Chapter 6
Biological Environment

6.1 Fisheries and Aquatic Ecosystems

The CALFED Bay-Delta Program is expected to promote the recovery of fish species found in the Delta that are listed and proposed for listing, and to support and enhance sustainable populations of diverse and valuable aquatic species (such as chinook salmon, steelhead, delta smelt, splittail, striped bass, and sturgeon) through actions that improve and increase aquatic habitat and improve ecological processes in the Bay-Delta.

6.1 Fisheries and Aquatic Ecosystems

6.1.1 SUMMARY

Aquatic ecosystems in the Bay-Delta support important recreational and commercial fisheries worth millions of dollars and provide substantial intangible cultural, scientific, and social value. The role of aquatic species in ongoing conflicts over beneficial uses of water in the Bay-Delta ecosystem is testimony to their value, especially for species listed under the Endangered Species Acts (ESAs). Conserving the values provided by aquatic species for future generations requires maintenance and enhancement of ecosystem health concurrent with existing and increasing human demands for water supply, flood control, and other aquatic ecosystem functions.

All Alternatives. Fisheries and the aquatic ecosystem would benefit from implementation of many elements included in the CALFED Bay-Delta Program (Program) alternatives. The Ecosystem Restoration Program would reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. The program also is expected to increase the abundance and distribution of desired aquatic species, possibly including delta smelt, sturgeon, splittail, chinook salmon, and steelhead. Aquatic species would benefit from improved and reestablished ecosystem processes, including streamflow, sediment supply, floodplain connectivity, stream temperature, and biological productivity. Restoration of aquatic areas through levee setbacks and other actions would increase species habitat, and new fish screens would reduce entrainment losses. Actions to improve harvest and artificial propagation management would rehabilitate naturally producing fish populations.

The Levee System Integrity Program would reduce the risk of catastrophic levee failure, reducing the likelihood of the resulting rapid hydrodynamic and salinity changes that could adversely affect species habitat abundance, movement, and losses to diversions. Levee maintenance and construction practices (for example, setback of levees and construction of channel-side berms) would allow development of aquatic and riparian communities, subsequently providing habitat for Delta species.

The Water Quality Program would reduce input of contaminants to the system, resulting in improved productivity and species survival, growth, and reproductive success. Aquatic species in the Sacramento River and San Joaquin River systems, the Delta, and the Bay would benefit from reduced metabolic stress.

New storage allocated to environmental water supplies and water acquisitions for environmental uses could benefit aquatic species through enhancement of seasonal flow needs, potentially improving water temperature conditions and increasing habitat abundance. New storage and implementation of the Water Use Efficiency and Water Transfer Programs, combined with increased operational flexibility, could allow flow management that would improve water temperature and other flow-related habitat conditions for aquatic species. Although potentially reducing storage yield, entrainment losses also could be minimized through change in the timing of diversions to periods when species vulnerability is low. Under the Watershed Program, activities are expected to improve water quality and flow conditions in the upper watershed, potentially improving species habitat in downstream areas through reduced contaminant input, cooler water temperature, and flow conditions that more closely meet species needs.

Some of the elements included in the Program could adversely affect fish and the aquatic ecosystem. In most cases, however, implementation strategies and mitigation would be developed and implemented to reduce adverse impacts to a less-than-significant level. Construction-related adverse impacts would be avoided and minimized though implementation of BMPs. Restoration of habitat would consider species needs relative to structure, seasonal availability, and stressors where stressors include contaminants, diversions, and impaired ecosystem processes—such as flow, temperature, sediment movement, and nutrient input.

Some potential adverse impacts may be significant and unavoidable. Habitat restoration, given the existing hydrologic and hydraulic conditions, and the existing altered biological community structure, may adversely affect native species. Newly created habitat may increase the abundance of non-native species, potentially increasing competition and predation on native species. Increased urban and industrial development in response to more reliable water deliveries may increase contaminant input and the incidence of human-caused disturbance to aquatic communities.

Preferred Program Alternative. Elements of the Preferred Program Alternative with substantial uncertainty relative to impacts on fish and aquatic resources include the diversion facility on the Sacramento River, setback levees or dredging along the Mokelumne River channel and Old River, and south Delta barriers. The components have the potential to provide substantial benefits through increased operational flexibility, creation of habitat, and improved Delta flow conditions. Because of uncertain species responses to the Program elements, the potential also exists for adverse impacts. Uncertainty must be addressed and Program elements would be constructed and operated only after information clearly confirms that potentially significant adverse effects on fish and aquatic species populations can be avoided. Key to implementation of the Preferred Program Alternative is a strategy to address the uncertainty of species and ecosystem responses to Program elements. Ongoing activities to increase understanding of natural physical and biological processes and species habitats include the Strategic Plan for the Ecosystem Restoration Program (Strategic Plan); the Comprehensive Monitoring, Assessment, and Research Program (CMARP); and the MSCS.

Beneficial effects of habitat restoration for native species may be assured through consideration of species habitat needs relative to structure, seasonal availability, and stressors. Conditions needed to minimize value to undesirable non-native species would be identified.

To minimize and avoid potential adverse effects of changes in flow and diversion, construction and operation of new facilities, such as barriers, fish screens, and conveyance channels, may be preceded by focused studies to determine the environmental effects, including species population response. Actions may be implemented progressively over the long term, and actions would be integrated with monitoring and evaluation to assess effects on the aquatic ecosystem, achievement of the Program objectives, and conform-ance to Program solution principles. Potential operations flexibility provided through coordination with existing water supply system components and other Program elements, such as the Water Use Efficiency, Water Transfer, and Watershed Programs and Storage, would be identified.

Although adverse effects on aquatic species population would be avoided or reduced to a less-than-significant level with mitigation strategies, harm to individual organisms could result from certain aspects of the Program elements (for example, entrainment loss and migration delay). For special-status species, such as species listed under federal and California ESAs, harm to individual organisms and their habitat is considered a potentially significant adverse impact. Mitigation strategies are expected to reduce impacts on individuals of special-status species to a less-than-significant level. The MSCS includes a framework for applying mitigation strategies during implementation to ensure that the Program avoids, minimizes, or compensates for its impacts on special-status species. Further, the Program has committed to implementing mitigation strategies that will minimize potentially significant adverse impacts prior to, or concurrent with, construction and operation of Program elements.

Alternatives 1, 2, and 3. Changes in Delta flow conveyance facilities and channels could benefit Delta species. DCC operations (under Alternatives 2 and 3) and the head of Old River barrier would increase survival of juvenile chinook salmon entering the Delta from the Sacramento and San Joaquin Rivers. New SWP and CVP fish screens would reduce entrainment losses of all species relative to conditions under the No Action Alternative or existing conditions. Setback levees along the Mokelumne and Old River channels are expected to increase riparian and tidal marsh communities, and provide additional habitat for Delta aquatic species. Relocation of the SWP intake on Clifton Court Forebay (CCFB) would reduce entrainment losses from the south and central Delta. Under Alternative 3, relocation of the intake would increase the frequency and magnitude of natural net channel flow in the south and central Delta, potentially reestablishing conditions that would increase productivity, enhance species movement, and reduce entrainment in Delta diversions.

Substantial uncertainty relative to impacts on fish and aquatic resources is associated with the diversion facility on the Sacramento River, set back levees or dredging along the Mokelumne River channel and Old River, and south Delta barriers. Potentially significant unavoidable adverse impacts may occur that would potentially limit restoration options and success discussed for other elements of the alternatives. Placement of barriers in the south Delta and at Hood under Alternative 2 may block access to habitat, and alter water quality and flow conditions. Under Alternatives 2 and 3, the diversion facility on the Sacramento River and fish screen may increase fish mortality through abrasion, increased predation, and delayed migration. The Hood diversion would also reduce flow in the Sacramento River, potentially reducing survival and degrading habitat conditions for species downstream of the diversion. Changes in operations and diversion locations under Alternative 3, including relaxation of current SWP pumping restrictions that allow use of the full 10,300-cfs pumping capacity, may reduce or otherwise alter flow conditions in the Delta, potentially reducing system productivity, impairing species movement, increasing losses to diversions, and reducing habitat abundance.

The following table presents a summary of the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact. See the text in this chapter for a more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Potential increased non-native species abundance and distribution to levels detrimental to native species from reestablishment of aquatic areas (4,9).

Potential blocked access to habitat and potentially altered water quality and flow conditions from placement of barriers in the south Delta (3,5).*

Potential altered natural ecosystem structure, removal of benthic communities, and creation of conditions that may damage habitat for desired species from dredging activities (1,2,3).

Release of toxic substances into surface waters (10,11,12).

Potential short-term disturbance of existing biological communities and species habitat, mobilized sediments, and input contaminants from construction activities (1,2).

Potential reduced streamflow and Delta outflow, changed seasonal flow and water temperature variability from water supply management, and changes in salinity associated with several Program elements—potentially resulting in reduced habitat abundance, impaired species movement, and increased loss of fish to diversions (5,9).*

Potential increased entrainment loss of chinook salmon and other species from diversions to new off-stream storage (5,6,7,9).

Potential reduced frequency and magnitude of net natural flow conditions in the south and central Delta (potentially reducing system productivity, impairing species movement, and increasing losses to diversions) from DCC operations and south Delta barriers (5,9).*

Potential for reduced net flow conditions in the Sacramento River downstream from the diversion facility on the Sacramento River, potentially reducing fresh-water area and affecting species movement and survival (5,8,9).*

Potential increased fish mortality through abrasion, increased predation, and other factors from the new fish screen facility for the diversion facility on the Sacramento River (5,7,8,9).*

Potential delayed migration and reduced spawning success for adult fish moving from the Mokelumne River channels into the Sacramento River from fish screens and the diversion facility on the Sacramento River (5).*

Mitigation Strategies

1. Implementing BMPs, including a stormwater pollution prevention plan, toxic materials control and spill response plan, and vegetation protection plan.
2. Limiting construction activities to windows of minimal species vulnerability.
3. Creating additional habitat for desired species, including increasing aquatic area and structural diversity through construction of setback levees and channel islands.
4. Controlling undesirable non-native species.
5. Operating new and existing diversions to avoid and minimize effects on fish (avoiding facility operations during periods of high species vulnerability). The operational changes could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."
6. Locating the diversion point to avoid primary distribution of desired species.
7. Controlling predators in the diversion facility (screen bays) and modifying diversion facility structure and operations to minimize predator habitat.
8. Constructing a barrier to fish movement on Georgiana Slough. Adverse impacts of a flow barrier, however, would need to be considered.
9. Coordinating and maximizing water supply system operations flexibility consistent with seasonal flow and water temperature needs of desired species.
10. Conducting core sampling and analysis of proposed dredge areas and engineering solutions to avoid or prevent environmental exposure of toxic substances after dredging.
11. Capping exposed toxic sediments with clean clay/silt and protective gravel.
12. Locating constructed shallow-water habitat away from sources of mercury until methods for reducing mercury in water and sediment are implemented.

Bold indicates a potentially significant and unavoidable impact.

* Potentially significant impacts of the Preferred Program Alternative on fish and other aquatic species populations would be avoided or reduced to a less-than-significant level through application of mitigation strategies. The asterisk identifies those potentially significant impacts that reflect potential harm to individual organisms of special-status species.

6.1.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. Below is a brief description of the areas of controversy for this resource category. Given the programmatic nature of this document, many of these areas of controversy cannot be addressed; however, subsequent project-specific environmental analysis will evaluate these topics in more detail.

Aquatic species, especially species listed and proposed for listing under California and federal ESAs, are key factors in ongoing conflicts over beneficial uses of water in the Bay-Delta ecosystem. It should not be surprising that areas of controversy arise over uncertainty in the relationships that link potential species responses to implementation of Program elements. For many relationships used in this impact assessment, alternative species responses could reasonably be expected.

