# Moro Cojo Slough

## Agricultural Management Practice and Treatment Project Summary

1996 - 2017

## Moon Glow Dairy

**Restoration Events**: 1996-1999, 2002-2003, 2009-2012
**Partners**: CCWG, Coastal Conservation and Research, Moon Glow Dairy
**Land Owner**: Moonglow Dairy
**Funding**: State water Resources Control Board, USEPA

### Background

Figure 1 Moon Glow Dairy Restoration Sites on August 24th, 2005 (top) and July 23, 2009 (bottom).

The first restoration work at Moon Glow Dairy took place in 1996 when a low lying 2.6 acre portion of a grazing lot was fenced off from cattle. The area was in extremely poor condition and mainly served as a mud wallow for the cows. The area was expanded by 1 acre when the southeast corner of fencing was added in 1997. The fencing prevented cattle from grazing and trampling the area and allowed for the native seedbank present in the soil to re-establish a native wetland plant population. In 2002-2003, planting of native species began. Hundreds of trees, perennial shrubs, herbaceous plants and grasses were planted. Due to historical soil disturbance at this site, there are extensive amounts of weeds, especially in the upland areas. Weed management occurred over the entire site using weed whacking and hand pulling methods. In the corners of the site we planted additional native wetland and upland species. This assisted with weed management and generally increased the habitat value of the site for wetland fauna. The wetland and the surrounding buffer zone of native plants now acts as a filter for the dairy operations on the surrounding hillsides and improves water quality running into the Moro Cojo Slough.

### Results

Water quality was improved through the project. Turbidity was reduced through the buffer areas and wetland by 30% to 75%. Multiple input points from both dairy and agricultural runoff to this site led to inconsistent trends of filtering through the wetland. Nitrate was reduced through the buffer and wetlands by 15-40%, with all exiting concentrations below the drinking water standard. Ammonia was not measured.

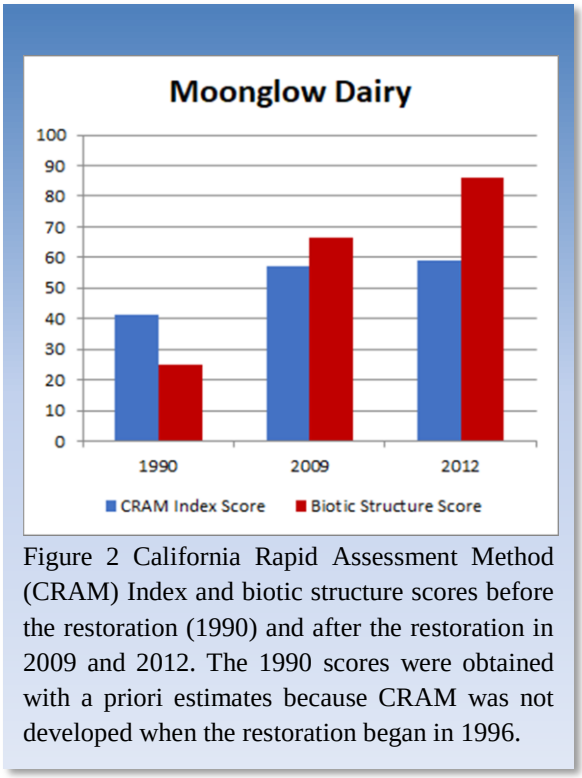


Figure 2 California Rapid Assessment Method (CRAM) Index and biotic structure scores before the restoration (1990) and after the restoration in 2009 and 2012. The 1990 scores were obtained with a priori estimates because CRAM was not developed when the restoration began in 1996.

In addition to water quality improvements, this project significantly increased aquatic habitat of the Moro Cojo Slough. Non-native plants identified for removal included: Bristly Ox Tongue (*Picris echioides*), Curly Dock (*Rumex crispus*), Hemlock (*Conium maculatum*), Mustard (*Brassica campestris*), and Radish (*Raphanus sativus*).

Species planted included: California Sage (*Artemisia californica*), Coyote Bush (*Baccharis pilularis*), Santa Barbara Sedge (*Carex barbarae*), Salt Grass (*Distichlis spicata*), Lizard Tail (*Eriophyllum staechadifolium*), Gum Plant (*Grindelia stricta*), Irishleaf Rush (*Juncus xiphoides*), Creeping Wild Rye (*Leymus tritichoides*), Bush Lupine (*Lupinus arboreus*), Common Silverweed (*Potentilla anserina*), Cottonwood (*Populus balsamifera*), Black Sage (*Salvia mellifera*), California Lilac (*Ceanothus*) and Willow (*Salix*). During the most recent enhancement effort, between 2009 and 2012, 1381 native plants for added to the site.

