Chorro Flats Enhancement Project

Final Report

to the

California State Coastal Conservancy

Prepared by the
Coastal San Luis Resource Conservation District
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Executive Summary

The Chorro Flats Enhancement Project was implemented to reduce sediment loads to Morro Bay by allowing Chorro Creek to overflow on its original floodplain. The project has restored and enhanced 83 acres of wetland and wildlife habitat. The remaining 45 acres of prime farmland are reserved for agricultural production.

This report summarizes site acquisition, planning, construction, maintenance and monitoring associated with the project, and serves as a final report for a grant administered by the California State Coastal Conservancy.

A study completed in 1988, "Sediment Processes in Morro Bay, California," prepared by Philip Williams & Associates, Ltd. for the District and the Coastal Conservancy, showed that Morro Bay had been filling in at a rate ten times greater during the last one hundred years than it had previously. The major source of the sediment is the brushlands in Chorro and Los Osos Valleys.

The Coastal San Luis Resource Conservation District, using funds provided by the Coastal Conservancy and Cal Trans, purchased the Chorro Flats site in 1991. Consultants prepared an Enhancement and Management Plan for the site. During all phases of the planning process extensive public input was solicited and encouraged.

In 1994, a wildfire burned 35% of the Chorro Creek watershed in the steep brushy areas of the Santa Lucia Range. The Natural Resources Conservation Service improved the sediment trapping capability of Chorro Flats by creating a 450 foot breach of the creek levee. The following winter, the most extreme floods of record followed this major fire, resulting in significant sediment deposition on Chorro Flats.

Middle portion of project, August 1997

Middle portion of project, early 1998.

Middle portion of project, September 2002

The State Water Resources Control Board, the Coastal Conservancy, and Cal Trans provided funding for construction and maintenance costs. Work began in July of 1997, and was completed in late November of that year.

During the El Niño winter of 1997-98, the entire site was repeatedly flooded, and significant amounts of sediment were deposited on the site. By January 2001 approximately 198,000 cubic yards of material had been captured, approximately 23% of the load that would have otherwise ended up in Morro Bay. It is expected that the Chorro Flats site will fill in 35 years. A simple cost-benefit analysis shows that the per-cubic-yard cost of sediment capture is similar to in-bay dredging costs.

During early 1998, erosion lowered the thalweg of the overflow channel. The flow in Chorro Creek now passes through the overflow channel, with the old creek channel now acting as an overflow channel. The stream is developing a dynamically stable configuration.

Since 1998 the California Conservation Corps, Americorps Environmental Stewards, District staff, and contractors have performed maintenance on planted materials: checking each plant location and condition, hand weeding, clearing, building irrigation basins, watering, and placing mulch. Other maintenance activities have included installation of "willow mattresses" and other riparian tree species by Cal Poly students, application of herbicide to control undesirable weed species, seeding of some grasslands, periodic mowing of the grasslands, and additional willow plantings along the banks of the creek. Additional trees and shrubs have been installed each year to replace plants that had not survived. The riparian plant community is developing. Willow growth exceeds expectations. Most of the other riparian plant species are large enough to persist without additional maintenance.

Beginning in 1999 and concluding in 2001, 34 log and boulder structures were installed in Chorro Creek to improve steelhead trout summer rearing habitat. The work was partially funded by several CDFG fisheries restoration grants.

Habitat suitable for endangered species is being created. Pools and riffles are developing. Steelhead and red-legged frogs have been found on the site. Due to increased shading, water temperature in Chorro Creek drops a few degrees as it flows through the site. The site provides habitat for a wide variety of birds.

Numerous public education opportunities have been provided at the site, via the media, various public forums, and a scheduled monthly walk.

It is expected that within the next year California State Parks will assume ownership and responsibility for the maintenance of the wetland portion of the site.

Numerous suggestions are presented regarding lessons learned during the project. The suggestions focus on the planning process, the contracting process, alternative locations for the channel and the berm, and ways in which an "adaptive management" approach could have benefited the project.

Additional information regarding the Coastal San Luis Resource Conservation District can be found on the web at www.coastalrcd.org.

Introduction

Purpose of the Project

The purpose of the Chorro Flats Enhancement Project is to improve water quality entering Morro Bay by reducing sediment flowing into the bay from Chorro Creek. It allows Chorro Creek to overflow on its original floodplain for "passive" sediment capture. The project will also restore and enhance wetland and wildlife habitat, provide some public education opportunities, and continued agricultural operations which will emphasize environmentally sensitive agricultural practices.

Scope of the Project

The project has been implemented on a 128 acre site situated along Chorro Creek. Approximately 83 acres of the site have been converted to floodplain and wildlife habitat areas. The remaining 45 acres of prime farmland are used for agricultural production.

Setting

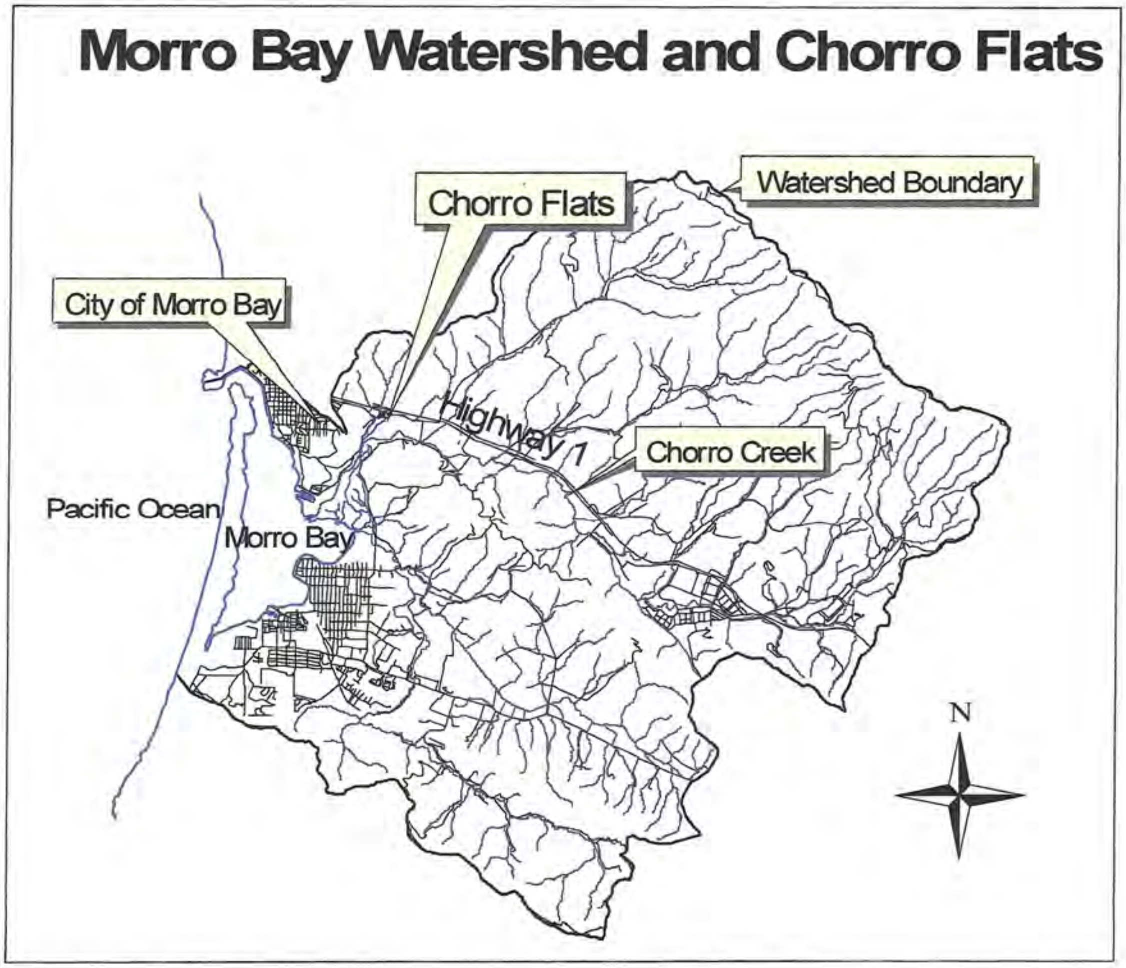

Figure 1. Vicinity Map

Morro Bay Watershed

Located in San Luis Obispo County, Morro Bay has been called the most biologically important estuary on the Central Coast (Arnold, 1991). Morro Bay is approximately four miles long and about one and three-quarters miles wide at its maximum width. At high tide, Morro Bay consists of approximately 2300 acres of open water (Haltiner, 1988).

The Morro Bay watershed is approximately 48,450 acres bounded by the Santa Lucia Range on the north, Cerro Romauldo Peak to the east and the San Luis Range to the south. Eventually draining to Morro Bay, the watershed contains two significant creek systems, Los Osos and Chorro Creeks. The Chorro Creek watershed drains approximately 27,670 acres, while Los Osos Creek drains 16,933 acres. The remaining area drains directly into the bay through small local tributaries or urban runoff facilities. Sixty percent of the Chorro Creek watershed is classified as rangeland, while twenty percent is brushland. The land use in the Morro Bay watershed is summarized below.

Table 1. Land Use in the Morro Bay Watershed

Land Use	Acres
Cropland/Hayland	3,149
Pasture (Irrigated/Domestic)	49
Rangeland	26,162
Forest/Woodland	3,093
Chaparral	8,516
Urban	3,389
Other	4,092
Total acres in watershed	**48,450**

Problem Identification and Watershed Planning

Erosion in the watershed was seen as a problem by many observers through the years. The Coastal San Luis Resource Conservation District (RCD) had long recognized the importance of the Morro Bay Estuary. In the 1970's District leaders adopted the reduction of erosion in the Morro Bay watershed as one of their long term goals. In 1987 the CSLRCD obtained funding through the California State Coastal Conservancy (SCC) to quantify the historical loss of open water in the bay, and to locate and quantify sediment sources to the bay in order to create a baseline for future reference. The results of the study indicated that the bay had been filling in at a rate ten times greater during the last one hundred years than it had previously (Haltiner, 1988). The results also showed that the bay has decreased in volume by 25 percent in the last century (Haltiner, 1988). The major source of the sediment is the brushlands in Chorro and Los Osos Valleys. Chaparral covers approximately 19% of the 48,450 acre watershed, but it contributes 30% of the sediment to the bay. Conversely rangeland covers 60% of the watershed, yet contributes only 17% of the sediment to the bay (USDA SCS, 1989).

Using these studies as a baseline the CSLRCD then hired the USDA Soil Conservation Service (now known as the Natural Resources Conservation Service) to develop the Morro Bay Watershed Enhancement Plan (MBWEP). The recommended plan detailed three phases of action. Phase I was land treatment. Phase II was a sediment trap on Los Osos Creek. Phase III was a sediment trap on Chorro Creek.

Phase III of the MBWEP is the Chorro Flats Enhancement Project (CFEP), a sediment capture, agricultural preservation, habitat restoration and education project. The CFEP has essentially reconnected Chorro Creek with its historical floodplain, allowing sediment to be deposited on the flats and not transported to Morro Bay. This is the most significant single action of the plan. It was estimated that 35% of the sediment entering the bay through Chorro Creek could be caught by a sediment trap at this site (USDA SCS, 1989).

Site Description

The 128 acre site located at the intersection of Quintana Road and South Bay Boulevard near the city of Morro Bay was once known as Chorro Cienaga (swamp). At that time, under the dense vegetation of willows and other riparian species, when Chorro Creek flooded, the water spread over the land and dropped sediment. Rich alluvial soils were created by this process. Millions of cubic yards of sediment were trapped here rather than being carried into the bay.

In the 1950's Chorro Creek was confined by a levee to a narrow channel along the southern edge of the property. This allowed the adjacent land to be used for growing vegetable and hay crops in the rich stream deposited soils. But the sediment-rich water flowing downstream was no longer able to spread out and deposit its load on the floodplain as it had been doing for eons. Instead, the sediment remained suspended until it reached the estuary, where much of it settled out.