Because Program elements and mitigation actions may or may not result in the expected or desired effect on species restoration and maintenance, the environmental, economic, and social cost of implementing specific actions requires measures to resolve controversy. The following sections discuss (1) the sources of uncertainty in relationships that are contributing to controversy, and (2) the ongoing Program processes that are addressing the uncertainty of species and ecosystem responses to implementation of Program elements.

Uncertainty in the Assessment. The assessment relationships link Program actions to outcomes for species and ecosystems. Ecosystem relationships encompass fundamental ecological processes and structures (such as flow, sediment input and movement, and productivity) that contribute to the well-being of species. For ecosystem relationships, progressing toward the natural condition was assumed beneficial to native species because native species lived and evolved in a system undisturbed by human activities.

Uncertainty in the relationships applied in this impact analysis occurs because environmental problems are extraordinarily complex. At the ecosystem level, uncertainty about relationships is attributable to:

- Limited knowledge about the natural system relative to highly modified existing structure and processes.
- Limited understanding of inter-relationships between ecosystem processes and structure, especially relative to historical changes to ecosystem structure or processes that are irreversible and potentially limiting to restoration or reestablishment of processes and structure.
- Unpredictability of environmental change in light of growing demands on Bay-Delta resources and additional land use disturbances in the watershed.
- Lack of expert consensus about the relative importance and effectiveness of different kinds of actions in restoring the ecosystem.

For species, uncertainty is attributable to:

- Limited knowledge of species needs relative to factors that limit population abundance and production.
- Unpredictability of species response to environmental change.
- Lack of expert consensus about the relative effectiveness of different actions in increasing species abundance.

The relationships used in this impact assessment clearly involve a substantial degree of uncertainty associated with the link between Program actions to outcomes for species abundance. The assessment, therefore, attempts to err toward the conservative. Where adverse impacts may occur, they are identified, and appropriate mitigation strategies are proposed (see the comparison of Program alternatives to the No Action Alternative in Sections 6.1.8 and 6.1.9, and mitigation strategies in Section 6.1.12). Resolution of uncertainty in the relationship prior to implementing project actions could counter initial assessment conclusions and negate the need for mitigation.

Addressing Uncertainty. Several ongoing Program activities will address the uncertainty of species and ecosystem responses through increased understanding of natural physical and biological processes and species habitats. Ongoing activities include the Strategic Plan for the Ecosystem Restoration Program, the CMARP, and the MSCS.

The Strategic Plan is intended to guide the implementation of the Ecosystem Restoration Program actions for rehabilitation of the Bay-Delta system, including the recovery and maintenance of native species. The Strategic Plan has eight elements: (1) clear and measurable goals and objectives; (2) an ecosystem approach that integrates environmental, economic, and social issues; (3) adaptive management; (4) conceptual models that define linkages between management actions and resource response; (5) staged implementation of the Ecosystem Restoration Program in coordination with other Program elements; (6) a strategy for compliance with regulations and legislative mandates; (7) external scientific, professional, and public review of Program objectives and results; and (8) a system to resolve disputes between conflicting interests where species or ecosystem recovery is at stake.

Adaptive management is key to the Strategic Plan and involves treating actions as experiments, deliberately taking the opportunity to learn from each management action so as to improve the process of management over time. The CMARP clearly has a critical role in adaptive management and will provide the necessary monitoring and evaluation of Ecosystem Restoration Program projects.

The MSCS complements the emphasis on addressing scientific uncertainty in the Strategic Plan. The MSCS outlines research needs for certain special-status species to further understanding of the species' ecological requirements, restoration needs, abundance, and distribution. This research also will assist with adaptive management and the design of restoration efforts.

Uncertainty of species and ecosystem responses to environmental changes resulting from implementation of all Program elements may be appropriately addressed through an adaptive management strategy. Adaptive management entails making decisions based on the best available analyses and modeling, being clear about restoration objectives relative to the ecosystem and species, designing actions that help distinguish between alternative relationships that link potential species responses to implementation of Program elements, and monitoring and evaluating the effects of Program actions (that is, the CMARP). Additional components required to address uncertainty associated with substantive actions could include:

- Clear statement of restoration goals and objectives (tangible and measurable), including geographic scope and time scale.
- Completion of a screening and prioritization process that incorporates scientific, professional, and public review and is based on the best available understanding of natural physical and ecosystem processes and species habitat needs.
- Clear separation of scientific and technical issues from societal and economic issues.
- Progressive implementation of elements included in the Program over the long term and integration with monitoring and evaluation to assess achievement of the Program objectives and conformance to solution principles.

- Targeted research or pilot projects to address high uncertainty and to demonstrate feasibility or ecosystem and species response.

The Program's position on fisheries and aquatic ecosystems is expressed in the Program mission statement and objectives, which are presented in Chapter 1.

6.1.3 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

The vast watershed encompassing mountain streams, Central Valley rivers, the Delta, and San Francisco Bay supports an important array of aquatic ecosystem values, including biological communities and individual species. Human-induced changes in the ecosystem have substantially degraded natural productivity, biodiversity, and ecological integrity. The following section summarizes historical changes leading to existing conditions.

Over 200 fish species occur in the Sacramento-San Joaquin River system, the Delta, and the Bay—most of which are marine species. Over 40 species commonly occur within the Delta and upstream fresh-water environments. Although the impact assessment considers overall ecosystem health, the assessment also focuses on fish species that occur in the Delta during at least some portion of their life cycle and are listed or proposed for listing under the federal ESA. These species include winter-, spring-, fall-, and late fall-run chinook salmon; steelhead; delta smelt; and splittail.

Detailed information on the life history, historical population abundance, and factors affecting production for specific species can be found in the March 1998 Fisheries & Aquatic Resources Technical Report. Information can also can be found in Volume 1 of the Ecosystem Restoration Program Plan under "Ecosystem Processes," "Habitats," "Species and Species Groups," and "Stressors." Information by location is presented in Volume 2 of the Ecosystem Restoration Program Plan. For species listed under the ESA, the MSCS provides detailed information by species. Most of the species discussed have suffered declining populations in response to direct loss of spawning and rearing habitat, environmental degradation (for example, degraded water quality, altered hydrology, and diversions), barriers to migration, historical commercial fisheries, sport fisheries, and competition with non-native species.

6.1.3.1 DELTA REGION

Historically, wetlands dominated land cover throughout the Delta, but levee construction and channelization eliminated over 95% of the original tidal wetlands and many miles of sloughs. The Delta consisted of backwater areas, tidal sloughs, and channel networks that supplied and drained highly productive tidal-marsh and wetland complexes. The marsh vegetation, in turn, supplied the Delta aquatic system with an abundant source of coarse organic matter. Marsh vegetation also slowed the movement of water through the Delta during floods, increasing hydraulic residence times and the opportunity for nutrients to be consumed.

The Delta Region includes the tidally influenced aquatic areas from the Sacramento River at the confluence with the American River and the San Joaquin River at Vernalis downstream to Chipps Island. The total surface area of the Delta area is approximately 678,200 acres, most of which is irrigated cropland. A lesser portion consists of riparian vegetation, wetlands, and other forms of "idle land." The remaining portion is occupied by channels, sloughs, and other open water. Under existing conditions, most of the open water is deep-channel habitat that has been modified to provide passage for ocean-going vessels as well as efficient conveyance of fresh water from the Sacramento River through the Delta. Vegetation is removed from levees, primarily to facilitate inspection, repair, and flood fighting when necessary. Although current flood protection programs may allow for properly managed vegetation, the amount of shallow water and shaded riverine habitat throughout the Delta is much lower now than it was historically, largely having been replaced by a patchwork of agricultural islands and revetted levees.

The bulk of the total fresh-water inflow to the Delta originates from the Sacramento River, and most of the total inflow occurs during winter and early spring. Compared to historical conditions, the average residence time of Delta water, nutrients, algae, and other forms of fine particulate organic matter has been greatly reduced by flow changes caused by channelization and diversions. Varying portions of the inflow are diverted under different conditions. Thus, at certain times, the amount of water, sediment, and nutrients flowing out of the Delta to Suisun Bay is greatly reduced. Agricultural, municipal, and industrial diversions directly remove fish, invertebrates, and nutrients from the system. Migration of adult and juvenile fish is affected by flow, temperature, dissolved oxygen, chemical cues, and physical barriers. Reverse flows in Delta channels caused by diversion operations may adversely affect migrating fish species and movement of planktonic larvae to nursery areas, by confusing migrants and delaying migration or lengthening the migration routes. Reverse flows and loss of algae and other food resources have contributed to the reduction of Bay-Delta productivity and of some Bay-Delta invertebrate and fish populations.

The rivers flowing into the Delta, together with agricultural return flows and urban wastewater flows in the Delta, transport contaminants in addition to water, sediment, and nutrients. Some contaminants arrive in dissolved forms but most, such as trace metals, a number of herbicides, and other synthetic organic toxicants, are transported in association with fine particulate sediment and organic matter. It is known that some contaminants accumulate within the foodweb, adversely affecting productivity and species abundance. The concentration in fish or other high-trophic-level organisms can be orders of magnitude greater than concentrations in the water or in algae, invertebrates, and other lower-trophic-level organisms.

With millions of acre-feet of water stored and diverted upstream of the Delta, and millions more diverted from the Delta, winter and spring flows through the Delta are substantially reduced relative to natural conditions. In many years, annual Delta outflow may be reduced by 30-60% relative to natural runoff. Delta flow affects the abundance and distribution of many species, and diminished flows have likely reduced species productivity in some years.

Introduced fish and macro-invertebrate species currently dominate the biological community of the Delta. Along with changes in sources, composition, and amounts of nutrients, introduced species have substantially modified Delta food webs relative to historical conditions. Although extremely difficult to substantiate, changes in the food web have undoubtably reduced the productivity of some species.

6.1.3.2 BAY REGION

The Bay Region extends downstream from Chipps Island to the Golden Gate Bridge and includes aquatic habitat in Suisun Marsh, Suisun Bay, San Pablo Bay, Central Bay, and South Bay. Shoals and mudflats cover most of the surface area of the Bay, whereas most of the Bay's volume is contained within deep, fairly narrow channels that are dredged periodically to maintain shipping lanes for ocean-going cargo vessels. From an ecosystem standpoint, the Bay functions as a temporary storage, mixing, and processing basin for fresh water, sediment, nutrients, and food resources flowing out of the Delta. The first embayment to receive these resources is Suisun Bay, including Suisun Marsh, a critical food production and food consumption area of the Bay Region aquatic ecosystem. Because of its highly dynamic and complex environmental conditions, the Bay estuary supports an extraordinarily diverse and productive ecosystem that serves as a critical rearing area for resident and anadromous fish.

Wetlands and related habitat are some of the most valuable natural resources in the Bay and Suisun Marsh. Most of the mudflats, tidal and seasonal marshes, and riparian woodland have been reduced by 50-80% over the past 140 years, primarily as a result of urban and agricultural development. Large areas that were once tidal marsh habitat have been transformed into salt ponds and agricultural land, reducing the shallow-water habitat available to fisheries resources. In addition, the Bay's open-water area has diminished by one-third, with wetland and riparian wildlife habitats eliminated or degraded. Seasonal stormflows have increased, and sediment and nutrient transport processes changed in the estuarine ecosystem. Past projects have decreased the surface area of the San Francisco Bay by 37%, and removed valuable habitat for aquatic and terrestrial organisms.

Where fresh water and sea water mix in Suisun Bay, high zooplankton populations develop, on which many estuarine resident and anadromous fish depend. The deterioration of the zooplankton community and its algal food supply in critical habitat areas of the Bay Region is considered a serious problem because striped bass, delta smelt, chinook salmon, and other species that use Suisun Bay and the Delta as a nursery area feed almost exclusively on zooplankton during early stages of their life cycles.

