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HABITAT RESTORATION COST REFERENCES FOR SALMON RECOVERY PLANNING

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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Introduction

The Endangered Species (ESA) requires that recovery plans for listed species include "estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal" (ESA Section 4(f)(1)(B)(iiii)). The purpose of this report is to facilitate recovery planning for ESA-listed salmonid stocks in California by providing information on costs associated with habitat restoration activities relevant to their recovery.

Data from publicly available sources were used to obtain estimates of restoration cost. Ideally these estimates would be identifiable to a specific restoration activity (e.g., fish screen, culvert replacement), include life cycle project costs (e.g., planning, design, permitting, construction, monitoring, maintenance), and be relatable to the scale, scope and location of the project. However, sources vary in terms of the extent to which they provide such details. Most cost estimates originate from sources generally intended for purposes other than recovery planning (e.g., contract administration). Thus reported costs may be incomplete if, for instance, some aspects of restoration are not covered by the contract or if the work involves a match from another funding source. For projects involving multiple restoration activities, costs are more typically broken down by input (e.g., labor, materials) than by activity. Given the diverse factors that affect restoration costs (see Allen *et al.* 2004) and the lack of standardization in available project and cost data, a meta-analysis of project costs as they relate to project characteristics was not possible. However, some of the sources do provide insights into factors affecting costs; to the extent that such information is available, it is briefly summarized in the tables below.

Many of the projects discussed in this report were funded by the California Department of Fish and Game (CDFG) as part of the Fisheries Restoration Grants Program and (to a lesser extent) the Klamath River Restoration Grant Program. The report is thus approximately organized according to the restoration categories used by these two programs. Restoration activities covered by this report are as follows:

- Fish ladders (FL)
- Fish passage at stream crossings (FP) - culvert replacement/improvement
- Fish screening of diversions (SC)
- Instream barrier modification (HB) - modification of fish passage barriers in the stream channel and along the streambank (tidegates, sandbars, dams, other non-culvert barriers)
- Instream habitat restoration (HI) - enhancement of stream channel and streambank habitat (instream structures, spawning gravel supplementation, floodplain tributary reconnection, side channel reconnection, wetland/floodplain restoration, levee evaluation/repair/setback)
- Riparian restoration - restoration of area, including fencing, between the fence and middle of stream (e.g., livestock exclusion, revegetation)

- Streambank stabilization (HS) - stabilization of eroding, collapsing of otherwise de-stabilized banks
- Upland watershed restoration (HU) - largely pertains to upslope erosion control (e.g., road decommissioning/upgrade, landslide/gully stabilization, upslope planting)
- Tailwater management (TM)
- Water conservation (WC) - e.g., ditch lining, piping
- Water purchase/lease (WP)
- Habitat acquisition and conservation easement (HA)
- Monitoring status and trends (MD) - monitoring of baseline conditions and status/trends in habitat, watershed processes and/or populations.
- Monitoring watershed restoration (MO) - monitoring to determine if project treatments were constructed correctly and as planned, effectiveness monitoring to determine if restoration has produced desired habitat conditions and/or watershed processes, and validation monitoring to determine if hypothesized responses of habitat, watershed processes and/or populations to restoration were correct
- Watershed evaluation, assessment and planning (PL) - developing watershed plans with site-specific, prioritized recommendations for restoration of salmon/steelhead habitat. Includes partial assessments (e.g., road erosion surveys, stream surveys).
- Watershed organizational support and assistance (OR) - organizational support to local watershed groups and development/maintenance of databases that facilitate organizational aspects of restoration
- Cooperative fish rearing (RE)
- Water measuring devices (WD) - e.g., head gate
- Wildlife management (WM) - e.g., control of exotic species such as pike minnow
- Research (RES) - general research on productivity (e.g., life cycle monitoring/analysis), spatial structure (fish distribution surveys), genetic diversity (laboratory analysis of tissue samples), and estimation of abundance.

Restoration cost estimates were obtained by searching the published and gray literature, including the following:

- reports that provide actual or estimated costs associated with specific projects (e.g., grant proposals, contract reports),
- reports that provide average costs for multiple projects involving the same restoration activity,
- reports that describe “typical” costs associated with a particular restoration activity,
- cost guidelines associated with environmental improvement programs sponsored by entities such as the Natural Resources Conservation Service (NRCS),
- reports that use regression and other methods to relate project costs to selected project characteristics, and
- environmental impact statements that provide cost estimates for each of the restoration alternatives considered.

Only restoration cost estimates that met at least one of the following criteria are included in this report:

- Top priority for inclusion are cost estimates pertaining to restoration activities in California. However, examples from other states are also included (as available) for those activities where California examples are limited. A notable exception: Cost estimates developed by Evergreen Funding Consultants for restoration in Puget Sound (Evergreen 2003) are particularly instructive, as they cover a wide range of restoration activities, provide life cycle estimates of project costs, and demonstrate how costs vary with project characteristics. Thus all of Evergreen's cost estimates are included in this report - even when they pertain to activities where a fairly large number of California examples are also available.

- Cost estimates are generally more useful for recovery planning when related to the scale of restoration. Thus only cost estimates that are accompanied by a relevant measure of project scale (e.g., stream miles, acres of land) are included in this report.

- For most projects involving multiple types of restoration activities, data sources typically do not provide a cost breakdown by activity. Given the focus of this report on activity-specific costs, most of the cost estimates were by necessity obtained from single-activity projects. However, to ensure some representation of multi-activity projects, some projects involving several closely related activities (e.g., fencing + stockwater system, fish ladder + screen) conducted at the same site are included in this report. Also, cost summaries provided by the Pacific States Marine Fisheries Commission for projects sponsored by CalFED's Ecosystem Restoration Program (Holycross *et al.* 2007) include some estimates of cost per activity for multi-activity projects.

- To help ensure that cost estimates reflect fairly recent restoration technology, the report focuses largely on projects that have occurred since 1998. However, in cases where project data for a particular restoration activity are sparse, pre-1998 project data are also provided, as available.

All costs described in this report pertain to direct expenditures on restoration and do not include economic opportunity costs (e.g., foregone profits associated with restrictions on livestock grazing, timber harvest and other activities). It is important to note the following:

- Even the direct costs described in this report are not necessarily comparable across projects, as some cost estimates are more inclusive than others. Some data sources - e.g., Evergreen Funding Consultants (2003), Neal (2004), Steere (2004) - provide cost estimates that include pre- and post-construction requirements as well as construction itself. In other cases, cost estimates are largely limited to engineering and/or implementation aspects of the project (e.g., CDFG's Fisheries Restoration Grants

Program, NRCS Environmental Quality Improvement Program) and do not include agency involvement in planning, design, management, maintenance and monitoring. In still other cases, documentation is not adequate to determine exactly what is included and excluded from the cost estimates.

- For most projects involving capital construction (e.g., bridges, fish screens), costs are not amortized but rather provided as a lump sum. One notable exception is the Independent Economic Analysis Board's (2002) estimates of amortized capital construction costs for Columbia River hatcheries.

For each restoration activity, one or more tables are provided that include cost estimates for that activity - by location, year, project scale, cost per scale unit, and data source.

- Depending on available information, each project example is variously identified by stream/creek/river, watershed, county, recovery domain,[1] or state.

- Depending on the source of a cost estimate, year may pertain to the year of a funding proposal or contract. In cases where a document includes cost estimates for projects conducted in years prior to publication of the document, the project year is used when available; otherwise the publication year is used.

- The metric used for project scale varies, depending on the nature of the restoration activity. Thus for instance, design approach velocity (cubic feet per second, cfs) is used for fish screens; linear feet for levee work, fencing, bank stabilization; acres for revegetation, wetland restoration, land purchase/easement; and miles for road decommissioning/upgrade.

- As indicated above, this report focuses largely on 1998-2006 projects. Cost estimates for these projects are provided in current dollars (uncorrected for inflation). In situations where paucity of 1998-2006 data warranted inclusion of pre-1998 projects, costs of pre-1998 projects were corrected to 2006 dollars. In some cases, the data sources themselves provide inflation-corrected cost estimates. The base year for these estimates is documented in this report, along with the year(s) when the restoration actually occurred (e.g., Hildner/Thomson's (2007a) results are denoted "98-05" and "2003$" to reflect the fact that their cost estimates are based on 1998-2005 project data and have been corrected to 2003 dollars).

[1] The recovery domains include: Southern Oregon/Northern California Coast (SONC), North/Central California Coast (NOCECA), Central Valley, and South Central California Coast (SCACO). There is an area of geographic overlap between the SONC and NOCECA, which is referenced in this report as NOCECA-SONC.

- The nature of the cost estimates vary somewhat, depending on the data source: (i) In cases where cost is reported for a specific project, total project cost, project scale, and average cost per scale unit are provided, as available. (ii) In cases where cost is reported as an average value across multiple projects, the sample size and range of project costs (as available) are reported along with average cost. (iii) In cases where a "typical" cost is reported, the "typical" cost and the range of "typical" costs (as available) are provided. (iv) In cases where cost is estimated from a regression equation, the equation itself is provided as well as a range of fitted values associated with the regression parameters.

- In cases where management/administrative costs are reported for a multi-activity project and the cost estimate in the table pertains to one activity, management/administrative costs (which are not solely attributable to that one activity) are provided separately and not included in the calculation of cost per scale unit.

- Data sources are identified in the tables by last name or initials of author(s) and table and/or page numbers as appropriate. In cases where the data sources were grant proposals submitted to CDFG's Fisheries Restoration Grants Program (FRGP) or Klamath River Restoration Grant Program (KRRGP), those sources are identified in the tables by the fiscal year in which the proposal was submitted (01-02 through 06-07) and the project ID number (CDFG-xxx for the FRGP, Kxxx for the KRRGP). In cases where the data sources are projects sponsored by CALFED's Ecosystem Restoration Program (ERP), the projects are identified by the year of the proposal and the project ID (ERP-xx-xxx). In cases where costs associated with an ERP project could be broken down by activity, that project ID appears multiple times in the tables. All data sources are fully documented in the "References" section at the end of this report.

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FL - FISH LADDER.

Table FL-1 provides estimates of fish ladder costs. CDFG's Coho Recovery Strategy (CDFG'04, p1.14) assumed $500K/ladder on tributaries and $900K/ladder on streams. This cost range pertains to central/northern CA coastal streams and is not necessarily applicable to projects outside that geographic range. However, most of the projects in Table FL-1 do fall within that range. Notable exceptions (exceeding $2M/ladder) include a project in the South Central California Coast (SCACO) recovery domain (HT07a-T61, p121) and several Central Valley projects (HT07a-T61, p121, ERP-99-B03) . Note: Some of the projects pertain to ladders only, others to ladder/screen combinations.

Table FL-1. Fish Ladder ($/project)				
Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	Small waterway (tributary): $500K/ladder Large waterway (stream): $900K/ladder	CDFG'04, p1.14
Young'sDam	03-04	1ladder	$494K - sloping plate, selfclean, excluding design	CDFG-057
SONC CentralVly SCACO	98-05 2003$	1site 1site 1site	$530.1K $2.1M $2.1M	HT07a-T61, p121
Gorrill Dam/Butte Creek	1997	2ladder	$660K ($330/ladder) +$12.8K project mgmt + $58.8K construction mgmt - construct ladder and screen	ERP-97-M03
Adams Dam/Butte Creek	1997	1ladder	$298.7K (+$6.3K project mgmt + $3K project coordination) - construct ladder and screen	ERP-97-M04
Battle/Soap/ Ripley Creeks	1999	3projs	$2.7M ($902.7K/project) - decommission several PG&E dams, provide ladders/ screens for remaining dams	ERP-99-B01
Sacramento River	1999	2 projs	$4.56M ($2.28M/project) + $130K project mgmt - Anderson-Cottonwood Irrig Dist	ERP-99-B03
Battle Creek	1999	1 proj	$731K +$105.3K project mgmt - improve CNFH fish ladder & barrier weir	ERP-99-B08

FP - FISH PASSAGE AT STREAM CROSSINGS.

Tables FP-1 and FP-2 pertain to culvert replacement, Table FP-3 to culvert replacement with a bridge, and Table FP-4 to culvert improvement.

Table FP-1 describes Evergreen's estimates of culvert replacement costs, while Table FP-2 provides similar estimates from other data sources. Evergreen's estimates include not only construction but also design, permitting, monitoring, maintenance and management, and are much more inclusive than the estimates in Table FP-2. Most of the latter examples are derived from grant proposals submitted to CDFG's Fisheries Restoration Grants Program - with costs largely limited to engineering/construction aspects of the project. The Table FP-2 estimates generally fall within the range of $100K-$400K/culvert, although there are some projects that cost in the $10,000s (e.g., Dupont-T10, p66; HT07a-T60, p118; HT07a-T61, p121) and one very costly project ($4.1M, CntySBPublicWrks) in Santa Barbara. Culvert type is reported here when available from the data source.

Evergreen's estimates show typical culvert replacement costs for Puget Sound by road type and size of waterway.Like Evergreen, Hildner/Thomson show cost per culvert being lower for rural roads than major highways (HT07b-T42, p61) and increasing with stream order (HT07b-T44, p62). Excluding 4+ lane highways (which are not covered by Hildner/Thomson), the estimates obtained by HT from restoration contractors fall within Evergreen's cost ranges. E.g., forest roads - Evergreen: $15K-$150K, HT: $23.4K; minor 2 lane road - Evergreen: $50K-$280K, HT: $227K; major 2 lane road - Evergreen: $100K-$450K, HT: $420K. Small waterway - Evergreen: $15K-$200K, HT: $70K; medium waterway - Evergreen: $50K-$350K, HT: $175K; large waterway - Evergreen: $80K-$450K, HT: $286K.

