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SAN JUAN CREEK WATERSHED MANAGEMENT STUDY
ORANGE COUNTY, CALIFORNIA

FEASIBILITY PHASE

ECOSYSTEM RESTORATION FORMULATION AND EVALUATION APPENDIX

AUGUST 2002

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SAN JUAN CREEK WATERSHED MANAGEMENT STUDY
ORANGE COUNTY, CALIFORNIA
ECOSYSTEM RESTORATION FORMULATION AND EVALUATION REPORT

1.0 INTRODUCTION

Because of the desire by many watershed stakeholders to restore the creek channels and the associated floodplains, the watershed management plan will be formulated to include elements of environmental restoration. The Corps has a strong emphasis toward including ecosystem restoration as an integral component of Civil Works projects. Within the Civil Works Program, one of the topics considered for inclusion in the budget are projects that restore degraded ecosystem functions and values, including the ecosystem's hydrology, plant and animal communities, and/or portions thereof, to a less degraded ecological condition.

Pursuant to the Corps' Environmental Restoration and Protection guidelines, restoration concepts focus on water and related land resources. The natural historic and future (without project) conditions of the potential restoration areas are assessed prior to developing conceptual restoration plans. In addition to restoring a degraded ecosystem's functions and values, the restoration approach also recognizes that existing and planned infrastructure is a legitimate feature of the human environment and should co-exist compatibly with the natural features of ecosystems in which they are placed. Therefore, existing land use constraints and opportunities were considered during the development of the conceptual restoration alternatives.

Another important aspect of the development of restoration concepts has been collaboration with other agencies. The U.S. Fish and Wildlife Service (USFWS) and U.S. Environmental Protection Agency (EPA) have been active participants in the contribution of philosophies and strategies for achieving successful restoration concepts in other studies. Meetings and field visits will be conducted with these and other interested resource agencies, organizations, and individuals to discuss potential options for environmental restoration.

In developing restoration alternatives, it is the consensus of the participating stakeholders that each conceptual plan must: 1) incorporate and integrate ecosystem restoration as a valuable

factor in providing flood control; 2) function as natural as possible to eliminate or minimize maintenance activities and persist over the long term; and 3) provide connectivity and corridors between other important natural environments in the area.

2.0 SUMMARY OF METHODOLOGY UTILIZED TO ASSESS HABITAT OUTPUTS OF POTENTIAL RESTORATION MEASURES

The Hydrogeomorphic Methodology (HGM) is a means for estimating the capacity of a wetland or riverine system to perform its natural functions. A preliminary HGM was developed by Lee et al. (1997, pre-draft in review) for the Santa Margarita watershed in Southern California. The Santa Margarita HGM is appropriate for use in other similar coastal watersheds of southern California and was the selected method (with modifications) for determining existing and future with-project conditions for this restoration plan. An HGM assessment was conducted at each of the 11 sites where potential restoration alternatives have been identified (ER-1 to ER-11, described in Section 2.0).

HGM allows for a rapid field assessment of a number of biotic and abiotic indicators, which are used to estimate the hydrologic, biogeochemical, and biologic functional capacity of the wetland. These indicators are known as variables; their equations are presented in Figure 1 and their definitions in Table 1. The methodology allows for two scores to be generated including a baseline habitat output score and a future with-project habitat output score. The first score represents the existing functional conditions at the potential restoration site, while the second score indicates the expected functional conditions in the future. Typically, the future with-project score reflects conditions expected to be achieved after 50 years have passed. Ultimately, these scores will be incorporated into the incremental cost analysis, which will analyze the cost and habitat benefits of each restoration alternative to determine which alternatives have the greatest benefit for low cost.

Existing and future scores are calculated using the equations in Figure 1. First, the existing scores for each of the variables are summed and divided by the total number of variables to get an average existing functional capacity index score (FCI). The FCI score is then multiplied by the total area (in hectares) it occupies, which results in a score called the Habitat Unit (HU)

output. For this project, future with-project HU output scores were calculated for years 1, 25, 40, and 50 and then averaged to determine the average annual increase in HU outputs. This sample calculation is for Site ER-1:

- The existing Functional Capacity Index Score is 0.16. (Existing FCI = 0.16)
- This existing value is multiplied by the site area of 22.5 ha, which results in 3.6 Habitat Unit outputs. (0.16 FCI * 22.5 ha = 3.6 HU)
- The future Functional Capacity Index scores for years 1, 25, 40, and 50 are 0.32, 0.61, 0.64, and 0.64, respectively, which average out to 0.55. (Average Annual Future FCI = 0.55)
- This future value is multiplied by the site area of 22.5 ha, which results in 12.4 HUs. (0.55 FCI * 22.5 ha = 12.4 HU)
- The average annual increase in habitat benefits is 8.8 HU outputs. (12.4 Existing HU – 3.6 Future HU = 8.8 HU Increase).
- In this case, the increase in HUs from existing to future conditions is 247%.

This final change in HU value is used during the incremental cost analysis to determine which restoration alternatives have the greatest HU output improvement for an average annual cost. The percent increase is shown to further illustrate the gain in habitat benefits with each alternative. Each of the calculations for the remainder of the restoration alternatives is provided in Tables 2 through 7.

In some instances, the HGM utilized for the assessment of the ten evaluation areas in this report has been revised from previous HGMs (Lee et al. 1997). Because areas within the watershed are critical habitat for the arroyo toad, we included a variable indicating the suitability of the habitat to support the toad. It is included as a variable for the function of maintaining spatial distribution of vertebrates. Fish passage and neotropical migrant habitat conditions were also taken into consideration under the same heading. Additional alterations include slight changes to variable definitions.

HGM

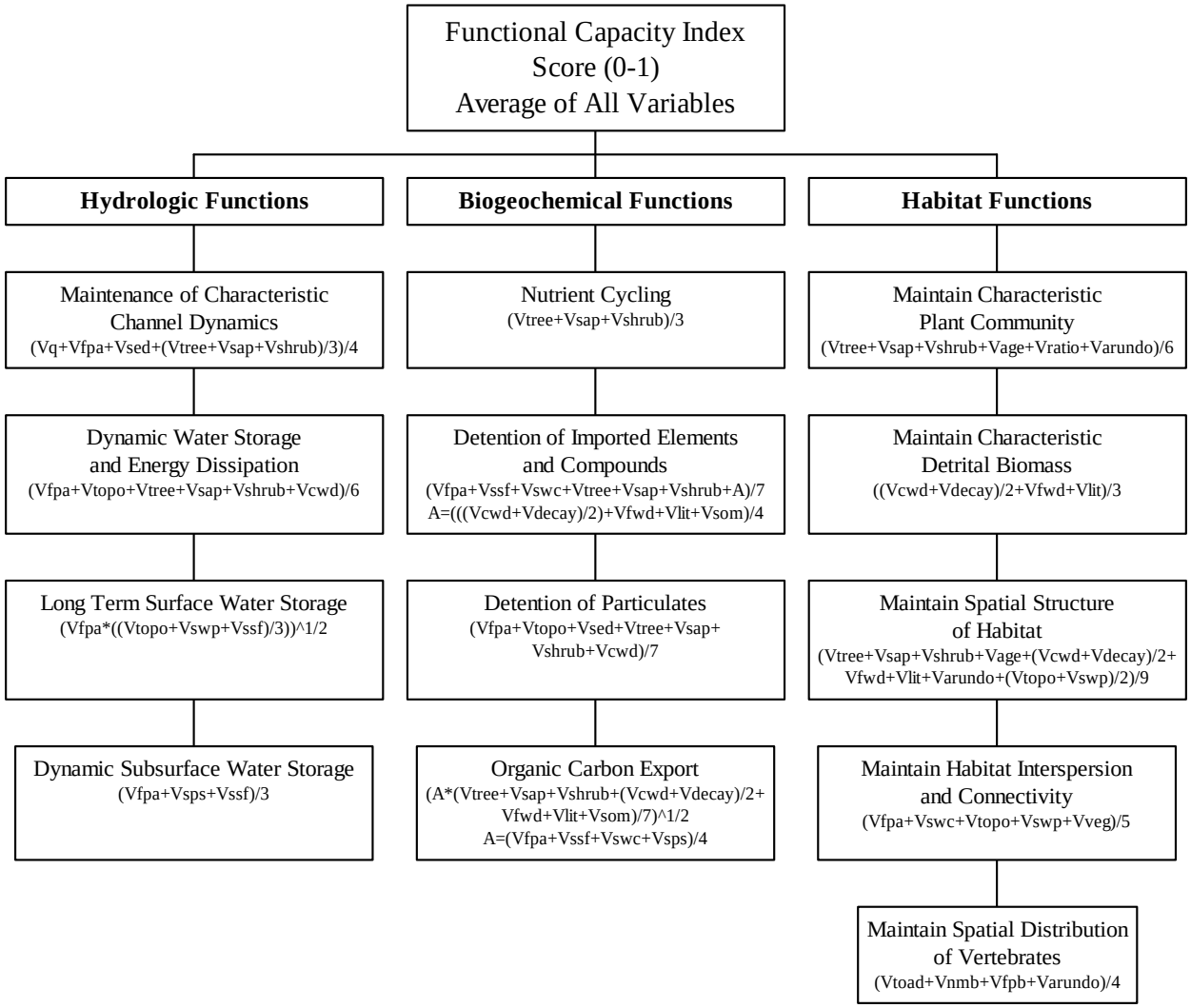

Figure 1. HGM Functional assessment indicators based on low gradient streams of 3rd, 4th, and 5th orders.

Table 1. Definitions for indicator variables scores for low gradient 3rd, 4th, and 5th order streams	
Vage	**Stand age distribution for trees, small trees, saplings, and seedlings**
1.0	Evaluation area (EA) supports trees (including small trees), saplings, and seedlings.
0.75	EA supports trees (including small trees), and saplings or seedlings.
0.50	EA has no trees (including small trees), but supports saplings and/or seedlings.
0.25	EA supports trees (including small trees), but no saplings or seedlings are present.
0.1	EA does not support any trees, saplings or seedlings. Variable is recoverable and sustainable through natural processes under current conditions.
0	EA does not support any trees, saplings or seedlings. Variable is not recoverable or sustainable through natural processes under current conditions.
Vveg	**Contiguous vegetation cover and corridors between wetlands, uplands, upstream, and downstream areas**
1.0	EA is connected to adjacent and up/down stream reaches through plant communities dominated by native species along >75% of its boundary. Communities extend at least 100' beyond EA boundary.
0.75	EA is connected to adjacent and up/down stream reaches through plant communities dominated by native species along 50-75% of its boundary. Communities extend at least 100' beyond EA boundary.
0.50	EA is connected to adjacent and up/down stream reaches through plant communities dominated by native species along 25-50% of its boundary. Communities extend at least 100' beyond EA boundary.
0.25	EA is connected to adjacent and up/down stream reaches through plant communities dominated by native species along 10-25% of its boundary. Communities extend at least 100' beyond EA boundary.
0.1	EA is connected to adjacent and up/down stream reaches through plant communities dominated by native species along 0-10% of its boundary. Variable is recoverable and sustainable through natural processes under current conditions.
0	EA is connected to adjacent and up/down stream reaches through plant communities dominated by native species along 0% of its boundary. Variable is not recoverable or sustainable through natural processes under current conditions.
Vsap	**Abundance of small trees (>5" dbh, <20' height), saplings (single stem, woody, <5" dbh, >3' height) , and seedlings (single stem, woody, <5dbh, <3' height)**
1.0	Sapling cover is between 36-60%.
0.75	Sapling cover is between 24-35% or >60%.
0.50	Sapling cover is between 12-23%.
0.25	Sapling cover is between 2-11%.
0.1	Sapling cover is between 0-2%. Variable is recoverable and sustainable through natural processes under current conditions.
0	Sapling cover is between 0-2%. Variable is not recoverable or sustainable through natural processes under current conditions.
Vshrub	**Abundance of multiple stem, woody, shrub species**
1.0	Shrub cover is between 41-68%.
0.75	Shrub cover is between 21-40% or >68%.
0.50	Shrub cover is between 14-27%.
0.25	Shrub cover is between 3-13%.
0.1	Shrub cover is between 0-3%. Variable is recoverable and sustainable through natural processes under current conditions.
0	Shrub cover is between 0-3%. Variable is not recoverable or sustainable through natural processes under current conditions.
Vtree	**Abundance of trees (>5" dbh, >20' height)**
1.0	Tree cover is between 53-88%.
0.75	Tree cover is between 36-52% or >88%.