Much of the plant biomass and other forms of organic matter consumed by zooplankton in the Bay Region is not produced in the Bay but is transported in from the Sacramento and San Joaquin Rivers, and accumulates in Suisun Bay and the west Delta. The proportion of the organic material imported to or produced within and upstream of the Delta that reaches Suisun Bay varies considerably from year to year and depends, in part, on prevailing flow conditions. As indicated for the Delta, annual outflow in many years has been reduced by 30-60% relative to natural runoff. At higher flows, much of the organic material brought in by the rivers would travel to Suisun Bay or to San Pablo and central San Francisco Bays. At low flows, more biological production remains in the Delta. Reduced flows likely reduces the transport of organic material to the Bay in some years.

The Bay-Delta foodweb has changed in recent years, especially as algae abundance has declined in Suisun Bay. Low chlorophyll levels in Suisun Bay coincide with very low Delta outflow during the drier years (such as in 1977, 1987, and 1992) and high outflow in the very wet years (such as in 1983 and 1995). In some wet years, some of the algae biomass in Suisun Bay is washed downstream into the wider expanses of San Pablo Bay. Many native aquatic invertebrate species have become less abundant or more narrowly distributed, while dozens of new, non-native species have become well established and widely dispersed. In general, the abundance of plankton has declined, while populations of many bottom-dwelling invertebrates, most notably introduced Asian clams, have increased. This transition has been most evident in Suisun Bay.

Contaminants enter the Bay with stormwater runoff, from hundreds of municipal and industrial discharges, and from the Delta. The decline of fish and zooplankton populations in the Bay Region may be a result, at least in part, of the effects of heavy metals, herbicides, pesticides, and other toxic substances. Very low concentrations of these substances in the water column may act individually or in combination to reduce productivity. Substantial recent improvements in treatment have substantially reduced contaminant problems, although urban runoff remains a considerable source of contamination.

Most of the tributary streams in the Bay Region have lost habitat through channelization, riparian vegetation removal, reduced water quality, and the construction of fish barriers. The fish of the tributary streams of the Bay are sensitive to changes in habitat, and reduced fish abundance in these streams generally reflects the intensity of urbanization of the surrounding lands.

6.1.3.3 SACRAMENTO RIVER REGION

The Sacramento River Region encompasses aquatic habitat in the major stream reaches in the Sacramento River basin. The major reservoirs (reservoirs that provide flood control and water storage) on the Sacramento River and its tributaries also are included in this region. The March 1998 Fisheries & Aquatic Resources Technical Report describes each of the streams and reservoirs in the Sacramento River Region.

Historically, wetlands covered an estimated 1,400,000 acres of the Sacramento Valley. These wetlands were comprised of mostly riparian forests and semi-permanently flooded tule marshes. Currently, approximately 170,000 acres of wetlands remain and are dominated by tule marsh. In addition, a large portion of agricultural lands are subject to flooding during wet years. Some 500,000 acres of riparian forest historically fringed the entire length of the mainstream Sacramento River channel. Today, less than 5% of the mainstream riparian forest remains. As in the Delta, wetland plants and riparian forests provided food and shelter for aquatic biota and greatly increased the hydraulic residence time of the system.

Under existing conditions, most of the acreage adjacent to the river is protected by levees, and long sections of the river have been straightened to maximize agricultural land and improve channel conveyance capacity. On the Sacramento River, the section from Chico Landing to the Delta is contained within levees. Consequently, the frequently inundated floodplain currently is limited to a narrow terrace. Miles of meanders, backwaters, and sloughs have been eliminated; and less than 5% of historical wetlands remains. As in the Delta, levees are reinforced and kept relatively free of vegetation, measures that have greatly reduced the occurrence of sloughs and side channels, the supply of organic material, and the quality of invertebrate and fish habitat in the river ecosystem.

Much of the annual runoff volume of the Sacramento River system is stored in reservoirs; therefore, Sacramento River and tributary flows are highly regulated and under the direct control of Reclamation, DWR, and others. The main purposes of the reservoirs are flood control and storage for subsequent release to downstream diverters and generation of electricity. Relative to the natural flow regime, the present river flows are lower in spring and winter but higher in summer and fall. Spring flows have been reduced by more than 50% in some years, attributable to both reservoir operations and diversions. Hundreds of diversions entrain fish and nutrients with diverted water, removing productivity from the river system.

The dams creating reservoirs block access to over 80% of spawning and rearing habitat historically available to chinook salmon and steelhead. The reservoirs also function as settling basins for all of the coarse sediment and organic material, and a large fraction of the fine sediment brought in by inlet streams. Sediment movement diminished by the reservoirs has degraded downstream spawning and rearing habitat. The major reservoirs have low nutrient levels and support modest phytoplankton production. Algal biomass and fine particulate organic matter derived from terrestrial vegetation form the basis of the foodweb in the downstream river ecosystems. Planktonic algae abundance is generally low because residence time is short and relatively high amounts of suspended sediment prevent light penetration.

Existing Central Valley reservoirs do support sport fisheries. The species supported by reservoirs and targeted by anglers are primarily non-native (such as largemouth bass, spotted bass, red-ear sunfish, crappie, and catfish) or hatchery-supplemented fish populations (such as rainbow trout).

Reservoir operations, removal of riparian vegetation, agricultural drainage, and channel modification have created water temperature conditions that adversely affect species habitat below reservoirs. In addition, loss of riparian and floodplain habitat have reduced nutrient inputs. In combination with changes in flow and introduction of new species, natural food webs have been altered and native species eliminated or their abundance substantially reduced.

Inactive and abandoned mines discharge acid mine drainage into the upper Sacramento River and tributaries. This drainage contains trace metals, especially copper and zinc, that are toxic to aquatic organisms. Abandoned mines and natural erosion in other parts of the catchment contribute mercury. Urban runoff and municipal and industrial discharges are sources of metals and organochlorine compounds that can accumulate in fish and other high-trophic-level aquatic organisms. Agricultural return flows also discharge potentially harmful herbicides and pesticides into the system, as well as increasing turbidity through input of fine sediments.

6.1.3.4 SAN JOAQUIN RIVER REGION

The San Joaquin River Region encompasses aquatic habitat in the major stream reaches in the San Joaquin River basin. Human-induced changes discussed for the Sacramento River Region also have occurred in this region. Major reservoirs include San Luis Reservoir and dozens of reservoirs on the San Joaquin River and its tributaries. The aquatic system, as in the Sacramento River, consists of a mainstream San Joaquin River and its major tributaries—the Stanislaus, Tuolumne, and Merced Rivers—and several hundred small tributary streams. The Mokelumne, Cosumnes, and Calaveras Rivers are considered in this region, although these rivers could more appropriately be considered as independent Delta tributaries. The March 1998 Fisheries & Aquatic Resources Technical Report describes each of the streams and reservoirs in the San Joaquin River Region. The region encompasses approximately 10.2 million acres, of which approximately one-third is the San Joaquin Valley. Approximately one-fifth of the region supports irrigated agriculture, whereas only a small portion of the area is urban.

Precipitation in the San Joaquin River basin is less than that in the Sacramento River Region. Snowmelt runoff is the major source of water for the San Joaquin River and the larger tributaries. Historically, peak flows occurred in May and June, and natural overbank flooding occurred in most years along all the major rivers. When flood flows reached the valley floor, they spread out over the lowland, creating several hundred thousand acres of permanent tule marshes and over 1.5 million acres of seasonally flooded wetlands and native grasslands. The rich alluvial soils of natural levees once supported large, diverse riparian forests. Above the lower floodplain, the riparian zone graded into higher floodplains, supporting valley oak savanna and native grasslands interspersed with vernal pools. Currently, about 126,000 acres of wetlands remain in the San Joaquin Valley. Riparian forest acreage is less than 5% of its former extent and exists in small, isolated patches. Human-made levees isolate the river from most of its former floodplain.

Most of the total volume of annual runoff in the San Joaquin River Region is stored in reservoirs; therefore, outflow from this region is highly regulated. Relative to natural flow conditions, the present flow of the San Joaquin River and its tributaries is lower year-round, especially in spring and winter. The reservoirs function as settling basins for all of the coarse sediment and organic material, and a large fraction of the fine sediments brought in each year by inlet streams.

The mainstream of the San Joaquin River during the summer growing season is composed of primarily agricultural return flow that is rich in nutrients and suspended solids. In winter, soils are flushed to reduce salt buildup, and the resulting wastewater is conveyed to the streams and San Joaquin River by an extensive system of tile lines and drainage ditches. High nutrient concentrations and long residence times combine to make the San Joaquin River mainstream an extremely productive system. Therefore, the San Joaquin River contributes a disproportionately high percentage of inflowing nutrients and food resources to the Delta. These nutrients and food resources contribute to Bay-Delta productivity but, in combination with sewage and urban discharge, may substantially alter foodweb dynamics and lead to reduced summer and fall dissolved oxygen levels in localized reaches of deep, poorly flushed channels.

On the west side of the region, over 100,000 acres of land are underlain by shallow, semi-impermeable clay layers that prevent water from percolating downward. Soils in this region are naturally high in selenium. Inadequate natural drainage, salt accumulation, and high selenium concentrations in agricultural return flow have been long-standing problems in this area and have intensified with the importation of irrigation water from the Delta. In addition to nutrients, the San Joaquin River is a major source of herbicide and pesticide loading to the Delta.

6.1.3.5 OTHER SWP AND CVP SERVICE AREAS

Two distinct, noncontiguous areas are included in the Other SWP and CVP Service Areas: in the north, are the San Felipe Division's CVP and the South Bay SWP service areas; to the south, are the SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

Reservoirs, streams, and estuaries in the Other SWP and CVP Service Areas receive water exported from the Delta. Much of the area receiving Central Valley water is highly urbanized, although extensive agricultural areas exist. The Los Angeles basin, formed by the Los Angeles, San Gabriel, and Santa Ana Rivers, has been the site of extensive urbanization. Streams in the region have been severely degraded by loss of streamflow to diversions and groundwater pumping; discharge of municipal, industrial, and agricultural waste; and channel modification, including dams, levees, and concrete channels to minimize flood damage.

Importation of water from the Central Valley has maintained or increased urban and agricultural development, further degrading aquatic systems through loss, disturbance, and contamination of species habitat. In addition, imported Central Valley water has introduced non-native species into and altered the foodweb dynamics of streams and estuaries.

6.1.4 ASSESSMENT METHODS

The presentation of impacts is organized by region and subdivided into Program elements. The Program elements would affect physical, chemical, and biological features of the aquatic ecosystem. The effect of Program implementation on fish and aquatic resources are described using qualitative data, which include hypothetical relationships between potential Program actions and expected ecosystem or species response; measured data, such as changes in floodplain acreage or river length; and modeled data, such as simulated flow, reservoir storage, and diversion.

The purpose of the assessment is to describe, in a broad sense, the environmental impacts of proposed Program actions. The level of detail is consistent with the programmatic nature of the document and will enable decisions to be made regarding Program direction and content. The programmatic document identifies a broad range of potential impacts and broad mitigation strategies. Implementation of substantive CALFED actions will require project-specific environmental documents that will provide detailed scientific analysis. These documents will improve the distinction between potentially significant and less-than-significant impacts. Additional information on the relationships discussed below, including references, is provided in the Ecosystem Restoration Program Plan (Volumes 1, 2, and 3) and the MSCS, as well as in the March 1998 Affected Environment and Environmental Consequences Technical Reports for Fisheries and Aquatic Resources.

