Ecosystem Work Group Recommendations
Strategic Plan for
Restoring the Delta's Ecosystem

Delta Vision

Developing Draft
5/13/2008

The EWG presented the prior draft of this document, dated 4/24/08, to the Blue Ribbon Task Force on April 25, 2008. This update adds Table 3 – summary of the proposed strategies, slightly revises Table 2 – Performance Targets, and adds some additional text. Not all comments received to date have been incorporated in the text though the tables are revised.

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1 Introduction

The purpose of the Delta Ecosystem Restoration Strategic Plan is to chart a specific suite of strategies that when followed are intended to reverse the changes in Delta ecology such that desirable ecological communities, including native species, their natural habitats, and the ecological processes necessary for their support are all returned to a level that can be resilient in the longer term. This document represents the recommendations as currently being formulated by the Delta Vision Ecosystem Work Group for the Ecosystem Restoration component of the Delta Vision Strategic Plan.

The Ecosystem Work Group has used the following steps to develop its recommendations; Fig 1 illustrates the linkages between these steps:

Step 1: Define the problems and their underlying drivers (Section 2)
Step 2: Define the desired ecosystem characteristics that represent the Delta as part of a healthy estuarine ecosystem and that represent solutions to the problems (Section 3)
Step 3: Define indicators of each desired ecosystem characteristic and establish performance targets for each indicator, quantitative wherever possible (Section 3)
Step 4: Develop strategies for achieving the desired ecosystem characteristics, based on understandings of forcing functions of the defined problems and factors affecting their solutions (Section 4)
Step 5: Recommend actions to implement these strategies (Section 5)
Step 6: Suggested performance measures to evaluate effectiveness of strategies and actions (Section 6)

Figure 1. Developing Ecosystem Recommendations

This draft of April 24, 2008 represents ~75% completion of steps 1 through 3. Steps 4 and beyond will be undertaken imminently.

All of this work is presented in the context of the overarching ecosystem goals for Delta Vision:

1) For the Delta to function as part of a healthy estuarine ecosystem
2) For ecosystem and water supply reliability to be co-equal

Each element of this document follows the "restoration recipe" presented in Figure 2. It provides very clear guidance for articulating problems, desired futures, performance targets, and the strategies and actions necessary to meet targets.

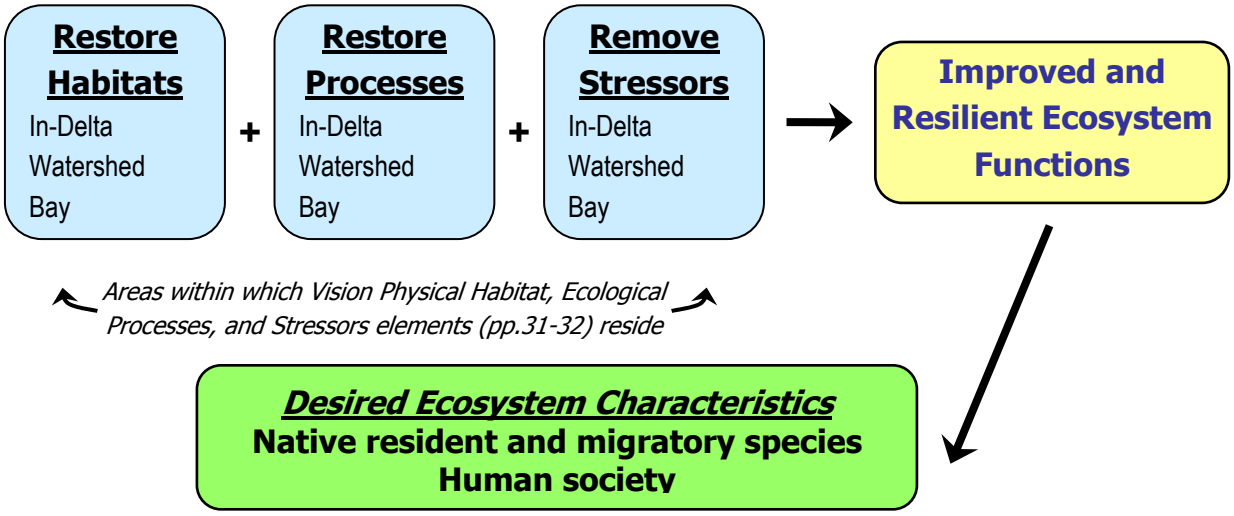

Figure 2. Ecosystem Restoration "Recipe"

These recommendations complement work being undertaken by the CALFED Ecosystem Restoration Program (ERP) Conservation Strategy, the ERP Delta Regional Ecosystem Restoration Implementation Plan (DRERIP), the Bay Delta Conservation Plan (BDCP), the Interagency Ecological Program (IEP), the Operating Criteria and Plan (OCAP), the Suisun Marsh Plan (SMP), and resource agency recovery plans.

2 Problem Statement

What are the measures or indicators of today's poor Delta ecosystem function? What underlying causes drive that poor function? By defining these indicators and the range of possible underlying causes, we can begin to identify strategies for their resolution. The information presented here comes from primary technical efforts that have been seeking to identify underlying causes and/or to develop strategies to improve the Delta. These problems and their underlying drivers are addressed

in Section 4 via strategies to improve the Delta as a functioning component of a healthy estuarine ecosystem.

