2014 Annual Self-Monitoring Report
Don Edwards San Francisco Bay National Wildlife Refuge
Fremont, California

Prepared for:

California Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, California 94612

National Marine Fisheries Service
Santa Rosa Field Office
777 Sonoma Avenue, Room 325
Santa Rosa, California 95404

Prepared by:

Melisa Amato, Wildlife Refuge Specialist
U.S. Fish and Wildlife Service
Don Edwards San Francisco Bay National Wildlife Refuge
1 Marshlands Road
Fremont, California 94555

Laura Valoppi, Lead Scientist
South Bay Salt Pond Restoration Project
U.S. Geological Survey
6000 J Street, Placer Hall, Suite 4001
Sacramento, California 95819

Revised April 10, 2015

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Introduction

The South Bay Salt Pond Restoration Project (Project) 2014 Annual Self-Monitoring Report (Report) has been prepared to provide: 1) an update of the Project's 2014 accomplishments; 2) information on on-going operations of the Alviso and Ravenswood Ponds; 3) results of the 2014 studies conducted at Pond A8, A16 and SF2; 4) results of fisheries monitoring and studies; and 5) an update on Phase II planning efforts.

In previous years, this annual report has focused on water quality monitoring results and has been submitted to the California Regional Water Quality Control Board (Water Board) to comply with the Self-Monitoring Program (SMP) as described in the Final Order (No. R2-2008-0078). This is the fourth year the report will also be submitted to NOAA's National Marine Fisheries Service (NMFS) because we have included additional fisheries monitoring conducted as part of the Science Program's Applied Studies, which are intended to fill the most important gaps in our knowledge about South San Francisco Bay (South Bay) ecosystem

It is anticipated that both water quality and fisheries information will help the Water Board and NMFS: 1) understand the status of the Project; 2) provide feedback and guidance to the Project Management Team on current and future applied studies and monitoring; and 3) assist in identifying emerging key uncertainties and management decisions required to keep the Project on track toward its restoration objectives as we approach Phase 2.

2014 Project Accomplishments

Much of the effort in 2014 has focused on Phase 2 Planning for the Project. A summary of Phase 2 planning will be discussed later in this report. The following are a summary of accomplishments made by the Project in 2014.

Tidal Marsh Restoration

- A draft plan to restore 3,000 acres of Refuge lands to salt marsh, including adding sloping habitat from salt marshes to uplands, was circulated to the public as part of the South San Francisco Bay Shoreline Study (see Flood Protection below).

Enhanced Ponds

- Pipes, earthen berms and a pump for a nine-cell pond system were installed at Ponds E12 and E13 designed to attract shorebirds by offering a variety of salinity levels and prey. Scientific research led the project to include islands and mounds in new shapes and textures designed to be more bird-attracting. Workers brought in 13 truckloads of oyster shells to spread on a dry pond, to provide camouflage and protection to eggs and chicks of the endangered snowy plover. The $3 million construction project also includes new recreational features. The work, funded by the state Wildlife Conservation Board, was 80% complete by year's end.
- To encourage terns and plovers to nest, the Don Edwards San Francisco Bay National Wildlife Refuge began resurfacing islands in Alviso Pond A16 and Ravenswood

PondSF2. The gravel surfaces are attractive to birds and stop mud from cracking and forming crevices that threaten chicks.

Public Access

- A smartphone audio tour app is now available for portions of the Bay Trail, including a 4.5-mile stretch at the Alviso ponds. Information and links to download the app are at http://www.baytrail.org/audiotour.html.

- Construction neared completion on a boardwalk and kayak launch in Eden Landing (see Enhanced Ponds above).

Flood Protection

- A draft Feasibility Study/EIR/EIS for a 15.2-foot levee north of Alviso to protect against high tides and sea level rise was released in December 2014 by the U.S. Army Corps of Engineers, the State Coastal Conservancy and the Santa Clara Valley Water District, as part of the Congressionally authorized South San Francisco Bay Shoreline Study. If finalized and approved by Congress, it could be constructed in 2017. The Shoreline Study plan also includes new trails and significant habitat restoration.

- Managers investigated options for coupling Eden Landing salt marsh restoration with an innovative sloped and vegetated flood barrier along the Bay. To build the slopes, managers are considering partnering with the Port of Redwood City to use Port dredged mud.

Science and Adaptive Management

- The Project recorded the first siting of an endangered species in our restored Island Ponds, a California Ridgway's rail (previously named California clapper rail).

- Scientists launched a study to tag and track threatened steelhead trout in the Guadalupe River watershed. Preliminary results were encouraging, with no juvenile fish found trapped in our nearby Pond A8 complex. Steelhead and mercury studies guided a decision by regulators and managers to open more Pond A8 gates. Further study could help pave the way for fully opening Pond A8 gates.

Project Attention

- The Project was featured in a national television newscast on PBS NewsHour, viewable at http://www.pbs.org/newshour/bb/san-francisco-salt-marshes/.
- The Project received a Conservation Achievement Award from the California-Nevada Chapter of the American Fisheries Society for outstanding contributions to fisheries conservation.
- Friends and supporters of Representative Don Edwards donated thousands of dollars to the Project to honor his 100th birthday.
- The Restoration was the subject of an episode of the Exploratorium's monthly web-based video program, at http://www.exploratorium.edu/tv/index.php?project=104&program=1529&type=clip

<u>Progress Towards Our 3 Goals</u>

Goal 1: Restore & Enhance Habitat

<u>3,040 Acres of Habitat Restored</u>
To date, we have opened 3,040 acres of former industrial salt ponds to the Bay so nature can recreate wetlands. We are now planning our second phase of restoration work, which could include restoring thousands of additional acres to salt marsh. Our initial goal is to restore half of our land, 7,500 acres, to tidal marsh, with the other 50% in managed ponds.

<u>Work Proceeds on 230-Acre Eden Landing Bird Pond Multiplex</u>
Project goals call for reconfiguring 1,600 acres of former salt ponds so they provide optimal habitat for a variety of shorebirds and waterbirds. The project has enhanced 477 pond acres. In 2014, we neared the end of construction on 230 additional acres in Eden Landing.

Goal 2: Provide Public Access

<u>Alviso: New Smartphone Audio Tour App Available</u>
The Project's public access vision: establish an interrelated trail system; provide viewing and interpretation opportunities; create small watercraft launch points; and allow for waterfowl hunting. The project to date has created 2.9 trail miles. In 2014, a smartphone audio tour of a 4.5-mile Alviso section of the Bay Trail launched.

Goal 3: Provide Flood Risk Management

<u>Draft Plan for New Alviso Levees Released</u>
A goal of the Project is to maintain or improve existing flood protection. Managers are committed to ensuring that flood hazards to nearby communities and infrastructure do not increase as a result of the restoration: restoring salt marsh in flood-critical parts of the Project area will not occur until flood protection is established. In 2014, a draft plan was released by the U.S. Army Corps of Engineers and local agencies for 15-foot-high Bay levees near Alviso and the San Jose water pollution plant. Project managers also studied ways to couple salt marsh restoration and new flood protection near Hayward.

2014 Pond Operations

The 2014 Pond Operation Plans are included in Appendix A. In general, the goal for all ponds is to maintain circulation through the ponds while maintaining discharge salinities. A summary of pond management is described below.

Alviso Pond System A1/A2W
The management objectives for Pond System A1/A2W is to maintain full tidal circulation through ponds A1 and A2W while maintaining discharge salinities to the Bay at less than 40 ppt. These ponds are part of the planning process for Phase 2 of the Project, and may be breached in

the next 5-10 years to restore the ponds to tidal marsh. The Draft Phase 2 EIS/EIR is expected to be released to the public by summer 2015.

Alviso Pond System A3W

The Alviso Pond System A3W consists of Ponds AB1, AB2, A3W, A2E, and A3N. The objectives for the Alviso Pond A3W system are to: 1) maintain full tidal circulation through ponds AB1, AB2, A2E, and A3W while maintaining discharge salinities to Guadalupe Slough at less than 40 parts per thousand (ppt); 2) maintain water levels in Pond A3N to cover the pond bottom due to mercury "hotspots" by leaving the A3N / A3W gate fully open, year round; and 3) maintain water surface levels lower in winter to reduce potential overtopping of A3W levee adjacent to Moffett Field. In August 2014, the Pond A3W/Guadalupe Slough water control structure failed due to corrosion of the structure's tie backs within the levee (Figure 1). As a result, 2 of the 3 culverts began leaking Bay water into pond A3W from Guadalupe Slough. A plug has been installed to keep water levels from increasing to high levels in avoid overtopping and additional levee damage in Pond A3W. Thus the entire system is being held at a lower water level as only a third of the gate is open for discharge. Engineering has been completed and the repair, estimated at $1.2 million, will occur in summer 2015.

Figure 1 - Pond A3W Discharge

Failure of the structure was noticed in August 2014 and temporary measures were employed to maintain water levels during winter high tides and storm events in 2014. This figure shows the tie backs on the left that are corroding and causing levee damage. Many of the water control structure in the system have exceeded their "10-year life span" and are expected to have similar complications and need for repair or replacement.

Pond System A8

The Pond A8 system consists of Ponds A5, A7, A8N, and A8S. This system is operated to maintain muted tidal circulation through the ponds while maintaining discharge salinities to the Bay at less than 40 ppt. As part of the Phase 1 initial actions, a 40-foot armored notch with multiple bays that can be opened and closed independently at A8 and Alviso Slough was installed. Current operation (October 2014) is that 5 bays were opened, year round to gather data on salmonid tracking with UC Davis. On-going mercury studies continue. Pond A8 is identified as tidal habitat in the long-term programmatic restoration of the Project. In October 2014, the gate on the intake at A5 from Guadalupe Slough has failed and intakes water at high tides (cannot be fully closed). This structure is also in need of repair, however, the Service has not identified funds at this time.

Pond System A14

The Pond A14 System consists of Ponds A9, A10, A11, A14, and Ponds A12, A13, and A15. The objectives of the Alviso Pond A14 systems are to: 1) maintain full tidal circulation through ponds A9, A10, A11 and A14, while maintaining discharge salinities to Coyote Creek at less than 40 parts per thousand (ppt); 2) maintain pondsA12, A13 and A15 as a higher salinity pond and operate at 80 – 120 ppt salinity during summer to favor brine shrimp development, as possible. During the winter of 2014, Ponds A9-14 were operated at lower levels due to levee erosion along the Alviso Slough side. In January and February 2015, The Santa Clara Valley Water District moved some of the internal levee material in this system to A10 and A11, inside the ponds along the Alviso Slough side to prevent further damage. Currently, the Service has a need for more material to rebuild the internal levees, which will be described in our 2015 proposed O&M report.

Pond System A16/17

Alviso Pond A16/A17 was the final Phase I action that was completed in 2012. It allows Pond A17 to become tidal marsh with uninhibited hydraulic connection to Coyote Creek and Pond A16 provide 243 acres of managed shallow pond habitat with 16 new nesting islands (along with 4 existing islands). The Pond A16 intake has a fish screen that has been non-operational since approximately June 2014. The fish screen was repaired on March 4, 2015 and is currently running 3 screens.

Pond System SF2

The objectives of the Pond SF2 System is to manage a 155-acre pond with 30 nesting islands for nesting and roosting shorebirds, and an 85-acre seasonal wetland for western snowy plover nesting. The water level in SF2 is designed to maintain shallow water to provide foraging habitat for shorebirds and waterfowl. Water control structures will be used both to manage water levels and flows into and out of Pond SF2 from the Bay, and between cells, for shorebird foraging habitat and to meet water quality objectives.

Sustainability of Managed Ponds

Maintaining dissolved oxygen (DO) levels in the Alviso Ponds while meeting water quality objectives and Final Order requirements has been a significant management challenge for the Service during operation of the ponds. Over the last several years, the Service in conjunction with the California Regional Water Quality Control Board (RWQCB) developed and implemented a number of BMPs in an attempt to improve DO levels in the ponds (baffles, solar aerators, timing of discharge, etc.). Some of these BMPs appeared to be temporarily effective in either raising DO levels within ponds or minimizing the impacts of low pond DO to the receiving waters. However, the Service no longer considers these BMP's to be practical or effective on a long-term basis. Based on previous lessons learned, the Service has been operating the ponds as continuous flow-through systems to try and reduce the water resident time as much as possible, while supporting species that use these ponds (e.g., migratory, wintering, and nesting birds).

Pond A16 and Pond SF2 Continuous Water Quality Data

For 2014, the Service committed to conducting sampling at Pond A16 and Pond SF2 for Water Board compliance with Continuous Circulation Monitoring (CCM) water quality standards (salinity <44 ppt, 10th percentile DO >3.3 mg/L, pH 6.5-8.5). One datasonde was to be placed at the discharge of Pond A16 and one at Pond SF2 to monitor continuously from July 1 through September 30, 2014. Due to delays in waiting for back-ordered equipment from Hach, the datasondes were not deployed until August 20, 2014.

This data was sent to the USFWS' Inventory and Monitoring Program hydrologist for data review and interpretation. On March 4, 2015, we received a memo "Review of continue water quality data collected at sites A16 and SF2 at Don Edwards San Francisco Bay National Wildlife Refuge" (Appendix B). In summary, there was some uncertainty as to the degree of accuracy of all of the DO readings at both sites. Some of the suspect data was deleted by our hydrologist in an attempt to ensure that remaining data are representative of true water quality conditions. In general, we still have low DO in both pond systems with DO falling below 3.3 mg/L.

In Pond A16, DO varies with tidal depth, with peak DO at low tide. This is not surprising as seawater generally contains less dissolved oxygen than freshwater - this is also caused by the fact that seawater has a lower 100 air saturation of oxygen than freshwater. The low DO conditions show that the water has gone anoxic (less than 2 mg/L) at high tide. In Pond SF2, the relation between tidal variation and DO is slightly off. Peak DO occurs just before peak tide. It could be more affected by diurnal temperature than tide. Low DO (and anoxic conditions) are more likely to occur at night (when temperatures are low too) when plants are not photosynthesizing and not producing oxygen. Other water quality parameters are discussed in Appendix B of this document.

Other DO studies in Ponds A8, A21, SF2, and E9

This summary of the draft report **"Dissolved Oxygen Levels and Frequent Hypoxia Associated with Restored Tidal Ponds in South San Francisco Bay", prepared by Felipe La Luz, et al., 2015** was prepared by the Project's Lead Scientist, Laura Valoppi. The final reports will be posted on the Project website at: http://www.southbayrestoration.org/documents/technical/ once it has been finalized.

This report describes a series of diel cyclic hypoxic (low dissolved oxygen in the water) events observed in Pond A21 during the summer of 2013 and a summary of DO monitoring in Pond A8 during the summer of 2014. A water quality sonde was deployed from 6 to 15 days from June to October 2013 at four locations (A8 near the east end by the notch, A21 just inside the western breach, SF2 inside the eastern levee, and E9 at the Mt. Eden Creek breach). A8 is a muted tidal system, A21 and E9 are fully breached restorations, SF2 is a managed pond system.

Pond A21 had 18 out of 32 days with hypoxic events, all occurring in the early morning to early afternoon hours, with the majority occurring between 7:00 am and 11:00am. Dissolved oxygen levels (DO) were lowest when low tide followed a period of overnight highest high tide during a Spring tide/new moon in June. This is indicative of oxygen poor water draining from the ponds into Coyote Creek, and is likely due to planktonic organisms and benthic invertebrates respiring overnight, after photosynthesis has stopped. Elevated DO levels were recorded as the pond drained following the midday high tide. The pond effectively acts as an oxygen source during daylight hours and as a sink overnight when high tides are centered on midday and mid-night. During the Neap tide/waxing moon in June, the higher low tide occurred overnight, resulting in daytime inundation just after sunrise and again before sunset. Hypoxic conditions were rare during this period. A similar pattern observed during the June Spring tide/new moon was observed during the August Spring tide/new moon when the lowest low tide occurred just after sunrise, hypoxic conditions were observed, attributed to oxygen poor waters exiting the pond after nighttime respiration. In October, during a Neap tide waxing moon, the lowest low tide occurred at night, with high and highest high tides occurring just after sunrise and just at/after sunset. Higher DO was observed mid-day during low tide on the 3rd day of observation, but not the prior two days. The lowest DO was observed at night-time lower low tide event, when the water that was depleted in oxygen overnight was exiting the pond.

In Coyote Creek, observations were made in August and September, with low and high tide occurring in the middle of the night, respectively. In August, the Neap tide, lowest low water coincided with nighttime, with high tides occurring around sunrise and sunset. Changes in DO appeared to track tidal fluctuations in both periodicity and magnitude. DO levels were higher during the higher high tide than the lower high tide. Higher high tide occurred in the afternoon when DO levels are typically elevated, therefore elevated DO levels that coincide with the higher high tide cannot be attributed to greater tidal magnitude or well oxygenated water entering the system form the Bay. In September, the high tides occurred in the middle of the night and midday, and low tides occurred around sunrise and sunset. The lowest DO was associated with the lowest low tide that occurred early in the morning; the afternoon low tides did not have low DO. Spikes in DO coincided with both day and night high tides. This can be attributed to well oxygenated bay water being pushed upstream in Coyote Creek as the tide rises. Extremely low DO levels at low tides can be attributed to low DO water draining from upstream ponds and sloughs passing the sondes as the tide recedes.

At Pond E9 observations were made during a Spring Tide in early July 2013 when high tide occurred overnight, inundating the ponds at midnight and mid-day. DO levels dropped below 4 mg/l only a few hours, when high tide peaked less than 3 hours before sunrise. These low DO events were not as severe or frequent as observed at Pond A21. The highest DO levels occurred at midday and overnight.

Pond SF2 has limited tidal range since flow is controlled by water control structures and is managed for shorebirds. However, tide still influenced DO levels, with highs and lows coinciding with high and low tides.

Pond A8 followed a diel pattern in which DO levels peaked just prior to sunset and decreased until mid-morning, and then variable though generally increasing in the early afternoon. Wind speed was also highest in the afternoon, predominantly blowing from the northwest; and average water temperature also peaked in the afternoon. Tidal influence is limited in this pond as flow is controlled through gates, and appears to only affect water quality when the stage exceed about 4 to 6 feet. Hypoxic events occurred in the 5 out of 48 days of monitoring, and some persisted for several hours in the summer months.

In summary, hypoxia, with DO levels less than or equal to 2 mg/L, were recorder over 50% of the days monitored at Pond A21. This is attributed to the close proximity of Pond A21 to the Santa Clara wastewater treatment plant which provides a nutrient input (via Artesian Slough), and the limited tidal mixing in Pond A21 due to the low volume, making this pond more susceptible to hypoxia. Similarly, Coyote Creek also is influenced by effluents from the Santa Clara and Sunnyvale wastewater treatment plants. Hypoxia was not documented at Pond E9 or SF2. Both these sites have constrictions that limit tidal mixing, but are positioned relatively close to the main body of baywater and not in close proximity to waste water treatment plants. Pond A8 DO levels appear to be more influenced by diel cyclic patterns in wind and temperature.

