APPENDIX A: Supplemental Plan Formulation

Supplemental Plan Formulation Information

Overview

This appendix provides supplemental information regarding the planning process conducted as part of the Hamilton City Feasibility Study. In order to keep the main report succinct, additional detail is presented in this appendix. Topics discussed are:

- Flood Fighting
- Ecosystem Plan Formulation Methodology
- Passive vs. Active Ecosystem Restoration
- Floodplain Reconnection
- Guiding Principles
- Ecosystem Restoration Alternatives

Relation to the Planning Process

The following section describes how each of these topics relates to the plan formulation process.

A-1: Flood Fighting

Information on both known and forecasted flood fighting costs and historic performance will be used to refine the without project condition, specifically, to adjust the estimated equivalent annual damages to account for costs associated with flood fighting activities and to adjust the without project levee performance to reflect flood fighting. This will allow for a more accurate evaluation of each alternative plan, when each is considered against the without-project condition. Two write-ups are included: without-project costs for flood fighting, and the methodology to incorporate flood fighting into the assessment of without-project levee performance and economic damages.

A-2: Ecosystem Plan Formulation Methodology

This description sets forth the basic formulation methodology followed for formulation and comparison of alternative plans.

A-3: Passive vs. Active Ecosystem Restoration

This information contributes to formulation and comparison of alternative plans. Each of these basic approaches was identified when measures were developed and considered. At the measures screening stage of plan formulation, there was a strong indication that, despite the higher cost of active restoration, passive restoration would not be as effective in attaining the desired benefits. Consequently, passive restoration was screened out as a measure and the alternative plans that were formulated included active restoration. To better substantiate this initial screening, a more detailed comparison of the two approaches was undertaken.

A-4: Floodplain Reconnection

This information contributes to the evaluation of alternative plans. By understanding the anticipated effects of reconnecting the river to the floodplain, benefits of doing so can be identified and quantified.

A-5: Guiding Principles

This information presents the detailed description of the Guiding Principles that were developed as part of the overall Comprehensive Study.

A-6: Ecosystem Restoration Alternatives

This section describes the ecosystem restoration alternative plans.

Supplemental Information

Following are full discussions of each topic.

A-1: Flood Fighting

Flood Fighting

Incorporate Flood Fighting into the Assessment of Without-Project Levee Performance and Economic Damages

Incorporating Flood Fighting Into the Hamilton City HEC-FDA Analysis

The U.S. Army Corps of Engineers and The Reclamation Board of the State of California have conducted a feasibility study to develop and evaluate potential alternative plans to reduce flood damages and restore the ecosystem along the Sacramento River near Hamilton City. An existing private levee, constructed by landowners in about 1904 and known as the "J" levee, provides some flood protection to the town and surrounding area. The "J" levee is not constructed to any formal engineering standards and is largely made of silty sand. Since the construction of Shasta Dam in 1945, flooding in Hamilton City due to problems with the "J" levee has occurred only once (1974) causing about $50,000 in damage and about $22,000 in levee repair costs (current year dollars). Although the levee has never "failed" from over topping or catastrophic failure, it has been spared only because of very extensive flood fighting, most notably in 1983, 1986, 1995, 1997, and 1998. If floodfighting had not been successful during these events, significant damage and potential loss of life would have likely occurred within Hamilton City.

Problem

The problem confronting the Study Team is how to incorporate floodfighting into the HEC-FDA analysis, which is used to develop estimates of damage reduction due to plans (i.e., benefits) and project performance statistics indicating the relative performance of alternative plans. One of the key inputs into the HEC-FDA model are levee failure assumptions, but these are based upon the physical characteristics of levees and not floodfighting actions taken to protect those levees. Thus, the HEC-FDA does not explicitly take into account floodfighting efforts. As a result, estimates of benefits and project performance statistics are likely to be biased without accounting for floodfighting. In addition, floodfighting is very expensive; therefore its costs need to be incorporated into the overall benefit/cost analysis. And, finally, to the extent that alternative plans rely upon HEC-FDA statistics to define the size of structures, then these plans may be biased as well. For example, the primary objective of the Hamilton City study is to provide ecosystem restoration, which will likely involve breaching the existing "J" levee and replacing it with a setback levee further from the river. The key question is: what will be the height of this "replacement" levee? Will it be the same as the existing levee (albeit very weak levee), or will the new levee height be based upon HEC-FDA project performance statistics? In other words, HEC-FDA project performance statistics can be used to define a *functionally equivalent levee* that will likely be much lower than the existing "J" levee. The problem is further complicated because estimating the probability of a successful floodfight is very difficult.

HEC-FDA

HEC-FDA is the Corps' primary flood damage reduction model, which integrates hydrologic, hydraulic, and geotechnical engineering and economic data for the formulation and evaluation of flood damage reduction plans. The program incorporates risk analysis by quantifying uncertainties in the hydrologic, hydraulic, geotechnical and economics data utilizing Monte Carlo simulation. The two primary outputs from HEC-FDA include expected annual damage estimates and project performance statistics. Expected annual flood damage is the average of all possible damage values, taking into account all expected flood events and associated hydrologic, hydraulic, geotechnical and economic uncertainties. Project performance statistics provide information concerning the risk within an area of annual (or long-term) flooding and the ability to safely pass flood events of given magnitudes. These statistics describe the hydraulic performance of a plan incorporating geotechnical levee failure assumptions. These include *expected annual exceedance probability* (the annual probability of having a damaging flood event in a given year, such as a levee failure), *long-term risk* (the chance of having one or more damaging events over a period of time), and *conditional non-exceedance probability* (the probability of containing specific flood events and avoiding damage).

HEC-FDA Geotechnical Inputs

Geotechnical specialists are responsible for developing *levee failure curves* that depict the probability of levee failure as water surface elevations rise in the channel. Typically, the probability of failure increases as water surface elevations approach the top of a levee, although the shape of the curve are dependent upon many variables, such as construction materials, adequacy of maintenance, wind/waves, etc. Although the curves can be defined with many points, typically the most important points include the probable non-failure point (PNP), the probable failure point (PFP) and the top of levee (TOP). The NFP is the water surface elevation at which there is about a 15% chance of levee failure and the PFP is the water surface elevation with about an 85% chance of levee failure.

The "J" levee failure curve used for the Northern impact area (which includes the town of Hamilton City) is shown in Table A-1.1 and the actual FDA data input screen is shown in Figure A-1.1, including the plot of the levee failure curve.[1] As can be seen in the plot, within HEC-FDA points below the PNP are assumed to have 0 probability of levee failure and points above the PFP are assumed to have 100% of levee failure. This levee failure curve is based upon the physical characteristics of the "J" levee and does not reflect changes that might be attributable to flood fighting.

[1] There are 2 other impact areas that were analyzed in the Hamilton City analysis (Southern #1 and Southern #2), but because these are primarily agricultural areas this paper focuses upon the Northern impact area that includes the town itself.

Table A-1.1: Northern Impact Area Levee Failure Curves

Levee Failure Curve	Northern Impact Area (No Floodfighting)
Top of Levee (TOL)	149.2
Probable Failure Point (PFP)	146.8
Probable Non-Failure Point (PNP)	144.3

Figure A-1.1: Northern Impact Area Levee Failure Curve FDA Input Screen

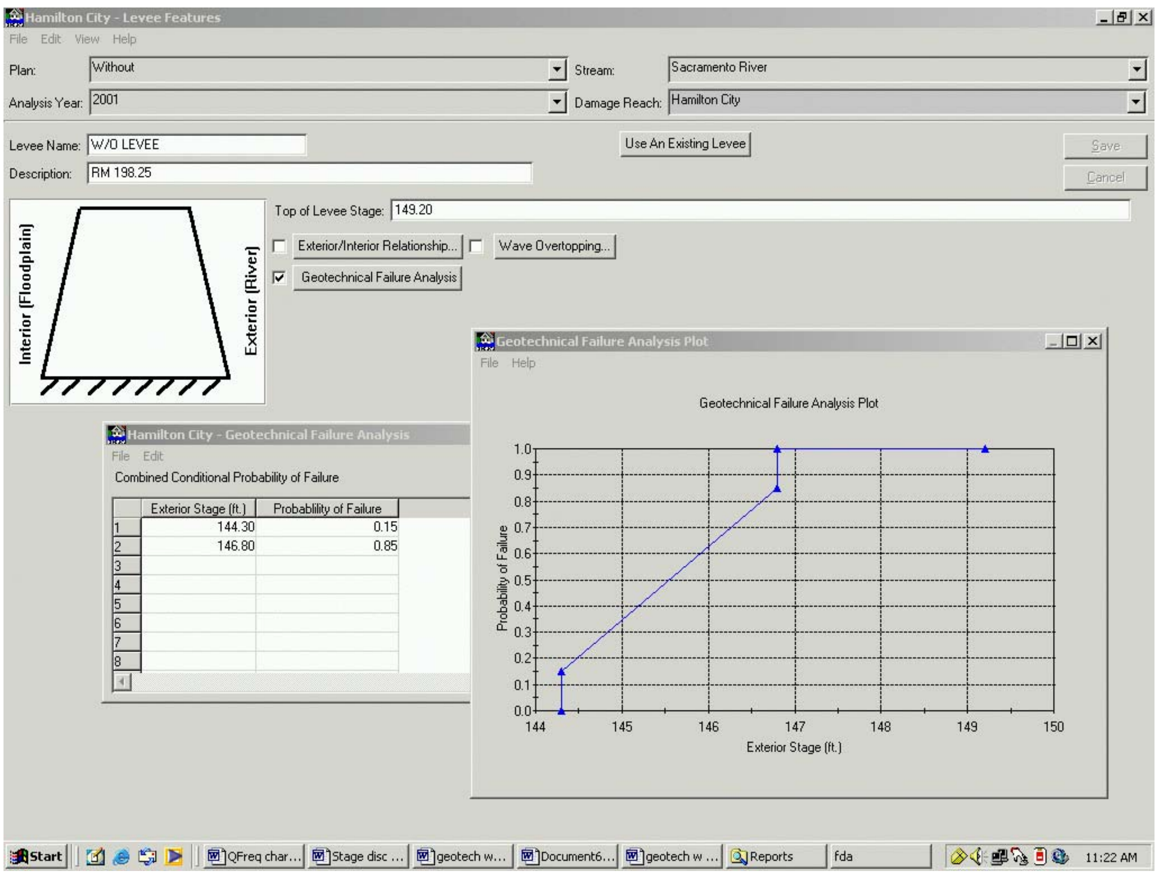


Table A-1.2: Northern Impact Area Project Performance Statistics Without Project

Impact Area	Annual Exceedance Probability (Expected)	Long Term Risk (Years)			Conditional Non-Exceedance Probability by Events					
		10	25	50	10%	4%	2%	1%	0.40%	0.20%
Northern (No Floodfighting)	0.1160	0.7086	0.9542	0.9979	0.4805	0.0881	0.0240	0.0054	0.0005	0.0001

HEC-FDA Results—Assuming No Floodfighting

Table A-1.2 presents the Hamilton City project performance statistics obtained from FDA, assuming no floodfighting. In other words, the levee failure curve shown in Table A-1.1 was input into HEC-FDA with no changes. For example, in Table A-1.2, the expected annual exceedance probability is estimated to be 0.1160, indicating that there is about a 12 percent chance of a damaging flood event along that particular river reach in any given year.

For long-time residents of Hamilton City, this 12 percent chance of flooding annually may seem exaggerated because the town has not suffered major flooding in the last 30 years or so even though severe flood events have occurred, most recently in 1997. The reason the town has not flooded is because of floodfighting—significant local, state and federal resources are typically used to combat flood events in Hamilton City so that the levee has not failed. If these events were not flood fought, then the chance of failure would have been greater, probably to what is indicated by the HEC-FDA AEP results. The equivalent annual damage estimate (without project conditions) for this impact area is about $418,000 (October 2002 price levels), assuming no floodfighting.

If floodfighting were to be assumed in the analysis (primarily by adjusting the levee failure curve as described below), then it's likely that the annual exceedance and equivalent annual damage estimates would be somewhat lower. However, the costs of floodfighting would have to be added to the EAD estimate.

Suggested Procedure to Adjust FDA Analysis For Floodfighting Efforts

To adjust the HEC-FDA analysis for floodfighting requires that the levee failure curve be modified somehow to reflect social actions taken to protect the levee (patrolling, sandbagging, plastic sheathing, boil repairs, etc.). These actions are not typically included in the levee failure curve, which primarily reflects the physical characteristics of the levee.[2] Modifications to the levee failure curve would most likely include raising the PNP and PFP to reflect floodfighting efforts.

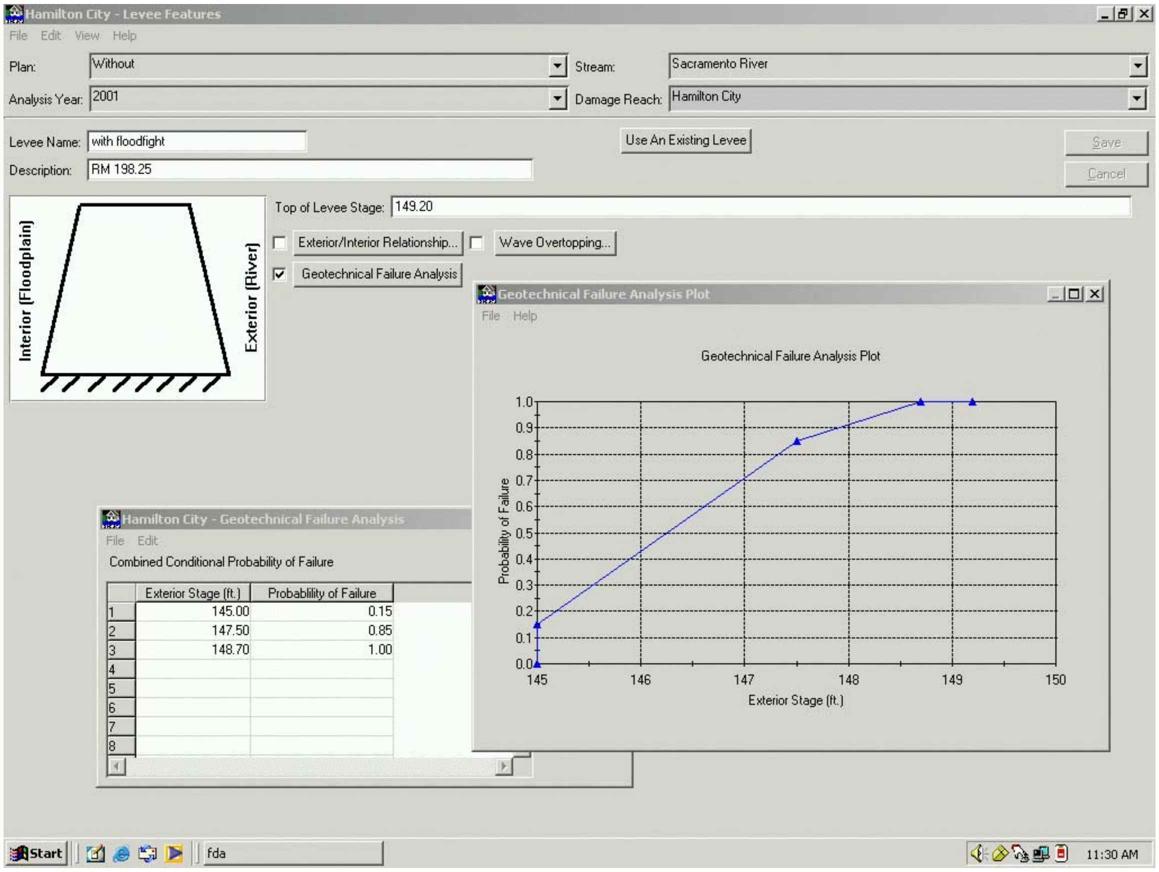
[2] Geotechnical specialists might argue that these actions should *not* be included in a levee failure curve because of the inherent uncertainties whether or not they will be successful.