Problem Indicators

The Delta is changed from abundant populations of fish and wildlife species, highly productive, variable conditions, extensive diverse habitats, good migration corridors, and free of contaminants to many listed species, impaired primary and secondary production, homogenous conditions, minimal and uniform habitats, poor transit corridor, and contaminant-affected water and sediment quality. Specifically:

1. **Population declines of native resident and migratory fish species:** Across a broad range of functional groups of native resident and migratory fish species that utilize the Delta, there have been major recent population declines – Delta smelt, longfin smelt, splittail, salmon, sturgeon. Their past declines already lead to their protected status and, with the recent declines, provide clear indication of the Delta's degraded ecological functions.
2. **Impaired primary and secondary production:** Reduced primary production, shift in phytoplankton assemblages away from diatoms, and loss of productivity to invasive species result in greatly reduced capacity to support higher trophic level native aquatic organisms
3. **Low variability in the aquatic environment:** Low intra- and inter-annual variability in inflows and outflows, environmental water quality, residence time, and channel geometry result in greatly reduced ability to support life history requirements of native species that utilize or depend on the Delta at different locations and times of year
4. **Minimal and uniform habitat with poor connectivity:** Major loss of natural habitats and reduced diversity and connectivity of remaining habitat types results in greatly reduced capacity to meet life history requirements of native species that utilize or depend on the Delta at different locations and times of year
5. **Poor transit corridor for migratory fish:** Altered flow regimes, diversions, predators, and poor water quality adversely affect juvenile and adult migration success leading to declines in abundance and fitness
6. **Poor water quality:** Exposure to contaminants in the water column and sediments generate lethal and sublethal toxicity effects in fish and wildlife populations and impairments of temperature, salinity, and dissolved oxygen reduce environmental water quality, both leading to declines in abundance and fitness

Problem Drivers

These problems derive from a number of factors:

- Physical habitat loss
- Flow-related habitat loss
- Loss of connectivity and extensive interfaces between different elements of the terrestrial and aquatic environments
- Dominance by aquatic invasive species; competition and predation by invasive species
- Altered flow regimes: reduced Delta inflow, reduced long-term Delta outflow, increased exports within and from the Delta, reversed river flows from through-Delta conveyance
- Altered geometry of Delta waterways in planform and cross section
- Low variability in surface water residence times throughout Delta waterways
- Entrainment
- Contaminant loadings

Relationships between Drivers and Indicators

Strategies and actions to achieve the desired ecosystem characteristics (Sections 4 and 5) are aimed at those underlying drivers of the problems that can be manipulated with direct human intervention, recognizing that some interventions may be difficult to implement.

Table 1. Indicators and Drivers of Poor Ecosystem Function

	Drivers of Poor Ecosystem Function *								
Indicators of Poor Ecosystem Function	Physical habitat loss	Flow-related habitat loss	Connectivity and interface loss	Nuisance Invasives	Altered flow regimes	Altered geometry	Low residence time variability	Entrainment	Contaminant loadings
1) Population decline	✓	✓	✓	✓	✓	✓	✓	✓	✓
2) Impaired primary and secondary production	✓	✓	✓	✓	✓	✓	✓	✓	✓
3) Low variability in the aquatic environment	✓	✓	✓	✓	✓	✓	✓		
4) Minimal and uniform habitats and poor connectivity	✓	✓	✓		✓	✓	✓		
5) Poor transit corridor for migratory fish	✓	✓	✓	✓	✓	✓	✓	✓	✓
6) Poor water quality	✓	✓	✓		✓	✓			

Agents of Ongoing Change

The final piece informing development of strategies and actions are those forces that will drive ongoing change in the Delta, the lower estuary, and the watershed:

- Land use and population growth
- Sea level rise
- Climate change
- Seismicity
- Levee stability
- New invasions of nuisance species

3 Desired Ecosystem Characteristics, Their Indicators, and Performance Targets

This section will be expanded in a subsequent draft to provide explanatory text to help the reader understand how the Ecosystem Work Group arrived at the information presented

We have developed two categories of desired ecosystem characteristics, following the general concept of the restoration recipe presented above: (1) the species and human outcomes and (2) the underlying habitats, processes, and stressor reductions necessary to achieve the species and human outcomes.

Group 1: Characteristics and Indicators: Species and Human Outcomes

In order to have a Delta that highly productive, variable conditions, extensive diverse habitats, good migration corridor, and free of contaminants, the Ecosystem Work Group recommends establishing the following five desired ecosystem characteristics and their associated indicators:

1) Viable populations of native resident fishes and migratory birds

a. Abundance of selected species that represent a diversity of functional groups
b. Geographic distribution

2) Functional corridors for migratory fish species

a. Migration success
b. Connectivity to upstream and downstream habitats
c. Suitable environmental water quality and flow along migratory corridors

3) Ecosystem functions that support human services

a. Flood protection
b. Water quality
c. Recreation
d. Buffers

Group 2: Characteristics and Indicators: Habitats, Processes, and Stressor Reductions

4) Diverse mosaic of habitats and ecosystem processes to support native resident and migratory estuarine species

a. Areal extent of tidal marsh, seasonal floodplain, uplands, and open water
b. Attributes of the target ecosystems: complexes of multiple habitats, spatial distribution of complexes, connectivity within and between complexes, productivity, and durability or resiliency

5) Stressors reduced to below levels of adverse effects

a. Reduced contaminants impacts
b. Reduced or eliminated entrainment
c. Reduced impact of current and possible future nuisance invasive species

Performance Targets for Each Indicator

Table 2 presents the full suite of performance targets for each of the indicators listed above.

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

Desired Ecosystem Characteristics and Their Indicators		Performance targets
1 Viable populations of native resident fishes and migratory birds		
A) Abundance (population size and partial proxy for genetic diversity)		
	Fish	**delta smelt:** ≥100% 1967-1983 Fall Midwater Trawl index
		longfin smelt: ≥100% 1967-1983 Fall Midwater Trawl index
		splittail: exceed low levels observed during 87-91 drought
	Birds	**Ducks:** ≥1.4 million sustained at peak wintering abundance (CVJV population objective) Delta and Suisun combined
		Shorebirds: ≥70,000 sustained at peak wintering abundance, January through February (CVJV population objective) Delta and Suisun combined
		Aleutian Canada goose: Sustain 50% of the world's population during winter residence
		Tundra swan and white-fronted goose: Sustain 40% of the Pacific Flyway population during winter residence
		Canvasback: Sustain 20% of the Pacific Flyway population during winter residence
		Raptors (Swainson Hawks) & Song Birds
	Plants, Herps, Mammals	***Include only functionally critical species, TBD***
B) Distribution (partial proxy for genetic diversity and habitat quality)		
	Fish	**delta smelt:** present in all FMWT sites that occur within the target fall habitat (see below)
		splittail: spawning adults present in all accessible seasonal floodplain habitats
	Birds	***Pending***
	Plants, Herps, Mammals	***Include only functionally critical species, TBD***