Table FP-1. Culvert Replacement - $/project (Source: Evergreen 2003, p. 21)
Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management

Size of Waterway	Road Type			
	Forest Road	Minor 2 Lane	Major 2 Lane	Hwy 4+ Lane
Small 0-10'	$15K-40K	$50K-100K	$100K-200K	$200K-350K
Med 10-20'	$50K-100K	$140K-240K	$200K-350K	$300K-450K
Large 20-30'	$80K-150K	$180K-280K	$250K-450K	$600K-800K

Table FP-2. Culvert Replacement - $/project				
Location	Year	Units	Cost Per Unit	Source
AlbionR/Marsh Crk-MendcnoCnty	01-02	3culvrt	$180.5K ($60.2K/culvert)	CDFG-007
PeacockCrk-DelNorteCnty		1culvrt	$295.0K - open bottom	CDFG-009
JohnsonCrk-MendcnoCnty		1culvrt	$100.9K - bottomless pipe arch	CDFG-009
DeerCrk-MendcnoCnty		1culvrt	$97.5K - bottomless pipe arch	CDFG-010
JordanCrk-DelNorteCnty		1culvrt	$246.3K - box culvert	CDFG-059
RyanCrk-MendcnoCnty		1culvrt	$151.5K - bottomless pipe arch	CDFG-068
PorterCrk-RussianR	02-03	2 culvrt	$266,250 ($133.1K/culvert)	CDFG-028
StansberryCrk-MattoleR		1culvrt	$197.5K	CDFG-265
GibsonCrk-MattoleR		1culvrt	$213.1K	CDFG-266
StanleyCrk-MattoleR		1culvrt	$239.4K	CDFG-267
SaundersCrk-MattoleR		1culvrt	$269.5K	CDFG-268
IndianCrk-MattoleR		1culvrt	$55.0K	CDFG-270
DarkGulch-MndocnoCnty		1culvrt	$202.1K	CDFG-305

AlbionR/Marsh Crk-MendcnoCnty	03-04	2culvrt	$299,592 ($149.8K/culvert) - natural bottom pipe arch	CDFG-098
RyanCrk-MendocnoCnty		1culvrt	$278.8K - natural bottom pipe arch	CDFG-099
JohnsonCrk-BigR-MendocnoCnty		1culvrt	$128.1K - natural bottom pipe arch	CDFG-104
YonkersCrk-DelNorteCnty		1culvrt	$242.6K - bottomless arch	CDFG-149
GrahamGulch-HumboldtCnty		1culvrt	$245.8K - bottomless multiplate arch	CDFG-165
PainterCrk-MattoleR-HumboldtCnty		1culvrt	$246.2K - bottomless multiplate arch	CDFG-166
SoldierCrk-TrinityR-TrinityCnty		2culvrt	$305.3K ($152.7K/culvert)	CDFG-236
BatesCanyonCrk-MarinCnty	04-05	1culvrt	$208.4K	CDFG-026
WarrenCrk-MadR-HumboldtCnty		1culvrt	$326.3K - bottomless multiplate arch	CDFG-233
WardenCrk-EelR-HumboldtCnty	05-06	1culvrt	$44.5K - bottomless arch	CDFG-062
RockyGulch-HumboldtCnty		2culvrt	$381.6K ($190.8K/culvert) - embedded structural plate metal box culvert	CDFG-137
CA	98-05 2003 $	3culvrt	$13.3K ($1.9K-$24.2K)	HT07a-T60, p118
SONC SONC-NOCECA SCACO	98-05 2003 $	1culvrt 1culvrt 1culvrt	$1.9K $13.9K $24.2K	HT07a-T61, p121
	02-04		<u>Road Type:</u>	HT07b-T42, p61,contrctr
CA		27clvrt	ForestRoad: $23.4K ($379-$217.9K)	
CA		13clvrt	Minor2Lane: $227.1K ($5.1K-$412.8K)	
CA		1culvrt	Major2Lane: $420.4K	
	02-04		<u>Stream Order:</u>	HT07b-T44, p62,contrctr
CA		30clvrt	1st order: $70.4K ($970-$420.4K)	
CA		8clvrt	2nd order: $175.4K ($851-$412.8K	
CA		1culvrt	3rd order+: $285.5K	

CA CA	02-04	7culvrt 11clvrt	Culvert Type: Open-btm arch:$262.8K ($124K-$401K) Pipe: $7.4K ($970-$17.2K)	HT07b-T49, p71,contrctr
Sta Ynez	07-12	2culvrt	$8.11M ($4.1M/culvert, reinforced concrete box culvert)	CntySB PublicWrks
Idaho		1culvrt	$15K-$25K - bottomless arch, 30-60 yrs $8K-$20K - buried culvert, 20-50 yrs $500-$5K - ford	Dupont-T10, p66

Costs of culvert replacement with bridge described in Table FP-3 generally range from $100K to $500K/bridge. A few projects cost <$50K (e.g., 02-03 CDFG-065; 03-04 CDFG-201 & CDFG-311; 05-06 CDFG-077; Dupont-T9, p65). Projects that cost >$650K all occurred in southern or south-central California (04-05 CDFG-031 & CDFG-241; 06-07 CDFG-090). Information on bridge type - which is reported here when available from the data source - suggests that prefabricated bridges fall toward the lower end of the cost spectrum. Dupont provides information on expected lifetime of various types of bridges, although his information pertains to Idaho rather than California.

Table FP-3. Culvert Replacement with Bridge ($/project)

Location	Year	Units	Cost Per Unit	Source
JohnSmithCrk-MendcnoCnty	01-02	1bridge	$189.5K - flat car bridge	CDFG-043
HayworthCrk-MendocnoCnty		2bridge	$89,711 ($44.9K/bridge)	CDFG-060
ApanolioCyn-SanMateoCnty	02-03	1bridge	$250K - 3sided bridge	CDFG-015
OldCreekRd-VenturaR			$111.5K	CDFG-038
SoFork CottanevaCrk-MendcnoCnty			$22.6K	CDFG-065
TrinityR			$500K	CDFG-119
KellyGulch-SiskiyouCnty			$163.2K	CDFG-284

FrenchmansCrk-SanMateoCnty	03-04	1bridge	$130.2K - clear span bridge	CDFG-028
FrykmanGulch-BigR-MendcnoCnty			$77.6K	CDFG-052
IndianCrk-HumboldtCnty			$437.3K	CDFG-168
LindsayCrk-MadR			$26.0K - manufactured	CDFG-201
QuarryBridge-GualalaR			$46.0K - 45' modular	CDFG-311
ArroyoSecoR-MontereyCnty	04-05	1bridge	$1.5M	CDFG-031
CampCrk-NavarroR-MendcnoCnty			$234.6K - includes rock weirs	CDFG-041
O'NeilCrk-KlamathR-SiskiyouCnty			$100K - concrete, single span	CDFG-064
SolsticeCrk-LA			$653.3K - precast open bottom	CDFG-241
LindsayCrk-MadR-HumboldtCnty	05-06	1bridge	$54K	CDFG-077
CedarCrk-SmithR-DelNorteCnty			$347.9K	CDFG-269
StaRosaCrk-SanLuisObispo	06-07	1bridge	$746.3K	CDFG-090
SoquelCrk-StaCruzCnty			$409.6K	CDFG-195
HorseCrk-Klamath	06-07	1bridge	$230.5K	K002
Idaho	2000	typical	<u>Bridge Type:</u> Wood stringer, 25-50yr lifetime: $10-$20K Prefab concrete, 40-60yr lifetime: $15K-$25K Railroad, 40-60yr lifetime: $15K-$30K Steel/concrete, 50-75yr lifetime: $30K-$50K	Dupont-T9, p65
SONC	98-05 2003$	1site	$109.6K	HT07a-T61, p121

CA	02-04	6sites	$217.9K ($23K-$420.4K)	HT07b-T49, p71,contrctr
CA	98-05 2003$	2sites	$261.3K ($22.7K-$500K)	HT07b-T41, p59,CHRPD
CA	FY07	typical	Bridge Size: >40ft: $100K <40 ft, flatbed railroad: $50K	NRCS

Most of the culvert improvement costs described in Table FP-4 range from about $5K to $65K. The two notable exceptions are $463.1K (03-04 CDFG-320) and $485K (05-06 CDFG-162) - both of which seemed to also involve substantial habitat work around the culvert. The NRCS examples pertain to culvert removal rather than improvement, but are included here in case such actions are considered for farmland in recovery planning.

Table FP-4. Existing Culvert Improvement - $/project

Location	Year	Units	Cost Per Unit	Source
JollyGiantCrk -Arcata	01-02	1culvrt	$10.2K	CDFG-124
SoForkBigR-MendcnoCnty	02-03	1culvrt	$23.3K	CDFG-286
ElCapitanCrk -StaBarbCnty	03-04	1culvrt	$463.1K - baffles, replace culvert floor, construct pools	CDFG-320
BrownsCrk-PajaroR-StaCruzCnty	04-05	1culvrt	$65.5K - replace floor, add weirs	CDFG-068
ChaddCrk-EelR-HmboldtCnty	05-06	1culvrt	$485K - 9.5 ft dia steel plate culvert, retrofit w/baffles & jump pools	CDFG-162
Idaho	2000	1culvrt	Culvert Type: Angle iron fish ladder: $1,185 Chimney block fish ladder - $375 Baffles - $2,530 Downstream drop structure - $1,180	 Dupont-T1, p59 Dupont-T2, p60 Dupont-T3, p60 Dupont-T4, p61
NOCECA	98-05 2003$	1site	$4.7K/baffle	HT07a-T61,p121

CA	02-04	1culvrt	Culvert Type: Boulder weir: $13.3K Baffles: $17.9K Other: $575	HT07b-T50, p74,contrctr
CA	98-05 2003$	2culvrt	$9.4K ($4.7K/culvert) - baffle	HT07b-T51, p74,CHRPD
Sonoma Crk	2000	1culvrt	$21.6K	ERP-00-E04

SC - FISH SCREENING OF DIVERSIONS

Table SC-1 provides cost estimates for fish screens relative to the design approach velocity of the screen (cubic feet per second, cfs). Cost of screens produced by the CDFG screen shop range from $2K to $10K/cfs (BM, p. J-3). Most of the other cost estimates in the table fall within this range. Some notable exceptions include projects on the Klamath River (e.g., 05-06 CDFG-200) and in the Central Valley (e.g., ERP-00-B02, ERP-95-M05, ERP-96-07, ERP-97-C01, ERP-97-M07).

Table SC-1. Fish Screen - $/cfs, $/screen

Location	Year	Units	Cost Per Unit	Source
CA	2005	typical	$2K-$10K/cfs (CDFG screen shop)	BM, pJ-3
KlamathR KlamathR KlamathR	05-06	15.3cfs 3.51cfs 1.2cfs	$99,173/screen ($6.5K/cfs) - self clean $39,758/screen ($11.3K/cfs) $29,961/screen ($25K/cfs) - design/install preexisting tube screen	CDFG-049 CDFG-173 CDFG-200
CA	2004	typical	Type of Waterway: Small tributary: $10K/screen Large stream: $40K/screen	CDFG'04, p1.15
CalFED	2000	 4scrns 1scrn	Flow Range: 350-800cfs: $8.5K-$15K/cfs 15-20cfs: $100K ($3.3K-$5K/cfs)	 Hayes-Fig2,p174 Hayes-p183

WA	2000	Sample of 1-15cfs screens	***Figure 2: C=6060.4 cfs ^1.2405*** 2cfs: $14,320/screen ($7.2K/cfs) 4cfs: $33,834/screen ($8.5K/cfs) 6cfs: $55,950/screen ($9.3K/cfs) 8cfs: $79,944/screen ($10K/cfs) 10cfs: $105,439/screen ($10.5K/cfs) 12cfs: $132,198/screen ($11K/cfs) 14cfs: $160,056/screen ($11.4K/cfs)	Hudson-p192
		Sample of 1-58cfs screens	***Figure 3: C=8221.2 cfs ^ 1.0108*** 10cfs: $84,282/screen ($8.4K/cfs) 20cfs: $169,831/screen ($8.5K/cfs) 30cfs: $255,864/screen ($9K/cfs) 40cfs: $342,214/screen ($8.6K/cfs) 50cfs: $428,799/screen ($8.6K/cfs) 60cfs: $515,573/screen ($8.6K/cfs)	Hudson-p192
		Sample of 1-210cfs screens	***Figure 4: C=11083 cfs ^ 0.9025*** 50cfs: $344,279/screen ($6.9K/cfs) 100cfs: $643,561/screen ($6.4K/cfs) 150cfs: $927,923/screen ($6.2K/cfs) 200cfs: $1,203.010/screen ($6K/cfs)	Hudson-p193
OR	2000	12scrns 4scrns 3scrns 3scrns 2scrns 10scrns 10scrns	<u>Screen Type, Flow Range*:</u> Rotary drum, 0.4-25 cfs: $1.3K-$11.3K/cfs Rotary drum prefab, 0.8-2cfs: $3.9K-$9.4K/cfs Belt, 10cfs: $2.3K-$3.2K/cfs Panel, 12-30cfs: $2.8-$3.1K/cfs Pump, low veloc, 0.5-1.8cfs: $0.8K-$1.9K/cfs Pump, Clemons, 0.6-4.2cfs: $0.5K-$2.2K/cfs Pump, SureFlo, 0.5-6cfs: $0.5K-$2.5K/cfs	Kepshire-T1, p207
* Engineering costs incurred only for screens >25 cfs.				
CA farmland	FY07	typical	<u>Flow Range*:</u> <1cfs: $2K/screen ($2K/.5cfs=$4K/cfs) 1-5cfs: $6K/screen ($6K/2.5cfs=$2.4K/cfs) 5.1-10cfs: $14K/scrn ($14K/7.5cfs=$1.9K/cfs) >10cfs: $20K/screen (<$2K/cfs) * $/cfs estimated using midpoint of cfs range	NRCS CA

WA	1999$	16scrns 19scrns 5scrns 7scrns 5scrns	Flow Range: 1-10cfs: $3.6K-$17.8K/cfs 10-50cfs: $4.5K-$16.6K/cfs 50-100cfs: $4.5K-$9.8K/cfs 100-1000cfs: $2.4K-$7.0K/cfs >1000cfs: $2.0K-$7.0K/cfs	WDFW
Sacrmnto River	2000	1 scrn	$435.4K (44.6 cfs screen, $10K/cfs) - Pump Station #1	ERP-00-B01
Sacrmnto River	2000	1 scrn	$303K +5K project mgmt + $2.5K project coordination + $59.6K engineering design (20 cfs screen, $15K/cfs) Tuttle Pump Relocation Project	ERP-00-B02
Amer/Sacramento R	2001	2 projcts	$40.4M + $750K project mgmt + $3.1M construction mgmt ($20.2M/screen) - replace intake SacR Water Treatment Plant, replace screen EA Fairbairn Water Treatment Plant.	ERP-01-N51
Sacrmnto River	2001	10scrns 8-39cfs	$1.1M + $521.7K program admin/mgmt/ coordination ($111.7K/screen)	ERP-01-N52
Sacrmnto River	1995	1 projct 150 cfs	$3.2M + $100K project mgmt + $173K construction mgmt ($21.3K/cfs) - decommission old diversion at M&T Ranches' Parrot-Phelan Pumping Station, relocate/construct/screen new diversion	ERP-95-M05
Suisun Marsh	1995	5 screens	$765.3K ($153.1K/screen) Phase 1 - diversion evaluation & selection	ERP-95-M07
Sacrmnto River	1996	1 projct 600 cfs	$9.4M + $698.3K project coordination ($15.7K/cfs) - consolidate 3 diversions into 1 new diversion, Princeton-Codora-Glenn Irrig Dist & Provident Irrig District	ERP-96-07
Yuba River	1996	1 projct 65 cfs	$202K ($3.1K/cfs) - Browns Valley Irrig District	ERP-96-M17
Sacrmnto River	1997	1 projct 700 cfs	$10.4M ($14.0K/cfs) - Reclamation District 108's diversion structure at Wilkins Slough	ERP-97-C01
Butte Creek	1997	1 projct 162 cfs	$660.3K + $12.8K project mgmt + $58.8K construction mgmt ($4.1K/cfs) - Gorrill Dam	ERP-97-M03