Reduced tidal mixing, high nutrient input and elevated water temperature all contribute to persistent DO problems within some SBSPRP sites. A more detailed study with long term monitoring and greater spatial resolution would be required to accurately describe which factors are most critical in preventing or minimizing hypoxia.

Update on Mercury Studies

The following is a summary as of January 2015 of the most recent mercury study results have become available prepared by the Project's Lead Scientist, Laura Valoppi.

While it is a goal of the South Bay Salt Pond Restoration Project (SBRP) to restore as much as 50% or more of the ponds to tidal marsh, concerns with legacy mercury deposits in the Alviso Complex due to historic mercury mining activities upstream, gave the managers pause in moving forward with a full tidal breach of the Pond A5/A7/A8 system (Pond A8). Pond A8 had some of the highest levels of mercury detected in sediments in the area, as well as high levels of mercury in bird eggs, fish and other organisms. The concerns with opening up Pond A8 to tidal flows were twofold: 1. Opening Pond A8 would increase the erosion of sediments in Alviso Slough, which would likely release mercury that had long been buried in the slough sediments, and 2. Opening Pond A8 might increase the methylation of mercury and result in increased uptake of mercury in birds, fish, and other aquatic life. Methyl mercury is the more toxic form of the compound and of most concern. In response, managers installed a 40’ notch consisting of eight 5-foot gates that could be successively opened over time to study the effect of opening of the Pond A8 notch on wildlife within the pond itself as well as in the adjacent Alviso Slough. Starting in 2010, prior to the notch opening in 2011, and continuing every year thereafter, a range of mercury studies have been conducted to assess the effect of opening the Pond A8 notch.

2013 Bird Egg Results

Bird eggs were collected by Josh Ackerman of the U.S. Geological Survey for mercury analysis in 2011, right after the Pond A8 notch was opened. Dr. Ackerman found that mercury concentrations in Tern eggs increased by 69% between 2010 (prior to the notch opening) and 2011 (after the notch opening) at Ponds A5/A7/A8 (Pond A8) after the restoration actions, compared to a slight decline in egg mercury concentrations (by 10%) between years at Reference Ponds. These results were made available to managers in Spring of 2013. This very dramatic increase in mercury related to the notch opening concerned the managers, and therefore they decided to open the same number of gates (3 of 8) in June of 2013 as was opened in 2012. Lack of funding in 2012 allowed only limited study of scour in Alviso Slough in response to the opening of the Pond A8 notch.

In 2013, due to a grant from the U.S. Environmental Protection Agency, researchers were able to collect samples of bird eggs and slough fish in Pond A8 and Reference Ponds. Results from the 2013 study found Tern egg mercury concentrations decreased by 59% between 2011 and 2013 at Pond A8, compared to a decline of 23% between years at Reference Ponds. The end result of the 3-year comparison between 2010 and 2013 was that Tern egg mercury concentrations decreased by 31% at both Pond A8 and Reference Ponds. In addition to these changes between years, Tern egg mercury concentrations in Pond A8 were 6% higher than levels in Reference Ponds in 2013, and similar to 2010 baseline conditions. Tern egg mercury concentrations in Pond A8 are currently at levels that are similar to what would have been expected without the opening of the notch having occurred. Despite this good news, the majority of Tern egg mercury concentrations in Pond A8 in 2013 (70%) still remained above those associated with reproductive impairment (>0.90 µg/g fww). In particular, Ponds A7 and A8 are still a mercury “hotspot” for bird eggs compared to other ponds in 2013.

2013 Slough Fish Results

Darell Slotton of University of California, Davis collected three-spined stickleback and Mississippi silverside fish from 2 locations in Alviso Slough, at the notch (ALSL2) and mid-way down the slough (ALSL3). Fish were also collected from Reference locations in Artesian Slough (aka Mallard Slough) to the east of Alviso Slough and also on the Guadalupe Slough (GUASL) to the west of Alviso Slough, and near the Sunnyvale Wastewater Treatment Plant (SUNNY) on a channel that leads into the Guadalupe Slough.

In 2011, with opening of one gate of eight gates at the Pond A8 notch, fish collected in Alviso Slough showed an initial increase in mercury which persisted for some 1-3 months in comparison to data collected in Alviso Slough prior to the opening, as well as at the Reference site on Mallard Slough. Mercury in Alviso Slough fish returned to near baseline soon by the Fall of 2011.

With the 3-gate opening in 2013, stickleback fish collected in Alviso Slough near the notch showed unusually elevated levels in April and May, though the notch was sealed throughout that time and before (notch was closed in December of 2012, per NMFS permit restrictions). Silversides, with much lower variability, showed no similar early season elevation. Both species in 2013 had Hg at levels similar to baseline collections from 2010, with moderate increases following the 3 gate notch opening between July and August, though within the ranges seen in 2010. Interestingly, there was a very similar trend at the new reference locations GUASL and SUNNY, which are remote from the A8 notch activities, suggesting that the seasonal trend may be have been more regional in nature.

At the mid-Alviso Slough location (ALSL3), between the Pond A8 operation and potential impacts from Pond A6, stickleback Hg was higher in April and May 2013. Again, April and May preceded the A8 notch opening. Stickleback mercury levels from July, August and October sampling events saw no trend. So, in conjunction with a lack of trend closer to the notch, these observed mercury levels may be unrelated to A8 notch activities. Silverside data across 2013 at this mid-Alviso Slough site were very steady and generally equal to or lower than corresponding readings from 2010 and 2011.[3]

In 2013, Mallard Slough shifted from control site to another test case site, with the opening of Pond A16 (a managed pond) outflows to Mallard Slough on March 15, 2013. A sharp increase in stickleback mercury levels was noted in April and July, though not in May, and levels were back to baseline by August. Silversides were somewhat elevated in July, August, and October in 2013 (relative to 2010-11) though remaining at a similar range as seen in April. These results suggest that there was perhaps a temporary increase in fish mercury levels in Mallard Slough as a result of the opening of Pond A16 outflows.

New Reference locations on Guadalupe Slough (GUASL) and SUNNY (Sunnyvale WWTP discharge) were similar to each other, particularly in silversides. Silverside Hg was highest in Aug and October at both sites, similar to trends noted in Alviso Slough. Stickleback Hg was more variable, but often similar to trends seen in Alviso Slough. Guadalupe Slough may provide a new Reference location to compare to Alviso Slough fish data. The Sunnyvale WWTP channel site will be discontinued, due to its very close correspondence with the Guadalupe site.
In summary, the 2013 slough fish data do not appear to show major increases in sentinel slough fish Hg in relation to the opening of the Pond A8 notch to triple its previous volume (2011 1-gate, 2013 3-gates).

2013 Bathymetry and Mercury Remobilization Results

Bathymetric studies (mapping of the seafloor) of Alviso Slough were conducted from late 2010 to November 2013 by Bruce Jaffe of the U.S. Geological Survey. Data collected through the end of 2012 found that most of the scour and erosion of sediments on the bottom of Alviso Slough occurred near the Pond A6 breaches, which was restored to full tidal flows in December of 2010. Upstream of the Pond A6 breaches, but downstream of the Pond A8 notch, Alviso Slough was eroding slightly. Deep cores of the sediment, with interval sampling of mercury with depth were previously collected by Mark Marvin DiPasquale of the U.S. Geological Survey. The mercury core data were used in conjunction with the bathymetric mapping to estimate the amount of mercury that was released from the slough sediments eroding. It was estimated that 10.8 to 12.9 kg of Total Mercury have been remobilized in Alviso Slough by the end of 2012 - with over half of the THg remobilized being from the segment around Pond A6. This is much less than an early estimate based on the amount of scour to achieve channel equilibrium that predicted 66 kg Total Mercury released with 4 of the 8 gates open, and 125 kg of Total Mercury released if all 8 gates were opened. This estimate did not consider the breaching of Pond A6, but only the construction and operation of the adjustable notch structure in Pond A8.

Continued bathymetric studies in April and November 2013 found that most of the erosion was continuing to occur near the Pond A6 breach locations, but that upstream more of the sediments in Alviso Slough were beginning to erode. Additional deep sediment cores for mercury were taken in 2012 to better characterize the amount of mercury being released in the eroded sediments. All the mercury core data, along with the latest bathymetric data, estimated that about 24 kg of Total Mercury have been released from 2010 to 2013, with most of the remobilized mercury associated with the erosion from the breaching of Pond A6.

2013 Sediment Flux Study Results

In order to characterize the amount of sediment moving in Alviso Slough, a sediment flux (turbidity and velocity) and water quality (temperature, salinity, and dissolved oxygen) station was installed about midway between the Pond A8 notch and the mouth of Alviso Slough. Dave Schoellhamer and Greg Shellenbarger of U.S. Geological Survey have studied the sediment movement at this location since WY2011. This station tracks the amount of suspended sediment and temperature, salinity, and dissolved oxygen in the slough water that is moving past the station every 15 minutes as the tides ebb and flood daily. They have found that net sediment movement in the water is generally landward, or upstream, except during rainfall events. Interestingly, peak suspended sediment levels are associated with the movement of the salt wedge past the station during flood tides, which can cause concentration of particulates through flow convergence, resuspension of benthic particles from increased shear, and formation of flocs from chemical changes in the water due to the presence of salts. The data indicate that during Spring Tides, peak suspended sediment levels occur on the flood tide cycle, while during Neap Tides, peak suspended sediment levels (neap concentration peaks are about three times lower than flood peaks) occur on the ebb tide cycle. Preliminary water quality data also indicates that opening of the gates stabilizes and slightly increases the salinity levels in Alviso Slough water.

2013 Mercury Diel Study Results

Understanding the movement of sediment in Alviso Slough allows for a better understanding of the movement of mercury in the slough since much of the mercury is attached to the suspended sediment particles (though some is also dissolved in the water). To better understand the relationship between the sediment and the mercury attached to the sediment, a Mercury Diel Study was conducted by Mark Marvin-DiPasquale of the U.S. Geological Survey in 2012/2013, in conjunction with the sediment flux study noted above. Four times a year, Spring, Summer, Fall, Winter, along with a first-of-the-season storm event (‘first flush”), a station was set up at the sediment flux station and over a 24 hour period, to capture the full tidal cycle, samples for mercury speciation and additional water quality parameters were collected every 60 minutes.

Results from this intensive study indicate that suspended particulate Total Mercury concentrations responded strongly to tidal cycles, generally increasing during ebb tide and decreasing during flood tide. Peak Total Mercury on particles in the water corresponded to the lower of the two low tides during each sampling event. The December ‘first flush’ event exhibited the least amount of concentration variability. More detailed analysis found that the portioning of Total Mercury between the particulate and dissolved phases changed throughout the tidal cycle, with the strongest portioning of Total Mercury onto suspended particles during the low tide phases. To the degree that dissolved Hg is more bioavailable (for uptake into aquatic life) than is particle bound Hg, this suggests an enhanced degree of Hg bioavailability during the flood tide phase. Both the magnitude and direction of net daily sediment and associated mercury flux changed seasonally, with the highest flux being net landward during the spring & summer periods carrying approximately 15-17 g THg per day. During the fall/winter and 1st flush periods the THg flux was net bayward with an approximate range of 0.5-6.3 g THg per day.

Pond A6 Sediment Mercury Accumulation Results

All of the above studies have been done in Pond A8, the adjacent slough and the associated Reference locations. Researchers have also initiated a study to begin to understand the mercury accumulation in sediments of a pond newly restored to full tidal flows. Pond A6 was restored to full tidal flows in December of 2010 by breaching the levee at four locations – two on the east side into Alviso Slough, and two on the west side into Guadalupe Slough. John Callaway of University of San Francisco was periodically collecting information on sediment accumulation rates within Pond A6 bottom after tidal restoration. Mark Marvin-DiPasquale of U.S. Geological Survey arranged for Dr. Callaway to also collect surface sediment samples for mercury analysis, resulting in a time series of mercury concentrations as sediment accumulated in a newly restored pond (from December 2010 (pre-breach) through March 2013). Analysis of the mercury sediment samples evaluated pre vs. post breach and seasonal differences in mercury sediment concentrations.

Results indicate that there was no difference in Total Mercury or Methyl Mercury or % of Methyl Mercury levels in the time series of sediments before versus after the breach opening. During the postbreach period exclusively, there were significant seasonal differences in the pools of both sediment “Reactive Mercury” and Methylmercury. The former is operationally defined (tin-reducible Hg(II)) and represents the pool of inorganic mercury in the sediment that is most readily available for bacteria for Hg(II) methylation. During summer, Reactive Mercury concentrations were low, while Methylmercury concentrations were high. This contrasted with samples collected during the winter, when reactive mercury concentrations were high, while Methylmercury concentrations were low.

Marvin-DiPasquale also estimated that approximately 132 kg of Total Mercury was deposited into Pond A6 during the first 2 years post-breach, with only about 10 kg of that attributable to scour in the slough around A6 breaches. The vast majority of the mercury in Pond A6 is likely not available for methylation. It is not known if the mercury accumulating in Pond A6 is coming from the sediments derived from the larger South Bay area, or if it is coming from upstream sources within Alviso Slough (an/or its watershed), or a combination of sources. Also unknown is the amount of the mercury that is accumulating in wildlife that inhabit Pond A6.

Conclusion

It was not completely unexpected that mercury levels inside Pond A8 would increase after opening the notch to muted tidal flows. Other wetlands systems and reservoirs have observed a spike in Hg levels in birds, fish and other aquatic life initially after restoration or construction, called “the reservoir effect”. Often the mercury levels in fish and wildlife return to baseline levels, in a timeframe ranging from a few years to several decades. So while it is very encouraging that 2 years after the opening of the notch at Pond A8 that levels in bird eggs have decreased, it is too soon to say if this trend will continue as more gates are opened and there is increased tidal flows through Pond A8 and potential continued sediment erosion in the upper end of Alviso Slough, near the A8 notch. Outside the Pond, in Alviso Slough, biosentinel fish mercury returned to pre-notch baseline levels after brief increases in the several months immediately following the initial 1-gate opening in 2011. It was particularly encouraging that 2013 samples were also at baseline levels following the increase in connectivity and flow from opening 1 gate to opening 3 gates.

In consultation with National Marine Fisheries Service, in late 2013 we initiated a steelhead smolt study which enabled managers to open Pond A8 notch early, in March of 2014. Mercury researchers and managers believed this might improve water quality conditions in Pond A8 to minimize mercury methylation, and to stabilize water levels to benefit nesting birds. Based on the results from 2013, the group decided the available information supported keeping 3 gates open from March through the end of the planned 2014 Hg sampling period (Fall of 2014), and then open 2 more gates for a total of 5 out of 8 gates (25 feet open out of a 40 foot notch). In addition, managers will not be closing the gates from December 1 to June 1 as was done in prior years, in hopes of further reducing mercury accumulation in wildlife.

Researchers have continued to collect fish and bird egg samples in 2014, and plans are in place for continued collections in 2015. Researchers are also developing a sediment scour model of Alviso Slough to better understand the effect of opening additional gates at the Pond A8 notch will have on erosion and remobilization of mercury in Alviso Slough, and where the sediments might be depositing. These studies will enable managers to determine the best management of the Pond A8 system to minimize mercury accumulation in wildlife and prevent unacceptably high rates of erosion and mercury remobilization in Alviso Slough.

Publications/Presentations

The final Hg biosentinel report for 2010 through 2011 is available at: http://www.southbayrestoration.org/documents/technical/Mercury OFR Report May28_2013_Final.pdf.

The final 2014 Open File Report for the Waterbird Eggs is available at: Ackerman, J.T., Herzog, M.P., Hartman, C.A., Watts, T., and Barr, J., 2014, Waterbird egg mercury concentrations in response to wetland restoration in south San Francisco Bay, California: U.S. Geological Survey Open-File Report 2014-1189, 22 p., http://dx.doi.org/10.3133/ofr20141189 http://www.southbayrestoration.org/documents/technical/Ackerman_etal_2014_Bird%20Egg_Mercury_ ofr2014-1189.pdf

Dr. Marvin-DiPasquale prepared and presented a poster at State of the Estuary conference (Oakland CA; October. 29-30), which highlighted results from the Alviso Slough Hg flux study, including the Methylmercury results paid for under this EPA grant. Marvin-DiPasquale, M., Schoellhamer, D., Downing-Kunz, M., and Shellenbarger, G., 2013, Mercury In Motion - Quantifying Mercury Flux in Alviso Slough, State of the Estuary, 11th Biennial Meeting, October 29-30, 2013: Oakland, California, Poster Presentation. On-line: http://www.southbayrestoration.org/science/SOE2013posters/SotE 202013 Poster – Alviso Hg flux 2.pdf

Dr. Bruce Jaffe also prepared and presented posters at the State of the Estuary conference which described the bathymetryic studies conducted in conjunction with the Hg core work, to estimate amount of scour in Alviso Slough and the amount of Hg remobilized in Alviso Slough. http://www.southbayrestoration.org/science/SOE2013posters/Fregoso Hg Bathy SOE 2013.pdf http://www.southbayrestoration.org/science/SOE2013posters/SOE_2013_Foxgrover_et al(1).pdf

The final Open File Report for the bathymetric data results collected through October 2012 is available, http://pubs.usgs.gov/of/2011/1315/ .

Dr. Gregg Shellenbarger is presenting this work at an international conference: Shellenbarger, G.G., M.A. Downing-Kunz, and D.H. Schoellhamer. 2014. Suspended-sediment dynamics in the tidal reach of a San Francisco Bay tributary. Proceedings of the 17th Physics of Estuaries and Coastal Seas Conference, 19-24 October 2014, Porto de Galinhas, Brazil. 5 p.

Findings from the December 9, 2013 Researcher/Managers meeting are available at: http://www.southbayrestoration.org/science/Summary Notes from 2013_PI PMT meeting Final.pdf

Fisheries Monitoring

The following is a summary as of draft March 2015 of **"**Assessing the Benefits of Tidal Pond Restoration for Nekton in the Alviso Marsh. Draft 1. Final Report", by Jonathan Cook, et al., 2015 prepared by the Project's Lead Scientist, Laura Valoppi. The final report will be posted on the Project website at: http://www.southbayrestoration.org/documents/technical/ once it has been finalized.

This report summarizes and analyzes four years of monthly and bi-monthly fish monitoring surveys conducted in Alviso area between July 2010 and July 2014. During that time period, surveys were also conducted in Eden Landing, Ravenswood, and Bair Island complexes, however earlier reports determined that the Alviso Complex had the most abundant and diverse fish assemblages. This report focus on the Alviso Complex data to evaluate use of newly restored tidal ponds compared to adjacent slough habitat to understand the benefits of tidally restored ponds on fish and aquatic invertebrate populations. Researchers hypothesized that the abundance and diversity of species in the Alviso area would not be different between tidal restoration ponds and slough habitats. Restored ponds included the "Island Ponds" (A19, A20, A21 restored in March 2006), Pond A6 (restored in December 2010) and adjacent sloughs (Alviso Slough and Coyote Creek).