Table 1. Definitions for indicator variables scores for low gradient 3rd, 4th, and 5th order streams	
0.50	Tree cover is between 18-35%.
0.25	Tree cover is between 4-17%.
0.1	Tree cover is between 0-3%. Variable is recoverable and sustainable through natural processes under current conditions.
0	Tree cover is 0-3%. Variable is not recoverable or sustainable through natural processes under current conditions.
Vratio	**Ratio of non-native to native trees in each stratum**
1.0	Dominant species are >75% native and no stratum is dominated by non-natives.
0.75	Dominant species are 50-75% native and/or up to 25% of the strata present are dominated by non-native species.
0.50	Dominant species are 25-50% native and/or up to 50% of the strata present are dominated by non-native species.
0.25	Dominant species are 0-25% native and/or up to 75% of the strata present are dominated by non-native species.
0.1	All of the dominant species are non-native and/or up to 100% of the strata present are dominated by non-native species.
0	There is no vegetation. Variable is not recoverable or sustainable through natural process under current conditions.
Vq	**Alterations of hydroregime that affect the flood frequency, duration, and magnitude**
1.0	No additions, diversions, or damming of flow (including water harvesting, farming practices, stormwater management, etc.).
0.75	Evidence of additions, diversions, or damming of flow but no evidence that these have resulted in changes in impacts to channel pattern, dimension, and profile.
0.50	Evidence of additions, diversions, or damming of flow and there is evidence that these have resulted in changes in vegetation abundance. No evidence of increased sediment deposition or scour.
0.25	Evidence of additions, diversions, or damming of flow and there is evidence that these have resulted in increased sediment deposition and scour.
0.1	Evidence of additions, diversions, or damming of flow that have resulted in significant impacts to Channel pattern, dimension, and profile. Variable is recoverable and sustainable through natural Processes under current conditions.
0	Permanent alterations to the assessment area hydroregime. Variable is not recoverable or sustainable Through natural processes under current conditions.
Vfpa	**Floodprone area defined by the projection of a horizontal plane at a level twice the bankfull Thalweg depth**
1.0	Floodprone area not clearly modified by cultural processes (such as artificial levee construction, entrenchment, riprap, concrete, etc.).
0.75	Floodprone area is confined by an artificial levee or a culturally accelerated entrenched channel on One side of the EA only.
0.50	Floodprone area is confined within artificial levees or a culturally accelerated entrenched channel, and Floodprone area is greater than 2 times the bankfull width.
0.25	Floodprone area is confined within artificial levees or a culturally accelerated entrenched channel, and Floodprone area is less than 2 times the bankfull width. Variable is recoverable and sustainable Through natural processes under current conditions.
0.1	Floodprone area is confined within artificial levees or a culturally accelerated entrenched channel, and Floodprone area is less than 2 times the bankfull width. Variable is not recoverable or sustainable Through natural processes under current conditions.
0	Floodprone area is entirely within a concrete or riprap channel. Variable is not recoverable or Sustainable through natural processes under current conditions.
Vsed	**Extent of sediment delivery to water/wetland from culturally accelerated sources**

Table 1. Definitions for indicator variables scores for low gradient 3rd, 4th, and 5th order streams	
1.0	No culturally accelerated sources of sediment input into the EA (such as tributaries that drain Orchards or other agricultural lands, grazing in or adjacent to EA, road crossings within 200' of the EA.) No evidence of culturally accelerated delivery of sediment to the EA.
0.75	Culturally accelerated sources of sediment input to the EA, but little or no evidence of accelerated Delivery of sediment to the EA.
0.25	Culturally accelerated sources of sediment input to the EA and evidence of accelerated delivery of Sediment to the EA.
0.1	Culturally accelerated sources of sediment input to the EA and evidence of accelerated delivery of Sediment to the EA that is resulting in an extreme change in channel morphology and/or high rates Of vegetation mortality.
0	EA is entirely filled.
Vssf	**Subsurface flow into the water or wetland**
1.0	Areas adjacent to, upstream of, and within the assessment area are predominantly undisturbed. Native soils and plant communities are present, and direct evidence of subsurface flow to the EA is observed. Undisturbed, native soils and plant communities must extend at least 100' beyond the EA boundary.
0.75	Areas adjacent to, upstream of, and within the assessment area are predominantly undisturbed. Native soils and plant communities are present, and no direct evidence of subsurface flow to the EA is observed. Undisturbed, native soils and plant communities must extend at least 100' beyond the EA boundary. **OR** Areas adjacent to and/or upstream of and/or within the assessment area are predominantly disturbed soils and plant communities and direct evidence of subsurface flow to the EA is observed.
0.50	Areas adjacent to and/or upstream of and/or within the EA are predominantly utilized for agricultural activities and no direct evidence of subsurface flow to the EA is observed.
0.25	Areas adjacent to and/or upstream of and/or within the EA are predominantly fill and no direct evidence of subsurface flow to the floodprone area is observed.
0.1	Areas adjacent to and/or upstream of and/or within the EA are predominantly impervious and no direct evidence of subsurface flow to the floodprone area is observed.
0	The bankfull channel is entirely contained within a concrete channel, culvert, etc.
Vswc	**Surface hydraulic connections between the bankfull channel and the floodprone area**
1.0	Presence of secondary channels within the floodprone area and it is not confined within artificial levees or a culturally accelerated entrenched channel.
0.75	Presence of secondary channels within the floodprone area but it is confined within artificial levees or a culturally accelerated entrenched channel.
0.50	Secondary channels, if present, are located outside of the floodprone area. Secondary channels are engaged at flood events that exceed the floodprone width, but no with a frequency, duration, and force sufficient to create and maintain surface connections to the bankfull channel. Indicators include accumulations of organic matter within secondary channels.
0.1	Area above bankfull stage but within floodprone area is a steep bank. Variable is recoverable and sustainable through natural processes under current conditions.
0	Area above bankfull stage but within floodprone area is a steep bank. Variable is not recoverable or sustainable through natural processes under current conditions.
Vswp	**Duration of surface water persistence after flows recede**
1.0	Evidence of surface water ponding for >1 day. In the lower gradient systems, surface water often ponds in depressions that have a thin veneer of silty material that impedes infiltration. In the higher gradient systems, surface water often ponds in tenajas below the bankfull stage.
0.75	Evidence that surface water ponding occurs for both > 1 day and < 1 day on some occasions.
0.50	Evidence of surface water ponding for greater than hours but less than one day.
0.1	EA provides no features that could pond water. Variable is recoverable and sustainable through natural processes under current conditions.
0	EA provides no features that could pond water. Variable is not recoverable or sustainable through

Table 1. Definitions for indicator variables scores for low gradient 3rd, 4th, and 5th order streams	
	natural processes under current conditions.
Vlit	**Abundance of leaf litter and other detrital matter**
1.0	Litter cover between 59-100%.
0.75	Litter cover between 39-58%.
0.50	Litter cover between 20-38%.
0.25	Litter cover between 4-19%.
0.1	Litter cover between 0-3%. Variable is recoverable and sustainable through natural processes under current conditions.
0	Litter cover between 0-3%. Variable is not recoverable or sustainable through natural processes under current conditions.
Vsom	**Soil organic matter content**
1.0	Presence of incipient A and/or O horizons and/or pockets of buried detrital matter and/or stripped matrix in sandy soil due to translocation of organic material.
0.50	No direct evidence of organic material incorporated within the soil profile and stocks of organic matter within the EA suggest that the indicator is recoverable and sustainable under current conditions since there is one or more of the following: well-developed plant community, fine roots common, abundant leaf litter, fine wood, and/or coarse wood.
0.1	No direct evidence of organic material incorporated within the soil profile and stocks of organic matter within the EA suggest that the indicator is not recoverable or sustainable under current conditions.
0	The EA is entirely contained within a concrete channel or culvert, etc.
Vsps	**Soil pore space available for storing subsurface water**
1.0	Soil texture within the floodprone area is sand-sandy loam and no restrictive layer is present within the upper 24” of the soil profile.
0.50	Soil texture within the floodprone area is finer than sand sandy-loam and/or restrictive layer is present within the upper 24” of the soil profile.
0.1	Modal soil profile within the floodprone area highly compacted within the upper 24” due to heavy grazing, extensive placement of fill, etc.
0	The EA is entirely contained within a concrete channel or culvert, etc.
Vfwd	**Fine woody debris**
1.0	Cover between 30-51%.
0.75	Cover between 21-29% or >51%.
0.50	Cover between 10-20%
0.25	Cover between 2-9%.
0.1	Cover between 0-1%. Variable is recoverable and sustainable through natural processes under current conditions.
0	Cover between 0-1%. Variable is not recoverable or sustainable through natural processes under current conditions.
Vcwd	**Coarse Woody Debris**
1.0	Cover between 8-13%.
0.75	Cover between 6-7% or >13%.
0.50	Cover between 3-5%.
0.25	Cover between 1-2%.
0.1	Cover between 0-1%. Variable is recoverable and sustainable through natural processes under current conditions.
0	Cover between 0-1%. Variable is not recoverable or sustainable through natural processes under current conditions.