Butte Creek	1997	1 projct 135 cfs	$515.9K + $6.3K project mgmt + $3K project coordination ($3.8K/cfs) - Adams Dam	ERP-97-M04
San Joaquin R	1997	1 projct 250 cfs	$7.6M + $62K project mgmt + $411K construction mgmt + $154K post-construction services ($30.4K/cfs) - vertical V fish screen, Banta-Carbona Irrig District	ERP-97-M07
Sacrmnto River	1998	1 projct 22 cfs	$270.5K ($12.3K/cfs) - Boeger Family Farm Fish Screen Phase II: Construction	ERP-98-B26
Lindsay Slough/ Cache Slough	1998	1 projct 53 cfs	$416K ($7.8K/cfs) - Hastings Tract Fish Screen Phase II: Construction	ERP-98-B27
Battle/ Soap/ Ripley Creeks	1999	1 projct	$1.06M (3 screens - 55 cfs, 70 cfs, 220 cfs; $3.1K/cfs) - decommission several PG&E diversion dams, provide ladders/screens for those that remain	ERP-99-B01
Sacrmnto River	1999	1 projct 450 cfs	$4.56M + $130K project mgmt ($10.1K/cfs) - ACID Fish Screen Phase III: Construction	ERP-99-B03
Sacrmnto River	1999	1 projct 960 cfs	$6.222M ($6.5K/cfs) - Tisdale Positive Barrier Phase IV: Construction/Performance Eval	ERP-02D-P70

HB - INSTREAM BARRIER MODIFICATION FOR FISH PASSAGE

This section covers modification of non-culvert fish passage barriers in the stream channel and along the stream bank. Table HB-1 focuses on tide gates, Table HB-2 on sandbars, Table HB-3 on dam,, and Table HB-4 on other barriers.

Based on a limited number of examples, the replacement cost of a tide gate is ~$105K; retrofit cost is $26K.

Table HB-1. Tide Gates - $/unit				
Location	Year	Units	Cost Per Unit	Source
HumboldtBay	03-04	3 tidegates	$317,148 ($105.7K/tidegate) - replace 2 tidegates & add 3rd	CDFG-143
HumboldtBay	2005	1 tidegate	Retrofit: $26K	MA, p2

Based on a single example, cost of sandbar breaching is $13K/breaching.

Table HB-2. Sandbar Breaching - $/unit				
Location	Year	Units	Cost Per Unit	Source
Estero de San Antonio (MarinCnty)	1993	1breaching	$10K/breaching *(2006$: $13.1K)* - incl equip rental	WC, p19

Based on a single example, cost of dam decommission is $1.5M.

Table HB-3. Dam Decommission/Removal - $/unit				
Location	Year	Units	Cost Per Unit	Source
BattleCrk/SoapCrk/ RipleyCrk	1999	5 dams	$7.53M ($1.5M/decommission)	ERP-99-B01

Barrier modification projects identified in Table HB-4 typically involve weirs, head gates, fish screens and/or measuring structures. Most of the modifications cost $30K-$170K, with the exception of two $1M+ barrier removal/fish screen projects on the Shasta River (06-07 K010 & K011). A single estimate of weir repair cost is provided: $10.8K/weir (06-07 K034).

Table HB-4. Other Non-Culvert Barrier Modification - $/unit				
Location	Year	Units	Cost Per Unit	Source
EastForkScott/French Crk/ShacklefordCrk// ScottR-KlamathRiver	06-07	13 barriers	$962.9K ($74.1K/barrier) - remove seasonal barriers/install head gate to measure diversion volume	K025
ShastaR-Klamath	06-07	1 barrier	$1356.5K - remove barrier/install fish screen	K010
ShastaR-Klamath	06-07	1 barrier	$981.9K - remove barrier/install fish screen	K011
ColdCrk-KlamathR	06-07	1 barrier	$65.1K - replace diversion w/fish passable weir, update screen	K014
ShastaR-Klamath	06-07	4 barriers	$120.9K ($30.2K/barrier) - replace 2 barriers w/boulder weirs; install head gate/fish screen/measuring weir on 2 unscreened diversions	K023
Scott-KlamathR	06-07	1 barrier	$170K - replace barrier with boulder weirs/head gate/ measuring structure	K032
FrenchCrk/MinersCrk/ PattersonCrk/ ShackefordCrk-KlamathR	06-07	6 weirs	$65K (10.8K/weir) - repair storm-damaged secondary weirs in 6 locations	K034
Guadalupe River (So SanFran Bay)	1998	2 passage structures	$147.9K ($74K/structure)	ERP-98-B23
Carriger Creek (Sonoma Creek)	2001	1 barrier	$67.6K - boulder weir ladder	ERP-01-N27

HI - INSTREAM HABITAT RESTORATION

This section covers restoration of instream habitat. Tables HI-1 & HI-2 pertain to instream structures such as wood/boulder structures and large woody debris, Table HI-3 to spawning gravel supplementation, Table HI-4 to floodplain tributary reconnection, Tables HI-5 and HI-6 to channel restoration, and Table HI-7 to wetland/floodplain restoration.

Evergreen (Table HI-1) estimates restoration costs for small/medium streams with small/medium transportation & material requirements on a per-mile basis, and estimates costs for large streams with medium/high transportation & material requirements on a per-structure basis. The examples in Table HI-2 also represent a mixture of per-mile and per-structure estimates; however, the units of measure in Table HI-2 were not based on any systematic criterion (as per Evergreen) but rather reflect whatever units were available from each data source. Cost-per-mile tends to be lower using Evergreen's estimates ($10K-$50K/mile) than the Table HI-2 estimates, which ranged from ~$25K to $500K/mile (with the exception of a $1.4M/mile project (01-02 CDFG-156) where cost per mile was derived by expanding the cost of that 40' project to an entire mile). Conversely cost-per-structure tends to be higher using Evergreen's estimates ($10K-$80K/structure) than the Table HI-2 estimates (~$500-$11K/structure). These results are not surprising, given that Evergreen systematically applied cost-per-mile to lower-cost projects and cost-per-structure to higher-cost projects.

Table HI-1. Engineered Logjams and Large Woody Debris - $/structure, $/stream mile (Source: Evergreen 2003, p. 25)

Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management costs. All estimates assume purchased materials.

Stream Size (cfs)	Transportation & Material Requirements		
	Low Cost	Medium Cost	High Cost
Small 1-100 cfs	$10K-30K*	$20K-50K*	$20K-40K
Med 100-2000 cfs	$20K-50K*	$15K-45K	$40K-70K
Lge 2000+ cfs	$10K-20K	$40K-60K	$60K-80K

* Cost per stream mile, assuming 100-400 pieces per stream mile. Estimates in all other cells measured as cost per structure.

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Table HI-2. Instream Structures - $/mile, $/structure				
Location	Year	Units	Cost Per Unit	Source
WindR-WA	2000	typical 1 project 1 project	Channel rehab: $86K ($41K-$137K)/mi Onsite material: $65K/mi Imported material: $140K-$160K/mi	Bair-pp107-108
UpperMattoleR-HumboldtCnty EelR LowerSodaCrk-EelR-MndcnoCnty	01-02	12 strctrs 40' 640'	$23,507 ($1959/structure) - log $10,979 ($1.4M/mi) $54,329 ($448.8K/mi)	CDFG-048 CDFG-156 CDFG-258
FelizCrk-RussianRiver MoonCrk-KlamathR-DelNorteCnty	02-03	1300' 15 strctrs	$20,580 ($83.7K/mi) $40,600 ($2707/structure)	CDFG-011 CDFG-127
HayworthCrk/NFNoyoR-MendcnoCnty UpperMattole-HumboldtCnty	03-04	55 strctrs 14 strctrs	$30,422 ($553/structure) $36,510($2608/structure) - wood/boulder	CDFG-216 CDFG-233
SultanCrk-SmithR-DelNorteCnty WilsonCrk-DelNorteCnty RedwoodCrk-RussianR-SonomaCnty	04-05	10 strctrs 10 strctrs 1.08 mi	$20,497 ($2050/structure) $25,998 ($2600/structure) $60,419 ($55.9K/mi)	CDFG-143 CDFG-145 CDFG-247
EelR DelNorteCnty	06-07	4.5 mi 10 strctrs	$112,437 ($25K/mi) $46,753 ($4675/struc) - +1000 native conifers to replenish wood instream	CDFG-056 CDFG-110

CA	2004	typical	Distance from Road: 0.25-0.5mi: $26K/mi 1-2mi: $27K/mi 2-3mi: $28K/mi >3mi: $29K/mi	CDFG'04 p1.24
TectahCrk-KlamathR	06–07	5 mi	$275.4K ($55.1K/mi) - LWD construction/placement with helicopter	K003
ScottR-Klamath	06-07	6-8 major structures	$65.8K ($8.2K-$11K/structure)	K037
CA		37projcts	20 struc/mi: $25.3K ($5.6K-$70.8K)/mi, $1762/structure)	Hampton-T1, pp122-123
CA		37projcts	***$/mile=24,482+427*#structures/mi*** 20 struc/mi: $33.0K/mi 50 struc/mi: $45.8K/mi 100 struc/mi: $67.2K/mi 200 struc/mi: $109.9K/mi 300 struc/mi: $152.6K/mi 400 struc/mi: $195.3K/mi	Hampton-p124
CA	98-05 2003$	24 sites 5 sites	$2.5K ($214-$11.3K)/structure $364.5K ($220.5K-$552.1K)/mi	HT07a-T60, p118
SONC SONC-NOCECA NOCECA NOCECA SCACO SCACO	98-05 2003$	3 sites 5 sites 1 site 15 sites 4 sites 1 site	$1.3K ($214-$2.1K)/structure $3K ($2.4K-$3.5K)/structure $534.1K/mi $2K ($680-$4.1K)/structure $322K ($220.5-$552.1K)/mi $11.3K/structure	HT07a-T61, p121
CA	02-04	58 sites	$12,375 ($250-$175K)/structure	HT07b-T53, p74,contrctr
CA	02-04	45 sites	$2.2M ($4K-$46.8M)/mi	HT07b-T54, p75,contrctr
OR-priv forest OR-state forest OR-USFS	2000	typical	Assume 120 trees/mile: $77.6K/mi - non-contract $82.4K/mi - contract $47.6K/mi - LWD-helicopter	Lacy-p139 Lacy-p139 Lacy-p140
King County, WA		600'	$113.5K ($99.8K/mi)	Neal-T4, p163

Table HI-3 pertains to spawning gravel supplementation. The WDFW example (WDFW-T3, p14), which is actually based on a British Columbia data source, estimates cost of spawning gravel supplementation at $20-$40/cubic yard. With the notable exception of the Stanislaus River project (ERP-97-N21) - where costs include evaluation as well as gravel treatment - the Central Valley examples indicate a range of costs ($11-$36/cubic yard) similar to WDFW's.

Table HI-3. Spawning Gravel Supplementation - $/cubic yard (cy)				
Location	Year	Units	Cost Per Unit	Source
WA	2004	typical	Gravel placement: $50-$70/m^3* Sorted gravel: $20-$40/cubic yard	WDFW-T3, p14
* Gravel placement - sorted gravel supplied, limited delivery distance, machine placed, does not include control structures.				
Tuolumne River	2002	10K cy	$3.59M + $50K project mgmt/admin ($36/cy)	ERP-02-P29
Sacramento River	1995	4964 cy	$52.5K ($11/cy)	ERP-95-M04
Tuolumne River	1997	6632 cy	$191.2K ($20/cy)	ERP-97-C11
Stanislaus River	1997	9220 cy	$667.9K ($72/cy) - Knights Ferry, incl evaluation of effects of diff size/sources of gravel on habitat utilization	ERP-97-N21

Tables HI-4 and HI-5 describe Evergreen's cost estimates for floodplain tributary reconnection (which vary with material and earthmoving requirements) and sidechannel reconnection (which vary with earthmoving requirements and energy of waterway).

Table HI-4. Floodplain Tributary Reconnection - $/acre
(Source: Evergreen 2003, p. 39)

Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management.

Materials	Extent of Earthmoving		
	Minimal	Moderate	Substantial
Minimal	$5K-10K	$10K-20K	$30K-40K
Moderate	$10K-20K	$20K-30K	$40K-60K
Substantial	$30K-40K	$40K-60K	$60K-80K

Table HI-5. Side Channel Reconnection - $/acre (Source: Evergreen 2003, p. 41)

Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management.

Extent of Earthmoving	Energy of Waterway		
	Low	Medium	High
Minimal/Near	$20K-40K	$40K-70K	$60K-90K
Moderate/Avg Distance	$40K-60K	$70K-100K	$100K-200K
Substantial/Far	$60K-100K	$130K-200K	$200K-300K

Table HI-6 provides cost estimates for channel restoration projects. All estimates pertain to Central Valley rivers and range from $1.2M/mile (ERP-99-B01) to $8.7M/mile (ERP-97-M08).

Table HI-6. Channel Restoration - $/mile				
Location	Year	Unit	Cost per Unit	Source
Merced River	1999	2.19 mi	$2.635M ($1.2M/mi) - large-scale reach restoration-channel realignment/floodplain creation	ERP-99-B01
Tuolumne River	2002	1.2 mi	$8.29M + $74.1K construction mgmt ($6.9M/mile) - large-scale reach restoration-channel realignment/floodplain creation	ERP-02-P19-D
Tuolumne River	1997	0.23 mi	$2.011M + $174K construction/proj mgmt ($8.7M/mile) - restore natural channel morphology	ERP-97-M08
Tuolumne River	1997	2.6 mi	$5.054M + $284 construction mgmt ($1.9M/mile) - restore natural channel morphology	ERP-97-M09
Tuolumne River	1998	2.2 mi	$5.054M ($2.3M/mile) - restore natural channel processes & habitats	ERP-98-F06
Merced River	1998	2.2 mi	$3.635M ($1.7M/mile) - restore natural channel processes & habitats	ERP-98-F11

Most of the wetland restoration cost estimates in Table HI-7 pertain to San Francisco Bay/Estuary; several estimates of annual operations & maintenance (O&M) and monitoring costs are included. Steere's information is notable in that he provides estimates by wetland type. The NRCS estimates indicate much lower wetland restoration costs for farmland ($75-$375/acre); these projects are likely much more modest in scale than the types of projects that occur in San Francisco Bay.