The effects of Program elements are considered at the ecosystem and species level. The ecosystem-level analysis focuses on the change in functional and structural characteristics of the aquatic ecosystem. The ecosystem relationships are consistent with the ecosystem level of management considered by the CALFED Program (that is, a primary CALFED objective is restoration of ecosystem health). Because species—especially those listed or proposed for listing under the ESAs—are key factors in conflicts over beneficial uses of water in the Delta-Bay ecosystem, effects of changes in environmental characteristics on species abundance and distribution also are assessed. Indicators of change in functional and structural characteristics are evaluated to determine the beneficial or adverse impacts of an action. The assessment relationships were selected based on:

- Sensitivity to change in environmental variables that enables at least a qualitative comparison of the alternatives at the programmatic level of analysis.
- Availability of supporting data, including current and historical data or professional judgement.
- Fair and consistent applicability to all alternatives.

Assessment of impacts requires application of explicit relationships. The relationships that follow are based on the best available information, but most of the relationships identified below have a high degree of uncertainty relative to action and response mechanisms. The uncertainty stems from natural variability in ecosystem function and structure, and from the absence or inaccuracy of information about ecosystem and species responses to particular variables. Resolution of the controversy resulting from uncertainty in the relationships was previously discussed (see Section 6.1.2, "Areas of Controversy").

Ecosystem-Level Analysis. Analysis at the ecosystem level addresses fundamental ecological processes and structure that help create and maintain biological communities and associated species habitat. Ecosystem processes act directly, indirectly, or in combination to shape, form, and maintain the Bay-Delta river system. Processes included in the programmatic impact assessment are flow; water temperature (heat transfer and storage); sediment, nutrient, and contaminant input and movement; and productivity. Ecosystem structure refers to physical components of the Bay-Delta river system and their spatial relationships to one another.

Flow. Flow affects a multitude of physical, chemical, and biological processes that operate in stream and estuarine channels, and flow is a primary driving force within the riverine ecosystem. The assessment relationship for flow assumes that reestablishing the basic hydrologic features reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Basic hydrologic features include:

- Flow variability that approximates the natural seasonal flow variability (that is, the pattern and magnitude), including effects of Delta outflow on natural seasonal variability in salinity distribution.

- Flow conditions in Delta channels, including net and tidal flow effects, that emulate natural channel flow conditions.

Changes in flow that approximate the natural seasonal pattern were assumed to restore flow-related processes in the aquatic ecosystem, including residence time, flow pattern, and transport rates. Natural pattern and magnitude refer to the unimpaired hydrograph. However, the key concept is "approximates." In the absence of detailed, project-specific information, changes that generally move toward the natural condition are assumed to be beneficial. It is recognized that flow magnitude approaching the unimpaired hydrograph may be detrimental, given the existing structure of the ecosystem. For example, the natural hydrograph in rivers constrained between levees will result in substantially different hydraulics and effects on species and their habitat than would the same flow prior to channelization. Also, Delta habitats currently are constrained between levees; salinity intrusion would result in substantially different effects on species and their habitat than would the same level of intrusion prior to channelization. In Delta channels, flow pattern includes net flow direction and tidal flow. The natural net flow direction for Delta channels is toward Suisun Bay. Bi-directional tidal flow in the Bay-Delta is affected by change in structural characteristics. Tidal flow affects essential processes associated with mixing, cycling, and movement. Reestablishing historical tidal connections and restoring the natural structure of the Delta were assumed to restore essential processes associated with tidal flow.

The Bay-Delta ecosystems are characterized by short-term, seasonal, annual, and long-term variability in salinity. Natural variability in salinity distribution is important to maintaining a healthy estuarine ecosystem. Salinity influences a multitude of ecological processes, including those influencing the distribution and abundance of wetland vegetation and other aquatic organisms. Flow is the primary determinant of salinity distribution. Changes in Delta outflow that result in salinity distribution more closely approximating the natural seasonal pattern were assumed to restore salinity-related processes in the Delta and Bay ecosystems.

Water Temperature. Water temperature is primarily a function of heat transfer and storage. Water temperature affects a multitude of physical, chemical, and biological processes. Human-caused changes in the Bay-Delta river system have altered heat transfer and storage mechanisms, and have resulted in major changes in short-term and seasonal water temperature variability. The assessment relationship for water temperature assumes that reestablishing basic heat transfer and storage mechanisms reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Actions that may restore basic heat transfer and storage mechanisms include:

- Reduction or relocation of agricultural return flows.
- Reduction or relocation of municipal and industrial discharges of thermal waste.
- Reestablishment of natural channel structure.
- Reestablishment of basic hydrologic features consistent with water temperature conditions required to maintain desired biological communities.
- Restored riparian vegetation and shaded riverine aquatic cover.
- Improved watershed management.

Reduced return flows and reduced discharge of heated municipal and industrial effluent may reduce thermal inputs to natural channels. Restoration of riparian vegetation, shaded riverine aquatic cover, and channel structure will provide shading and reestablish natural heating and cooling processes.

Although reestablishing natural channel structure and basic hydrologic features would facilitate natural heat transfer and storage, existing and future social and economic needs may prohibit such actions. For example, reservoirs substantially alter heat transfer and storage in rivers, but removal of dams may be infeasible given the ongoing needs of society. Therefore, the needs of desired biological communities (for example, cool-water biological communities that support chinook salmon and steelhead) must be considered in determining reservoir operations criteria. The detail required to determine the effects of reservoir operations on water temperature exceeds the detail of the hydrology simulated for this programmatic impact assessment; therefore, water temperature in river channels potentially affected by reservoir operations was not simulated, and assessment will be necessary in project-specific environmental documentation. Program actions could increase the availability of cool-water releases from reservoirs, however, and potentially maintain water temperatures that meet the needs of desired biological communities. Actions that could increase the availability of cool water include:

- Construction of multi-level reservoir release structures.
- Increased carry-over reservoir storage.
- Increased volume of water dedicated for ecological flow and water temperature purposes.

Multi-level release structures improve management of the cold-water pool, allowing release of warmer water during periods of low species sensitivity or low ambient air temperature. The cold-water pool in the reservoir is conserved for use during periods of greater species sensitivity and months when river water temperatures may exceed species needs. Similarly, increased carry-over storage and increased volume of water dedicated to flow and water temperature needs may increase the cold-water pool or increase the ability to affect downstream reaches, providing water temperature within target ranges. The actions identified above are applicable to river reaches below reservoirs and would minimally affect Delta water temperature. Because of the distance from the upstream reservoirs, water temperature in the Delta is primarily driven by weather.

Sediment and Nutrient Input and Movement. Input and movement of sediment and associated nutrients are important processes affecting the development and maintenance of the Bay-Delta river system. The assessment relationship for sediment and nutrient input and movement assumes that reestablishing natural sediment and nutrient delivery and movement within the system reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Basic sediment and nutrient delivery and movement mechanisms are reestablished by:

- Removal of dams and other barriers to sediment and nutrient movement.
- Cessation of or reduction in sediment extraction, such as gravel mining and dredging.
- Reestablishment of natural channel structure.
- Reestablishment of basic hydrologic features consistent with sediment movement dynamics required to maintain desired biological communities.
- Improved watershed management.
- Restoration of riparian, shaded riverine aquatic cover, marsh, and floodplain communities.
- Implementation of BMPs during construction activities.

Several of the actions reestablish pathways for sediment movement. Dams retain sediment, preventing movement from the upper watershed to downstream reaches. Removal of dams would reconnect the supply of sediment to downstream reaches of rivers and the estuary. Limits on sediment extraction also would maintain the supply of sediment to downstream reaches. Reestablishment of natural channel structure, including floodplain connections and river meanders, restores processes affecting movement of sediment within the main channel and from adjacent lands. Reestablishment of natural channel structure may include removal of levees, weirs, and bank protection.

Watershed actions in both the upper and lower watersheds may address grazing, wildfires, agriculture, and urban development. Improved watershed management and restoration of riparian vegetation, shaded riverine aquatic cover, marsh, and floodplain communities would affect erosion and deposition processes, increasing sediment stability and restoring channel dynamics. Implementation of BMPs during construction activities would prevent short-term increases in sediment input that may adversely affect aquatic communities through increased sedimentation or turbidity.

Reservoirs capture sediment destined for downstream reaches, and flood control elements of the Bay-Delta river system, such as levees, have resulted in major changes to channel structure. Although reestablishment of natural flow patterns potentially restores natural sediment input and movement processes, natural flows through the existing system could mobilize previously stable sediments and damage existing or desired biodiversity and the integrity of the aquatic ecosystem. Biological communities and species with specific sediment requirements (for example, spawning gravels for chinook salmon and steelhead) could be adversely affected. Reestablishment of natural flow patterns requires consideration of management priorities and concurrent actions to reestablish natural channel structure and restore riparian, floodplain, wetland, and aquatic communities.

Because dams, gravel mining, and subsequent flow conditions have reduced sediment abundance in some river reaches, adding sediment replaces, to some degree, the natural process of gravel recruitment now interrupted by dams. Although adding gravel to river channels is inconsistent with reestablishing natural sediment and nutrient delivery and movement, the action may be necessary to maintain and enhance desired biological communities and species populations.

Contaminant Input and Movement. Contaminants are substances that are toxic to aquatic organisms or create conditions that adversely affect aquatic organisms in the Bay-Delta river system. Contaminants include metals (for example, mercury, copper, cadmium, and zinc), selenium, ammonia, salinity from runoff, pesticides, fertilizers, sewage, uncharac-teristically high fine sediment loading, and warmwater. Toxic effects of contaminants may include death, reduced growth rate, and reduced fertility of individual organisms. Reduced dissolved oxygen levels, in response to input of excessive nutrients from agricultural and urban runoff, sewage, or warmwater discharge, also may adversely affect aquatic organisms.

The assessment relationship for contaminant input and movement assumes that reducing contaminant delivery and movement within the system reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reduced contaminant input and movement may be achieved through:

- Development of more benign application techniques, development of narrow-spectrum pest control methods, and use of shorter-lived or less mobile agricultural and industrial chemicals.

- Improved point and nonpoint wastewater treatment prior to discharge.

- Improved watershed management.

- Implementation of BMPs during construction activities.

Improved point and nonpoint wastewater treatment may include upgraded sewage treatment, construction of stormwater runoff storage, and discharge to constructed wetlands prior to discharge to the Bay-Delta river system. Watershed management could reduce excessive input of fine sediment, pesticides, and other material. Watershed actions in both the upper and lower watersheds may address grazing, wildfires, agriculture, and urban development. Implementation of BMPs during construction activities would prevent short-term discharge of contaminants and reduce the probability of contaminant spills.

In addition to reduced inputs, natural biological processing of contaminants may be increased by restoring marshes and wetlands. Reliance on natural processing of contaminants, however, must include implementation of monitoring and mitigation components. Monitoring should focus on detecting increased contaminant concentrations and the potential for aquatic organisms to accumulate, magnify, transform, and mobilize contaminants to the detriment of aquatic communities or individual organisms. The mitigation should include potential actions to reduce or eliminate input of contaminants and remove contaminants accumulated in sediment or vegetation.

Although reduced contaminant input is the primary avenue for reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations, reduced contaminant effects also may be achieved through avoidance mechanisms, including:

- Discharging contaminants during nonsensitive periods.
- Relocating discharges to less sensitive areas.
- Providing dilution flows during periods of high biological sensitivity.

Contaminants may be discharged when biological communities are less sensitive or when sensitive life stages are not present. Relocating the discharge to areas not supporting sensitive species also would minimize adverse affects. Channel flow may reduce the concentration of contaminants (such as salts from agricultural return flow to the San Joaquin River); increased flow may be achieved by increasing reservoir releases, reducing diversion, or operating barriers to direct flow along pathways receiving contaminants. The need for dilution flows needs may not coincide with other flow needs associated with reactivation and maintenance of ecological processes and structure, and may have limited ecosystem benefits because contaminants continue to enter the ecosystem.

Productivity. Productivity is the capacity of the aquatic ecosystem to produce a product of interest (for example, a species population or group of species). The capacity of an ecosystem to produce a product of interest depends on basic energy and material resources, both those developed within an ecosystem and those introduced from external sources. Changes in energy and material resources inevitably lead to changes in the abundance of species and in ecological communities. Healthy fish, wildlife, and plant populations in the Bay-Delta river system depend on the maintenance and improvement of processes that affect productivity.