The Hamilton City Study team met to discuss how the levee failure curve could (and whether it should) be modified. The focus of the meeting was upon the PFP of 146.80 (Table A-1.1). It was mentioned that the "J" Levee safely passed the 1997 event through extensive floodfighting. The maximum river stage at the Hamilton City gage (just upstream of the Gianella bridge) in 1997 was 147.92 (National Geodetic Vertical Datum). This was the highest recorded stage in the past 20 years. The estimated stage at the Northern index point for the 1997 event was 147.5. Thus, it was decided to change the without project PFP of 146.8 to 147.5 since the levee seemed able to withstand this type of event—with floodfighting. The PNP was increased an equivalent distance (0.7 feet) from 144.3 to 145.0, since it is reasonable to assume floodfighting would be at least as effective at a lower river stage. In addition to raising the PNP and PFP values, it was also decided to add another point on the levee failure curve for input into HEC-FDA. This point was one-half foot less than the top of levee (148.70) and it was assigned a probability of failure of 99%. The purpose of this point was to provide more definition to the levee failure curve. Table A-1.3 compares the levee failure curves under both scenarios—no floodfighting vs floodfighting. Figure A-1.2 shows the FDA levee failure curve input screen.

Table A-1.3: Northern Impact Area Levee Failure Curves

Levee Failure Curve	Northern (No Floodfighting)	Northern (With Floodfighting)
Top of Levee (TOL)	149.20	149.20
Additional point (.99 prob failure)	n.a.	148.70
Probable Failure Point (PFP)	146.80	147.50
Probable Non-Failure Point (PNP)	144.30	145.00

Figure A-1.2: Northern Impact Area Levee Failure Curve (With Floodfighting)
FDA Input Screen



HEC-FDA Results—Assuming Floodfighting

Tables A-1.4 and A-1.5 display the HEC-FDA results for the without project analysis for the Hamilton City impact area, floodfighting vs no floodfighting. The only difference within HEC-FDA for these 2 analyses is the levee failure curves shown in Table A-1.3. For project performance (Table A-1.4)), expected annual probability declines from .1160 to .0860. This implies that assuming floodfighting is successful, we can decrease the probability of levee failure from about a 1 in 9 chance in any given year to a 1 in 12 chance in any given year. Equivalent annual damage is also reduced from $418,000 to $397,000, again assuming that floodfighting improves the function of the levee. This reduction in EAD would be more than offset by the significant costs associated with floodfighting.

Table 4
Northern Impact Area Project Performance Statistics
Floodfighting vs. No Floodfighting
Without Project

Impact Area	Annual Exceedance Probability (Expected)	Long Term Risk (Years)			Conditional Non-Exceedance Probability by Events					
		10	25	50	10%	4%	2%	1%	0.40%	0.20%
Northern (No Floodfighting)	0.1160	0.7086	0.9542	0.9979	0.4805	0.0881	0.0240	0.0054	0.0005	0.0001
Northern (With Floodfighting)	0.0860	0.5929	0.8942	0.9888	0.6628	0.2157	0.0956	0.0349	0.0057	0.0006

Table 5
Northern Impact Area Equivalent Annual Damage Estimates
Floodfighting vs. No Floodfighting
Without Project
(October 2003 Prices)

Impact Area	Equivalent Annual Damage
Northern (No Floodfighting)	$438,000
Northern (With Floodfighting)	$406,000

A-2: Ecosystem Plan Formulation Methodology

ECOSYSTEM PLAN FORMULATION METHODOLOGY

The ecosystem restoration planning and evaluation methodology consists of coordination with resource agencies to ensure consistency among restoration approaches, development of an existing condition inventory, projection of with-project restoration benefits, and calculation of the relative habitat value of outputs between alternative restoration plans. Coordination with groups and agencies doing restoration work in the study area began early in the study process. The inventory of existing habitat consisted of generating a Geographic Information System (GIS) database of the study area including vegetation, elevation, topography, soils, and hydraulics/hydrology layers. With-project vegetation was projected using reference site restoration habitat percentages projected to the entire study area. Evaluation of habitat values was calculated using United States Fish and Wildlife Service (USFWS) Habitat Evaluation Procedures (HEP). These HEP models selected were developed by the USFWS and include: *Red-tailed hawk, Habitat Suitability Index Models: Riparian Forest, Habitat Suitability Index Models: Scrub-shrub Cover Type for Riparian Areas*. Cost Effective/Incremental Cost Analysis (CE/ICA) was used to compare restoration alternatives to better inform the selection of a restoration plan.

Coordination

The existing condition inventory and projected restoration methodology were developed through extensive coordination with the USFWS, California Department of Fish and Game (DFG), National Oceanic and Atmospheric Administration (NOAA) Fisheries, The Nature Conservancy (TNC), Sacramento River Partners, and Sacramento River Preservation Trust. Coordination began early in the study process and has continued throughout study development. Numerous meetings were held to gain agreement on the characterization of the existing conditions, as well as defining the problems and potential restoration opportunities of the area, exchange data, information, ideas, and generate a project that could be supported. In addition, coordination with Calfed has been ongoing throughout the study process and specifically includes the review and input of the Independent Review Panel established specifically with Calfed for this study.

Existing Information

GIS based mapping has been developed for the study area. The study area is bounded by the Sacramento River to the east and the Glenn-Colusa Canal to the west and extends about two miles north and six miles south of Hamilton City. The area includes the private lands, DFG, USFWS, and other public lands. GIS layers include; aerial photographs, topography, soils, elevation, vegetation, hydraulics, and hydrological information.

Historic black and white aerial photography for the area was taken in 1948 and copied from U.C. Davis archives. Ayers and Associates provided updated black and white aerials of the area for 1995 and color aerial photos were taken in 2002.

Topography and elevations of the area were gathered from Comprehensive Study topography and elevation data. Soil information was collected from the Glenn County soil surveys (Begg, 1968).

Regional hydrologic and hydraulic information was developed in 2001 as part of Sacramento & San Joaquin River Basins Comprehensive Study. The information was refined to reflect site-specific conditions in the Hamilton City area in 2003.

For initial vegetation mapping, the classification system was adapted from Holland's (1986) *Preliminary Descriptions of the Terrestrial Vegetation of California*. Existing vegetation acreages were calculated from Glenn County land use files. The classification was subsequently simplified to conform to available habitat suitability index (HIS) models to be used in the habitat evaluation procedure for existing and predicted habitat. The final classification used the following habitat types:

- Riparian forest
- Scrub
- Oak Savannah
- Grassland
- Orchard/Grain

Habitat Prediction

The projected with-project conditions were determined using a model developed by The Nature Conservancy for projected vegetation for the RX Ranch reference site (see Zone A4 on the Restoration Zones map). The model used 4 GIS data layers to predict the acreage of converted vegetation types; existing vegetation, the soil type, elevation, and topography. Glenn County soil surveys (Begg, 1968) were initially used to project restoration vegetation potential. These soils maps were found to be non-specific. On the RX Ranch area 27 soil cores were sampled by CSU Chico Biology Department under contract to TNC over the 259-acre area to develop site-specific soil maps. The predicted vegetation acres at the RX Ranch were converted to percentages. The vegetation categories were combined to describe more general habitat types to project to the entire study area and facilitate the use of HEP models for habitat quality prediction. The percentages calculated for the RX Ranch reference site are summarized in Table A1. The predicted habitat percentages within the RX Ranch reference site were then projected to the entire study area with the exception of Zones A1 and I (see Restoration Zones map). Due to the elevation of these zones, TNC determined that these zones would likely support predominantly savannah habitat and therefore the conversion of orchard/grain in zones A1 and I was to 100% savannah.

Table A-2.1: Vegetation Composition Based on Soil Type, Elevation, and Topography (TNC RX Ranch Restoration Site)

Vegetation Type	Percent
Scrub	18
Riparian	73
Grassland	5
Oak Savannah	4
Total	**100**

The main assumption underlying the projected with-project condition is that the vegetation composition of restored areas would be similar to the vegetation composition at the restoration reference site within the study area.

Additional assumptions of the vegetation projections were:

- Vegetation that is currently native habitat in an area under the No-Action Alternative would not change under any of the alternatives, however, the value of riparian and scrub habitat would increase if flooding is introduced to the zone and associated benefits of nearby restoration,

- Where restoration is proposed, all orchard, grain, or hay habitat would be completely converted to native habitat,

- Orchards not proposed for restoration (the south-western section of the study area) would remain in orchard but would include the purchase of flowage easements,

- All potential restoration areas would be actively (as opposed to passively) restored, although there is a potential for some minimal passive restoration test sites

- The period of analysis is 50 years.

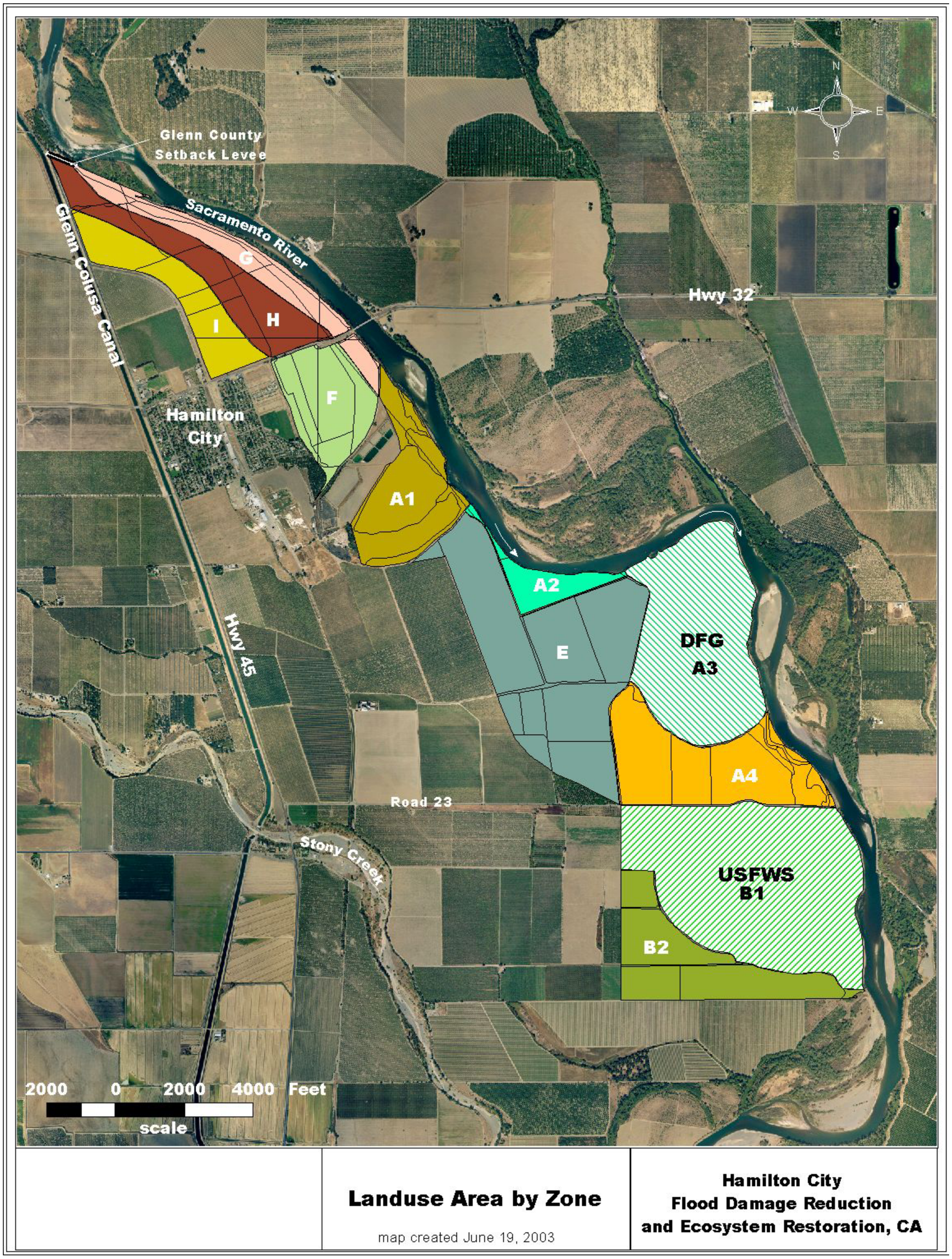


Figure A-2.1 Habitat Valuation (Future with- vs without-project)

The existing ecosystem values and predicted benefits of each alternative were characterized in terms of the assessment methodology called HEP. The HEP methodology, in widespread use since first developed by the USFWS in the early 1980's, compares the suitability of habitat conditions in the study area for a particular species or habitat to ideal conditions for that same species or habitat. HEP takes into account both the quality and quantity of habitat by multiplying a habitat or species-specific numerical HSI by the aerial extent of the habitat under consideration. The HSI value, which varies from 0 to 1 ("0" represents no value as habitat, while "1" represents ideal habitat), is multiplied by acreage to yield habitat units. Habitat units serve as a quantitative expression of environmental output.

We began by evaluating the existing information collected and selected the following HEP models/cover type:

- red-tailed hawk/grassland
- scrub-shrub/scrub
- red-tailed hawk/orchard and grain
- riparian forest/riparian forest
- red-tailed hawk/savannah

These HEP models selected were developed by the USFWS and include: *Red-tailed hawk, Habitat Suitability Index Models: Riparian Forest, Habitat Suitability Index Models: Scrub-shrub Cover Type for Riparian Areas*. The red-tailed hawk, scrub-shrub, and riparian forest models requirements seemed to best fit the river conditions expected with the restoration. Much of the study area is in orchard. In selecting the models it was important to be aware that an orchard could potentially give you high numbers if the wrong models were selected. The red tail hawk seemed the most appropriate when applied to the savannah, grassland, and orchard habitats. The biggest adjustment made to the models was to include a floodplain variable which considered plant germination, shaded riverine aquatic (SRA), large woody debris (LWD), and natural banks when the models were applied to the riparian and scrub habitat. These habitats account for approximately 91% of the potentially restored area and the floodplain variable better reflected the improved function of restoring flooding to the floodplain on these two habitat types.

Historically, rivers in the Central Valley had large floodplains. Over time rivers were leveed and floodplain habitat was converted to agricultural land. Floodplain habitat were productive agricultural areas due to the many years of fine sediment and nutrient buildup. As a result, riparian habitat has become restricted to narrow bands within or adjacent to the levees. The loss of the natural floodplain has caused a loss of features which are typically found in a healthy sustainable riparian corridor such as: 1) colonization of woody plants such as cottonwood and willows; 2) shaded riverine aquatic habitat establishment; 3) supply of large woody debris; and 4) establishment of natural banks. An active floodplain enables these four components to exist within a riparian area. Areas hydrologically connected to the main channel received a 1.0 rating and areas not hydrologically connected to the main channel received a 0.0 rating.

For ease of planning, the study area was split into nine potential restoration zones (see Restoration Zones map). These zones are the potential building blocks for various alternatives. The existing condition HEP was done for these zones and were combined together for each of the different alternatives. The restoration area was inventoried by the HEP team, which included USFWS and Study Team members, and measured in terms of habitat variables (e.g. tree density, habitat complexity, etc) critical to supporting the life requisites of the red tailed hawk, scrub-shrub, and the riparian forest. Using the USFWS HEP models, HSI values were calculated for each habitat type within each zone, which was then multiplied by zone-habitat acreage to yield the number of habitat units for both the future with- and without-project conditions.