Table HI-7. Wetland Restoration - $/acre				
Location	Year	Units	Cost per Unit	Source
Topanga Crk-LA	05-06	12acres	$249.8K ($20.8K/acre) - remove 26Ktons of lead contaminated fill matl	CDFG-029
SF Bay/ Estuary	1995	typical	$20K-$30K/acre, up to $80K/acre *(2006$: $25K-$38K/acre, up to $101K/acre)*	Anon '95

SF Bay/ Estuary	2000	typical	<u>Wetland Type:</u> Tidal wetland: $5K-$100K/acre Seasonal wetland: $9K/acre (large-scale project) Wetland enhancement: $1K/acre (reveg, exotic species removal, limited irrig, modest mgmt) Monitoring: $500/acre for 5 yrs	Steere, pp231-233
SF Bay/ Estuary	1999	5 sites	(1) 500 acre wetland: $14K/acre/yr for 5 yrs, $35K/yr thereafter (land acquisition =$5M, planning/permitting=$250K, construction=$1.3M,monitoring=$25K/yr for 5 yrs, O&M=$35K/yr) (2) $1K/acre (restore tidal action to salt pond) (3) $18K/acre (seasonal/tidal wetland) (4) $27K/acre (levee construction/repair, extensive dredging) (5) $56K/acre (highly engineered, large soil volume, channel excavation, low berms)	USEPA '99, p170 USEPA '99, p172 " " "
CA farmland	FY07	typical	Light: $75/acre Moderate: $187.50/acre Intensive: $375/acre	NRCS

HR - RIPARIAN RESTORATION

This section covers restoration of erosion-prone banks adjacent to the stream and within the riparian corridor. Riparian area is defined as the area, including any necessary fencing, between the fence and the middle of the stream. Table HR-1 pertains to fencing/livestock exclusion, Table HR-2 to fence maintenance, Tables HR-3 and HR-4 to riparian planting, Table HR-5 to irrigation, and Table HR-6 to invasive/noxious weed control.

As indicated in Table HR-1, Evergreen (Evergrn p11) estimates fence construction costs at $1-$12/foot, with an "overall average" of $3-12/foot. CDFG's Coho Recovery Strategy (CDFG'04, p1.20) uses the midpoint of this latter range ($8/foot). Cost of all individual fencing projects (CDFG-xxx, HT07a, HT07b, NRCS CA) are expressed in $ per foot, even for projects that also include components other than fencing (e.g., revegetation, irrigation, stock water systems). For most of these projects (even those with added components), costs generally fall within the $1-$12/foot range indicated by Evergreen.

Table HR-1. Fencing/Livestock Exclusion - $/foot

Location	Year	Units	Cost Per Unit	Source
Puget Snd	2003	typical	Fence Material: Simple: $1-$4/ft Average: $5-$8/ft Complex: $9-$12/ft Overall Average: $3-$12/ft	Evergrn p11
CA	2004	typical	$8/ft	CDFG'04, p1.20
ShastaR	01-02	7800'	$56.6K ($7.26/ft, 7800' fence, 6 stockwater areas)	CDFG-065
EelR	02-03	1.1 mi	$40,800 ($7.02/ft)	CDFG-026
EelR		2 mi	$19,993 ($1.89/ft)	CDFG-116
EelR		3.5 mi	$28,664 ($1.55/ft)	CDFG-193
SLO Cnty		7600'	$56.4K ($7.42/ft; fencing, alternative water sources for cattle, riparian planting, temporary irrigation)	CDFG-243
TrinityCnty		1 mi	$31,138 ($5.90/ft)	CDFG-251
ShastaR		1250'	$7,032 ($5.63/ft, +10yr maint & grazing exclusion)	CDFG-324
ShastaR		850'	$4963 ($5.84/ft, +10yr maint & grazing exclusion)	CDFG-342
SmithR (dairy)	03-04	2K'	$32,890 ($16.45/ft, incl riparian plant)	CDFG-131
RussianR		800'	$6.7K ($8.40/ft; fencing, water pump in stream to provide water for livestock)	CDFG-195
ShastaR	04-05	13,500'	$91,944 ($6.81/ft,native plants 1,685')	CDFG-194
ShastaR		25,000'	$116,674 ($4.70/ft)	CDFG-231
ShastaR		3200'	$61,604 ($19.25/ft)	CDFG-243
SmithR	05-06	3000'	$21,259 ($7.09/ft, native trees)	CDFG-046
KlamathR		2600'	$17,494 ($6.73/ft, trees 3 acres)	CDFG-188
KlamathR		3600'	$25,850 ($7.18/ft)	CDFG-266

ShastaR	06-07	3500'	$28,213 ($8.06/ft, riparian veg)	CDFG-078
CA	98-05 2003$	10 sites	$7 ($2.43-$22.07)/ft - $37K/mi	HT07a-T60, p118
SONC SONC-NOCECA SCACO	98-05 2003$	6 sites 3 sites 1 site	$9 ($4.58-$22.07)/ft - $48.1K/mi $3.39 ($2.43-$4.89)/ft - $7.9K/mi $5.15/ft - $27.2K/mi	HT07a-T61, p121
CA	02-04	 2 sites 7 sites 2 sites	<u>Fence Material:</u> Simple: $1.89 ($0.79-$3.00)/ft Avg: $4.32 ($2.00-$7.00)/ft Complex: $4.72 ($3.44-$6.00)/ft	HT07b-T13, p34,contrctr
CA	98-05 2003$	9 sites	$7.24 ($2.43-$22.07)/ft	HT07b-T12, p33, CHRPD
CA	FY07	typical	<u>Fence Material:</u> Conventional: $3/ft Conventional extreme terrain: $8/ft Electric: $2/ft Woven: $6/ft	NRCS CA

OR	1993	typical	System Type: Access ramp: $600+fence ($100/yr maint) *(2006$: $788, $131/yr maint)* Nose/stream powered pump (surf/grndwtr): $350-$450/pump+fence ($50/yr maint) *(2006$: $460-$591, $66/yr maint)* Stream-powered pump w/flow&elev needs: $500-$1000/pump+fence ($50/yr maint) *(2006$: $657-$1314, $66/yr maint)* Plastic pipe (grndwtr): $1-$2/pipeline ft +troughs ($50/yr maint) *(2006$: $1.31-$2.63/ft, $66/yr maint)* Solar powered pump (grndwtr): $2K-$6K for solar equip, tank, fence, pad *(2006$: $2628-$7884)* Spring development (grndwtr): $700+fence+trough ($50/yr maint) *(2006$: $920, $66/yr maint)*	TSWCD, p6

Fence maintenance costs described in Table HR-2 range from $0.09 to $0.26/foot/year, depending on the fencing material. It should be noted that these estimates pertain to Iowa, not California.

Table HR-2. Fence Maintenance - $/foot

Location	Year	Units	Cost Per Unit	Source
Iowa	2005	1330'	Fence Material: Woven wire: $0.26/ft/yr Barbed wire: $0.21/ft/yr Hi-tensile, non-elec: $0.15/ft/yr Hi-tensile, elec: $0.09/ft/yr	MO-T6

Table HR-3 describes Evergreen's estimates of riparian planting cost, while Table HR-4 describes estimates from other data sources. Evergreen's estimates are $5K-135K/acre, and vary with the level of site preparation and material/site accessibility. The estimates used for CDFG's Coho Recovery Strategy (CDFG-04, p1.17) are $30K-60K/acre and were selected to fall within the range of Evergreen's estimates. Project costs reported in HT07a and HT07b are ~ $100K-$120K/acre (with the notable exception of a $434.8K/acre project). The NRCS estimates are at the low end of this range: ~$100-$1800/acre - depending on what is planted (trees or plants) and planting requirements (e.g., protected, shelters, wire cages, native species). An NRCS estimate of landing clearing costs is also included to address situations where clearing is a prerequisite for planting. The Bair example - $110/acre, pertaining to riparian reforestation - was also at the lower end of Evergreen's range .

For the examples from CDFG and Hampton, costs could be calculated on a per-mile but not a per-acre basis. Costs vary widely ($1K to > $200K/mile); some of this difference may be due to variations in the width of the buffer being planted (which is not clear from the data sources). Evergreen uses the following conversion from miles to acres (with acreage doubled when planting on both sides of the stream).
1 mile x 50 foot buffer = 6 acres (100% planted)
1 mile x 50 foot buffer = 1.8 acres (30% planted)
1 mile x 150 foot buffer = 18.2 acres (100% planted)
1 mile x 150 foot buffer = 5.5 acres (30% planted).

Table HR-3. Riparian Planting Projects - $/acre (Source: Evergreen 2003, p. 16)
Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management.

Materials/Site Accessibility	Level of Site Preparation		
	Flat/Light Clearing	Avg Slope/Avg Clearing	Steep/Heavy Clearing
Low Cost	$5K-25K	$20K-50K	$60K-100K
Medium Cost	$10K-35K	$45K-65K	$70K-120K
High Cost	$30K-50K	$55K-80K	$100K-135K

Table HR-4. Planting - $/acre, $/stream length For entries involving multiple projects, cost reported as mean or mean (range) as avail.				
Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	Distance from Road (assuming 50' buffer along streams): <0.25 mi: $30K/acre 0.25-0.5mi: $35K/acre 0.5-1mi: $45K/acre 1-2mi: $50K/acre 2-3mi: $55K/acre >3mi: $60K/acre	CDFG-04 p1.17
SONC SONC NOCECA NOCECA CentralVly SCACO	98-05 2003$	1 site(10ac) 2 sites(4mi) 4sites(128ac) 7 sites(3mi) 4sites(610ac) 1 site(28ac)	$1.8K/acre $30.8K ($8.8K-$52.9K)/mi $8K ($1.8K-$13.5K)/acre $95K ($3.7K-$436.6K)/mi $4.8K ($2K-$7.8K)/acre $23.6K ($495-$63.1K)/acre	HT07a-T61, pp121-125
CA	02-04	 18 sites 14 sites 10 sites	Site Accessibility: Easy:$55.8K ($600-$434.8K)/acre (median=$8.9K/acre) Average: $9.1K ($40-$87.5K)/acre (median=$1.3K/acre) Difficult: $4K ($910-$15.1K)/acre (median=$2.3K/acre)	HT07b-T21, p 43.contrctr
CA	02-04	 19 sites 11 sites	Prevailing Wages Required: No: $1.8K ($40-$8.5K)/acre Yes: $77.1K ($1.8K-$434.8K)/acre	HT07b-T30, p50,contrctr

CA	02-04	2 sites 8 sites 8 sites 22 sites	<u>Irrigation Type</u> Dri-water: $46.1K ($8.5K-$83.7K)/acre Drip irrig: $33.0K ($163-$120.5K)/acre Hand irrig: $26.2K ($414-$100K)/acre None: $27.1K ($40-$434.8K)/acre	HT07b-T34, p54,contrctr
CA farmland	FY07	typical	170-259 trees/acre: $109/acre 260-300 trees/acre: $154/acre 301-435 trees/acre: $182/acre 436-681 trees/acre: $240/acre 110 trees/acre (protected): $770/acre 300 trees/acre (protected: $2000/acre 170-260 trees/acre (shelters): $130/acre 261-325 trees/acre (shelters): $175/acre 326-434 trees/acre (shelters): $200/acre >435 trees/acre (shelters): $260/acre 95-150 plants/acre (wire cages):$225/acre 151-200 plnts/acre (wire cages):$320/acre 201-325 plnts/acre (wire cages):$470/acre 95-150 plants/acre (native spp): $735/acre 150-200 plnts/acre(native spp):$1050/acre 200-260 plnts/acre(native spp):$1380/acre 261-325 plnts/acre(native spp):$1755/acre Land clearing: $400/acre	NRCS CA
WindR-WA	2000	mile	$5K ($4K-$8K)/mi; $110/acre - riparian reforestation	Bair-p107
MaacamaCrk-SonomaCty	01-02	300'	$12,790 ($225K/mi) - willow walls	CDFG-186

KlamathR WilsonCrk ShastaR	02-03	2600' 1 mi 2 mi	$27.6K ($52.8K/mi) $18.1K/mi $109,934 ($55K/mi)	CDFG-170 CDFG-208 CDFG-296
GarciaR-MendcnoCnty LowerTerwer Crk-KlamathR-DelNorteCnty	03-04	1600' 1600'	$67,695 ($223K/mi) - bioengineer $39,671 ($131K/mi) - willows, native	CDFG-117 CDFG-223
Klamath ShastaR	04-05	1600' 7000'	$55,868 ($184K/mi) - willow/native trees/bioengineer/removal of exotics $79,573 ($60K/mi)	CDFG-122 CDFG-172
CA	2000	11 projects	$13.7K ($1.0K-$47.5K)/mi	Hampton-T3, p125
CA		12 projects	$8 ($0.17-$23)/ft or $42.2K ($898-$121K)/mi	Hampton-T4, p125

Some of the projects in Table HR-4 above included irrigation in combination with revegetation. Table HR-5 provides estimates of irrigation costs only (NRCS CA) that range from $800 to $3K/acre and vary by irrigation method and habitat type. An example of capital cost (irrigation pumps, CDFG-279) is also provided.

Table HR-5. Irrigation - $/acre, $/project

Location	Year	Units	Cost Per Unit	Source
CA farmland	FY07	typical	Irrig system, surf & subsurface: $3K/acre Micro-irrig, hillside: $1.5K/acre Micro-irrig, wildlife-upland habitat: $800/acre Sprinkler irrig, hillside/sloping: $2.5K/acre	NRCS CA
Eel R	04-05		$17.3K - solar powered irrigation pumps to ensure seedling survival until natural roots grow	CDFG-279

Information on invasive weed control is limited: $5K-$12K/acre for projects on the Napa and Smith Rivers (04-05 CDFG-072 & CDFG-077). NRCS cost estimates for farmland are much lower ($10-$375/acre) and vary, depending on eradication method (e.g., mechanical/chemical, mechanical/chemical/handtool), land type (e.g., upland, wetland), and vegetation type (e.g., woody, herbaceous). A Russian River project (02-03 CDFG-325) can be costed on a per-mile basis but cost per acre is not known.