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

Desired Ecosystem Characteristics and Their Indicators	Performance targets
2 Functional corridors for migratory fish species	
A) Migration success	
Salmon and steelhead	≥95% survival of adult fish migrating through the Delta; ≥50% survival of juvenile fish migrating through the Delta (measured by tagging studies)
Sturgeon	≥95% survival of adult fish migrating through the Delta; ≥50% survival of juvenile fish migrating through the Delta (measured by tagging studies)
B) Connectivity to upstream and downstream habitats	
Salmon, steelhead, and sturgeon	Zero incidents per year of upstream or downstream passage delay, blockage or mortality blocked by physical barriers
C) Suitable environmental water quality and flow along migratory corridors	
Salmon, steelhead, and sturgeon	Zero incidents per year of upstream or downstream passage delay, blockage or mortality from low DO, high temperatures, or toxic contamination
San Joaquin salmon	>0 cfs net downstream flow on the San Joaquin River at Jersey Point (i.e., no reverse flow condtions) from October 1 through June 30
Dissolved oxygen	>5 mg/L in all locations at all times
3 Ecosystem functions that support human services	
A) Flood protection B) Water quality C) Recreation D) Buffers	***Pending***

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

Desired Ecosystem Characteristics and Their Indicators	Performance targets
4 Diverse mosaic of habitats and associated ecosystem processes to support native resident and migratory estuarine species	
A) Areal extent of tidal marsh, seasonal floodplain, uplands, and open water	
Tidal wetlands (on lands within tide range and <~5ft subsided; intertidal elevations currently being updated by DWR)	**Long-term (>30yr):** all suitable lands (80,000 acres Delta, 50,000 acres Suisun) **Short-term (<30yr):** half of all suitable lands (40,000 acres Delta, 25,000 acres Suisun) **Interval targets at 10 and 20 years:** 1/3 and 2/3 of short-term target
Floodplains (need to evaluate land elevations and river stages to improve opportunity area understanding)	> 50,000 acres with variable inundation conditions to support resident and migratory fish and migratory shorebirds and waterfowl and including annual vegetation (e.g., ongoing agricultural) and riparian forested lands
Terrestrial grasslands/seasonal wetland complexes/sea level rise accommodation (upper elevations not yet confirmed)	**Long-term (>30yr):** all suitable lands (~130,000 acres Delta, 5,000 acres Suisun) **Short-term (<30yr):** half of all suitable lands (~65,000 acres Delta, 2,000 acres Suisun) **Interval targets at 10 and 20 years:** lower-elevation lands, lands at high risk of urbanization, corridor between Suisun Marsh and Cache Slough
Open Water	**Delta smelt fall habitat:** Provide 35,000 acres (quantity existing prior to the declines beginning in 1984) of fall open water habitat with salinities between 0.5 to 6 psu, turbidity of XX, and temperature < YY **Delta smelt spring and summer habitat:** temperature within spawning range **Longfin smelt habitats:** pending
B) Attributes of the target ecosystems: value of restored ecosystems proportional to number of these attributes achieved; *we can probably improve the quantitative descriptions of these attributes*	
1) Complexes of multiple habitats	**Multiple large complexes of connected habitats** spanning the aquatic to terrestrial gradient in space and aquatic habitats in time
	Long interfaces (e.g., >500m) between uplands and tidal wetlands, tidal wetlands and open water
	Dendritic systems of large waterways that allow for in-channel geomorphic adjustment and are connected to adjacent tidal marshes and floodplains

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

Desired Ecosystem Characteristics and Their Indicators	Performance targets
	Direct organism and material transport between terrestrial grassland/seasonal wetland complexes, adjacent tidal wetlands and/or seasonal floodplains, and open water
2) Spatial distribution of habitat complexes	**Distributed along multiple locations** of gradients of salinity, riverine vs. tidal inundation, sediment supply
	Located in areas that **support populations of target species**
	Located in areas **not subject to adverse effects of stressors**
3) Connectivity within and between complexes	**Waterways linking patches** of tidal wetlands, seasonal floodplains, and open water with flow velocities and net direction allowing aquatic organisms freedom of movement within their physiological tolerances and production to be transported from source areas to target organisms
	Wetlands and uplands corridors within diverse habitats mosaic that allow terrestrial species to move between patches of habitats
4) Productivity	**Pelagic food web:** predominantly diatom based **Wetlands:** predominantly native species vascular plant and diatom based **Floodplains:** *Pending from Jeff Opperman* **Upland/seasonal wetland complexes:** densities of small mammals, invertebrates, herps at levels found in similar systems locally (e.g., Jepson Prairie)
5) Durability/Resilience	All restored habitats **located in places not subject to natural or anthropogenic loss or degradation over time**, eg climate change, urbanization