Table 1. Nitrate and Turbidity levels measured throughout the restoration site at Moon Glow Dairy. Results show the restoration site effectively decreases turbidity and nitrate.

| | **Above Restoration** | **Middle of Restoration** | **Below Restoration** |
|---|---|---|---|
| **Turbidity (Turbidity Units)** | 600-200 | 1200-600 | 400-50 |
| **Nitrate (ppm NO3)** | 13-1.75 | 7.5-0.5 | 5-0.25 |

# Tottino Ponds Restoration Project

**Restoration**: 1999-2003, 2009-2012
**Partners**: CCWG, Coastal Conservation and Research, PG&E, Sea Mist Farms
**Land Owner**: Sea Mist Farms
**Funding**: State Water Resources Control Board, PG&E, USEPA

**Background**

The Tottino Ponds Restoration Project took place on 14 acres of land considered unsuitable for farming due to frequent flooding (Figure 3). The total project treats approximately 50 acres of farm runoff and sends treated water to an ag ditch that eventually flows into the Moro Cojo Slough (note: flow was later redirected to an adjacent wetland restoration project in 2016). The original site had been flat land covered with annual non-native plants. It had been regularly disced and baited with poison to prevent an excessive rodent population from invading nearby crops. Five ponds were created in 1999 by excavating shallow basins and pumping in water. Water was originally pumped to the ponds during restoration using a pipe system that brings recycled water to farms. An additional 6th pond was created in 2002 adding another 2 acres of wetland. Water is now sourced from groundwater, adjacent farm runoff, and road drainage. Weeds were removed by mowing, weed whipping and hand removal as well as flooding.

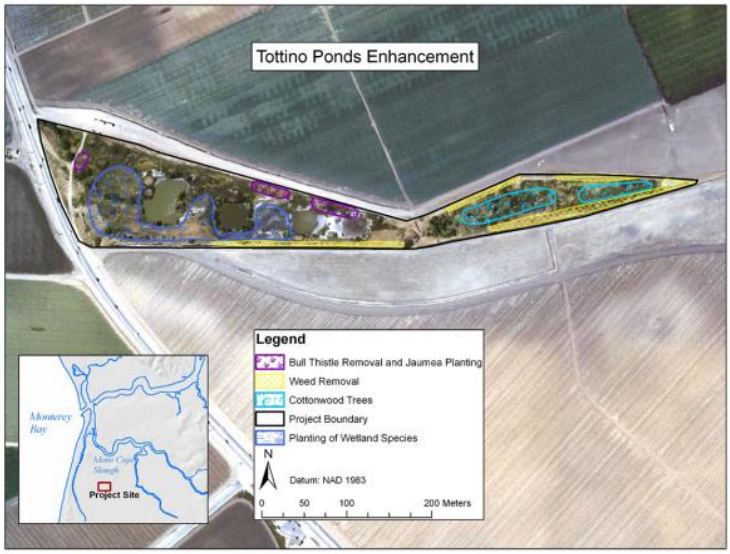


**Figure 3 Overhead schematic of Tottino Ponds**

Figure 4 Tottino Ponds Restoration Sites on January 25th, 1998 (left), January 4th, 2008 (middle), and August 4th, 2017 (right). In 1998, the site was bare dirt, and after the restoration, willows and other native plants have become prevalent. Biotic structure of the site has improved significantly during this time.

Over the past twenty years this site has shown a dramatic transformation from a barren field to a fully functioning wetland ecosystem with breeding birds, threatened amphibians and a diverse freshwater invertebrate community. Ongoing weed management is needed to maintain the dominance of native plants. This is especially true along the edges, which come in contact with farm equipment. The newer ponds at the eastern end of the site have become overrun with rushes. These rushes die each year and create a dense mat of dead vegetation, ideal for rodent communities.

**Results**

In total, 550 trees and 60 shrubs were planted in addition to seeding (drilled or broadcast) across 12 of the 14 acre site. The site was assessed with CRAM in 2009 and 2012, and both the CRAM index score and biotic structure scores increased for perennial and seasonal ponds during this time. An a priori estimates of initial CRAM score was 35, further recognizing the habitat value of this restoration project.