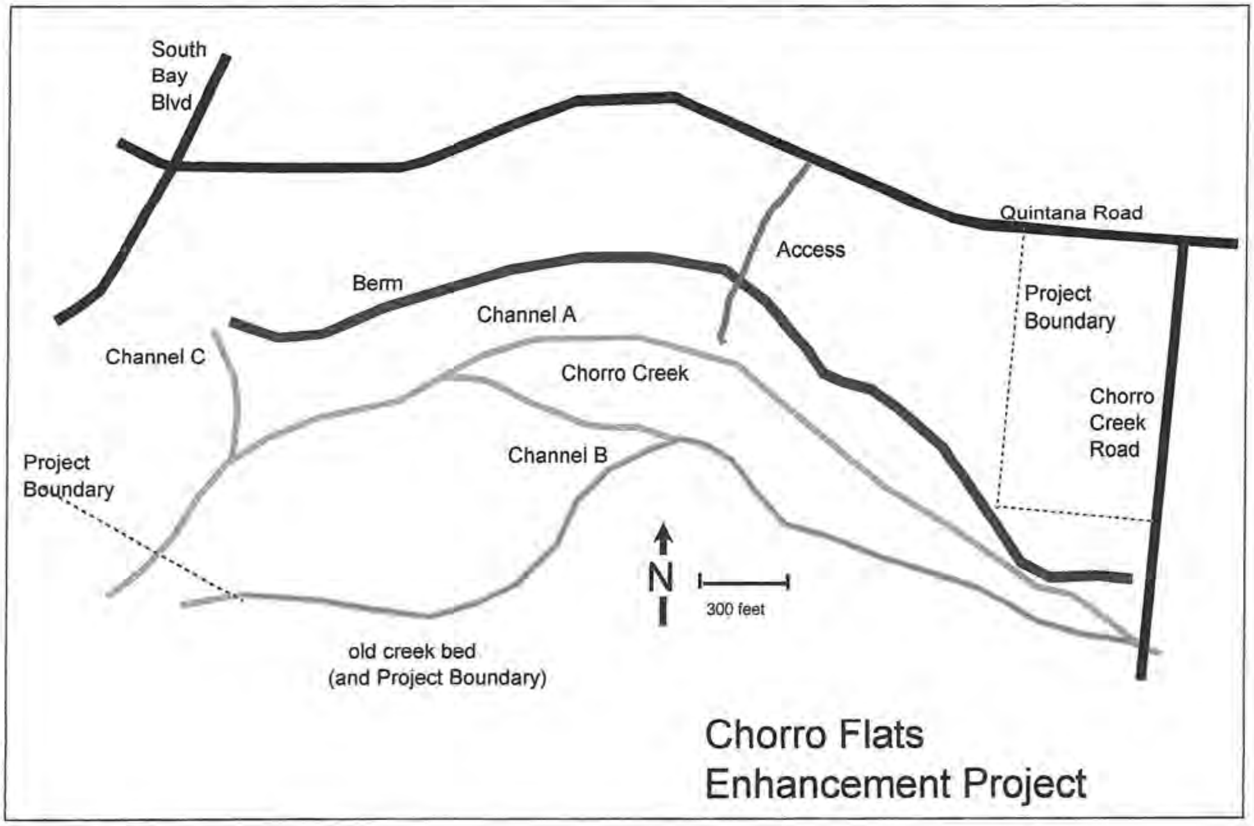

Figure 2. Site Plan

Site Acquisition

The Morro Bay Watershed Enhancement Plan recognized that the Chorro Flats site would be an ideal place to trap sediment before it reached the Bay. About that time, the Domenghini family that owned and farmed the site put the land on the market. Carol Arnold of the State Coastal Conservancy entered into negotiations with the family to purchase the land. The Coastal Conservancy provided funds to the CSLRCD to acquire and restore the site. The purchase price of $1,450,000 required more funds than those available to the Conservancy at that time, so Ms. Arnold applied for and received $800,000 from Proposition 111 funds, administered by Cal Trans. The CSLRCD received the title for the land on December 18, 1991, and immediately began the planning process for the Chorro Flats Enhancement Project.

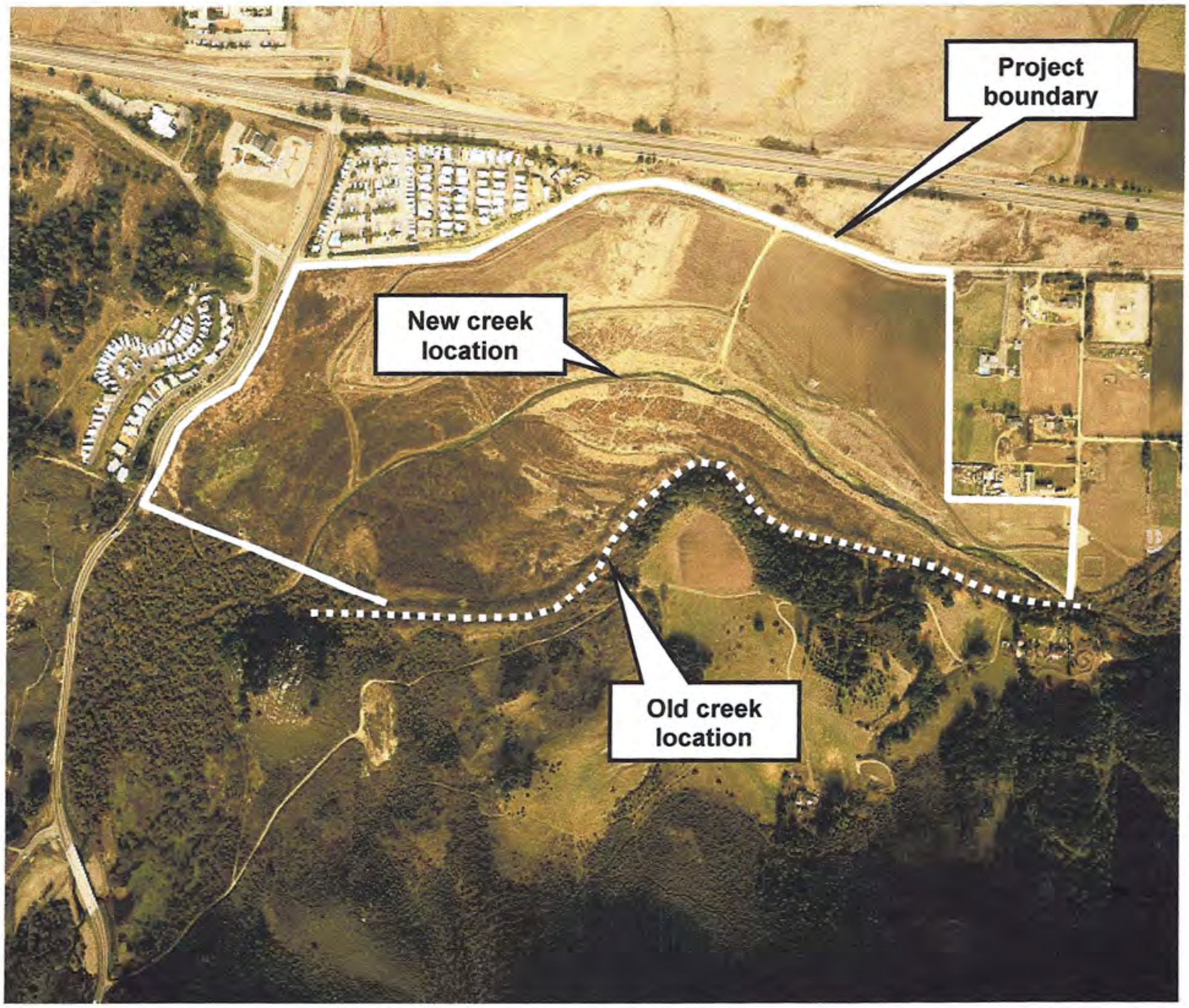

Figure 3. Aerial Photo of Site and Vicinity, January 1999

Project Planning

The Chorro Flats site is especially suitable for sediment trapping because:

- Chorro Creek runs through the site;
- Chorro Flats is at the terminus of the watershed;
- Chorro Flats is relatively flat and well suited to trap sediment;
- The site historically was a floodplain, covered with riparian vegetation that naturally trapped sediment.

Sediment control was the principal reason behind the acquisition of the property, however the CSLRCD and the SCC recognized that a number of other important natural resources on the site could be protected and enhanced. These resources include the aquatic habitat and fisheries, the riparian habitat and wildlife, groundwater, agricultural use and water quality and quantity.

With another grant from the Coastal Conservancy, the CSLRCD hired consultants to prepare an Enhancement and Management Plan for the site. Several preliminary studies preceded the preparation of the final plan. The first report was an assessment of the planning area covering topography, hydrology, groundwater, soils, agriculture, vegetation, wildlife, fisheries, archeology, easement, and regulatory polices applicable to the site. The results of this study were published in the *Existing Conditions Background Report.*

During all phases of the planning process extensive public input was encouraged. Several public meetings were held. The Morro Bay Task Force was involved in the planning process. A Technical Advisory Committee composed of members of the public, the California Department of Fish and Game, the State Department of Parks and Recreation, the Regional Water Quality Control Board, the County of San Luis Obispo, the City of Morro Bay, the U.S. Fish and Wildlife Service, the Army Corps of Engineers, the SCC, the NRCS, the National Estuary Program, the Sierra Club, the Friends of the Estuary and neighbors of the site met on a regular basis to discuss and decide on issues.

Next, specific goals and objectives for the plan were articulated in a report entitled *Goals and Objectives for Chorro Flats*. These related to sediment trapping, agriculture, fisheries and wildlife enhancement.

The consultant team presented three alternatives for the site in the *Analysis of Options and Alternatives Report*. These alternatives were considered and discussed at a number of public meetings. Alternative one emphasized agriculture and devoted more of the site to that purpose. Alternative two increased the size of the floodplain, while still maintaining a viable agricultural parcel on a portion of the site best suited for farming. The third alternative included an active sediment removal basin that would require periodic dredging of a sediment basin located off the main channel of Chorro Creek. This alternative would have resulted in continual maintenance costs and negative impacts related to fisheries and aesthetics.

The public and the Technical Advisory Committee overwhelmingly favored alternative two. The final plan was based on this alternative although adjustments and refinements occurred in the final detailed planning. The final plan was published in April of 1994 as the: *Conceptual Plan, Chorro Flats Enhancement and Management Plan.*

The passive sediment trapping system allows sediment to accumulate on the floodplain as a result of deposition during over-bank flows. Increased vegetation on the floodplain helps to reduce the velocity of over-bank flows and increase the rate of sediment deposition. Approximately 83 acres were included in the floodplain and 45 acres were reserved for agriculture. This allowed for a capacity of in excess of 600,000 cubic yards and a projected lifespan of at least 50 to 70 years. The deposited sediment will primarily be sand sized particles with a moderate amount of fine grained materials (silt and clay). Most of the coarse grained material (pebble and cobble) will be trapped in the creek channel.