In each zone, the expected number of habitat units to occur in the future without the restoration project was subtracted from the number of habitat units expected with a restoration project. This difference represents the "benefits" due to the site restoration. The habitat units were converted to average annual habitat units (AAHU's) to reflect the fact that full ecosystem benefits would not occur immediately. AAHU's for each preliminary ecosystem restoration alternative are displayed on Table A-2.2.

Table A-2.2: With and Without -Project Vegetation Acreages and Associated Average Annual Habitat Units

Summary by Alternative

Alternative 1

Total	**Acres**			**Increase in**	**Increase in AAHU**
	Without	**With**	**Change**	**Habitat Acres**	
Riparian	97.1	955.7	858.5	858.5	843.6
Grassland	83.7	145.6	61.9	61.9	63.3
Savannah	0.0	140.4	140.4	140.4	136.9
Scrub	0.0	227.1	227.1	227.1	219.1
Orchard	1,288.0	0.0	-1,288.0	-	-479.6
Total	**1,468.8**	**1,468.8**	**0.0**	**1,288.0**	**783.3**

Alternative 4

Total	**Acres**			**Increase in**	**Increase in AAHU**
	Without	**With**	**Change**	**Habitat Acres**	
Riparian	94.1	780.3	686.3	686.3	682.1
Grassland	83.6	133.6	50.0	50.0	51.4
Savannah	0.0	130.8	130.8	130.8	127.5
Scrub	0.0	183.9	183.9	183.9	177.4
Orchard	1,050.9	0.0	-1,050.9	-	-396.6
Total	**1,228.6**	**1,228.6**	**0.0**	**1,050.9**	**641.8**

Alternative 5

Total	**Acres**			**Increase in**	**Increase in AAHU**
	Without	**With**	**Change**	**Habitat Acres**	
Riparian	109.8	1,215.8	1,105.9	1,105.9	1,072.9
Grassland	84.8	163.4	78.7	78.7	80.1
Savannah	0.0	154.6	154.6	154.6	150.8

Scrub	0.0	291.3	291.3	291.3	281.1
Orchard	1,630.5	0.0	-1,630.5	-	-599.7
Total	**1,825.1**	**1,825.1**	**0.0**	**1,630.5**	**985.2**

Alternative 6

Total	**Acres Without**	**With**	**Change**	**Increase in Habitat Acres**	**Increase in AAHU**
Riparian	97.1	1,093.7	996.6	996.6	965.1
Grassland	84.6	155.1	70.4	70.4	71.8
Savannah	0.0	147.9	147.9	147.9	144.3
Scrub	0.0	261.2	261.2	261.2	252.1
Orchard	1,476.2	0.0	-1,476.2	-	-545.6
Total	**1,657.9**	**1,657.9**	**0.0**	**1,476.2**	**887.6**

Alternatives Analysis

In accordance with current Corps policy for ecosystem restoration projects, restoration outputs are measured in non-monetary units. The outputs in this study have been measured using average annual habitat units discussed and displayed above. Cost effectiveness and incremental analysis are used to compare the dollars invested vs., in this case, the average annual habitat unit outputs to better determine which level of investment is desirable and affordable. Cost effective analysis identifies the least cost solution for each possible level of output as well as those solutions which provide more output for equal or less cost than others. Subsequent incremental cost analysis evaluates how the cost of increases as output increases. CE/ICA consists of comparing the costs and outputs of alternative plans, identifying plans that are, first, not cost effective; and second, not cost efficient. Best buys are the subset of the cost effective plans that are the most efficient plans, at producing output as project scale is increased – they provide the greatest increase in output for the least increase in cost. By identifying the cost and output differences across cost effective solutions, planners can then decide which level of output is worth the cost. While cost effectiveness and incremental cost analysis will not identify an optimal solution, they do organize and present information that can facilitate the informed selection of a single solution.

Next Steps

The original plant design developed by The Nature Conservancy in 2001 provided a blueprint for which the Corps was able to extract the initial plant community acres and designations for the purposes of hydrologic modeling. The initial restoration communities were developed using TNC's best judgement and knowledge of the Project area in addition to a limited number of soil cores for the area. In 2003 The Nature Conservancy provided the Corps with a detailed soils and restoration community-level plan for the 246-acre RX Ranch located in the southern end of the Project area. This information was used to extrapolate a more fine-tuned community-level plan for the entire Project area.

The next steps in preparing the restoration design for the Project are as follows. Detailed soil sampling and synthesis of data on groundwater and topographic data throughout the remaining Project area is needed. This information will allow the development of the detailed plant community designs for the entire Project area. Accordingly, there will be adjustments made in the final proposed restoration communities between the initial TNC recommended communities and the communities to be derived from the detailed topographic, groundwater, and soils data that are yet to be collected.

A-3: Passive vs. Active Ecosystem Restoration

PASSIVE VS. ACTIVE ECOSYSTEM RESTORATION

Habitat restoration can be both passive and active. Passive restoration is a technique whereby the restoration area is left in a condition conducive to natural recruitment of native vegetation with little or no intervention. Active restoration is restoring natural habitats by active measures such as site preparation, native plant species propagation and planting, weed control, and supplemental irrigation. Both techniques have both habitat and financial benefits and costs.

PASSIVE RESTORATION

General Considerations

The theory behind passive restoration is that by simply reducing or eliminating the sources of degradation, habitat recovery will occur over time. Passive restoration focuses on the removal of a stressor or stressors that have contributed to system decline. The main intervention techniques utilized in passive restoration are the exclusion of livestock or removal of roads that serve as weed corridors. One of the major benefits of passive restoration is the low cost. The risk of restoration failure, however, is potentially substantial. Some factors that may indicate potential failure of a passive restoration site include:

- Competition from non-native species for sunlight and moisture (Adams et al. 1992, Danielson and Halvorson 1991),
- Seed predation and girdling of young trees associated with rodents (Knudsen 1984, Griffin 1980),
- Browse pressure from herbivores (insects, rabbits, and deer) (Griffin 1971), or
- The combination of these factors (Griffin 1971, 1976, Knudsen 1984, McCreary 1990).

Weeds may be the most important biological risk factor because they compete fiercely with natives for sun and water. In addition, the weed cover provides ideal habitat for rodents (Chouinard et al., 1999), which in turn can girdle young trees or consume seeds and acorns.

At passive sites, shade and other factors lead to weeds out-competing native species. Even in active restoration sites, without weed control, weeds out-compete the natives and success can drop by up to 50%. In addition, the unbroken cover of passive restoration areas results in a much higher usage by rodent populations, which significantly reduces the survival of native species.

Figure A-3.1 shows the potential restoration areas, or zones, in the study area. The Sacramento River Partners (SRP) have developed a Riparian Restoration Plan for the Pine Creek Unit, adjacent to the study area and identified as Zone A3 in Figure 1. SRP surveyed the nearby vegetation and identified an elevation of 128 feet above sea level (approximately the 2-year floodplain). Areas exposed to river processes below this elevation appeared to be dominated by natural recruitment. SRP further determined that given the current conditions of the area and despite the cessation of agricultural practices nearly nine years ago, natural recruitment on the area is likely to be limited because of the higher elevation, lower available surface soil moisture, and heavy weed competition.

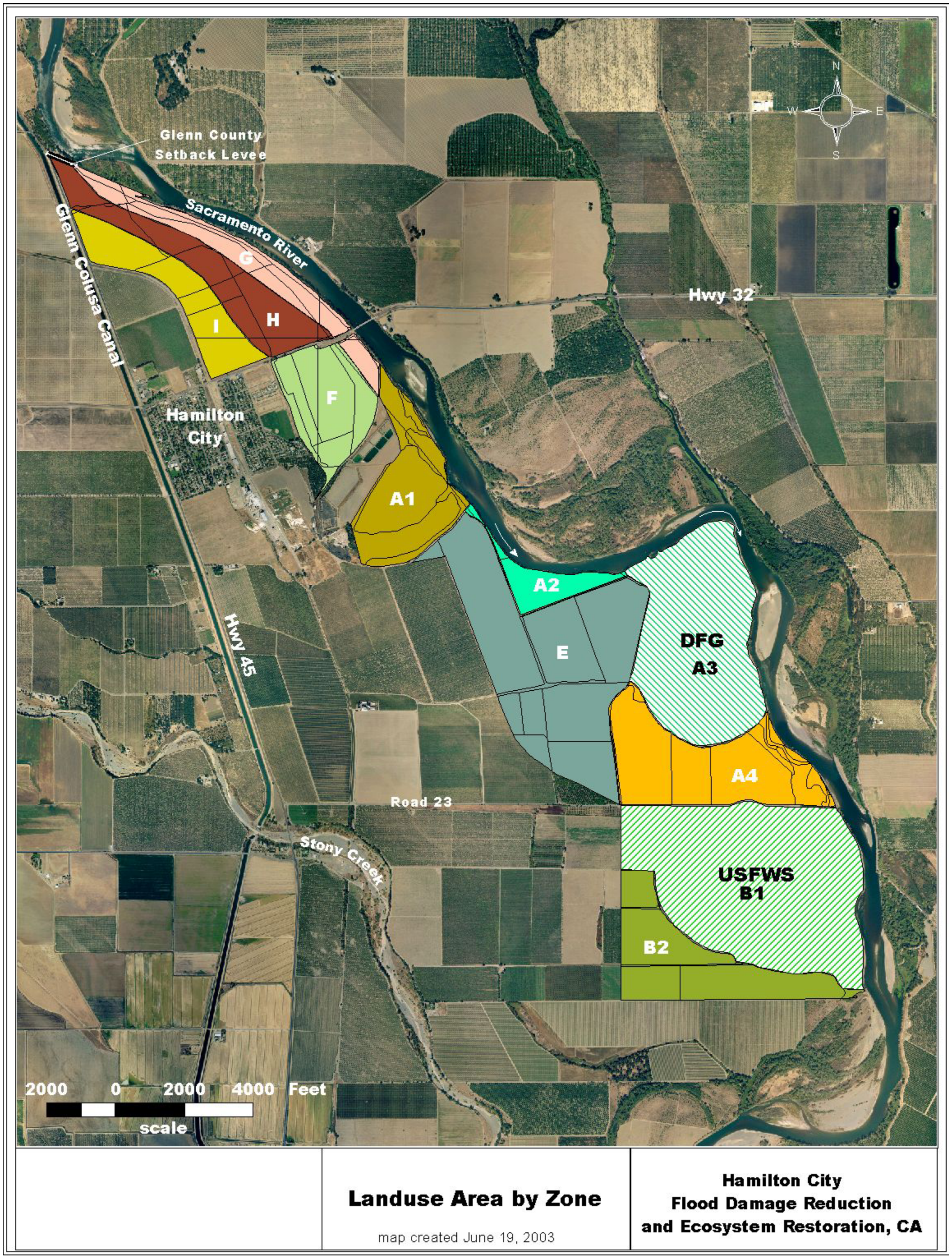


Figure A-3.1: Potential Restoration Area Zones.

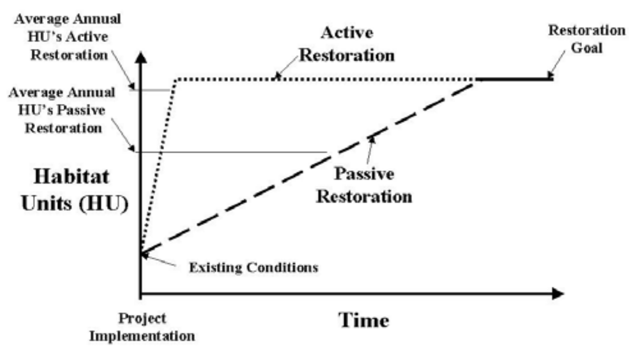
Therefore, undesirable non-native plants are likely to dominate, leaving the site devoid of native vegetation (and desirable wildlife habitat) for decades. Passive restoration was, therefore, unfeasible for the Unit.

Since passive restoration depends fundamentally on natural processes, achieving the established restoration objective often can take many years. In restoration areas along the Sacramento River, research by The Nature Conservancy has shown that although natural regeneration occurred on some of the restoration areas, the regeneration rate was less than that of the active restoration rates. Thus a longer period of time, possibly decades, is necessary to capture the full benefits of restoration at passive sites. Due to the risk of failure, there is also a possibility of not being able to capture the benefits at all. This lag in achieving the restoration goal is depicted in Figure A-3.2.

Habitat benefits are quantified in Habitat Units. Habitat Units are developed using US Fish and Wildlife Service Habitat Evaluation Procedure (HEP) Models to express the quality of both existing and predicted habitat. The expected number of habitat units to occur in the future in the absence of the restoration project was subtracted from the number of habitat units (between the with- and without-project conditions) represents the "benefits" due to the site restoration.

As shown, since the passive restoration takes longer to achieve the restoration goal, the average annual increase in habitat units is usually less than for active restoration. Passive restoration, saves up front costs by not planting and has reduced long term operation and maintenance costs, however, the potential risk of failure with passive restoration and the delayed benefits over time further diminishes the potential savings of passive restoration.

Figure A-3.2: Passive vs. Active Habitat Units



Feasibility Study Analysis

For the Hamilton City Flood Damage Reduction and Ecosystem Restoration Feasibility Study analysis, the 2-year floodplain (comparable to the 128-foot elevation identified by SPR) was used as a general marker for potential passive restoration areas. The cost savings of passive restoration (as opposed to active) within the study area could be substantial and worth the potential risks associated with passive restoration. The cost of orchard removal and the cost of fencing would still apply; however, the potential cost savings from not planting and maintaining the restoration area could be quite substantial. The following table identifies the acres by zone that are within the 2-year floodplain for the study area and potential cost savings associated with passive restoration.

Table A-3.1: Potential Passive Restoration Within the 2-Year Floodplain

		Increase in		Ac Within	Orchard	Potential
Zone	**Cost[1]**	**Habitat Acres**	**Cost/Acre**	**2-yr FP**	**Removal**	**Cost Savings**
A1	854,050	90	9500	80	80000	680,000
A2	453,970	58	7875	16	16000	109,993
A4	1,981,761	252	7872	252	251700	1,729,747
E	4,220,486	535	7885	0	0	0
F	1,215,838	154	7878	0	0	0
G	810,491	103	7835	0	0	0
H	1,491,690	189	7903	0	0	0
I	1,490,265	157	9500	0	0	0
Total	**12,518,551**	**1,538**		**348**	**488100**	**2,519,740**

[1] These estimates only include the costs to remove orchards, plant, irrigate, and monitor for three years. The costs do not include contouring, if necessary, breaching of the "J" levee, EDSA, and fencing.

Application of this approach to the study area shows a potential passive restoration area of 348 acres and a potential cost savings of $2.5 million. This cost savings is potentially significant however the risk of failure of passive restoration within the study area is substantial. Several studies on the Sacramento River (Alpert et al. 1999, Baird, 1989, Laycock, 1995, Peterson, unpubl.,) have indicated that planting, irrigating, and weed control are all required for successful restoration of riparian vegetation due to the high risk that non-native species would out-compete native species. This would seem to indicate that there is a high risk of failure with passive restoration in the study area.

ACTIVE RESTORATION

General Considerations

Active restoration is restoring natural habitats by active measures such as planting trees and shrubs or removing exotic plants and animals from a native landscape or waterway. Active planting can effectively accelerate the natural recovery process. Active strategies for restoration include orchard removal, non-native species eradication, planting riparian, scrub, savannah, and grassland habitats, providing irrigation, fencing, and contouring for flow. The following costs for active restoration include the costs to remove orchards, plant, irrigate, and monitor for three years. The costs do not include contouring, if necessary, breaching of the "J" levee, EDSA, and fencing.