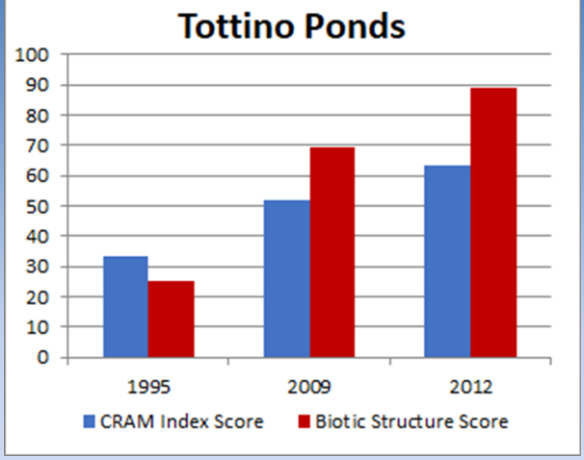


Figure 5 CRAM scores and Biotic Structure Scores at the Tottino Ponds Restoration Site before the restoration (1995) and after the restoration in 2009 and 2012. The 1995 scores were obtained with an a priori estimate because the CRAM method was not yet developed in 1995.

Because of the diffuse origin of the source water, no water quality monitoring has occurred.

## *Dolan Conservation Easements and North and South Fingers Restoration*

**Restoration**: 2009-2012
**Funding**: Moss Landing Power Plant
**Land Owner**: Dolan Family
**Other Partners**: Lazzerini Farms, Monterey County Agricultural Land Trust, Creative Environmental Consulting, Coastal Conservation and Research, Melanie Mayer Consulting

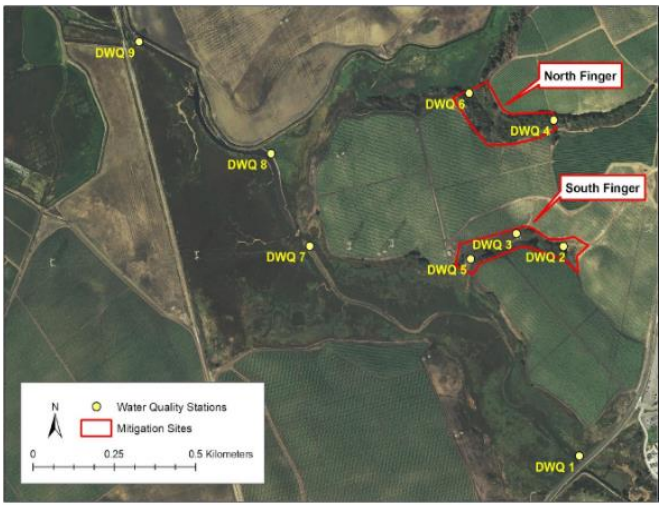


Figure 6 Locations of North and South Finger Restoration

**Background**

The Monterey County Agricultural Land Trust negotiated with the Dolan family to place habitat (122 acres) and agricultural (281 acres) conservation easements on parcels in the Moro Cojo watershed. The easement contributes to larger wetland restoration and conservation efforts in the Moro Cojo Watershed, improving the ecological value of Moss Landing Power Plant's off-site mitigation investment. To enhance wetland and upland habitat resources within the lower Moro Cojo watershed, this project created areas for freshwater impoundments within the lower slough watershed between Moss Landing Road and Castroville Boulevard.

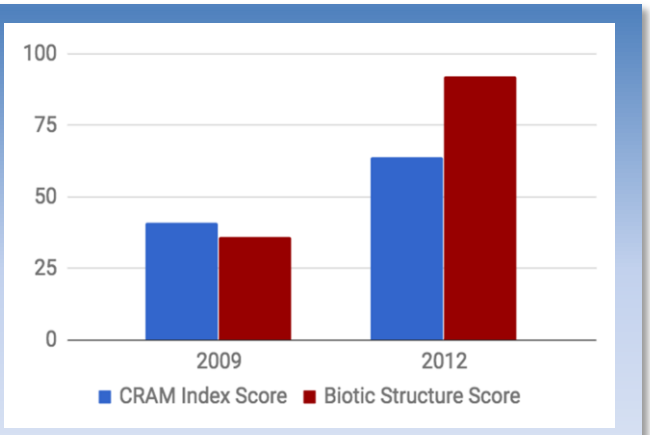


Figure 7 CRAM Index and Biotic Structure scores for the Dolan North and South Finger Restoration in 2009 and

The project also included the creation of buffers between wetlands and agricultural land uses, specifically in areas upstream of the Southern Pacific Railroad Tracks. Within the North and South finger project, sediment catchment basins were designed for both "fingers" of the wetland, and a raised road and culvert were created in the South finger. The North Finger treats about 120 acres of farm land, while the South Finger treats about 65 acres. The entire wetland easement area was fenced off, and weeding and planting were done in both fingers. Water quality, amphibians, and birds were monitored before and after the restoration.

