



Left: Green Gulch during construction. Right: Green Gulch site two years post-construction, fully vegetated and with abundance stream flow from recent rains. Photo credit: Sustainable Conservation.

# California Fish Passage Forum

## Barrier Removal Effectiveness Monitoring

## Green Gulch Habitat Enhancement Project Monitoring

### Background

The San Francisco Zen Center (SFZC) has owned Green Gulch Farm (GGF) since 1972 and operates a retreat center and an organic farm and garden on the property. SFZC inherited a creek that was historically straightened, shortened, and pinned in place with small concrete dams and concrete lining. Four on-channel ponds had been constructed for agricultural water use. SFZC completed a restoration plan in 2012 for the creek below Zendo Pond, the lowest instream pond, with funding from the Marin Community Foundation, NOAA Estuary Program, and the California Department of Fish and Wildlife (CDFW) Fisheries Restoration Grant Program (FRGP). The first phase, re-creation of 700 linear feet of natural meandering channel and associated wetland and riparian habitat, was implemented in 2013/2014 with a NOAA Estuary grant, another FRGP grant, volunteer planting, and donations from private individuals. This phase included relocation of a portion of the farm road away from the creek and replacement of a sheet-steel crossing with an HS20-rated bridge to increase channel capacity and provide improved access to the GGNRA trail network for emergency vehicles and disabled park users. The second phase, reconnection of Spring Valley Creek to supply coarse sediment and summer flow, was completed in 2015 with grants from the Resources Agency and Natural Resources Conservation Service as well as private donations. SFZC also received a grant from the Wildlife Conservation Board to assess and develop a management plan for water conservation and storage for the purpose of increasing summer streamflow. Since 2009, SFZC has raised more than \$2M for restoration of Green Gulch Creek through grants, donations, and in-kind contributions.

### Project Purpose

The Green Gulch Habitat Enhancement Project (Project) is a multi-phase program designed to restore natural function and habitat value to Green Gulch Creek and adjoining habitat and to re-establish connectivity from protected lands in the upper watershed to the Pacific Ocean—while maintaining one of the oldest continually-operated organic farms in the country. The Green Gulch Project is intended to support and complement the concurrent effort by Golden Gate Recreation Area (GGNRA) to restore mainstem Redwood Creek and Big Lagoon. Both projects provide habitat for coho salmon, steelhead trout, California red-legged frog, and many other aquatic and terrestrial wildlife species. The objectives of the project were to provide spawning and year-round rearing habitat for coho salmon in lower Green Gulch Creek, develop habitat redundancy in the Redwood Creek estuary as predicted climate change impacts occur, and support a diversity of native wildlife species while maintaining a viable organic farm.

### Project Effectiveness

One of the project goals was to help improve biotic habitat conditions, especially for salmonids, in the Redwood Creek watershed. The Redwood Creek watershed is one of the last streams on the Central California coast with a remaining wild run of coho salmon. Restoring habitat in the watershed is among one of the highest priorities for coho recovery in the region (NOAA Fisheries Service 2012). Despite channel modifications and land uses practices, Green Gulch Creek historically supported a small run of steelhead, based on anecdotal information from farm staff.

### PROJECT AT-A-GLANCE

**Project Title:** Green Gulch Habitat Enhancement Project

**Project Applicant:** San Francisco Zen Center

**Partners:**

**Project funding provided by:** Marin Community Foundation, NOAA Estuary Program, California Department of Fish and Wildlife Fisheries Restoration Grant Program, California Natural Resources Agency, Sustainable Conservation, California Coastal Commission, Natural Resources Conservation Service, Wildlife Conservation Board, private donations

**Groups Conducting Monitoring:** PCI's biologist and other staff, Green Gulch Farm staff, and Golden Gate National Recreation Area/Point Reyes National Seashore biologists

**Project Location:** Green Gulch Creek on Green Gulch Farm in Marin County, CA



Green Gulch Creek post-restoration.

In the winter of 2004/2005, a pair of coho salmon, the first seen in many years, successfully spawned in the creek. Their presence renewed interest in improving habitat in the creek and was the impetus for the restoration project.