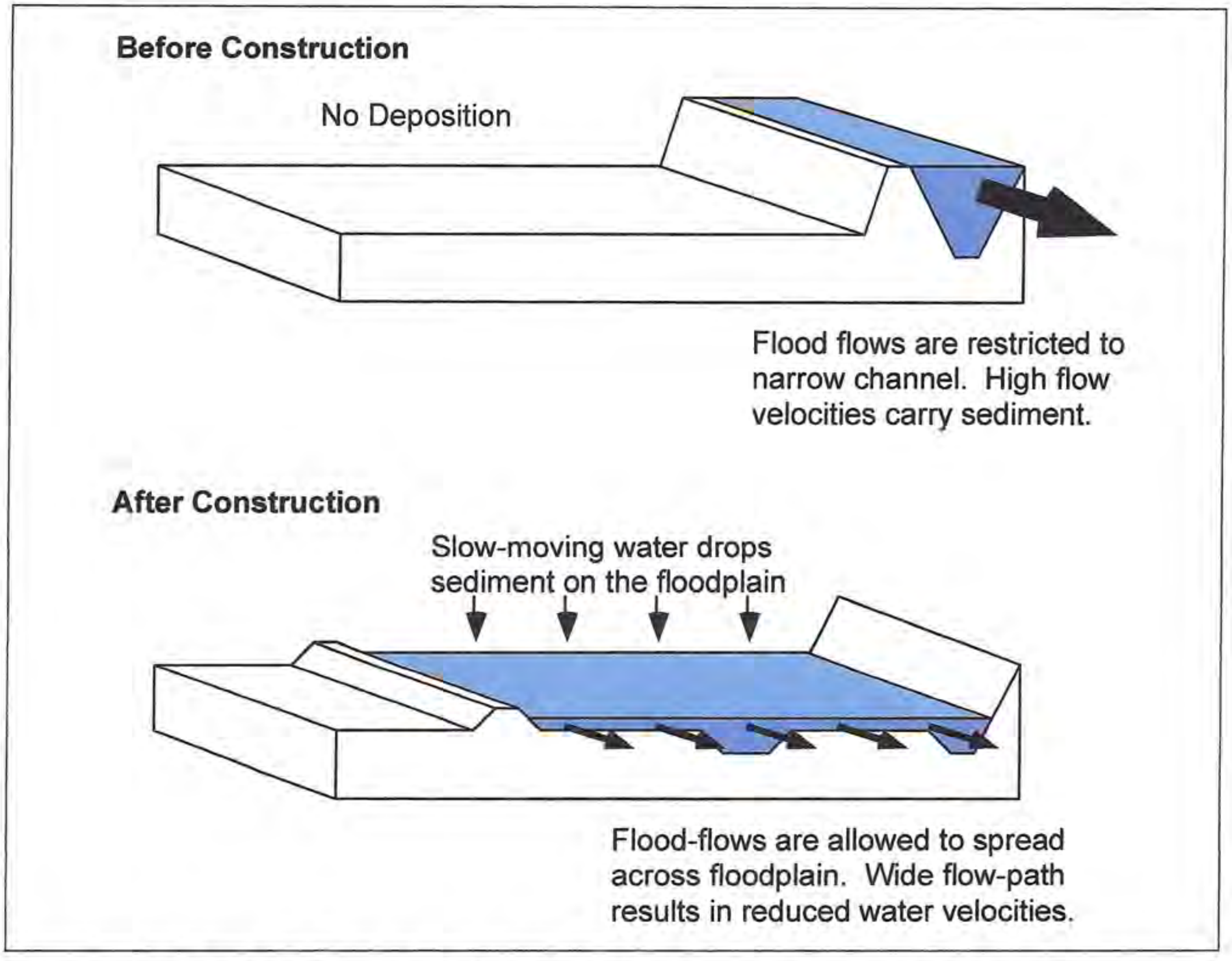

Figure 4. Simplified Chorro Flats fluvial processes, pre- and post-construction

Interim Site Development

Not long after the completion of the Conceptual Plan, the August 1994 "Highway 41 Fire" erupted. The fire burned 9700 acres, or 35% of the Chorro Creek watershed. The area that burned was the steep brushy areas of the Santa Lucia Range (Cuesta Ridge). Slopes as steep as 60% were left denuded of protective vegetation. The CSLRCD took advantage of a federal Emergency Watershed Protection (EWP) program administered by the NRCS for Chorro Flats.

The NRCS improved the sediment trapping capability of Chorro Flats by creating a 450 foot breach of the levee and stockpiling the material in a berm perpendicular to the channel.

In an exceptionally rare combination of extreme events, this major fire was followed by the most extreme floods of record the following winter. In mid-January and again in mid-March of 1995 intense rainstorms produced tremendous flows in Chorro Creek. The 2 to 3 day rainstorms producing these flows had a recurrence interval of between 100 and 1000 years (Jim Goodridge, former State Climatologist). Flood debris left on the radio towers at Chorro Flats was more than thirteen feet above the ground surface.

Project Implementation

Design

In 1996 work began on the final working drawings and the specifications for the construction contract. Plant ecologists and restoration specialists worked on developing the planting program. Only plants native to the watershed were selected. The planting was to be done in bands adjacent to the new channels in order to promote the riparian corridor and get it established prior to the expected channel avulsion. The ground in between the plants and the wide areas beyond the planting zones were to be planted with native grasses. The final plant count was over 10,792 plants including 211 Red osier dogwood trees, 431 California sycamores, 845 Black cottonwoods, 72 Coast live oaks and nearly 8900 red and arroyo willows. Additionally, wax myrtle, coffeeberry, gooseberry, California wild rose, blackberry, twinberry, hummingbird sage and elderberry were selected. The native grass mix included California brome, blue wild rye, meadow barley and creeping wild rye.

Additional Funding

The CSLRCD also applied for funding from the State Water Resources Control Board and was granted $300,000 for construction and maintenance of the project. The Coastal Conservancy once again provided funding to implement the project. Carol Arnold applied for and received $300,000 from Cal Trans, and the Coastal Conservancy contributed $170,000 toward the construction and maintenance costs.

Permits

A public hearing was held by the San Luis Obispo County Planning Commission on February 13, 1997. The commission heard testimony from numerous interested parties, and then voted unanimously to grant a Coastal Development Permit for the project. A responsiveness summary was prepared that summarized the views and comments received during that meeting, and specific responses to those comments.

After a lengthy process, all the required permits were received from the appropriate agencies, including the City of Morro Bay, the Army Corps of Engineers, the Department of Fish and Game, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Regional Water Quality Control Board, and the Air Pollution Control District.

Construction

Requests for proposals for construction professional services was developed and distributed in May 1997. Bids were due by June 16, 1997 and were reviewed by the Awards Committee. Whitaker Contractors of Santa Margarita was selected to construct the project. The construction work was awarded to Whitaker Contractors, Inc. Engineering services were provided by Engineering Development Associates (EDA), geotechnical services were provided by GeoSolutions, LLC, biological monitoring and vegetative support services were provided by Garcia and Associates (GANDA).

Pre-construction activities began in June. The California Conservation Corps constructed a 2,500 foot straw bale barrier along Chorro Creek to protect water quality and installed 9,400 feet of t-posts and nylon webbing to protect and delineate existing riparian and wetland vegetation. These items were removed at the completion of construction.

A ceremonial groundbreaking was held and was well attended on July 9, 1997; five and one-half years after the CSLRCD acquired the land.

Figure 5. Groundbreaking ceremony July 9, 1997.

Required day and night surveys for California red-legged frogs were conducted pre-construction and during construction. None of these animals were found on site during these surveys.

A grading permit was obtained in July. Earthmoving activities continued until mid-September. A significant amount of invasive exotic plant species (cape ivy and hoary cress) was removed and burned. A construction staging area was established along the agricultural road to facilitate equipment storage and meetings. A hazardous materials storage and refueling site was installed to protect water quality.

Construction included the abandonment of two existing irrigation wells; protection for the two remaining wells; removal of an existing earth levee and earth stock pile areas; construction of a new berm; excavation and shaping of earth channels and swales; installation of a gravel turnout and access road; and removal of five power poles and an overhead electric line. An interpretive display sign and turnout area was developed along Quintana Road. An interpretive display sign was also installed near the parking lot atop Black Hill in Morro Bay State Park. Earthwork associated with the project is summarized below.

Table 2. Summary of Construction Earthwork

New channels and swales			
	Channel A	22,260 cubic yards cut	4,340 linear feet
	Channel B	5,860 cubic yards cut	976 linear feet
	Channel C	680 cubic yards cut	600 linear feet
	swales	2,790 cubic yards cut	3,375 linear feet
Levee removal		17,620 cubic yards cut	2,570 linear feet
New berm		9,125 cubic yards fill	
Raise surface of agricultural land		39,750 cubic yards fill	
Rip rap protection on new channels and swales			900 linear feet

Revegetation of the site took approximately 6 weeks and was completed by the end of October. A total of 340 shrubs and 1570 trees were grown in containers and transplanted on site. An additional 8882 willow cuttings were planted (GANDA, 1998.) The final step, seeding with grasses for erosion control, was completed in November, 1997.

The County of San Luis Obispo Department of Planning and Building performed a final inspection on the project on December 24, 1997. At the beginning of December when viewed from Black Hill the Chorro Flats Enhancement Project looked very much like the finished engineering drawings.

Monitoring and Maintenance Planning

A monitoring and maintenance plan (M&M plan) was developed in 1998 by the CSLRCD, and approved in July of that year by the RWQCB, the U.S. Army Corps of Engineers, and the State Coastal Conservancy. The M&M plan was produced to comply with permit requirements; to track and address localized problems of erosion, revegetation needs, and other modifications identified as the project matures; and to assess the overall success of the project in meeting its goals and objectives. The M&M plan specified short-term activities planned for the first two years following construction and long-term activities planned for the next five years. Long-term monitoring activities are planned to measure deposition, document channel morphology changes, and monitor riparian vegetation establishment. Long-term maintenance activities are planned to focus on establishment of riparian vegetation, promotion of stable stream banks, and maintenance of roads, berms, and other improvements. These activities will initially be funded from a combination of grants. With time, as monitoring and maintenance needs decrease, rental income from of the agricultural portion of the site will be used for these activities.

Maintenance

Routine plant maintenance

The native trees and shrubs were regularly maintained with hand weeding, mowing, building irrigation basins, irrigation, and placing mulch. These actions began in May 1998 and were repeated as needed through the summer of 2002. Typical procedures are illustrated below.

First you must find the plant. In this case a cottonwood.

Then clear away competing plants using hand tools.

After the irrigation basin is formed, approximately 2 gallons of water are applied.

The finished site includes 3 inches of mulch and a flag to aid future identification.

Figure 6. Typical Plant Maintenance Procedure

Replanting and reseeding

During the El Niño winter of 1997-98, the entire site was repeatedly flooded, and portions of the newly installed channel banks were eroded. Vegetation losses occurred where banks and newly installed willow stakes were eroded and where seedlings were smothered under sediment. During later years, vegetation mortality occurred due to lack of moisture, rodent and other animal impacts, and competition from other plant species. To mitigate these losses, additional plant material was installed on the site, typically during the wetter winter months, as listed below.

In November 1999, approximately 15 acres of grassland were replanted with native grass seed and mulched with rice straw. A filter strip of native grasses was planted between the agricultural fields and the swale that drains these fields.

Table 3. Tree and Shrub Replanting

Planting season	Trees and shrubs planted
1998-99	1,087
1999-2000	1,555
2000-01	610
2001-02	421

Replanting willow banks

Due to unexpected scouring that occurred during the El Niño winter of 1997-98, several portions of stream bank required replanting with willows. Several different methods were employed, as described below.

Willow Mattresses

In June 1998, Dr. Brian Dietterick and his resource management students from Cal Poly installed a "willow mattresses" along a portion of the new channel. This work has continued during subsequent years. By October 2002, mattresses had been installed at 6 separate locations.

Installation of the willow mattress 5-29-98.

View from upstream side 5-29-98

View from same location October 2002.

View from same location October 2002.

Figure 7. Willow Mattress
Installation May 1998, and after 4 years.

Willow wattles (fascines) and baffles

Bank erosion at the upstream end of the project and near the mid-project well was addressed by the installation of willow wattles, or fascines, during September 1998, and during July 1999, as shown below.

Willow baffle installation September 1998

Completed installation September 1998


Willow fascine near mid-project well November 1998.


Willow fascines at upstream end of project November 1998

Willow fascines at upstream end of project November 1998.


Willow fascines at upstream end of project (same location as above) October 2002.

Figure 8. Willow baffles and fascines
Installation September 1998, after 2 months, and after 4 years.

Weed and pest control

Weed control was accomplished by hand weeding around young trees and shrubs, by mowing with "weed whippers", push-type brush mowers, or tractor mounted mowers, and by herbicide application.

During June 1999, eleven raptor perches have been installed within the riparian zone along Chorro Creek, to enhance rodent control.

Figure 9. Raptor perch on Chorro Flats.

Miscellaneous maintenance activities

In October 1998 "No Access" signs were installed. During the third quarter of 2000 access roads were re-surfaced at three locations on the site.

Aquatic Habitat Improvement Structures

During 1999, 12 log and boulder structures were installed in the upstream portion of the project to improve steelhead trout summer rearing habitat. During 2001 an additional 22 structures were installed in the middle and downstream portions of the project and one previously installed structure was modified. This $145,384 effort was funded largely by CDFG fisheries restoration grants, with some funding coming from the National Fish and Wildlife Foundation. All work followed procedures in the DFG *California Salmonid Stream Habitat Restoration Manual*. Rock for the project was imported from local quarries to the project site. Some root wads which were installed into the banks in 1997, and which were too high to function properly, were removed and used for this project. Additional root wads and logs were supplied by Morro Bay State Park and from a private contractor from Nipomo.

Photographs were taken to document conditions before, during, and after construction, and have been taken again in subsequent years. (This effort complements the photo documentation which is part of the ongoing CFEP). Each spring, the integrity and functionality of each structure will be evaluated, and each structure will be repaired or modified as needed.

Figure 10. Instream habitat structure installation, 1999.

Opposing wing deflector after installation, 1999. Opposing wing deflector, June 2001.

Figure 11. Instream habitat structure and pool development.

During the last quarter of 2000: a CCC crew working with a backhoe operator maintained instream habitat structures that were installed in 1999.

Monitoring Results

Monitoring activities were designed to answer the following "big" questions:

- How much sediment is being collected?
- Is a riparian plant community developing?
- Is the stream developing a dynamically stable configuration?
- Is habitat suitable for endangered species being created?
- Are beneficial uses being enhanced or is water quality being improved?