During the surveys, a total of 58 aquatic organism taxa were identified, including 40 species of fish (10 native, 10 non-native). Shrimp made up 61% of the total number of organisms counted, fish comprised 20.4 % and Clams were the third most abundant taxa making up 17% of the total catch. Grass Shrimp was the most abundant species encountered during the study (56.3% of catch-per-unit-effort, CPUE); other shrimp species collected included native and non-native species. The total fish catch (number of individual fish) was 90% native fish, with the dominate seven species being: Pacific Staghorn Sculpin, Three-spine Stickleback, Northern Anchovy, English Sole, Yellowfin Goby, Pacific Herring and Arrow Goby. A majority of the fish by total catch were benthic habitat specialists (47%), while littoral species made up 31% and pelagic species, 21% of the catch. Clams consisted of few species, the majority consisting of non-native Overbite Clam. Crabs were the fifth most numerous taxa and consisted of three species, two native, the Oregon Mudcrab and the Dungeness Crab, and the European Green Crab (of which only a single specimen was observed).

Species assemblages were based on classification of origin (native vs. non-native), status, habitat affinity, estuarine use, life stages, feeding modes, reproductive modes, and seasonal abundance patterns. The result was a great diversity of species based on function, therefore a hierarchical approach to organizing assemblages was employed, first by assembling species based on seasonal patterns. The result was a "winter-assemblages" and "summer-assemblages" of species, along with year-round residents. However many species were abundant in more than one season due to different life stages, so species and life stage were assigned to a seasonal assemblage. Then habitat assemblages (benthic, littoral, or pelagic) within seasonal assemblages were assigned. Feeding modes were strongly associated with habitat affinity. The estuarine use guild was associated with the life stages present in the marsh, where marine recruits were primarily juvenile life-stages in spring, Estuarine residents included juvenile and adult stages but were numerically dominated by juveniles in spring and summer, while anadromous species consisted of sub-adult and adult life stages in the winter Researchers did not observe a distinct segregation of species assemblage characteristics between the tidal restoration ponds and adjacent slough habitats during this study.

Water quality varied considerably seasonally, and freshwater flows varied over the study period – 2011 was one of the wettest period in the last 20 years, while the ensuing years between 2012 to 2014 were one of the driest periods since 1977. Freshwater flows from Coyote Creek and Guadalupe River were highest in the winter months and were extremely high in February of 2010 and March of 2011. Water temperatures were highest in summer (April to August) and lowest in winter. Temperatures were slightly warmer within the tidally-restored ponds compared to adjacent sloughs, but not statistically significant. Salinity was highest in summer (7 - 23 ppt range) and lower in winter (4 – 21 ppt range) due to freshwater flows. Salinity was higher in the tidally-restored ponds compared to adjacent sloughs during several surveys. Dissolved oxygen was lowest during the summer months (3 – 6 mg/L range) and highest in winter (5 to 8 mg/L range). Dissolved oxygen (DO) also exhibited a diurnal pattern where DO was lowest in early morning and gradually increased throughout the day. No difference in DO was observed between tidally-restored ponds and adjacent sloughs during trawl surveys.

Although species richness (the total number of species identified in each survey) varied considerably over the seasons, though the mean species richness in tidally-restored ponds and sloughs did not differ significantly. March surveys tended to have the highest species richness when spring recruits (such as Speckled Sanddab and English Sole) arrived while winter assemblages still resided in the area.

Catch-per-unit-effort (CPUE) for shrimp in the ponds was lower than the sloughs for a majority of the monthly surveys except for the surveys in 2010 and was overall lower across seasons. For clams, CPUE in the sloughs was greater in all months except one survey, July 2011, and across seasons.

For littoral fish species, such as three-spine stickleback, mean CPUE was lower from 2013-2014 compared to 2010 to 2012. Pelagic species mean CPUE was higher in spring and summer months, and was extremely high in January of 2014. Some species that utilize or prefer lower salinity habitat than other species, declined in abundance over the study period such as three-spine stickleback, Pacific herring juveniles, and Rainwater killifish. Other species increased during the summer period, mostly the summer assemblage taxa such as California halibut, California tonguefish, chameleon goby, leopard shark, longjaw mudsucker, northern anchovy, shiner surfperch, speckled sanddab, Shokahazi goby, striped bass and yellowfin goby. Some species had a higher proportional CPUE in the tidally-restored ponds than in the sloughs, such as arrow goby, diamond turbot, jacksmelt, Pacific herring, starry flounder, yellowfin goby, polychaete worms, and mysid shrimp.

For the most part, the assemblage and abundance of aquatic organisms were similar between tidally-restored ponds and adjacent sloughs. This is likely the result of the high degree of tidal connectivity between pond and slough habitats. The observed seasonal and inter-annual variability in the newly restored ponds reflects the fluctuations observed in other California bays and estuaries due to variability in freshwater outflow, salinity, temperature, and life-histories. Thus the seasonal and inter-annual variability of bay or ocean spawned recruits may be more influenced by processes other than the restoration sites, and could obscure patterns within the restoration sites... This may make it more difficult to assess benefits of tidal restoration, especially on more mobile organisms.

At this stage of development for the restored ponds, they are effectively functioning as intertidal habitat, and therefore community assemblages are similar A majority of the species found in the Alviso Marsh during spring were juvenile life-stages of late winter-early spring spawning species, many of which spawn within the marsh and the tidal restoration ponds (e.g. Pacific Staghorn Sculpin and Northern Anchovy) while others were spawned in the bay or ocean (e.g. English Sole, Speckled Sanddab, California Halibut) and recruited to Alviso Marsh. The tidal ponds did provide habitat for a large number of diverse taxa, many of which were juvenile life-stages, emphasizing the role of tidal marsh habitats as nurseries for estuarine organisms.

During the study period, the Island Ponds supported large numbers of mysid shrimp, a key prey species that has experienced dramatic declines in the northern part of San Francisco Estuary. Abundances of this species were much greater in Alviso Marsh compared to Suisun Marsh, so restoration of the salt ponds may provide a great benefit to the Estuary's food web. The Island Ponds also provide over-wintering and potentially spawning habitat for the State-listed longfin smelt. Longfin smelt were one of the most abundant species in the winter months in Alviso Marsh, and at times, were found to be more abundant than surveys found in the North Bay, where they are known to spawn during the winter. While there are apparent benefits to aquatic organisms from the newly restored ponds, at this stage they are acting like intertidal habitat and the large expanses of shallow water, when combined with the nutrient load from the wastewater treatment plants, may be contributing to hypoxic conditions.

Pond A8 Steelhead Study

Background

The Pond A8 Project completed construction of an armored notch through the perimeter levee that separates Pond A8 complex (Ponds A5, 7, 8 and 8S) and upper Alviso Slough in 2011 and the structure is equipped with eight 5-foot wide weirs (or gates) that can be opened independently of each other. Operation of the structure was initiated on June 1, 2011. However, there is known to be high mercury concentrations in the sediment from the historic upstream mining activities (both within the ponds, and buried in the sediments of Alviso Slough). Therefore, in 2011, only 1 gate was opened, while 2012 and 2013, a total of 3 gates were opened each year. To prevent the possible entrainment of steelhead into the pond complex, the gates remain closed during the salmonid migration period from December 1st to June 1st of each year. The preliminary results from USGS and UC Davis to assess the effect of these actions on mercury remobilization, methylation, and its effect on biota indicate these periodic perturbations (opening and closing of the notch) may be worsening the mercury effects. Therefore, it was proposed that the Project either: 1) open the gates earlier so that we can ameliorate the local effects observed on nesting terns and fish, or preferably, 2) leave the gates open all year.

As a result of monitoring mercury levels in the Pond A8 Complex, the Project developed an applied study that proposes to improve water quality relative to methyl-mercury while at the same time study the movement of steelhead smolt in the Guadalupe River and Pond A8 Complex.

The operations at the Pond A8 Complex were to open gates at the armored notch on June 1st and close the gates on Dec 1st each year. Number of gates opened can be progressively increased each year pending no adverse impacts from mercury or scour. To assist in the development of this applied study, the SBSP Restoration Project had ESA-PWA conduct a modeling exercise to look at the flow split between the river and the notch opening under a variety of flow regimes during the period between December 1 and May 31. These results were provided to NMFS in the summer of 2013. Additional coordination with NMFS in November and December 2013 resulted in the applied study for juvenile steelhead.

Five electrofishing surveys were conducted at a total of 7 sites within the Guadalupe River watershed between mid-December 2013 and mid-March 2014. Seventy Steelhead smolts were tagged using a Passive Integrated Transponder (PIT) encoded with a unique identification number, and released. Radio Frequency Identification (RFID) antennas were installed inside PVC piping and attached to the Pond A8 notch structure, the water control structures in Ponds A5 and A7, and in the lower Guadalupe River upstream of the Pond A8 notch just downstream from the San Jose International Airport (to detect out-migrating steelhead that might pass by Pond A8 notch). RFID works by emitting an alternating magnetic field in a radio frequency range from a reader (detector) through a conductive metal. When the fish with the PIT passes the RFID electromagnetic field, it is picked up by the reader and recorded.

The RFID antenna and reader systems were installed by March 6 of 2014, at which time three of the Pond A8 gates were allowed to be opened early as part of this study. Of the 70 fish that were tagged, 6 fish were detected at the upstream antenna located on the Guadalupe River, or 9% of the tagged fish. The remaining fish that were tagged but not detected at the upstream antenna may have been missed out-migrating when the upstream antenna was down during rainfall events, or the tagged fish were eaten by predatory fish such as largemouth bass, or the tagged fish were not of the ecotype that migrate (may be rainbow trout), or the tagged fish just have not migrated yet (smolts can migrate between ages 1 to 3).

One fish was detected at the Pond A8 antenna on March 27, 2014, and was inferred to be exiting the notch based upon the tide stage at the time detected. This fish was detected passing the upstream antenna on March 16. The Pond A8 antennas were dislodged and damaged on March 12, and were reinstalled on March 24. So it was presumed that this smolt entered Pond A8 sometime when the antennas were down, then detected exiting on March 27. The other 5 tagged fish detected at the upstream antenna presumably out-migrated past the Pond A8 notch.

After June 1, 2014, and through December 1, 2015, the project may open additional gates up to the full 8 pending the physical and biosentinel results of the mercury studies and the steelhead entrainment results. In July, 2014 it was determined that the mercury studies showed a decline in Hg concentrations, therefore, On September 29, 2014, the notch was opened to 25 feet (5 gates). In December 2014, the gates remained open to continue the steelhead smolt studies (tagging fish in Fall 2014 and monitoring their outmigration/movement into Pond A8 from March 2015 – June 2015).

2014-15 Progress

The Santa Clara Valley Water District (District) stepped in to provide both financial and staff resources for the study because of their interest in supporting the investigations that should lead to opening the Pond A8 Notch fully. In the fall of 2014, Dr. Jim Hobbs and District staff tagged 28 fish (2 in Alamitos Creek and the rest in Guadalupe Creek). No fish were found in the main stem. Dr. Hobbs suspected that were not many steelhead smolt in the system at that point after the extended drought and that it would take substantial rain to reconnect the upper creeks to the estuary. These small rain events seemed to wash down into the downtown area and then the water quality is degraded.

The antennae installed downstream of Hwy 101 in the Guadalupe has had a series of technical problems. It has been washed out repeatedly. The conditions at this site make installation and operation unsafe, so a new site needs to be chosen, in consultation with NMFS. In December 2014, equipment was purchased by the District to set up the additional two antennas at the Pond A8 notch. On February 24, 2015, three antennae on the Pond A8 notch were turned on with two working well; one mal-functioning. The District is currently working with Oregon RFID to troubleshoot the third antennae. Within the next few weeks, two new antennas will be installed and configured for the two additional gates on the A8 notch. Re-tuning will occur on all antennas once they the two new antennas are in place.

The District inspected the antenna on A5 on March 6, 2015 and found that the antenna was destroyed. The entire infrastructure associated with antennae was lost or damaged beyond repair and it is not feasible to install antennae at this location until the A5 water control structure can be repaired. The District inspected the antennae on A7 on March10, 2015 and found that antennae and housing were destroyed. An antenna was in two pieces and no PVC housing remained, however, the wooden frame remained intact.

The District continues to monitor the equipment that is still in place at the A8 notch, swap batteries as needed (~twice a month), download data, and provide data to Dr. Hobbs for analysis. The Refuge will monitor and maintain equipment for the Pond A7 antenna once it is reinstalled, but it is unknown whether the A5 antenna will be reinstalled since the structure needs repair. The District has agreed to finish the set-up at the A8 notch and commit to monitor/maintain that site twice a month until June 1, 2015. To date, we have detected three striped bass that were tagged by Jim Hobbs last year. This demonstrates the antennas at the A8 notch are working. The Refuge will reinstall and monitor and maintain the antennae at A7 until June 1. Dr, Hobbs will take all the data and prepare a report after June 1, 2015.

Reported Fish Kills

No fish kills were observed during 2014 that were associated with pond operations or Phase I restoration ponds.

Phase II Planning

The Project Management Team (PMT) is currently reviewing an internal draft Environmental Impact Statement/Environmental Impact Report (EIS/R) for the Phase 2 of the Project. The public draft will likely be available in late April 2015 and finalized in September – October 2015. Once the PMT selects the Preferred Alternative, the designs and construction applications will be completed in late fall of 2015. A summary of the Phase 2 alternatives is described below:

Alviso Island Ponds (A19, A20, and A21)

The alternatives focus on modifying the existing breaches in the ponds to improve habitat complexity and conductivity in Pond A19. Other alternatives involve additional breaches on the northern sides of A20 and A21 as well as the breaches in A19.

Alviso A8 ponds (A8 and A8S)
Phase 2 will add an upland transition zone/ecotone in one or two corners of A8S near San Tomas Aquino Creek and the Baylands Community Park. The ecotone size will largely depend on the available material at the time of construction, but we are assuming to build a 30 to 1 slope. There could be a space between ecotones in A8S, because Santa Clara Valley Water District may connect the San Tomas Aquino Creek to the A8 complex in the future.

Alviso Mountain View ponds (A1 and A2W)
The primary difference between the alternatives is whether to include Charleston Slough. The City of Mountain View is required to eventually transition Charleston Slough to tidal marsh – If Charleston Slough is excluded from Phase 2, then the levee along the western and southern corner of A1 will need enhancements to compensate for flood protection loss once tides are allowed into A1. An action alternative including Charleston Slough would involve lowering the current levee between the slough and A1, enhancing the west levee in the Slough and wrap it around the area to high ground.

Ravenswood ponds (R3, R4, R5, and S5)
All the alternatives would enhance the All American Canal to offset the flood protection that Pond R4 currently provides. Pond R4 will become tidal marsh, and Pond R3 will remain as a salt panne for endangered snowy plover nesting habitat. The major difference among the alternatives is the outcome for R5 and S5:

- R5/S5 could become traditional managed ponds,
- managed ponds for receiving peak stormwater from Redwood City, or
- a tidal mudflat and managing for regular tidal flows (basically functioning similarly to Charleston Slough).

Eden Landing Southern Ponds
Phase 2 would focus on the ponds between Alameda Creek Flood Control Channel and Old Alameda Creek. The alternatives primarily differ in how they provide the primary flood control as the ponds ultimately become tidal marsh. The PMT proposes using either a traditional, a phased, or a managed pond approach.

- The traditional ("Flood Control") approach would include building a large permanent backside levee, then breaching other ponds and excavating to allow more flow for tidal marsh restoration. The Bay Trail would be completed on Alameda County and California Department of Fish and Wildlife land.
- A phased approach follows an adaptive management methodology and involves using a landmass and ecotone sloping east into the bay ponds, building barrier islands the backside ponds, and building a (temporary) mid-complex levee. Based on future conditions, managers can continue to restore ponds to tidal or decide whether to make the mid-complex levee permanent to retain "Inland" managed ponds because there may be compelling reasons to maintain more ponds.
- The "managed ponds" approach would reserve the inland ponds as managed ponds, with a land mass on the bayside and tidal restoration of the bayfront ponds. There would also be upland transition zones on the bayside (and mainland-side) of the pond complex. If the inland ponds are managed (long-term) then there would not be an upland transition zones

on the mainland-side along the inland managed ponds, but rather could be on the mid-complex levee.

Beneficial Reuse of Dredged Material

In a related project, the beneficial reuse of dredged material for habitat restoration and enhancement in the Phase II ponds is being investigated. Planning for reuse of this material will be included in the Phase II EIS/EIR. More information on Phase II planning and how to participate is located on the Project's website: http://www.southbayrestoration.org/planning/phase2/.

APPENDIX A

DON EDWARDS SF BAY NWR

POND OPERATION PLANS

Updated 2/24/15

Monitoring
The system monitoring will require weekly site visits to record pond and intake readings. The monitoring parameters are listed below.

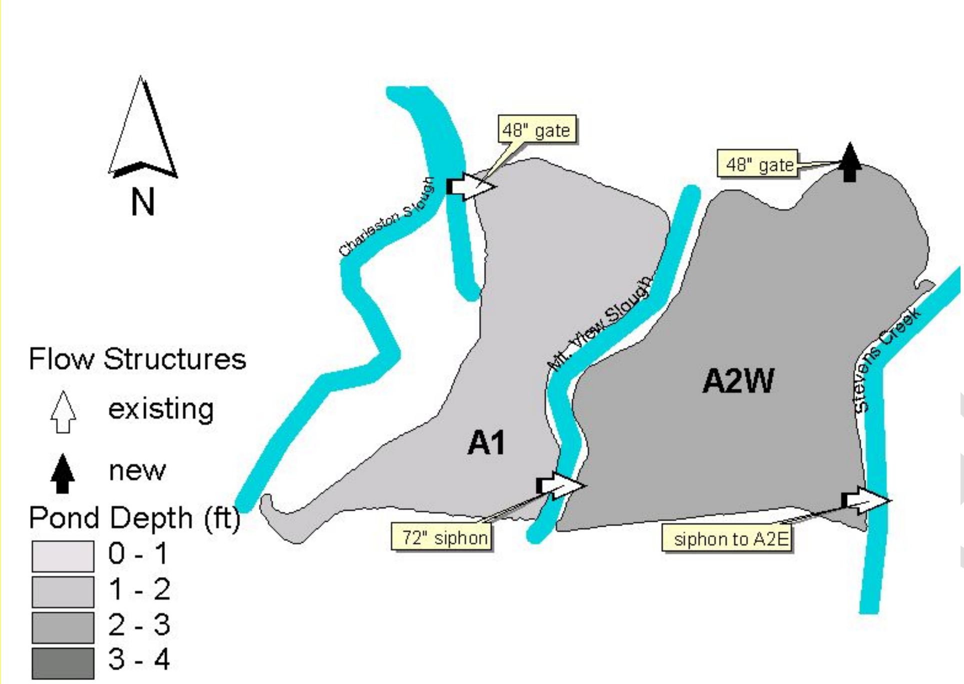
Weekly Monitoring Program

Location	Parameter
Intakes	Salinity
In-pond	Depth, Salinity, Observations
Discharges	Depth, Salinity, Observations

The weekly monitoring program will include visual pond observations to locate potential algae buildup or signs of avian botulism, as well as visual inspections of water control structures, siphons and levees.