Table A-3.2: Potential Active Restoration

Zone	Cost	Increase in Habitat Acres	Cost/Acre
A1	854,050	90	9500
A2	453,970	58	7875
A4	1,981,761	252	7872
E	4,220,486	535	7885
F	1,215,838	154	7878
G	810,491	103	7835
H	1,491,690	189	7903
I	1,490,265	157	9500
Total	**12,518,551**	**1,538**	

Active restoration costs more up front, in this case $12.5 million, but provides benefits within the first two years of establishment. In fact the Point Reyes Bird Observatory (PRBO) has done surveys of restored areas which showed benefits to passerine bird species two years after planting and full restoration benefits captured as early as 3-4 years. In contrast, passive restoration may take up to 20 years, if at all; to become a restored area that demonstrates beneficial uses to bird and other species.

Feasibility Study Analysis

While a little more difficult to calculate in dollars, this time delay of beneficial results has a cost as well. Habitat units are used to calculate habitat quality over the life of the project. The habitat units were converted to average annual habitat units (AAHU's) to reflect the fact that full ecosystem benefits would not occur immediately. The maximum potential average annual habitat units for the project are displayed in Table A-3.3. These AAHU's would be reduced with a delay in the restoration over time. This demonstrates the detrimental effect that passive restoration will have on habitat quality, ultimately reducing the overall benefits of the project.

Table A-3.3: Potential Habitat Units

Habitat Types	Increase in AAHU
Riparian	1,072.9
Grassland	80.1
Savannah	305.3
Scrub	281.1
Orchard	-654.6
Total	**1,084.8**

CONCLUSIONS

For the Hamilton City Feasibility Study, the assumption will be to use active restoration because of the risks associated with using passive restoration. Restoration areas will have to be further surveyed during the pre-construction, engineering, and design phase of project development. Site-specific indications of risk and potential for passive vs. active restoration will be identified based on the presence of non-natives, hydrology, and soils.

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A-4: Floodplain Reconnection

FLOODPLAIN RECONNECTION

The Hamilton City Study area contains important natural resources characteristic of the Sacramento Valley. Historically this section of the river periodically overflowed its banks and spilled out onto a broad floodplain. As the land became developed for agricultural production, landowners have constructed private levees such as the J levee protecting the Hamilton City area. Currently the "J" levee does not adequately protect the lands or the town but does sever the Sacramento River from its historic floodplain. Relatively frequent flooding is ecologically significant and has many benefits including the establishment and sustainability of riparian vegetation and associated components. More specifically, the establishment of riparian vegetation and associated components has the benefits of allowing for (a) colonization of woody plants such as cottonwoods and willows, (b) establishment of shaded riverine aquatic (SRA) cover, (c) establishment of large woody debris (LWD), and (d) establishment of natural banks, all of which would ultimately benefit a variety of aquatic and terrestrial animal species. Over time periodic inundation of the floodplain allows for the continued regeneration of the riparian community through seed dispersal, removal of senescent vegetation and establishment of pioneer species.

An array of alternative plans to reduce flood damages and restore the ecosystem are being developed and evaluated during the study. Each alternative plan consists of one or more measures. Potential measures include, but are not limited to constructing a new levee along an alignment setback from the river, and restoration of native vegetation and habitats.

(a) Colonization of woody species such as cottonwood and willows

The disturbance pattern of flooding in riparian areas assists in creating a mosaic of vegetation patterns, while other environmental influences such as light, temperature and humidity create a transition zone between riparian and adjacent grasslands, wetlands or meadow areas (Gregory et al. 1989). Dynamics of the river/stream channel interact closely with the vegetation structure. Early stages of riparian plant development are mainly determined by the hydrologic regime and energy in the riparian corridor (USACE 2001). Habitat complexity created by vegetative layers, including various woody species, contributes to the diversity of wildlife. In the Central Valley, riparian forests that exhibit good structure (older, taller vegetation), regeneration, and high vegetative diversity (particularly if plant species are native) also exhibit increased bird diversity and nesting success (PRBO 1995).

Riparian corridors form links among many portions of the landscape and, consequently, contain high levels of biodiversity. The high diversity of riparian plants is thought to be related to, among other factors, the intensity and frequency of floods and small-scale variations in topography and soils as a result of lateral migration of river channels (USACE 2001). The migration capacity of plants along riparian corridors is also an important factor in explaining the high biodiversity observed along stream/river channels (USACE 2001).

(b) Establishment of SRA Cover

SRA Cover is defined as the unique, nearshore aquatic area occurring at the interface between a river (or stream) and adjacent woody riparian habitat (USFWS 1992). Key attributes of this aquatic area include (a) the adjacent bank being composed of natural, eroding substrates supporting riparian vegetation that either overhangs or protrudes into the water, and (b) the water containing variable amounts of woody debris, such as leaves, logs, branches, and roots, often substantial detritus, and variable water velocities, depths, and flows (USFWS 1992). These attributes provide a highly productive and complex land-water interface which supports an array of fish and wildlife species adapted to this habitat. Subsequently, the U.S. Fish and Wildlife Service has designated SRA cover as a Resource Category 1 under its Mitigation Policy, which designates that the habitat is unique and irreplaceable on a national basis or in the ecoregion of the Central Valley and warrants no loss of existing habitat value (USFWS 1981). Overhanging vegetation shades and cools the water and surroundings, helping provide thermal refuges in an otherwise exposed environment (USACE 2001). Roots and debris are colonization sites for algae and macroinvertebrates, and organic matter is eaten by macroinvertebrates. Many organisms take refuge from predators and currents among the roots, rocks, and other structures. Also, entire trees, which periodically become dislodged from the adjacent eroding banks, often contribute to the instream structure of SRA cover.

Setback levees allow for the growth of SRA Cover on banks which would benefit fishes. Overhanging or fallen trees or branches on banks is important to the survival of many fish species. River productivity is increased by the organic materials and energy input from terrestrial vegetation. This vegetation provides food and habitat which in turn serves as food for numerous bird species and several fish species such as Chinook salmon and steelhead trout (Hydrozoology 1976 in USFWS 1992; Sekulich and Bjornn 1977 in USFWS 1992). It also provides shaded escape cover for fish, feeding perches for birds such as belted kingfisher, and nesting and resting areas for birds such as heron, egrets, and wood ducks (USFWS 1992).

SRA cover is important to several federally listed species, such as the threatened Sacramento splittail and delta smelt. Shallow, flooded areas are important to the survival and recovery of the splittail. Because they require flooded vegetation for spawning and rearing, they are frequently found in areas subject to flooding. Delta smelt spawn in shallow, fresh or slightly brackish water upstream of the mixing zone. Most spawning happens in tidally-influenced backwater sloughs and channel edgewaters. SRA refugia is important to both the Sacramento splittail and the delta smelt as they allow these species to evade predators, resist detrimental transport from the system, and rear in more productive areas. Refugia are provided by biological factors such as flooded, overhanging, emergent, and aquatic vegetation (USFWS 2000b).

(c) Establishment of Large Woody Debris

Large woody debris is generally described as fallen riparian wood pieces that exhibit both large size (e.g., often less than 15 feet in length or greater than 18 inches in diameter) and high complexity, such as occurs when an entire mature tree, including root mass, is undermined by erosion and falls into the river (USFWS 2000a)

Large woody debris can to store inorganic sediment and organic matter, while also serving as in-water cover for fish (USFWS 2000). This is important, because to contribute habitat (inorganic sediment) or energy to the food web of a stream reach (organic matter), the material must first be retained in the channel where it can function and be processed (Murphy and Meehan 1991 in USFWS 2000a; Gregory et al. 1991 in USFWS 2000a; Bisson et al. 1987 in USFWS 2000a). Large pieces of debris are generally able to store higher quantities of sediment and organic material than other kinds of structures, such as boulders or exposed root systems (Bisson et al. 1987 in USFWS 2000a). Smaller woody debris, such as branches, sticks, and twigs which create sieve-like accumulations, are the most efficient structures for retaining leaves (Gregory et al. 1991 in USFWS 2000a; Murphy and Meehan 1991 in USFWS 2000a) is important. From a biological perspective, streams require complex arrays of different woody debris sizes to maximize benefits from organic matter retention (Gregory et al. 1991 in USFWS 2000a). Woody material (dead snags, fallen debris and a diversity of mature and young vegetation) on the banks and bar surfaces of riparian areas provides sites for seed accumulation, germination, propagation and regeneration of plants. Taken together, the structural complexity and improved ecosystem functioning riparian ecosystems translate into higher species diversity and abundance of all wildlife.

Perhaps no other structural component of the environment is as important to salmon habitat as is large woody debris (NRC 1996 in USFWS 2000a). Numerous reviews of the biological role of large woody debris in streams of the Pacific Northwest have concluded it plays a key role in physical habitat formation, sediment and organic-matter storage, and in maintaining a high degree of habitat complexity in stream channels (e.g., NRC 1996; Sedell et al. 1990; Bisson et al. 1987 in USFWS 2000a). In large rivers such as the Sacramento River, debris often provides essential salmonid habitat by "capping" side channels, and causing scour holes, velocity breaks, and other habitat complexities in the shallower river braids (Murphy and Meehan 1991 in USFWS 2000a). Deposited debris is also capable of increasing channel width, producing mid-channel bars, and facilitating development of meander cut-offs (Keller and Swanson 1979 in USFWS 2000a). Large woody debris provides habitat complexity, protecting fish from predation, excessive competition and physical displacement (Dolloff 1994 in USFWS 2000a).

Furthermore, complex near-shore areas enhanced by wood are particularly critical as refuge areas during floods (Gregory et al. 1991 in USFWS 2000a; Dolloff 1994 in USFWS 2000a). During floods and other large-scale severe disturbances, large woody debris can diversify hydraulic forces and maintain structural complexity, thereby providing fish with important shelter areas (Shirvell 1990 in USFWS 2000a). Such diversity and provision of refugia may be critically important along the Sacramento River, due to its extensive channelization and disconnection from historical floodplain where critical refuge and rearing habitat were formerly provided.

(d) Establishment of natural banks

A setback levee at Hamilton City would allow creation of natural banks. Several wildlife species use natural banks for cover and reproduction. For example, the bank swallow, a State listed threatened species, feeds predominantly over open riparian areas, and uses holes dug in cliffs and vertical river banks for cover (Zeiner et al. 1988-90a). Also, the belted kingfisher, a resident species, usually excavates a nest in a steep earthen bank of sandy, or otherwise friable, soil, and the nest near water (Zeiner et al. 1988-90a). The American mink, a semi-aquatic mammal, uses most aquatic habitats. It forages along waterways such as rivers and streams, and uses existing cavities and burrows in wetland and riparian vegetation for cover, and dens in burrows under trees, snags, stumps, logs, and rocks near water (Zeiner et al. 1988-90b). Western pond turtles utilize rivers and streams with emergent aquatic vegetation and deep pools with undercut banks for escape, and prefer partially submerged rocks and logs, open mud banks, matted floating vegetation or sandbars in and along rivers and streams for basking (Holland 1994). Amphibians and reptiles often hibernate in submerged nearshore muddy, debris- covered substrates, and also use woody debris and leaf litter which washes up on river shorelines as cover.

The riverine littoral zone is most often characterized as the river bank from the edge of the water to the top of the bank, and may include active bars, shelves, and islands within the channel (Hupp and Osterkamp 1985 in USACE 2001). Compared to riprapped or channelized rivers, areas with natural stream banks show greater concentrations of several important organic and inorganic nutrients (Dahm et al. 1987). The upper portions of the bank, forested with riparian vegetation species, and overhanging vegetation, exposed roots, rocks, and debris provide excellent habitat structure along the mid- and upper-portions of the bank. The lowest portion of the bank and shelves are usually barren sediments that are exposed at low river stages (USACE 2001). This zone is unique because it provides constant contact between the aquatic and terrestrial portions of the riparian corridor and is directly affected by river level fluctuations and currents. High river stages inundate the entire littoral zone and provide fish and other aquatic species access to resources of the upper littoral zone. Conversely, low river stages remove access to refuge, food, and spawning areas for fish and aquatic species when the higher elevation areas become exposed. However, periods of low water are necessary in order to allow terrestrial plants and animals to recover from inundation (USACE 2001). The diversity and abundance of species tend to be greatest at this edge between two the aquatic and terrestrial habitats (Odum 1978 in USACE 2001). Edges and their ecotones are usually richer in wildlife than adjoining areas because the species inhabit multiple ecotypes (Thomas, Maser, and Rodiek 1980 in USACE 2001).

Summary

The Hamilton City area provides a great opportunity to remove constraints that prevent the river from connecting with its floodplain and to create new areas where natural processes and habitat can be restored. The U.S. Army Corps of Engineers and The Reclamation Board, sponsors of the Hamilton City Study have the opportunity to significantly contribute to the on-going restoration efforts by others by being the only two agencies with authority to alter the flood management features to both improve flood protection for Hamilton City and to restore natural ecological processes in this area.

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A-5: Guiding Principles

Guiding Principles

A set of basic principles is needed to ensure that changes to the flood management system integrate flood damage reduction and ecosystem restoration, while considering system-wide implications of those changes. The Guiding Principles were designed in response to this need to (1) promote coordination and partnerships for the public good, (2) reduce or eliminate conflicts, and (3) serve as a guide for modifications to the flood management system. They were established and refined through agency coordination and public outreach to address the wide range of stakeholder concerns to integrate flood damage reduction and ecosystem restoration, and to ensure a system-wide approach in evaluating proposed changes. These principles will guide the planning of changes to the flood management system and will be applied to future studies and projects regardless of their aerial extent or level of detail. The Guiding Principles will apply to anyone planning projects that modify effect of the flood management system. Projects should demonstrate that they are consistent with the Guiding Principles. In addition to compliance with the Guiding Principles, each project will be subject to site-specific environmental documentation and mitigation requirements.

Each of the Guiding Principles supports a system-wide approach for project planning. The Sacramento and San Joaquin rivers function as hydrologic systems, and ecosystem needs are tied to hydrologic processes. Accordingly, one must approach these rivers as complete systems when considering flood damage reduction and ecosystem restoration objectives. The fact that these rivers have not been consistently treated as comprehensive systems in the past has led to some of the problems that are experienced today. Focusing on flood management within limited reaches without full consideration of hydraulic effects in reaches both upstream and downstream has resulted in modifications to the system that have shifted local problems to other reaches. Likewise, the cumulative impacts of modifications to the system have contributed to a general decline in the health of the ecosystem. The cumulative impacts of habitat restoration projects can also reduce flood conveyance. It is important to ensure that the integrity and continuity of the system is maintained and enhanced to allow the river system to function in a manner where flood management and the ecosystem are compatible.

The following Guiding Principles are integral to achieving a system-wide approach to flood damage reduction and ecosystem restoration along the Sacramento and San Joaquin rivers.

1) Recognize that public safety is the primary purpose of the flood management system. Proposed changes to the flood management systems must not compromise public safety. The flood management systems for the Sacramento and San Joaquin River basins were authorized, designed, and are operated to protect public safety. Public safety considerations include the transportation and communications infrastructure necessary to accommodate an effective emergency response program. Since flooding often results in widespread economic and social hardships, it is recognized that protection of public safety is the primary purpose of the flood management systems. Public safety means increased security for people, infrastructure, and agricultural production.

2) Promote effective floodplain management. The floodplains of the Sacramento and San Joaquin rivers include overflow areas that store and convey large volumes of floodwater during flood events. This storage contributes to the flood protection of downstream property. All projects proposing modifications to the flood management system should consider the benefits of the roles of the floodplain in flood management and maintaining ecosystem processes. It is important to recognize that floodplains can be managed to further

reduce damages and to avoid future damages without changing flood frequencies or modifying existing uses. It is essential to encourage and promote effective floodplain planning and management practices that improve public safety, reduce the susceptibility to damaging floods, preserve agriculture and habitat, and restore degraded ecosystems in the floodplain. Effective floodplain management involves actions that remove or modify damageable property; adapt land uses to be more compatible with flooding; influence future project decisions that benefit social, agricultural, and environmental values; and discourage development in areas with high flood risk. A clear communication of residual risk in those areas protected by structural features of the flood management system will encourage improved floodplain management practices.