The answers to these questions are discussed in the sections that follow.

Sediment Collection

Between 1992 and 2000 approximately 198,000 cubic yards of material were collected on Chorro Flats. Assuming a weight of 84 lb/cubic foot, this material would weigh 224,000 tons.

Approximately 23% of the total load and 76% of the bed-load, from Chorro Creek between 1992 and 1998 was captured on Chorro Flats (Robbins and McEwen, 1999). This trapping efficiency was determined by:

- modeling sediment loads to the upstream end of Chorro Flats; and then
- measuring the volume of sediment collected;
- using sediment samples to estimate the particle size distribution and mass of the collected material; and then
- comparing modeled sediment loads to measured amounts of sediment captured.

Monthly precipitation recorded at Cal Poly, San Luis Obispo, from October 1992 to September 2002 is shown in Figure 12.

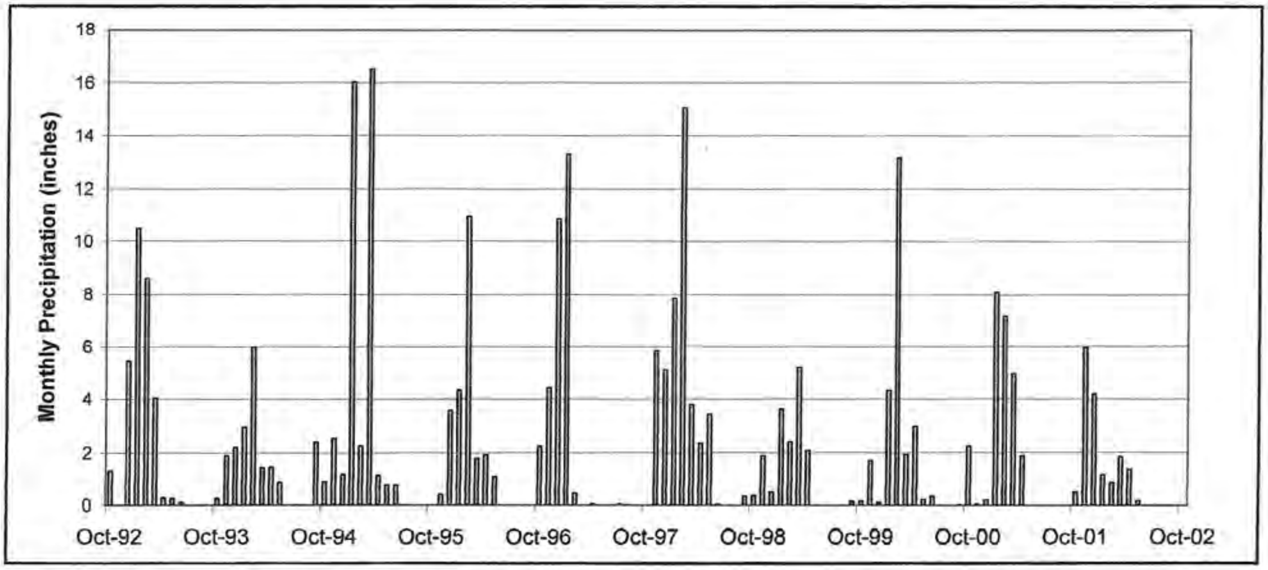

Figure 12. Monthly precipitation between October 1992 and September 2002.

Total sediment loads to Chorro Flats from Chorro Creek were modeled based on flow rates measured at a gage on Walters Creek, a tributary to Chorro Creek. Annual total sediment yield and bed material yield for the Chorro Creek watershed has been modeled for the 1993 through 1996 water years. Additionally, the long-term average annual total sediment yield for the watershed has been estimated to be 60,689 tons, with an average annual bed material yield of 6,980 tons (Tetra Tech, 1998). These modeled estimates are listed in Table 4, and are also converted to volumes, based on an assumed density of 84 lb/cubic foot.

Table 4: Estimated Sediment Loads to Morro Bay from Chorro Creek

Water Year (ending Sept. 30 of the year shown)	Estimated Total Load, tons	Estimated Bed Material Load, tons	Estimated Total Load, cubic yards	Estimated Bed Material Load, cubic yards
1993	43,040	11,225	37,954	9,899
1994	277	165	244	146
1995	734,891	49,063	648,052	43,265
1996	20,777	5,294	18,322	4,668
1997	60,689*	6,980*	53,518*	6,155*
1998	60,689*	6,980*	53,518*	6,155*
1999	60,689*	6,980*	53,518*	6,155*
2000	60,689*	6,980*	53,518*	6,155*
Total Load	1,041,741	93,6670	918,643	82,599

(* Long-term average values)

(**Bed material consists of particles which are larger than very fine sand particles, 0.074 mm.)

The volume of sediment which was collected on site was measured as follows: Topographic surveys were conducted in 1992 (EDA, 1997), in January 1999 (Vaughan Surveys, 1999), and in January 2001 (Vaughan Surveys, 2001). Comparison of this topographic data showed that approximately 188,000 cubic yards of sediment were collected on site between 1992 and 1998, and an additional 10,000 cubic yards were collected between 1998 and 2000, bringing the total volume of sediment collected to 198,000 cubic yards. A topographic map comparing 1992 to January 1999 elevations is shown in Figure 13. (Green indicates areas of almost no change in elevation. Warmer colors indicate the elevation lowered. Cooler colors indicate areas of elevation increases, i.e., sediment deposition.)

The particle size distribution of the deposited sediments was found by subjecting sediment samples to a #200 sieve wash (Earth Systems Consultants, 1998). Samples were collected in the fall of 1998 from eroded stream banks, from the creek and overflow channel beds, and from the surface of the floodplain. Particle-size data were combined with topographic data to estimate the net deposition on site for all sediments, and the net deposition for bed material. These results are summarized in Table 5, and are compared to estimated sediment loads from the watershed.

Table 5: Sediment capture on Chorro Flats, 1992-2000, by particle-size

	All Sediment, tons	Bed Material, tons	All Sediment, cubic yards	Bed Material, cubic yards
Load from watershed	1,041,741	93,667	918,643	82,599
Deposited on Chorro Flats	224,255	71,537	197,756	63,084
Percent capture	22%	76%	22%	76%

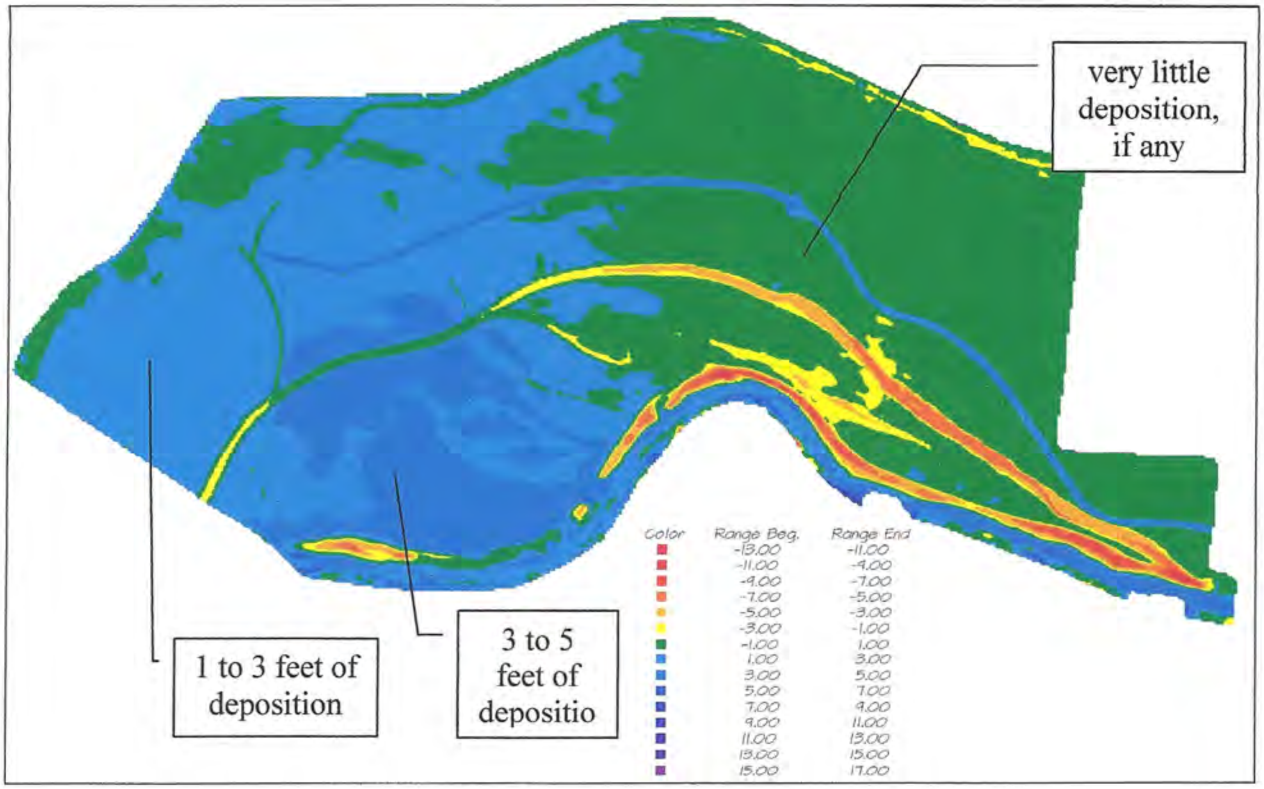

Figure 13. Comparison of 1992 Elevations to 1998 Elevations.

These figures show that approximately 22% of the total load from Chorro Creek, and 76% of the bed-load, was deposited on Chorro Flats between 1992 and 2000. A significant amount of deposition occurred on site between 1992 and 1997 as a result of breaks in the levee, some naturally occurring, and the one enlarged in 1994 through the EWP program to collect sediment following the Highway 41 Fire. Significant deposition also occurred during the El Niño winter (1997-98), just months after construction was completed.

Available Storage Capacity and Project Longevity

During the planning process for the project, it was estimated that "Alternative 2" (i.e., the selected alternative) would have 76 acres available for sediment deposition, with a total storage capacity of 610,000 cubic yards (i.e., filled to a depth of 5 feet.). The *Analysis of Options and Alternatives* report (Crawford Multari &Starr, 1993) presented an estimate of project longevity assuming that 10,000 cubic yards of material would be deposited per year, regardless of the alternative selected. Under this analysis the selected alternative would remain effective for 61 years.

Between 1992 and 2000, a comparison of topographic information shows that 198,000 cubic yards of material were collected, capturing approximately 22% of the modeled sediment loads from Chorro Creek during this time period. Therefore, assuming an initial capacity of 610,000 cubic yards, the site had an available capacity of 412,000 cubic yards in January 2001. If the long-term average sediment yield from the watershed is 53,500 cubic yards (60,689 tons) per year (Tetra Tech, 1998), and the collection efficiency remains at 22%, then over the long term approximately 11,800 cubic yards per year will accumulate annually, filling the available capacity in 35 years.

Table 6. Estimates of Project Longevity

	1993 estimate	2001 estimate
Area for deposition	76 acres	76 acres
Potential storage (cubic yards)	610,000	412,000
Sediment load from watershed (cubic yards per year)	27,000*	53,500**
Trapping efficiency		22%
Projected sediment capture rate (cubic yards per year)	10,000	11,800
Years needed to fill site	61 years	35 years

* USDA SCS 1989

** TetraTech 1998

Note that the period between estimates contained two exceptional winters – the 1995 floods following the highway 41 fire, and the 1997-98 el Niño winter. The large sediment loads captured from these events "used up" 198,000 cubic yards of capacity, approximately a third of the total capacity, in only 8 years, thereby shortening the effective life-span of the project.

It is worth mentioning that any actions upstream of the Chorro Flats Enhancement Project which reduce sediment loads to the creek will also serve to enhance the longevity of this project. Specific actions could include implementation of additional best management practices for erosion and sediment control or development of additional sediment trapping areas (mini-Chorro Flats) further upstream.

Comparison of Sediment Removal Economics

The Chorro Flats costs were paid for by a number of different funding sources, as follows:

- $835,000 from Caltrans in 1991 for site acquisition.
- $510,000 from the Coastal Conservancy in 1991 for site acquisition.
- $100,000 from the Coastal Conservancy in 1991 for conceptual planning.
- $99,000 from the Coastal Conservancy in 1993 for project design.
- $255,000 from the Water Resources Control Board in 1996 for implementation, monitoring and maintenance.
- $500,000 from the Coastal Conservancy in 1997 for implementation, monitoring and maintenance.