Through density-dependent relations, an increase or decrease in the basic energy and material resources changes the abundance of food, affects the abundance of species, and changes production-biomass relationships. Even small changes in basic energy and material resources (for example, input of organic material) may cause substantial changes in the capacity of the Bay-Delta river ecosystem to produce organisms, altering aquatic communities and affecting species abundance.

The complexity and magnitude of energy and material transfer through the ecosystem have limited the understanding of cause-and-effect productivity relationships to relatively simple controlled studies. Pathways of energy and material transfer through the Bay-Delta river ecosystem eventually may be described in qualitative terms; but quantifying rates of food consumption, assimilation, respiration, growth, and production through all trophic pathways in the ecosystem is not possible. Although results will be speculative, impacts of project actions on productivity of the Bay-Delta river system warrants consideration because human activities substantially affect production, including changes in species abundance.

The assessment relationship for productivity assumes that reestablishing natural conditions of energy and material transfer through the ecosystem reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Basic energy and material transfer mechanisms are reestablished by:

- Reducing the loss of nutrients and organisms to diversions.
- Reducing input of contaminants.
- Reestablishing basic hydrologic features, including flow variability and residence time.
- Reestablishing conditions that approximate the natural sediment and nutrient delivery to the system.
- Restoring structural characteristics to approximate the natural structural characteristics of the aquatic ecosystem.

Diversions remove material from the ecosystem, affecting the capacity of the ecosystem to produce products of interest through direct reduction of both food and species abundance. Adverse impacts of diversions on productivity may be lessened through reduced diversion volume, relocating diversions outside the range for species of interest (although relatively large diversions may continue to affect downstream productivity though removal of nutrients and organisms), reoperating diversions to avoid sensitive periods (for example, during periods of high biomass or susceptible life stages), and installing fish protection facilities (for example, fish screens).

Input of contaminants may increase mortality or decrease reproduction and growth, reducing food and species abundance. Actions that reduce contaminant input are discussed under "Contaminant Input and Movement."

Reestablishing basic flow and structural features, in combination with reestablishing natural sediment and nutrient delivery, moves the system toward natural ecosystem conditions. Restoring marshes and riparian forests would increase primary production by emergent vascular plants, and greater open water area could increase phytoplankton production. Restoration of upstream floodplain connections would reestablish delivery of organisms, detritus, and dissolved organic material to the Delta. Increased productivity for products of interest, however, is speculative because of the complexity and magnitude of energy and material transfer through the ecosystem; and because historical changes, including introduced species, continue to affect future productivity. Exotic species such as Asian clams may impede reestablishing any semblance to natural energy and material transfer.

Structure. Ecosystem structure refers to physical components of the Bay-Delta river system and their spatial relationships to one another. Structure substantially affects processes discussed above, including flow, water temperature, sediment and nutrient input and movement, contaminant input and movement, and productivity. The assessment relationship for structure assumes that reestablishing the natural structural features reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reestablishment of natural structure may include:

- Restoration of area, volume, and length of major surface and subsurface features of the aquatic ecosystem.
- Removal of channel constraints.
- Reestablishment of riparian, marsh, and wetland plant communities.

Major surface and subsurface features of the aquatic ecosystem include floodplain, flooded islands, dead-end sloughs, tidal and river channels, riparian communities, and tidal marsh. Delta island levees may be breached to create additional aquatic habitat. Dams and barriers may be removed to reconnect aquatic habitats to the existing aquatic ecosystem. The floodplain may be reconnected to the river through breached or setback levees, or reconfiguration of floodplain elevation—increasing the frequency, duration, and area of flooded habitat. Removal of channel constraints may include removal of bank revetment, setback levees, and suspension of dredging activities. Removal of channel constraints, in addition to reconnecting the floodplain to the aquatic ecosystem and increasing aquatic area, would allow reestablishment of channel density and complexity—increasing species habitat diversity. Allowing and encouraging reestablishment of riparian, marsh, and wetland vegetation through planting and revision of vegetation control programs would add structure to the aquatic ecosystem; provide cover for species; contribute to processes that increase channel density and complexity; and subsequently create additional ecosystem area, volume, and length.

Species-Specific Analysis. This section describes the method for assessing the effects of Program actions on species. All aquatic species in the Bay-Delta system possess an intrinsic value as components of biological diversity. Several species in the system also have significant social and political value, including value to commercial and sport fisheries.

The factors that limit abundance and production are generally not known, which is an inherent problem in species analysis. Without knowing limiting factors, cause-and-effect relationships are speculative, and predicted effects or responses to specific actions are uncertain (see Section 6.1.2, "Areas of Controversy"). A qualitative analysis at the species-specific level is based on factors that may affect abundance and distribution of selected aquatic species, primarily species listed or proposed for listing under federal and California ESAs (winter-, spring-, fall-, and late fall-run chinook salmon; steelhead; delta smelt; and splittail). Assessment relationships are grouped into eight categories: habitat, water quality, entrainment, water surface level, movement, species interactions, artificial production, and harvest. Species and life-stage needs, along with geographical and seasonal occurrence, determine application of the species-specific relationships identified below.

Physical Habitat Relationships. Physical habitat includes the resources and conditions present in an area that allow an organism to survive, grow, and reproduce. These factors include spawning areas, rearing areas, and migration pathways. In the project area, habitat loss and degraded value have substantially contributed to the decline of many species. Providing habitat is critical to maintaining and increasing the abundance and distribution of all representative species.

Physical habitat relationships focus primarily on habitat abundance. "Habitat abundance" refers to the abundance of specific resources that are used by an organism. For example, increased area of spawning gravel increases the spawning habitat abundance for chinook salmon. Although density-dependent factors partially determine whether habitat is limiting the abundance and distribution of a species, the assessment relationship for habitat assumes that increased habitat abundance benefits a species (that is, increased habitat improves survival, growth, and reproductive success; and ultimately increases abundance and distribution). Depending on the species, habitat abundance may increase when:

- Levees and hard bank protection (for example, rip-rap) in the Delta and along rivers are breached, set back, removed, or alternatively managed for biological benefits.
- Barriers to movement of organisms are removed from river or Delta channels.
- Flow, water temperature, and salinity are modified to provide for specific species needs.
- Riparian, wetland, and marsh areas are restored and reconnected to the Delta or riverine aquatic ecosystem.
- Natural or artificial sediment input and movement is reestablished (for example, removal of dams or addition of gravel to selected stream reaches).

An increase in the area, volume, and length of habitat (from breach, setback, or removal of levees in the Delta and along rivers) and an increase in the length of river or Delta channels not blocked by dams and other barriers were assumed to provide additional habitat for the representative species. The extent of benefits to individual species will depend on the location and type of restoration relative to the spawning and rearing habitat needs of each species.

Improved habitat conditions attributable to flow, water temperature, and salinity changes that provide for specific species needs were assumed to increase habitat abundance. As mentioned previously, species needs relative to factors limiting abundance are speculative, and the assessment is based on a general understanding of expected species response to ecosystem processes, not on a clear understanding of specific mechanisms. For example, abundance of many species is higher under high Delta outflow conditions. High abundance may be attributable to many mechanisms, including increased habitat abundance and other mechanisms discussed below (for example, entrainment and movement).

Flow and water temperature needs of some species may be inconsistent with natural conditions. For example, reservoirs have blocked access to most of the historical habitat used by chinook salmon and steelhead, and existing populations are restricted to habitat downstream of the major reservoirs. Under natural conditions, the river reaches below reservoirs may have provided marginal water temperature and flow conditions that were insufficient to sustain viable chinook salmon and steelhead populations. Therefore, the target range for flow and water temperature management with reservoir operations must reflect the needs of desired species.

Increased habitat abundance was assumed to benefit species of interest, but habitat created near major diversions may be of minimal benefit because individuals or food organisms may be lost to entrainment. In addition, restoration may not increase habitat abundance because the restored or reclaimed areas are isolated from existing species populations or do not provide environmental conditions that are consistent with a species needs (for example, depth, velocity, salinity, substrate, and cover). Introduced species further complicate the response of native species populations to increased habitat abundance because introduced species populations may increase, subsequently increasing competition and predation on native species (for example, interactions between introduced silversides and native delta smelt or the effects of introduced Asian clams on primary productivity).

Sediment input and movement affect fish spawning and rearing habitat, including turbidity effects on feeding and changes in the composition of the channel bottom. In general, streams with gravel-cobble substrates support greater diversity and abundance of invertebrates important as food for stream fish, including chinook salmon and steelhead (Waters 1995). In addition, gravel substrates are needed to support spawning of chinook salmon, steelhead, and other species. Adult steelhead and chinook salmon require relatively clean gravels in which to lay their eggs. A high proportion of sand and silt in gravel substrates reduces production of invertebrates and reduces spawning success for steelhead, chinook salmon, and other fish species. The smaller spaces between gravel particles are filled with silt and sand, thereby limiting the available space and reducing the flow of water and oxygen to eggs, larvae, and aquatic invertebrates in the gravel. Fine sediments also can reduce or prevent young fish from emerging after they have hatched. As discussed under "Sediment and Nutrient Input and Movement," reestablishing natural levels of sediment delivery and movement will help to sustain healthy fish populations.

Water Quality Relationships. Death, reduced growth, or reduced reproductive success occur when water quality stresses the metabolic tolerances of an organism. The detail provided by information developed for this programmatic EIS/EIR is insufficient for species-level assessment of water quality impacts. Impacts identified at the ecosystem-level assessment for contaminants were assumed to reflect impact direction for species that occur in the affected areas.

Entrainment Relationships. Water diversions cause fish mortality through entrainment (and subsequent movement to inappropriate habitat), impingement on fish screens or other diversion structures, abrasion, stress as a result of handling, and increased predation. Entrainment and associated mortality is a concern for all fish species included in the impact assessment. Life stages most vulnerable to entrainment vary by species. For example, chinook salmon and steelhead are most affected during fry and juvenile rearing and downstream migration. Some species, such as striped bass and American shad, are most vulnerable during the egg and larval stages, although they are also vulnerable to entrainment as juveniles. Delta smelt are vulnerable as larvae, juveniles, and adults because of their small size at maturity and year-round residence near diversions. Adults of the large-bodied species, such as striped bass, chinook salmon, green and white sturgeon, and American shad, are minimally affected by diversion operations and facilities.

The assessment relationship for entrainment assumes that reduced entrainment-related losses will increase species abundance and distribution. Entrainment-related losses may be reduced by:

- Constructing new or improved fish screens.
- Locating diversions to avoid the primary distribution of a species, including geographical location and position in the water column.
- Redistributing species populations to Suisun Bay, subsequently reducing exposure to Delta diversions.
- Reoperating diversions to avoid periods when species are present and when the life stages present are vulnerable to entrainment-related mortality (for example, larvae).
- Redesigning diversions and associated facilities to reduce predator habitat or control predators in diversion facility components (that is, screen bays).

Program actions to construct and improve fish screens would reduce the loss of life stages large enough to be efficiently screened; however, fish screens would provide minimal protection for planktonic eggs and larvae. American shad and striped bass spawn planktonic eggs that are small and pass through the fish screens. The planktonic larvae of American shad, striped bass, delta smelt, and longfin smelt would either pass through the screens or, because larvae are weak swimmers, be impinged on the screen surface.

Diversion facilities provide habitat and increased feeding opportunity for predatory fish. Predation on desired species may be reduced by control of predators within facility components or a change in facility design to reduce predator habitat and prey vulnerability.