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

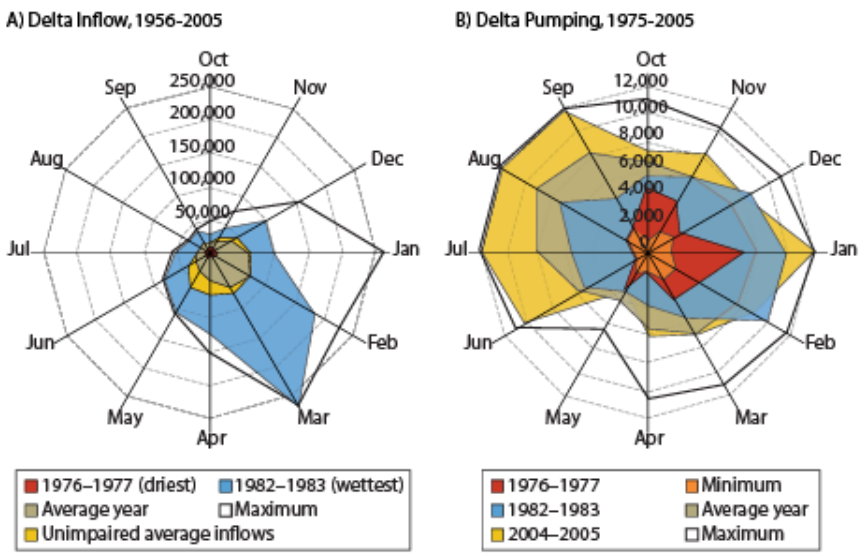
Desired Ecosystem Characteristics and Their Indicators	Performance targets
5 Stressors reduced to below levels of adverse effects on native resident and migratory species and their habitats	
A) Reduced contaminant impacts	
1) Concentrations in Delta waters and/or sentinel organisms	<5% estuarine and anadromous fish show evidence of exposure and there are zero incidents of fish kills
2) Nitrogen:Phosphorus ratio	Restore nutrient loadings to N:P ratios supportive of diatoms
B) Reduced or eliminated entrainment	
1) Delta smelt, longfin smelt	Entrainment proportional to preceding FMWT adults and juveiles separately - see DWSG notes for numbers
	Entrainment of pre-spawning females least in Jan-Feb - half of DSWG for numbers, double in March-April
2) Salmonids	Entrainment no more than 2% of outmigrating population
3) Productivity	***Pending***
C) Reduced impact of current and possible future nuisance invasive species	
1) *Corbula* (saline species)	<100% of 1995-2000 average abundance and distribution
2) *Corbicula* (freshwater species)	***Pending***
3) *Egeria*	<50% average 1990-2000 abundance and distribution
4) Control future invasions	No new introductions from ballast waters No new introductions from commercial and recreational vessels No new introductions from other accidental or intentional releases

4 The Complex Delta: Opportunities and Constraints

The complexity of the Delta defines the opportunities and constraints within which we must develop restoration strategies and actions. Inadequate knowledge, unpredictability, lack of control, uncertainty, and tightly coupled human-natural systems undermine our abilities to develop effective approaches. Ecological improvements will necessitate finding mutual human-ecological interests, accepting some trade offs, and working with complexity.

Flow

Restoring flows for the Delta ecosystem can be accomplished in numerous ways and developing and evaluating options is an active pursuit of other Delta planning efforts. Critical to defining how to restore flows is to understand the timing of needed flows to accomplish its many purposes. Native species evolved under natural Mediterranean climate conditions – winter wet, summer dry. We regulate inflows via dam operations and upstream diversions (Figure 3A). We export throughout the year at varying magnitudes (Figure 3B), a setting relatively disconnected from natural conditions.



Seasonal and Annual Variability of (A) Delta Inflows and (B) Delta Pumping, from DWR DAYFLOW DATA. Note scale difference in flow rates between the two diagrams. *From PPIC 2007*

Figure 3. Delta Inflow and Pumping, Seasonal and Annual Variability

The Narrow Elevation Band of Intertidal Marshes, Tide Ranges, and Land Elevations

Tidal marsh exists within a narrow elevation band associated with the local tidal range (Figure 4). Tidal freshwater marsh vegetation grows at most intertidal elevations; Suisun's tidal brackish marsh

vegetation grows across a narrower range of intertidal elevations; and the lower estuary's tidal salt marshes grow in the narrowest upper intertidal elevations.

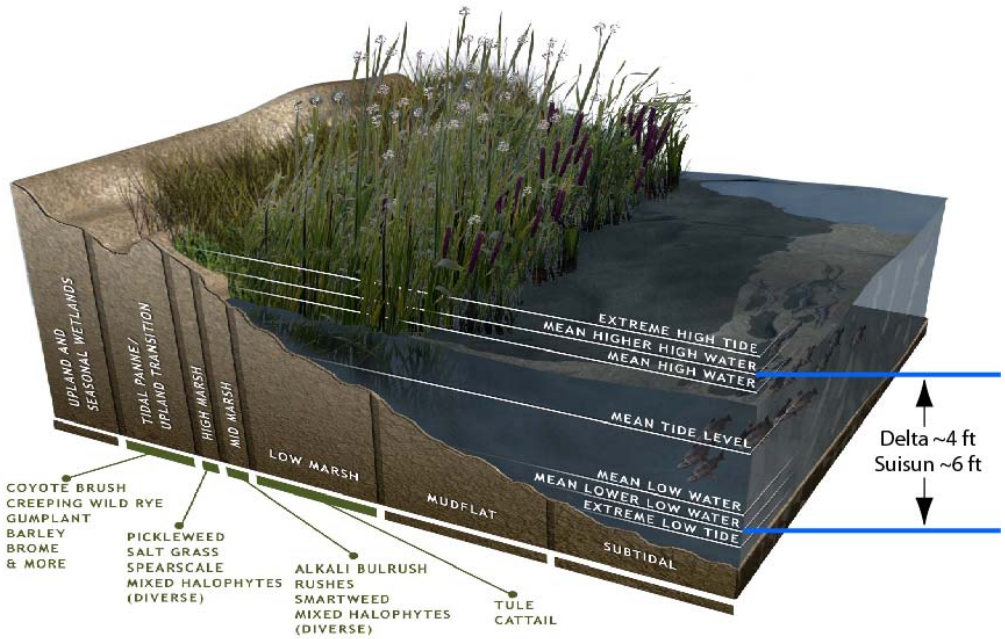
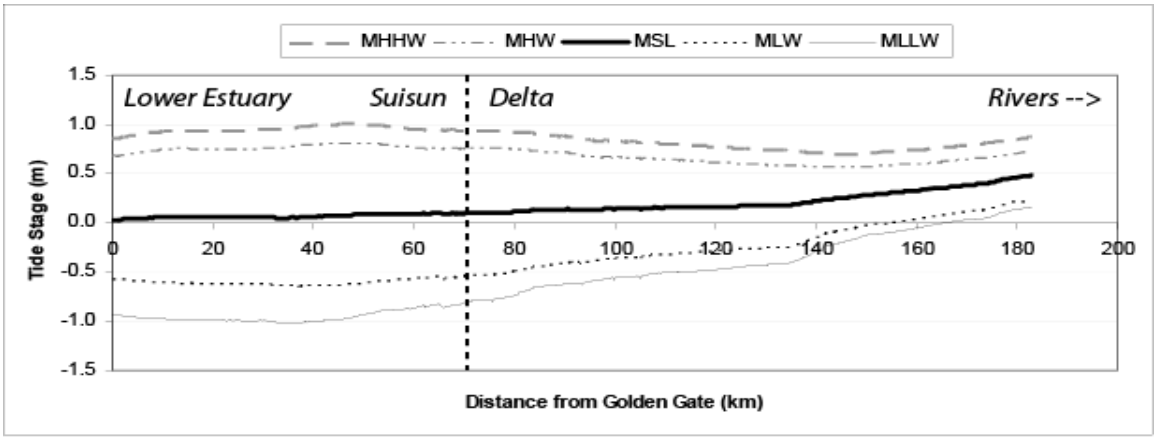