3) Recognize the value of agriculture. Future projects will take into account individual and cumulative impacts of project development on agriculture and other open space lands, the flood damage reduction and ecosystem benefits of these lands, the economic and environmental effects on crop production, and the effects on associated service industries, infrastructure, and local communities. Agricultural lands in the Central Valley contribute significantly to the economy and quality of life in the region, the state, and the nation, and provide essential habitat components for many important species. Agricultural and open space lands offer substantial benefits in protecting natural values and in incurring lower monetary flood damages than more intensive land uses.

4) Avoid hydraulic and hydrologic impacts. The hydrology and hydraulics of the Sacramento and San Joaquin rivers and associated floodplains and ecosystems will be considered as complete systems at local and watershed levels. Studies clearly demonstrate that the hydrologic and hydraulic characteristics of the waterways and associated floodplains and ecosystems of each river basin represent a complete and interconnected system, and that changes to one part of the system will change other parts of the system. Future projects will be evaluated individually and cumulatively to ensure that there are no significant hydraulic effects to other lands and communities along the system and to ensure compatibility with local and regional flood damage reduction and ecosystem restoration goals. In working towards the restoration of a dynamic river system, some effects may be considered either beneficial or adverse, depending upon what is being affected. Each proposed project will undergo assessment for its potential effect on all aspects of the flow regime (flood magnitude, timing, duration, frequency, and rate of change) that affect natural functions such as sediment supply, transport and deposition processes, and channel cross-sectional and planform changes, as well as man-made and natural resources, upstream and downstream of project sites. Hydrologic evaluations will take into account the best available information on the effects and uncertainties of potential climate changes.

5) Plan system conveyance capacity that is compatible with all intended uses. Future projects that modify system conveyance capacity will utilize a watershed approach to establish system conveyance capacities that are compatible with release rates for reservoirs and functional geomorphic and biological processes. Modifications to conveyance capacities should account for effects of restored habitat.

6) Provide for sediment continuity. Management of sediment throughout the river systems is critical for maintaining the ecosystem and flood damage reduction functions of the river corridor. Providing for more natural movement of sediment through a river system will balance areas of erosion and deposition and support the dynamic habitat changes that characterize a healthy, self-sustaining riverine ecosystem. Future projects should be

consistent with an integrated flood management design, including sediment inputs, that provides a balanced sediment budget within the channel to benefit geomorphic processes and riparian habitats, maintains the integrity of the design capacity, and reduces maintenance costs.

7) Use an ecosystem approach to restore and sustain the health, productivity, and diversity of the floodplain corridors. The ecosystem approach restores and sustains the health, productivity, and biological diversity of ecosystems by factoring in a full range of ecological components in project planning. The ecosystem approach recognizes and seeks to address the problems of habitat fragmentation and the piecemeal restoration and mitigation previously applied in addressing natural resources. Ecosystem restoration uses a systems view in assessing and addressing restoration needs and opportunities and in formulating and evaluating alternatives. Biotic resources are dependent on, and functionally related to, other ecosystem components. Recognition of the interconnectedness and dynamics of natural systems interwoven with human activities in the landscape is integral to this process. The philosophy behind ecosystem restoration promotes consideration of the effects of decisions over the long term and incorporates the ecosystem approach. Future projects will consider the needs of native aquatic, wetland, and terrestrial communities to improve the potential for their long-term survival as self-sustaining, functioning systems.

8) Optimize use of existing facilities. Significant contributions to both flood damage reduction and ecosystem restoration may be attainable through integrated or facility-specific reservoir re-operation, integrated use of public land for multiple purposes, and protection and management of existing high-value habitats within the flood management system. Therefore, the operation and management of existing facilities could be optimized to reasonably maximize system benefits and minimize the need for new facilities. Presently, there is a substantial array of facilities that directly or indirectly contribute to flood management and/or ecosystem health along the Sacramento and San Joaquin rivers. The objectives of the general design, construction, and operation of these facilities is to meet the needs of the immediate impact area or limited resource targets. At the time these facilities were constructed, it was not possible to measure or take into account effects that may have occurred in other areas of the river system. Because of their design and information available at the time of their construction, many existing facilities do not achieve their full potential for providing ecosystem benefits. The system-wide models can be used to evaluate system-wide effects.

9) Integrate with the CALFED Bay-Delta Program and other programs. Future projects should consider the status and objectives of ongoing flood management and ecosystem restoration programs, including, but not limited to CALFED, to ensure awareness of other planning efforts and prevent unintentional conflicts in designs or duplication of efforts. Projects need to recognize and support the CALFED single blueprint for ecosystem restoration and species recovery in the Bay-Delta and its watershed. To the extent possible, projects should integrate and adopt those CALFED ERP goals, objectives, targets and programmatic actions associated with the flood management system of the Sacramento and San Joaquin rivers, and incorporate conservation measures from the CALFED Multi-Species Conservation Strategy (MSCS). In that context, future projects will give priority to those actions that provide benefits for both flood damage reduction and ecosystem restoration. The CALFED science program and CALFED's considerable institutional and administrative framework was established to expand and communicate relevant, unbiased scientific knowledge, monitor performance, implement an adaptive management process, and measure progress. Future

projects should build upon the CALFED ERP, rather than develop independent, parallel restoration programs, and implement applicable portions of the CALFED ERP to the extent of potential non-Federal sponsor interest. Additionally, future projects should take into account the floodplain areas and conveyance capacities needed by major regional planning efforts such as the San Joaquin River Management Plan (SJRMP) and the Sacramento River Conservation Area Forum (SRCAF).

10) Promote multi-purpose projects to improve flood management and ecosystem restoration. Proposals for modifying the flood management system for the primary purpose of either flood damage reduction or ecosystem restoration should consider opportunities for benefiting more than a single purpose. Multiple-purpose projects are more effective, considering costs and resource conservation. Projects that include both flood damage reduction and ecosystem restoration (as well as other potential purposes) will foster partnering, reduce conflicts, and serve the overall public interest. In accordance with State law, projects with multiple-purposes are eligible for increased State cost sharing.

11) Protect infrastructure. Future modifications to the flood management system should consider direct and indirect impacts to infrastructure, including, but not limited to transportation (highways, railroads, navigation), communications, utility, and water transport systems. Transportation corridors and facilities are necessary for economic viability, emergency/evacuation response, and public safety. Potential impacts to infrastructure could limit future options and could result in unintended consequences.

A-6: Ecosystem Restoration Alternatives

ECOSYSTEM RESTORATION ALTERNATIVES

PLANNING ZONES

To facilitate formulation and evaluation of alternative plans, the study area was divided into a number of areas, or zones. Twelve zones were used for the economic analysis and nine zones for the ecosystem analysis.

Economic Zones

The zones used in the economic analysis are shown in **Figure A-6.1**. The flood damage conditions in each zone were varied depending on the management measures included in a given alternative plan. Conditions in a zone could remain unchanged (i.e., same as the future without-project condition), the zone could be protected by a new levee, the zone could be converted from agriculture to native habitat (eliminating most flood damages), or a flowage easement could be purchased within the zone to compensate for induced flooding (caused by breaching the existing private levee). A more complete discussion of how the zones were used in the economic analysis is included in the Economic Appendix.

Ecosystem Zones

The zones used in the ecosystem analysis are shown in Figure A-6.2. Zones E, F, G, H, and I are the same as used for the economic analysis. Zones A1, A2, A4, and B2 are sub- areas within the economic zones A and B. Zones A3 and B1 are California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service (USFWS) lands. These lands were assumed to be restored under the No Action alternative and were not used in the formulation of the other alternative plans. More information about how the zones were used in the ecosystem analysis is described in the paper, "Ecosystem Restoration Planning and Evaluation Methodology," which is included in the Plan Formulation Appendix.

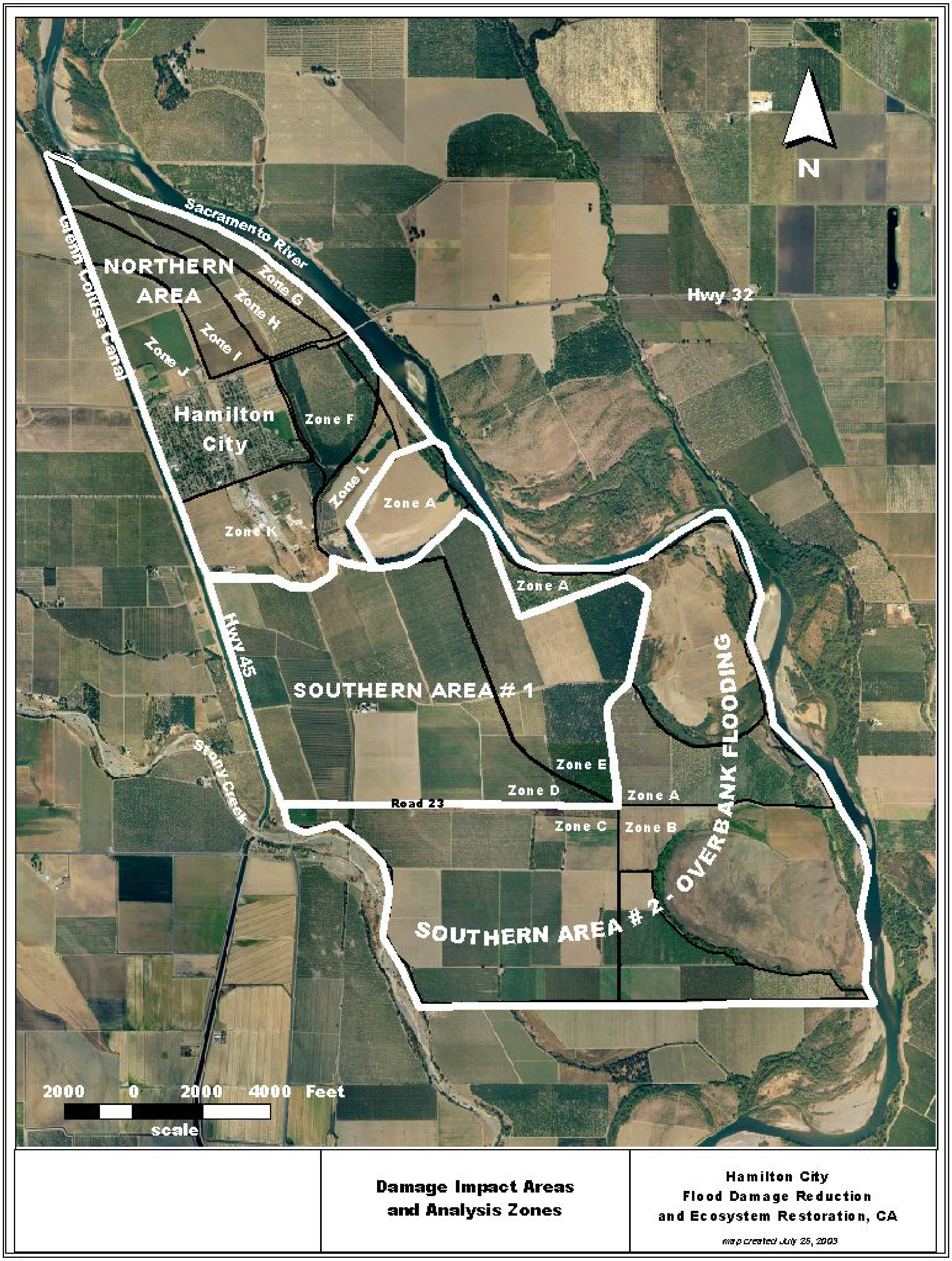

Figure A-6.1: Economic Zones

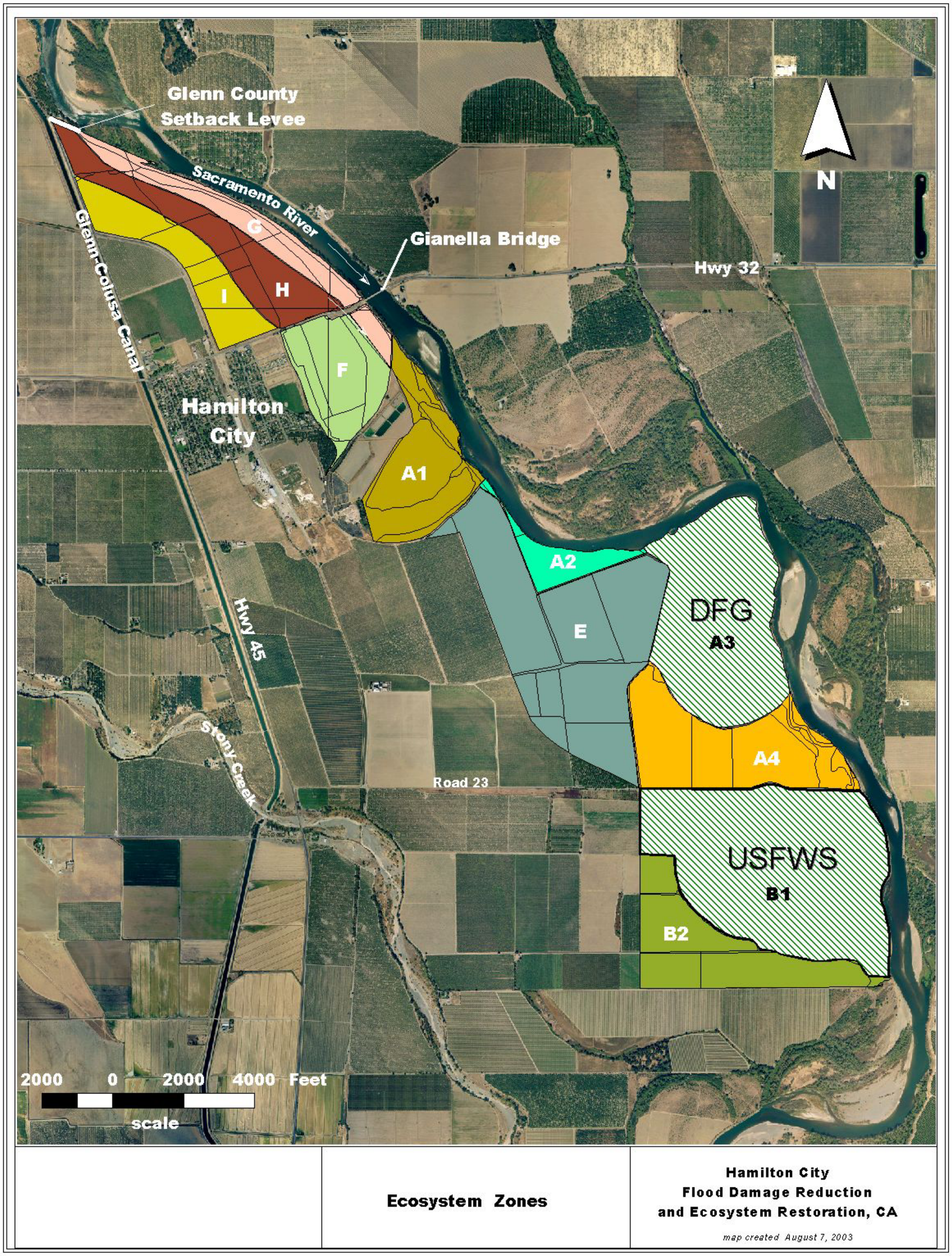

Figure A-6.2: Ecosystem Zones

DESCRIPTION OF PRELIMINARY ECOSYSTEM RESTORATION ALTERNATIVE PLANS

A preliminary array of alternative plans was developed by creating various combinations of the measures retained during the measures screening process. The array of preliminary plans, including No Action, is described below. Alternatives 1, 5 and 6 were retained for further consideration and referred to as the Final Array of Ecosystem Restoration alternative plans.