Table 1. Definitions for indicator variables scores for low gradient 3rd, 4th, and 5th order streams	
Vdecay	**Stage of decay of coarse woody debris**
1.0	Greater than 3 coarse wood decay classes are present.
0.75	A total of 3 coarse wood decay classes are present.
0.50	A total of 2 coarse wood decay classes are present.
0.25	Only 1 coarse wood decay class is present.
0.1	There are no pieces of coarse wood. Variable is recoverable and sustainable through natural processes under current conditions.
0	there are no pieces of coarse wood. Variable is not recoverable or sustainable through natural processes under current conditions.
Vtopo	**Macrotopography and microtopography complexity**
1.0	Floodprone area is characterized by subtle macro and microtopographic relief such as secondary channels, pits, hummocks, and depositional bars.
0.50	Floodprone area is characterized by the presence of subtle macro and microtopographic relief but the predominant conditions are relatively homogeneous surfaces that lack this relief.
0.25	Floodprone area is characterized by relatively homogeneous surfaces that lack relief.
0.1	Floodprone area is entirely within a concrete channel or culvert, etc.
0	Floodprone area is entirely buried and the site is no longer a water/wetland.
Varundo	**Presence of giant reed *(Arundo donax)***
1.0	There is no giant reed in the EA.
0.75	Giant reed cover is 0-5%.
0.50	Giant reed cover is 5-10%.
0.25	Giant reed cover is 10-20%.
0.1	Giant reed cover is 20-40%.
0	Giant reed cover is >40%.
Vntm	**Presence of neotropical migrants and their required habitat**
1.0	Suitable riparian habitat present and migration corridors are well connected.
0.75	Riparian habitat is suitable, although somewhat disturbed, and migration corridors are intact.
0.50	Riparian habitat and migration corridor connectivity are moderately disturbed.
0.25	Riparian habitat present but disturbed and largely isolated.
0.1	Riparian habitat is minimal, isolated, and highly disturbed.
0	No riparian habitat is present.
Vtoad	**Presence of Arroyo toads and their required habitat**
1.0	Arroyo toad habitat is present including surface water ponding, sandy terraced slopes, good oak/cottonwood/willow cover, and sufficient soil pore space. Habitat is connected to adjacent upland/upstream/downstream habitats.
0.75	Arroyo toad habitat is present including surface water ponding, sandy terraced slopes, good oak/cottonwood/willow cover, and sufficient soil pore space. Habitat is somewhat fragmented from adjacent upland/upstream/downstream habitats.
0.25	Arroyo toad habitat is present but has been significantly disturbed. Habitat is significantly fragmented.
0.1	Channel is contained within a concrete- or riprap- lined channel. Variable is recoverable and sustainable through natural processes under current conditions.
0	Channel is contained within a concrete- or riprap- lined channel. Variable is not recoverable or sustainable through natural processes under current conditions.
Vfp	**Passability for fish species during migratory period**
1.0	Adult and juvenile fish passage is not inhibited up- or down- stream.
0.75	Adult and/or juvenile fish passage is infrequently inhibited up- or down- stream.

Table 1. Definitions for indicator variables scores for low gradient 3rd, 4th, and 5th order streams	
0.50	Adult fish passage is not inhibited up- or down- stream, but juvenile passage is periodically inhibited.
0.25	Adult and/or juvenile fish passage is periodically inhibited up- or down- stream.
0.1	Passage to juvenile fish is inhibited and adult fish passage is frequently inhibited.
0	Adult and juvenile fish cannot migrate freely throughout the EA.

3.0 PRELIMINARY ENVIRONMENTAL RESTORATION ALTERNATIVES

Eleven potential restoration sites were identified using 1998 and 2000 color aerial photographs and field reconnaissance visits. Potential restoration sites were selected based on recommendations made by the USFWS in their Planning Aid Letter (USFWS 2000), restoration needs from the watershed study, and from Corps personnel familiar with the watershed. Although constraints to restoration occur throughout the watershed, locations selected were considered to have fewer constraints and are suitable for restoration actions. Overall, the lower reaches were the sites of greatest degradation to habitat conditions and the areas of greatest potential for restoration, including lower San Juan, Oso, and Trabuco Creeks. Each potential restoration site was visited and data were collected to determine existing conditions using a modified version of the Hydrogeomorphic Methodology (HGM) developed by Lee, et al. (1997) for the Santa Margarita watershed. Finally, conceptual restoration plans were developed and future with-project scores were preliminarily determined. A description of the HGM and a detailed explanation of the scoring process for each restoration alternative are provided in Section 1.0.

The potential restoration sites identified include 6 sites on San Juan Creek (ER 1-6), 2 sites on Oso Creek (ER 7-8), 2 sites on Trabuco Creek (ER 9-10), and a site at the Oso/Trabuco confluence (ER-11). The location, existing conditions, constraints to restoration, and potential restoration measures are described in the following sections.

ER-1: San Juan Creek between Stonehill Road and Pacific Coast Highway

This is the downstream-most site on San Juan Creek, located upstream of the Pacific Coast Highway crossing and ending at the Stonehill Road bridge. The left bank area was previously

the location of a water treatment plant, but has since been used for staging of equipment and other miscellaneous uses. A nursery and boatyard are the primary businesses present in the immediate left bank floodplain, and much of the land there is unused. The right bank floodplain is fully developed.

This reach is constrained on both banks by concrete-lined levees, and beyond that, residential and commercial development. This, coupled with the cumulative effects of upstream degradation, has resulted in this site receiving a poor overall score for existing conditions. Concrete levees prevent connectivity with the floodplain, subsurface flow, surface water connectivity, development of macro/micro topography, and the establishment of trees, shrubs, and saplings due to the significant amount of sediment deposition occurring in the reach. Surrounding developments contribute to culturally accelerated sources of sediment input and a highly modified hydrologic regime. The lack of riparian vegetation results in negligible amounts of soil organic matter, detrital layer, and coarse and fine woody debris. A low, sparse herb layer with a few mulefat saplings is present and is dominated primarily by non-native species. A single *Arundo donax* plant was observed, but was on the south side of the left bank levee and not in the channel. Currently there is no corridor for migration of either fish or wildlife species.

Potential restoration measures at this site are limited by the presence and need for the concrete-lined levees to protect existing development and infrastructure. However, unused land areas on the left bank currently exist and provide opportunities for restoration. In particular, land once occupied by the water treatment plant is currently vacant. Possible restoration measures here could include the creation of off-channel or floodplain habitat, such as side channels or wetlands. These habitats could be created through setback of the concrete levee or creation of an overflow section of the levee to allow inundation of the floodplain. Within the newly opened area, the creation of wetlands would significantly increase the overall riparian and wetland habitat value in the area, as well as modestly improve surface water quality, floodplain habitat, enhance infiltration to groundwater, and enhance local aesthetics. This location is unlikely to support arroyo toad, but is frequently used by neotropical migratory birds in its current state and improvements to the habitat will directly benefit bird populations.

The conceptual restoration plan (Sheet 3 in plates) is to setback the concrete levees to the rear of the properties near the railroad line, excavate the floodplain down to the 2-year inundation level, and create wetland areas of even lower elevation (yearly inundation), and revegetate the floodplain with native riparian and wetland plant species. Any existing native vegetation will be left intact as much as possible. Banks will require sloping to accommodate vegetation and for stability. Slopes are proposed to be a minimum of 3H:1V.

ER-2: San Juan Creek at Maintenance Site

This site is on San Juan Creek immediately upstream of the I-5 crossing. The left bank is fully developed into a residential community and golf course and a golf course fairway runs the length of the left bank through the site. Adjacent to the golf course but within the bankfull width of the channel is a narrow wetland dominated by cattails with some standing water. The water source for this wetland was not observed, although golf course runoff is a likely source. The immediate right bank area appears to be under development; a road and cul-de-sac have been constructed, but no structures have been built. This area is known as the maintenance site and has been used for staging of equipment for various construction activities. The area is currently used primarily as an off-road biking area.

Existing habitat conditions were better than ER-1, primarily due to the absence of concrete levees. However, riprap lining was present on the right bank and is likely present on the left bank to protect the golf course. The presence of the golf course and commercial development are the primary constraints to restoration at this site. Although there are changes to a natural hydro-regime evident in the area in the form of stormwater runoff management, evidence of surface water connectivity and subsurface flow were observed. Willows and mulefat were the most abundant native species; a Mojave River study found that willows in the riparian zone relied on ground water for their perennial sustained supply of water (Lines 1999). Riparian conditions received the poorest scores at this site compared to other variables. In particular, contiguous vegetation was limited to less than 100 feet (33 m) beyond the site boundary. Saplings were the most abundant age class and trees and shrubs were less abundant. *Arundo donax* was present and had a total cover of 5%. Herbaceous layers were dominated by non-native species. Lack of

riparian vegetation results in poor scores for fine and coarse woody debris, soil organic matter, and detrital layer.

Because the lack of riparian vegetation is a significant limiting habitat factor in this area, restoration measures should include revegetation and removal of non-native species. The greatest improvement would be achieved through revegetation of both banks of San Juan Creek from the I-5 crossing to the La Novia Road crossing. Riparian and upland revegetation will improve cover, soil organic matter, detrital layer, and recruitment of fine and coarse woody debris. Additional measures may include floodplain connections on the right bank, where no structures have been built. This area could be excavated and terraced to provide for the creation of a wetland with transitional terracing to upland habitat. Benefits would primarily include the improvement of surface water quality, riparian habitat, local aesthetics, and may also increase recreational and educational opportunities if bike and hiking paths are constructed around or within the wetland area.

The conceptual restoration plan (Sheet 4 in plates) is to excavate the floodplain down to the 2-year inundation level, and create wetland areas of even lower elevation (yearly inundation), removal of non-native species, and revegetation of the floodplain and banks with upland, riparian and wetland species. Both banks will require sloping, although only minimally on the left bank. Existing native riparian vegetation existing on the right bank will be left intact as much as possible.

ER-3: San Juan Creek Upstream of La Novia Road Crossing

This site is located immediately upstream of the La Novia road crossing and extends eastward approximately 3,600 feet (1,100 m). The left bank is almost entirely developed commercially, with only small parcels of unused land. The immediate right bank area is open space designed with trails for bike and equestrian use. This open space area is narrow and runs the entire length of the site. Beyond the open space, land is fully developed for residential use.

Variable scores for this site are similar to those of ER-2 likely due to their close proximity. Again, the hydro-regime and floodprone area have been highly modified here. Removal of sediment has occurred in this reach for flood control purposes, and incision is evident. However, surface and subsurface water flows are also evident. Poorest scores were again given to riparian conditions, although they were slightly better than at ER-2. While saplings, shrubs and the detrital layer were given moderate to high scores, moderate to low scores were given to trees, coarse and fine woody debris, soil organic matter, and contiguous vegetation. Connectivity of vegetation occurs between upstream and downstream habitats, but does not expand more than 100 feet (30 m) beyond the site. Overall, riparian vegetation scores are moderately low and enhancement of the area would be beneficial and provide a corridor linking upstream to downstream habitats. *Arundo donax* was present, however its total cover was estimated at only 5%. Currently, horses have access to a trail that passes directly through the existing thalweg and this likely contributes fecal coliform and nutrients. A significant amount of manure was observed in the channel.

The opportunity to expand riparian vegetation northward on the right bank is possible due to the presence of open space. Although some structures (water pipelines) do exist in this area, it is primarily dedicated to the bike/equestrian trail and reaches approximately 300 feet (90 m) in width in many locations. Excavation of this area for floodplain or wetland creation would improve surface water quality, surface water storage and infiltration to groundwater, floodplain habitat, riparian vegetation, and enhance local aesthetics. Again, recreational and/or educational opportunities could be incorporated into the site. Restoration measures could include riparian revegetation, non-native vegetation removal, and wetland creation. In addition, horse access to the streambed should be eliminated to reduce bacteriological contamination.