Table HR-6. Invasive/Noxious Weed Control - $/acre, $/mile

Location	Year	Units	Cost Per Unit	Source
RussianR	02-03	2.5mi	$30.2K ($12.1K/mi,broom,native reveg)	CDFG-325
NapaR	04-05	22,865yd^2 (4.7acres)	$55.7K ($11.9K/acre, arundo erad)	CDFG-072 CDFG-077
SmithR		10acres	$49.5K($5K/acre,Eng ivy, plantseedlng)	

CA farmland	FY07	typical	***Exotic Vegetation Management*** Woody veg, mech/chem/handtool Light: $18.75/acre Moderate: $37.50/acre Intensive: $75/acre Mechanical/chemical, upland Light: $10/acre Moderate: $20/acre Intensive: $50/acre Woody veg (early successional), mech/chem/handtool Intensive: $50/acre Herbaceous veg, early successional, mech/chem/handtool Moderate: $25/acre Mult applic/yr, wetland, mech/chem/ handtool Light: $75/acre Moderate: $187.5/acre Intensive: $375/acre ***Competing Vegetation Management*** Conservation cover General: $50/acre Riparian herbaceous: $50/acre Forest stand improvement Mastication: $920/acre Hand, 0-15%slope, 20-40%cover:$600/acre Hand, 15-30%slope, 40-60%cover:$900/acre Hand, 30-50%slope, 60-90%cover:$1200/acre Brush rake: $379/acre Chemical: $150/acre	NRCS CA

HS - BANK STABILIZATION

This section covers stabilization of eroding, collapsing or otherwise de-stabilized bank.s. Table HS-1 provides Evergreen's cost estimates for streambank stabilization, Table HS-2 provides similar estimates from other data sources, and Table HS-3 focuses on levee restoration.

Evergreen's estimates ($30-$1000/foot) vary by extent of excavation and waterway size. Cost estimates used in CDFG's Coho Recovery Strategy (CDFG'04, p1.19) were $250-$350/foot and fall within the range of Evergreen's estimates for small/medium waterways. Generally speaking, other project costs in Table HR-2 also fall within Evergreen's range of estimates.

The higher cost projects appear to involve stabilization work other than just revegetation and/or work on steep terrain (e.g.,03-04 CDFG-285, 04-05 CDFG-263). For those projects that are identifiable to location, costs also appear to be higher in urban areas - e.g., southern California (05-06 CDFG-065, 069, 097) and King County, WA (Neal-T2, p159 & Neal-T3, p161). By contrast, cost in the rural Wind River watershed ($9-$42/ft, Bair-p107) falls toward the low end of Evergreen's range.

Table HS-1. Streambank Improvements - $/lineal foot (Source: Evergreen 2003, p. 30)
Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management.

Extent of Excavation	Size of Waterway		
	Small	Medium	Large
Minimal	$30-60	$60-150	$150-400
Moderate	$60-100	$150-250	$400-700
Substantial	$100-200	$250-500	$700-1000

Table HS-2. Bank Stabilization - $/foot

Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	Distance from Road: 0.25-0.5mi: $250/ft 0.5-1mi: $275/ft 1-2mi: $300/ft 2-3mi: $325/ft >3mi: $350/ft	CDFG'04, p1.19
GualalaR	01-02	3200'	$91,850 ($29/ft)	CDFG-196
NF MattoleR EelR BearR-HmbldtCnty	02-03	1500' 4915' 260'	$46,806 ($31/ft) $157.3K ($32/ft) $37,962 ($146/ft)	CDFG-096 CDFG-134 CDFG-181
StaRosaCrk-SonomaCnty	03-04	350' long x 30' high creekbank	$124,201 ($355/ft) - stabilize/ construct/revegetate)	CDFG-285

SalmonCrk RussianR VanDuzenR StaYnezR	04-05	150' 150' 1500' 520'	$15,187 ($101/ft) - bioengineer $18,774 ($125/ft) - bioengineer $75,065 ($50/ft) - boulder, bioengineer $296,692 ($571/ft) - stabilize/ construct/revegetate	CDFG-030 CDFG-069 CDFG-158 CDFG-263
VenturaR StaYnezR StaMonicaBy KlamathR EelR	05-06	300' 1600' 300' 950' 3080'	$62,571 ($209/ft) $264,605 (165/ft) $110,894 ($370/ft) $86,609 ($91/ft) $92,241 ($30/ft) - incl riparian tree planting	CDFG-065 CDFG-069 CDFG-097 CDFG-118 CDFG-279
SONC NOSECA/ SONC SCACO	98-05	1 site(0.2mi) 1 site(0.03mi) 1 site(2.0mi)	$163.9K/mi ($31/ft) $181.9K/mi ($34/ft) $510K/mi ($97/ft)	HT07a-T61, pp121-124
CA	98-05 2003$	3 projects	$54 ($31-$97)/ft	HT07b-T63, p 90,CHRPD
CA	02-04	 10 projects 25 projects 18 projects	<u>Material Complexity:</u> Minimal:$30 ($5-$59)/ft Moderate:$120 ($4-$750)/ft Substantial:$181 ($6-$895)/ft	HT07b-T69, p 96,contrctr
Sacrmnto/San JoaquinDelta	2002	3.72 mi	$1.5M ($76/ft) - bioengineering, planting/baffling	ERP-02-P12
WindR-WA	2000	typical	$9-$42/ft	Bair-p107
King County, WA	1995 1997	1400' 100'	$444K ($317/ft) - instream/ floodplain)* *(2006$: $560K/project, $400/ft)* $93K ($930/ft) - LWD/bank stabilization* *(2006$: $113K/project, $1133/ft)*	Neal-T2, p159 Neal-T3, p161
* Includes design, land/easements, permits, SEPA and construction. For 1995 project, replanting, irrigation and 5 year plant maintenance also included.				

Table HS-3 provides levee-related cost estimates for several Central Valley rivers, the Pajaro and San Lorenzo Rivers (in Santa Cruz/Monterey counties), and Green River (in Washington). Comparison of estimates from different time periods suggests that levee repair costs have increased significantly (beyond the rate of inflation) - perhaps reflecting major change in levee demand and/or input supply conditions in recent years.

<u>Central Valley:</u> A single example of levee evaluation costs was found ($11/foot; Harder 06, p21). Levee repair costs from the 1980s and early 1990s were ~$500-$1000/foot (after correcting for inflation). More recent cost estimates are ~$5K-$6K/foot. Although per-foot cost estimates were not available for the Yuba/Feather River project (EPS '06, Tables B1&B2), levee improvement: environmental mitigation cost ratios from that project (25:1 for the Yuba, 8:1 for the Feather) are provided here, as they may also be useful for recovery planning.

<u>Pajaro/San Lorenzo River:</u> The 1989 cost estimates were ~$200-$500/foot (after correcting for inflation). The more recent estimates (developed by USACOE to evaluate various alternatives for Pajaro River flood protection) are ~$1.5K to $5K/foot.

<u>Green River:</u> Suggests the wide range of costs possible for levee repair.

Table HS-3. Levee Evaluation/Repair/Setback/Habitat Enhancement ($/foot)

Location	Year	Units	Cost per Unit	Source
CentralValley	2006	typical	$60K/mi (11/ft) - structural re-evaluation	Harder 06, p.21
SacrR	2006	29 sites, 30K ft	$172.5M ($5750/ft) - emergency erosion repair	DWR 06
SacrR	1980s 2005	typical typical	$300/ft - repair *(2006$: $500/ft)* Up to $5K/ft - repair	DWR 05, p.5
Bear River	2007	10K ft	$51M ($5.1K/ft) - setback	GEI 07
Twitchell Island, SanJoaqR	early 90s	3K ft	$2.5M/mi ($473/ft) - setback *(2006$: $636/ft)* $3.5-$4M/mi ($663-$758/ft) - setback+planting *(2006$: $891-$1019/ft)*	Nuedeck 00
Yuba R Plain FeatherRPlain	2006		Levee improve$:envir mitigatn$ $40.5M:$1.6M=25:1 $191.6M/$23.4M=8:1	EPS 06, Tables B-1 & B-2
SanLorenzoR PajaroR	1989	5.2K ft 12K ft	$1.75M ($337/ft)-rebuild levee *(2006$: $499/ft)* $1.84M ($153/ft)-repair *(2006$: $226/ft)*	McDonnell '92

Pajaro River mainstem	2002	11.4mi* 60,192'	Alt 1-$145.8M ($2422/ft), floodwall/levee raise Alt 2-$175.4M (2914/ft), 100'setback Alt 3-$177.3M ($2946/ft), 100'-225' setback Alt 4-$322.2M ($5353/ft), floodwall	USACOE '02
Pajaro River tributaries (Salsipuedes &Corralitos Creeks)	2002	4.4mi* 23,232'	Alt T1-$35.1M ($1511/ft), levee raise Alt T2-$38.8M (1670/ft), setback Alt T3-$34.7M ($1494/ft), hybrid raise/setback	USACOE '02
Pajaro River mainstem (MS) & tributaries (T)	2003	15.8mi* 83,424'	Alts 2A&T4-$217.7M ($2610/ft), 100' setback Alts 3&T3-$218.3M ($2617/ft), 225' setback Alts 2A&T3-$215.3M ($2581/ft), 100' MS, 225' T Alts 3&T4-$220.7M ($2646/ft); 225' MS, 100' T	USACOE '03
* Info on project size obtained from MIG Inc (2001), p. 14. Mainstem includes river reaches 1-4; tributaries include river reaches 5-6.				
Green River, Seattle	2007	typical	$1K-$15K/ft, repair	Johnson 07

HU - WATERSHED RESTORATION (UPSLOPE)

This section covers upslope restoration to reduce stream sedimentation. Table HU-1 pertains to road decommissioning, Table HU-2 to road upgrade, Table HU-3 to landslide/gully stabilization and Table HU-4 to planting in upland areas (as distinct from riparian planting described in Table HR-4).

According to Weaver/Hagans (WH-T7, p100), road decommissioning costs generally range from $2K-$35K/mile but may go as high as $51K/mile for moderately difficult roads. Most of the other examples fall within Weaver/Hagans' range. CDFG's Coho Recovery Strategy (CDFG '04, p1.28) assumes $9K/mile, which is toward the lower end of the Weaver/Hagans' range.

Table HU-1. Road Decommissioning - $/mile				
Location	Year	Units	Cost Per Unit	Source
CA	2000	typical	Moderately difficult roads: $51K/mi Range of roads: $2K-$35K/mi	WH-T7, p100
CA	2004	typical	$9K/mi	CDFG'04 p1.28
KlamathR Mendcno Klamath	02-03	9 mi 3.5 mi 34.3 mi	$32,029 ($3.6K/mi) - timber road $105,025 ($30K/mi) $348,407 ($10.2K/mi) - forest road	CDFG-214 CDFG-233 CDFG-331
TrinityR NoyoR	03-04	3.6 mi 8.5 mi	$43,690 ($12.1K/mi) $137,495 ($16.2K/mi)	CDFG-197 CDFG-267
SalmonR KlamathR TrinityR	04-05	5.9 mi 4.5 mi 1.4 mi	$259,087 ($43.9K/mi) $257,787 ($57.3K/mi) $130,567 ($93.3K/mi)	CDFG-004 CDFG-006 CDFG-251
TrinityR VanDuzenR HumboldtBy HumboldtBy	05-06	5 mi 2.25 mi 3 mi 9.7 mi	$320,866 ($64.2K/mi) $188,560 ($83.8K/mi) $333,736 ($111.2K/mi) $411,567 ($42.4K/mi)	CDFG-015 CDFG-119 CDFG-120 CDFG-121
Klamath-FS TrinityR	06-07	13.3 mi 2.33 mi	$392,797 ($29.5K/mi) $25,000 ($10.7K/mi)	CDFG-169 CDFG-104
SONC	98-05 2003$	2 sites	$121.6K ($8.2K-$235K)/mi	HT07a-T61, p121
CA	02-04	39 sites	$34,090 ($4K-$200K)/mi	HT07b-T76, p101.contrctr
CA	98-05 2003$	3 sites	$285.2K ($164K-$510K)/mi	HT07b-T77, p102,CHRPD
WA- ForestSvc	2000	6 sites	$6,522 ($1,8K-$15K)/km, or $4.1K ($1.1K-$9.3K)/mi	Coffin-T1, p53

According to Weaver/Hagans (WH-T7, p100), road upgrade costs are generally $10K-$35K/mile but may go higher than $45K/mile for difficult or high-density sites. CDFG's Coho Recovery Strategy (CDFG '04, p1.27) assumes $15.9K/mile, which is toward the lower end of the Weaver/Hagans' range (~$23K/mile). Most of the other examples fall within Weaver/Hagans' range.

Table HU-2. Road Upgrade - $/mile				
Location	Year	Units	Cost Per Unit	Source
CA	2000	typical	Upgrade Type: Difficult, 100 yr design: $42.5K/mi Mod-diff, hi-site density: $45.5K/mi Watershed-wide, low/high priority, 100 yr design: $25K-$35K/mi Watershed-wide avg, 100 yr design: $10K-$35K/mi	WH-T7, p100
CA	2004	typical	$15.9K/mi	CDFG'04 p1.27
MendcnoCnty SiskiyouCnty	01-02	1.1 mi 17.6 mi	$32,963 ($30K/mi) $741,656 ($42.1K/mi)	CDFG-159 CDFG-165
KlamathR SalmonR SalmonR	02-03	22.2 mi 16.7 mi 16.7 mi	$558,016 ($25.1K/mi) $698,384 ($41.8K/mi) $492,376 ($29.5K/mi)	CDFG-017 CDFG-018 CDFG-019
SmithR MndocinoCnty	03-04	10.9 mi 6 mi	$509,363 ($46.7K/mi) $173.3 ($28.9K/mi)	CDFG-007 CDFG-037
EelR RussianR GarciaR EelR RussianR MattoleR	04-05	12.1 mi 11.7 mi 5.25 mi 23.1 mi 11 mi 2 mi	$176,718 ($14.6K/mi) $560,476 ($47.9K/mi) $155,382 ($29.6K/mi) $299,076 ($12.9K/mi) $427,212 ($38.8K/mi) $59,706 ($29.9K/mi)	CDFG-027 CDFG-111 CDFG-195 CDFG-225 CDFG-268 CDFG-285
EelR	06-07	8 mi	$389,486 ($48.7K/mi)	CDFG-009
CA	98-05 2003$	12 sites	$18K ($1.9K-$52K)/mi	HT07a-T60, p118

SONC NOCECA-SONC NOCECA	98-05 2003$	3 sites 2 sites 7 sites	$12.3K ($2.1K-$32.1K)/mi $12.7K ($3.3K-$22.1K)/mi $22K ($1.9K-$52K)/mi	HT07a-T61, p121
CA	02-04	43 sites	$169K ($1K-$3.5M)/mi	HT07b-T86, p123,contrctr

Limited information contained in Table HU-3 (mostly from the Eel River) shows landslide repair costs ~ $1K-$3.5K/site.

Table HU-3. Landslide and Gully Stabilization - $/acre

Location	Year	Units	Cost Per Unit	Source
EelR EelR MarinCnty EelR	04-05	34 sites 54 sites 80 sites 30 sites	$115.9K ($3410/site) $86.5K ($1601/site) $279.8K ($3497/site) $29.7K ($990/site)	CDFG-156 CDFG-160 CDFG-174 CDFG-213

The estimate of upland planting cost in Table HU-4 falls toward the lower end of riparian planting costs previously described in Table HR-4; however, it is difficult to generalize from a single example.