A shift in estuarine salinity may alter the geographic distribution of aquatic organisms. The occurrence of the 2-parts per thousand (ppt) salinity zone upstream of Chipps Island shifts the primary distribution of larval and juvenile delta smelt and striped bass into the Delta. Redistributing species to Suisun Bay, through provision of conditions meeting species needs (for example, salinity), reduces exposure to Delta diversions and potentially reduces diversion-related mortality.

Water Surface-Level Relationships. Short-term changes in water surface levels may result in mortality by exposing nests, stranding individuals, reducing or eliminating cover, and other means. Chinook salmon, steelhead, largemouth bass, and splittail are representative of species sensitive to water surface-level fluctuation in rivers; largemouth bass are representative of species sensitive to reservoir fluctuations. Chinook salmon and steelhead lay eggs in gravel nests, splittail lay eggs on flooded vegetation, and largemouth bass lay eggs in nests in relatively shallow water near the reservoir shore. Increased frequency and magnitude of short-term water surface-level fluctuation increases mortality caused by exposure of nests; desiccation of eggs; and mortality associated with movement of larvae and juveniles into less optimal habitat, where food may be less available and vulnerability to predation may increase.

The assessment relationship for water surface-level assumes that reduced human-caused fluctuation will reduce losses and increase species abundance and distribution. Information developed for this programmatic EIS/EIR is generally insufficient for species-level assessment of water surface-level changes; however, effects of Program actions that reduce human-induced water surface-level fluctuations are considered qualitatively. Human-caused water surface-level fluctuations may be reduced by:

- Management of reservoir operations to minimize short-term flow fluctuation in rivers.
- Management of reservoirs to minimize drawdown during spawning and early rearing periods.
- Construction of Program elements that minimize human-caused isolation of aquatic ecosystem components.

Program actions that minimize flow reduction in rivers over short time intervals were assumed to improve habitat conditions affected by water surface-level fluctuation and benefit affected species. For reservoirs, Program actions that minimize drawdown during spring and summer were assumed to reduce mortality attributable to short-term water surface-level fluctuation and benefit reservoir species.

Program elements that minimize human-caused isolation of aquatic ecosystem components include filling gravel mining pits; establishing permanent or seasonal connections between oxbows and sloughs and the main river channel; and recontouring the flood bypasses, including isolated ponds, agricultural fields, and sloughs, to establish efficient connections to main drainage channels. Seasonal connections must coincide with species needs relative to use of spawning and rearing habitat.

Movement Relationships. Movement of organisms includes passive transport, migration, and attraction. Passive transport is the movement of organisms with flow. In rivers, passive transport is downstream. In the Delta and Bay, passive transport with tidal currents is bi-directional. Planktonic or free-drifting organisms, including planktonic fish eggs and larvae, depend on passive transport to reach rearing habitat, although some planktonic organisms may vertically migrate to slow or accelerate movement in a specific direction. American shad, striped bass, delta smelt, longfin smelt, and splittail have planktonic egg or larval life stages dependent on passive transport.

Migration entails active movement of organisms either with or against flow; attraction is active movement in response to flow or water quality stimuli. Many adult and juvenile fish, including chinook salmon, American shad, splittail, steelhead, longfin smelt, and delta smelt, migrate in response to seasonal spawning and rearing habitat needs. Flow and water quality may stimulate and guide seasonal migration.

The assessment relationship for movement assumes that improved transport, migration, and attraction conditions will improve growth, survival, and reproduction, as well as increase species abundance and distribution. Transport, migration, and attraction conditions may be improved by:

- Reestablishing natural hydrologic features.
- Establishing appropriate seasonal water temperature conditions in managed reaches that are consistent with the needs of desired species.

- Restoring natural water quality conditions, including sediment, nutrient, and contaminant input and movement.

- Reestablishing ecosystem connectivity.

Improvement in transport, migration, and attraction conditions attributable to reestablishing natural hydrologic features that provide for specific species needs (for example, flow, water temperature, and salinity) was assumed to improve growth, survival, and reproduction. As mentioned previously, species needs relative to factors limiting abundance are speculative; assessment is based on a general understanding of expected species response to ecosystem processes, not on a clear understanding of specific mechanisms. For example, abundance of many species is higher under high Delta outflow conditions. High abundance may be attributable to many mechanisms, including increased habitat abundance, increased prey availability, improved access to spawning and rearing habitat, improved migratory cues, and transport away from diversions.

Flow that emulates natural patterns was assumed to improve survival during downstream movement of juvenile chinook salmon and steelhead; striped bass eggs and larvae; sturgeon larvae and juveniles; and American shad eggs, larvae, and juveniles. In addition, natural flow patterns are assumed to ensure necessary attraction cues for adult chinook salmon, steelhead, delta smelt, splittail, and other species. Project actions that provide flow events consistent with natural flow patterns and consistent with species needs were assumed to move juvenile fish into suitable rearing areas, provide cues that reduce outmigration delay, provide attraction for upstream migration of adults, and increase survival.

In the Delta, natural net channel conditions (for example, flow toward Suisun Bay) were assumed to facilitate movement of organisms to downstream habitat more conducive to increased growth and survival. For chinook salmon of both Sacramento River and San Joaquin River origin, mortality during migration through the Delta may vary depending on pathway and environmental conditions, such as water temperature and dissolved oxygen levels. Under existing conditions, the mortality of juvenile chinook salmon that move into the DCC and Georgiana Slough from the Sacramento River is greater than the mortality of juvenile chinook salmon that continue down the Sacramento River toward Rio Vista. Steelhead were assumed to be affected similarly.

For San Joaquin River chinook salmon, juveniles that move with flow into Old River at Mossdale may suffer greater mortality than juvenile chinook salmon that continue down the San Joaquin River toward Stockton. Additionally, increased net flow toward the south in Old and Middle Rivers and connected channels may increase entrainment of chinook salmon, steelhead, delta smelt, striped bass, and other species in the south Delta diversions.

Ecosystem connectivity may be reestablished through removal and modification of barriers, installation and improvement to fish passage facilities, and restoration of channel structure to facilitate access to resources and conditions that allow a species to survive and reproduce.

Relationships discussed above are controversial because of uncertainty arising from limited knowledge of species needs and unpredictable responses to environmental changes. Implementation of actions that support movement will depend on developing knowledge of species needs and understanding effects of Program elements (see Section 6.1.2, "Areas of Controversy").

Species Interactions. Predation occurs naturally in the system; however, fish and other aquatic organisms that are stressed by toxicants, elevated water temperatures, turbulence created by barriers or screening facilities, and other factors may be more susceptible to predation and experience artificially high mortality rates. Artificial structures can create predatory fish holding areas and ambush sites. Artificial structures that block and delay fish passage may increase predation opportunities. In-channel gravel mining and other activities affecting channel structure has created predator habitat and increased vulnerability of desired species to predation.

The assessment relationship for species interactions assumes that maintenance of native species communities will improve survival and increase the abundance and distribution of desired species. Native species assemblages of aquatic organisms have been irreversibly altered, especially in the Delta where introduced species dominate the existing fish fauna. Eradication of introduced aquatic species is currently infeasible; however, native species communities would benefit from programs that reduce or eliminate the influx of non-native aquatic species in ship ballast water and reduce the potential for influx of non-native aquatic plant and animal species at border crossings. Controlling the introduction of non-native species potentially halts continued escalation of unnatural levels of competition, predation, and disease.

Maintaining and restoring natural habitats, including a return to hydrologic, temperature, and structural conditions that favor native species, also would benefit native species communities. Where societal goals limit restoration, programs that control predator populations or reduce habitat for predators may be implemented to increase the survival of desired species.

Artificial Production. Supplementation of natural populations may be necessary if (1) natural populations are declining, (2) habitat is available but under-utilized, (3) future losses to the population cannot be averted through restoration actions in the near term, and (4) artificial production technologies exist that enable enhancement of natural populations. Artificial production that increases the fitness of natural spawning and rearing populations will increase the abundance and distribution of desired species. Fitness is the ability of a population to survive under variable environmental conditions and the capacity to reestablish pre-disturbance abundance and distribution. Fitness of natural spawning and rearing populations may be maintained through:

- Careful selection of wild populations to be supplemented.
- Limiting the amount of artificial production added to a natural population based on numbers needed to maintain population integrity.
- Use of only wild fish as broodstock. Marking of all artificially produced fish is an integral part of wild fish identification.
- Consideration of stocking location and timing relative to natural fish population sensitivity.
- Modification of artificial rearing environments to be more similar to natural environ-ments and to reduce differential reproductive success.
- Consideration of genetic effects in benefit-cost determinations for the need of artificial supplementation.

Artificial production of salmon and steelhead can increase predation and competition with naturally produced populations, lower the genetic integrity of natural populations, and increase harvest rates on natural populations. The beneficial impacts of artificial production for natural populations are uncertain, and only avoidance or minimization of supplementation will clearly avoid adverse effects on desired species populations.

Harvest. Harvest management recommendations would be designed in a manner consistent with the Program solution principle of "no significant redirected impacts" on fishing interests. Illegal and legal harvest of fish can adversely affect the abundance of desired natural populations, such as chinook salmon, steelhead, striped bass, and other sport and commercially valuable species. Harvest that is consistent with maintaining the fitness of natural spawning and rearing populations will avoid adverse effects on the abundance and distribution of desired species populations. Fitness of natural spawning and rearing populations may be maintained through:

- Increased law enforcement and implementation of programs to increase public awareness and reporting of illegal harvest violations.
- Limiting the harvest of natural populations based on numbers needed to maintain population integrity, including allowances for variable environmental conditions that affect productivity.
- Clear separation of harvest goals for artificially and naturally produced fish, possibly requiring marking of all artificially produced fish.

6.1.5 SIGNIFICANCE CRITERIA

The general nature of the planning and the broad range of settings and impacts contained in the Phase II Report dictate the use of qualitative thresholds of significance for the Programmatic EIS/EIR. Thresholds are phrased in qualitative terms, indicating potential changes from either existing conditions or conditions under the No Action Alternative.

Program actions are considered beneficial if the changes in structural and functional characteristics may result in an ecosystem that emulates a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs. In addition, actions are considered beneficial if changes in environmental conditions are likely to halt or reverse downward trends in native species abundance and distribution relative to existing conditions.

Adverse impacts are considered potentially significant when Program actions cause or contribute to substantial short- or long-term reductions in aquatic ecosystem characteristics, and degrade conditions that potentially reduce abundance and distribution of species populations. An adverse effect is considered potentially significant if it substantially degrades aquatic ecosystem processes; substantially reduces the structural characteristics of the aquatic ecosystem; substantially degrades the conditions affecting or potentially affecting the abundance or range of a species with economic or social value; harms a rare, threatened, and endangered species or its habitat; or has considerable effects when viewed with past, current, and reasonably foreseeable future projects. A "substantial" change likely would be detectable, given expected natural variability. Degradation of ecosystem processes occurs whenever the trend is away from the natural condition. Degradation of conditions affecting the abundance or range of a species refers to loss of habitat or increase in stressors that would adversely affect a species survival, reproduction, migration, or growth.

6.1.6 NO ACTION ALTERNATIVE

Existing conditions are the environmental baseline against which the expected ecosystem and species response to future actions are compared. Given the programmatic level of analysis, what we know of existing conditions, and what we can predict to 2020, the discussion of differences between the No Action Alternative and existing conditions focus primarily on changes in water project operations, new or modified facilities, and projected increase in water demands that are not associated with the Program.

6.1.6.1 DELTA REGION

Although simulated SWP and CVP annual deliveries would increase by about 7% relative to existing conditions, monthly Delta inflow and outflow would be similar under the No Action Alternative and existing conditions. Operations rules and hydrologic variation would limit the ability to alter flow patterns and the associated salinity distribution in the Delta. Possible ESA protection criteria could reduce annual SWP and CVP south-of-Delta deliveries relative to existing conditions. The change in Delta flow patterns could move slightly toward natural patterns, potentially benefitting Delta species.