Figure 4. Tidal Marsh Profile with Adjacent Uplands and Open Water
Moffatt & Nichol and Stuart Siegel, 2007

The vertical range of the tides is not large – much of the Delta experiences tidal variations of around four feet; Suisun tides are closer to six feet. Not only does tide range decrease moving up the estuary to the rivers, the base height or mean sea level also rises because of the river inflows. Consequently, the actual elevations that are "intertidal" vary around the Delta and establishing the relationship between the land and water requires more than a simple analysis and to date has not been accomplished though DWR has efforts underway to provide these data.

Within the ~500,000-acre Delta, there are about 58,000 acres of undeveloped, diked lands at intertidal elevations of which about 3,000 acres are at moderate to high risk of development (Figure 6). Suisun has about 28,000 acres at suitable intertidal elevations. Where sediment supply is higher such as the North Delta and parts of Suisun Marsh, sedimentation can raise land elevations; thus, lands that have very shallow subtidal elevations may be suitable for tidal marsh restoration as well. Suisun has another ~23,000 acres of shallow subtidal lands and the Delta about 25,000 acres. ***Areas will be updated with new data pending from DWR.***



San Francisco Estuary-California Delta Tidal Datum Profile (modeled). *From DWR 2004*

Figure 5. San Francisco Estuary Tidal Datum Profile (modeled)

Floodplains and Lowland Grasslands

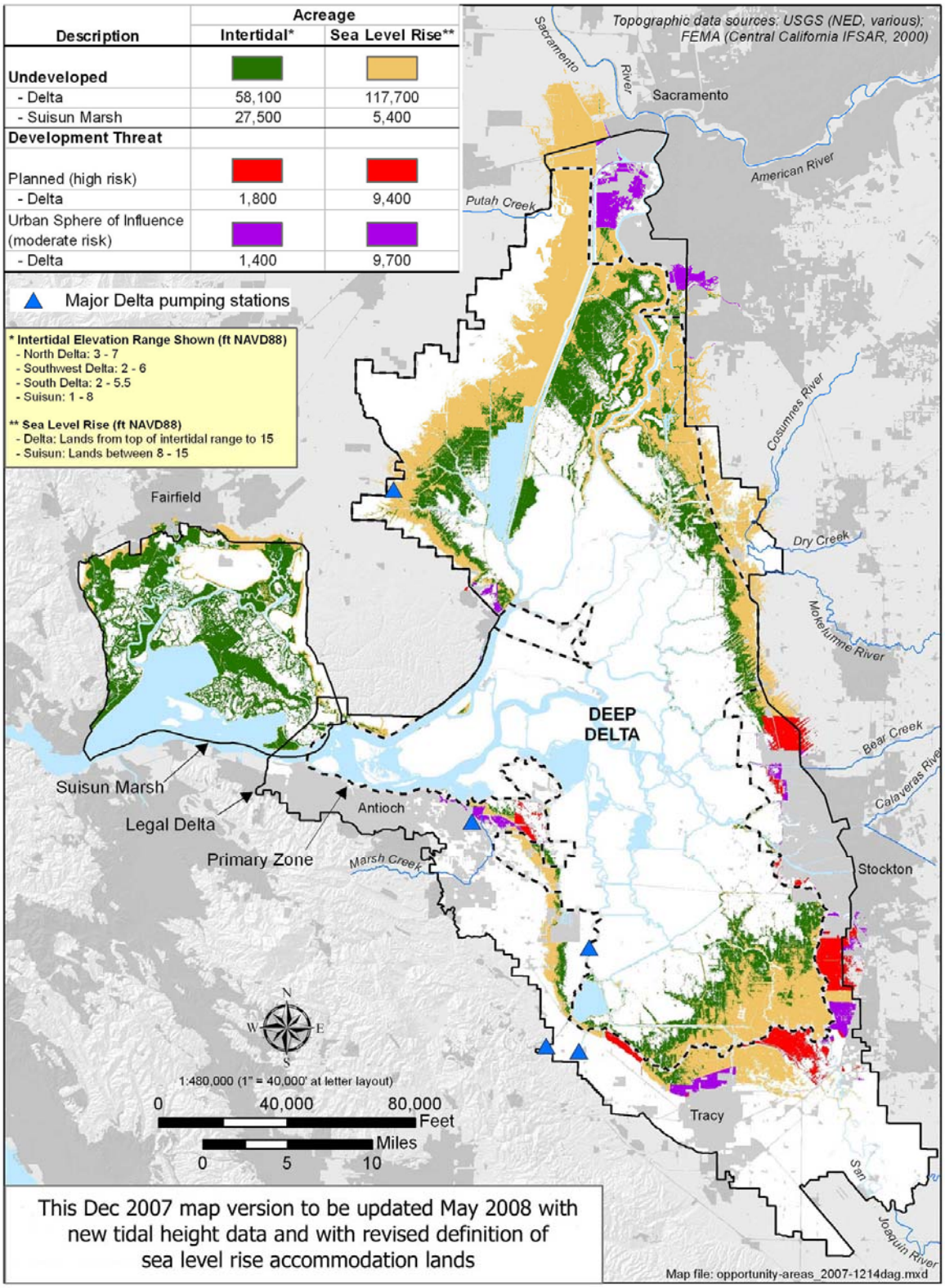
About 118,000 acres in the Delta are undeveloped lowlands extending above current high tide heights to the +15 ft elevation; Suisun Marsh has about 5,000 acres. These lands could be used for accommodating sea level rise, floodplain restoration where land elevations and river stage can be reconnected effectively (large tracts already are actively managed floodplains: Yolo and Cosumnes), and habitats for wildlife species that utilize landscape mosaics of estuarine and grassland areas. Floodplains can and do extent further upstream than this somewhat arbitrary elevation indicates. About 19,000 acres are at moderate to high risk of development in the Delta. Were a higher sea level rise accommodation elevation used, then there would be more land acreage of this type.