Table HU-4. Planting - $/acre

Location	Year	Units	Cost Per Unit	Source
TrinityCnty	02-03	100 acres	$194,468 ($1945/acre)	CDFG-254

TW - TAILWATER MANAGEMENT

Cost of tailwater management is represented in Table TW-1 in terms of acres of farmland irrigated by tailwater. Costs are ~$20-$400/acre. The NRCS example suggests that cost per acre declines as total acreage increases.

Table TW-1. Tailwater Management System - $/acre				
Location	Year	Units	Cost Per Unit	Source
SiskiyouCnty	01-02	540 ac	$220.2K ($408/acre, collect, hold and return water to high end of unit for re-use)	CDFG-049
CA	1987	typical	$125/acre *(2006$: $198/acre)*	USEPA p13
CA-rice	1990	typical	<u>System Type:</u> Static irrig system*:$95/acre (6-10 acre basin) *(2006$: $135/acre)* Recirculating system: $20/acre (1000 acre system) to $150/acre (80 acre system) *(2006$: $28-$214/acre)*	Hill 4/7 Hill 3/7
* Static irrigation consists of a ditch and flashgated pipe system that limit inflow into basin to amount required to replenish water lost to evapotranspiration and percolation. This recent innovation in rice irrigation eliminates possibility of tailwater spillage into public drains.				
CA	FY07	typical	***Size of Area Covered by System:*** 1-50 acres: $10K, $400/acre(=$10K/25ac) 51-100 acres: $20K, $267/acre 101-200 acres: $30K, $200/acre 201-300 acres: $40K, $160/acre 301-400 acres: $60K, $171/acre 401-500 acres: $80K, $178/acre	NRCS CA
CA-cotton	2000	typical	Furrow irrig+tailwater system: $60-$80/acre	Sanden
Colorado	1998	typical	$150-$225/acre (earthwork, pipeline install, pump assembly)	Broner

WC - WATER CONSERVATION MEASURES

This sections cpertains to methods of providing more efficient use of water extracted from stream systems. Table WC-1 pertains to ditch lining and Table WC-2 to piping.

Canal lining costs described in Table WC–1 are ~ $15-$96/foot. Such projects often involve installation of related equipment such as control structures. For large projects, the cost of planning/environmental/administrative aspects can comprise a substantial portion of total project costs (e.g., 62% of total costs for the ACID project). Project life ranges from 20-50 years. In cases where proponents provided estimates of project benefits (in terms of value of conserved water), benefits were estimated using water prices of $25-$75/acre foot.

Table WC-1. Ditch Lining - $/ditch length, $/acre farmland treated

Location	Year	Units	Cost Per Unit	Source
Anderson	01-03	2 mi	Cost Breakdown: Planning/environ/admin: ~$4M Control struc, measurement flumes, SCADA systems@13 sites: $1.494M ($114.9K/site) Concrete anal lining: $1M ($96/ft) Project life=30yrs Value conserved water=$50/af	ACID
MercedCnty	01-03	25K' 600 ac	$2M ($79/ft, $3.4K/acre) Includes 50 control structures Project life=50yrs Value conserved water=$25/af	MCWD
CA	FY07	typical	Liner Type: Plain concrete: $20/ft Flexible membrane: $15/ft Galvanized steel: $20/ft	NRCS CA
CA	01-03	13.5K’	$251K ($19/ft) - concrete Project life=20yrs Value conserved water=$75/af	OWID
CA	2001	8K’	$242K ($30/ft) - concrete Project life=20yrs	OWID ‘01

PlacerCnty	01-02	3 mi	Cost Breakdown: Planning/environ/admin: $81K 12 remote flow monitoring stns:$450K ($37.5K/stn) Canal lining: $794K ($50/ft) - concrete Project life=25 yrs Value conserved water=$40/af	PCWA

As indicated in Table WC-2, the only piping example found was $16/foot.

Table WC-2. Piping - $/pipe length				
Location	Year	Units	Cost Per Unit	Source
CA farmland	FY07	typical	$16/ft - irrig water conveyance, aluminum pipeline	NRCS CA

WD - WATER MEASURING DEVICES

This section pertains to instream and water diversion measuring devices to track mainstem/tributary flows. Table HB-4 above provides cost estimates for instream projects that involve use of head gates with other devices. Table WD-1 pertains to head gates alone. The limited examples provided indicate head gate costs of $2.8K-$10K.

Table WD-1. Head Gate - $/project				
Location	Year	Units	Cost Per Unit	Source
SiskiyouCnty	01-02	123 diversions	$350K ($2.8K/diversion) - lockable head gate & flow measuring device	CDFG-056
ScottR-Klamath	06-07	14 diversions	$142K ($10.1K/diversion) - head gate & flow measuring device	K033
CA farmland	FY07	typical	Headgate <3cfs: $5K Headgate >3cfs: $10K	NRCS CA

WP - WATER PURCHASE/LEASE

Table WP-1 pertains to purchase/lease/acquisition of short- or long-term water rights to improve water quality and/or quantity. The DWR sources indicate Central Valley water transfer prices of $43 - $246/acre foot/year. CDFG's Coho Recovery Strategy (CDFG'04, p1.43) assumes $100/af/yr - a value within the range of the DWR data. The water prices in Table WC-2 (previously presented in section "WC-Water Conservation Measures") are considerably higher than the prices imputed to water conserved in estimating value of water conserved by ditch lining in Table WC-2. A major distinction between the two is that Table WC-2 pertains to conserved water valued at the existing price being paid by the water user, while the Table WP-1 prices are transfer prices.

Table WP-1. Purchase/Lease of Water Right - $/acre foot (af)				
Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	$100/af/yr	CDFG'04 p1.43
Central Valley	01-02	 135K af 7.1K af 36.8K af 60.6K af	***Upstream of Delta*** State-YubaCntyWater Agency: $10.1M ($75/af/yr) Fed-SacmntoGrndwtrAgency: $535.7K ($75/af/yr) ***South of Delta*** State-KernCntyWtrAgency: $6.7M ($181/af/yr) Fed-KernCntyWaterAgency: $11M ($181/af/yr)	DWR
Central Valley	02-03	 4.9K af 65K af 125K af 20K af	***Upstream of Delta*** State-OrovilleWyandotteIrrigDist: $386.6K ($75/af/yr) State-YubaCntyWaterAgency: $5.5M ($85/af/yr) ***South of Delta*** State-KernCntyWaterAgency: $21.3M ($170/af/yr) Fed-StaClaraVlyWaterDist: $3.2M ($162/af/yr)	DWR
Central Valley	03-04	 100K af 20K af 35K af	***Upstream of Delta*** State-YubaCntyWaterAgency: $8.8M ($88/af/yr) State-PlacerCntyWaterAgency: $1.7M ($83/af/yr) ***South of Delta*** State-KernCntyWaterAgency: $8.6M ($246/af/yr)	DWR

Central Valley	04-05	4.6K af 89.7K af 8.8K af	***Upstream of Delta*** State-YubaCntyWaterAgency: $200K ($43/af/yr) ***South of Delta*** State-KernCntyWaterAgency: $15.8M ($177/af/yr) State-StaClaraVlyWaterDist: $1.6M ($184/af/yr)	DWR

HA - HABITAT ACQUISITIONS/LEASES/CONSERVATION EASEMENTS ($/ACRE)

Tables HA-1 and HA-2 respectively describe Evergreen's cost estimates for undevelopable land and parcels with medium-high development potential. Table HA-3 describes costs of easements and land purchases administered by California's Wildlife Conservation Board (WCB). Tables HA-4 and HA-5 respectively describe land acquisition and easement costs from a variety of other sources. Evergreen's estimates are inclusive of transaction and management costs as well as land acquisition price, while WCB's estimates include only acquisition price. The other data sources likely also include only acquisition price.

Evergreen's prices are $700-$4800/acre for undevelopable land (Table HA-1. For parcels with medium/high development potential and low to high amenity value, prices are $5K-$300K/acre for rural residential land, $60K-$600K/acre for suburban residential land, and $300K-$1.2M/acre for urban land; prices of parcels with very high amenity value are unpredictable (Table HA-2).

Table HA-1. Cost of Undevelopable Land - $/acre (Source: Evergreen 2003, p. 7)
Cost estimates pertain to Puget Sound. Estimates include appraisal, closing, commission, surveying, legal, project management costs.

Proximity to Urban Area	Zoning	
	Forest	Agricultural
Far 41+ mi	$700-1800	$1800-2400
Medium 21-40 mi	$1800-2400	$2400-3600
Near 0-20 mi	$2400-4800	$3600-4800

Table HA-2. Cost of Parcels with Medium-High Development Potential - $/acre (Source: Evergreen 2003, p. 6)

Cost estimates pertain to Puget Sound. Estimates include appraisal, closing, commission, surveying, legal, project management costs.

Zoning	Amenity Value			
	Low	Medium	High	Very High
Rural Residential	$5K-35K	$24K-60K	$60K-300K	$300K-1.2M
Suburban Residtl	$60K-120K	$120K-240K	$300K-600K	Unpredictable
Urban	$300K-600K	$600K-1.2M	Unpredictable	Unpredictable

The prices in Table HA-3 were derived by dividing WCB's expenditures for purchase/easement in each county by the number of acres subject to purchase/easement. These derived prices are $42 -$104.7K/acre for easements, and $267-$45.5K/acre for acquisitions. The acquisition prices are on the low side relative to Evergreen's estimates of $5K-$300K/acre for rural land and $300K-$1.2M/acre for urban land, (Table HA-2) and likely underestimate actual costs, as WCB's wildlife habitat acquisitions are often done on a cost-share basis.

Table HA-3. WCB Actions in 2000-2004: Total Acreage and $/Acre, by County (Source: Wildlife Conservation Board, 2005)

	Conservation Easement		Fee Title	
County	Acres	$/Acre	Acres	$/Acre
Alameda			16,500	$4,485
Alpine				
Butte	10,369	$866	4,557	$726
Calaveras	3,669	$395		
Colusa	13,131	$128		
Contra Costa			3,808	$843
Del Norte			25,675	$812
El Dorado	1,178	$501	1,295	$4,239
Fresno			1,310	$7,291

Glenn			24,158	$568
Humboldt	3,640	$253	5,905	$5,184
Imperial				
Inyo			218	$4,394
Kern			4,743	$1,093
Lake			269	$968
Lassen			278	$1,079
Los Angeles			4,178	$43,083
Madera	443.5	$1636	1,140	$15,380
Marin			737	$7,017
Mariposa	6,801	$487		
Mendocino	560	$6607	39,704	$267
Merced	15,620.9	$893	4,359	$818
Modoc			2,080	$640
Mono	6,350	$506		
Monterey	27,715	$241	14,598	$1,408
Napa	17	$104,706	12,817	$546
Nevada			494	$1,387
Orange			6,508	$12,782
Placer			155	$1,131
Plumas	21,137	$140	279	$1,935
Riverside	1,324	$591	60,926	$1,871
Sacramento	5,526	$577	4,819	$1,159
San Bernardino			572	$6,324
San Diego			54,871	$2,135
San Francisco				
San Joaquin	3,515	$545		

San Luis Obispo	82,106	$420	32,551	$1,045
San Mateo	1,000	0	6,020	$2,495
Santa Barbara	1,406	$2,156	948	$15,651
Santa Clara			5,205	$1,822
Santa Cruz	18	$167	464	$12,349
Shasta	3,784	$158	1,524	$2,949
Sierra	500	$620	2,147	$12,809
Siskiyou	2,479	$42	118	$1,102
Solano	535	$1,903	5,536	$701
Sonoma	165	$10,333	5,484	$2,279
Stanislaus				
Sutter				
Tehama	21,557	$116	8	$44,063
Tulare	722	$176	2,667	$413
Tuolumne			333	$302
Ventura			3,018	$45,518
Yolo	6,983	$351	21,106	$865
Yuba	2,115	$56	2,153	$2,152
Total				

Tables HA-4 and HA-5 include information on habitat type, when available. Several projects involved expenditures on both acquisition and easement where it was not possible to determine how much was spent on each. Such projects were placed in Table HA-4 if most of the acreage involved acquisition and in Table HA-5 if most of the acreage involved easement; cost per acre was estimated by dividing total cost by total acreage (acquisition + easement).

Land acquisition values used by NMFS for the Columbia River Estuary Recovery Plan were $5K/acre for rural land and $100K/acre for urban land (Table HA-4, NOAA p5-46). These values are as low or lower than Evergreen's lowest prices for rural and urban land ($5K/acre and $300K/acre respectively, Table HA-2). For most other acquisitions described in Table HA-4, prices are ~ $200-$20K/acre, with the notable exception of several multi-million-dollar-per-

acre purchases in north/central California and southern California - both highly urbanized areas (Table HA-4: HT07a-T61, p121, NOCECA and SCACO). Prices of conservation easements (Table HA-5) are ~$300-$5.7K/acre - with the notable exception of a $65K/acre easement in Santa Barbara (CntySBPublicWrks).