A conceptual plan for restoration (Sheet 5 in plates) includes excavation of the right bank to a 2-year level of inundation, excavation of wetland areas, removal of non-native vegetation, limitation of equestrian access to stream, and upland, riparian and wetland revegetation. Sloping will be required for stabilization of banks and accommodation of vegetation. A minimum slope of 3:1 is recommended. Existing native vegetation will be left intact as much as possible.

ER-4: San Juan Creek Downstream of Antonio Parkway

San Juan Creek passes beneath the Ortega Hwy and Antonio Parkway near their intersection and two sites are located in this region. The first is located at the southwest corner of the intersection of Ortega Hwy and Antonio Parkway. Moving upstream from Ortega Hwy to Antonio Pkwy, the channel becomes wider and less constrained by urban development. However, the site is still surrounded by agricultural development, including a plant nursery on the left bank and another agricultural operation on the right bank. Bankfull width varies on average between approximately 300-500 feet (90-150 m).

There is evidence of channel incision at this site, and a mosaic of upland, riparian and channel habitats exists here. Mitigation for the construction of Antonio Parkway has reportedly occurred on the site, but no evidence was seen of the mitigation. There is no water present in the channel during low flow periods; all flow goes subsurface in the relatively sandy substrate. *Arundo donax* is present, however only 5-10% total cover.

The conceptual restoration plan (Sheet 6 in plates) for this site includes removal of non-native species, revegetation of upland and riparian areas, and sloping of banks in some locations. Existing native vegetation will be left intact as much as possible. This site has potential arroyo toad habitat, so no significant disturbance is proposed.

ER-5: San Juan Creek Upstream of Antonio Parkway

The second site near the intersection of Ortega Hwy and Antonio Pkwy is upstream of Antonio Parkway. This is the location of a proposed detention basin for flood control purposes. Immediately upstream of the parkway on the left bank is a small developed area, which may be an extension of the plant nursery that exists downstream of the parkway. However, no other land use excepting roads was readily observable via aerial photograph for several thousand feet upstream. According to 1998 aerial photography, the widest point is approximately 1,000 feet (305 m).

There is evidence of channel incision at this site, and a mosaic of upland, riparian and channel habitats exists here. Mitigation for the construction of Antonio Parkway has reportedly occurred on the site, but was not readily observable. There is no water present in the channel during low flow periods; all flow goes subsurface in the relatively sandy substrate. *Arundo donax* is present but estimated to have only 5-10% total cover. It appears that development is occurring on the right bank near Antonio Parkway. There has been no provision of a buffer at this time. This is an area of extensive floodplain shrub habitat, which is critical habitat for arroyo toad. Restoration measures removal of non-native species, protection of existing buffers, and riparian and upland revegetation. The existing floodplain scrub habitat should be preserved and connected to upstream and downstream habitats.

The conceptual restoration plan (Sheet 7 in plates) for this site includes removal of non-native species, revegetation of upland and riparian areas, and sloping of banks in some locations. A minimum slope of 3:1 is recommended. Existing native vegetation will be left intact as much as possible.

ER-6: San Juan Creek at Quarry

This site extends from the Conrock Quarry Bridge to approximately 1.25 miles (2 km) upstream of the bridge. Both banks are constrained by the presence of roads and the quarry. The quarry is present on the right bank and several access roads run adjacent to the stream. The Ortega Hwy runs along the left bank on high ground and is paralleled by another access road lower in elevation and adjacent to the stream. Through this area, San Juan Creek becomes highly incised, running through a small canyon. Permission to access to this reach was not obtained; bankfull width and other data for the canyon were not collected. The riparian and floodplain plant communities are highly disturbed at this site due to excavation and equipment access. *Arundo donax* is more widespread here than at any other site on San Juan Creek (20-40% overall cover).

Restoration measures could include regrading the channel and floodplain to a more natural configuration, sloping down the highly incised channel banks, removal of non-native species,

and revegetation with upland, riparian and wetland species. A minimum slope of 3:1 is recommended. (See Sheet 8 and Sheet 9 in plates)

ER-7: Oso Creek at Galivan Detention Basin

This site is a detention basin located off-line from Oso Creek north of the Crown Valley Parkway and between Cabot Road and the railroad. It is constrained on both sides by these roads. The basin has sand walls and a sand invert with a concrete low flow channel. Two culverts enter the basin, one from the northwest is a large box culvert and one from the northeast is a small round culvert surrounded by riprap. This detention basin reduces stormwater flow into Oso Creek, but does not have a direct connection to the Creek at the upper end.

Because of the creation of this area as a detention basin, it is highly unnatural and altered. Index scores for this area typically fall between 0 and 0.1. Hydrology, biogeochemical, and habitat functions are all severely limited. However, the score for sediment delivery was 0.25, primarily since the area is used only during flood events and does not receive excessive amounts of sedimentation on average. Also, leaf litter was a relatively high score of 0.5. This is likely due to the presence of a layer of annual herbaceous species, as well as collection of detritus that settles out and remains in the detention basin after flood flows have moved through.

The detention basin may be restored as a floodplain for overflow events, with upstream and downstream connections to Oso Creek. Excavation of wetland pockets and terracing to upland habitat would further enhance habitat diversity. Restoration measures at this site (Sheet 10 in plates) could include creating regular connections to Oso Creek (approximate yearly event at upstream; the downstream end will need to be designed to still allow functioning of the detention basin), removal of concrete low flow channel, grading to create a mosaic of elevations from wetland to upland, and revegetation with upland, riparian and wetland species.

ER-8: Oso Creek at Golf Course

This site is located within the Mission Viejo County Club Golf Course where Oso Creek is east of I-5 and south of Oso Parkway. The entire reach is bounded by golf course on both banks and is highly channelized and straightened. According to aerial photographs, the creek runs through pipes or becomes subsurface flow for approximately 300 feet within the golf course.

Typically, existing conditions scores are low and range between 0 and 0.25. However, better scores were given to sediment delivery and soil pore space. Overall, riparian vegetation was given the poorest scores. Vegetation was not connected to adjacent habitats and few saplings, shrubs, or trees were present. As a result, poor scores were also given for soil organic matter, woody debris and its decay, and the detrital layer. Additionally, the ratio of non-native to native plants was high.

Restoration opportunities are constrained in this reach due to golf course maintenance. Optimally, this reach would benefit from a realignment of the stream to create a naturally meandering system, sloping back of the stream banks to a minimum 3:1 slope, wetland creation in selected locations, and revegetation of the riparian zone to at least a 25-foot width. Also, daylighting of the stream through piped portions would improve habitat. (See Sheet 11 in plates)

ER-9: Trabuco Creek at the I-5 Crossing

Trabuco Creek passes beneath I-5 and is completely concrete-lined from the upstream end of I-5 to just downstream of Camino Capistrano road. Bridge piers separate the concrete lined portion into two channels. A low flow channels exists on each side. Downstream of Camino Capistrano road the creek exits the concrete channel and flows into a large pond fringed with wetland vegetation. Beyond the pond, the channel is riprapped on both banks because of severe incision and erosion. In this area, orchards are present on both banks. The site includes both the portion of the stream that flows through the concrete lined channel beneath I-5 as well as the area approximately 100 feet (30 m) downstream of the concrete lining.

Existing conditions are extremely poor. The presence of the concrete lined channel prevents both natural functioning and the possibility of attaining it and prevents all fish passage. Many scores for this reach were 0. Although conditions are better downstream of the concrete lining, the scores reflect an average of the conditions from directly beneath I-5 and downstream of the concrete lining. Only a sparse herbaceous layer grew at the margins of the low flow channels, while some seedlings and shrubs had become established along the banks at the downstream end. Stand age distribution received the highest score of 0.5. The remaining scores were all below 0.25.

Restoration measures at this site (Sheet 12 in plates) should include reconfiguration of the concrete channel to allow fish passage. The two existing low flow channels should be joined into one channel and widened and deepened, and the slope down to the pool should be a series of steps (less than 1.5 feet (0.5 m) in height) with pools as opposed to the existing steep concrete slope. Downstream of the concrete the channel is severely incising and also eroding the adjacent right bank. The bed could be stabilized here with a series of step weirs (less than 1.5 feet (0.5 m) in height), designed to accumulate sediment and rebuild the channel back up nearer to its original elevation. The right bank could be sloped back to a more stable slope (3:1) and revegetated with upland and riparian vegetation. Existing native vegetation will be left intact as much as possible.

ER-10: Trabuco Creek east of Lakes

This site is east of Saddleback College and just upstream of the right bank lake previously created through quarry activity. Access roads occur on both banks, but do not tightly confine the channel. There is no surface water connection between Trabuco Creek and the lake located on the right bank.

Scores for this area were relatively good, typically ranging from 0.75-1.0. Shrub cover received the poorest score of 0.5. The area has a somewhat altered hydro-regime, but showed evidence of good subsurface flow, surface water connectivity, surface water persistence, and floodprone area. Additionally, riparian vegetation was in good functioning condition. Vegetation was contiguous,

connected to upstream and downstream and upland habitats and there was a good mix of all age classes. Trees and saplings were present and >75% of species present were native.

This large, relatively intact area has a high potential for enhancement or protection of existing function. Restoration measures should include removal of non-native vegetation, grading as appropriate to return the channel to a natural profile (3:1 slopes), enhancement of riparian vegetation, and revegetation of upland areas. Existing native vegetation will be left intact as much as possible during construction. Including a connection from Trabuco Creek to the quarry lake and the adjacent floodplain at this site would further increase potential future conditions scores and should be investigated (Sheet 13 in plates).

ER-11: Confluence of Oso and Trabuco Creeks

This site is located where Oso and Trabuco Creeks come together, west of the railroad bridge. Land use in this area is primarily agricultural and orchards border the banks of both creeks in this reach. Oso Creek has incised significantly due to higher peak flows and scouring of sediment. A deep canyon has been scoured in the 1.5 miles (2.4 km) upstream of the confluence. Trabuco Creek has also begun to incise from the confluence to the railroad bridge in response to the change in invert elevation of Oso Creek. Beneath the railroad bridge, a large cement bib has been placed in the creek to prevent undermining of the bridge and further incision of Trabuco.

This evaluation area received moderate to high scores in general and this indicates that properly functioning conditions are present, but somewhat disturbed. The limiting variables included trees, floodprone area, alterations to the hydro-regime, soil organic matter, fine and coarse woody debris, and the presence of *Arundo donax*. Each of these variables receives scores between 0.1 and 0.5.

Restoration options in this reach must include channel bed stabilization. A series of step weirs (less than 1.5 feet (0.5 m) in height) could be designed to accumulate sediment and slowly build up the channel bed to near its original elevation (Sheet 14 in plates). The weirs could also be designed to provide in-line wetlands for water quality treatment, by keeping water pooled behind

the weirs. The vertical banks should also be sloped back (3:1) and revegetated with upland and riparian vegetation. Non-native species should be removed in this reach. Existing native vegetation will be left intact as much as possible.