No-Action

The No-Action alternative assumes that no project would be implemented by the federal government or by local interests to achieve the planning objectives. The No Action plan is shown in **Figure A-6.3**. Critical assumptions in defining the No-Action alternative include:

- The "J" levee would continue to be privately owned. Some periodic maintenance could be expected to occur as limited funding allows. The "J" levee would remain in relatively poor geotechnical condition. No improved method of flood protection would be accomplished because the community and county, who in past years has expended its flood control budget protecting Hamilton City, would not likely have enough funding to implement a project on their own.
- Extensive flood fighting of the "J" levee would continue to be necessary to maintain the integrity of the levee when water levels rise in the Sacramento River.
- The existing level of flood protection would not change. Although with flood fighting the "J" levee has historically passed high flood events, statistically it only has about a 66 percent chance of passing a 10-year event assuming significant flood fighting efforts. This would also equate to a 90 percent chance of passing an event smaller than a 10-year event. Another way to state this is that on an annual basis, the community currently has about a 9 percent chance of flooding in any given year, again assuming flood-fighting efforts.
- Erosion of the levee toe at the northern end of the "J" levee would continue, but the Glenn County backup levee would maintain the flood control function of the "J" levee.
- Hydrologic and hydraulic conditions in the study area would remain similar to existing conditions with no significant changes.
- Agricultural crops and production in the study area would remain similar to existing conditions.
- Future development in the study area was estimated to be limited to the build-out of homes in a new subdivision on the east side of Hamilton City (scheduled for completion in 2004) and construction of an adjacent middle school (assumed completion in 2010).
- TNC property within the study area would remain in agricultural production, as would other privately owned agricultural lands. Neither funds nor permits are in place to allow for restoration work to occur.
- The DFG and USFWS lands in the study area would be restored with native habitat.
- Glenn County would continue to flood fight the Glenn-Colusa Irrigation District (GCID) canal berm at a low spot north of the study area.
- The problems and opportunities in the study area would remain unresolved.

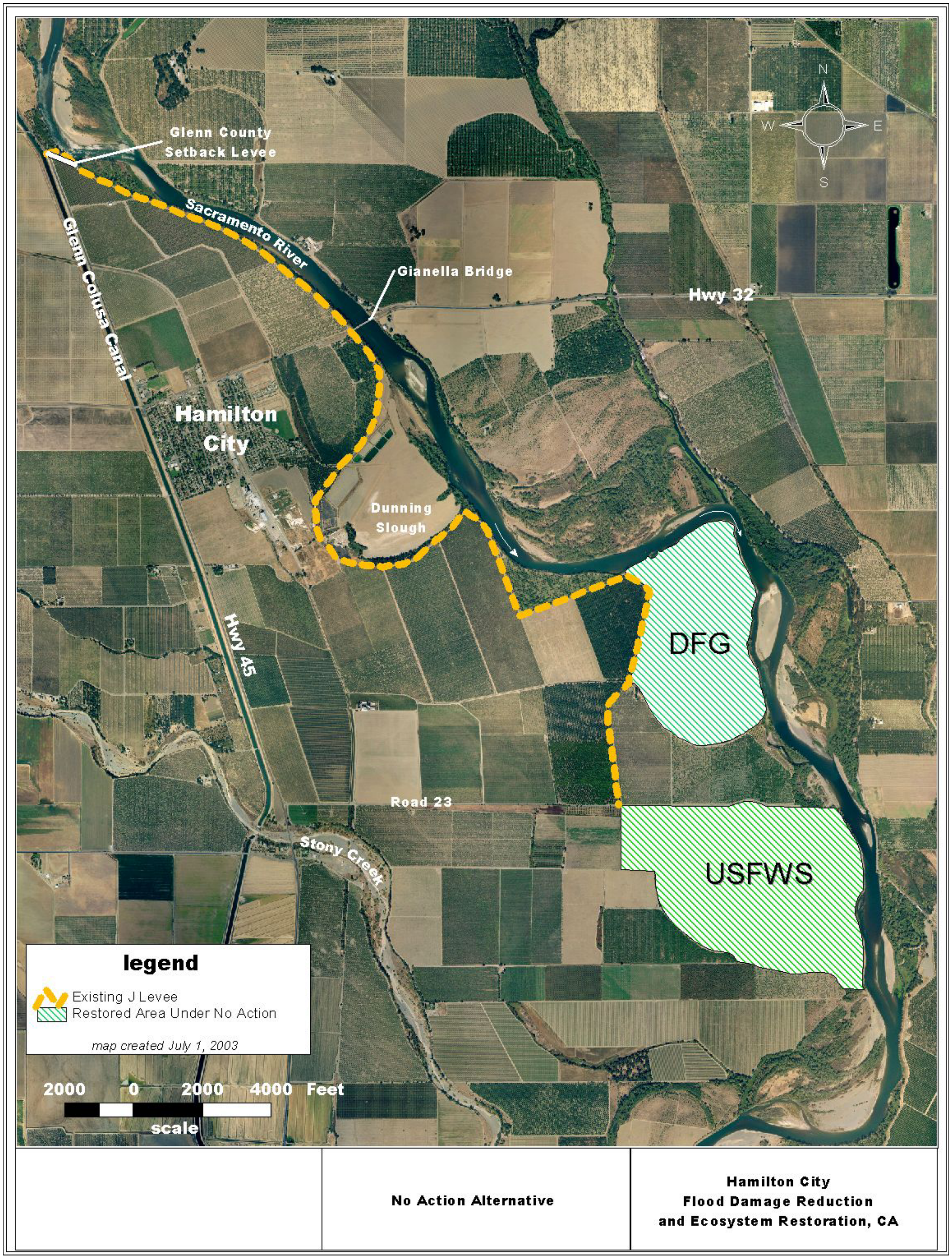

Figure A-6.3: No Action Alternative

- Glenn County would continue to operate the existing flood warning system and utilize the existing emergency preparedness plan.
- The State of California has the responsibility to operate and maintain the Chico Landing to Red Bluff Project. Any future placement of rock as part of that project would need to consider a jeopardy opinion issued by the U.S. Fish and Wildlife Service that pertains to the valley elderberry long-horned beetle and includes the study area.
- A small portion of the urban area of Hamilton City is within the FEMA 100 year floodplain and the structures within this area have been elevated above the FEMA 100-year floodplain. The unincorporated area of Glenn County, including Hamilton City, is enrolled in the National Flood Insurance Program, but does not have a Flood Mitigation Plan, both of which are requirements for applications for FEMA floodplain buyout programs. Glenn County has not considered participating in these buyout programs (Glenn County, pers. com., January 20, 2004) and it is unlikely to do so in the future.

Ecosystem Alternative 1 – Locally Developed Setback Levee.

This alternative is based on a levee alignment developed by the Hamilton City Community Services District and several landowners in the study area. This alternative consists of constructing a levee about 6.6 miles long and about 6 feet high, set back roughly 500 to 7,600 feet from the river, and removal of most of the existing "J" levee. It includes actively restoring about 1,300 acres of native habitat in Zones A1, A2 and A4, E, G, and B2, waterside of the setback levee. This alternative is shown in **Figure A-6.4**.

In order to accomplish ecosystem restoration, most of the existing "J" levee would be removed to reconnect the river to the floodplain. While this action would enable ecosystem restoration, it would lower the community's existing flood protection. The Federal and State governments would be obligated to mitigate the effect of removing the private levee that protects Hamilton City. In order to ensure that the replacement levee would have the same possibility of passing a flood as the existing "J" levee could with flood-fighting, the replacement levee would be of the same height as the existing "J" levee.

In order to compensate for degrading the "J" levee, it is important to consider existing rock on the "J" levee. The existing "J" levee has about 11,250 square feet of rock greater than 20 inches in diameter (450 feet long by about 25 feet high). This rock was placed during flood fighting efforts in 1997 because the levee was eroding. This rock was placed because the existing "J" levee is of poor quality and subject to erosion. A replacement levee would be constructed to Corps' standards, which, by itself, would be an improvement to the existing condition of the "J" levee, so this rock would not need to be replaced.

North of Highway 32, the levee alignment ties into the newly constructed Glenn County backup levee and runs roughly parallel to and about 500 feet to the west of the Sacramento River. At Highway 32, the levee ties into the existing approach to the Gianella Bridge. The highway would not need to be raised, but measures to protect the highway embankment and bridge from floodwaters would be necessary.

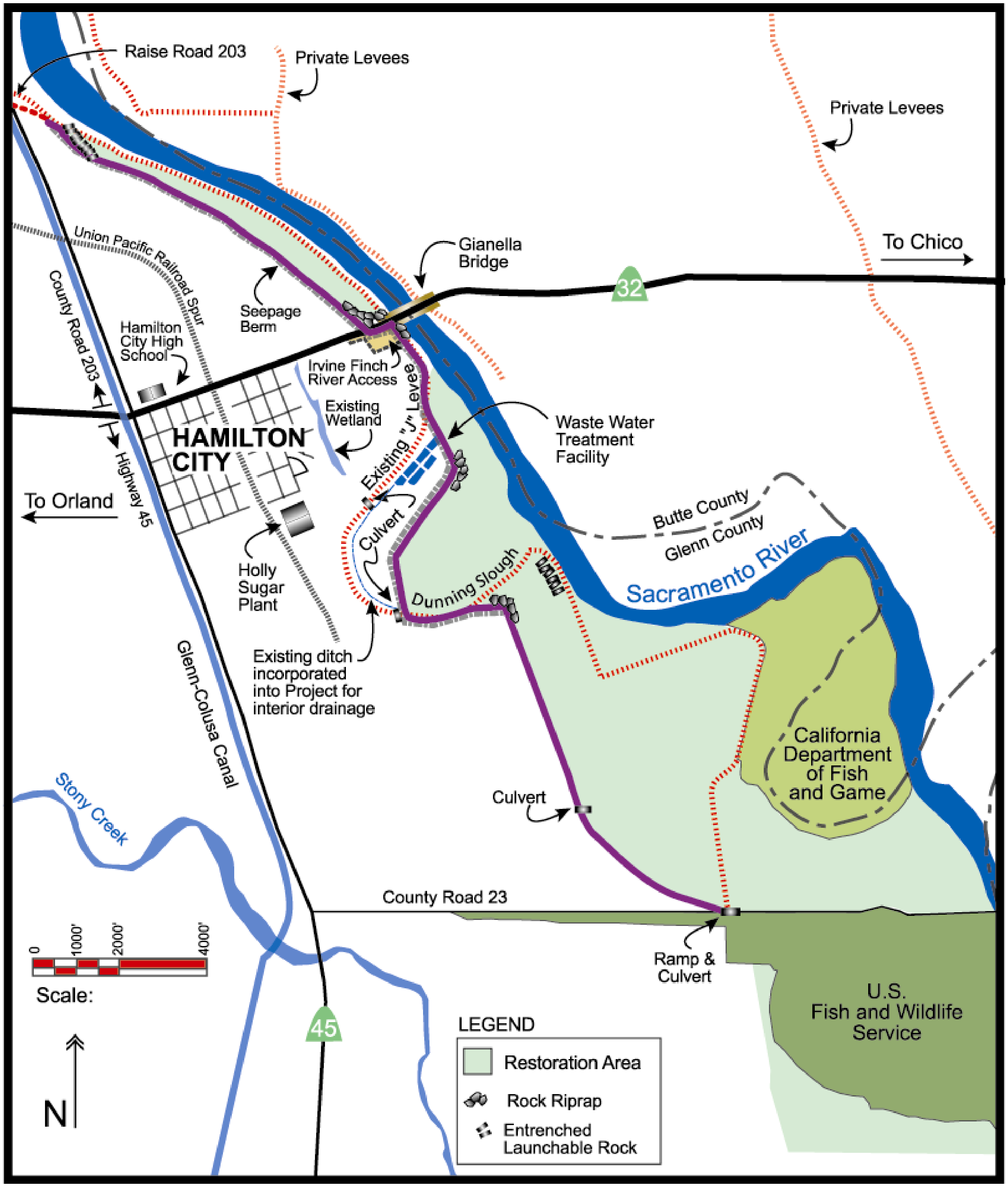

Figure A-6.4: Ecosystem Alternative 1 - Locally Developed Setback Levee

South of Highway 32, the alignment cuts across the easternmost section of the Irvine Finch River Access (just south of the highway), requiring modification of the River Access entrance and parking lot. The alignment also cuts across a portion of Dunning Slough providing protection to the Hamilton City wastewater treatment ponds, some abandoned holding ponds for the old Holly Sugar plant (in which the community would like to expand the treatment plant in the future), and a lime disposal pile. About 1,500 feet of rock would be placed on the setback levee in Dunning Slough as erosion protection.

South of Dunning Slough, the alignment roughly follows along the western edge of the habitat restoration area before turning east toward the southern end of the "J" levee at Road 23. The alignment ends at Road 23, not tying into high ground.

All lands to the waterside of the setback levee would be actively restored with a mixture of riparian, scrub, oak savannah, and grassland habitat (except the DFG and FWS lands, which are assumed to be restored under the without-project condition). The "J" levee would be removed, except for portions where it would serve to reduce velocities of the Sacramento River for establishment of newly planted habitat. Established riparian vegetation waterside of the existing "J" levee would be avoided wherever possible.

Many in the local community favor this alternative because it is located the greatest distance from Hamilton City of any of the alternatives and it protects the wastewater treatment plant and agricultural land south of town.

Erosion Control. Placement of rock (entrenched and revetment) was considered necessary at some points along the replacement levee to ensure the existing flood protection is not lessened and to offset potential scouring from changes in flows. Placement of rock would be as follows:

North end of the Project. Entrenched rock would be buried in a 1,500 foot-long trench in Zone G, parallel to County Road 203 and approximately 200 feet from the toe of the levee. When the river erodes away the bank at the location of the trench, the rock would fall and armor the bank preventing erosion beyond that point.

Highway 32 Gianella Bridge. Because a replacement levee would be set back from the existing "J" levee, the northern bridge abutment would be exposed to direct flows. It is not currently exposed to these direct flows, which could scour the abutment. In order to ensure that bridge is not compromised by the potential project, 1,000 feet of rock riprap would be placed on and around the abutment. Because this rock would be necessary to maintain the existing condition, it is considered a part of equitable replacement of the existing "J" levee.

Dunning Slough. Because a replacement levee would be set back from the existing "J" levee, a bend in the replacement levee would be exposed to overland flows from multiple angles, which could erode a replacement levee. In order to ensure that the replacement levee is not subject to this erosion, 500 feet of rock riprap would be placed along the levee at the bend. Because this rock would be necessary to maintain the existing condition, it is considered a part of equitable replacement of the existing "J" levee.

Southernmost extent. A replacement levee would not affect the existing erosion conditions south of Dunning Slough. It is assumed that the Chico Landing to Red Bluff Project (local site constructed in 1975-1976) would remain authorized and continue to be maintained. For the new levee to perform to the same level as the existing "J" levee, erosion control at the end of the levee would consist of planting significant amounts of vegetation (about 20 feet or so from the levee toe) to reduce velocities at the levee.

Hydraulic Effects. The alternative would reduce stages in the floodplains of the regions. Increases in water surface elevation would either occur in areas intended to be exposed to flooding (between the existing "J" levee and the setback levee) or would be contained in the river channel and would not constitute an adverse hydraulic impact.

Uncertainty. Average yearly river migration is 6 feet per year. However, the extreme northern and southern ends of the potential project area have experienced rates above that average. (Larson, Anderson, Avery, Dole, 2002.) The study area is also within the Sacramento River Chico Landing to Red Bluff Bank Protection Project limits that authorized placement of bank protection in areas of high erosion, which has constrained the river's ability to move. Based upon aerials from the past 100 years, risk of levee failure due to river meandering seems very low. This information is being refined through continuing hydraulic studies.