Projects identified as part of the No Action Alternative would cause minimal effects on water temperature, sediment input and movement, and ecosystem structure relative to existing conditions. Actions upstream of the Delta, such as the Sacramento River Flood Control Project (SRFCP), may slightly alter sediment supply and movement; but the small effects cannot be determined at the programmatic level and would need to be determined for specific projects.

Contaminant input under the 2020 level of development may increase. Increased input of urban and industrial contaminants would increase stress on biological processes (for example, reduced organism growth and fecundity, and increased organism susceptibility to disease) and would adversely affect species population distribution and abundance.

Relative to existing conditions, projects under the No Action Alternative that could increase biological productivity and nutrient input and movement in the aquatic ecosystem include changes in wildlife refuge operations and restoration associated with the Stone Lakes National Wildlife Refuge (NWR) and the SRFCP.

Structural characteristics of the Delta also would be similar for both the No Action Alternative and existing conditions. A project that may affect structural characteristics in a small part of the Delta ecosystem is the Stone Lakes NWR. Change in structural characteristics is considered a beneficial impact when the change moves toward a natural condition. Restoration of tidal marsh and connecting sloughs in the Stone Lakes NWR would result in small beneficial effects relative to the existing Delta aquatic system. The structural changes could result in a slight increase in spawning and rearing habitat for Delta species, including chinook salmon, Sacramento blackfish, Sacramento splittail, largemouth bass, and striped bass.

6.1.6.2 BAY REGION

Under the No Action Alternative, effects on fisheries and aquatic ecosystems in the Bay Region primarily depend on movement of contaminants, sediment, nutrients, and production from the Delta Region. Change in simulated Delta outflow would be small and produce little effect on the Bay Region ecosystem, including the Suisun Marsh.

6.1.6.3 SACRAMENTO RIVER REGION

Although operations and surface water and groundwater storage would change under the No Action Alternative, Sacramento River and tributary flows would be similar to flows under existing conditions. Operations rules and demands, similar under both the No Action Alternative and existing conditions, would limit the ability to change flow patterns. Yuba River flows may be altered in response to revised regulations that will improve spawning and rearing conditions, providing a beneficial impact primarily on chinook salmon and steelhead.

Based on the relatively small change in flow and reservoir operations, water temperature conditions in most rivers in the Sacramento River Region under the No Action Alternative would be similar to temperature conditions under existing conditions. However, projects assumed under the No Action Alternative that could affect water temperature include the Shasta Temperature Control Device and interim reoperation of Folsom Reservoir. The additional flexibility for water temperature control from operation of the Shasta Temperature Control Device would benefit all runs of chinook salmon and steelhead trout that spawn and rear in the Sacramento River below Keswick Reservoir. In the American River, steelhead and chinook salmon currently are restricted to habitat below Nimbus Dam. Reoperation of Folsom Reservoir may reduce summer flows and the availability of cool water released to the American River. Water temperature may increase, adversely affecting rearing and spawning conditions.

The SRFCP may affect structural characteristics of the Sacramento and American Rivers. Change in levee maintenance practices to allow development of natural riparian and shaded riverine aquatic communities would produce small beneficial effects relative to the existing levee system. The structural changes could result in a slight increase in rearing habitat for river species, including chinook salmon, steelhead trout, and Sacramento splittail.

6.1.6.4 SAN JOAQUIN RIVER REGION

As for the Sacramento River, differences between the No Action Alternative and existing conditions reflected by simulated flow changes are minimal. San Joaquin River and tributary flows would be similar to flows under existing conditions. In the Mokelumne and Tuolumne Rivers, short-term flows may be altered to improve spawning and rearing conditions, providing a beneficial impact primarily for chinook salmon. Extended flows during April-May could provide benefits to San Joaquin River species present in spring of some years. Flow provided for the VAMP could affect reservoir storage. However, the change in storage volume, when apportioned among the Stanislaus, Tuolumne, and Merced Rivers, would not substantially affect flow and water temperature conditions and is not expected to adversely affect chinook salmon or steelhead.

Water quality conditions in most rivers in the San Joaquin River Region under the No Action Alternative would be similar to water quality conditions under existing conditions. The retirement of 35,000-45,000 acres of agricultural land could reduce input of contaminants to the San Joaquin River Region and improve the survival and spawning success of aquatic species, including chinook salmon and splittail, in the San Joaquin River. Change in contaminant effects, however, likely would be minimal.

6.1.6.5 OTHER SWP AND CVP SERVICE AREAS

The 2020 level of development under the No Action Alternative, including increased exports from the SWP and CVP Delta facilities, may assist growth in the Other SWP and CVP Service Areas. Additional agricultural or urban development would adversely affect aquatic ecosystems in the service areas, especially through increased input of contaminants. ESA limitations on QWEST and extension of the VAMP could slightly reduce exports relative to existing conditions, thereby avoiding increased adverse impacts. The San Joaquin River agreement (VAMP), however, is applicable for 12 years. No extension of the agreement has been negotiated.

MWD's Diamond Valley Reservoir Project would create additional habitat for reservoir species. The Coastal Aqueduct and MWD's Inland Feeder Project transport Delta water to streams, reservoirs, and estuaries outside the Central Valley. Introduction and establishment of non-native species to areas currently isolated from the Central Valley may adversely affect native species communities through increased competition for resources, predation, and disease. Imported water also may alter seasonal flow patterns, possibly increasing summer flow through increased runoff in storm drains. Increased flow relative to natural conditions could improve habitat for introduced species and stress native species that are adapted to natural flow regimes.

6.1.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

The No Action Alternative is the environmental baseline against which the expected ecosystem and species response to the Program elements are compared. The differences between the No Action Alternative and the Program alternatives result from implementation of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs. In addition, new water storage might be constructed. Storage facilities could include groundwater and surface water components. Changes in flow discussed in the following analysis are based on simulations used in Section 5.2, "Bay-Delta Hydrodynamics and Riverine Hydraulics."

Impacts on the aquatic ecosystem are described for each Program element. Implementation of elements common to all alternatives included in the Program will be progressive, depending on achievement of the Program objectives and conformance to solution principles. The impacts will change as the Program moves forward, and impact occurrence will depend on the extent to which each Program element is implemented. Because of the complexity of the aquatic ecosystem, response to implementation of Program elements represented by the impacts on the aquatic ecosystem identified below is often uncertain. Resolution of the controversy resulting from uncertainty was previously discussed (see Section 6.1.2, "Areas of Controversy").

6.1.7.1 DELTA REGION

Ecosystem Restoration Program

The goal of the Ecosystem Restoration Program is to improve and increase aquatic and terrestrial habitats, and to improve ecological functions in the Bay-Delta, in order to support sustainable populations of diverse and valuable plant and animal species (see the Ecosystem Restoration Program Plan). The program aims to restore ecosystem processes in order to (1) create and maintain habitat essential to species dependent on the Delta; and (2) reduce the adverse effects of stressors that inhibit ecosystem processes, limit habitat, and reduce species productivity. A Strategic Plan is being developed to guide implementation of the Ecosystem Restoration Program, including the type and intensity of actions needed to achieve Program targets.

The Ecosystem Restoration Program includes elements in four broad categories: ecosystem processes, habitats, species and species groups, and stressors. Ecosystem processes act directly, indirectly, or in combination to shape and form the ecosystem. Habitats are areas occupied by plants, fish, and wildlife that provide specific conditions essential to the needs of plant and animal communities. Species and species groups include species listed or proposed for listing under the California or federal ESAs, species of special concern as designated by the California Department of Fish and Game (DFG) or theUSFWS, species important in recreational or commercial fisheries, and important prey or foodweb species. Stressors are natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species.

In the Delta, actions addressing ecosystem processes are proposed to improve stream flows, natural sediment supply, natural floodplains and flood processes, stream temperatures, channel hydraulics, and the aquatic foodweb. Restored or reestablished habitat benefitting aquatic species would include tidal perennial aquatic habitat, nontidal perennial aquatic habitat, sloughs, midchannel islands and shoals, fresh emergent wetland, seasonal wetlands, and riparian and riverine aquatic habitats. Species-specific actions would target delta smelt, longfin smelt, splittail, white and green sturgeon, chinook salmon, steelhead, striped bass, American shad, resident fish species, and aquatic foodweb organisms. The primary stressors reduced by Program actions would include water diversions; effects of levees, bridges, and bank protection; dredging and sediment disposal; non-native species; predation and competition; contaminants; harvest; and human distur-bance (for example, recreational boating).

Implementation of the Ecosystem Restoration Program would reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. The program is expected to increase the abundance and distribution of desired aquatic species, possibly including delta smelt, sturgeon, chinook salmon, and steelhead. The Delta would benefit from Ecosystem Restoration Program elements implemented upstream in the Sacramento River and San Joaquin River Regions and downstream in the Bay Region. River flows move sediment, nutrients, contaminants, and organisms to the Delta; and bi-directional tidal flow intimately connects Delta and Bay environments. Phased implementation integrated with adaptive management would avoid or minimize adverse impacts on aquatic communities and desired species, and guide the type and intensity of actions needed to achieve Program targets.

A primary action includes restoration of aquatic areas—possibly several thousand acres—through breaching levees, flooding existing agricultural lands, and setting back levees along existing Delta channels. The conversion of some Delta islands from agricultural use to inundated wetlands and open-water habitat would markedly increase the abundance of aquatic habitat for Delta species. If restored areas are located near export facilities, are isolated from existing aquatic habitat, or provide depth or salinity unsuitable for important Delta species, the habitat value may be minimal. Under the existing Delta configuration, habitat restored in the south Delta potentially has the least value to Delta species because of their potential entrainment in Delta diversions. Increased flooded area in the central Delta also may be of minimal habitat value to many species because of the effects of diversion and export, and also because setting back levees and flooding of Delta islands would create primarily deep-water conditions. More extensive restoration actions that reduce water depth and increase channel complexity also could increase the habitat value of deep-water areas.

Restoration of aquatic areas also must consider contaminant concentrations in affected habitats and the potential for aquatic organisms to accumulate, magnify, transform, and mobilize contaminants to the detriment of aquatic communities or individual organisms. Effects of contaminants associated with habitat restoration are considered potentially significant. Mitigation strategies described in Section 5.3 would reduce these impacts to a less-than-significant level by ensuring that problem areas are identified and that restoration plans avoid the problem area or incorporate design measures to minimize the problem.

Restored habitats in the north Delta are farthest from the export facilities, potentially include more shallow-water habitat with greater channel complexity, and are near existing more natural habitat. In addition, production from north Delta habitat is more likely to contribute to production in habitats downstream, in the Suisun Marsh and the Bay. Because the location of restoration actions and the characteristics of the flooded habitat are not known, it is difficult to assess the benefits to individual Delta species. New spawning and rearing habitat may be provided for resident species in the Delta, such as delta smelt, Sacramento splittail, Sacramento blackfish, Sacramento pikeminnow, tule perch, largemouth bass, and white catfish. Anadromous species, such as striped bass, chinook salmon, steelhead, American shad, and white sturgeon, also may benefit from the availability of additional juvenile rearing and adult habitat. Although shallow-water environments will be constructed to provide habitat for native and other desirable fish species, colonization by non-native aquatic plants, such as *Egeria densa*, may alter the structure and reduce habitat value. Newly created habitat also may increase the abundance and distribution of carp, inland silverside, or other non-native species that compete with or prey on native species and species with higher economic and social value (for example, chinook salmon, delta smelt, and striped bass). Although it is hoped that habitat restoration would provide benefits to target species, this potentially significant impact may be unavoidable.