Table 2. Index scores for each variable at eleven restoration alternative sites for existing conditions (t=0 years)											
Variable	**ER-1**	**ER-2**	**ER-3**	**ER-4**	**ER-5**	**ER-6**	**ER-7**	**ER-8**	**ER-9**	**ER-10**	**ER-11**
Vage, Stand Age Distribution	0	1	1	1	1	1	0.1	0.25	0.5	1	0.75
Vveg, Contiguous Vegetation	0	0.2	0.2	0.2	0.5	0.25	0	0	0.1	0.75	0.5
Vsap, Saplings	0.1	0.5	0.75	0.5	0.5	0.25	0.1	0	0.25	0.75	0.75
Vshrub, Shrubs	0	0.25	0.5	0.5	0.5	0.25	0.1	0	0.1	0.5	0.75
Vtrees, Trees	0	0.5	0.5	0.25	0.25	0.5	0	0	0	0.75	0.5
Vratio, Ratio Native to Nonnative Veg	0.25	0.75	0.75	0.75	0.75	0.5	0.1	0.25	0.25	1	0.75
Vq, Alterations of Hydroregime	0	0.25	0.25	0.5	0.5	0.5	0	0	0	0.75	0.25
Vfpa, Floodprone Area	0.25	0.5	0.5	0.75	0.75	0.5	0.1	0.5	0	0.9	0.5
Vsed, Sediment Delivery	0.25	0.75	0.75	0.75	0.75	0.75	0.25	0.75	0.1	0.75	0.5
Vssf, Subsurface Flow	0.1	0.75	0.75	0.75	0.75	0.75	0.1	0.25	0.1	1	0.75
Vswc, Surface Water Connection	0	0.75	0.75	0.75	0.75	0.75	0	0.25	0	1	0.75
Vswp, Surface Water Persistence	0	0.75	1	1	1	1	0	1	1	1	0.75
Vlit, Litter / Detrital Layer	0	0.5	0.5	0.5	0.5	0.5	0.25	0.25	0.1	1	1
Vsom, Soil Organic Matter	0.1	0.5	0.5	0.5	0.5	0.25	0.1	0.1	0.1	1	0.5
Vsps, Soil Pore Space	1	1	1	1	1	1	0.1	1	0.1	1	1
Vfwd, Fine Woody Debris	0	0.25	0.25	0.1	0.5	0.1	0	0	0	0.75	0.5
Vcwd, Coarse Woody Debris	0	0.1	0.1	0.1	0.1	0.1	0	0	0	0.5	0.5
Vdecay, Decay of CWD	0	0.5	0.25	0.5	0.5	0.5	0	0	0	1	1
Vtopo, Macro/Microtopography	0.25	0.5	0.75	0.75	0.75	0.5	0	0.25	0.25	1	0.75
Varundo, *Arundo donax*	1	0.75	0.75	0.5	0.5	0.1	1	1	1	0.75	0.1
Vtoad, Arroyo Toad	0	0.25	0.25	0.5	0.75	0.25	0	0.1	0	0.25	0.1
Vnmb, Neotropical Migratory Birds	0	0.25	0.25	0.5	0.75	0.25	0	0.1	0.1	0.25	0.25
Vfp, Fish Passage	0.75	0.75	0.75	0.5	0.5	0.5	0	0	0.1	0.1	0.25

Table 3. Index scores for each variable at eleven restoration alternative sites for future with-project conditions (t=1 year)											
Variable	**ER-1**	**ER-2**	**ER-3**	**ER-4**	**ER-5**	**ER-6**	**ER-7**	**ER-8**	**ER-9**	**ER-10**	**ER-11**
Vage, Stand Age Distribution	0.5	1	1	1	1	1	0.25	0.25	0.5	1	0.75
Vveg, Contiguous Vegetation	0	0.2	0.2	0.2	0.5	0.25	0.1	0	0.1	0.75	0.5
Vsap, Saplings	0.25	0.5	0.75	0.5	0.5	0.25	0.25	0.1	0.25	0.75	0.75
Vshrub, Shrubs	0.25	0.5	0.5	0.5	0.5	0.25	0.25	0.1	0.1	0.5	0.75
Vtrees, Trees	0.1	0.5	0.5	0.25	0.25	0.5	0.1	0.1	0	0.75	0.5
Vratio, Ratio Native to Nonnative Veg	0.75	1	1	1	1	1	1	1	1	1	1
Vq, Alterations of Hydroregime	0	0.25	0.25	0.5	0.5	0.5	0	0	0	0.75	0.25
Vfpa, Floodprone Area	0.5	0.75	0.75	0.75	0.75	0.75	0.1	0.5	0.1	0.9	0.75
Vsed, Sediment Delivery	0.25	0.75	0.75	0.75	0.75	0.75	0.25	0.75	0.1	0.75	0.5
Vssf, Subsurface Flow	0.1	0.75	0.75	0.75	0.75	0.75	0.1	0.25	0.1	1	0.75
Vswc, Surface Water Connection	0	0.75	0.75	0.75	0.75	0.75	0	0.25	0	1	0.75
Vswp, Surface Water Persistence	0.75	0.75	1	1	1	1	1	1	1	1	0.75
Vlit, Litter / Detrital Layer	0.1	0.5	0.5	0.5	0.5	0.5	0.25	0.25	0.1	1	1
Vsom, Soil Organic Matter	0.5	0.5	0.5	0.5	0.5	0.25	0.1	0.1	0.1	1	0.5
Vsps, Soil Pore Space	1	1	1	1	1	1	1	1	0.5	1	1
Vfwd, Fine Woody Debris	0.1	0.25	0.25	0.1	0.1	0.1	0.1	0.1	0.1	0.75	0.5
Vcwd, Coarse Woody Debris	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0.1	0.5	0.5
Vdecay, Decay of CWD	0.1	0.5	0.25	0.5	0.5	0.5	0	0	0	1	1
Vtopo, Macro/Microtopography	0.5	0.5	1	1	1	1	1	0.25	0.5	1	1
Varundo, *Arundo donax*	1	1	1	1	1	1	1	1	1	1	1
Vtoad, Arroyo Toad	0	0.25	0.25	1	1	0.5	0.1	0.1	0.1	0.5	0.25
Vnmb, Neotropical Migratory Birds	0.1	0.25	0.25	0.5	0.5	0.5	0.1	0.1	0.1	0.25	0.5
Vfp, Fish Passage	0.75	0.75	0.75	0.75	0.75	0.75	0.1	0.75	0.5	0.75	0.75

Table 4. Index scores for each variable at eleven restoration alternative sites for future with-project conditions (t=25 years)											
Variable	**ER-1**	**ER-2**	**ER-3**	**ER-4**	**ER-5**	**ER-6**	**ER-7**	**ER-8**	**ER-9**	**ER-10**	**ER-11**
Vage, Stand Age Distribution	1	1	1	1	1	1	0.5	0.25	0.75	1	1
Vveg, Contiguous Vegetation	0.1	0.2	0.2	0.2	0.5	0.25	0.1	0	0.1	1	0.5
Vsap, Saplings	1	1	1	0.75	0.75	0.5	0.5	0.25	0.5	1	1
Vshrub, Shrubs	1	1	1	0.75	0.75	0.5	0.5	0.25	0.75	0.75	1
Vtrees, Trees	1	1	0.75	0.5	0.5	0.75	0.25	0.25	0.5	1	0.75
Vratio, Ratio Native to Nonnative Veg	1	1	1	1	1	1	1	1	1	1	1
Vq, Alterations of Hydroregime	0	0.25	0.25	0.5	0.5	0.5	0	0	0	0.75	0.25
Vfpa, Floodprone Area	0.5	0.75	0.75	0.75	0.75	0.75	0.1	0.5	0.1	0.9	0.75
Vsed, Sediment Delivery	0.25	0.75	0.75	0.75	0.75	0.75	0.25	0.75	0.1	0.75	0.5
Vssf, Subsurface Flow	0.1	0.75	0.75	0.75	0.75	0.75	0.1	0.25	0.1	1	0.75
Vswc, Surface Water Connection	0	0.75	0.75	0.75	0.75	0.75	0	0.25	0	1	0.75
Vswp, Surface Water Persistence	0.75	0.75	1	1	1	1	1	1	1	1	0.75
Vlit, Litter / Detrital Layer	0.75	0.75	0.75	0.75	0.75	0.75	0.5	0.5	0.25	1	1
Vsom, Soil Organic Matter	0.5	0.5	0.75	0.75	0.75	0.5	0.5	0.25	0.25	1	1
Vsps, Soil Pore Space	1	1	1	1	1	1	1	1	0.5	1	1
Vfwd, Fine Woody Debris	0.5	0.5	0.5	0.5	0.5	0.5	0.25	0.25	0.25	1	0.75
Vcwd, Coarse Woody Debris	0.1	0.25	0.25	0.25	0.25	0.25	0.1	0.1	0.1	0.75	0.5
Vdecay, Decay of CWD	0.25	0.5	0.5	0.5	0.5	0.5	0.1	0.1	0	1	1
Vtopo, Macro/Microtopography	0.5	0.5	1	1	1	1	1	0.25	0.5	1	1
Varundo, *Arundo donax*	1	1	1	1	1	1	1	1	1	1	1
Vtoad, Arroyo Toad	0	0.25	0.25	1	1	0.5	0.25	0.1	0.1	0.5	0.5
Vnmb, Neotropical Migratory Birds	0.25	0.25	0.5	0.5	0.5	0.75	0.25	0.25	0.25	0.5	0.75
Vfp, Fish Passage	0.75	0.75	0.75	0.75	0.75	0.75	0.25	0.75	0.5	0.75	0.75