A brief comparison is presented below between the costs and the benefits of the Chorro Flats enhancement project and recent dredging in Morro Bay by the US Army Corps of Engineers.

Table 7. Cost Comparison of Dredging versus Upstream Deposition

Technique	Dredging	Upstream Deposition - partial capacity	Upstream Deposition - full capacity
Project	Morro Bay harbor dredging 1990-98 US Army Corps of Engineers	Chorro Flats 1992-2001 Coastal San Luis RCD	Chorro Flats 1992-capacity Coastal San Luis RCD
Yards removed	2,424,094	197,756	610,000
Cost	$11,063,412	$2,299,000	$2,299,000
Cost per yard	$4.56/yd	$11.63/yd	$3.77/yd
Unquantified costs	Ecosystem damage		
Unquantified benefits		Habitat enhancement Reduction in peak flows downstream of project.	Habitat enhancement Reduction in peak flows downstream of project.

Notes: Dredging costs include engineering, administration, overhead and etc. (US Army Corps of Engineers, 1999.) Chorro Flats costs include $1.45 million acquisition, $477,000 construction, and $433,000 monitoring and maintenance.

The comparison is relatively simple and assumes that the cost of continuing maintenance of Chorro Flats will equal the income from leasing the agricultural portion of the site.

Note that the per-cubic-yard cost for the sediment removed to date is higher than dredging costs in the bay. This reflects the high "start-up" costs and the fact that the site is only one-third "full". When the site is filled with sediment, the per-cubic-yard cost will be slightly lower than dredging.

Riparian Plant Community Development

The riparian plant community is developing. Willow growth exceeds expectations. Other riparian plant species are growing and are now, or will soon be, large enough to persist without additional maintenance.

During October, 1997, the banks of Channels A, B, and C, and a 50 foot wide band adjacent to the banks, were planted with a mixture of native trees and shrubs. A total of 340 shrubs and 1570 trees were grown in containers and transplanted on site. An additional 8882 willow cuttings were planted (GANDA, 1998.) Annual revegetation success surveys were conducted in 1998, 1999, 2000, and 2001. Results of the 2001 vegetation survey are presented below.

Table 8. Plant Survival Results

Species	Planted in 1997	Counted in 2001
Coyote bush	0	162
Twinberry	50	11
California wild rose	75	25
California blackberry	46	26
Fuscia-flowering gooseberry	26	0
Hummingbird sage	24	0
Wax myrtle	14	1
Coffeeberry	66	36
Elderberry	39	38
Red Osier Dogwood	211	61
Box Elder	11	6
Black cottonwood	845	443
Coast live oak	72	77
California sycamore	431	373
Willows	8,882	8,882
Total all plants	**10,792**	**10,141**
Survival Rate		**94%**

Figure 14. Chorro Flats from Black Hill, winter 1997-98.
Note lack of riparian vegetation along new channel.

Figure 15. Chorro Flats from Black Hill, November 2001.
Compare to previous photo. Note extensive riparian vegetation development.
The channel is largely obscured.

Numeric "plant count" results indicate that the plant maintenance, annual revegetation activities, and native vegetation recruitment has produced the desired result: a vibrant riparian plant community has developed within the revegetation area.

Of the 8,882 willows planted as stakes in 1997, 3,231 were Red willows, and 5,651 were Arroyo willows. Additional willow stakes were planted in early summer of 1998 to replace plants lost in El Niño events during the winter of 1997-98. During the first revegetation survey in the fall of 1998, the total number of willows within the replanting area was estimated to be 22,982. Many of these willows were "volunteer" sprouters. In 1999 and 2000, additional willows were planted along the banks of the newly established Chorro Creek (formerly overflow Channel A). This has developed into a continuous, solid cover along the banks and is crucial to the success of the project. Consequently, revegetation surveys performed after 1998 did not attempt to quantify the additional willow growth.

Figure 16.
Middle portion of project, August 1997

For purposes of evaluating success, Table 8 counts only the 8,882 willows from the initial planting effort. 1,910 shrubs and non-willow trees were planted in 1997. In 2001 1,259 of these species were counted in the revegetation area. In total, in 1997 10,792 native plants were introduced to the site. In 2001 10,141 healthy, growing native plants were counted, a survival rate of 94%.

Figure 17.
Middle portion of project, early 1998.

Note that the plan for the project assumed that the revegetated channels would act as "overflow" channels, carrying water intermittently during winter – but not at all during summer. However, because the main channel "migrated" to the overflow channel, the new channel is now "wetter" during the peak growth season than initially planned.

Figure 18.
Middle portion of project, August 2001

Development of a Stable Stream Configuration

The stream is developing a dynamically stable configuration. First-winter changes were significant. Subsequent changes were much smaller. Future changes are expected to be minimal because the banks are more thickly vegetated and therefore more stable, and because the first-winter changes significantly increased the flow capacity of the channel.

During the El Niño winter of 1997-98, the entire site was repeatedly flooded, and significant amounts of sediment were deposited on the floodplain, within the old creek channel, and within a secondary overflow channel. High flows spilled into the overflow channel with such force that approximately 12,000 cubic yards of fine grained material eroded from the banks of the upstream portion of the newly installed channel. The erosion lowered the thalweg of the overflow channel so that the majority of the flow in Chorro Creek now passes through the overflow channel, with the old creek channel acting as an overflow channel. The predicted channel avulsion occurred the very first rain season following construction.

The following photos show the upstream end of the site, where significant erosion occurred during early 1998, where willow fascines were planted in 1998 to protect the bank, and where habitat improvement structures were installed in 1999.

Figure 19. Upstream end of "overflow" channel. November 1997.

Figure 20. "Overflow" channel at upstream end of project. February 1998.

Figure 21. Chorro Creek at upstream end of project. January 2000.
Note habitat improvement structures and willow wattle growth.

Figure 22. Chorro Creek at upstream end of project. July 2002.
Note willow growth.

It should be noted that a significant amount of channel realignment occurred immediately after project construction during the "El Niño" winter of 1998. We can expect that future annual changes in channel alignment will be smaller than those of 1998 because:

- these high flows occurred when the banks were relatively unprotected by vegetative growth;
- these banks are now covered by riparian vegetation; and
- the erosion of 1997-98 significantly increased channel capacity, thereby reducing shear stress on the banks.

Cross-sections of the old and new channels were measured in late 1998. These cross-sections are compared to available data regarding pre-1998 conditions, and are discussed below. Cross-sections were not re-measured after 1998 because it did not appear that significant changes in channel shape have occurred, and because topographic information was being collected for deposition assessment purposes. Cross section locations are shown below.

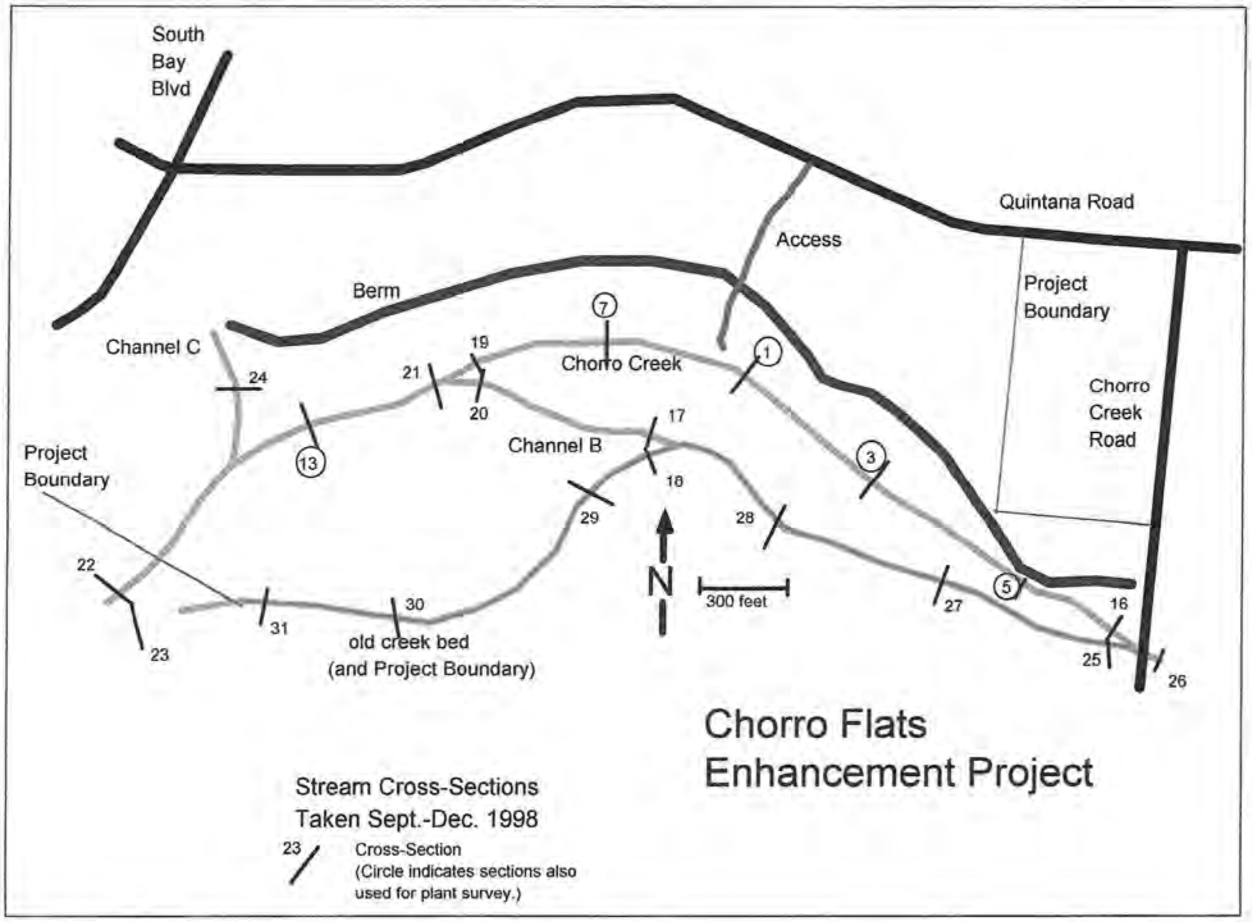

Figure 23. Cross-section locations

Cross-sections measured in the upstream portion of the new channel show significant erosion between 1997 and 1998. In this portion of the project, the thalweg is from 4 to 2 feet lower than the bottom of the overflow channel constructed in 1997.