Table HA-4. Land Acquisition - $/acre				
Location	Year	Units	Cost Per Unit	Source
ColR	2006	typical	Rural: $5K/acre Urban: $100K/acre	NOAA, p5-46
Mill/RockCrks-SmithR-DelNorteCnty	01-02	24,580 ac	$5M ($203/acre)	CDFG-034
SLOCreek	02-03	80 acres	$100K ($1250/acre)	CDFG-218
SONC SONC-NOCECA NOCECA CentralValley SCACO	98-05 2003$	16 sites 16 sites 51 sites 67 sites 87 sites	$12.1K ($157-$37.3K)/acre $10K ($316-$53.7K)/acre $295.6K ($138-$1.8M)/acre $5.9K ($195-$32.6K)/acre $87.3K ($387-$1.7M)/acre	HT07a-T61, p121
SanFranBay	1999	typical	$6K-$15K/acre (South Bay) $2K-3K/acre (North Bay)	USEPA ’99, p171
Badger Creek (Cosumnes River)	1996	4300 acres	$12.0M ($2.8K/acre) - wetland/ forest/vernal pool, Valensin Ranch	ERP-96-M06
Cache Slough (SacrmntoR/ SanJoaquinDelta)	1997	4760 acres	$8.747M ($1.8K/acre) - tidal wetland/ riparian corridor/upland, Liberty Island	ERP-97-B03
San Joaquin River	1997	6288 acres	$20.5M ($3.3K/acre) -floodplain, USFWS SanJoaq Natl Wildlife Refuge 4324 acr fee, 1964 acr easement	ERP-97-B04
Sacramento River	1997	1880 acres	$8.705M ($4.6K/acre) - seasonal wetland/riparian/riverine/aquatic	ERP-97-N02
Sacramento River	1997	95 acres	$838.7K ($8.9K/acre)	ERP-97-N04
Butte Creek	1997	93 acres	$151K ($1.6K/acre) - partial funding only	ERP-97-N06

Cosumnes River	1997	1655 acres	$5.210M ($3.1K/acre) - agricultural/dairy/woodland/ grassland/seasonal wetlands, incl cleanup/repair	ERP–97-N14
Napa River	1998	68 acres	$910K ($13.4K/acre) - marsh wetland, incl restoration	ERP-98-B13
Merced River, Tuolumne River	1998	360 acres	$830.5K ($2.3K/acre) -riparian/ wetland/riverine, Basso Bridge Ecological Reserve & Merced River ranch land	ERP-98-CO4/CO5
Butte Creek	1998	93 acres	$160.4K ($1.7K/acre) - riparian/ wet meadow/grassland/woodland	ERP-98-F03
Sacramento River	1998	537 acres	$2.123M ($4.0/acre) - aquatic/ wetland/riparian, Stones Lake NWR	ERP-98-F12
Petaluma River	1998	181 acres	$255K ($1.4K/acre) - Petaluma Marsh	ERP-98-F13
San Joaquin River	1998	224 acres	$1.1M ($4.9K/acre) - riparian wetland, San Joaquin NWR	ERP-98-F21
Napa River Marsh	1998	453 acres	$1.976M ($4.4K/acre) - South Napa R Tidal Slough	ERP-98-F23
Cosumnes River	1999	1512 acres	$5.2M ($3.4K/acre) - farmland/ riparian, McCormack-Williamson Tract	ERP-99-F04
Tuolumne River	2000	303 acres	$1.386M ($4.6K/acre) - Bobcat Flat Floodplain Acquis	ERP-00-F01
Cosumnes/ Mokelumne Rivers	2001	771 acres	$2.843M + $12.1K project mgmt ($3.7K/acre) - agricultural/ seasonalwetlands/upland/vineyard	ERP-01-N10
Stanislaus River	2001	371 acres	$2.613M ($7K/acre) - riparian/ agricultural land	ERP-01-N11
Sacrmnto/San Joaquin Delta	2001	9269 acres	$12.659M + $87.5K program mgmt ($1.4K/acre) -agricultural/ marsh/riparian/riverine land, Staten Island	ERP-01-N23

Sacrmnto/San Joaquin Delta	2002	1166 acres	$23M ($19.7K/acre) - wetland/ upland, Dutch Slough	ERP-02-C07-D
Tuolumne River	2002	198 acres	$706.6K($3.6K/acre) - floodplain/ riparian habitat, Big Bend 66 acres fee, 132 acres easement	ERP-02-D01
Stanislaus River	2002	184 acres	$2.4M + $357K project mgmt & admin ($13.2K/acre)	ERP-02D-C11
PetalumaRivDelta, SanPabloBay	2002	631 acres	$2.0M ($3.2K/acre) - tidal wetland/adjacent upland, Bahia site	ERP-02-P14
BigChicoCreek/ MudCreek/ SacrmntoRiver	2002	146 acres	$2.278M + $59.5K project mgmt & admin ($15.6K/acre) - irrigated cropland	ERP-02-P16-D
Crevis Creek (Deer Creek, Cosumnes River)	2002	294 acres	$823.2K ($2.8K/acre)	ERP-02-P49

Table HA-5. Conservation Easement - $/acre

Location	Year	Units	Cost Per Unit	Source
CA	03-04	typical	$209-$730/acre - rangeland	Anon'06,p4
Wolverton Gulch-Van DuzenR-HmboldtCnty	04-05	48 acres	$30K ($625/acre)	CDFG-128
ArroyoSeco R-MntereyCnty		100 acres	$300K ($3K/acre)	CDFG-259
SouthCoast StaBarbCnty	07-12	5 acres	$3.525M ($65K/acre)	CntySB PublicWrks
San Joaquin River	2001	362 acres	$2.075M ($5.7K/acre) - riparian/seasonal wetland	ERP-01-N08
Battle Creek	2001	2499 acres	$851.6K ($341/acre)	ERP-01-N24

NorthFork Cosumnes R	2002	2162 acres	$2.0M ($925/acre) - riparian/upslope 1814 acres easement, 348 acres fee	ERP-02-P02
Mill Creek/ Deer Creek	2002	23,846 acres	$4.470K ($187/acre - agricultural land	ERP-02-P26
Tuolumne River	1998	140 acres	$687.0K ($4.9K/acre) - permanent easement, Grayson Riv Ranch	ERP-98-F07
San Joaquin River Delta	1998	168 acres	$425K ($2.5K/acre) - permanent easement, Fern Headreach Island complex	ERP-98-F16
Deer Crk/Mill Crk - Sacr R	1998	166 acres	$688K ($4.2K/acre) - orchards/row crop agriculture/lowlands	ERP-98-F20
Sacrmnto River	1999	1512 acres	$2.0M ($1.3K/acre) - riparian/riverine	ERP-99-B12
LwrTuolumne /San Joaquin	1999	1073 acres	$1.4M ($1.3K/acre) - floodplain	ERP-99-R01
Battle Creek	1999	6851 acres	$2.048M ($299/acre) - 3 ranches, woodland/riparian/grassland/chaparral	IMM-02-I01

MD - MONITORING STATUS AND TRENDS (includes monitoring of baseline, status and trends in habitat, watershed processes and/or populations)

Table MD-1 includes monitoring projects funded by CDFG's Fisheries Restoration Grants Program over the past three fiscal years. Information on the nature of monitoring is provided, as available. Most of the projects focus on life history, migration, distribution, and abundance of particular species on particular streams. Costs are ~$12K-$300K/project. Most of the >$200K projects (e.g., 04-05 CDFG-054, CDFG-208, CDFG-260, CDFG-261; 05-06 CDFG-158 and CDFG-159) appear to have a strong analytical as well as monitoring component.

Table MD-1. Physical/Project-Scale Monitoring - $/project			
Location	Year	Cost Per Unit	Source
TopangaCrk	04-05	$98.3K-relate rainfall to recruitment/survival	CDFG-009
StaMonicaBay		$152.9K-steelhead abund/distribution	CDFG-010
MillCrk		$156.9K-life history, pop size	CDFG-012
SproulCrk(EelR)		$45.9K-production, run timing & size	CDFG-040
HumboldtBay		$216.2K-estuary use/residence time	CDFG-048
UpprRedwdCrk		$65.1K-juvenile migration, biometric data	CDFG-051
LowrRedwdCrk		$62.3K-juvenile migration, biometric data	CDFG-052
MendocnoCnty		$281.2K-life history in 6 streams, eval potential biases in spawning surveys	CDFG-054
ScottCrk		$192K-life history, support artificial propag programs to maintain ESA-listed pops	CDFG-153
SoCenCA		$82.4K-baseline data on spawning/rearing habitat conditions in 8 watersheds	CDFG-196
ScottR		$67K-data on watershed condition/stock status	CDFG-200
ScottR		$77.8K-outmigrant trapping	CDFG-202
ScottR		$45.9K-streamflow/precip gauging for Water Balance Model	CDFG-205
PrairieCrk-Hmbldt		$211.2K-validate monitoring protocols for watershed restoration	CDFG-208
Scott/ShastaR		$169.4K-juvenile migration	CDFG-224
DelNorte/Hmbldt		$307.1K-juvenile sal abundance for 2 regional watersheds, validate effectiveness of juvenile abundance trends as indic of adult pop conds	CDFG-260
SLO		$238.3K-distribution/habitat use; quantify linkages among stream physical habitat, water quality, macroinverts, land use & fish	CDFG-261
CanoeCrk-Hmbldt		$65.8K-effect of wildfire on habitat & aquatic ecosystem processes	CDFG-071

Mattole	05-06	$11.5K-life stage monitoring, smolt prod est	CDFG-082
Eel/Salinas,SLrnzo		$78.2K-historical baseline for genetic monitoring	CDFG-089
McGarveyCrk(KlamathRiver)		$141.9K-life history, pop status	CDFG-116
MendocnoCnty		$183.8K-life history 3 streams, evaluate potential biases in spawning surveys	CDFG-158
FreshwaterCrk		$264.8K-life history, eval potential biases in spawning surveys	CDFG-159
UpperRdwoodCrk		$48K-estimate smolt pop using mark-recapture	CDFG-164
LowerRdwoodCrk		$53.9K-estimate smolt pop using mark-recapture	CDFG-166
TomalesBay		$149.5K-life history	CDFG-245
Scott/ShastaR		$170.4K-juvenile migration	CDFG-252
MatilijaCrk		$140K-steelhead assessment	CDFG-277
MattoleR	06-07	$15.6K-downstream migrant monitoring, abundance estimate for chinoook/coho	CDFG-207
MattoleR		$17K-smolt production monitoring	CDFG-208
UpprRedwoodCrk		$48.4K-smolt abundance estimation	CDFG-064
LowrRedwoodCrk		$54.4K-smolt abundance estimation	CDFG-066
Scott/ShastaR		$170K-juvenile emigration monitoring	CDFG-127
MattoleR		$30K-escapement monitoring	CDFG-204
HumboldtBay		$168K-estuary use/residence time by juv sal	CDFG-062
TopangaCyn		$55.3K-steelhead distribution/abundance	CDFG-027
VenturaR		$76.6K-juvenile stlhead distribution/abundance	CDFG-034

MO - MONITORING WATERSHED RESTORATION

Table MO-1 pertains to implementation monitoring to determine if project treatments were constructed correctly and as planned, effectiveness monitoring to determine if restoration has produced desired habitat conditions and/or watershed processes, validation monitoring to determine if hypothesized responses of habitat, watershed processes and/or populations to restoration were correct.

The descriptions in Table MO-1 pertain to the type of restoration activity being monitored, with the cost estimates pertaining only to the monitoring component. The highest cost ($221.7K, ERP-97-N13) was for a bank stabilization project involving large-scale monitoring of many variables. Costs associated with monitoring of other individual projects ranged from $7K (for revegetation project ERP-97-N08) to $90K (for fish screen evaluation project ERP-97-C02). Several other estimates ($87.4K for 04-05 CDFG-036, $142K for 05-06 CDFG-171) involved monitoring of multiple projects funded by CDFG's Fisheries Restoration Grants Program.

Table MO-1. Implementation, Efectiveness and Validation Monitoring - $/project			
Location	Year	Cost Per Unit	Source
CA	04-05	$87.4K - monitor pending/completed Fisheries Restoration Grants projects	CDFG-036
CanoeCrk-Hmbldt		$65.8K - effect of wildfire on habitat&aquatic ecosystem processes	CDFG-071
ShastaR		$61.4K - monitor restoration sites for project effectiveness (habitat and fish)	CDFG-273
Mattole		$65.1K - evaluate effectiveness of watershed rehab project	CDFG-284
CA	05-06	$142K-monitor pending/completed Fisheries Restoration Grants projects	CDFG-171
Sacramento River	1997	$90K-screen evaluation project at Princeton Pumping Plant Fish Screen Facility	ERP-97-C02
Tuolumne River	1997	$47.6K - spawning gravel introduction (11K tons)	ERP-97-C11
Sacramento River	1997	$34K - restoration of 200 acres agricultural land to native riparian forest	ERP-97-N03a
Sacramento River	1997	$102.5K - restoration of 93 acres agricultural land to native riparian forest	ERP-97-N03b
Mill Creek/ Sacramento River	1997	$7.0K - restoration of native riparian vegetation for anadromous fish	ERP-97-N08
Barker/Lindsay/ Cache Sloughs-Sacr/SanJoaqDelta	1997	$29.8K - vegetative restoration	ERP-97-N10
Barker/Lindsay/ Cache Sloughs-Sacr/SanJoaqDelta	1997	$48.7K - exotic species removal	ERP-97-N10
Georgiana Slough/ NoMokelumne R-Sacr/SanJoaqDelta	1997	$221.7K - evaluation of alternative vegetative/ biotechnical techniques for stabilizing bank erosion/restoring levees	ERP-97-N13
Tolay Creek-San Pablo Bay	1997	$60K - 435 acre wetland restoration	ERP-97-N19

Prospect Island/ Cache Slough-SacramentoRiver	1998	$2.353M - levee repair and pump out; large scale monitoring of fish/wildlife/water quality/ phytoplankton/zooplankton/vegetation/benthic/ bathymetry/organic carbon	ERP-98-A01
SacramentoRiver	1998	$49K - fish screen construction	ERP-98-B26
Sacramento River	2000	$10.8K - fish screen installation on intake structure at Pump Station #1	ERP-00-B01
SanJoaquinRiver	2001	$233.4K - riparian/wetland restoration	ERP-01-N08
Sacramento River	2001	$86.3 ($8.6K/screen) 10 vertical screens <40 cfs	ERP-01-N52
Tuolumne River	2002	$203K - riparian floodplain/riverine habitat	ERP-02-P19-D
Mokelumne River	2002	$224.9K - songbird response to riparian restoration	ERP-02-P20

PL - WATERSHED EVALUATION, ASSESSMENT AND PLANNING

Table PL-1 provides examples of watershed evaluations/assessments, including partial assessments such as road erosion surveys and stream surveys. Almost all of the examples in the table come from CDFG's Fisheries Restoration GrantsProgram. Information on the nature of the assessment is provided, as available. Included are road inventory/sediment assessments (costed at $/mile), stream crossing assessments (costed at $/crossing), and watershed/estuary plans (costed at $/acre). According to Weaver/Hagans (WH-p91), the Grants Program allows up to $1.2K/mile for road assessments; just about all the road assessment examples in Table PL-1 meet this criterion. Stream crossing assessments cost $650-$1365/crossing. Most of the watershed plans cost $8-$13/acre and appeared to pertain mostly to erosion control. Several exceptions include a project on the Klamath River to address riparian/channel problems ($76/acre, 05-06 CDFG-115) and two projects involving Humboldt Bay ($853 and $3157/acre, 02-03 CDFG-169 & 227). CDFG's Coho Recovery Strategy (CDFG'04, p1.34) uses a planning cost estimate that is not scaled to the size of the plan ($200K/ planning exercise).