**Results:**

The restoration site was assessed with CRAM in 2009 and 2012, at the beginning and end of the restoration effort. CRAM Index scores and Biotic Structure scores both increased during this time (Fig. 7). The presence of native plants has increased significantly from the site's initial weedy state.

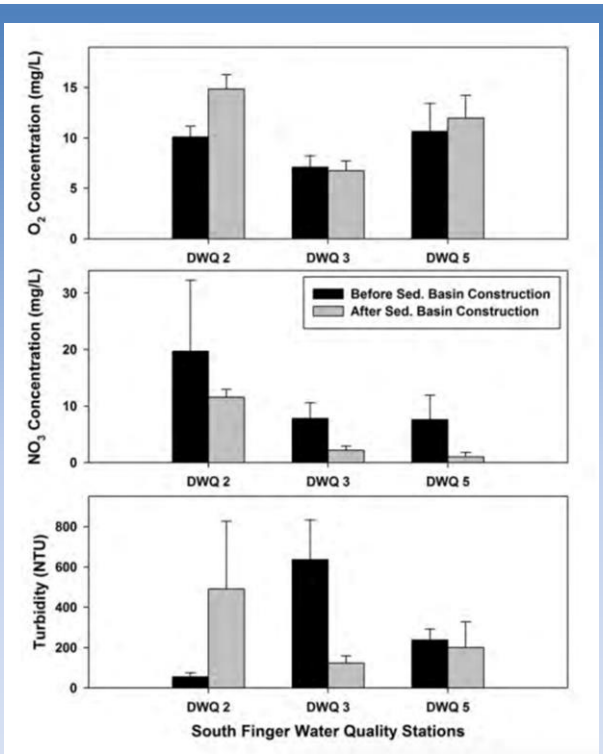


Figure 8 Water quality parameter changes before and after implementation of the sediment basin. Shown are oxygen, nitrate, and turbidity at South Finger

Most of the water quality data were measured in the South Finger, because water has rarely ponded in the North Finger during the relatively dry winters of 2010-2012. Water quality monitoring was conducted following large storm events. A YSI, Turbidometer and pH monitor were used onsite to measure water quality parameters including temperature, salinity, turbidity and pH (Figure 8). Grab samples were collected, labeled, and then frozen for lab analysis. At the end of the season the samples were analyzed for nutrient levels at Moss Landing Marine Labs. Nitrate concentrations at all three monitoring locations in the South Finger showed significant reduction post construction of the sediment basin compared with pre-construction by more than 50%.

## Sea Mist Farms Treatment Wetland and Bioreactor

**Restoration**: 2006 - present
**Funding**: State Water Resource Control Board
**Land Owner**: Ocean Mist Farms
**Partners**: CCWG, PG&E, Monterey County, California Public Utilities Commission, Ocean Mist Farms
**Cost**:

SeaMist Treatment Wetland: $1,096,999
SeaMist/Oceanmist Bioreactor:
Construction: $88,000
Land: $5000
Bioreactor Total: $93,000
**Total: $1,189,999**

**Background**

In 2006, CCWG built a treatment wetland at Sea Mist Farms to treat agricultural runoff from adjacent farms. Three ponds and connecting channels totaling more than 21 acres of shallow freshwater habitat were created on the Sea Mist parcel, just downstream of the Union Pacific Railroad crossing (Figure 9). Water from approximately 150 acres of irrigated agriculture is directed to this restoration site for treatment and to provide valuable freshwater habitat. Water was also diverted from Castroville Slough to the Sea Mist parcel, flooding approximately 20 acres. Additionally, the north side of the main channel of the slough was fenced off from cattle providing an important opportunity for restoration of the main Moro Cojo channel. Wetland and upland habitat were planted or drill seeded with native plant species to provide habitat and reduce erosion.

In 2016, CCWG added a bioreactor to the treatment system at Sea Mist Farms. The Ocean Mist bioreactor is a one-acre triangular shaped woodchip water quality treatment system designed to

remove nitrate and other contaminants commonly found in agricultural runoff. Agricultural water in the project area runs off agricultural fields predominantly growing artichokes and brussel sprouts into a series of ditches and is diverted via a pump to the treatment bioreactor. The Ocean Mist bioreactor treats this water, primarily through microbial processes to remove nitrate, before it is discharged into the natural wetland habitat of the Sea Mist wetland. Water quality is further improved through the restored SeaMist Wetland before it eventually reaches the Moro Cojo Slough.

Although the system is designed for low maintenance, periodic maintenance activities will occur to assure its continued effectiveness. Native plantings on the containment berm and weed suppression activities will be completed as needed, and the wood chips will be replaced periodically as needed. Water chemistry data will be collected to quantify nutrient load reduction. The chambers may be emptied for maintenance and water may be diverted through a single or neither of the chambers as needed. If the chambers become an attractive nuisance to wildlife the chambers may be covered or fenced as needed to dissuade wildlife from entering the treatment system area.