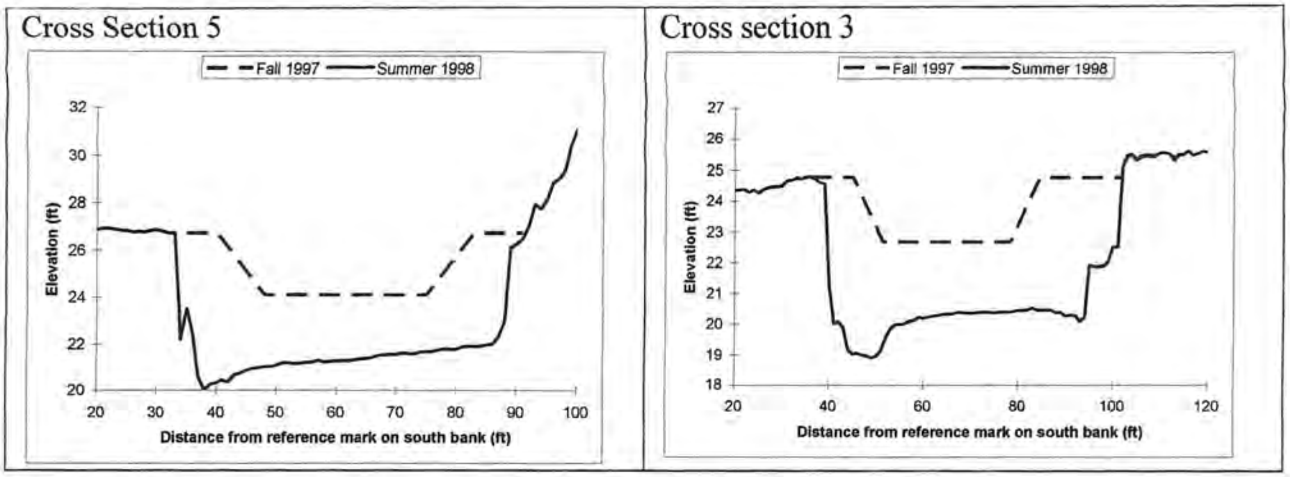

Figure 24. Cross-sections from the upstream portion of the project

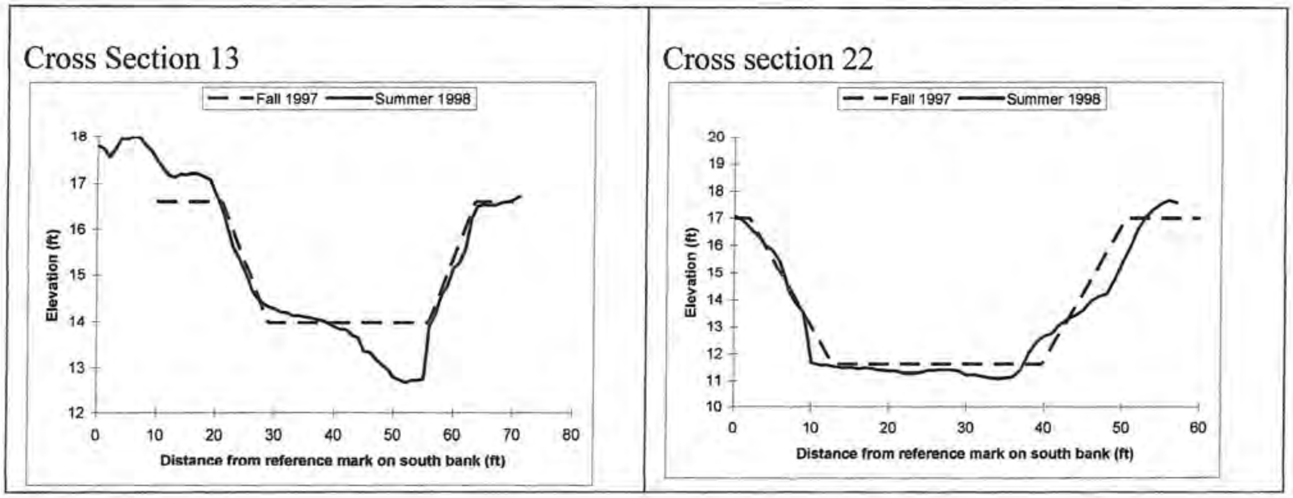

Figure 25. Cross-sections from the downstream portion of the project

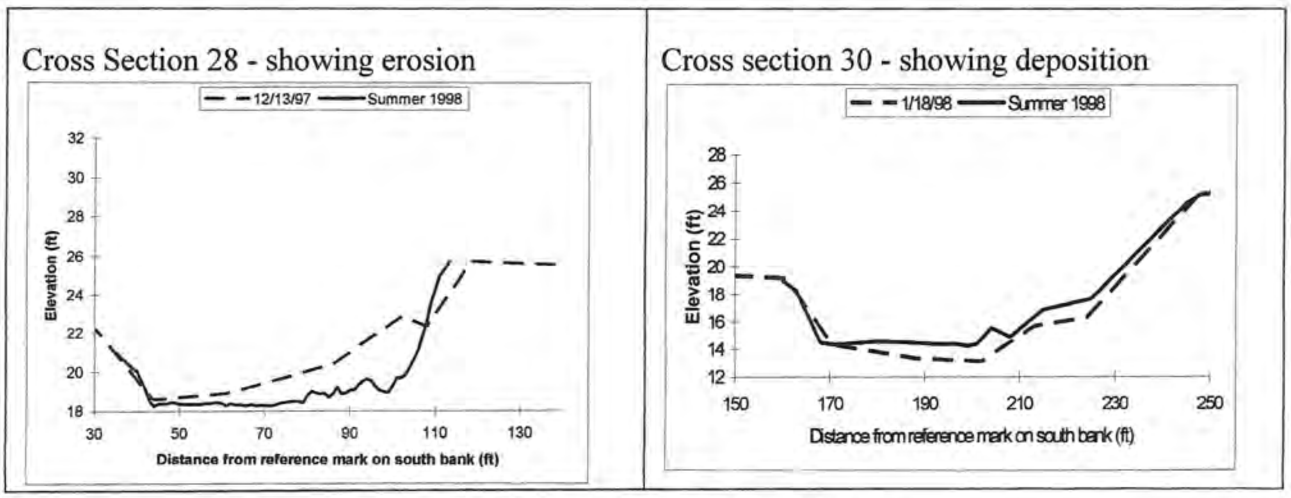

Figure 26. Cross-sections from the old channel of Chorro Creek

Cross-sections measured in the main channel in the downstream portions of the project show much less realignment than those in the upstream portion of the project. Thalveg elevations are much closer to channel bottom elevations constructed in 1997 than those found in the upstream portions of the project and the banks show very little erosion.

Cross sections measured in the old Chorro Creek channel show a mix of erosion and deposition.

Cross sections measured in overflow channel "B" show significant amounts of deposition.

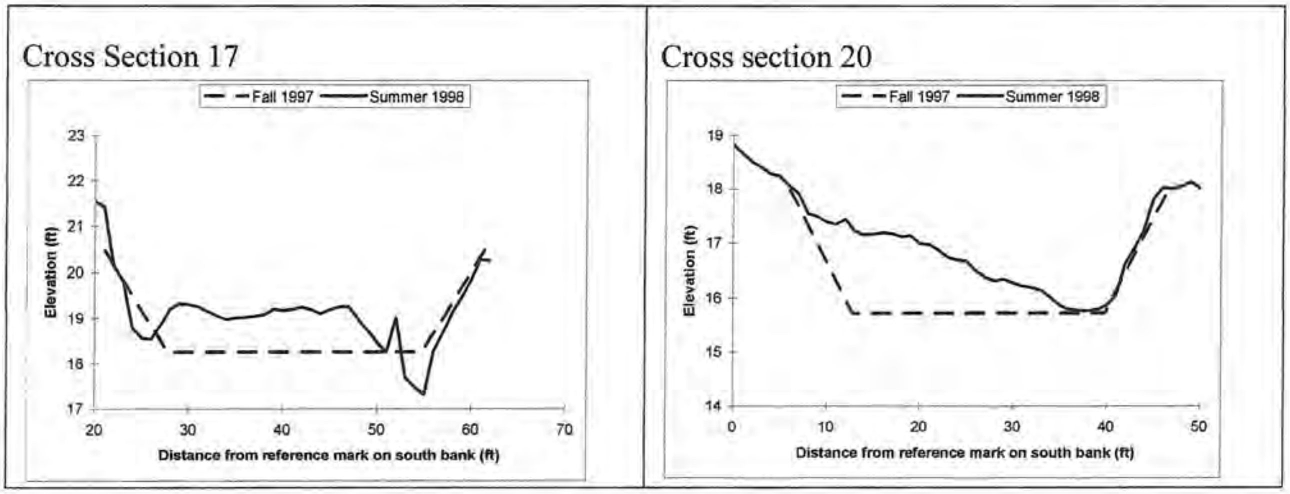

Figure 27. Cross-sections from overflow channel "B"

The developing stream meanders are creating pools which provide important habitat for fish. A fish habitat survey was conducted in June and July, 1998, by the California Department of Fish and Game. Another survey, conducted using identical protocols, was conducted during 2001 as part of a steelhead restoration planning project. These surveys found pool habitat to have increased from 7% to 26% of the length of stream surveyed (Nelson, 1999, and CSLRCD, 2001). This increase in the amount of pool habitat can be attributed in part to natural channel forming processes, and in part to scouring associated with the instream habitat structures that were installed in 1999 and 2001.

Endangered Species Habitat

As the riparian vegetation and stream channel system has developed, habitat suitable for endangered species is being created. Pools and riffles are developing. Steelhead and red-legged frogs have been found on the site.

During the fish habitat survey in 1998, CDFG personnel also sampled fish populations. They found six individual steelhead in Chorro Creek. One 5-inch steelhead was found near the center of the project and five 10-inch steelhead were found near the upstream boundary of the project (Highland, pers. comm., 2000). During 2001, 7 steelhead were observed in a pool near the upstream boundary of the project (T.R. Paine and Assoc., 2001.)

In 1997 no California red-legged frogs (CRLF) were found on the project site during surveys conducted in July and August (Garcia and Associates, 1998.) During 1999 and 2001 CRLF were found in Chorro Creek in the upstream portion of the project as part of monitoring associated with installation of instream habitat improvement structures (Wilcox, 1999, Morro Group, 1999, Tenera, 2001.) Therefore, it appears that habitat suitable for this species is being created.

Beneficial Uses and Water Quality

Aquatic and riparian habitat beneficial uses are being enhanced. Water quality is being improved by reducing sediment loads to Morro Bay. Riparian vegetation is now providing significant shading and downstream peak summertime water temperatures are noticeably lower than upstream temperatures. Water temperatures upstream and downstream of the site have been collected to document temperature changes within the project, and are discussed below. Use of the site by migratory birds has also been monitored, and is also discussed below.

Water Temperature

The riparian plantings are now shading Chorro Creek.

Figure 28.
Downstream portion of project, June 1998.

Figure 29.
Same downstream location, August 2001.

Due to the extensive growth of the riparian zone plantings, and the subsequent shading of the channel, peak daily summer water temperatures in Chorro Creek now decrease as water flows through the project. This is the reverse of the conditions found in 1998. During 1998, daily maximum temperatures were seen to increase as water flowed through the site. In the summer of 2002, the situation was reversed, with peak downstream temperatures typically lower than peak upstream temperatures.

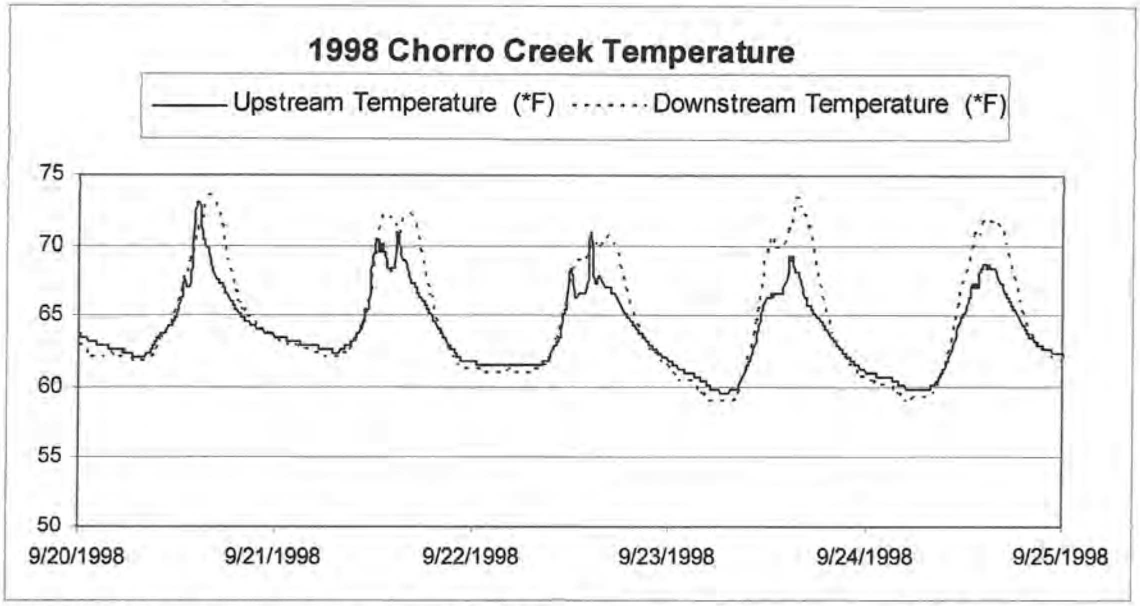

Figure 30. 1998 water temperatures in Chorro Creek at the upstream and downstream ends of the Chorro Flats Enhancement Project.