Contents

A1 AND A2W



Objectives
Maintain full tidal circulation through ponds A1 and A2W while maintaining discharge salinities to the Bay at less than 40 ppt. These ponds are part of the planning process for SBSPRP Phase 2, and may be breached in the next 5-10 years.

Structures
The A2W system includes the following structures needed for water circulation in the ponds:

- 48" gate intake at A1 from lower Charleston Slough
- NGVD gauge at A1
- 72" siphon under Mountain View Slough between A1 and A2W
- staff gauge (no datum) at A1
- 48" gate outlet structure with 24' weir box at A2W to the Bay
- NGVD gauge at A2W
- Note that siphon to A2E is present, but closed

The system will discharge when the tide is below 3.6 ft. MLLW.

Summer Operation: May through October

Summer Pond Water Levels

Pond	Area (Acres)	Bottom Elev. (ft, NGVD)	Water Level (ft, NGVD)	Water Level (ft, Staff Gauge)
A1	277	-1.8	-0.4	2.0
A2W	429	-2.4	-0.5	NA

Water Level Control
The water level in A2W is the primary control for the pond system. The outlet at A2W includes both a control gate and control weir. Either may be used to limit flow through the system.

The A1 intake gate can be adjusted to control the overall flow though the system.

Design Water Level Ranges

Pond	Design Water Level Elev. (ft, NGVD)	Maximum Water Elev. (ft, NGVD)	Maximum Water Level (ft, Staff Gauge)	Minimum Water Elev. (ft, NGVD)	Minimum Water Level (ft, Staff Gauge)
A1	-0.4	1.2	3.6	-0.6	1.8
A2W	-0.5	1.1	NA	-0.7	NA

Based on system hydraulics, pond A2W would typically be about 0.1 feet below pond A1.

Winter Operation: November through April

Winter Pond Water Levels

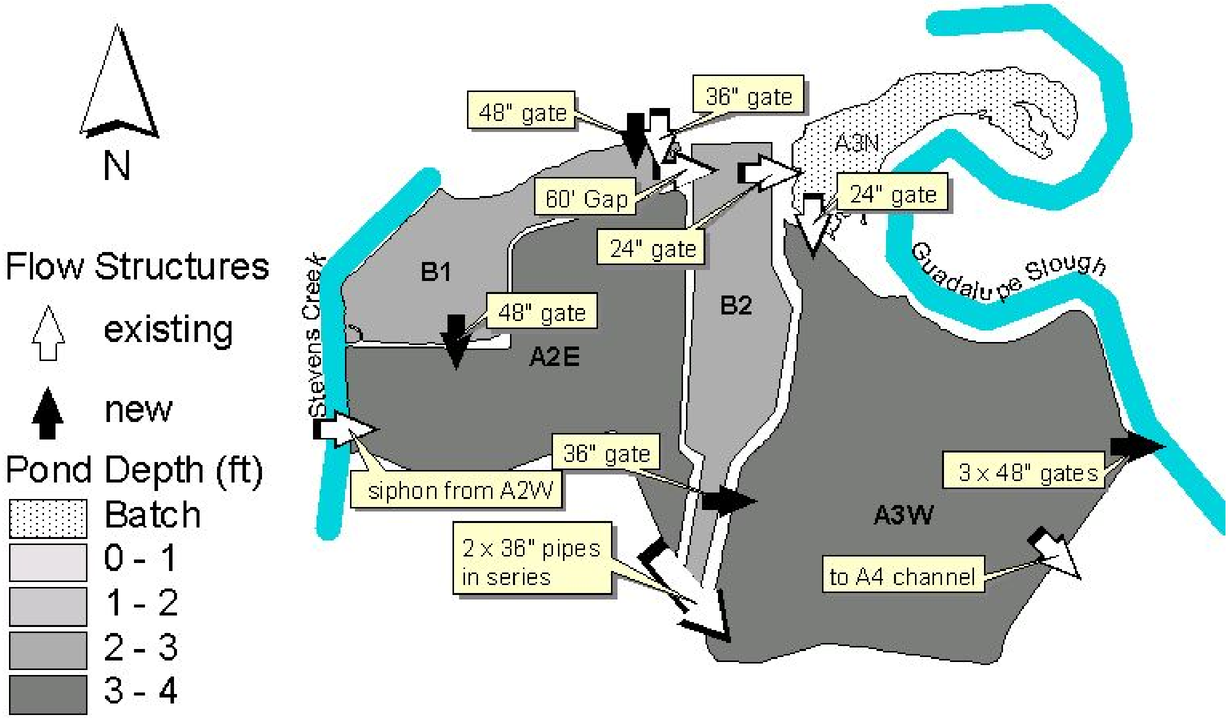
Pond	Area (Acres)	Bottom Elev. (ft, NGVD)	Water Level (ft, NGVD)	Water Level (ft, Staff Gauge)
A1	277	-1.8	-0.6	1.8
A2W	429	-2.4	-0.6	NA

Water Level Control
Normal winter operation would have the intake gate partially open to reduce inflow during extreme storm tides. The pond water level may vary by 0.2 ft due to the influence of weak and strong tides, and over 0.5 ft due to storms

During winter operations, the water levels should not fall below the outlet weir elevation. If the elevation does decrease in April, it may be necessary to begin summer operation in April instead of May.

During winter operations, if the water levels exceed approximately 1.2 ft NGVD, the A1 intake should be closed to allow the excess water to drain. Note that without rainfall or inflow, it will take approximately 3 weeks to drain 1.0 ft from the ponds.

B1, B2, A2E, and A3W



Objectives

1. Maintain full tidal circulation through ponds B1, B2, A2E, and A3W while maintaining discharge salinities to Guadalupe Slough at less than 40 parts per thousand (ppt).
2. Due to mercury hotspots in Pond A3N, maintain water levels to cover the pond bottom. This can be done by leaving the A3N / A3W gate fully open, year round.
3. Maintain water surface levels lower in winter to reduce potential overtopping of A3W levee adjacent to Moffett Field.
4. CURRENT CONDITIONS, October 2014 include a broken tide gate at A3W/Guadalupe Slough. Thus the entire system is being held at a lower water level as only a third of the gate is open for discharge. Repairs are expected in spring/summer 2015.

Structures

The A3W system includes the following structures needed for water circulation in the ponds:

- 36” gate intake structure from the bay at B1
- 48” gate intake from the bay at B1
- 48” gate between B1 and A2E
- 2x36” pipes in series between A2E and A3W (no gates)
- 36” gate between B2 and A3W

- gap between B1 and B2
- 24” gate between B2 and A3N
- 24” gate between A3N and A3W
- 3x48” gate outlet at A3W to Guadalupe Slough. Two are outlet only, and one allows both inflow and outflow, no weir
- staff gauges at all ponds and NGVD gauges at all ponds
- siphon from A2W is closed, but available if needed
- siphon to A4 is available (via pump) for emergency purposes in conjunction with SCVWD

Summer Operation: May through October

Summer Pond Water Levels

Pond	Area (Acres)	Bottom Elev. (ft, NGVD)	Water Level (ft, NGVD)	Water Level (ft, Staff Gauge)
B1	142	-0.8	0.4	1.3
B2	170	-0.6	0.4	1.3
A2E	310	-3.1	-0.5	3.0
A3W	560	-3.2	-1.4	2.1
A3N	163	-1.4	NA	NA

* Pond B1 and B2 will be operated at lower water levels on an experimental basis in an attempt to improve shorebird nesting and foraging habitat. If water quality or operations are jeopardized from lower water levels in Ponds B1 or B2, the system will be reverted back to normal operating levels, during non-hunting season.

Water Level Control

The flow through B2 to A3W is only required to maintain circulation through B2. This circulation prevents local stagnant areas which may create areas of higher salinity or algal blooms.

The flow through A2E is controlled by the gates from B1 to A2E. The partial gate opening is to maintain the water level differences between A2E and B1. There are no gates on the culverts between A2E and A3W, therefore the water levels in those two ponds should be similar.

The B1 intake gates should be adjusted to control the overall flow through the system. The water levels in B1 (and therefore B2) will change due to the change in inflow.

Water levels in Pond AB1 and Pond AB2 of Pond A3W system will be lowered during the summer to improve shorebird nesting and foraging habitat

Design Water Level Ranges

Pond	Design Water Level Elev. (ft, NGVD)	Maximum Water Elev. (ft, NGVD)	Maximum Water Level (ft, Staff Gauge)	Minimum Water Elev. (ft, NGVD)	Minimum Water Level (ft, Staff Gauge)
B1	0.4	1.6	2.5	-0.2	0.7
B2	0.4	1.6	2.5	-0.2	0.7
A2E	-0.5	-0.2	3.3	-2.0	1.5
A3W	-1.4	-0.2	3.3	-2.0	1.5
A3N	NA	NA	2.6	NA	NA

Salinity Control
The summer salinity in the system will increase from the intake at B1 to the outlet at A3W, due to evaporation within the system. The intake flow at B1 should be increased when the salinity in A3W is close to 35 ppt. Increased flow will increase the water level in A3W. Water levels in pond A3W above elevation -0.2 ft NGVD (3.3 ft gauge) should be avoided as they may increase wave erosion of the levees.

Winter Operation: November through April

Winter Pond Water Levels

Pond	Area (Acres)	Bottom Elev. (ft, NGVD)	Water Level (ft, NGVD)	Water Level (ft, Staff Gauge)
B1	142	-0.8	0.9	1.8
B2	170	-0.6	0.9	1.8
A2E	310	-3.1	-1.8	1.7
A3W	560	-3.2	-1.8	1.7
A3N	163	-1.4	NA	NA

Water Level Control
The water levels in A3W are important to prevent levee overtopping. The south levee separates the pond from the Moffet Field drainage ditch. The levee is low, and subject to erosion with high water levels.

Whenever possible, the system intake at B1 should be closed in anticipation of heavy winter rains and high tides. When the system intake gates are closed, the internal gates from B1 to A2E and from B2 to A3W should also be closed to keep water in the upper ponds (B1 and B2).

There is no gate between A2E and A3W. During winter operations with reduced flows through the system, the A2E water level will be similar to the A3W water level. During the summer, the higher flows will establish approximately 0.9 ft difference due to the head loss through the two pipes in series which connect the ponds.

A5, A7, AND A8

Objectives

The Pond A8 system is operated to maintain muted tidal circulation through ponds A5, A7, A8N and A8S while maintaining discharge salinities to the Bay at less than 40 ppt.
Note that SCVWD is currently placing fill along the southern portion of A8S as part of their beneficial reuse program. This will continue for at least the next 5 years during the dry season.

Structures

The A8 system includes the following structures needed for water circulation in the ponds:

- 2x48” gate intake at A5 from Guadalupe Slough. CURRENT LY (Oct 2014) this tide gate is broken and intakes water a high tide (cannot be fully closed)
- 2x48” gate in/outlet with two 24’ weir boxes at A7 from Alviso Slough; this functions as the outlet for the system when needed
- NGVD gauges at A5 and A7 structures
- notches in the levees between A5/A7/A8/A8S; these ponds effectively function as one
- siphon between A4 to A5 will generally be closed; this siphon is pump driven rather than gravity fed.

- 40-foot armored notch with multiple bays that can be opened and closed independently at A8 and Alviso Slough. Current operation (October 2014) is 5 bays open, year round to gather data on salmonid tracking with UC Davis.

Weir Structure: A portion of the levee adjacent to Pond A8 was reconfigured as part of the Lower Guadalupe River Flood Protection Project to act as an overflow. The 1,000-ft long overflow weir at Pond A8 would allow high flood flows to exit Alviso Slough when water levels reach approximately 10.5 ft NAVD88. The water levels have never overtopped the weir since 2004, but it remains in place in case of a flood event.

A4 Siphon: It is possible to pump water from Pond A4 into Pond A5 or vice versa, if necessary, in accordance with the SCVWD Pond A4 Water Management Operations Plan (December 2005).

System Description
Water exchange through the notch connection is limited and the tidal range within the ponds is muted. All gravity intake flow occurs at high tide, and all outflow occurs when the tide is below 8.12 ft. MLLW. Previous seasonal water levels no longer apply here.

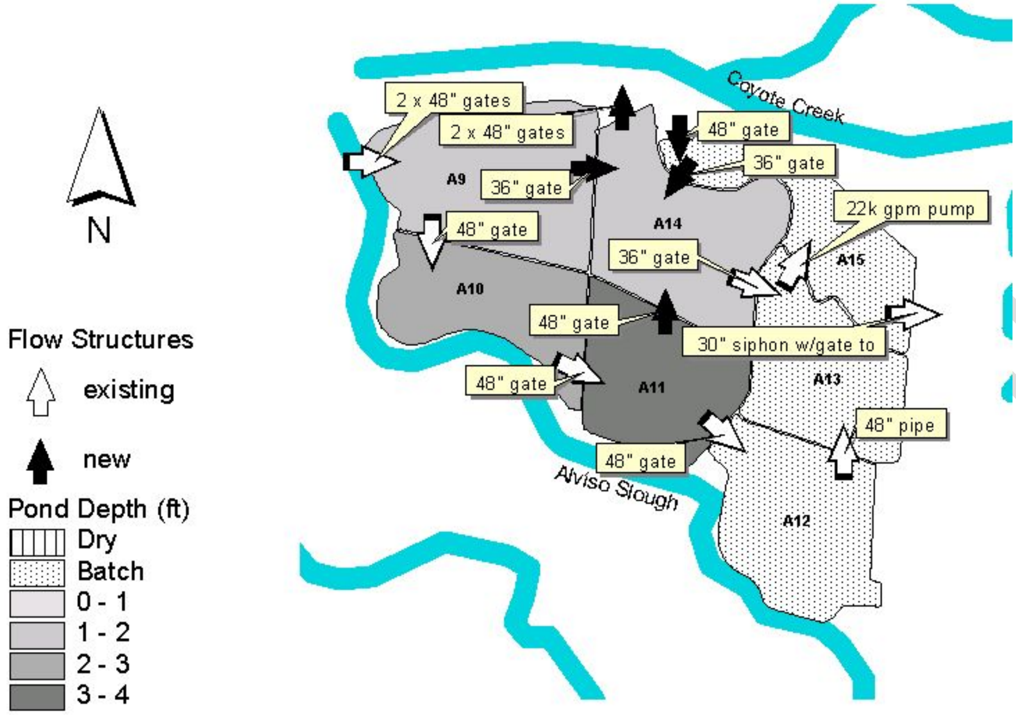
Water Level Control
The A5 and A7 intake gates can be adjusted to control the overall flow through the system. After the installation of the “notch”, water levels are much higher here due to a muted tidal system into A8.

Winter Operation

Previous operation of this system included the notch is being closed during winter months (December – May) to prevent entrapment of migrating salmonids. During these winter months, Pond A8 system was operated by intaking water at A5 and releasing water at A7. Five bays of the notch are left open year round as of 9/29/14 in conjunction with salmonid research by UC Davis.

Note that without pumping, rainfall or inflow, it will take approximately 3 weeks to drain 1.0 ft from the ponds.

A9, A10, A11, A14 AND A12, A13, A15



Objectives

1. Maintain full tidal circulation through ponds A9, A10, A11 and A14, while maintaining discharge salinities to Coyote Creek at less than 40 parts per thousand (ppt).
2. Maintain pond A15 as a higher salinity pond and operate at 80 – 120 ppt salinity during summer to favor brine shrimp development, as possible.
3. CURRENT CONDITIONS (Oct 2014): A9-A14 are currently being operated at lower levels due to levee erosion along Alviso Slough. During the winter of 2014 SCVWD is proposed to come in and move some of the internal levee material in this system to A10 and A11, inside the ponds along the Alviso Slough side.

Structures

The A14 system includes the following structures needed for water circulation in the ponds:

- 2 x 48” gate intake at A9 from Alviso Slough
- 48” gate between A9 and A10; 48” gate between A9 and A14- left open always
- 48” gate between A10 and A11; 48” gate between A11 and A14- - left open always
- 48” gate between A11 and A12; 48” gate between A12 and A13
- 36” gate between A14 and A13
- 36” gate between A15 and A14; 22,000 gpm pump from A13 to A15 (no power, would need a generator to operate)
- 48” gate intake at A15 from Coyote Creek
- 2 x 48” gate outlet at A14 into Coyote Creek
- staff gages at all ponds and NGVD gages at all pond
- internal breaches in levees between A9/A10/A11/A14 were put in place in 2008 to

improve water flow

System Description
The normal flow through the system proceeds from the intake at A9, then flow through A10-A11- to the outlet at A14. All gravity intake flow would occur at high tide, and all outflows would occur when the tide is below 6.2 ft. MLLW.

Pond	Area (Acres)	Bottom Elev. (ft, NGVD)	Water Level (ft, NGVD)	Water Level (ft, Staff Gauge)
A9	385	-0.2	2.0	3.3
A10	249	-0.8	1.8	3.0
A11	263	-1.8	1.3	2.5
A14	341	-0.0	0.9	2.3
A12	309	-2.0	1.2	2.5
A13	269	-1.1	1.1	2.6
A15	249	0.7	2.8	4.1

Summer Operation: May through October

Summer Pond Water Levels

Water Level Control
The water level in A14 is the primary control for the pond system. The system flow is limited by the inlet capacity at A9. Normal operation would have the outlet gates fully open. Water levels are controlled by the weir elevation at A14. The A14 weir should be at approximately 0.0 ft NGVD to maintain the summer water level in A14 at 0.9 ft NGVD (2.3ft gauge).

Due to the internal levee cuts, water flows freely between ponds A9 to A10 to A11 to A14.

Operating the ponds at or near minimum depths will interfere with circulation through the ponds and may cause significant increases in pond salinity during the summer evaporation season. Exposing the pond bottom at A9 also brings in western snowy plovers to nest, further reducing our capacity to manage water here.

Salinity Control
Increased flow may increase the water level in A14. The inflow at A9 is constrained by the tide level in Alviso Slough since the intake gates would be fully open. Water levels in pond A14 above elevation 2.0 ft NGVD (3.4 ft gauge) should be avoided as they may increase wave erosion of the levees.