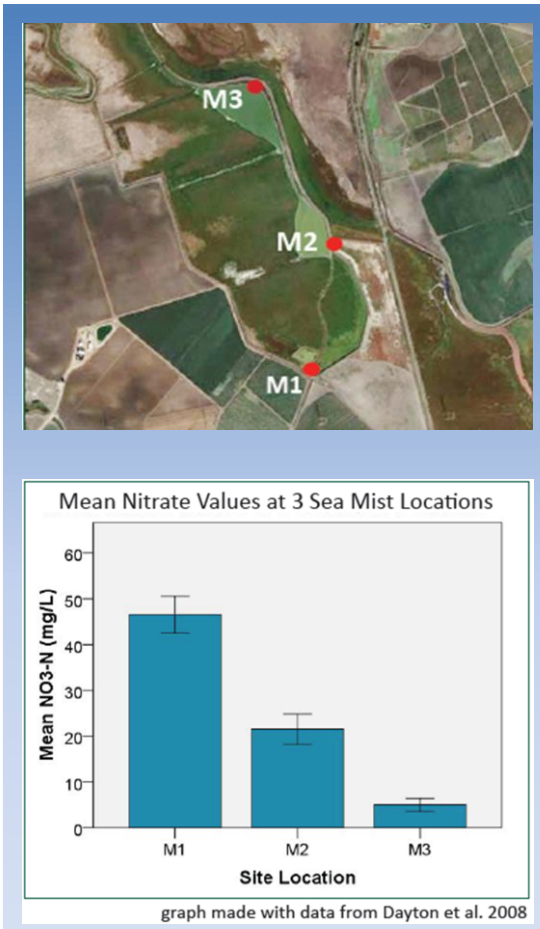


Figure 9 Sea Mist Treatment Wetland nitrate levels at three different locations: M1 (upstream), M2 (midstream) and M3 (downstream). Results show that the wetland effectively decreases nitrate levels.

**Results**

During the course of this restoration, 6640 plants were planted (shrubs, trees grass plugs), as well as 300 lbs of native grass seed and 350 lbs of creeping wild rye.

Of the plants that were planted, 3902 survived through December 2007. The highest mortality was of Lupine species at the Middle Moro Cojo Site as well as numerous plants at the North County High School. Lupine was planted along the border of the cleared area and the extensive stand of non-native mustard that borders the restoration site at the Middle Moro Cojo. The goal was to use a fast growing native species that would create a barrier to the mustard and inhibit movement into the restoration site. However, Lupine were consumed by deer, and likely rabbits as well. Other species that had high mortalities included willows, cottonwoods, and oaks at the Middle Site. These

species were planted near the inflow site and appeared to have died due to drought or perhaps high levels of minerals in the soil. There was also significant mortality at North County High School Site due to mowing. This was an example of poor communication between restoration staff and managerial staff.

Water quality also improves as water flows through the treatment wetland. Nitrate at the inflow was measured at a concentration of 40 mg/L while nitrate at the outlet was measured at a concentration of 10 mg/L. Flow also varies throughout the wetland, and this varied flow rate can be used to determine the mass removal of nitrate. At Mid 1, 45.9 mg/l x 98,412,829 L = 4517 kg of nitrate were present. At Mid 3, 4.4 mg/L x 98,412,829 L = 433 kg of nitrate were present. The result is a net loss of 4084 kg of nitrate.

CRAM assessments were completed at the treatment wetland before and after the restoration. The CRAM Index and Biotic Structure scores of the north and south ponds of the treatment wetlands improved between 2006 and 2009.

The Sea Mist bioreactor also provides nitrate reduction. It has been observed to provide 42% nitrate load reduction and 29% orthophosphate reduction. Estimates of annual load reduction are unavailable at this time.