Table 5. Index scores for each variable at eleven restoration alternative sites for future with-project conditions (t=40 years).											
Variable	**ER-1**	**ER-2**	**ER-3**	**ER-4**	**ER-5**	**ER-6**	**ER-7**	**ER-8**	**ER-9**	**ER-10**	**ER-11**
Vage, Stand Age Distribution	1	1	1	1	1	1	1	0.25	0.75	1	1
Vveg, Contiguous Vegetation	0.1	0.2	0.2	0.2	0.5	0.25	0.1	0	0.1	1	0.5
Vsap, Saplings	1	1	1	1	1	1	1	0.75	0.75	1	1
Vshrub, Shrubs	1	1	1	1	1	1	1	0.75	0.75	1	1
Vtrees, Trees	1	1	1	0.75	0.75	1	0.75	0.75	0.75	1	1
Vratio, Ratio Native to Nonnative Veg	1	1	1	1	1	1	1	1	1	1	1
Vq, Alterations of Hydroregime	0	0.25	0.25	0.5	0.5	0.5	0	0	0	0.75	0.25
Vfpa, Floodprone Area	0.5	0.75	0.75	0.75	0.75	0.75	0.1	0.5	0.1	0.9	0.75
Vsed, Sediment Delivery	0.25	0.75	0.75	0.75	0.75	0.75	0.25	0.75	0.1	0.75	0.5
Vssf, Subsurface Flow	0.1	0.75	0.75	0.75	0.75	0.75	0.1	0.25	0.1	1	0.75
Vswc, Surface Water Connection	0	0.75	0.75	0.75	0.75	0.75	0	0.25	0	1	0.75
Vswp, Surface Water Persistence	0.75	0.75	1	1	1	1	1	1	1	1	0.75
Vlit, Litter / Detrital Layer	1	1	1	1	1	1	1	0.5	0.5	1	1
Vsom, Soil Organic Matter	0.5	0.5	1	1	1	0.75	1	0.5	0.5	1	1
Vsps, Soil Pore Space	1	1	1	1	1	1	1	1	0.5	1	1
Vfwd, Fine Woody Debris	0.5	0.75	1	1	1	0.75	0.75	0.5	0.5	1	1
Vcwd, Coarse Woody Debris	0.25	0.5	0.5	0.5	0.5	0.5	0.25	0.1	0.1	0.75	0.75
Vdecay, Decay of CWD	0.5	0.5	0.5	0.5	0.5	0.5	0.25	0.25	0	1	1
Vtopo, Macro/Microtopography	0.5	0.5	1	1	1	1	1	0.25	0.5	1	1
Varundo, *Arundo donax*	1	1	1	1	1	1	1	1	1	1	1
Vtoad, Arroyo Toad	0	0.25	0.25	1	1	0.5	0.25	0.1	0.1	0.5	0.5
Vnmb, Neotropical Migratory Birds	0.25	0.25	0.5	0.75	1	0.75	0.25	0.25	0.25	0.75	0.75
Vfp, Fish Passage	0.75	0.75	0.75	0.75	0.75	0.75	0.25	0.75	0.5	0.75	0.75

Table 6. Index scores for each variable at eleven restoration alternative sites for future with-project conditions (t=50 years).

Variable	**ER-1**	**ER-2**	**ER-3**	**ER-4**	**ER-5**	**ER-6**	**ER-7**	**ER-8**	**ER-9**	**ER-10**	**ER-11**
Vage, Stand Age Distribution	1	1	1	1	1	1	1	0.25	0.75	1	1
Vveg, Contiguous Vegetation	0.1	0.2	0.2	0.2	0.5	0.25	0.1	0	0.1	1	0.5
Vsap, Saplings	1	1	1	1	1	1	1	0.75	0.75	1	1
Vshrub, Shrubs	1	1	1	1	1	1	1	0.75	0.75	1	1
Vtrees, Trees	1	1	1	1	1	1	1	0.75	0.75	1	1
Vratio, Ratio Native to Nonnative Veg	1	1	1	1	1	1	1	1	1	1	1
Vq, Alterations of Hydroregime	0	0.25	0.25	0.5	0.5	0.5	0	0	0	0.75	0.25
Vfpa, Floodprone Area	0.5	0.75	0.75	0.75	0.75	0.75	0.1	0.5	0.1	0.9	0.75
Vsed, Sediment Delivery	0.25	0.75	0.75	0.75	0.75	0.75	0.25	0.75	0.1	0.75	0.5
Vssf, Subsurface Flow	0.1	0.75	0.75	0.75	0.75	0.75	0.1	0.25	0.1	1	0.75
Vswc, Surface Water Connection	0	0.75	0.75	0.75	0.75	0.75	0	0.25	0	1	0.75
Vswp, Surface Water Persistence	0.75	0.75	1	1	1	1	1	1	1	1	0.75
Vlit, Litter / Detrital Layer	1	1	1	1	1	1	1	0.5	0.5	1	1
Vsom, Soil Organic Matter	0.5	0.5	1	1	1	1	1	0.5	0.5	1	1
Vsps, Soil Pore Space	1	1	1	1	1	1	1	1	0.5	1	1
Vfwd, Fine Woody Debris	0.5	0.75	1	1	1	1	1	0.5	0.5	1	1
Vcwd, Coarse Woody Debris	0.25	0.5	0.5	0.5	0.5	0.5	0.1	0.1	0.1	0.75	0.75
Vdecay, Decay of CWD	0.5	0.5	0.5	0.5	0.5	0.5	0.25	0.25	0	1	1
Vtopo, Macro/Microtopography	0.5	0.5	1	1	1	1	1	0.25	0.5	1	1
Varundo, *Arundo donax*	1	1	1	1	1	1	1	1	1	1	1
Vtoad, Arroyo Toad	0	0.25	0.25	1	1	0.5	0.25	0.1	0.1	0.5	0.5
Vnmb, Neotropical Migratory Birds	0.25	0.25	0.5	0.75	1	0.75	0.25	0.25	0.25	0.75	0.75
Vfp, Fish Passage	0.75	0.75	0.75	0.75	0.75	0.75	0.25	0.75	0.5	0.75	0.75

Table 7. Final FCI scores, areas, HU outputs and percent improvement for each restoration site											
Site	**Existing FCI**	**FCI (t=1)**	**FCI (t=25)**	**FCI (t=40)**	**FCI (t=50)**	**Average Annual FCI**	**Area (Ha)**	**Existing HUs**	**Average Annual HUs**	**Average Annual HU Score Improvement**	**Percent Improvement**
ER-1	0.16	0.32	0.61	0.64	0.64	0.55	22.5	3.59	12.44	8.86	247%
ER-2	0.50	0.59	0.76	0.79	0.79	0.73	9.8	4.92	7.15	2.23	45%
ER-3	0.56	0.64	0.78	0.84	0.84	0.78	17.1	9.54	13.26	3.72	39%
ER-4	0.55	0.61	0.72	0.84	0.87	0.76	15.3	8.37	11.67	3.29	39%
ER-5	0.59	0.62	0.73	0.85	0.88	0.77	49.9	29.24	38.40	9.16	31%
ER-6	0.44	0.58	0.69	0.85	0.86	0.74	63.1	27.99	46.97	18.99	68%
ER-7	0.11	0.28	0.38	0.58	0.61	0.46	9.2	0.98	4.26	3.29	336%
ER-8	0.25	0.32	0.39	0.55	0.55	0.45	3.9	0.98	1.75	0.78	80%
ER-9	0.14	0.22	0.37	0.44	0.44	0.37	3.7	0.51	1.36	0.85	168%
ER-10	0.79	0.81	0.91	0.94	0.94	0.90	24.3	19.19	21.95	2.76	14%
ER-11	0.61	0.72	0.82	0.86	0.86	0.82	21.5	13.17	17.56	4.38	33%

4.0 SCORING FOR RESTORATION ALTERNATIVES

The table below summarizes the Functional Capacity Index (FCI) and Habitat Unit (HU) output scores for the existing and potential future with-project conditions at each restoration site. These HU values will be utilized during the incremental cost analysis of the restoration alternatives, which will ultimately be the primary tool for identifying the preferred alternative(s).

Table 8. Final average annual HU score improvements for future with-project conditions at each restoration site[1]

Site Name	Existing FCI	Future Average Annual FCI[2]	Area[3] (Ha)	Existing HUs[4]	Future Average Annual HUs[5]	Average Annual HU Score Improvement[6]	Percent Improvement[7]
ER-1	0.16	0.55	22.5	3.59	12.44	8.86	247%
ER-2	0.50	0.73	9.8	4.92	7.15	2.23	45%
ER-3	0.56	0.78	17.1	9.54	13.26	3.72	39%
ER-4	0.55	0.76	15.3	8.37	11.67	3.29	39%
ER-5	0.59	0.77	49.9	29.24	38.40	9.16	31%
ER-6	0.44	0.74	63.1	27.99	46.97	18.99	68%
ER-7	0.11	0.46	9.2	0.98	4.26	3.29	336%
ER-8	0.25	0.45	3.9	0.98	1.75	0.78	80%
ER-9	0.14	0.37	3.7	0.51	1.36	0.85	168%
ER-10	0.79	0.90	24.3	19.19	21.95	2.76	14%
ER-11	0.61	0.82	21.5	13.17	17.56	4.38	33%

[1]See the Environmental Appendix for a detailed description of the calculations for these scores.
[2]Scores for years 1, 25, 40, and 50 were averaged.
[3]Area reflects the total restoration alternative project footprint.
[4]Result of multiplying the existing FCI by the total project area
[5]Result of multiplying the future average annual FCI by the total project area
[6]Difference between future average annual HUs and existing HUs
[7]Average annual HU score improvement divided by existing HUs

5.0 INCREMENTAL COST ANALYSIS

For ecosystem restoration projects, economic analysis consists of comparing the cost of alternatives to their relative output of habitat units. Each alternative and each component within an alternative increases the overall output of habitat values compared to the No Action Plan. The analysis uses the increase in habitat values in which relative HIs were identified for each restoration action (habitat feature). The increased habitat output, by alternative, is incrementally compared to the incremental cost of its implementation.

The Corps' IWR-PLAN software was used to conduct this analysis. IWR-PLAN, developed by the Corps' Institute of Water Resources, was used to identify the most cost-effective combinations of components and the best buys for the whole possible range of outputs of habitat units and associated costs.

Analysis and Results

In addition to the construction cost, the cost associated with LERRDs and monitoring cost for the first year after construction were included in the incremental analysis. Results from the analysis are presented in Table 9 below and graphically presented as Figure 2.

Table 9. Incremental Cost Analysis Results

Alternative Plan	Incremental Average Annual Cost ($)	Incremental Output (AAHU)	Total Output (AAHU)	Incremental Average Annual Cost per Unit ($/AAHU)
No Action	0	0.00	0.00	0
ER-7	496,739	3.28	3.28	151,445
ER-6	3,381,905	18.98	22.26	178,183
ER-1	1,739,156	8.85	31.11	196,515
ER-4	739,539	3.30	34.41	224,103
ER-3	916,702	3.72	38.13	246,425
ER-5	2,412,221	9.16	47.29	263,343
ER-2	609,273	2.23	49.52	273,217
ER-9	239,261	0.85	50.37	281,484
ER-10	1,360,973	2.76	53.13	493,106
ER-11	2,212,383	4.39	57.52	503,960
ER-8	958,043	0.77	58.29	1,244,212