Accomplishments. This alternative plan would restore 1,300 acres of habitat and provide 783 AAHU's.

Preliminary Ecosystem Restoration Alternative #2 - Intermediate Setback Levee

This alternative consists of constructing a setback levee about 3.8 miles long and setback roughly 1,300 to 2,700 feet from the river, breaching the existing "J" levee in several locations, and actively restoring about 1,400 acres of native habitat. The levee alignment is shown in **Figure A-6.5**.

In order to accomplish ecosystem restoration north of Highway 32, the existing J levee would be breached to reconnect the river to the floodplain. While this action would enable ecosystem restoration, it would lower the community's existing flood protection. The Federal and State governments would be obligated to mitigate the impact of breaching the private levee that protects Hamilton City. In order to insure that the replacement levee would have the same possibility of passing a flood as the existing J levee can with flood fighting, the replacement levee would be of the same height as the existing J levee.

The existing J levee has about 11,250 square feet (450 feet long by about 25 feet high; greater than 20 inch diameter rock). This rock was placed during flood fighting efforts in 1997 because the levee was eroding at that location. This rock was placed because the existing J levee is of poor quality and subject to erosion. A replacement levee would be constructed to Corps standards, which itself would be an improvement to the existing condition of the J levee.

North of Highway 32 the levee alignment ties into high ground at the northern end of the "J" levee, about 2 miles north of Hamilton City. The levee runs southeast along the Glenn Colusa Canal Road until turning easterly and running roughly parallel to and about 1,300 feet to the west of the Sacramento River, following higher ground.

At the eastern edge of town, the levee alignment crosses Highway 32 and runs south alongside a new housing development. This alignment requires raising Highway 32 (soil embankment) and relocation of a remnant slough channel that provides storm water runoff detention and conveyance. At the south end of town, the levee wraps around the Holly Sugar plant and ties into high ground along Highway 45.

All lands to the waterside of the setback levee north of Dunning Slough would be actively restored with a mixture of riparian, scrub, oak savannah, and grassland habitat. Between Dunning Slough and Road 23, the same lands restored in Alternative 1 would be restored in this alternative. The "J" levee would be breached in a number of locations to allow overbank flooding of the floodplain. The breaches would be large enough and located in such a way as to not induce high velocity flows and excessive erosion.

Flowage easements would need to be purchased on agricultural lands adjacent to the project south of the Holly Sugar Plant and west of the "J" levee to compensate landowners for increased flooding due to the removal of most of the "J" levee.

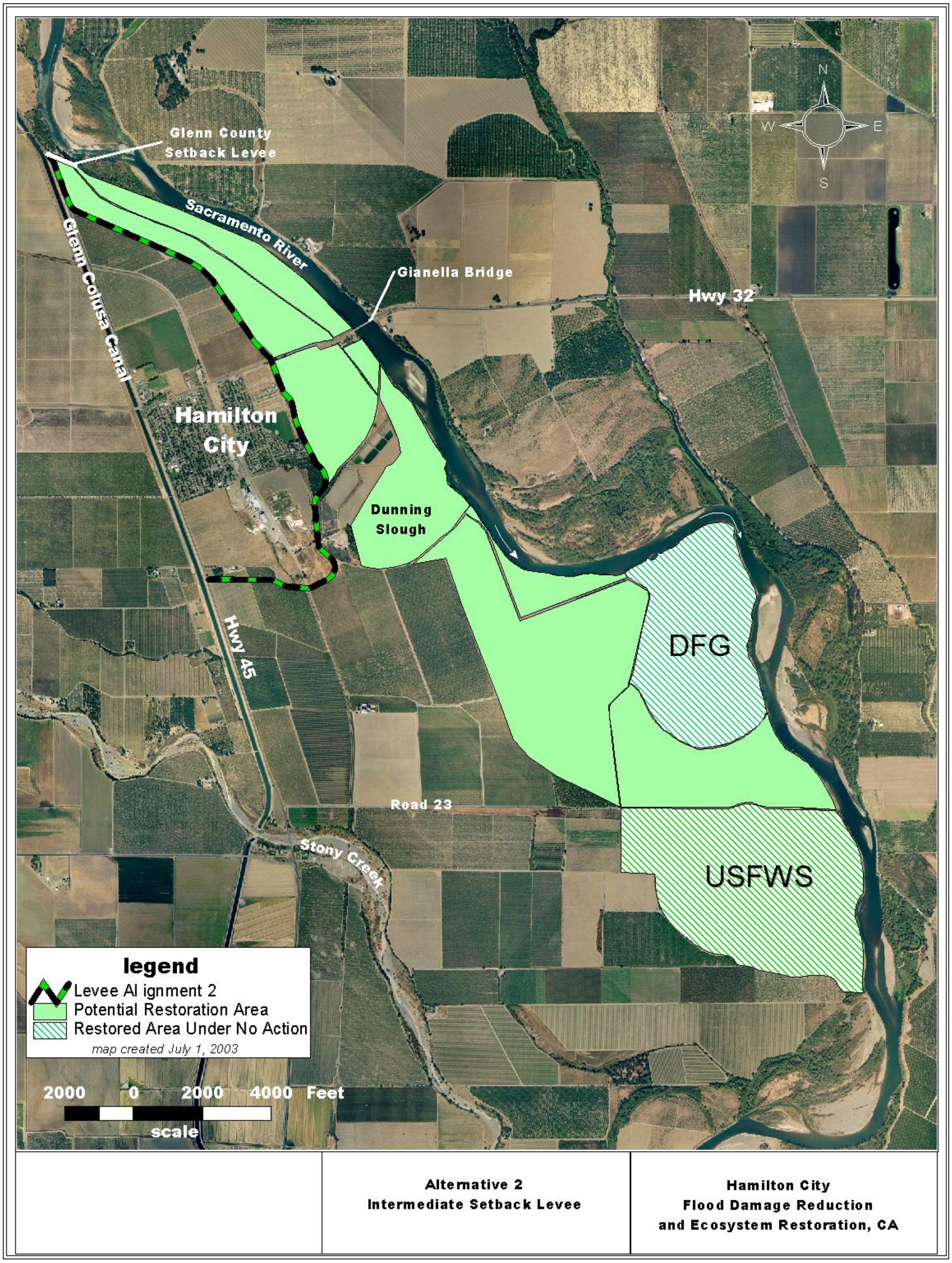

Figure A-6.5: Ecosystem Restoration Alternative #2 - Intermediate Setback Levee

Preliminary Ecosystem Restoration Alternative #3 - Ring Levee

This alternative consists of constructing a setback levee about 3.3 miles long and setback roughly 1,300 to 2,700 feet from the river, breaching the existing "J" levee in several locations, and actively restoring about 1,600 acres of native habitat. The levee alignment is shown in **Figure A-6.6**.

In order to accomplish ecosystem restoration north of Highway 32, the existing J levee would be breached to reconnect the river to the floodplain. While this action would enable ecosystem restoration, it would lower the community's existing flood protection. The Federal and State governments would be obligated to mitigate the impact of breaching the private levee that protects Hamilton City. In order to insure that the replacement levee would have the same possibility of passing a flood as the existing J levee can with flood fighting, the replacement levee would be of the same height as the existing J levee.

The existing J levee has about 11,250 square feet (450 feet long by about 25 feet high; greater than 20 inch diameter rock). This rock was placed during flood fighting efforts in 1997 because the levee was eroding at that location. This rock was placed because the existing J levee is of poor quality and subject to erosion. A replacement levee would be constructed to Corps standards, which itself would be an improvement to the existing condition of the J levee.

North of Highway 32 the levee alignment ties into high ground at the northern end of the "J" levee, about 2 miles north of Hamilton City. The levee runs southeast along the Glenn Colusa Canal Road until turning easterly and running parallel to the Union Pacific Railroad.

At the eastern edge of town, the levee alignment crosses Highway 32 and runs south alongside a new housing development. Similar to Alternative 2, this alignment requires raising Highway 32 (soil embankment) and relocation of a remnant slough channel that provides storm water runoff detention and conveyance. At the south end of town, the levee runs east and ties into high ground along Highway 45.

All lands to the waterside of the setback levee north of Dunning Slough would be actively restored with a mixture of riparian, scrub, oak savannah, and grassland habitat, except for the land nearest the railroad where oak savannah habitat would be restored due to the relative high elevation (and corresponding low frequency of flooding). Between Dunning Slough and Road 23, the same lands restored in Alternative 1 would be restored in this alternative. The "J" levee would be breached in a number of locations to allow overbank flooding of the floodplain. The breaches would be large enough and located in such a way as to not induce high velocity flows and excessive erosion.

Flowage easements would need to be purchased on agricultural lands adjacent to the project south of the Holly Sugar Plant and west of the "J" levee to compensate landowners for increased flooding due to the removal of most of the "J" levee.

Many in the local community dislike this alternative because it is located the closest to Hamilton City of any of the alternatives and it does not protect the wastewater treatment plant and agricultural land south of town. Because this alignment is the shortest of all alternatives, it has the lowest operation and maintenance cost.

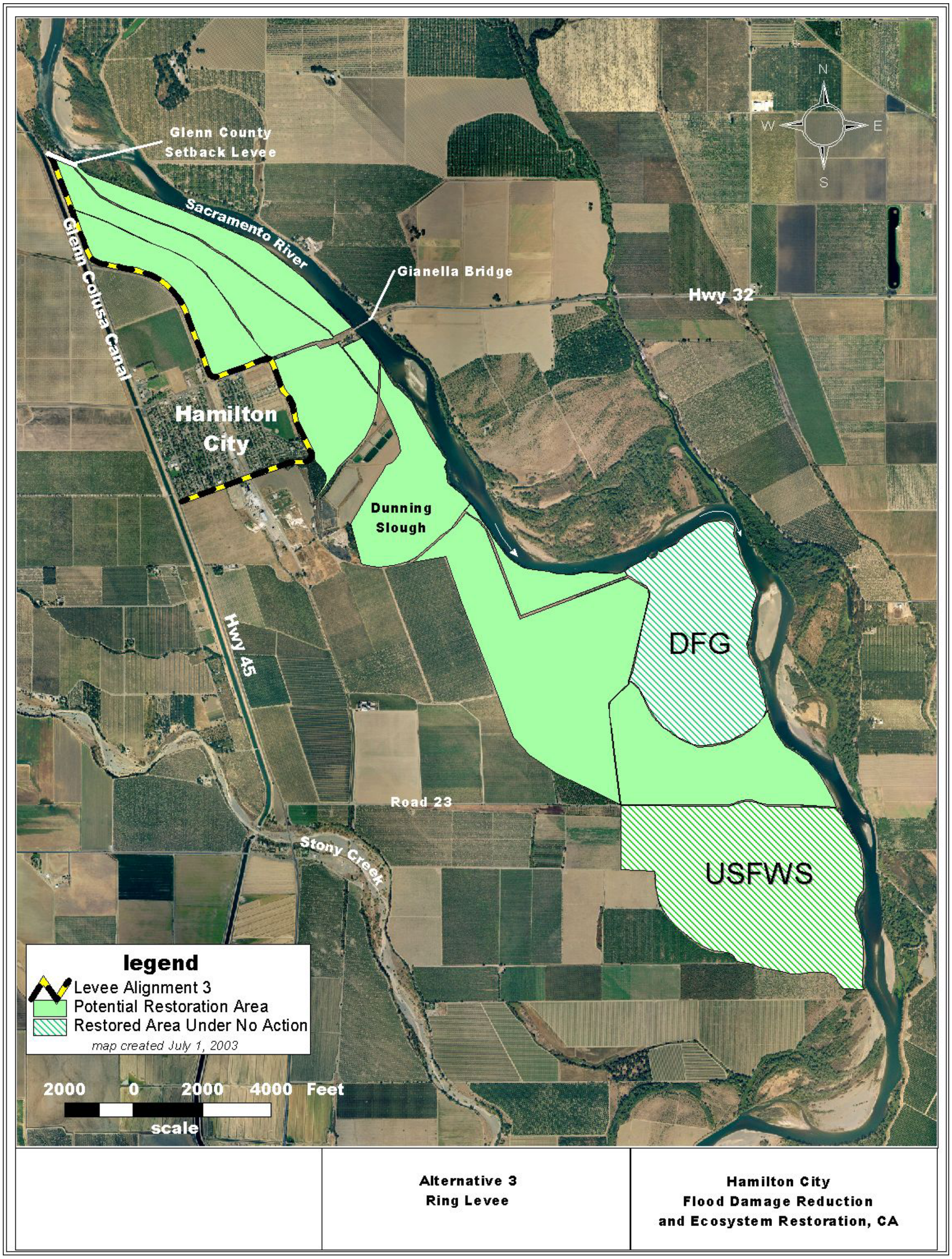

Figure A-6.6: Ecosystem Restoration Alternative #3 – Ring Levee

Ecosystem Alternative 4 - Locally Developed Setback Upstream of Dunning Slough Stopping at Road 23, Intermediate Setback Downstream of Dunning Slough

This alternative consists of constructing a levee about 4.1 miles long, about 6 feet high, set back roughly 500 to 2,700 feet from the river, removing most of the existing "J" levee, and actively restoring about 1,100 acres of native habitat. The levee alignment is shown in Figure 3-3. The levee alignment follows Alternative 1 in the north down to the southern end of Dunning Slough. At that point the alignment then wraps around the Holly Sugar Plant and ties into high ground along Highway 45. It protects the wastewater treatment plant and Holly Sugar plant, but not the agricultural lands south of town. The lands restored in this alternative would be the same as Alternative 1. This alternative is shown in **Figure A-6.7.**

The "J" levee would be removed, except for portions where it would serve to reduce velocities of the Sacramento River for establishment of newly planted habitat. Established riparian vegetation waterside of the existing "J" levee would be avoided wherever possible. Flowage easements would need to be purchased on agricultural lands adjacent to the project south of the Holly Sugar Plant and west of the "J" levee to compensate landowners for increased flooding due to the removal of most of the "J" levee.

Erosion Control. Erosion protection for this alternative would be the same as for Alternative 1, except that in Dunning Slough there would be 500 feet of rock.

Hydraulic Effects. See Alternative 1.

Uncertainty. See Alternative 1.

Accomplishments. This alternative plan would restore 1,100 acres of habitat and provide 642 AAHU's.