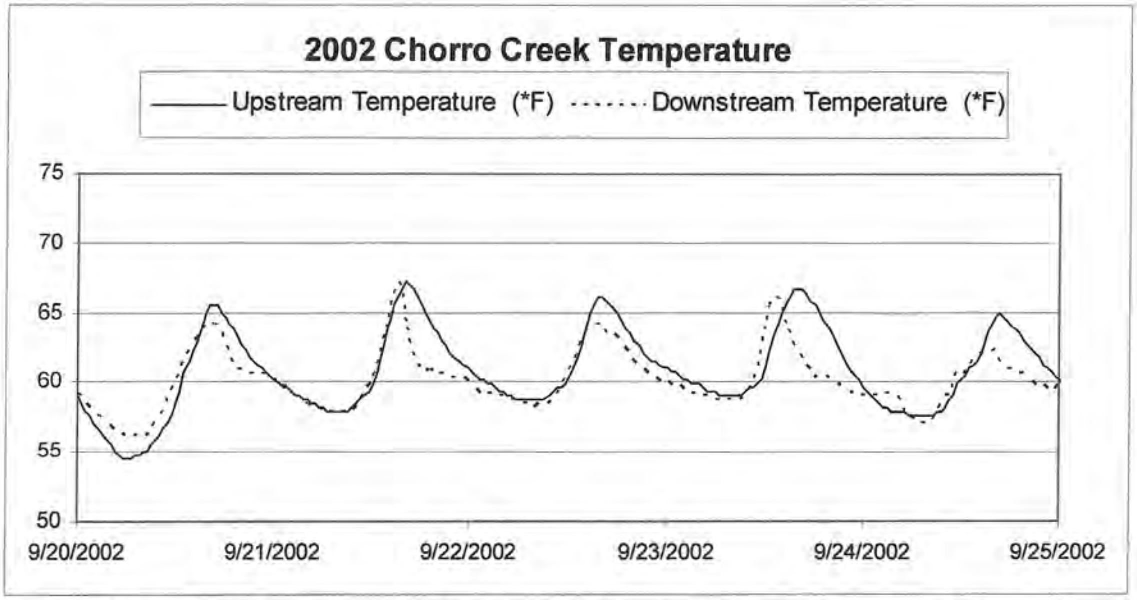

Figure 31. 2002 water temperatures in Chorro Creek at the upstream and downstream ends of the Chorro Flats Enhancement Project.

Bird Population Monitoring

A Monitoring Avian Productivity and Survivorship (MAPS) monitoring station was set up on the Chorro Flats site in 1999, and has continued to collect data each year since that time. MAPS is a nationwide program coordinated by the Institute for Bird Populations. The monitoring station consisted of 10 mist nets which were deployed approximately every two weeks between early May and early August. The monitoring program was sponsored by the Morro Coast Audubon Society chapter and coordinated by Paloma Nieto, a volunteer ornithologist. Summary results are presented below. These results indicate that the site provides habitat for a wide variety of birds.

Table 9. Summary MAPS Data

Year	1999	2000	2001	2002
New captures	413	465	162	205
Juvenile new captures	130	277	82	93
Recaptures	55	105	51	66
Juvenile recaptures	19	39	3	16
Number of species	36	32	24	28

Public Participation Opportunities

Numerous public participation opportunities have been provided at the site, via the media, and via various public forums. These activities are listed below.

A groundbreaking ceremony and news conference was held on July 9, 1997.

Figure 32. Groundbreaking ceremony July 9, 1997.

Weekly meetings were held during construction with CSLRCD and NRCS staff, contractors, subcontractors, suppliers, and members of the Technical Advisory Committee. Interpretive signs were developed and installed at the Quintana Road overlook and at the Black Hill overlook.

Figure 33. Dedication ceremony held October 9, 1998.

A dedication ceremony and news conference was held October 10, 1998. A memorial plaque for Russ Whitaker was installed on the boulder adjacent to the interpretive sign on Quintana Road. Approximately 40 people attended the ceremony, including Cathy Novak, the Mayor of Morro Bay, Bud Laurent, a San Luis Obispo County Supervisor, as well as representatives of

Congresswoman Lois Capps, and Assemblyman Tom Bordonaro. Many people participated in a site tour that was offered immediately after the ceremony. The dedication ceremony was videotaped and aired on local public television.

In January 1999, a summary of data available regarding deposition on the site was developed. This material was presented to local reporters and to the Morro Bay City Council and to the Morro Bay National Estuary Watershed Committee. A press release regarding sediment deposition on site was developed and distributed to the local media.

In early 1999, a paper regarding the project was presented at Urban Streams Conference, and was also posted to the CSLRCD web page (www.coastalrcd.org).

A presentation on Chorro Flats was delivered at the Urban Streams Conference (4/12/99) held in San Luis Obispo. Conference attendees toured the site on 4/11/99.

Public "nature-walks", held on the 4th Saturday morning of each month, began in May 1999 and continued through June 2001. These walks had good attendance. Topics have included wildflowers, bird monitoring activities, and comparison of pond and stream ecology.

Tours of site have been given to interested groups including Monarch Grove Elementary School, Foundation K'sh, Greenspace North Coast Summer Youth Work/Study Program, California Regional Water Quality Control Board TMDL workshop, National Non-point Source Monitoring Workshop, Friends of the Estuary, and a Cal Poly planning class.

In September 1999, preliminary monitoring results were presented at the National Non-point Source Monitoring Workshop in Morro Bay.

In 1999 a vegetation survey of the grasslands portion of the site was completed as a Senior Project by a Cal Poly student, Crystahl Handel.

Several Cal Poly classes have "learned by doing" by assisting with installation of plant material. Dr. Brian Dietterick's watershed management classes installed willow mattresses in spring 1998, fall 1999, fall 2000, spring 2001, and spring 2002. In November 1999 and February 2002, David Fross' habitat restoration class helped plant hundreds of native trees and shrubs from containers.

A presentation on Chorro Flats was delivered at the Riparian Habitat and Floodplains Conference (March 12-15, 2001) hosted by the Western Section of the Wildlife Society and the Riparian Habitat Joint Venture in Sacramento, and will be included in the conference proceedings.

A presentation on Chorro Flats was delivered at the California NPS Conference (October 23-25, 2001) hosted in Sacramento by the California State Water Resources Control Board.

Strategies for Long-term Monitoring and Maintenance

Long-term Maintenance Needs

Various types of long-term maintenance will be required for the site, and are discussed below.

Plant Maintenance

The riparian trees, shrubs, and grasses that were planted as part of the project are fairly well established. The older, 3, 4, and 5-year old trees and shrubs will require only minimal weed control while younger, smaller plants may require one or two more years of weeding and supplemental irrigation during summer months. Invasive weeds that continue to colonize the floodplain will need to be controlled periodically by hand removal and application of herbicide.

Channel Maintenance

Portions of the creek have unstable banks. It would be prudent to assume that significant erosive losses may occur in the future, and that some provision be made for continued streambank maintenance, such as additional willow plantings or other streambank protection measures.

Agricultural Use and Access Maintenance

The dirt access road from Quintana Road will require periodic maintenance. Vandalism and deterioration of irrigation equipment (i.e., the well, pump, and irrigation pipes), signs, fences, and other improvements will require periodic maintenance. Additionally, periodic cleaning of the drainage swales on the site may be required.

Required Monitoring

Monitoring is required to meet the terms of several permits and grants associated with the project. These requirements are discussed below.

USACOE Permits

The US Army Corps of Engineers issued a permit for the construction of the entire project, as implemented in 1997. This permit requires that plant surveys be conducted at least annually until 80% of the planted trees and shrubs survive. A final revegetation success survey was conducted in 2001 and submitted to the Army Corps in early 2002.

Two additional permits were issued for installation of instream habitat improvement structures in 1999 and 2001. Revegetation monitoring reports are required annually for three years following construction. These reports will contain monitoring results, photographs, a description of maintenance activities, and an assessment of attainment of performance criteria.

Desired Monitoring

Additional monitoring efforts were described in the Monitoring and Maintenance Plan. While these monitoring activities are not required, per se, they would provide information that may be useful in assessing the success of the project and in planning similar projects. These monitoring activities are listed below.

Table 10. Desired Monitoring Activities

Task	Description	Schedule
High-Flow Impact Assessment	Inspect site for impacts associated with high flow events.	Immediately after flow events exceeding a 5-year storm.
Measure Deposition	Conduct aerial topographic survey of entire site. Establish DTM grid on 50 foot intervals. Coordinate fly-overs with others if possible.	At least once every 5 years, or every two years if a 25-year storm has occurred during that time.
Survey Channel Cross-Sections	Establish permanent locations for cross-sections in old and new channels.	(in conjunction with aerial topo mapping)
Sediment Grain Size Analysis	Collect representative sample of annual sediment deposition at representative locations. Measure grain-size distribution using #200 wash only.	(in conjunction with aerial topo mapping)
Periodic Vegetation Inspection	Inspect site and assess need for maintenance activities: • weed control • pest control (gophers, etc.) • supplemental irrigation	As needed April through November
Photo Record	Take color photographs from representative photo points.	April and September
Monitor Agricultural Practices and Productivity	Record flood impacts to agricultural fields on site (if any). Document annual production and practices used.	Record flood impacts as needed following floods. Annual production recorded in November.
Instream Fish Habitat and Fish Passage Condition Survey	Using CDFG Stream Habitat Inventory methods, assess fish habitat in old and new channels, and at fish habitat improvement structures.	Biannually
Estimate flow rates through site	Use flow data and precipitation data collected by others (including CCRWQCB, SLO County, and the City of Morro Bay,) in conjunction with the streamflow model developed by the MBNEP, to estimate daily flow rates and peak flow rates through site.	Summarize Annually

Estimate sediment load to site	Use estimated daily flow rates and peak flow rates, in conjunction with the sediment load model developed by the MBNEP, to estimate annual sediment loads to site. Compare amount of sediment collected on site to estimated sediment load.	Annually
Water Temperature Monitoring	Measure temperature in channel, at upstream and downstream limits of project. May wish to include air temperature monitoring.	Hourly during July, August, and September.

Land Ownership

A lot line adjustment is being made so that the site will consist of three parcels.

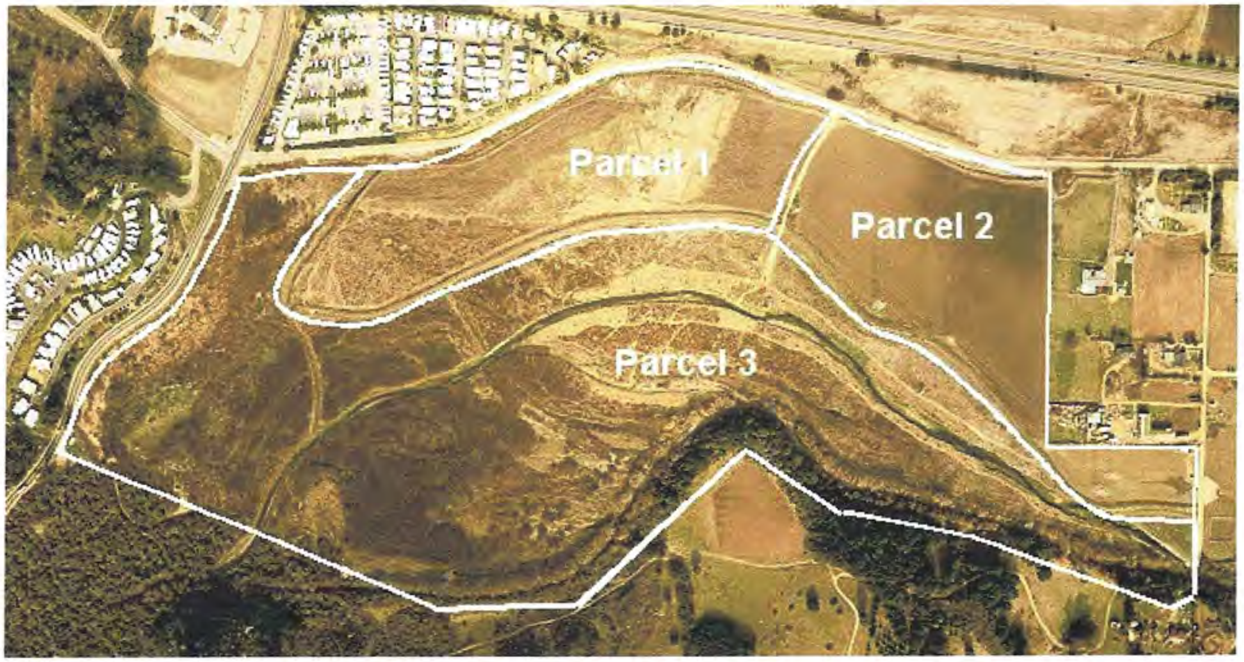

Figure 34. Lot Line Adjustment

The agricultural portion of the site (Parcels 1 and 2) will be split from the wetland portion of the site (Parcel 3). The agricultural portion will be split into two separate parcels at the access road. Both the agricultural parcels also include the berm on their southern border. The reason for this lot line adjustment was so that the wetland portion of the site could be transferred to some other agency for long-term ownership while the agricultural portion could be retained in agricultural production.

It is expected that within the year California State Parks will agree to assume ownership and responsibility for the maintenance of the wetland portion of the site.