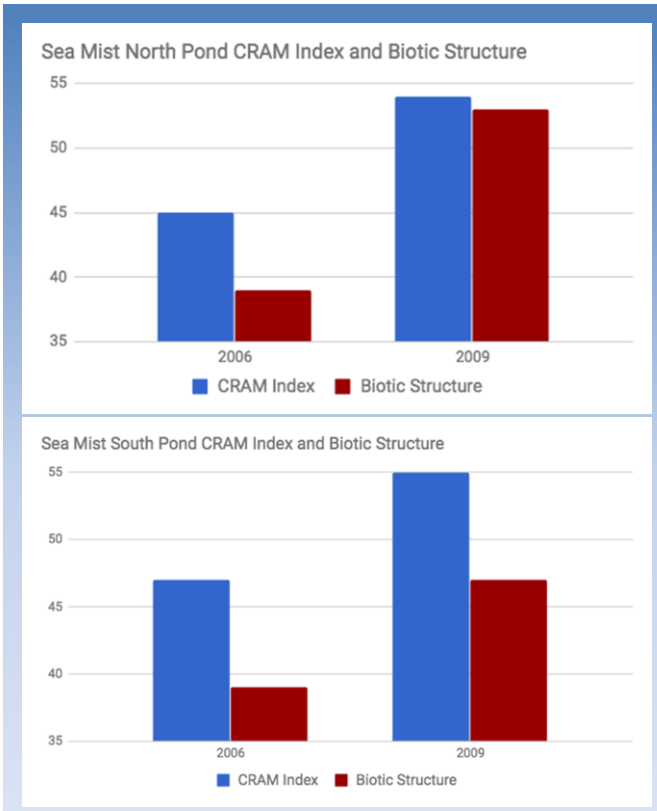

Figure 10 CRAM index and Biotic Structure scores for the North and South Ponds at SeaMist in 2006 and 2009.

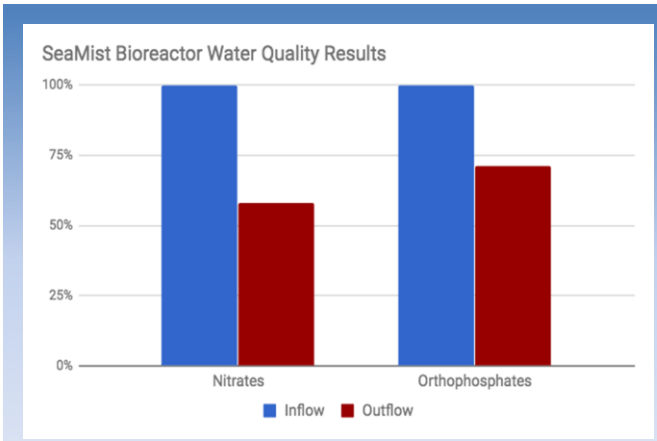

Figure 11 Nutrient reduction at the Sea Mist bioreactor.

# PG&E Treatment Wetland and Bioreactor

**Restoration**: 2013 - present
**Land Owner**: Pacific Gas and Electric
**Funding**: State Water Resource Control Board
**Partners**: CCWG, PG&E, Monterey County, California Public Utilities Commission
**Cost**:

Planning & Engineering: $100,000
Permitting & Preparation: $7,000
Land: $92,000
Construction & Mgmt: $480,000
**Total Cost**: $679,000

**Background**

The PG&E treatment wetland covers 12 acres of land in the Moro Cojo watershed. Inlet water is pumped from the Castroville Ditch which drains approximately 1000 acres of farmland, predominantly artichokes and brussel sprouts into the PG&E experimental bioreactor, which is located at the head of the PG&E Treatment Wetland. Water is then gravity fed through a 1.25 km sinuous channel with built in depressions and ponds that support wetland plants and habitats, leading to substantial denitrification for agricultural water. Treated water flows back into the Castroville Slough about 200m downstream of the inlet. The treatment capacity is estimated at 80,000 gallons/day, the average hydraulic retention time is four days.