Three years after construction of the meander reach project and two years after the Spring Valley reconnection, both reaches are profoundly changed from original conditions. In the meander reach, a diverse and predominantly native vegetation cover has been established with alder trees 15 feet and taller, willows, oaks, shrubs, native grasses and forbs, and a thick rim of sedges and rushes lining the channel. The redwood and salvaged wood structures have helped create a complex instream environment. The six designed pools are still present and four additional pools have formed. Much of the smaller gravel used in the construction of the meander reach riffles has been transported downstream. The riffles have coarsened, as coarse bedload (small to medium gravel) is limited in the system. Coarse sediment from the Spring Valley watershed, previously trapped behind Zendo Pond, is moving down the reconstructed Spring Valley Creek reach and into Green Gulch Creek. The expectation is that this gravel will eventually be transported to the meander reach.

## Monitoring Purpose

To evaluate the success of the restoration project, a fish monitoring program was implemented to assess the effectiveness of the restored meander reach to re-establish fish use within lower Green Gulch Creek. The primary components of the project validation monitoring included spawner/redd surveys in winter to document adult use and snorkel surveys in the spring/early summer for juvenile presence/negative findings. The monitoring target was to document an increasing trend of salmonid use in both numbers of adults spawning and numbers of juvenile salmonids successfully rearing.

## Monitoring Methods

Monitoring efforts have included adult spawner/redd surveys to document adult use and snorkel surveys to determine juvenile presence/negative findings. Surveys followed protocols described in the California Salmonid Stream Habitat Restoration Manual, Gallagher and Knechtle (2003), and UCCE protocols for the Russian River Coho Broodstock Program. During each survey, the entire project reach was evaluated – from downstream of the bridge to the upstream end of the restoration reach. A summary of the surveys completed is included as Table 1 below.

The primary objectives of the spawner/redd surveys were to document the presence of spawning salmonids and determine spatial spawning distribution within the restored reach. Adult surveys were completed from winter through early-spring to coincide with peak spawning periods of steelhead and coho salmon. Surveys consisted of wading upstream through the reach making visual observations of adult fish presence (i.e., live fish and carcasses) and evidence of spawning activity (i.e., excavated red, or other substrate disturbance). Five surveys were completed in winter 2014–2015, six in winter 2015–2016, and multiple surveys<sup>1</sup> in winter 2016–2017. Surveys were completed by PCI’s biologist and other staff, Green Gulch Farm staff, and Golden Gate National Recreation Area/Point Reyes National Seashore biologists.

The primary objectives of the summer snorkel surveys were to document successful spawning through the presence of rearing juvenile salmonids, density of fish, and spatial distribution within the reach. Juvenile surveys were completed during the late spring rearing period. A survey was completed in August 2012 prior to construction and post project implementation in May 2015, April 2016, and April 2017. Surveys were completed by a diver equipped with a wetsuit or dry suit, snorkel, mask, and underwater dive light. The diver would enter a pool at the downstream end and slowly work their way upstream observing and counting all native fish and aquatic wildlife. Data recorded for each dive survey included weather conditions, stream visibility, fish composition and approximate numbers by pool. Temperature readings were also taken at multiple locations within the project reach.

Due to staff availability, funding restrictions, and rainfall patterns under drought conditions, winter spawning surveys were not completed at ideal frequencies (e.g., every 2 weeks following rain events). However, the timing of the snorkel surveys did allow for documentation of fish utilization within the restored reach at preferred times.

## Monitoring Results/Discussion

### Biological Monitoring

Table 1. Summary of Green Gulch Biological Surveys.

Date	Personnel	Observations
8/28/12	PCI staff	Snorkel survey, no salmonids observed
8/11/14 to 8/27/14	PCI staff	Construction, visual surveys and relocation activities
1/30/15	PCI staff	Visual survey, steelhead observed
2/11/15	PCI biologist	Visual survey, no salmonids observed
2/27/15	GGF staff	Visual survey, possible salmonids observed
3/19/15	PCI staff	Visual survey, salmonids observed
4/30/15	PCI staff	Temperature monitoring
5/5/15	PCI biologist	Snorkel survey, steelhead observed
5/26/15	GGF staff	Temperature monitoring
8/19/15	PCI biologist	Visual survey, no salmonids observed
10/7/15	PCI staff	Visual survey, no salmonids observed
12/16/15	GGF staff	Visual survey, one small unknown fish observed