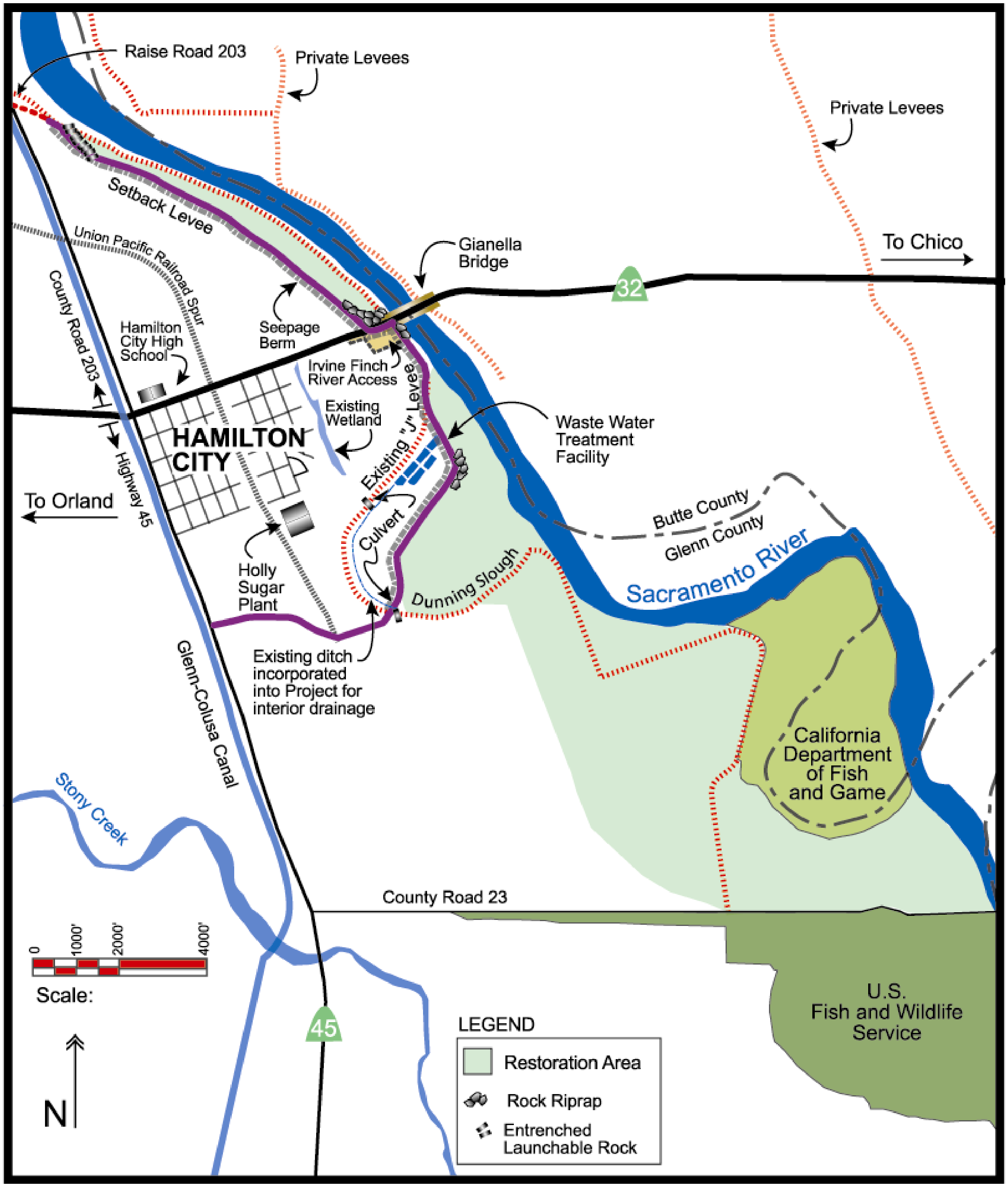

Figure A-6.7: Ecosystem Alternative 4 - Locally Developed Setback Upstream of Dunning Slough, Intermediate Setback Downstream of Dunning Slough

Ecosystem Alternative 5: Intermediate Setback Upstream of Dunning Slough, Locally Developed Setback Downstream of Dunning Slough

This alternative plan consists of actively restoring about 1,600 acres of native vegetation, constructing a setback levee about 5.3 miles long, and about 6 feet high, and removing most of the existing "J" levee. The alternative plan is shown in **Figure A-6.8** and includes restoration of Zones A1, A2, and A4, B2, E, F, G, and H waterside of the setback levee.

The setback levee alignment begins about 2 miles north of Hamilton City, at the point where the northern end of the "J" levee ties into high ground. From there, the levee alignment runs southeast along County Road 203 until turning easterly and running roughly parallel to and about 1,300 feet to the west of the Sacramento River, following higher ground.

At the eastern edge of town, the levee alignment crosses Highway 32 and runs south alongside a new housing development (Palisades subdivision). This alignment requires raising Highway 32 (with soil embankment), protecting the highway and bridge (and possibly the water treatment plant) from erosion caused by floodwaters, and relocating a remnant slough that provides a small but significant emergent wetland habitat and also is used to detain and convey storm water runoff. At the south end of town, the alignment wraps around Dunning Slough and then roughly follows along the western edge of the habitat restoration area before turning east and ending at the southern end of the "J" levee at Road 23. This alignment does not tie into high ground and therefore allows some backwater flooding of agricultural lands, just as does the "J" levee.

Lands waterside of the new levee would be restored to native habitat. Approximately 1,600 acres of native habitat would be restored including; 1050 acres of riparian, 300 acres of scrub, 150 acres of savannah, and 100 acres of grassland. The "J" levee would be removed, except for portions where it would serve to reduce velocities of the Sacramento River for establishment of newly planted habitat. Established riparian vegetation waterside of the existing "J" levee would be avoided wherever possible. The removal of most of the "J" levee would allow periodic overbank flooding, increasing the ecosystem value of riparian and scrub habitat in the floodplain (periodic flooding was assumed not to affect the value of grassland and oak savannah habitat).

Native vegetation would be restored on lands waterside of the new levee. Restoration would also occur on the land directly east of Hamilton City between Highway 32 and Dunning Slough (Zone F) and land within Dunning Slough (Zone A1). Existing orchards in the proposed restoration areas would be removed and native vegetation planted. The native vegetation would predominantly be riparian species, but some scrub, oak savannah and grassland species would also be included, based on hydrologic, topographic, and soil conditions. An exception to this is the land in the middle of Dunning Slough (Zone A1), which is a relatively higher elevation than the rest of the restored area, and oak savannah vegetation is anticipated to be more appropriate for these lands.

Erosion Control. See Alternative 1.

Hydraulic Effects. See Alternative 1.

Accomplishments. This alternative plan would restore 1,600 acres of habitat and provide 937 AAHU's.

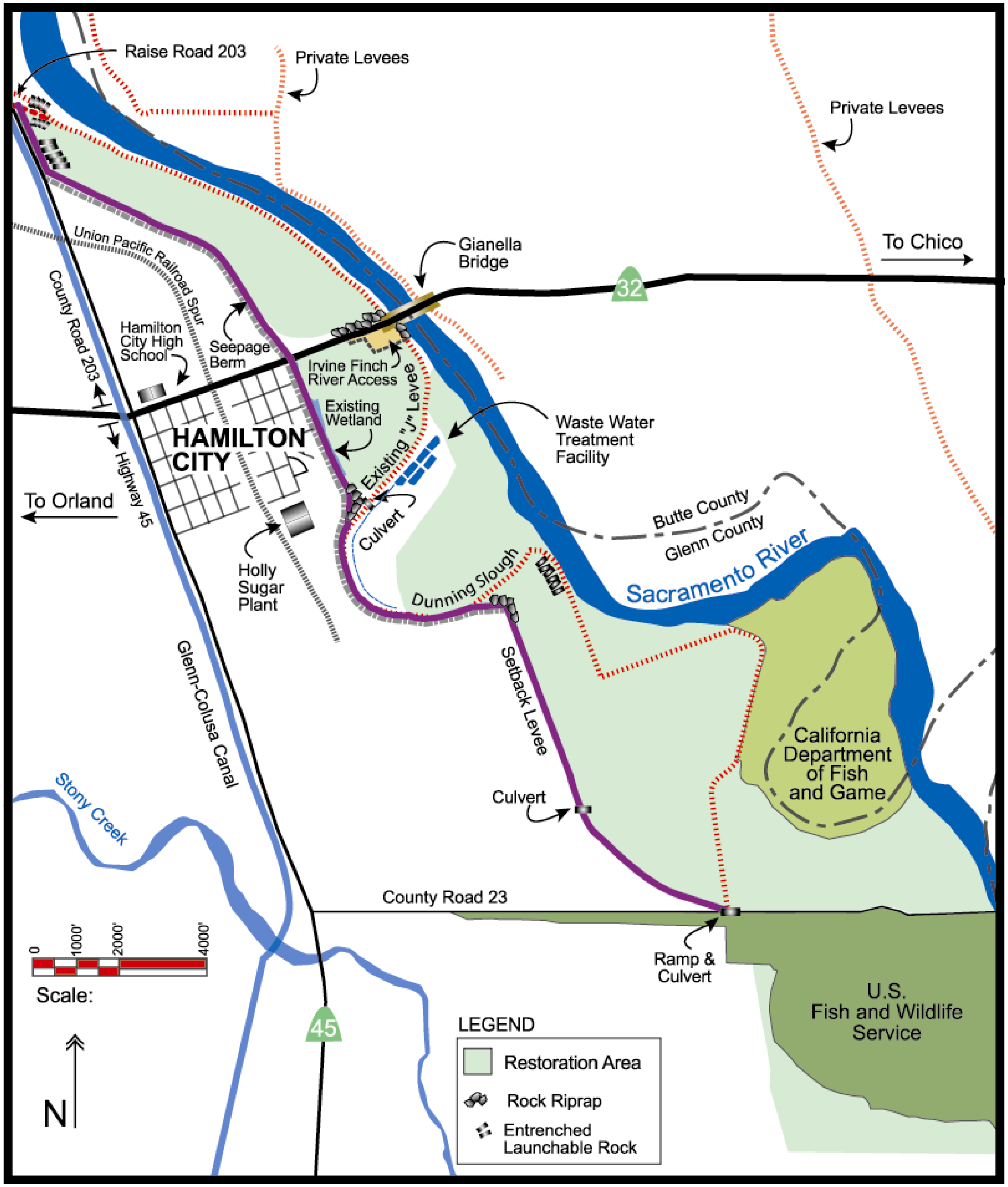

Figure A-6.8: Ecosystem Alternative 5 - Intermediate Setback Upstream of Dunning Slough, Locally Developed Setback Downstream of Dunning Slough

Uncertainty. Please see the description for Alternative 1.

Ecosystem Alternative 6: Intermediate Setback Upstream of Highway 32, Locally Developed Setback Downstream of Highway 32

This alternative plan consists of actively restoring about 1,500 acres of native vegetation, constructing a setback levee about 5.7 miles long, and about 6 feet high, and removal of most of the existing "J" levee. The alternative plan is shown in **Figure A-6.9** and includes Zones A1, A2, A4, B2 E, G, and H waterside of the setback levee.

North of Highway 32, the levee alignment ties into high ground at the northern end of the "J" levee, about 2 miles north of Hamilton City. The levee runs southeast along County Road 203 until turning easterly and running roughly parallel to and about 1,300 feet to the west of the Sacramento River, following higher ground.

At Highway 32, the levee turns east and runs parallel to the highway until tying into the approach to Gianella Bridge. The highway would not need to be raised in this alternative plan, but measures to protect the levee embankment and bridge from floodwaters would be necessary. South of Highway 32, the alignment follows the existing "J" Levee in order to minimize negative effects to the Irvine Finch River Access (just south of the highway). Some minor modifications to the River Access entrance and parking lot during levee construction may be required. The alignment also cuts across a portion of Dunning Slough providing protection to the Hamilton City wastewater treatment plant, some abandoned holding ponds for the old Holly Sugar plant (in which the community would like to expand the treatment plant in the future), and a lime disposal pile.

South of Dunning Slough, the alignment roughly follows along the western edge of the habitat restoration area before turning east and ending at the southern end of the "J" levee at Road 23. This alignment does not tie into high ground and therefore allows some backwater flooding of agricultural lands, just as does the "J" levee.

The restored area under this alternative is the same as the previous alternative, except that the land directly east of Hamilton City between Highway 32 and Dunning Slough (Zone F) would not be restored and the area south of Road 23 (Zone B2) would be restored. Existing orchards in the proposed restoration areas would be removed and native vegetation planted. The native vegetation would predominantly be riparian species, but some scrub, oak savannah and grassland species would also be included, based on hydrologic, topographic, and soil conditions. An exception is the land in the middle of Dunning Slough (Zone A1), which is relatively higher in elevation than the rest of the restored area and oak savannah vegetation is anticipated to be more appropriate for these lands.

The "J" levee would be removed, except for portions where it would serve to reduce velocities of the Sacramento River for establishment of newly planted habitat. Established riparian vegetation waterside of the existing "J" levee would be avoided wherever possible.

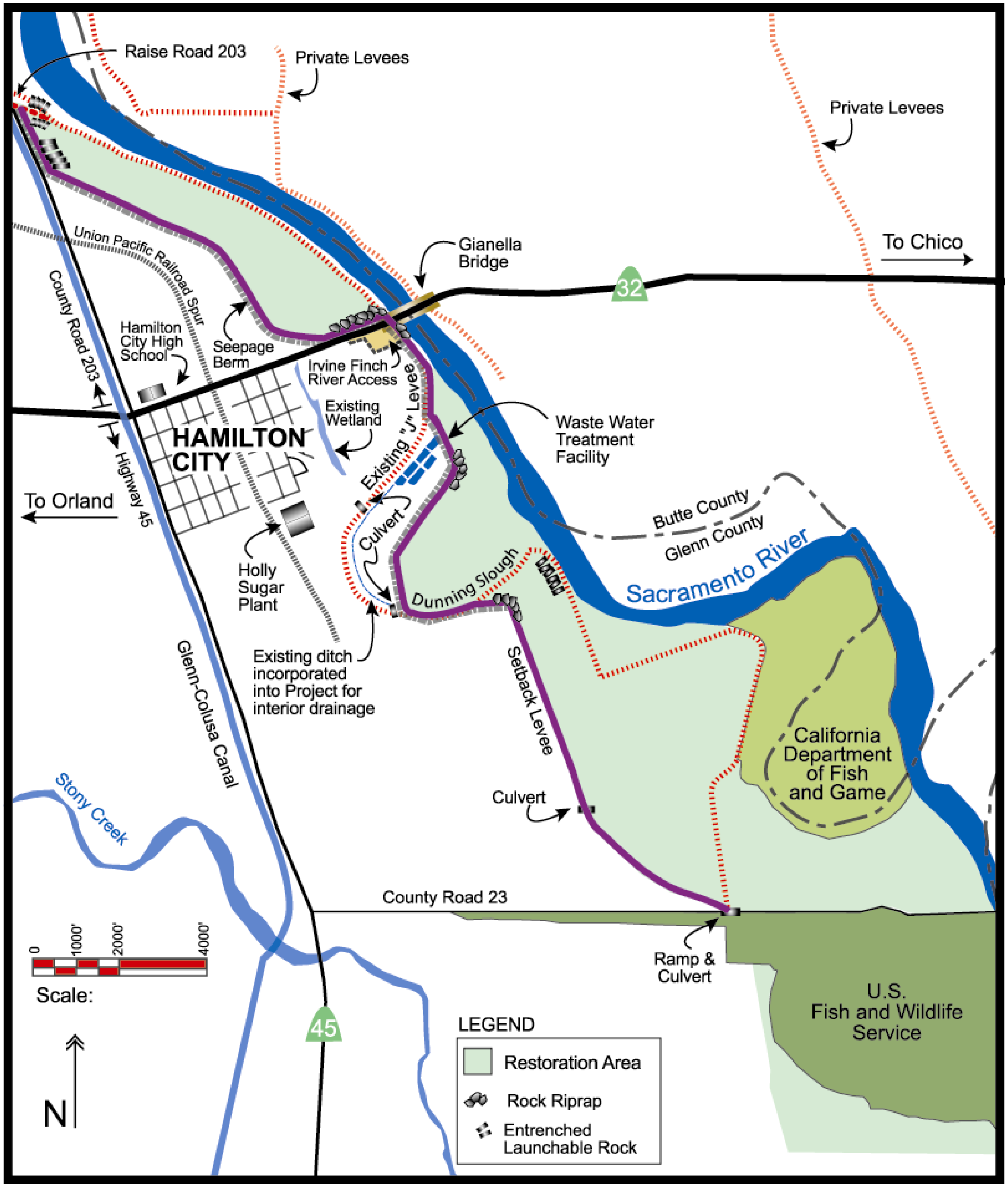

Figure A-6.9: Ecosystem Alternative 6 - Intermediate Setback Upstream of Highway 32, Locally Developed Setback Downstream of Highway 32

Erosion Control. Erosion protection would be the same for this alternative as for Alternative 1.

Hydraulic Effects. See Alternative 1.

Accomplishments. This alternative plan would restore 1,500 acres and provide 888 AAHU's.

Uncertainty. Please see the description for alternative 1.