Geometry

Humans have constructed numerous "connecting" waterways throughout the Delta for shipping and water supply conveyance (Figure 7). Connecting what were naturally disconnected waterways that produced significant heterogeneity in the aquatic environment has radically altered flow geometry and homogenized the aquatic environment, changing flow routes and residence time that affects fish, their food resources, and water quality. Native species evolved under natural heterogeneous conditions and likely a cause of their decline is the modern homogeneity of the Delta's remaining aquatic environments. The current water surface area of the Delta is about 57,000 acres (excluding Liberty Island and Little Holland Tract which add another 6,000 acres), much of which could be enhanced to provide improved open water habitats for aquatic species. Suisun has about 26,000 acres of open water.

Infrastructure and Land Use

This section to be written. Basic intent is to illustrate the range of constraints on restoration resulting from the infrastructure in the Delta and the current land uses. EWG will work with Bob Twiss to define appropriate maps to include to provide effective and simple illustration in restoration context.



Description	Acreage Intertidal*	Acreage Sea Level Rise**
Undeveloped		
- Delta	58,100	117,700
- Suisun Marsh	27,500	5,400
Development Threat		
Planned (high risk)		
- Delta	1,800	9,400
Urban Sphere of Influence (moderate risk)		
- Delta	1,400	9,700

Figure 6. Intertidal and Low-Lying Uplands Elevations in the Delta and Suisun

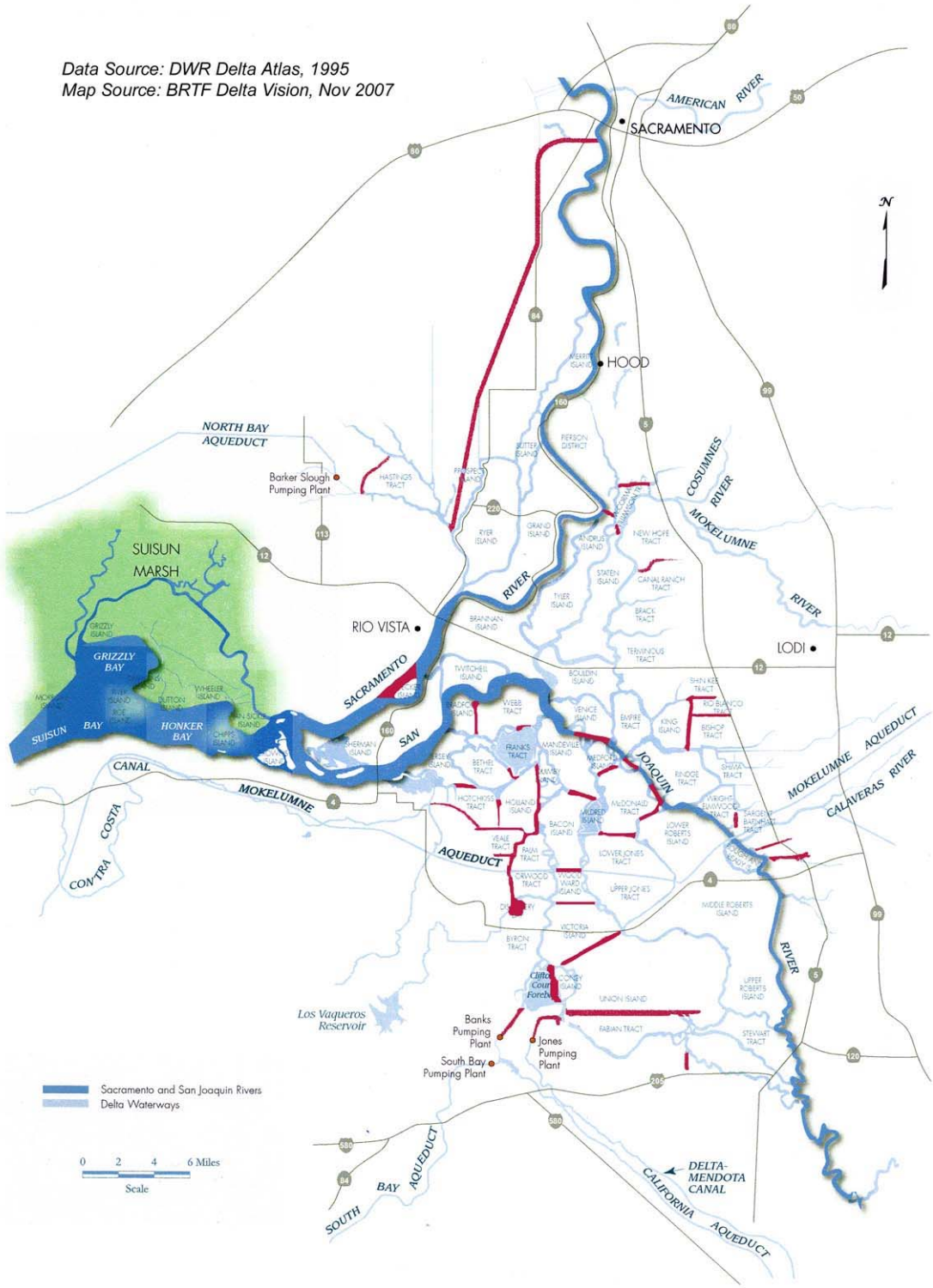


Figure 7. Constructed Delta Waterways

5 Strategies to Achieve Targets

This section to be written. Refer to Figure 1

Concepts Guiding Ecosystem Recovery Strategies

1) Restoration recipe
2) Healey principles of estuaries
3) Fifteen Delta Vision elements of a resilient, regenerated ecosystem
4) Conceptual models
5) Anticipating future agents of change

Strategies

The strategies recommended by the EWG for the Delta Vision Strategic Plan are summarized in Table 3. These strategies are organized around the nine *drivers of poor ecosystem function* described above in Section 2. We anticipate that addressing the underlying problems adversely affecting the Delta ecosystem and the species that utilize the Delta will result in achievement of the *desired ecosystem characteristics* described above in Section 3.