12/26/15	GGF staff	Visual survey, no salmonids observed
1/20/16	GGNRA/PRNS biologists	Visual survey, no salmonids observed
1/26/16	GGNRA/PRNS biologists	Visual survey, no salmonids observed
3/24/16	PCI biologist	Visual survey, steelhead observed
4/20/16	PCI biologist	Snorkel survey, steelhead and coho salmon observed
11/30/16	PCI biologist	Visual survey, no salmonids observed
Winter 2016/2017–Spring 2017	GGNRA/PRNS biologists	Visual surveys (spawning), no redds observed
3/6/2017	GGF staff, GGNRA/PRNS biologist	Visual survey, large possible steelhead
3/12/2017	GGF staff	Visual survey, small unknown fish
4/4/2017	PCI biologist	Snorkel survey, one salmonid observed
8/17/2017	GGNRA/PRNS biologists	Electrofishing survey of Redwood Creek, including one pool in the restoration reach, one juvenile coho salmon, one large steelhead

Prior to initiation of the restoration project, a pair of coho salmon were documented spawning in Green Gulch Creek during the winter 2008–2009. In the three consecutive winters following completion of the restoration project (2015–2017), adult spawner/redd surveys were completed. During the surveys, a small number of salmonids, but no spawning pairs or redds were observed. Fish observed during the surveys included:

- Two (4–5 inches) steelhead in January 2015
- School of 10 to 12 fish (2–3 inches), assumed to be salmonids in February 2015
- School of 12 salmonids (5–6 inches) in March 2015

In addition, throughout the monitoring period, a number of small fish were documented within the restoration reach, but could not be identified to species. In August 2017, GGNRA/PRNS biologists completed an electrofishing survey of Redwood Creek and Green Gulch Creek; the team surveyed one pool in the restoration reach; they observed one coho salmon (possibly over one year) and a large steelhead (6–7 inches).

Prior to completion of the bridge project, a snorkel survey of the project reach was completed. No salmonids were observed—only native threespine stickleback. In the three consecutive springs following completion of the restoration project (2015–2017), snorkel surveys were completed. During each snorkel survey, salmonids were observed within the restoration reach. These included:

- Three steelhead (over 6 inches in length and estimated to be 1-year or older fish) in May 2015
- Four young-of-the-year salmonids—two coho salmon and two steelhead in April 2016
- One juvenile salmonid (possible young-of-the-year, but identification uncertain) in April 2017

### Structural Monitoring

The objective of structural monitoring is to ensure that the constructed channel is performing as designed relative to providing habitat for salmonids. This includes measuring specific features of interest, such as number of pools, residual pool depth and size, riffle configuration and sediment composition. The specific targets defined in the monitoring plan were as follows:

- Maximum residual pool depths averaging 2–2.5 feet over 5-year monitoring period
- Pool areas >50% of installed and varying <10% over 5-year monitoring period
- Riffle configuration (elevations and slopes) stabilized after first winter
- Maintenance of well graded gravel deposits on pool tail-outs and riffles

Structural monitoring was conducted by PCI on July 17, 2017. Visual observations were conducted in 2015 and 2016 and included photo documentation of the site’s structural evolution. The 2017 monitoring effort included a channel profile survey, collection of sediment samples, and photo documentation. As part of the profile survey, several pool depths and edge geometries were measured to calculate pool volumes. The survey was conducted using a Trimble S6 Total Station. Monitoring survey results were compared to the pre-project channel profile survey (2009) and the Project design plans (2014 as-builts) to document changes in channel form. Sediment samples were collected from one riffle crest and one gravel bar.

Photos of the project site were taken annually to document changes that have occurred since project implementation. Photo analysis was used to supplement the physical measurements and track structural changes in the project site.

Three years after project installation, the channel bed has adjusted. Riffles have been scoured and flattened. Based on profile elevations, riffles in the upstream section of the project reach seem to have lost more sediment than the downstream riffles. Photos taken in 2015 and 2016 demonstrate that the river-run gravels placed on the riffles during construction were mobilized during high flows and deposited in the downstream pools. The 2016/17 winter high flows remobilized and transported these gravels out of the pools. Some of the gravels were deposited on riffles in the downstream reach. The upstream riffles are composed primarily of the coarse framework material installed during construction and show little to no new gravel accumulation, likely due to limited sediment supply in Green Gulch Creek. Although the Spring Valley Creek reconnection project was constructed in 2015 to provide additional gravels to Green Gulch, the new sediment load has not yet reached the meander bend reach.

***This case study was developed from the following publication: Prunuske Chatham, Inc. 2017. Monitoring Report: Green Gulch Habitat Enhancement Project. NOAA Estuary Program Grant NA11NMF4630233. Prepared for Green Gulch Farm/San Francisco Zen Center. 10pp.***