Batch ponds A12, A13, and A15 summer salinity levels should be between 80 and 120 ppt, to provide habitat for brine shrimp and wildlife which feeds on brine shrimp. However, due to limited flow through here (ultimately from the intake at A9) this batch system does not usually function this way. Further, we have reduced water levels in A12 and A13 in recent years to promote nesting by terns and shorebirds. These two ponds are often mostly dry during the summer with only high salinity water in the borrow ditches and some standing water.

Ponds A12 and A13 operate as a single unit, with inflow from pond A11 and outflows to either A14 or A15. The water levels in A12 and A13 would generally be between the elevations in A11 (higher than A12) and A14 (lower than A13); inflows from A11 and outflows to A14 would be by gravity. Pond A15 operates as a separate batch pond to some extent with inflow from A14 or by gravity from Coyote Creek.

If the salinity levels are high in A14, it may be necessary to reduce or suspend outflows from the batch ponds and allow the batch pond salinity to increase until later in the season. The salinity in a batch pond will increase by ~ 10 ppt per month during the peak evaporation months.

Winter Operation
During the winter season, the A9 intake will be closed to prevent entrainment of migrating salmonids; December through May 31. Excess water from rainfall would be drained from the system after larger storms and will require additional active management to adjust the interior control gates. In years with low rainfall and because there is no inflow to this entire system during the winter, water levels in A9 are often very low by spring. This can lead to western snowy plovers nesting on the exposed pond bottom, which further limits our ability to take in water as of June 1.

Winter Pond Water Levels

Pond	Area (Acres)	Bottom Elev. (ft, NGVD)	Water Level (ft, NGVD)	Water Level (ft, Staff Gauge)
A9	385	-0.2	1.5	2.8
A10	249	-0.8	1.5	2.7
A11	263	-1.8	1.4	2.6
A14	341	-0.0	1.3	2.7
A12	309	-2.0	1.4	2.7
A13	269	-1.1	1.2	2.7
A15	249	0.7	2.8	4.1

A16

Objectives
Provide 243 acres of managed pond habitat in Pond A16, with 16 new nesting islands (along with 4 existing islands).

Structures

- 63" culvert intake at A16 near the southwest corner of A17 (200 cfs capacity)
- outlet structure into Artesian Slough (180 cfs capacity) with 140-ft outlet pilot channel
- siphon into New Chicago Marsh

System Description
Flows into and out of Pond A16 can changed by adjusting slide gates.

Pond A16 is managed for shallow water habitat. A large majority of the pond bed has elevations ranging from 2.2 to 3.1 feet NAVD. In addition to the 20 islands, you can often see parts of the pond standing above the water line. The intake culvert has a tide gate to prevent water from flowing back into A17.

CURRENT CONDITIONS (Oct 2014): the fish screen is currently under repair and should be back in place and functional by Feb. 2015.

The Refuge and the USACE finished a project to place toppings on two islands for use by nesting Caspian terns (islands 11 and 12) and one for nesting western snowy plovers (island 3) in winter 2015. Decoys and sound systems will be placed here in 2015.

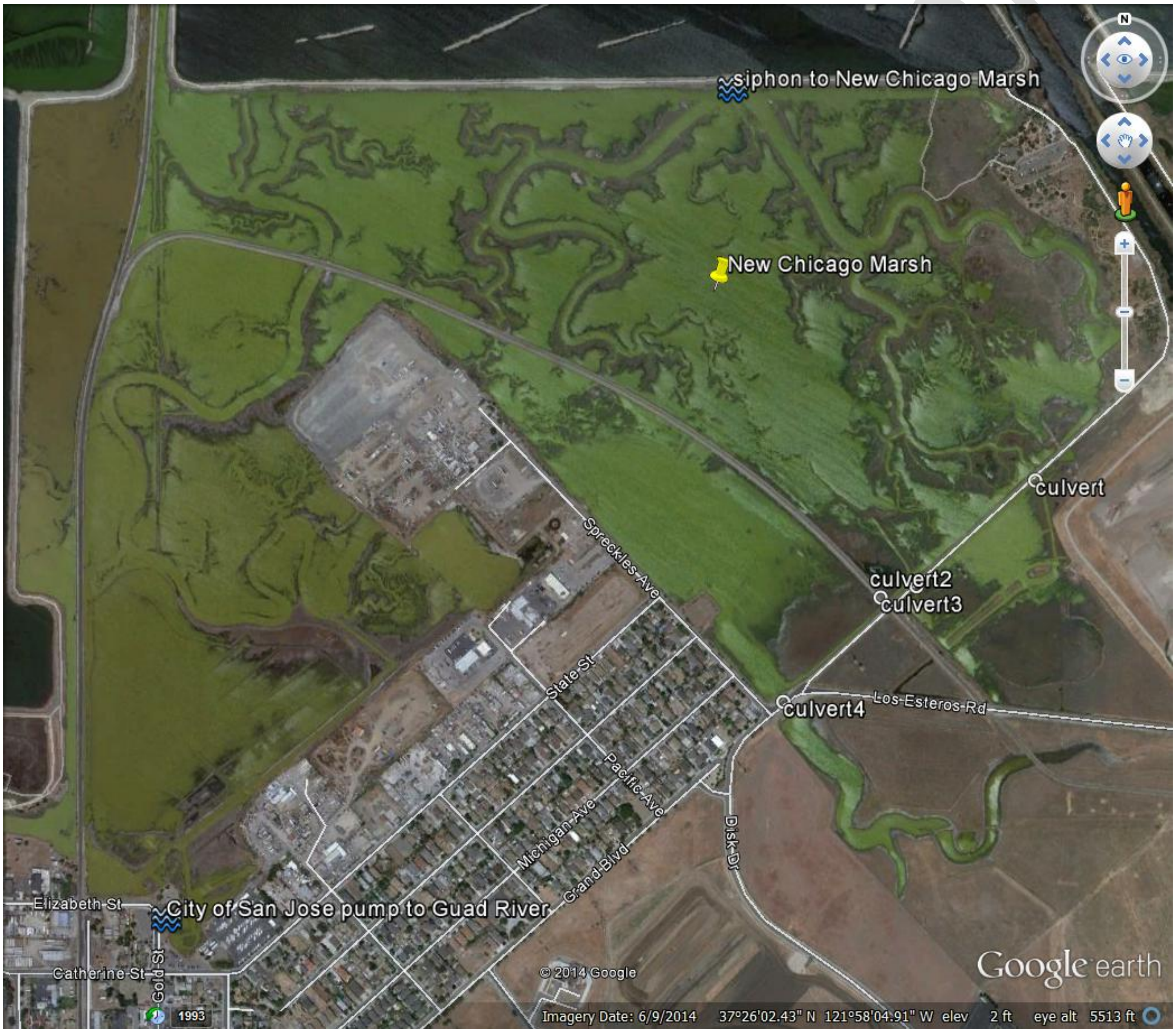
Outlet structure:

- Discharge a maximum capacity of 180 cfs to Artesian Slough during low tide events.
- Prevent water from flowing back into A16 through the outlet structure.

NEW CHICAGO MARSH

The siphon from A16 into NCM is closed in the winter unless water levels drop significantly due to low rain fall. In spring and summer the siphon is open ~3 inches to keep up with evaporation and not flood out nesting birds. Recommendations are to keep water levels between -2.5 to -2.7.

There is no outlet, although a small pump is available in the case of emergency. The pump is located in the southeast corner, along the entrance road into the EEC and releases water into Artesian Slough. Water in NCM drops ~1/10 or one inch every two days with the pump running full time. City of San Jose has a pump in the SW corner of NCM that is used to prevent flooding in Alviso.



A22 AND A23

There is one 48" gate located on Mud Slough at the cross levee between the two ponds. It takes a very high tide to get water to flow through the gate. There is no outlet for this system and these ponds currently function as seasonal ponds. Currently, the internal "donut" levee is cut to allow water to flow into A23 but not A22. The Refuge, in conjunction with LAM, has plans to add a cut into A22 to allow water flow into both ponds in winter 2014. As of December 2014, this breach is not yet low enough to allow water into A22 without first filling A23. We are working to get this lowered even more.

These two ponds are used for snowy plover habitat and need to remain dry during nesting season. Some water can be brought in during summer to allow for foraging habitat within channels and the borrow ditch. In 2014, this usually meant opening the water control structure for 3-5 days every 2-3 weeks.

SF2

Objectives

Manage 155-acre pond with 30 nesting islands for nesting and roosting shorebirds, and an 85-acre seasonal wetland for western snowy plover nesting. The water level in SF2 is designed to maintain shallow water to provide foraging habitat for shorebirds and waterfowl. The Refuge and the USACE finished a project to place toppings on three islands for use by nesting Caspian terns (islands 17, 21, 12) and one for nesting western snowy plovers (island 10) in winter 2015. . Decoys and sound systems will be placed here in 2015. Decoys only for Forster's terns will be placed on island 22.

Islands that need to be plowed (as of February 2015) to reduce cracks include: 13, 16, 20.

Structures

- intake structure consisting of 5: 4-foot intake culverts with combination slide/flap gates on each end of the culvert
- outlet structure consisting of 6: 4-foot outlet culverts, with combination slide/flap gates on both ends of each culvert
- there is one staff gauge at the outlet channel

System Description

Water flows into and out of pond SF2 through water control structures at the northern (cell 1) and southern ends (cell 4) of the bayfront levee. Weirs with adjustable flashboard risers are used to control flow in and out of cells 2 and 3. Water flows out of SF2 during low tides through the structures located along the bayfront levee. Within SF2, flashboard riser weirs are installed to convey flow into and out of cells.

The seasonal wetland area has 1 intake and 1 outlet structure. In addition, 4 cell outlet culvert structures are located where the berms cross deeper, historic channels and borrow ditches to drain deeper water from these channels for periodic maintenance and as a water quality management approach.

Summer Operation

June 1-January 31, the southern water control structure is operated as a one-way outlet and the northern water control structure is operated as a one-way intake. However, during the peak shorebird months, we may manipulate the water levels in cell 1 by operating the intake as a two-way flow. With this option, cells 2 and 4 would continue to operate as a one-way continuous flow, but cell 1 would drain through the intakes at low tide and provide mud flat areas for foraging habitat (until the rising tides refill cell 1). The 2 way flow also helps remove built up sediment in the intake channel on Bay side.

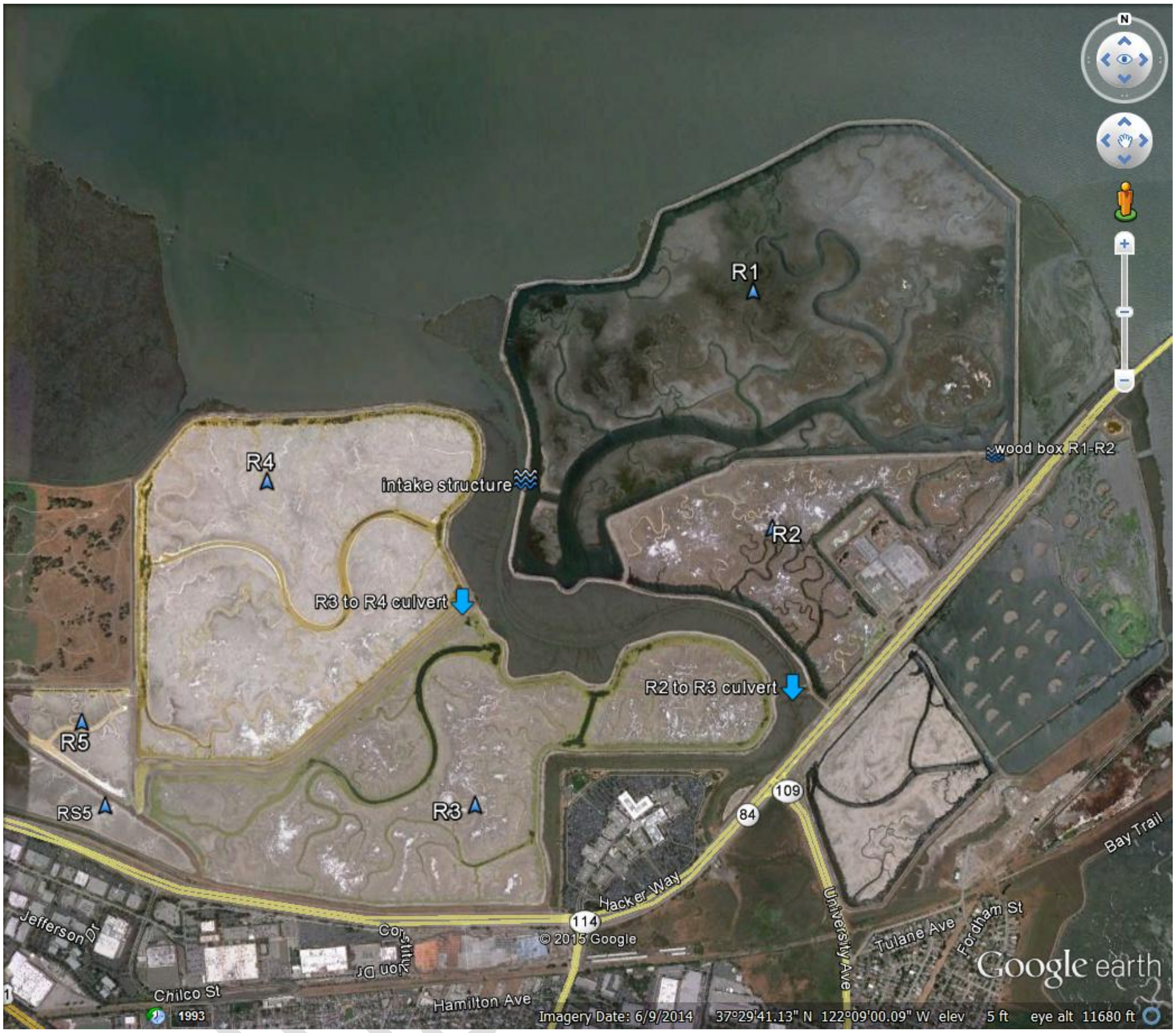
Water Level Control

Water levels are controlled by the outlet weirs located on cell 4.

Winter/Spring Operations

During the winter/spring season, both water control structures will be operated as 2-way flow to create muted tidal conditions, February through May. These measures also help protect juvenile salmon and steelhead entrainment.

R1, R2, R3, R4, R5 AND RS5



There are two 72" gates located at R1 which feed this entire pond system, there are no discharge points for the system. Water moves from R1-R2-R3-R4, and in general the previous pond must be filled before beginning to fill the subsequent pond. The All American Canal can be used to get water to R5 and RS5. All of the water control structure sin this system are old, and may not be totally operational. In particular the culverts R2-R3 and R3-R4 appear to not open and/or close properly.

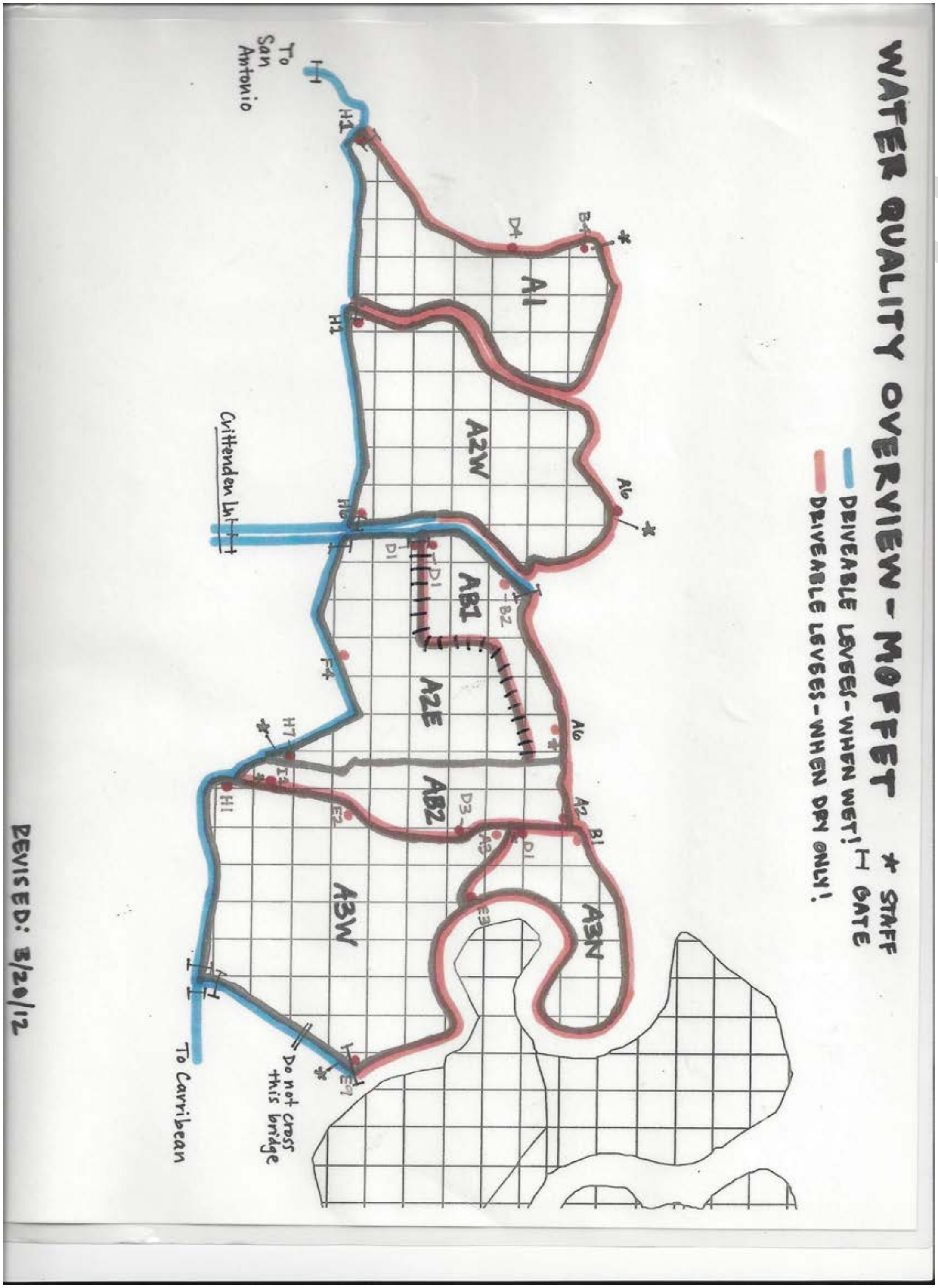
R3, R4, R5, and RS5 currently function as seasonal ponds and receive only rainwater.