The Strategies included in this May 13, 2008 draft are preliminary and subject to revision through discussion during and following the May 14, 2008 Ecosystem Work Group meeting.

Linking Strategies to Performance Targets

Many strategies are needed to achieve any given performance target described in Table 2. The next version of these *Recommendations* will include either modification to Table 2 or inclusion of a new table that illustrates these linkages.

Table 3. Summary of Ecosystem Restoration Strategies

Drivers of Poor Ecosystem Function
Categories of Strategies
Specific Strategies (provide 1 page details for each strategy)

A) Physical Habitat Loss: tidal marshes, floodplains, open water, uplands, other	
A.1	Immediate actions
A.1.1	Initiate restoration on state, federal, and NGO lands not dependent on further land rights to achieve restoration objectives -- eg, Dutch Slough, Prospect
A.1.2	Initiate final planning then implementation on state, federal and NGO lands and lands with existing easements where restoration awaits resolving design complexities -- eg, Yolo
A.1.3	Complete in-progress acquisitions and activitely seek new acqusitions with priority given to lands contiguous with state/federal/NGO holdings that would greatly improve overall restoration effectiveness -- eg, McMormick-Williamson/Staten Island area
A.2	Priority setting for acquisition and restoration based on ecosystem needs, implementation feasibility, economics, …
A.2.1	Identify areas that can yield the greatest benefits the most rapidly for least cost: high opportunities (eg, topography, connectivity, geography, SLR accommodation) and least constraints (eg, land use, infrastructure, conveyance, drinking water diversions)
A.2.2	Identify areas at risk of conversion to incompatible land uses
A.2.3	Identify areas where opportunistic acquisitions might arise
A.2.4	Formulate prioritized plan of approach for acquisition and restoration
A.3	Land rights acquisition
A.3.1	Implement significant land rights acquisition efforts ASAP using defined priorities
A.3.2	Focus on large blocks of adjoining parcels that facilitate restoration of ecosystem complexes with simplest re-engineering necessary
A.3.3	Restrict development in current and future suitable ecosystem lands
A.3.4	Identify and utilize array of acquisition approaches to provide short- and long-term restoration land needs
A.4	Guidelines for planning and implementation
A.4.1	Formulate adaptive management plan for restoration: design-outcome uncertainties and testable designs, monitoring programs, results integration into decision making
A.4.2	Formulate general design guidelines to improve planning efficiencies for projects and to ensure that projects include key design features (eg, connectivity, interfaces, dendritic channels, inundation regimes)
A.4.3	Develop restoration-oriented regulatory review guidelines to support local, state and federal permit processing efficiencies
A.5	Funding
A.5.1	Estimate long-term demands for acquisition, planning, implementation, monitoring, and research funds; revise estimates periodically
A.5.2	Establish <u>simple</u> mechanisms for dispersing funds for all aspects of restoration: maximize gains, minimize time spent pursuing funds
A.5.3	Seek diverse array of long-term funding sources
A.5.4	Integrate with other projects -- eg, green levees, flood management
A.6	Restoration coordination
A.6.1	Establish coordinating body to facilitate implementation, monitoring, research, and adaptive management

Table 3. Summary of Ecosystem Restoration Strategies

Drivers of Poor Ecosystem Function
Categories of Strategies
Specific Strategies (provide 1 page details for each strategy)

- A.6.2 Establish Delta-Suisun Ecosystem Restoration Design Review Board to faciliate optimum designs across a broad range of project sponsors and within adaptive management program context -- similar to the SF Estuary Project Wetlands Design Review process
- A.7 Phased Implementation, Monitoring, Adaptive Management
  - A.7.1 Ramp up restoration efforts rapidly
  - A.7.2 Early and comprehensive monitoring of potential adverse effects such as methyl mercury, invasive species
  - A.7.3 Early, comprehenisve, and phased long-term monitoring, research, and adaptive management programs that evaluates restoration effectiveness in meeting Targets and incorporates early lessons learned into later projects and decision making

B) Flow-Related Habitat Loss

- B.1 Fall: establish 35,000 ac open water Sep-Nov with salinities 0.5 to 6 psu, turbidity, temp,
  - B.1.1 Increase outflow Sep-Nov
  - B.1.2 Change geometry of the western Delta and/or Suisun Bay
  - B.1.3 Control invasive *Egeria*, clams, and fish (see D below)
  - B.1.4 Keep Suisun Marsh Salinity Control Gates closed (develop monitored experiment on effects)
- B.2 Spring: increase spring outflow to reflect upstream precipitation patterns better
  - B.2.1 Include Roe Island X2 requirement without trigger
  - B.2.2 Manage flows for maximum continuity of floodplain inundation

C) Connectivity and Interface Loss -- *TO BE COMPLETED*

- C.1 Link floodplains to Delta waterways
  - C.1.1 TBD
- C.2 Restore tidal marshes at Delta perimeter and remove/exclude levees to uplands
  - C.2.1 TBD
- C.3 TBD
  - C.3.1 TBD

D) Harmful Invasives

- D.1 Physical, chemical, and biological control approaches
  - D.1.1 Implement active physical and chemical control of aquatic weeds
  - D.1.2 Research predators, disease, parasites of invasive species to develop biological controls
  - D.1.3 Increase exploitation of invasive species. Consumptive fisheries for centrarchids, others?
- D.2 Prevention methods
  - D.2.1 Monitor and regulate likely pathways for new invasive species
  - D.2.2 Develop response and management plans for expected invasives: quagga and zebra mussels, northern pike, others?
- D.3 Flow and salinity variation approaches
  - D.3.1 Provide periodic salinity intrusions in summer and/or fall of driest years
  - D.3.2 Increase variability in flow and salinity conditions in spring to better reflect climatic variability
  - D.3.3 Increase variability in flow and salinity in fall to reflect conditions in the late 20th century
- D.4 Avoidance measures: restoration
  - D.4.1 Increase habitat diversity to produce more diversity in velocities and depth to favor native SAV and/or disfavor invasives