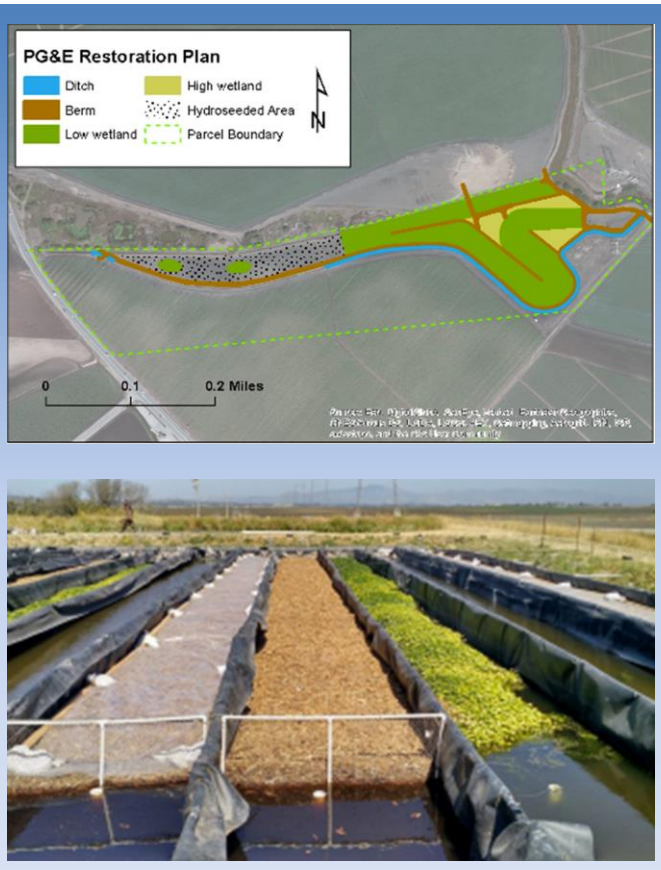


Figure 12 Depiction of the treatment wetland (top) and photograph of the bioreactor (bottom).

The PG&E experimental bioreactor is a twelve chamber treatment for incoming agricultural runoff from the Castroville

ditch. The bioreactor contains three different treatments and one control, with three channels of each. The treatments are woodchip bioreactor, heated woodchip bioreactor, and floating aquatic vegetation (*Hydrocotyl*). After flowing through the bioreactor, water flows to the PG&E treatment wetland.

**Results**

The treatment wetland was assessed with CRAM several times - before construction of the treatment wetland, after construction of the treatment wetland, and after planting. CRAM index scores increased throughout this period in three separate sections of the treatment wetland.

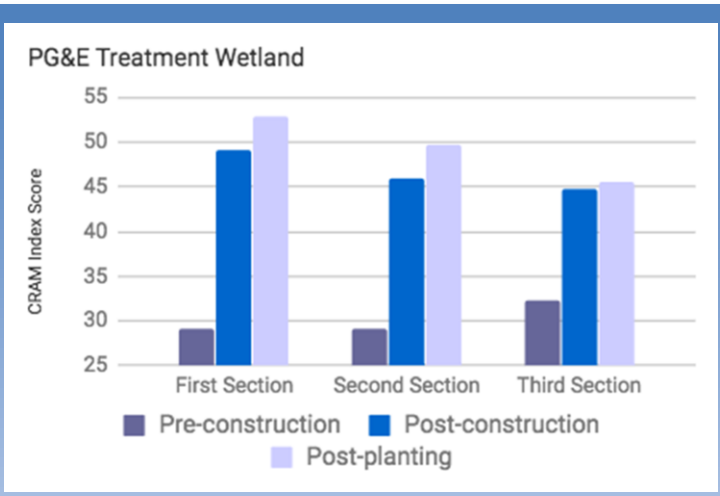


Figure 13 CRAM Index scores in three sections of the treatment wetland, during the pre-construction, post-construction and post-planting phases.

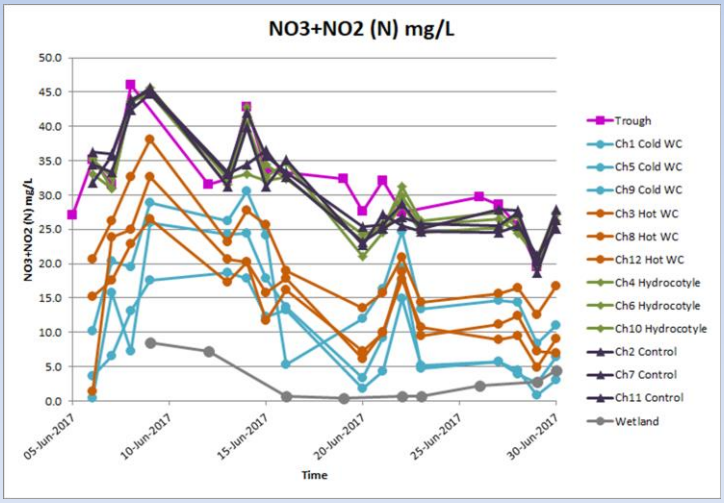


Figure 14 Nitrogen reduction levels in the PG&E bioreactor. Of the twelve chambers, the cold wood chips most effectively reduced nitrogen concentrations.

Both the bioreactor and the wetland effectively reduced nitrogen levels. Nitrate-N concentration entering the bioreactor were reduced by about 65% prior to entering the wetland at a concentration averaging under 10 mg/L. Of the three treatments in the bioreactor, cold woodchips were found to be most effective in reducing nitrogen concentrations.

Nutrient concentrations entering the treatment wetland from the bioreactor and exiting the wetland at the outlet were monitored by the CSUMB Class 660 in the fall of 2017. The concentration reduction for each nutrient are shown in Table 2 and plots depicting the reduction of each nutrient through the course of the channel are shown in Figure 14.