The agricultural parcels may be retained by the CSLRCD, or they may be used in some sort of a real estate transaction which would allow the CSLRCD to acquire other lands to implement additional soil and water conservation practices.

Funding

Currently, the site generates approximately $720 in annual income from leasing the agricultural portion of the site. The radio tower lessee bought out their lease in 2002, and are planning to remove the towers in the near future. The lease buy-out resulted in a one-time receipt of $23,250, equivalent to the discounted value of the approximately $7,200 per year lease which was to expire in 2005. Together these income sources are equivalent to an annual income of approximately $8,000 per year until 2005, and then $720 per year thereafter.

This amount may be sufficient for routine, small-scale weed abatement activities and periodic maintenance of other site features. It is not clear whether this amount is sufficient to meet all maintenance and monitoring needs of the site over the long term.

At the present time, no other long-term funding source has been identified.

Long-term Conceptual Recommendations (Lessons Learned)

The following recommendations are offered to enhance the success of projects similar to the Chorro Flats Enhancement Project (CFEP), and are not meant as criticism for any of the individuals who have contributed to this project. The project is highly successful at meeting its objectives, and the people who have worked on it should be congratulated for their worthwhile efforts.

Management

Planning

The long planning process associated with the project provided a strong foundation for implementation. Those wishing to implement similar projects should not be daunted by the amount of time required to bring a project from great idea to beneficial actuality.

However, it should be realized that the burdens of this long planning effort often fell to community members acting without compensation. Therefore, unless a community contains a number of dedicated individuals, willing to spend long hours at meetings, dealing with paperwork, etc., worthy project such as the CFEP may never be planned, and therefore never implemented. Therefore, it is recommended that *planning* efforts receive adequate funding, or some other way be found to encourage and support "volunteers" who work to plan these sorts of projects.

Scope of Work and Deliverables

Under the terms of the Coastal Conservancy grant, 10% of each invoice is withheld. This withholding builds up until the entire project is completed, and then it is paid to the CSLRCD.

This arrangement has resulted in the CSLRCD having to provide almost an additional $25,000 in funding – funds that are used to pay the amount withheld each invoice cycle.

It was beneficial that the project was broken up into two phases – Implementation and Maintenance & Monitoring – which allowed the full cost of construction to be paid once implementation was complete. However, it may have also been appropriate to break down the Maintenance & Monitoring work into annual phases. In this way a large, multi-year project could be undertaken by a relatively small organization without the need for additional funding to cover the 10% shortfall which builds up as the project progresses.

Project Design

Design of Upstream Connection to Chorro Creek

It should be recognized that the sediment trapping that occurred on the site following the early 1995 floods represented a significant benefit to Morro Bay and provides validation for the acquisition of this site. It also presented an opportunity to further refine the conceptual plan. A geomorphic review team recommended that the existing Chorro Creek alignment be allowed to remain as the primary flow channel. They further recommended that the primary restoration approach should be to remove the existing levee, construct a new berm far away from the channel and excavate a shallow swale to encourage some channel overflow and provide a secondary channel location for the inevitable channel avulsion.

The location of the overflow channel was modified so that the connection to Chorro Creek would occur at Chorro Creek Road. This location scoured severely following the high flows of the early and mid 90's, indicating that geomorphically, this was an alignment the channel wanted to take. Additionally, the ecologic impact and permitting issues were easier here, as there were fewer trees and impacts. Also, it made better use of the upstream and higher elevations of the site for sediment capture.

However, the upstream connection between the existing creek and the "overflow" channel eroded more quickly than expected during the winter of 1997-98. Perhaps this upstream connection could have been designed with more consideration given to maintaining grade at the point of connection.

Additionally, the connection between the overflow channel and Chorro Creek was made at the extreme upstream end of the site. Connecting to Chorro Creek at this location, in conjunction with the erosion noted above, has resulted in significant erosion very close to the berm and somewhat close to the high voltage power transmission towers that cross the site. A preferable location for the connection may have been somewhat further downstream, to avoid potential impacts to the berm and towers. See below.

Figure 35. Alternative Location for Channel Connection and Berm

It is important to highlight the sequence of extraordinary storms/winters that occurred following project design and sequential implementation. These storms were much more severe than would have been predicted based on longer term averages. Some of the benefits (i.e. rapid trapping of sediment), and problems (e.g., the immediate avulsion of the creek out of the old channel to the new, small, 2-year pilot channel), are related to these big events. In project planning, you always try and develop a plan that can accommodate these larger, unexpected events (as the CF project has), but nature is unpredictable. In particular, it was expected that the shift to the new pilot channel might occur gradually, over decades, by which time a dense vegetation cover would be established and problems of erosion (particularly near the power tower) would not have developed. In retrospect, this was the most serious problem that was not handled well in the design. (Haltiner, pers. comm., 2000)

Location of Berm and Agricultural Portion

The western portion of the agricultural part of the site frequently floods and has not been farmed since project implementation in 1997 due to continued wet conditions. (These conditions are not entirely due to project implementation. Minimal stream flow agreements have forced pumping from the aquifer below Chorro Fats to be reduced. The El Niño winter has also contributed to these wet conditions.) To improve this situation, material excavated from the "pilot channel" and from the old levee on Chorro Creek was spread over this portion of the site, thereby raising its elevation and improving drainage.

Conversely, the easterly end of the floodplain portion of the project is higher and drier than the rest of the site, and receives floodwaters (and sediment) less frequently. These observations lead to the suggestion that a better location for the berm may have been closer to the creek in the central portion of the site, and further from the creek in the westerly portion of the site. However, it should also be noted that prior to project implementation the western areas of the site were usually left fallow during very wet years. This leads to the idea that perhaps the berm could have been abbreviated (as shown above) so that the unproductive agricultural land could have been more directly connected to the floodplain, thereby enhancing sediment capture. The CSLRCD is currently considering removing or relocating the western portion of the berm for the reasons noted above.

During planning, an alternative was considered where no berm would be built, but that the wetland portion of the site would be sloped gently upward to the (higher) agricultural portion of the site. It has been suggested that the agricultural portion of the site might drain better if it had been sloped, rather than separated with a berm (Worcester, pers. comm., 2000). However, a berm was used for the following reasons:

- A berm would provide a permanent physical barrier between farming operations and the wetland portion of the site. This barrier would benefit the developing wetland portion by preventing any encroachment of agricultural activities.
- During moderate flood events the berm would prevent floating debris from washing onto the agricultural fields, and during large flood events would also keep large grained sediments out of the agricultural fields. Exclusion of these materials would benefit agricultural operations.

Avulsion of Overflow Channel

Because the upstream connection between the existing creek and the "overflow" channel eroded more quickly than expected during the first winter, Chorro Creek is now in a "new" location. Forcing Chorro Creek back into its old location has been considered. However, leaving Chorro Creek in its present location is preferable because the new channel provides better habitat for steelhead, and because forcing all the flow back to the old channel would effectively "dewater" the new channel - an action that could not be permitted. There is a related concern that the old channel would dry up before California red-legged frog tadpoles could reach maturity. However, this concern has proved groundless because water has been observed flowing into the old channel during late spring and early summer every year since 1998.

Implementation

Adaptive Management Measures

Because nature is unpredictable, it is inevitable that some features of a project will not function as designed. To "fix" these features, some of the recommendations discussed below involve adaptive responses carried out over several years. For this reason, it is important that sufficient resources be available after initial implementation is complete.

This project was fortunate to have a significant amount of resources allocated for monitoring and maintenance. However, in planning future projects, it may be wise to consider applying an adaptive management strategy from the beginning. This strategy would result in a phased implementation approach, periodic re-evaluations to provide "feedback", and an evolving set of "success" criteria. It is important to note that adaptive management processes will not always neatly match funding or permitting criteria.

The following discussions highlight how an adaptive management approach would benefit this project.

Timing of Plant Establishment and Creek Connection

The project was constructed so that during the first winter (not more than a few months after one-gallon shrubs and trees, 4-foot by 1-inch willow stakes, and native grass seed had been planted) the site would accept overbank flows from Chorro Creek. These first-year flows were very large. The resulting erosion of unprotected streambanks was unfortunate.

Perhaps a better strategy would have been to build an overflow channel *without removing the levees*. Then spend several years establishing the bank vegetation and floodplain vegetation. After two years, the levees could have been removed (with minimal disturbance to the new channel and associated vegetation) and the berm could have been constructed. Then, when the first year floods arrived, the waters would flow into a more protected, vegetated channel. This recommendation obviously would require that the project be phased over several years, thereby reducing the amount of sediment which could be captured during the first years. However, because the project was envisioned with a 50 to 70 year lifespan, a delay of a few years may not be significant.

It should be noted that an early recommendation called for creating a new, full-scale channel in the historic channel location, revegetating it for about 5 years, then excavating a connection and plugging the old channel (Crawford Multari & Starr, 1993). However, at the time, there were three areas of opposition to this approach (Haltiner, pers. comm., 2000):

- Some people recommended removing the levees along the old channel only, and not creating any new channel at all (ie, let the river do what it will).
- Geomorphologists involved with the project felt that any new channel would likely be unstable (over a time-frame of centuries), so excavating a new one would not likely be of much benefit.
- It was believed that a permit to block the old channel would not be issued, due to endangered species issues.
- During initial design work, there was no clear long-term site manager/entity identified that could guarantee that the 5-year planting/monitoring, then breaching of the opening would all occur. So it was decided to do an "all-in-one" restoration project, with a smaller emphasis on longer-term maintenance and monitoring.
- Funding agencies involved with the project were unwilling to support a phased approach. They needed to spend their money by a certain date or it would be re-allocated to other projects (Scott Robbins, pers. comm., 2000).

Some decision makers were uncomfortable with the idea of no new channel, as they felt in the short term, this could produce wild channel instability, and perhaps no defined channel for some period, and possible damage to property, roads etc.. The compromise on this issue was to excavate a "pilot" channel (which intersected the existing channel about 5' above the existing channel invert, and was only expected to infrequently carry water/sediment out to the floodplain). It was recognized that this might become the location for a new channel, but this might occur gradually over many years (Jeff Haltiner, pers. comm., 2000). Needless to say, it was fortunate this was in place when we had the huge storms the very next year, and the creek immediately shifted into this pilot channel.

Adaptive Channel Maintenance Measures

Because of erosion and downcutting in the upper portion of the project, overbank flows (and associated sediment capture) will occur less frequently in this portion of the site than initially planned. To respond to these changes, it would be wise to restrict the channel capacity in these areas to increase the frequency of overbank flow. These restrictions could be a combination of structural elements (e.g., wing deflectors) and vegetative elements (e.g., willow mattresses and willow baffles.)

Access to Southern Portion of Floodplain

During the planning of the project, it was consciously decided to not build a crossing or other type of access to the southern portion of the floodplain. The reasons for this had to do with reducing human impacts in the area which would provide wildlife habitat. However, this lack of access, and the fact that the channel migrated to the "overflow" channel during the first year, has made maintenance activities in that portion of the project more problematic. It would perhaps have been better to provide good access for a few years for maintenance purposes, then removed or modified the crossing to restrict human access after the site had matured.

Maintenance

Tree and Shrub Maintenance

During the first two seasons, the trees and shrubs were maintained with minimal irrigation, regular weeding, and application of mulch to conserve moisture and reduce weed growth in the immediate vicinity. Replacement seedlings were replanted in the fall or winter. Given the significant mortality (due to scouring or burying under sediment), and the wet conditions found during the first growing season, it may have been appropriate to replant in May of that year, and continue with generous irrigation through the first season.

Grassland Maintenance

Interplanting native grasses with native trees and shrubs made maintenance of the trees and shrubs difficult. Use of broad-leaf herbicides and mowing requires hand-directed equipment. It should be noted that an initial alternative for the project recommended planting only grasses the first year, then planting trees and shrubs the next year, after the grasses were well established and could exclude weeds (Crawford Multari & Star, 1993.)

When trees and shrubs were first replanted in December 1998, the areas that were to be replanted were rototilled before the plants were installed. However, this rototilling appears to have encouraged weed growth over the desired grass species. Therefore, it is not recommended that areas previously seeded to grass be tilled, unless additional grass seed is also being applied.

During the first growing season, little was done to control weeds in the grassland areas. The more noticeable and invasive species were removed by hand. Mowing was undertaken once, at the end of the season. In the few areas that were mown early during the first summer, grass growth the following season was significantly better than in non-mown areas. Therefore, it is recommended that regular mowing be incorporated in areas where grasses are planted.

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