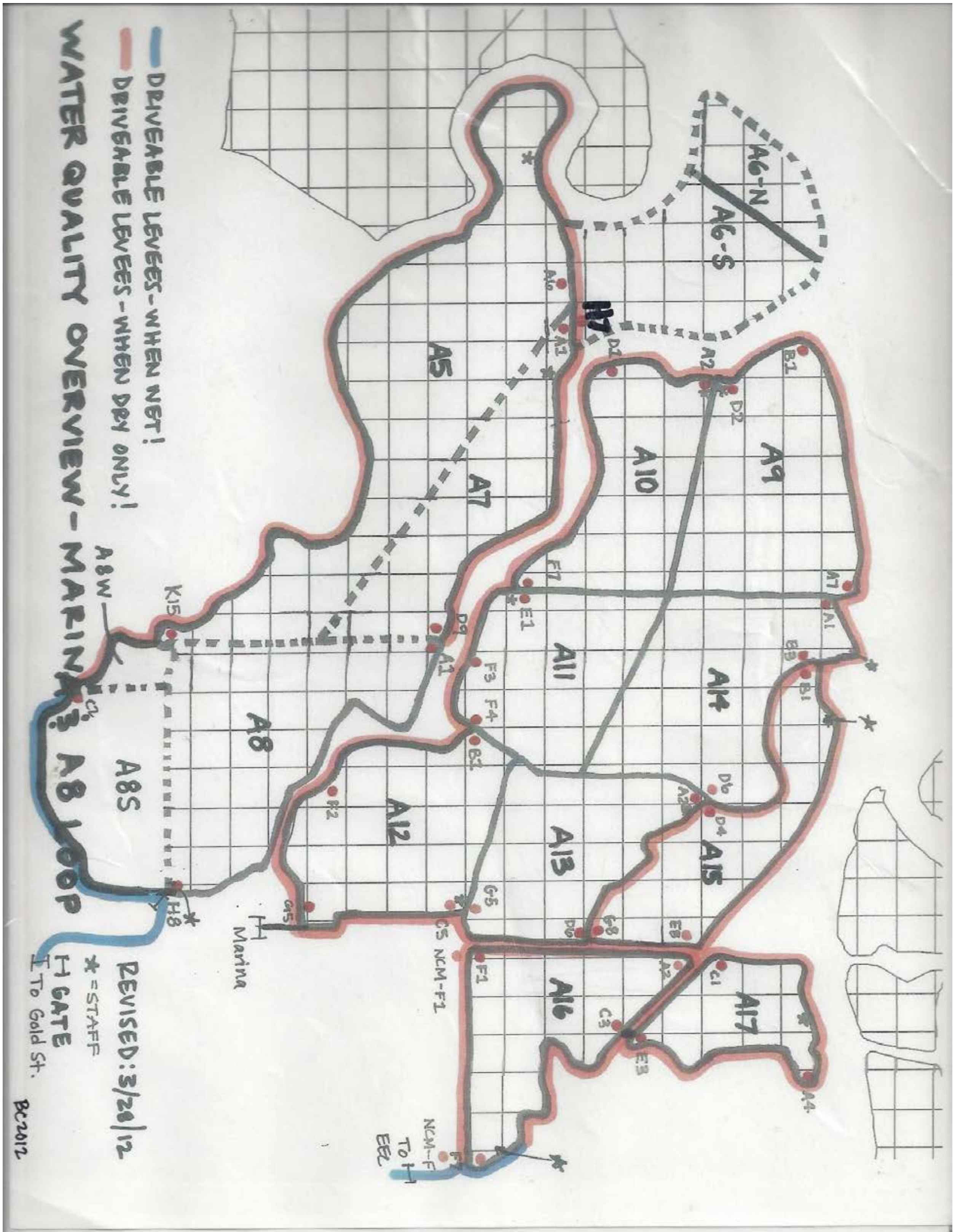
For R1 and R2, during summer operations, these ponds remain dry for snowy plover nesting habitat. During winter operations, one of the intakes approximately is opened ~ 20", and left open for several weeks to cover the pond bottom in R1 and R2 for the waterfowl hunting season, Oct–Jan.

If there is a build-up of vegetation on R3 and R4, then flood up the ponds to cover the pond bottom after nesting season by bringing in water: R1-R2-R3-R4. Let the water evaporate to expose pond bottom in time for nesting season. Drying time is at least a few months depending on rain. This was last done in ~2009.

LEVEE DRIVING AND STAFF GAUGE MAPS

Updated May 2012, by Stacy Moskal USGS




WATER QUALITY OVERVIEW - MARINA & A8 LOOP
DRIVEABLE LEVEES - WHEN WET!
DRIVEABLE LEVEES - WHEN DRY ONLY!
REVISED: 3/20/12
* = STAFF
H GATE
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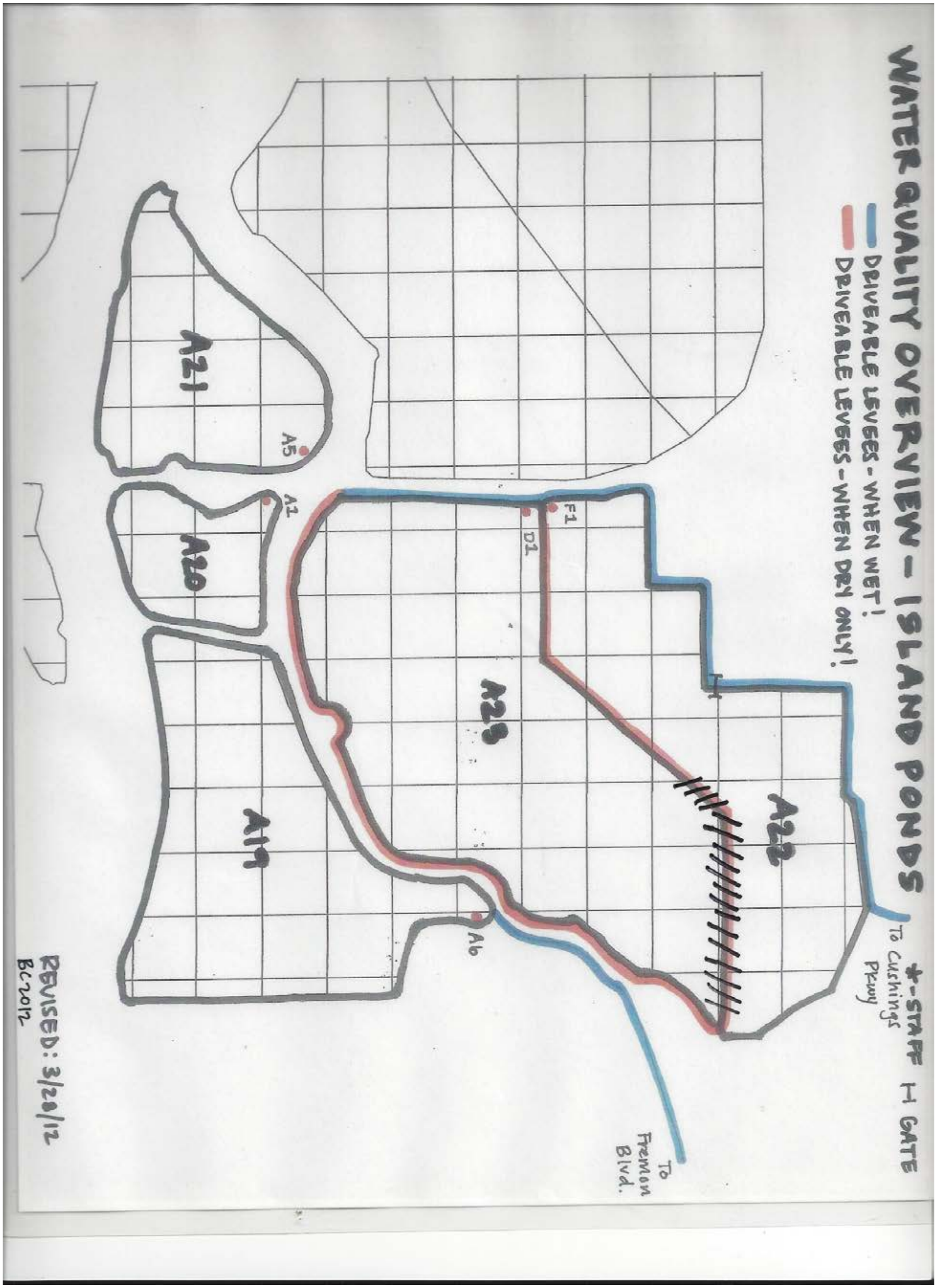
WATER QUALITY OVERVIEW – ISLAND PONDS
DRIVEABLE LEVEES – WHEN WET!
DRIVEABLE LEVEES – WHEN DRY ONLY!
✱ – STAFF
GATE
To Cushings Pkwy
To Fremont Blvd.
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A19
A23
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A5
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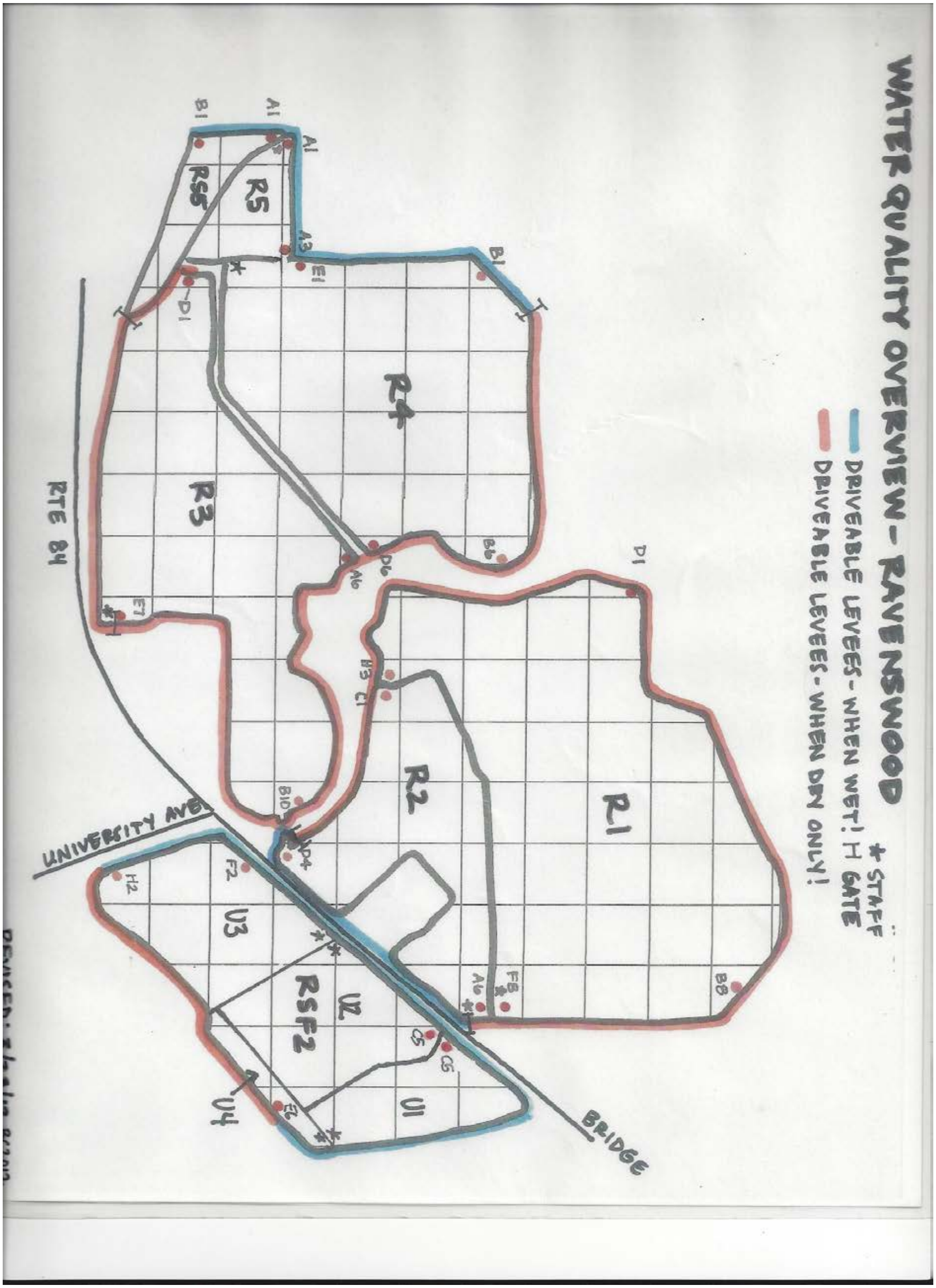
REVISED: 3/20/12
BC-2012


WATER QUALITY OVERVIEW - RAVENSWOOD
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DRIVEABLE LEVEES - WHEN WET! H GATE
DRIVEABLE LEVEES - WHEN DRY ONLY!
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RTE 84
UNIVERSITY AVE
BRIDGE

Appendix B

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Inventory and Monitoring Program

3020 State University Drive East, Suite 2007

Sacramento, California, 95819

3 4 2015

MEMORANDUM

To: Melisa Amato, Acting Refuge Manager, Don Edwards San Francisco Bay National Wildlife Refuge

From: Rachel Esralew, Hydrologist, Inventory and Monitoring Program, Sacramento, CA

Subject: Review of continue water quality data collected at sites A16 and SF2 at Don Edwards San Francisco Bay National Wildlife Refuge

Dear Melisa,

I reviewed the continuous water quality data for sites A16 and SF2 at Don Edwards National Wildlife Refuge. In short, I have some concerns about several parameters. The biggest issues are likely dissolved oxygen. DO at both sites frequently goes anoxic at night or at higher tide, which can be a concern for some aquatic organisms.

However, there was some uncertainty as to the degree of accuracy of all of the DO readings at both sites. Further QA should be done in the future to ensure that readings are representative of true water quality conditions.

In summary, to preserve data quality, I recommend that you:

1.) Delete the dissolved oxygen data from 9/3 to 9/22/2014 at A16 (sensor was excessively fouled)
2.) Delete all sensor data at A16 where SC values went below 36 mS/cm (sensors were likely out of water; or a bubble was present in the SC sensor)
3.) Delete depth data at SF2 from 9/2 to 9/22 (sensor was likely not reading correctly)

I have taken the liberty of applying these corrections and adding data quality ratings based on my review, which can be found in the excel file **2014_ContinuousQW_A16_SF2_Data_Cleaned_Reviewed_REsralew_20150304.xlsx**.

Background

Hydrolab continuous water quality sensors that measure temperature, dissolved oxygen (DO), specific conductivity (SC), salinity, and pH were deployed in late summer (August through early October) at two stations at the Don Edwards San Francisco Bay National Wildlife Refuge (DESFBNWR): A16 and SF2. Both sites are deployed at the discharge channel for pond units A16 and SF2, which are the terminal units for a multi-unit flow system. Site SF2 is located at 37°29'26.85"N and 122° 7'38.26"W. Site A16 is located at 37°26'35.17"N and 121°57'42.57"W.

Data are used to report to the California Regional Water Quality Control Board (San Francisco Bay) to maintain compliance with discharge permits. Refuge staff has requested assistance in reviewing the collected water quality data to ensure accuracy and to interpret water quality characteristics of the outflow to both units.

The purpose of this letter report is to a.) provide a review of the data quality to ensure that data of extremely questionable accuracy are not reported to the RWQCB and that data are not misinterpreted, b.) interpret characteristics of water quality data based on what is known about the sites and the system, and c.) provide recommendations for improvement of water quality data collection and field maintenance procedures to better ensure data accuracy in the future.

Data quality review

I reviewed the field reference readings and inspected the graphs of plotted data for each parameter to review the overall quality of the records. I developed a draft spreadsheet (attached to this memo) which I used to compute whether the drifts experienced from fouling and calibration were excessive enough to warrant data corrections or calibration. I based these on standard USGS procedures documented in Wagner et al (2006). Further detail on data review protocols are found in that report, but I did not repeat that in this report. I used personal judgment to determine whether a shift or data deletion was warranted based on inspection of the graphs of plotted data. Details are described below.

I also developed a spreadsheet with cleaned data and remarks pertaining to the discussion below. All of my data cleaning recommendations were made in this cleaned version **2014_ContinuousQW_A16_SF2_Data_Cleaned_Reviewed_REsralew_20150304.xlsx**.

A16

<u>General</u>

Based on your field notes, it appears that unit 45401 was deployed to A16 on 8/20/2014. The unit was then checked on 9/3/2014 although data is missing from 8/28 to 9/3 (the cause could not be determined). The unit was redeployed and checked again on 9/24 before redeployment. The unit was initially checked on 10/6 against the field sensor, but no fouling or calibration checks were performed before removing the in-situ sensor.

Based on field reference checks, temperature, SC, Salinity, and pH, appeared to be generally adequate at this station.

The fouling and drift correction on all data from 9/24 to 10/6 were not available because these parameters were not checked after sensor removal. Therefore, I would rate all of the data during this period as suspect because we are uncertain of any drift. See recommendations for improving data collection in the future.

Specific Conductance/Salinity

SC looked questionable at times - SC goes to zero or close to zero very often. This is likely not happening in nature - it also corresponds to a zero or negative salinity. It could be that your probe is out of water during these times, or there is a bubble in the sensor. ***I recommend deleting all sensor records where SC data was less than 38 mS/cm***. If the SC sensor is out of water, the rest of the sensors might also be as well. Salinity is computed from specific conductivity, so the same rules apply.

Dissolved Oxygen

The fouling drift for dissolved oxygen on the 9/3 visit was computed to be 4.2 mg/L, or 300 percent of the initial measured value. This most certainly indicates that the sensor was extremely fouled, and protocols in Wagner et al recommend data deletion. However, upon inspection of the plotted DO data, it appears that data look relatively reasonable from 8/20 to 8/28 before the sensor stopped reading. Therefore, I assumed that the fouling occurred after 8/28 and opted not to delete the data.

The fouling drift for dissolved oxygen on the 9/24 visit was computed to be 1.97 mg/L, or 75 percent of the initial value. The drift does not look to be gradual, but occurring almost immediately after your last site visit as indicated by extremely low DO values from 9/3 to 9/24. This is common in a DO sensor. This can occur if the sensor becomes buried in sediment, or there is a problem with the membrane. You can tell because your peaks pick up after that date. ***Therefore, I recommend deleting all of the DO data from 9/3 to 9/24 at this station because of highly questionable quality.***

SF2

General

Based on your field notes, it appears that unit 43105 was deployed to SF2 on 8/18. The unit was then checked on 9/2 but was removed prior to finishing post-cleaning readings. The unit was redeployed on 9/3 and checked again on 9/22 before redeployment. The unit was initially checked on 10/6 against the field sensor, but no fouling or calibration checks were performed before removing the in-situ sensor.