**Table 2. Nutrient reduction through the PG&E wetland in October 2017 (CSUMB Class 660 2017).**

| Nutrient | Inlet Concentration (mg/L) | Outlet Concentration (mg/L) | Concentration Reduction (%) |
|---|---|---|---|
| Average Nitrate | 6.02 | 0 | 99.97 |
| Average DIN | 9.03 | 0.08 | 99.1 |
| Average Phosphate | 1.34 | 0.25 | 81.43 |
| Average Ammonia | 2.25 | 0.07 | 96.95 |

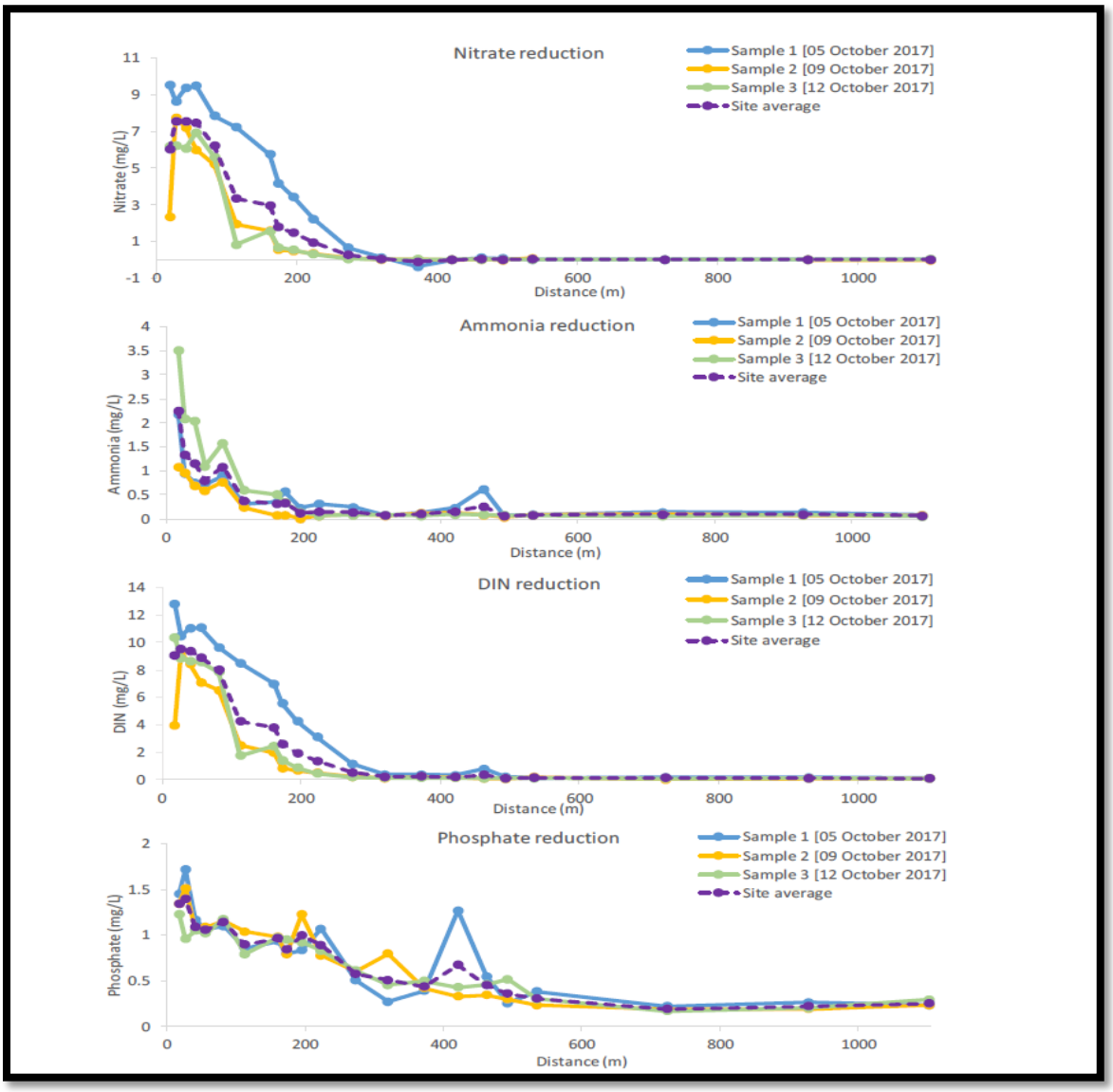


Figure 15. Nutrient concentration reduction along the length of the 1100 m channel of the PG&E Wetland. Image from CSUMB Class ENVS 660 Report 2017.

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