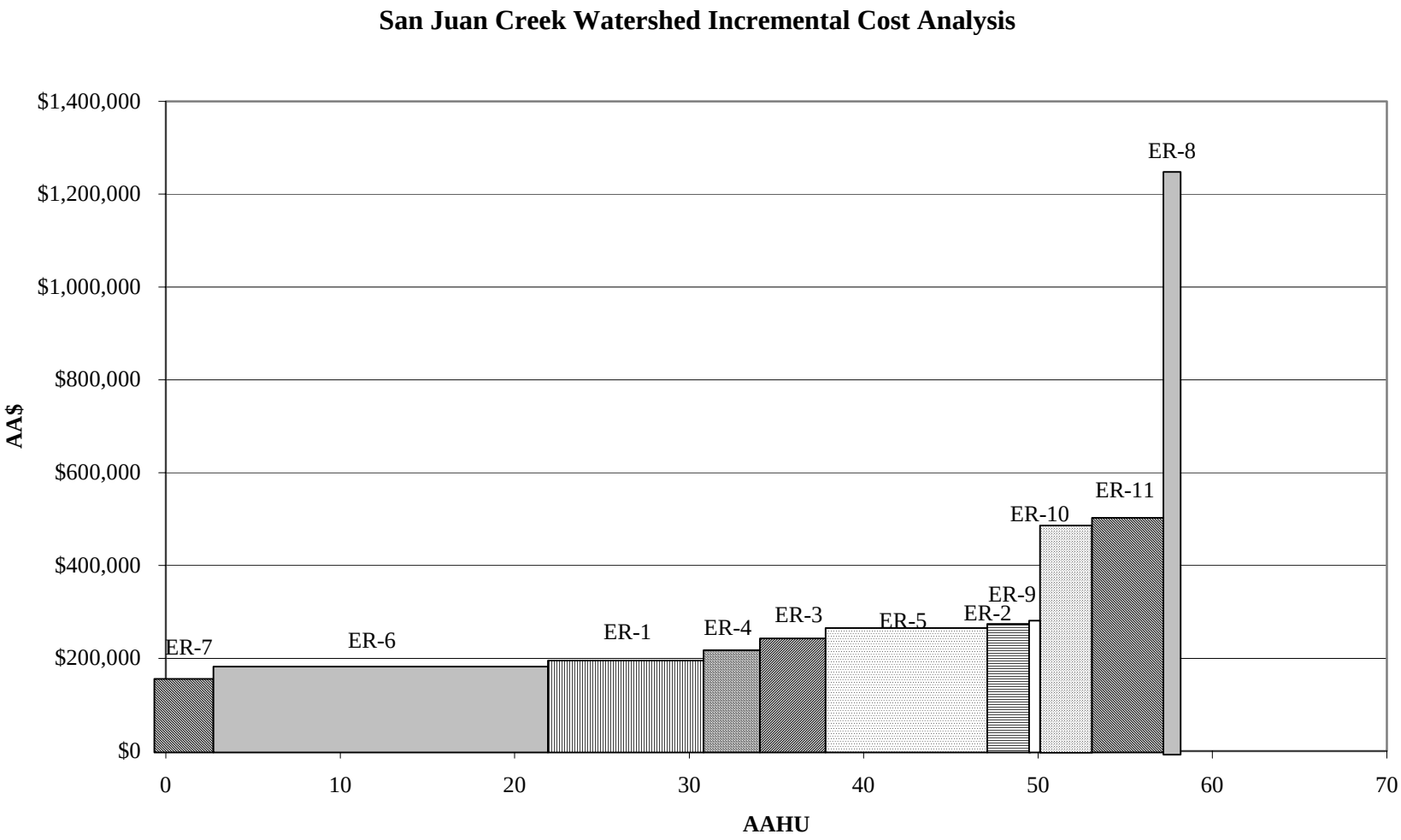

Figure 2. Incremental Cost Analysis

Examination of the incremental analysis data indicate that Ecosystem Restoration alternatives ER-7, ER-6, ER-1, ER-4, ER-3, ER-5, ER-2, and ER-9 (in descending order of cost-effectiveness) provide the most benefit at the least cost, and that each added increment (e.g., adding ER-6 onto ER-7) provides a significant added benefit at only a slightly increased cost per unit. Alternatives ER-8, ER-10, and ER-11 are significantly more expensive on a unit cost basis. Alternatives ER-1 through ER-7 and ER-9 maximize the use of available space, therefore maximizing the unit return per dollar at each site. Each of these alternatives is exclusive and can function as a stand-alone project. However, each is viewed as being a piece of a larger goal to restore connectivity to the larger San Juan Creek system. Therefore, the package of ecosystem restoration alternatives consisting of alternatives ER-1, ER-2, ER-3, ER-4, ER-5, ER-6, ER-7, and ER-9 are recommended as the preliminary NER plan, and recommended for inclusion in the larger comprehensive plan for flood control, ecosystem restoration, and comprehensive watershed management for the San Juan Creek watershed.

6.0 REFERENCES

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ATTACHMENT A

PLATES

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ATTACHMENT B

PRELIMINARY COSTS

Conceptual Habitat Restoration - San Juan Creek Mainstem Ecosystem Restoration

Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$451,457	$451,457	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	$500/day x 4 weeks per site
Recreation Enhancement	M	1,510	$59.00	$89,090	Pedestrian Path
Site ER-1 - San Juan Creek between Stonehill Road and Pacific Coast Highway					
Earthwork:					
Clearing and Stripping	Ha.	12.1	$6,420	$77,480	
Excavation (Levee, Wetlands and Riparian Slopes) and Stockpile	M^3	339,000	$6.50	$2,203,500	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	2.3	$24,691	$56,000	Price By TT/Portland
Revegetate Wetland and Riparian	Ha.	12.1	$75,000	$905,175	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	1.2	$14,321	$17,400	Price By TT/Portland
Set Back Levee					
Place, shape, and compact fill	M^3	26,000	$6.50	$169,000	
Excavate and Stockpile	M^3	59,700	$1.85	$110,445	FE Loader
Saw Cut Concrete	M	1,100	$12.00	$13,200	
Repair Concrete Edge	M	1,100	$20.00	$22,000	
Structural backfill with compaction	M^3	33,700	$8.00	$269,600	
Demolish and remove existing concrete embankment	M^3	1,800	$32.70	$58,858	Estimate for MM 2A Provided by COE-LAD
Net Disposal (Exacation - Fill for SJC-1)	M^3	279,300	$18.00	$5,027,400	12 cy truck, 10 mile round trip
Construction Subtotal				$9,480,605	
Contingency	20%			$1,896,121	
Total Construction Cost				**$11,376,726**	
Engineering and Design	9%			$1,023,905	
Construction Inspection and Administration	6%			$682,604	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*14.34*	*$62,000*	*$888,894*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-1				**$13,972,129**	
Annual Maintenance					
Road clean up 1-day/year on average				$267	
inspection and clean out					2 laborers @ 4 days twice a year
Exotic species control	Ha.	14.34	$500	*$7,169*	$500/ha
Total Annual Maintenance				**$7,435**	

Conceptual Habitat Restoration - San Juan Creek Mainstem Ecosystem Restoration

Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$82,050	$82,050	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	$500/day x 4 weeks per site
Recreation Enhancement	M	990	$59.00	$58,410	Pedestrian Path
Site ER-2 - San Juan Creek at Maintenance Site					
Earthwork:					
Clearing and Stripping	Ha.	3.2	$6,420	$20,540	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	45,970	$6.50	$298,805	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	1.2	$24,691	$29,000	Price By TT/Portland
Revegetate Wetland and Riparian	Ha.	3.2	$75,000	$239,963	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	1.2	$14,321	$16,820	Price By TT/Portland
Remove riprap & Stockpile	M^3	3,500	$40.00	$140,000	?
Net Disposal (Exacation - Fill for SJC-2)	M^3	45,970	$18.00	$827,460	12 cy truck, 10 mile round trip
Construction Subtotal				$1,723,047	
Contingency	20%			$344,609	
Total Construction Cost				**$2,067,657**	
Engineering and Design	9%			$186,089	
Construction Inspection and Administration	6%			$124,059	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*4.37*	*$62,000*	*$271,188*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-2				**$2,648,993**	
Annual Maintenance					
Road clean up 1-day/year on average				$267	
inspection and clean out					2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	4.37	$500	*$2,187*	$500/ha
Total Annual Maintenance				**$2,454**	

Conceptual Habitat Restoration - San Juan Creek Mainstem Ecosystem Restoration

Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$138,637	$138,637	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	$500/day x 4 weeks per site
Recreation Enhancement	M	730	$59	$43,070	Pedestrian Path
Site ER-3 - San Juan Creek Upstream of La Novia Bridge					
Earthwork:					
Clearing and Stripping	Ha.	0.9	$6,420	$5,980	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	101,650	$6.50	$660,725	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	4.3	$24,691	$107,000	Price By TT/Portland
Revegetate Wetland and Riparian	Ha.	0.9	$75,000	$69,863	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	3.2	$14,321	$46,400	Price By TT/Portland
Net Disposal (Exacation - Fill for SJC-3)	M^3	101,650	$18.00	$1,829,700	12 cy truck, 10 mile round trip
Construction Subtotal				$2,911,374	
Contingency	20%			$582,275	
Total Construction Cost				**$3,493,649**	
Engineering and Design	9%			$314,428	
Construction Inspection and Administration	6%			$209,619	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*5.27*	*$62,000*	*$326,430*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-3				**$4,344,127**	
Annual Maintenance					
Road clean up 1-day/year on average				$267	
inspection and clean out					2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	5.27	$500	*$2,633*	$500/ha
Total Annual Maintenance				**$2,899**	

Conceptual Habitat Restoration - San Juan Creek Mainstem Ecosystem Restoration

Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$17,430	$17,430	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	
Recreation Enhancement	LS				
Site ER-4 - San Juan Creek Downstream of Antonio Parkway					
Earthwork:					
Clearing and Stripping	Ha.	2.4	$6,420	$15,340	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	656	$6.50	$4,264	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	3.3	$24,691	$81,000	Price By TT/Portland
Revegetate Riparian	Ha.	2.4	$75,000	$179,213	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	3.3	$14,321	$46,980	Price By TT/Portland
Net Disposal (Exacation - Fill for SJC-4)	M^3	656	$18.00	$11,808	12 cy truck, 10 mile round trip
Construction Subtotal				$366,035	
Contingency	20%			$73,207	
Total Construction Cost				**$439,242**	
Engineering and Design	9%			$39,532	
Construction Inspection and Administration	6%			$26,355	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*5.67*	*$62,000*	*$351,540*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-4				**$856,668**	
Annual Maintenance					
Road clean up 1-day/year on average				$267	
inspection and clean out					2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	5.67	$500	*$2,835*	$500/ha
Total Annual Maintenance				**$3,102**	

Conceptual Habitat Restoration - San Juan Creek Mainstem Ecosystem Restoration					
Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$61,112	$61,112	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	
Recreation Enhancement	LS				
Site ER-5 - San Juan Creek Upstream of Antonio Parkway					
Earthwork:					
Clearing and Stripping	Ha.	13.0	$6,420	$83,460	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	600	$6.50	$3,900	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	3.6	$24,691	$88,000	Price By TT/Portland
Revegetate Riparian	Ha.	13.0	$75,000	$975,038	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	3.6	$14,321	$51,040	Price By TT/Portland
Net Disposal (Exacation - Fill for SJC-5)	M^3	600	$18.00	$10,800	12 cy truck, 10 mile round trip
Construction Subtotal				$1,283,349	
Contingency	20%			$256,670	
Total Construction Cost				**$1,540,019**	
Engineering and Design	9%			$138,602	
Construction Inspection and Administration	6%			$92,401	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*16.56*	*$62,000*	*$1,026,999*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-5				**$2,798,021**	
Annual Maintenance					
Road clean up 1-day/year on average				$267	
inspection and clean out					2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	16.56	$500	*$8,282*	$500/ha
Total Annual Maintenance				**$8,549**	