Table 3. Summary of Ecosystem Restoration Strategies

Drivers of Poor Ecosystem Function
Categories of Strategies
Specific Strategies (provide 1 page details for each strategy)

D.4.2	Design restoration areas to minimize spread of invasives -- learn lessons of errors made at Decker Island and apparent successes at Liberty and Little Holland
D.4.3	Focus restoration efforts in areas where conditions disfavor invasives -- use Suisun Marsh as model
E) Altered Flow Regimes	
E.1	Increase within-year diversity/seaonality of flows
E.1.1	Time reservoir releases in tributaries to condition of outmigrants in each tributary
E.1.2	Maintain integrity of pulse flows (and their fish) through delta
E.1.3	Allow dry season flows to limit predator populations along migratory corridor
E.1.4	Ensure non-toxic flows into freshwater marshes during rainy season
E.1.5	Ensure flows adequate to guide upmigrating salmon to their natal streams, particulalry in the San Joaquin watershed
E.2	Increase diversity of flows across years
E.2.1	Remove trigger requirement for Roe Island X2 requirement so that days of high outflow are required more often
E.2.2	Review outflow requirements to ensure that climate change impacts do not lead to increased stranding of migrants and newly spawned resident species
E.2.3	Minimize simultaneous fall flood control releases from reservoirs so that delta recieves variable inputs and upmigrating adults are presented with clear chemical guidance for homing
E.3	Use flow extremes to improve ecosystem management
E.3.1	In critical years allow salinity to invade normally freshwater areas to benefit natives
E.3.2	In high flow times, open barriers separating channels to promote washout of nutrients and invasives
E.3.3	Lower levees and weirs so that lower flows can inundate floodplains more frequently
E.3.4	Ensure that high flows can access habitats that benefit from occasional inundation (seasonal wetlands, vernal pools, riparian forest recruitment, etc.)
F) Altered Geometry and Low Residence Time Variability	
F.1	Create single migratory corridors for Sacramento, San Joaquin and Mokelumne rivers through delta and minimize diversions, barriers, branches that interfere with both downmigration of young and upmigration of adults
F.1.1	Close or install barriers such as Delta cross channel, head of Old River to minimize exposure of migrants to known hazards or to more convoluted migratory paths
F.1.2	Construct habitats along corridors that permit young outmigrants to hide during day from predators
F.1.3	Remove barriers or risks along corridor, including wastewater toxics, dissolved oxygen barriers, etc.
F.1.4	Ensure adequate flows along each corridor in appropriate months to promote successful migration
F.1.5	Where possible promote juvenile migration in areas that do not allow permanent predator populations, such as floodplains
F.2	Off of main migratory corridors restore dendritic nature of sloughs and channels so that unjoined lengths exceed neap tidal excursion distance
F.2.1	Install boat locks or other barriers in cutoff channels like Woodward canal and Victoria Canal

Table 3. Summary of Ecosystem Restoration Strategies

Drivers of Poor Ecosystem Function
Categories of Strategies
Specific Strategies (provide 1 page details for each strategy)

F.2.2	Restore levees and/or construct wetlands that can keep tidal excursions from mixing thoroughly
F.2.3	Lower levees and/or design wetlands so that substantial water from rising tides floods marshplains rather than flowing upstream
F.2.4	Place restoration sites at mouths of seasonal streams (e.g., Cosumnes River and Marsh Creek) so that rainy season flows mobilize productivity generated during dry season
G) Entrainment	
G.1	Flow alterations
G.1.1	Reduce exports in anticipation of entrainment of sensitive species in area of impact
G.1.2	Coordinate required periods of highest flows to occur at times of greatest benefit to sensitive species
G.1.3	Improve conjunctive use programs so that highest exports occur in years of greatest water abundance and lowest exports occur in years of least water abundance
G.1.4	Limit delta exports to times of high outflow
G.2	Diversions
G.2.1	Operate fish screens and facilities to their design parameters
G.2.2	Develop alternative diversion sites/ water sources outside of delta smelt range
G.2.3	Develop alternative diversion sites in areas where 'salvage' operations are not needed - eg Contra Costa's Old River diversion
G.2.4	Reconfigure/reoperate Clifton Court Forebay to minimize pre-screen predation
G.2.5	Update CVP screens
H) Contaminant Loadings	
H.1	Regulatory approaches
H.1.1	Improve discharge permit conditions to address ecosystem impacts
H.1.2	Improve discharge permit conditions to address mixtures/combined effects
H.1.3	Require discharge permits for all sources
H.2	Refine problem understanding and take appropriate, focused actions
H.2.1	Identify where concentration effects are more important than loads and coordinate flows with discharge to avoid effects
H.2.2	Identify where load effects are most important and reduce sources
H.2.3	Monitor fish health to identify locations and timings of contmainant impacts; manage those sources more closely
H.3	Source reduction approaches
H.3.1	Encourage organic/alternative agriculture/pest control to reduce source loads
H.3.2	Educate users on impacts of over use and mis-use of contaminants
H.3.3	Develop water reuse programs to return wastewater to other urban uses
H.3.4	Shift support (subsidies, capital loans) to encourage water use for agriculture that requires less water and uses less contaminants

6 Actions to Implement Strategies

This section to be written. Refer to Figure 1

This section will describe what actions will be necessary to implement the strategies identified in Section 4. At the level of the Strategic Plan, these actions will be more broad categories, such as land/easement acquisition, development of specific Delta Ecosystem Restoration Plan, coordinated modifications to through-Delta conveyance to benefit the ecosystem, undertaking site-specific - engineering design and permitting to move near-term actions to implementation, establishing reliable long-term funding stream, formulation of comprehensive Adaptive Management Plan that links science with management, and coordination with efforts on governance as it relates to long-term implementation of Delta ecosystem recovery efforts.

7 Evaluating Effectiveness of Identified Strategies

This section to be written.

This section will describe approaches to measuring the effectiveness of strategies to resolve the drivers of poor ecosystem function and achieve the desired ecosystem characteristics.