profile is produced based on CARI and a probabilistic CRAM survey of the condition on each wetland type within the PEA. Assuming this approach has been taken, EcoAtlas can be used to summarize the distribution, abundance, and diversity of wetlands within the PEA, based on CARI. The CRAM survey can be used to create a PEA Cumulative Distribution Function (CDF) of CRAM scores. A PEA CDF can be used to compare the condition of projects to other wetlands of the same or different kinds within the PEA. PEAs can be compared to each other based on their CRAM CDFs and CARI summaries. Furthermore, the CRAM CDF can be used to partition the wetland resources of the PEA into condition classes, such as poor, fair, and good, and to determine the percentages of the resources in each class. EcoAtlas has the capability of generating this information as a printable profile for any user0defined area, including a PEA. The contents of the profile can be used to complete the State water Board Checklist.

A profile of the distribution, abundance, and diversity of aquatic resources can be produce for any PEA using the Landscape Profile Tool in EcoAtlas. However, not all projects can afford to conduct an ambient survey of aquatic resource condition. In these cases, where an ambient survey of condition within the PEA is not available, and if a CDF of the condition of the resource is needed, the eco-regional CDF for the eco-region of the project, or a CDF for another, comparable PEA can be used.

The demonstration project also provided examples of how Habitat Development Curves (HDCs) can be used to help assessment the future capacity of wetland projects to support the wetland BUs. An HDC relates wetland condition to wetland age, and can be used to estimate if and when a project is likely to meet the WWQOs. In practice, the cram score(s) for a wetland are plotted on the HDC to determine its developmental status and rate. The CRAM scores can be used to diagnose the likely causes for slow development, and to identify corrective actions, to help assure that the project eventually supports the wetland BUs.

F. Watershed Approach to Wetland Planning, Assessment, and Tracking

A general watershed approach to wetland siting, assessment, and tracking can be synthesized from the findings and recommendations of the technical memoranda of this demonstration project. The intent here is to indicate how the various assessment tools and methodologies might be used together to operationalize the watershed approach, rather than provide detailed guidance on each aspect of the operation. The approach is presented as the following outline.

1. Project Siting
    - 1.1. Define the PEA
        - 1.1.1. The PEA may differ for compliance monitoring versus project siting and effectiveness monitoring. For compliance monitoring, the PEA could be the footprint of the wetland project. For the effectiveness monitoring and project siting, the PEA will need to be expanded to encompass the spatial extent of ecological or other factors strongly affected by the project. The evaluation of BUs will require the larger version of the PEA to account for interactions between the project and other aquatic resources.
        - 1.1.2. Digitize the PEA boundary and add it to EcoAtlas using the Landscape Profile Tool.
    - 1.2. Develop the PEA Profile
        - 1.2.1. Summarize the distribution, abundance, and diversity of wetlands and other aquatic resources using CARI. If necessary, update the CARI dataset for the PEA using the online CARI map editor.
        - 1.2.2. For the wetland type(s) of the PEA, complete a probabilistic survey of the condition of the wetlands in the PEA, using CRAM, and use the results to generate the CDFs for the CRAM Index scores and Attributes Scores.
        - 1.2.3. If a survey of wetland conditions in the PEA is not feasible, then use the pre-existing CDFs of CRAM Index scores and Attributes scores for the California Eco-region of the PEA, or create the CDFs from the survey data of other, comparable PEAs.
        - 1.2.4 Map the project boundary using the online mapping tool of Project Tacker. If this is a compensatory mitigation project, map the associated impact sites using the online mapping tool of Project Tracker.
        - 1.2.5 Complete the online project information form for Project Tracker.
    - 1.3. Complete the State Water Board Site Evaluation Checklist. The Checklist can be completed with information from EcoAtlas and from steps the 1.1 and 1.2 above. The result will be

recommendation to proceed with the site as planned and designed, make design changes, or select an alternative site.

2. Project Tracking

 2.1. Complete steps 1.2 and 1.3 immediately above, unless they've been completed already.

 2.2. Continue using the library functions of Project Tacker to store and share project information, including monitoring reports.

 2.3. Map the on-site and off-site locations of field data collection (i.e., monitoring locations) using the online mapping tool of Project Tracker.

3. Project Evaluation

 3.1 Develop and Implement a Monitoring Plan. The WRAMP framework can be used to guide the development and implementation of a monitoring plan to cost-effectively answer project management questions and inform regulatory actions affecting the project (see Figure 2 below).

 3.1.1 Driving Concerns (WRAMP Step 1). The first step in the WRAMP Framework is to define the management questions or information needs that the monitoring plan must address.

 3.1.2 Monitoring Questions, TimeLine, and Geographic Scope (WRAMP Step 2). The WRAMP Framework is largely about developing information through monitoring and assessment to directly address the Driving Concerns (Step 1). This requires translating the concerns into one or more discreet monitoring questions. The timeline for monitoring and assessment should reflect the timeline for addressing the Driving Concerns, and is usually tied to budgetary or statutory deadlines. The Geographic Scope is the PEA , which might be different for compliance versus and effectiveness monitoring (see 1.1.1 above).