Table PL-1. Watershed Evaluation, Assessment and Planning - $/acre, $/mile, $/crossing				
Location	Year	Units	Cost Per Unit	Source
CA	2000	mile	$1.2K (max allowed by CDFG FRGP for full inventory/assessment/erosion control plan for roads)	WH-p91
HumboldtCnty DelNorteCnty EelR HumboldtCnty HumboldtCnty	01-02	6063 ac 8718 ac 45 mi 7 mi 10.3 mi	$48,080 ($8/acre) - erosion/hab rest $83,959 ($10/acre) - erosion/hab rest $20,338 ($452/mi) - road inventory $2011 ($287/mi) - road inventory $11,387 ($1106/mi) - road inventory	CDFG-106 CDFG-107 CDFG-136 CDFG-140 CDFG-141
RussianR EelR EelR EelR HumboldtBay HumboldtCnty SanFranCnty StaCruz Dnorte/Humb/ MendoCnties	02-03	20 mi 100 mi 8 mi 9 mi 35 acres 76.9 acres 66 mi 153 mi 65 stream crossings	$16.1K ($805/mi) - road inventory $60K ($600/mi) - sediment assess $2.7K ($333/mi) $3.0K ($329/mi) $29.9K ($853/acre) - estuary rehab plan $242,785 ($3157/acre) - erosion/hab rest $70,786 ($1072/mi) $142,812 ($933/mi) - erosion $42,246 ($650/crossing)	CDFG-046 CDFG-077 CDFG-106 CDFG-125 CDFG-169 CDFG-227 CDFG-279 CDFG-332 CDFG-327
EelR	03-04	50 mi	$38.1K ($763/mi) - sediment assess	CDFG-266
SalmonCrk MattoleR GualalaR MendocinoCty SLO Cty EelR MadR SmithR NavarroR	04-05	50 mi 40 mi 22 mi 140 mi 130 mi 110 mi 49.1 sqmi (31424 ac) 6.7 sqmi (4288 ac) 22 mi	$48,621 ($972/mi) - road inventory $23,128 ($578/mi) - road inventory $16,756 ($762/mi) - road inventory $145,175 ($1037/mi) - sediment assess $124,269 $956/mi) - sediment assess $131,023 ($1191/mi) - sediment assess $329,810 ($11/acre) $55,828 ($13/acre) $22,771 ($1035/mi, sediment assess	CDFG-047 CDFG-062 CDFG-112 CDFG-197 CDFG-210 CDFG-238 CDFG-255 CDFG-256 CDFG-271

CottonevaCrk MendcnoCnty MendcnoCnty MontereyCnty KlamathR MendcnoCnty HumboldtBay	05-06	110 mi 165 mi 80 crossng 14 mi 383 acres 50 mi 1.75 mi	$107,637 ($979/mi) - sediment assess $163,001 ($988/mi) - sediment assess $64.4K ($805/crossing) -inventory/assess $23,549 ($1682/mi) - sediment assess $29,240 ($76/acre) - ripar/chnnel dysfunc $55,514 ($1110/mi) $47,338 ($27.1K/mi) - estuary rehab	CDFG-040 CDFG-078 CDFG-101 CDFG-109 CDFG-115 CDFG-130 CDFG-276
RussianR Eel-SmithR	06-07	10 mi 50 crossng	$15,606 ($1560/mi) - sediment assess $68.2K ($1364/crossing)	CDFG-051 CDFG-084
CA	2004	typical	$200K/planning exercise	CDFG'04 p1.34

WATERSHED ORGANIZATION SUPPORT AND ASSISTANCE (OR)

Table OR-1 includes organizational support projects funded by CDFG's Fisheries Restoration Grant Program during the three most recent fiscal years. These can be roughly divided into two categories:
(1) database maintenance, costed at $135K-$152K/project/year. Data requiring maintenance include the California Habitat Restoration Project Database (CHRPD)(04-05 CDFG-033 & 05-06 CDFG-023), passage assessment data (04-05 CDFG-039 & 05-06 CDFG -031), and stream inventory reports (05-06 CDFG-033);
(2) watershed coordination/outreach, costed at $24K-$259K/project . The low end of this range range ($24K, 04-05 CDFG-219) pertains to support of a part-time watershed coordinator, while the high end ($259.1K, 05-06 CDFG-076) pertains to organizational work by a southern California non-profit. CDFG's Coho Recovery Strategy assumes $60K per educational/ technical assistance program (CDFG'04, p.1.35).

Table OR-1. Organizational Support and Assistance - $/project

Location	Year	Units	Cost Per Unit	Source
CA	04-05	1 project	$134.3K - maintenance of CHRPD	CDFG-033
CA		1 project	$196.7K - passage assessment database	CDFG-039
SmithR		1 project	$52.0K - watershed coordinator	CDFG-120
HumboldtCnty		1 project	$95.9K - RCD org support to landowners	CDFG-211
LindsayCrk		1 project	$24.1K - parttime watershed coordinator	CDFG-219
ShastaValley		1 project	$137.3K - RCD outreach coordinator	CDFG-230

CA CA CA StaBarb/ Ventura SmithR SalmonR AptosCrk to ORborder	05-06	1 project 1 project 1 project 1 project 1 project 1 project 1 project 1 project	\$151K - maintain CHRPD \$116.9K - passage assessment database \$151.5K - consolidate stream inventory reports into CalFish \$259.1K - organizational support by Community Environmental Council \$103.8K - WatershedCoordinator \$54.2K - org support by Restoration Council \$141.3K - develop sampling frame for salmon monitoring	CDFG-023 CDFG-031 CDFG-033 CDFG-076 CDFG-098 CDFG-256 CDFG-268
CA	2004	typical	\$60K per education/tech assist program	CDFG'04 p1.35

PM - PROJECT MAINTENANCE FOLLOWING PROJECT IMPLEMENTATION

Weaver/Hagans suggest \$275/mile/year for culvert maintenance. Dupont estimates culvert life of 10-30 years, although his estimates pertain to Idaho (not California).

Table PM-1. Culvert maintenance - \$/culvert/year				
Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	Routine culvert replacement/cleaning/fill slope excavation: \$275/mile/year	WH, p101
Idaho	2004	typical	<u>Culvert Type:</u> Iron fish ladder - \$10/yr (30 yrs) Block fish ladder - \$10/yr (10 yrs) Baffled culvert - \$20/yr (30 yrs) Drop structure - \$40/yr (30 yrs)	Dupont-T5 (p62), T6 (p63)

Maintenance of 50 screens on Scott River cost \$1.4K/screen/year. These are probably fairly small screens. Maintenance costs may be higher for larger screens.

Table PM-2. Fish Screen Maintenance - \$/screen/year				
Location	Year	Units	Cost Per Unit	Source
ScottR	01-02	50 screens	\$68,896 (\$1378/screen/year)	CDFG-034

Weaver/Hagans suggest $25/mile/year for maintenance of forest roads. Estimates for other types of roads could not be found.

Table PM-3. Road Maintenance - $/mile/year				
Location	Year	Units	Cost Per Unit	Source
CA	2000	typical	Maintenance inspection forest roads: $25/mi/yr	WH, p101

The only plant thinning example found was specific to farmland. Costs were contingent on the method of thinning (mechanical, hand, chemical).

Table PM-4. Upslope/Riparian Plant Thinnings - $/project				
Location	Year	Units	Cost Per Unit	Source
CA farmland	FY07	typical	Forest Stand Improvement-Thinning Mechanical: $850/acre Hand,15-30%slope,40-60%cover: $900/acre Hand,30-50%slope,60-90%cover: $1200/acre Chemical: $150/acre	NRCS CA

RE - COOPERATIVE FISH REARING

Flagg and Nash (1999) make a number of recommendations regarding operation of conservation hatcheries - e.g., select broodstock using appropriate genetic protocols, maintain broodstock on natural photoperiod and water temperatures, provide incubation and rearing environments that mimic conditions in the wild (e.g., overhead cover, instream structures/substrates), reduce rearing densities, vary water-flow velocities, provide "natural" diet composition and feeding rates, provide bottom feed delivery systems, rear fish in water from the intended return location, release hatchery smolts at sizes similar to wild smolts, provide for volitional releases that do not exceed carrying capacity, have multiple broodstock facilities to protect against local disasters (e.g., equipment failure), establish appropriate monitoring and evaluation strategies. They conclude that "Implementation of such [conservation hatchery] programs would require significant capital expenditure, with increased hatchery operating costs and reduced fish production. Some increased costs would be offset by conservation hatcheries releasing smaller numbers of highly adaptable fish."

Construction and operational costs of a conservation hatchery depend on a variety of factors - e.g., whether the hatchery is newly constructed or a modification of an existing hatchery, which of the Flagg/Nash recommendations are implemented at the hatchery and the particular facilities and protocols needed for such implementation, scale of hatchery production, the particular species at the hatchery (since rearing time varies among species).

The Kingfisher Flat Hatchery on Big Creek operates an artificial propagation program to supplement depressed wild coho runs. The hatchery receives about $95K/year from the CDFG Fisheries Restoration Grants Program (Table RE-1). The extent to which the $95K reflects the cost of the hatchery's coho conservation program is difficult to determine, given that (1) the hatchery engages in other activities as well (e.g., chinook rearing), (2) the hatchery relies heavily on volunteer labor and also receives funding from other sources, (3) the SWFSC Santa Cruz's captive broodstock program provides gametes to the Kingfisher facility to increase coho genetic diversity (at no cost to the hatchery).

Table RE-2 describes capital and operating costs for a number of Columbia River hatcheries that are larger than Kingfisher Flat. While some of these hatcheries engage in some conservation activities, they are largely production hatcheries. Information provided in Table RE-2 is intended to give a very rough idea of hatchery costs.

Table RE-1. Hatchery Operation

Location	Year	Cost	Production	Source
Kingfisher Flat Hatchery	04-05	$94.3K/year	~240K chinook smolts, 45K steelhead smolts,100s coho smolts	CDFG-281
Kingfisher Flat Hatchery	05-06	$99K/year	~240K chinook smolts, 45K steelhead smolts,100s coho smolts	CDFG-276

Table RE-2. Columbia River Hatcheries (Source: IEAB 2002)			
Name/ Operator	Cost		
	Annual Cost: Annualized Capital (Cap)*, O&M, M&E	$/Released Fish	Production Goal
Spring Creek/ USFWS	$2.07M=$1.17M (Cap) +$900K (O&M)	$0.14	15M sub-yearling tule fall chinook
Clatsop Econ Development Council/ ClatsopCnty	AcclimationCosts: FallChin - $41.8K SprChin - $242K Coho - $98.4K FullCycleCosts: Coho - $124.2K	 $0.23 $0.28 $0.04 $0.18	 180K fall chinook smolts 850K spring chinook smolts 3.4M coho smolts
NezPerce/ tribe	$5.3M=$1.2M (Cap)+$2M (O&M)+$2.1M(M&E)	$2.60	1.4M fall chinook smolts 625K spring chinook smolts
Yakima/tribe	$4.7M=$1.5M (Cap) +$3.2M (O&M)	research facility	810K spring chinook smolts 700K coho smolts
Leavenworth/ USFWS	O&M by Facility: Leavenworth-$863K Entiat-$329K Winthrop-$430K (Built 1939-40, no capital cost, fully depreciated)	By Facility: $0.33 $0.46 $0.47	3M spring chinook smolts 200K summer steelhead smolts
PriestRapids/ WDFW	$527K=$210K (Cap) +$317K (O&M)	$0.08	3.7M fall chinook smolts
Irrigon/ ODFW	$1.95M=$794K (Cap) +$1.156K (O&M)	$1.30	1.7M summer steelhead smolts
McCall/ Idaho DFW	$899K=$418K (Cap) +$481K (O&M)	$1.09	8K adult summer chinook
* Annual capital costs, calculated as the original construction cost amortized over 50 years at 3%.			

WILDLIFE MANAGEMENT

The average cost per pikeminnow harvested in the Columbia River bounty program is $6.05/fish. Whether this cost estimate would be similarly applicable to a California eradication program would depend on the nature and scale of the program and the extent of angler interest and success in harvesting pikeminnow.

Table WM-1. Invasive Aquatic Species (e.g., pike minnow eradication)			
Location	Year	Cost Per Unit	Source
ColR	2005	Annual program cost (rewards+tags): $1,546,232 Avg $6.05/fish (=$1,460,724 total rewards/241,357 total fish harvested)	Porter, p41

RES - RESEARCH - productivity research (life cycle monitoring/analysis), spatial structure (fish distribution surveys), genetic diversity (laboratory analysis of tissue samples), and abundance estimates

Columns 2-3 of Table RES-1 describe start-up and annual costs of monitoring activities identified by CDFG/NMFS in several recent workshops. Several caveats in interpreting the cost estimates: (1) The estimates pertain only to coastal salmonids (i.e., exclude Central Valley), (2) the estimates are incremental in that they represent what is needed over and above what is currently being spent for coastal salmonid monitoring, and (3) the estimates assume that all labor is paid (no volunteers).

Monitoring costs are provided here because monitoring data are essential to conducting research on VSP (viable salmon population) attributes. Columns 4-7 of Table RES-1 identify which types of data are relevant to evaluating which VSP attribute. Because some of the data requirements relate to multiple VSP attributes, it is impractical to devise separate costs for each attribute.

As reflected in Table RES-1, the monitoring program is intended to follow different strategies in northern and southern areas. The northern area is defined as the Oregon border to Aptos Creek (five ESUs); the southern area is defined as the Pajara River southward (two ESUs). The boundaries of the two monitoring areas do not coincide with the boundaries of the recovery domains. However, it may be possible to allocate monitoring costs among domains (e.g., on the basis of proportion of total salmonid stream miles within each domain).

The costs noted in Table RES-1 are incomplete with regard to overall coastal salmonid research needs. Other activities mentioned in Boydstun and McDonald (2005) include: (1) habitat condition monitoring, (2) augmented samples for genetic monitoring, (3) other biological monitoring (e.g., otoliths, adult gender, length-weight samples), and (4) laboratory and computer analysis of data.

Table RES-1. Monitoring Activities and Costs as They Relate to Specific VSP Attributes Source: Boydstun & McDonald 2005 - pp 54-55 & Table8/p 58.						
Monitoring Activity	Estimated Cost		VSP Attribute			
	Startup	Annual	Abundance	Distri-bution	Genetic Diversity	Producti-vity
Northern spawner survey (OR border-Aptos Creek)	$566K	$2,545K	X	X	W/additnal sampling	X
Southern steelhead monitoring (PajaroR southward)	$65K	$541K	X			X
Life cycle monitoring stations (2 stns per coastal recovery domain)	$1,036K	$1,370K				X
Juvenile salmonid surveys	$177K	$1,307K	Cutthroat only*	X	W/additnal sampling	Cutthroat only*
25% hatchery fish marking (additional marking needed @ Iron Gate & Rowdy Creek only)	$0	$69K				X
Angler creel survey SmithR-SLO Creek, except Klamath/Trinity chinook/coho (already monitored by CDFG)	$14K	$369K				X
Administrative/ special studies	$36K	$789K				
* Assume monitoring from Eel River to Smith River and 30 miles inland.						

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