Based on field reference checks, temperature, SC, Salinity, and pH appeared to be adequate at this station. Depth at SF2 was not reasonable; there was a sudden jump from under 2 feet to over 10 feet during the second deployment period (9/3 to 9/22/2014). The data with the jump did not demonstrate tidal patterns like the data from 8/18 to 9/3 or 9/24 to 10/6. ***Therefore, I recommend that you delete the depth data from 9/3 to 9/22/2014.*** The rest of the data appear reasonable, therefore I do not think that sensors were compromised.

The fouling and drift correction on all data from 9/22 to 10/6 were not available because these parameters were not checked after sensor removal. Therefore, I would rate all of the data during this period as suspect because we are uncertain of any drift. See recommendations for improving data collection in the future.

Dissolved Oxygen

Dissolved oxygen was suspicious because a.) readings were consistently much lower in the in-situ monitor than the field monitor, and b.) because pre-calibration readings were not made. Furthermore, dissolved oxygen data checks indicated some deficiencies.

Even though protocols in Wagner et al (2006) recommended that the data be deleted from 8/18 to 9/2 because of excessive fouling drift (29 percent change), I opted not to adjust or delete DO data because I was uncertain about the accuracy of the excessive fouling shifts. However, I would rate these data as suspect.

A data correction for fouling was recommended from 9/3 to 9/22 because the data drifted by +.52 mg/L. This was counter-intuitive because typically fouling causes lower readings, not higher. It appears that the membrane was change during the de-fouling procedure. The DO sensor needs time to stabilize after the membrane is changed, sometimes up to 30 minutes. This might have explained the higher reading on the DO sensor. However, because of these uncertainties, I would rate the data as suspect.

pH

Initially, the pH sensor had substantial drift when calibrated prior to deployment (it read 1 unit higher in the 7 standard). While this was concerning, field readings showed that the sensor was reading within limits. I will assume that there was an issue with calibration but that it was resolved before deployment.

Temperature

Technically, the fouling drift on temperature was beyond the limit where data corrections are recommended. However, the field monitor showed great variation, likely because it was 24 hours before the de-fouling checks were made. I opted not to correct the data because I was uncomfortable with making a fouling drift correction. However, I have rated the data as fair.

General observations

Stagnant water would potentially explain your large DO variation and low DO at night at both sites.

It looks like you have far fewer unit cells that water has to travel through for SF2 than you do for A16 - I would expect higher SC the longer that water has to travel through units because of increased evaporation time. However, the SC was higher at SF2, which was not expected.

However, this would be relative to SC of the source water and how long water is held before release, not necessary on the travel distance between units. It looks like the source waters for A16 might be influenced in part by Coyote Creek, which I presume will have much lower SC than the Bay. Whereas with SF2, you really don't have as large of a freshwater input (inflow is coming from West Bay).

SC dropped at SF2 considerably on 9/28 - this could be because you had a flush of lower conductivity water into the unit. The SC at A16 has dropped more gradually over time, but I'm not sure of the reason.

Having water quality information for the source waters would be helpful to better interpret the meaning of these results - and to determine the impact that wetland management is having on water quality. If you ever decide to expand your monitoring, I suggest putting water quality monitors in source waters (so, for example, monitoring continuous water quality in the inlet channel of West Bay before it enters the R and S units; monitoring continuous water quality in Coyote Creek and/or Artesian Slough before it enters units A9-A16).

<u>Dissolved Oxygen</u>

As for pure concentrations, the only parameter that jumps out at me is the low DO and anoxic conditions. The large difference between the calibrated field meter and the in-situ monitor (whereby the in-situ monitor reads much lower than the calibrated field meter) has me suspicious that these data are not accurate. The fouling checks at SF2 were insufficient for me to determine whether the readings were real. The calibration readings seem to be alright, but without pre-calibration checks its hard to tell (see review of data quality for more information).

Assuming these data are correct, in general, concentrations below 2mg/L can cause acute effects for a host of aquatic species (at least in laboratory) - however, this is generally for persistent conditions and doesn't include these annual variations that you are seeing. Temporary dips into anoxic conditions are more complicated. The longer that anoxic conditions are present, the more aquatic organisms are at risk for exposure or recruitment issues. For example, in one experiment on the east coast, a 50 percent mortality was experienced in larvae when DO dipped below 2mg/L for 4 hours.

This doesn't mean that the conditions are necessarily harmful. It could be that aquatic fauna have adapted to the conditions in the system. More research and experimentation would need to be done to determine if the exposure to anoxic conditions result in harm for direct exposure or recruitment

You can read more about the criteria here: http://water.epa.gov/scitech/swguidance/standards/upload/2007_03_01_criteria_dissolved_docriteria.pdf

Anoxic conditions coupled with sulfate-reducing bacteria can also be a problem for mercury because these conditions facilitate methylmercury production. I don't know whether the concentrations you are observing have this effect.

pH

While not a real worry, pH also appears to get a little high at both sites at times (above 8.5). The EPA Saltwater Aquatic Life Protection criteria technically states that pH should be from 6.5 to 8.5 (mostly for marine waters), but is acceptable at 6.5 to 9.0 for shallow highly productive coastal and estuarine areas (the same as for freshwater). This is mainly to avoid a lethal limit of 9 for many fish species. Rapid fluctuations beyond baseline variability should be avoided (to avoid changes in mobilization of metals), but you do not have enough data to determine what normal variability is.

References to the pH criteria can be found in this very old book. It is still used today, in absence of more site-specific information.

http://water.epa.gov/scitech/swguidance/standards/criteria/current/upload/2009_01_13_criteria_redbook.pdf

Site-specific observations

A16

Dissolved Oxygen

Do varies with tidal depth, with peak DO at low tide. This is not surprising as seawater generally contains less dissolved oxygen than freshwater - this is also caused by the fact that seawater has a lower 100 air saturation of oxygen than freshwater.

The low DO conditions show that the water has gone anoxic (less than 2 mg/L) at high tide. While these conditions are not conducive to many aquatic organisms, I'm not sure what your biological objectives are for this location.

Specific Conductance/Salinity

No real association with depth could be seen, which seems surprising to me. The variability is quite low in the system. Consider measuring in µs/cm instead of ms/cm - you'll get one additional significant figure.

pH

pH appears to have a relation with depth as well, with lower values during peak tide. This is likely a result of seawater influence.

Temperature

Temperature varies by air temperature and is not generally affected by tidal influence.

SF2

Specific Conductance/Salinity

There are tidal variations, unlike A16. Low tide brings higher SC values. I wouldn't have expected this given that in a normal tidal system, this would be when fresher water is of greater influence and SC should be lower. However, I have no information about where this sensor is situated to explain why this is occuring. The variations at tides are still very low (ranging about 150 µS/cm).

pH

The relation between tidal variation and pH is slightly off. Peak pH occurs slightly before peak tide. It could be more closely related to diurnal air temperature.

Dissolved Oxygen

The relation between tidal variation and DO is slightly off. Peak DO occurs just before peak tide. It could be more affected by diurnal temperature than tide. Low DO (and anoxic conditions) are more likely to occur at night (when temperatures are low too) when plants are not photosynthesizing and not producing oxygen.

Temperature

Temperature varies by air temperature and is not generally affected by tidal influence.

Recommendations for improving data collection to better evaluate data quality

After reviewing the reference readings, I see some problems that have prevented me from adequately correcting your data. In summary, pre- and post- cleaning and pre- and post- calibration readings are necessary in the field to determine how much drift is acceptable. Without this information, it is difficult to verify the accuracy of data, and inaccurate readings may be mistaken for actual water quality conditions, leading to incorrect interpretation and management.

Here are my specific review comments and recommendations on your field readings:

1.) Be sure to log your dissolved measurements both pre *and* post calibration. Pre-calibration is much more important in the field. This will tell you how much drift you have, and whether the previous readings were acceptable.

2.) It looks suspiciously like you weren't recording the pre-calibration readings on specific conductivity for SF2. I'm surprised that it was spot on every time? Like dissolved oxygen, be sure that you are recording your readings pre-calibration, that way we can determine if the drift was acceptable.

3.) Don't replace the DO membrane until after your fouling and calibration checks. It can take the DO sensor quite some time to stabilize after a new membrane, sometimes up to 30 minutes. Therefore, post membrane-change readings might not always read correctly. Also, this way, you can see what impact the tear in the membrane had on reference readings.

4.) I recommend moving your sensors over to LDO if possible, because they are sturdier and you won't lose as much data to fouling or scratches in the membrane. If you keep the clark cell DO sensors, I strongly recommend changing the membrane after you perform a calibration check but before you re-deploy, so you can get the maximum life out of the sensor.

5.) Even if you are removing a sonde from deployment, finish your fouling and calibration checks. Again, you'll need these to look at the last set of logged readings to determine drift. Try to complete your fouling and calibration checks before removal of the sonde, even if you are going to return the unit to the field the next day.

To determine whether you should adjust the data for calibration drift or fouling, use the following thresholds. If your reference sensor and field sensor are different by more than this amount, you should apply a correction to the data. Fouling and calibration corrections are computed separately, but added in the end to determine the degree of shift.

The draft spreadsheets I attached includes all of these calculations (**A16_Correction_Worksheet.xlsx**, **SF2_Correction_Worksheet.xlsx**)

Table 7. Calibration criteria for continuous water-quality monitors.

[±, plus or minus value shown; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; mg/L, milligram per liter; pH unit, standard pH unit; turbidity unit is dependent on the type of meter used]

Measurement	Calibration criteria (variation outside the value shown requires recalibration)
Temperature	±0.2 °C
Specific conductance	±5 µS/cm or ±3 % of the measured value, whichever is greater
Dissolved oxygen	±0.3 mg/L
pH	±0.2 pH unit
Turbidity	±0.5 turbidity unit or ±5% of the measured value, whichever is greater

To determine whether you should delete the data for severe calibration drift or fouling, use the following thresholds. If your reference sensor and field sensor are different by more than this amount, you should delete the data. Conservatively, you should delete all the data for that period (the time since your last check) unless you can pinpoint where the error might have occurred.

Table 17. Maximum allowable limits for continuous water-quality monitoring sensors.

[±, plus or minus value shown; °C, degree Celsius; %, percent; mg/L, milligram per liter; pH unit, standard pH unit. Data corrections that exceed the maximum allowable limits should not be stored in the database]

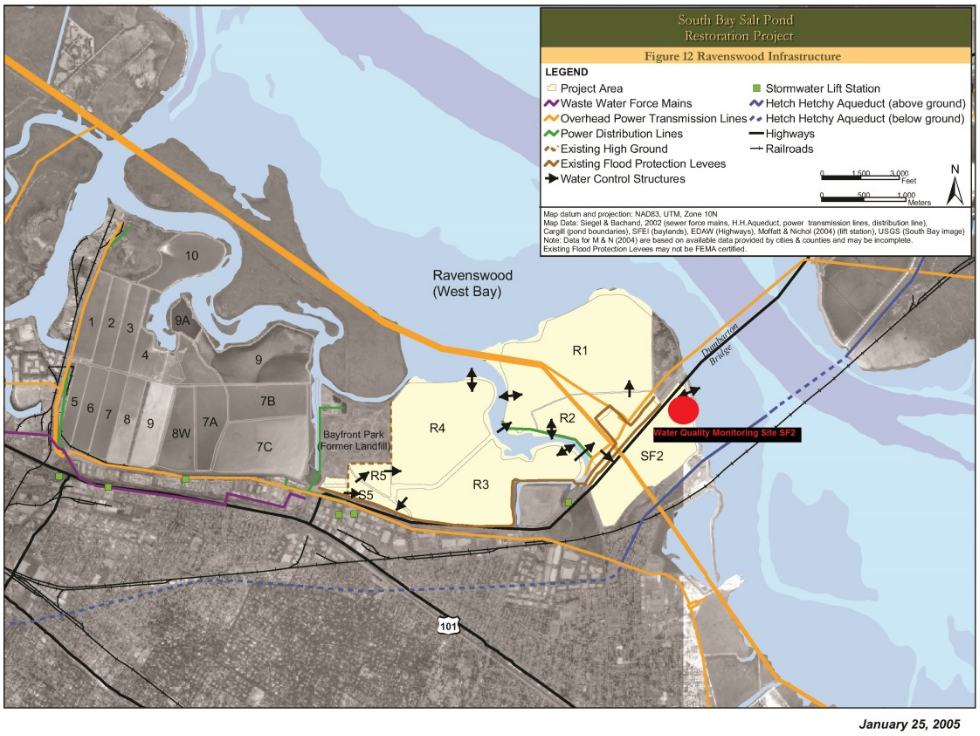
Measured field parameter	Maximum allowable limits for water-quality sensor values
Temperature	±2.0 °C
Specific conductance	±30%
Dissolved oxygen	±2.0 mg/L or 20%, whichever is greater
pH	±2 pH units
Turbidity	±3.0 turbidity units or ±30%, whichever is greater

More comprehensive information about USGS standard protocols for continuous water quality measurements and reporting can be found here: http://pubs.usgs.gov/tm/2006/tm1D3/pdf/TM1D3.pdf

References

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at http://pubs.water.usgs.gov/tm1d3

Phillip Williams and Associates. 2005. Flood Management and Infrastructure Existing Conditions Report http://www.southbayrestoration.org/pdf_files/Flood_Management_Existing_Conditions.3.30.05.pdf



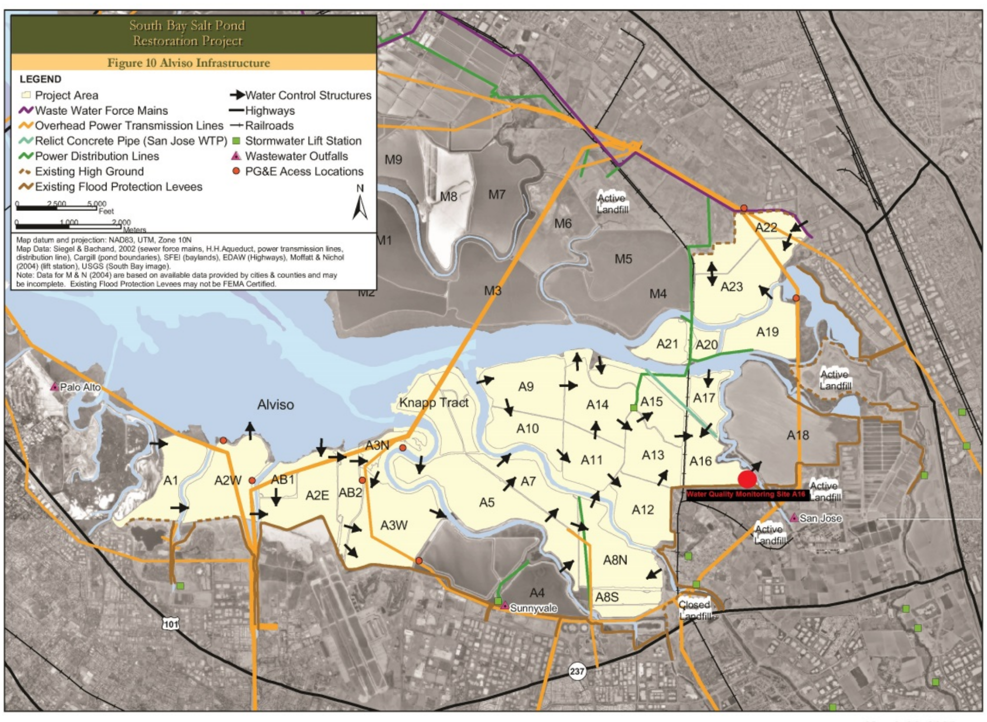


Figure 1. Locations of continuous water quality monitors at sites A16 and SF2 at Don Edwards San Francisco Bay National Wildlife Refuge (adapted from Phillip Williams and Associates, 2005)