 3.1.3 Conceptual Models (WRAMP Step 3). For the purposes of WRAMP, conceptual models are tools for identifying the factors and processes that must be monitored to address the management questions. The models should reflect what is known as scientific fact, what can be extrapolated from the facts, and what is likely based on consensus professional judgment.

 3.1.4 Data Needs and Analytics (WRAMP Step 4). The needed data represent factors that the models suggest are most directly related to the monitoring questions and hence the management questions. Analytics are the graphic and statistical methods of data analysis that will be used to summarize the monitoring results and prepare them for interpretation.

 3.1.5 Data Classification and Collection Methods (WRAMP Step 5). WRAMP incorporates the USEPA 3-Level framework for classifying wetland monitoring data.

 L1 includes maps and other inventories and databases for environmental information, plus the data and indicators provided by these sources, as well the methods to create them.

 L2 includes rapid assessments of overall field condition that require less than a day to apply at least once, and that do not rely on the collection of field materials or any laboratory analysis. CRAM is an L2 tool.

 L3 includes field data to quantify one or more aspects of aquatic resource condition or stress, relative to other aspects, or per unit time or space. L3 data may include any measures of specific ecosystem parameters, including physical, chemical, and biological data.

3.1.6 Sampling Design (WRAMP Step 6). In general, a different sampling design will be needed for different types of data. Each design should have adequate statistical power to accurately represent the PEA. To the degree possible, existing methods with established QAQC procedures should be utilized.

3.1.8 Information Development (WRAMP Step 7). This involves archiving maps of projects and sampling sites, data collection, and data analysis and interpretation. Each of these activities requires careful attention to many details that differ from one monitoring and assessment effort to another.

3.1.9. Results and Assessment (WRAMP Step 8). The monitoring results will consist of the finalized data and an explanatory report. The results should be formatted to directly address the driving concerns. If the results include CRAM scores, the assessment should include steps in the State Water Board Site Evaluation Checklist that involve plotting the scores onto the appropriate CDF and HDC to determine of the project is likely to support the wetland BUs at the time of the assessment and into the future.

3.1.10 Storage and Delivery (WRAMP Step 9). The finalized data sets and assessment report should be uploaded into EcoAtlas library for projects. Water quality chemistry data collected using protocols provided by the Surface Water Ambient Monitoring Program (SWAMP) can be uploaded into CEDEN. This makes the monitoring data and assessment report readily accessible to the public through simple spatial queries using EcoAtlas.

3.1.11 Revise Management Questions or Regulatory Information Needs (WRAMP Final Step). The last step of the WRMP framework is to revise the management questions or information needs based on the monitoring results.

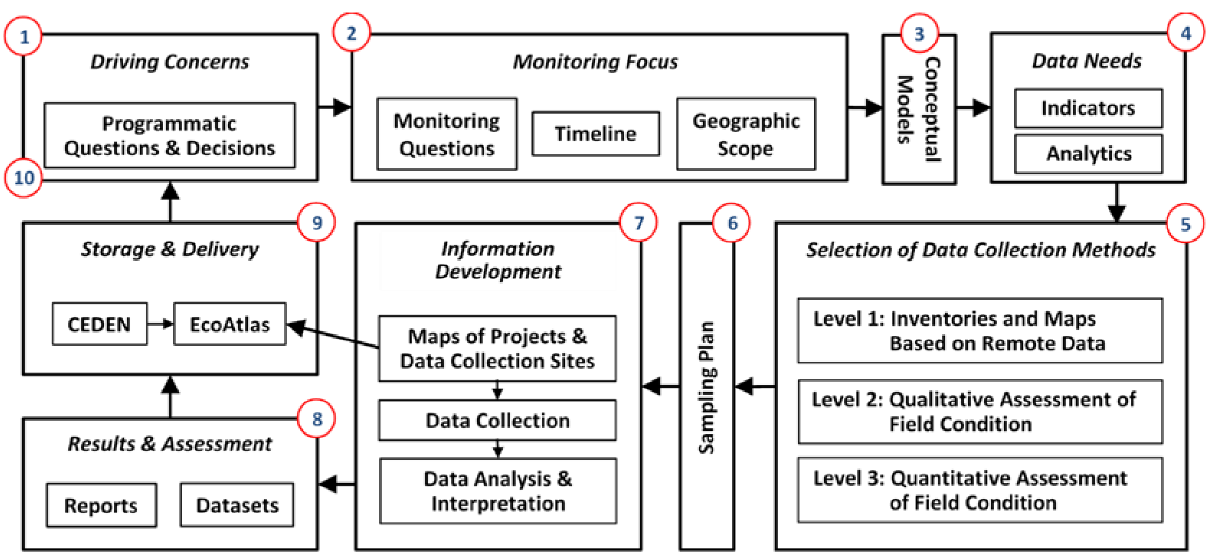

Figure 2. WRAMP Framework as a series of steps for developing a monitoring plan.