Conceptual Habitat Restoration - San Juan Creek Mainstem Ecosystem Restoration

Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$192,152	$192,152	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	
Recreation Enhancement	LS				
Site ER-6 - San Juan Creek @ Quarry Site					
Earthwork:					
Clearing and Stripping	Ha.	28.4	$6,420	$182,520	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	38,000	$6.50	$247,000	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	21.7	$24,691	$535,000	Price By TT/Portland
Revegetate Riparian	Ha.	28.4	$75,000	$2,132,325	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	3.6	$14,321	$52,200	Price By TT/Portland
Net Disposal (Exacation - Fill for SJC-6)	M^3	38,000	$18.00	$684,000	12 cy truck, 10 mile round trip
Construction Subtotal				$4,035,197	
Contingency	20%			$807,039	
Total Construction Cost				**$4,842,237**	
Engineering and Design	9%			$435,801	
Construction Inspection and Administration	6%			$290,534	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*50.10*	*$62,000*	*$3,106,107*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-6				**$8,674,679**	
Annual Maintenance					
Road clean up 1-day/year on average				$267	
inspection and clean out					2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	50.10	$500	*$25,049*	$500/ha
Total Annual Maintenance				**$25,316**	

Conceptual Habitat Restoration - Oso Creek Mainstem Ecosystem Restoration

Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$62,787	$62,787	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	$500/day x 4 weeks per site
Recreation Enhancement	LS	1			
Site ER-7 - Oso Creek @ Galivan Detention Basin					
Earthwork:					
Clearing and Stripping	Ha.	6.8	$6,420	$43,680	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	16,300	$6.50	$105,950	RSM, 14 cy scraper, 1500 m hual
Grading and Shaping	M^3	16,300	$6.50	$105,950	
Revegetate Upland	Ha.	2.4	$24,691	$60,000	Price By TT/Portland
Revegetate Wetland and Riparian	Ha.	6.8	$75,000	$510,300	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	1.2	$14,321	$17,400	Price By TT/Portland
Remove Concrete Pan					
Demolish and remove existing concrete v-ditch	M^3	440	$32.70	$14,387	From COE Estimate on MM 2A
Flow Through Channel					
Excavate (Ditch) and Stockpile	M^3	3,150	$6.50	$20,475	Hoe
Gated Headworks for 74 cm concrete pipe	LS	1	$4,000	$4,000	
74 cm reinforced concrete pipe	M	25	$250	$6,250	
Headwalls	LS	4	$1,000	$4,000	
Structural backfill with compaction	M^3	200	$8.00	$1,600	
Boring through Rail Road Embankment	M	4	$1,312.00	$5,248	
Net Disposal (Exacation - Fill for OSC-1)	M^3	19,250	$18.00	$346,500	12 cy truck, 10 mile round trip
Construction Subtotal				$1,318,527	
Contingency	20%			$263,705	
Total Construction Cost				**$1,582,233**	
Engineering and Design	9%			$142,401	
Construction Inspection and Administration	6%			$94,934	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*9.23*	*$62,000*	*$572,508*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-7				**$2,392,076**	
Annual Maintenance					
Road clean up 1-day/year on average				$800	
Culvert and Bridge inspection and clean out				$2,000	2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	9.23	$500	$4,617	$500/ha
Total Annual Maintenance				**$7,417**	

Conceptual Habitat Restoration - Oso Creek Mainstem Ecosystem Restoration					
Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$31,125	$31,125	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	$500/day x 4 weeks per site
Recreation Enhancement	LS	1	$20,000	$20,000	
Site ER-8 - Oso Creek at Golf Course					
Earthwork:					
Clearing and Stripping	Ha.	2.7	$6,420	$17,420	
Excavation (Wetlands, Riparian Slopes and Channel) and Stockpile	M^3	10,890	$6.50	$70,785	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	1.2	$24,691	$30,000	Price By TT/Portland
Revegetate Wetland and Riparian	Ha.	2.7	$75,000	$203,513	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	0.7	$14,321	$10,440	Price By TT/Portland
Remove and dispose existing pipe	M	100	$50.00	$5,000	
Grade Control Structures:					
Placed riprap	M^2	673	$42.00	$28,266	
Filter fabric	M^2	1125	$2.40	$2,700	
Excavation and Stockpile	M^3	1,580	$6.50	$10,270	Hoe
Place, shape, and compact fill	M^3	900	$6.50	$5,850	
Net Disposal (Exacation - Fill for OSC-2)	M^3	11,570	$18.00	$208,260	12 cy truck, 10 mile round trip
Construction Subtotal				$653,629	
Contingency	20%			$130,726	
Total Construction Cost				**$784,354**	
Engineering and Design	9%			$70,592	
Construction Inspection and Administration	6%			$47,061	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*3.93*	*$62,000*	*$243,567*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-8				**$1,145,575**	
Annual Maintenance					
Road clean up 1-day/year on average				$800	
Culvert and Bridge inspection and clean out				$2,000	2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	3.93	$500	$1,964	$500/ha
Total Annual Maintenance				**$4,764**	

Conceptual Habitat Restoration - Trabuco Creek Mainstem Ecosystem Restoration

Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$48,411	$48,411	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	$500/day x 4 weeks per site
Recreation Enhancement	LS	1			
Site ER-9 - Trabuco Creek beneath I-5					
Earthwork:					
Clearing and Stripping	Ha.	1.2	$6,420	$7,540	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	23,900	$6.50	$155,350	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	1.6	$24,691	$39,000	Price By TT/Portland
Revegetate Wetland and Riparian	Ha.	1.2	$75,000	$88,088	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	1.6	$14,321	$22,620	Price By TT/Portland
Fish Passage Low Flow Channel					
Excavate and Stockpile	M^3	441	$6.50	$2,867	Back Hoe
Saw Cut Concrete	M	235	$12.00	$2,820	
Repair Concrete Edge	M	235	$20	$4,700	
Remove concrete	M^3	71	$32.70	$2,322	From COE Estimate on MM 2A
Handplaced grouted river rock in LF channel	M^2	776	$89.25	$69,258	
Handformed concrete in LF channel	M^3	7	$589.00	$4,123	
Habitat Weir Structures:					
Placed riprap	M^3	845	$105.00	$88,725	
Gravel Bedding	M^3	90	$20.00	$1,800	
Filter fabric	M^2	676	$2.40	$1,622	
Excavation and Stockpile	M^3	1,555	$6.50	$10,108	Hoe
Place, shape, and compact fill	M^3	770	$6.50	$5,005	
Net Disposal (Exacation - Fill for TRC-1)	M^3	25,126	$18.00	$452,268	12 cy truck, 10 mile round trip
Construction Subtotal				$1,016,625	
Contingency	20%			$203,325	
Total Construction Cost				**$1,219,950**	
Engineering and Design	9%			$109,796	
Construction Inspection and Administration	6%			$73,197	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*2.75*	*$62,000*	*$170,748*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management ER-9				**$1,573,691**	
Annual Maintenance					
Road clean up 1-day/year on average				$533	
Fish Passage/ Culvert inspection and clean out				$2,000	2 laborers @ 4 days twice a year

Exotic species control Riparian Habitat	Ha.	2.75	$500	$1,377	$500/ha
Total Annual Maintenance				**$3,910**	

Conceptual Habitat Restoration - Trabuco Creek Mainstem Ecosystem Restoration

Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$102,144	$102,144	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	$500/day x 4 weeks per site
Recreation Enhancement	LS	1			
Site ER-10 - Trabuco Creek East of Lakes					
Earthwork:					
Clearing and Stripping	Ha.	10.7	$6,420	$68,640	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	25,920	$6.50	$168,480	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	10.1	$24,691	$249,000	Price By TT/Portland
Revegetate Wetland and Riparian	Ha.	10.7	$75,000	$801,900	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	10.1	$14,321	$144,420	Price By TT/Portland
Flow Through Channel					
Excavate and Stockpile	M^3	2,879	$6.50	$18,714	Hoe
74 cm reinforced concrete pipe	M	15	$250	$3,750	2 - 8 meter pipes
Headwalls	LS	6	$1,000	$6,000	
Structural backfill with compaction	M^3	195	$8.00	$1,560	
Placed riprap	M^3	529	$105.00	$55,545	
Net Disposal (Exacation - Fill for TRC-2)	M^3	28,604	$18.00	$514,872	12 cy truck, 10 mile round trip
Construction Subtotal				$2,145,025	
Contingency	20%			$429,005	
Total Construction Cost				**$2,574,029**	
Engineering and Design	9%			$231,663	
Construction Inspection and Administration	6%			$154,442	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*20.78*	*$62,000*	*$1,288,143*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management Site ER-10				**$4,248,277**	
Annual Maintenance					
Road clean up 1-day/year on average				$533	
Fish Passage/ Culvert inspection and clean out				$2,000	2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	20.78	$500	$10,388	$500/ha
Total Annual Maintenance				**$12,922**	

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Conceptual Habitat Restoration - Trabuco Creek Mainstem Ecosystem Restoration (Not For Construction)					
Description	Unit	Total Project Quantity	Unit Cost	Total Project Cost	Remarks
Mobilization/Demobilization	LS	1	$630,515	$630,515	~ 5% construction cost (previous Corps studies)
Dewatering	LS	1	$10,000	$10,000	$500/day x 4 weeks per site
Recreation Enhancement	LS	1			
Site ER-11 - Trabuco Creek confluence with Oso Creek					
Earthwork:					
Clearing and Stripping	Ha.	12.5	$6,420	$80,080	
Excavation (Wetlands and Riparian Slopes) and Stockpile	M^3	454,950	$6.50	$2,957,175	RSM, 14 cy scraper, 1500 m hual
Revegetate Upland	Ha.	5.3	$24,691	$132,000	Price By TT/Portland
Revegetate Wetland and Riparian	Ha.	12.5	$75,000	$935,550	Typical price by TTISG/COE
Remove non-native vegetation	Ha.	5.3	$14,321	$76,560	Price By TT/Portland
Habitat Weir Structures:					
Placed riprap	M^3	1,600	$105.00	$168,000	
Gravel Bedding	M^3	170	$20.00	$3,400	
Filter fabric	M^2	1,280	$2.40	$3,072	
Excavation and Stockpile	M^3	2,940	$6.50	$19,110	Hoe
Place, shape, and compact fill	M^3	1,450	$6.50	$9,425	
Net Disposal (Exacation - Fill for TRC-1)	M^3	456,440	$18.00	$8,215,920	12 cy truck, 10 mile round trip
Construction Subtotal				$13,240,807	
Contingency	20%			$2,648,161	
Total Construction Cost				**$15,888,968**	
Engineering and Design	9%			$1,430,007	
Construction Inspection and Administration	6%			$953,338	
1-year cost to establish vegetation, $62,000/ha	*Ha.*	*17.82*	*$62,000*	*$1,104,840*	*Water tubes @ $12350/ha/trip x 5 trips/year*
Total Management Site ER-11				**$19,377,153**	
Annual Maintenance					
Road clean up 1-day/year on average				$533	
Fish Passage/ Culvert inspection and clean out					2 laborers @ 4 days twice a year
Exotic species control Riparian Habitat	Ha.	17.82	$500	$8,910	$500/ha
Total Annual Maintenance				**$9,443**	