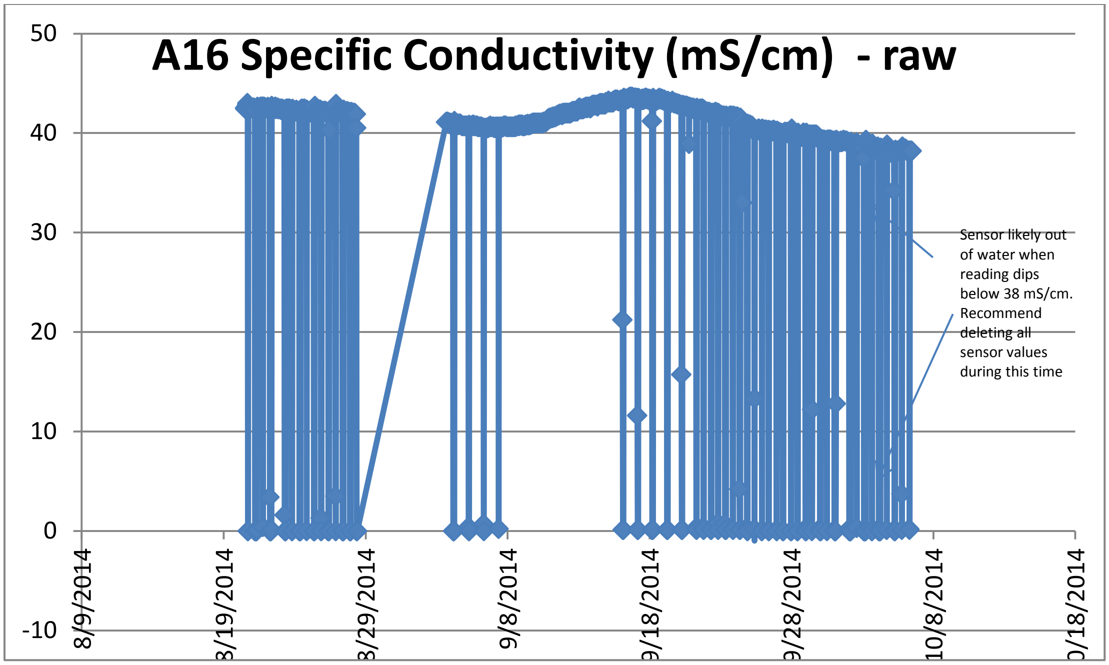


Figure 2. Raw specific conductivity at site A16 from August to October 2014

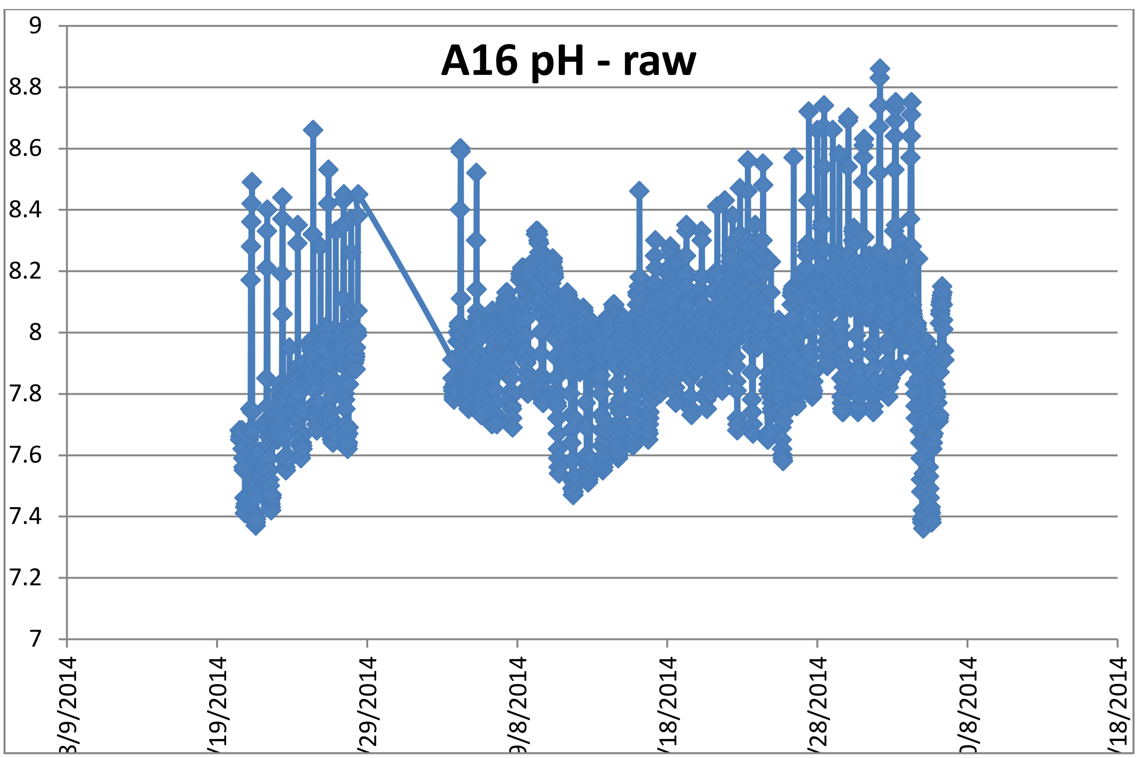


Figure 3. Raw pH at site A16 from August to October 2014

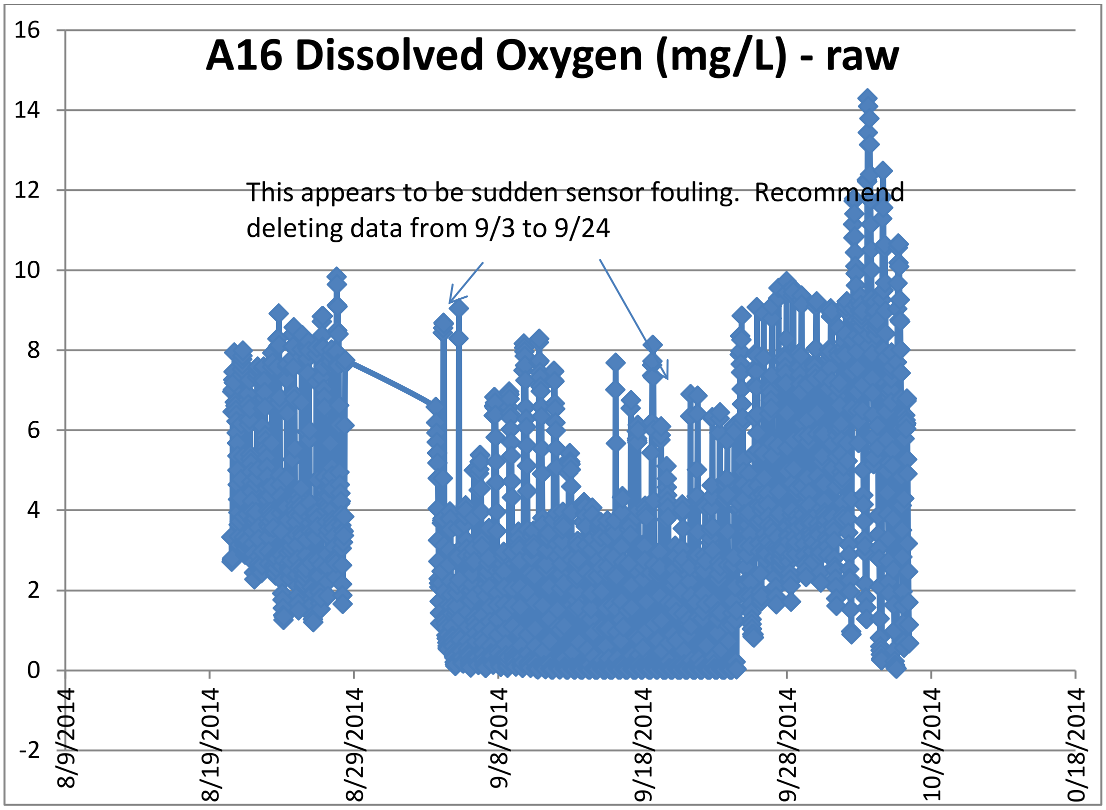


Figure 4. Raw dissolved oxygen at site A16 from August to October 2014

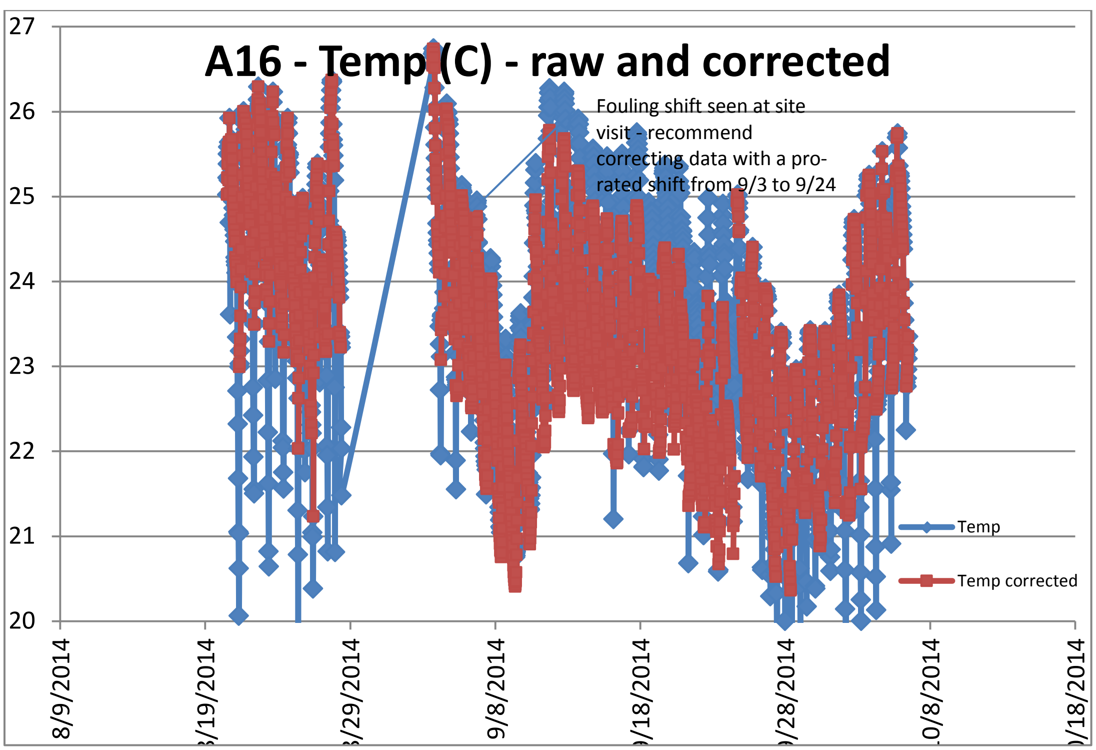


Figure 5. Raw and corrected temperature at site A16 from August to October 2014

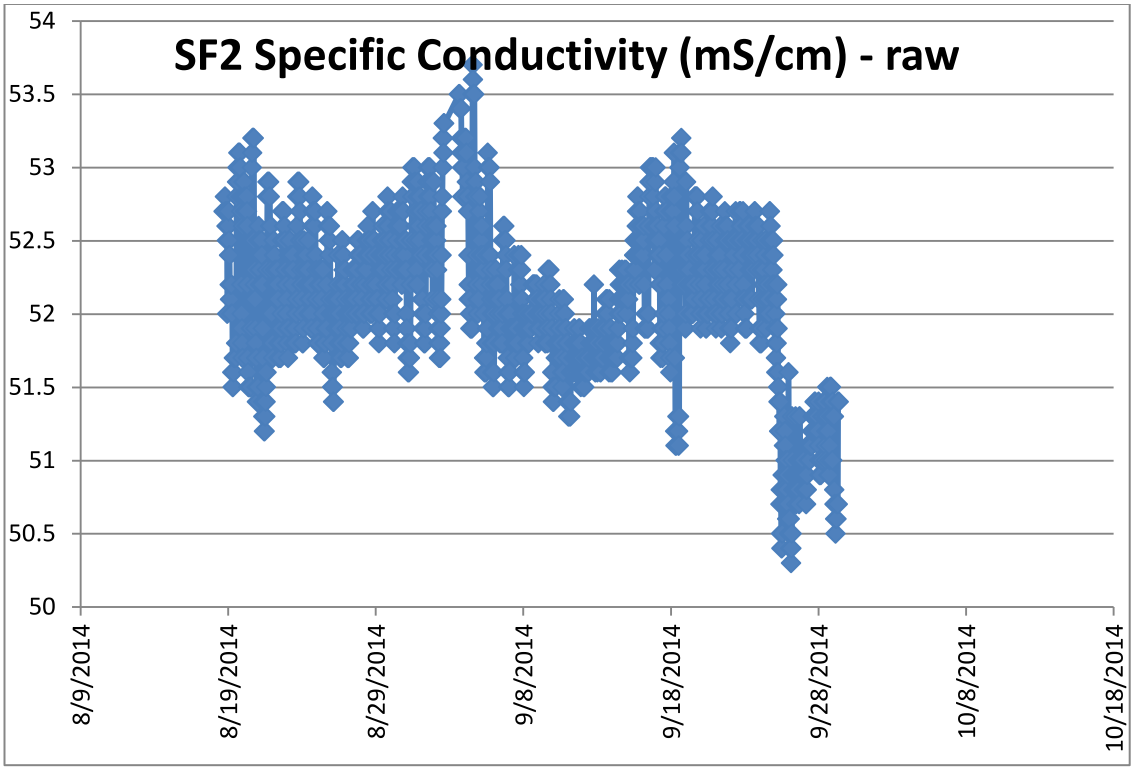


Figure 6. Raw specific conductivity at site SF2 from August to October 2014

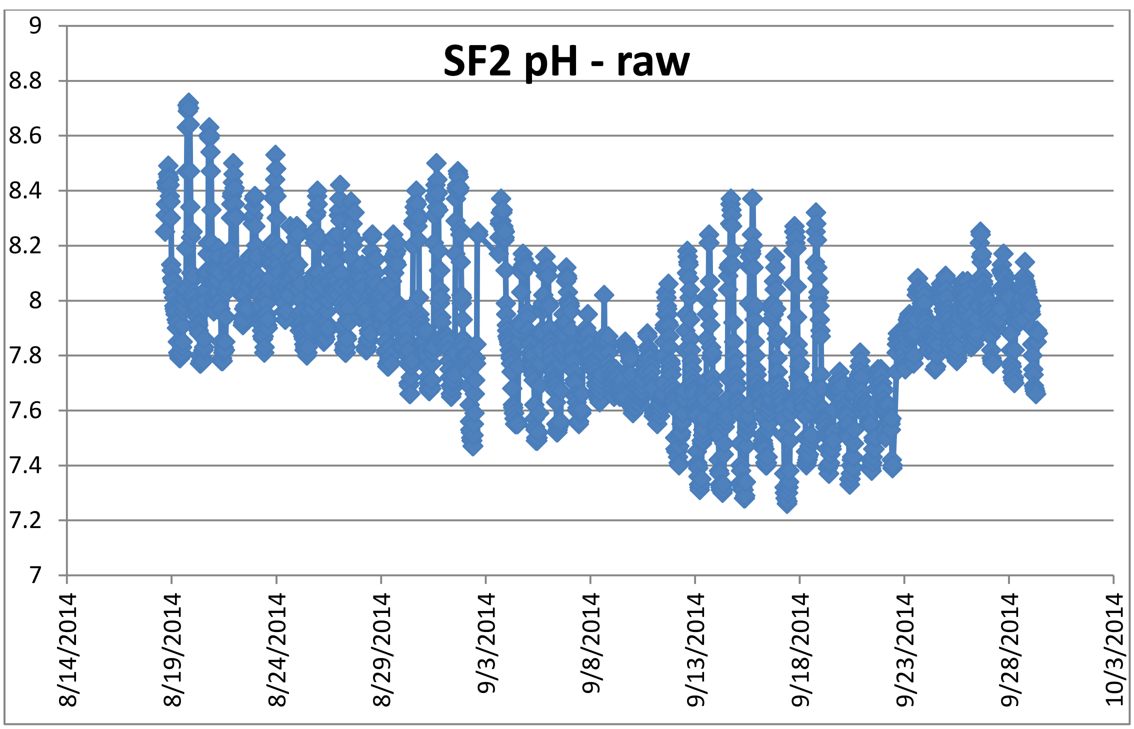


Figure 7. Raw pH at site SF2 from August to October 2014

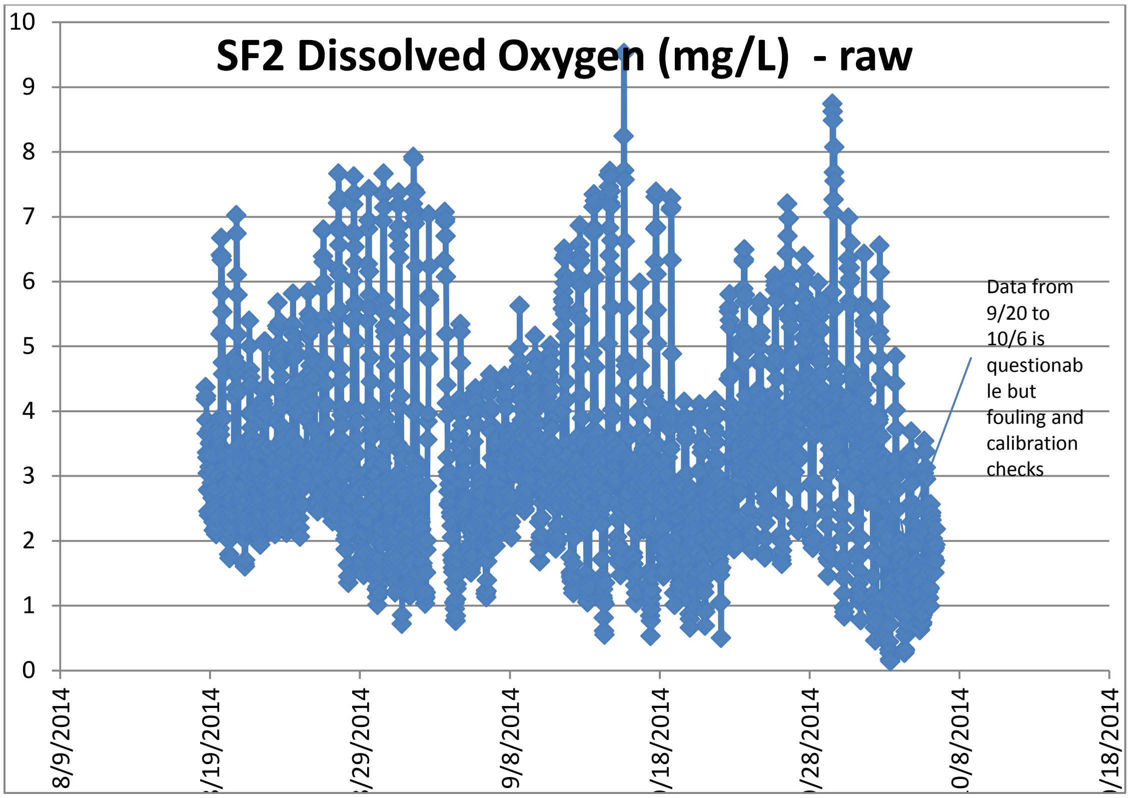


Figure 8. Raw dissolved oxygen at site SF2 from August to October 2014

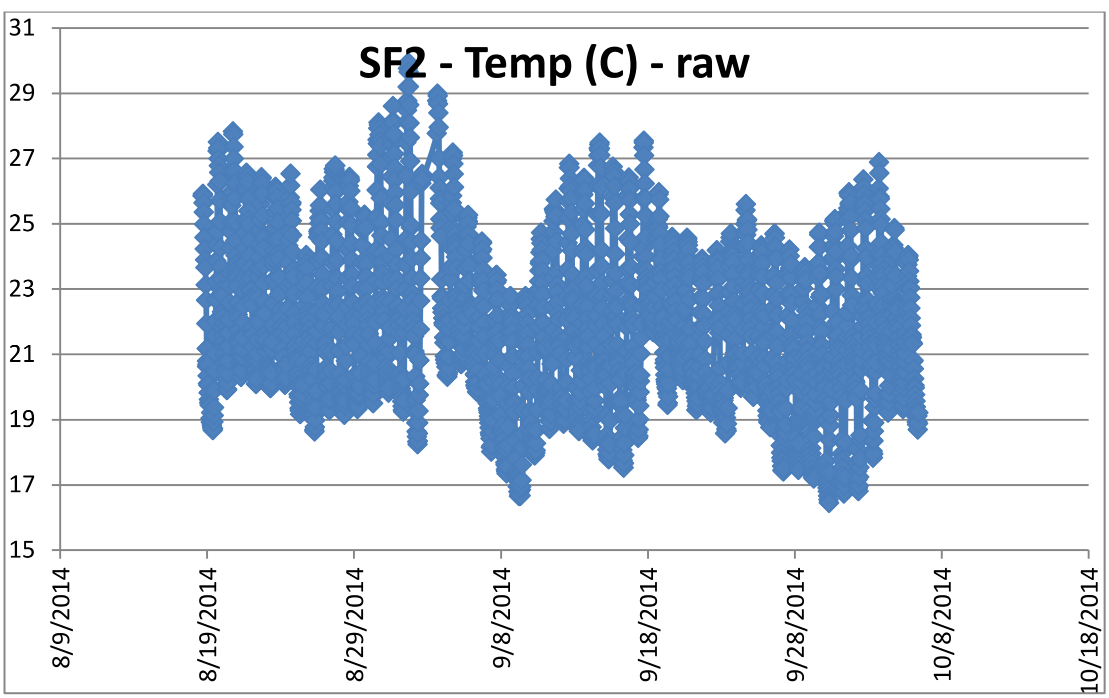


Figure 9. Raw temperature at site SF2 from August to October 2014