Construction activities associated with habitat restoration could result in adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. Sediment and contaminants may enter the Delta during in-water construction, erosion of disturbed soils during rain events, and direct discharge of construction-related materials. Substantial sediment input could degrade aquatic habitat conditions and bury fish eggs and less mobile organisms that serve as fish food. The extent that fish species are harmed by sedimentation depends partially on the extent that post-construction substrate conditions differ from preconstruction conditions. Elevated levels of turbidity (suspended particulate matter) may result when fine sediment is suspended in the water column. The duration and concentration of the turbidity depend on the extent of the activities and the efforts undertaken to eliminate and minimize activities within the waterway. Turbidity may cause indirect harm, injury, or mortality to fish species in the vicinity and downstream of the project area. High turbidity concentration can cause fish mortality, reduce fish feeding efficiency, and decrease food availability. All Delta species could be affected, depending on the timing and location of construction relative to species occurrence. These potentially significant impacts can be mitigated to a less-than-significant level.

Actions designed to reduce illegal harvest and improve sport harvest management for anadromous fish would increase the survival of adult fish and reduce impacts on self-sustaining natural populations. The existing DFG Delta-Bay Enhanced Enforcement Program provides enhanced law enforcement for illegal harvest of striped bass, salmon, steelhead, and sturgeon. Additional actions include improving harvest regulations, supplementing existing law enforcement efforts and community outreach, and developing additional cooperative programs to increase public awareness and provide additional means for reporting illegal-harvest violations. Species likely to benefit from such actions in the Delta Region include striped bass, chinook salmon, and sturgeon.

Water Quality Program

The Water Quality Program consists of actions designed to improve water quality in the Bay-Delta system and support all beneficial uses, including the protection and enhancement of aquatic life. The program relies on source control, increased enforcement of existing regulatory programs, and provision of incentives for action that goes beyond current regulatory programs. Potential actions would address contaminants from mine drainage, urban and industrial runoff, wastewater and industrial discharge, agricultural drainage and runoff, and unknown origins (for example, toxicity events affecting aquatic organisms that cannot be attributed to specific causes). Water quality parameters potentially affecting beneficial uses include metals and toxic elements, organics and pesticides, ammonia, dissolved oxygen, chloride, nutrients, alkalinity, turbidity, temperature, and salinity.

Receiving contaminants from river inflow and bi-directional tidal flow from the Bay, the Delta would benefit from Water Quality Program elements implemented upstream in the Sacramento River and San Joaquin River Regions and downstream in the Bay Region. In addition to actions identified for the Delta, improved source control and treatment of mine drainage; reduced scour of metal-laden sediments; and watershed actions, including improved land use practices, would reduce the movement of contaminants into the Delta system.

The Water Quality Program would reduce contaminant delivery and movement within the system, reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reduced contaminants could substantially increase system productivity, reestablishing basic energy and material transfer mechanisms through increased survival, growth and reproduction. Although available information is insufficient to develop specific impact conclusions for individual species, many species would benefit from reduced metabolic stress and increased survival.

Other Water Quality Program measures that may result in construction activities, such as relocation of water intakes, could cause impacts similar to those described in Section 6.1.8.1, "Preferred Program Alternative."

Levee System Integrity Program

The Levee System Integrity Program would reduce the risk to the ecosystem of catastrophic breaching of Delta levees by maintaining and improving the integrity of the levee system. Reduced likelihood of catastrophic breaching of Delta levees would reduce the likelihood of rapid hydrodynamic and salinity changes caused by sudden changes in Delta outflow and channel flow conditions. Although infrequently, species would benefit from the reduced frequency of sudden salinity shifts that could adversely affect habitat or delay transport to areas providing for specific species needs, such as spawning and rearing habitat. The change in flow and water quality conditions attributable to catastrophic breaching of levees also could increase entrainment in Delta diversions, depending on the change in the distribution of a species and the timing of breach relative to the vulnerability of specific life stages. Reduced risk of catastrophic breaching would reduce the risk of unexpected increased entrainment events.

Setting back levees and constructing channel-side berm and levee remnants, if implemented to maintain and improve Delta levee integrity, have great potential to improve the aquatic and riparian habitat characteristics of the Delta, Bay, Sacramento River, and San Joaquin River Regions when the substrate is stabilized and vegetation is restored. Changes in levee maintenance practices to allow development of natural riparian and marsh communities also would produce beneficial effects on aquatic and riparian habitat characteristics. Levee reconstruction, dredging, and the installation of rock revetment would result in both short- and long-term adverse effects due to habitat encroachment and losses. Construction activities could result in potentially significant adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be affected, depending on the timing and location of construction relative to species occurrence. These potentially significant impacts can be mitigated to a less-than-significant level.

Water Use Efficiency Program

The Water Use Efficiency Program could increase net water savings through implementation of conservation and water recycling actions. Net water savings could reduce the demand for Delta exports, increase water available for transfers, delay the need for new water facilities, and improve water quality. Reduced demands could increase reservoir and diversion operation flexibility, and allow flow management to meet species needs or to more closely approximate the natural seasonal flow variability (pattern and magnitude), including the effects of Delta outflow on seasonal variability in salinity distribution. Reestablishing natural seasonal flow variability (pattern and magnitude) could reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reduced contaminant delivery as a result of reduced applied water and subsequent reduced runoff would improve water quality, potentially reactivating and maintaining ecological processes that sustain healthy aquatic communities. Improved water quality also could increase productivity.

Species would benefit from reduced entrainment and impingement impacts that are associated with reduced diversions, modifications in flow timing and reservoir releases, improved in-stream water quality, and increased water available for ecosystem purposes.

Water Transfer Program

The Water Transfer Program could provide the incentive to implement practices that increase water use efficiency and subsequent availability of water for transfer. Impacts of the Water Use Efficiency Program are discussed above. Water transfers would affect fisheries and aquatic resources primarily through changes to riverine flow and export. Several factors, including the source of water for a transfer and the timing, magnitude, and pathway of each transfer, influence the likelihood for potentially significant impacts. To the extent that transfers are consistent with ecosystem needs and purposes, fisheries and aquatic ecosystems would benefit. Benefits could include reestablishing the natural seasonal flow and salinity variability, and reduced entrainment and impingement impacts associated with reduced or rescheduled diversions.

Potentially significant adverse impacts may result from transfers between agricultural and urban uses if proper planning and management of specific transfers are not undertaken. At the ecosystem level, transfers may affect seasonal flow variability and productivity. Adverse effects on species could include reduced habitat abundance attributable to flow effects, reduced transport and attraction in response to flow effects, and increased entrainment attributable to flow effects on species movement and distribution (for example, species response to change in estuarine salinity) relative to the location and volume of diversions. Mitigation strategies described in Section 6.1.11 are expected to reduce potentially significant adverse impacts from water transfers to a less-than-significant level. In addition, some of the actions described in the Water Transfer Program Plan (see Chapter 4 in the Water Transfer Program Plan), in conjunction with existing legal requirements placed on water transfers, are expected to protect against potentially significant adverse impacts on fisheries and aquatic resources.

Watershed Program

The Watershed Program could affect all of the programs described above. Watershed activities would focus on reducing stressors; and encompassing natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Actions could include stream bank restoration, slope stabilization, meadow restoration, point source contaminant control, and aquatic habitat restoration. Implementation of actions could improve water quality, increase species habitat, increase water availability, and restore the natural stream structure.

Most of the impacts in the Delta Region would result from activities in the Sacramento River and San Joaquin River Regions. Many potential watershed activities that are expected to improve water quality and flows in those regions also would improve water quality and flows in the Delta. Ecosystem-level benefits could include a closer approximation of natural seasonal flow (and salinity) variability, restoration of natural sediment delivery and movement, reduced contaminant input, increased productivity, and restoration of the natural ecosystem structure, such as floodplain connectivity. Species benefits primarily would accrue from increased habitat abundance due to improved flow conditions and increased survival, growth, and reproduction in response to improved water quality.

Construction activities associated with the Watershed Program could result in potentially significant adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. These impacts can be mitigated to a less-than-significant level.

Storage

New storage would provide the opportunity for additional flow management, potentially affecting the magnitude, timing, and duration of Delta inflow, Delta outflow, and exports. New storage would be constructed and operated only after information clearly confirms that potentially significant adverse impacts on fish and aquatic species populations can be avoided.

New storage could change Delta inflow and outflow. Relative to the natural seasonal flow variability (pattern and magnitude), however, simulated flows with new storage were similar to flows under the No Action Alternative. Actual effects will need to be determined for specific projects and will depend on location (for example, upstream of Delta, in-Delta, offstream, or existing reservoir enlargement) and operations rules. A portion of new storage may be allocated to environmental water supplies and could provide beneficial impacts through enhancement of seasonal flow needs for biological communities and species in the Delta. Species could benefit from increased productivity and improved conditions affecting movement. Total Delta outflow, however, would be reduced because of additional export. The adverse effects of reduced outflow, including the effects on estuarine salinity, would depend on timing and reduction in magnitude relative to base outflow conditions.

Filling in-Delta storage could adversely affect fish species, depending on the location of the storage and diversion facilities and the timing, magnitude, duration, and frequency of diversions. As discussed above, Delta outflow would be reduced. In addition, the magnitude of net reverse flow could increase in some Delta channels. Changes in Delta outflow and channel flow could affect the distribution of fish species, potentially increasing entrainment in CVP and SWP exports and other Delta diversions. Depending on the location of the diversion intake, some species populations may be more affected than others. For example, diversion from the Mokelumne channels or the San Joaquin River channel could result in potentially greater effects on Mokelumne River or San Joaquin River chinook salmon than on chinook salmon from the Sacramento River. Although the diversion into in-Delta storage would be screened, entrainment-related losses would occur, including predation, abrasion and impingement, and entrainment of fish life stages and other aquatic organisms that cannot effectively be screened given the existing technology. The operations flexibility of in-Delta storage, however, would provide the opportunity to avoid and minimize adverse effects on Delta fish species through diversions during periods when flow conditions would be minimally affected and when Delta species are least vulnerable to the effects of diversions. If diversions to in-Delta storage allow reoperation of other Delta diversions, lower diversions during periods of high fish vulnerability could benefit Delta fish species by reducing entrainment losses and potential adverse effects of Delta flows on species distribution.

For in-Delta storage, discharge directly to Delta export and diversion facilities could increase operational flexibility, potentially benefitting Delta fish species by minimizing exports or diversions during periods of high fish vulnerability. Discharge for environmental benefits could, given appropriate timing, improve Delta flow conditions—reducing the magnitude of net reverse flow and increasing Delta outflow during periods of potentially high fish sensitivity. Export or diversion of in-Delta storage discharged to Delta channels, however, could result in adverse effects.

Simulated operations demonstrated that increased storage in and upstream of the Delta could enable average annual CVP and SWP exports to increase by 500-700 TAF (an 8-12% annual increase). The simulated increase primarily occurs during January-March and in September. Higher exports could adversely affect the population abundance of Delta species through increased entrainment-related losses, including losses of winter-, spring-, and fall-run chinook salmon and adult delta smelt. In addition, increased exports would increase the magnitude of net reverse flow conditions in Old and Middle Rivers and possibly in the lower San Joaquin River. Net reverse flow conditions are counter to natural net flow conditions in Delta channels and could reduce productivity, impair species movement, and increase entrainment in Delta diversions. Species adversely affected could include chinook salmon, steelhead, delta smelt, and striped bass.

Mitigation is available to reduce these potentially significant flow-related impacts of storage operations to a less-than-significant level. However, mitigation potentially includes operational changes that could reduce water availability for other beneficial uses, as identified in Section 5.1, "Water Supply and Water Management."

Construction of storage facilities in the Delta could cause significant adverse impacts on fisheries and aquatic ecosystems though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be affected, depending on the timing and location of construction relative to species occurrence. Mitigation strategies are available to reduce these impacts to a less-than-significant level.

6.1.7.2 BAY REGION

Ecosystem Restoration Program

The Bay ecosystem would benefit from Ecosystem Restoration Program elements implemented in the Delta and upstream of the Delta. River flows move sediment, nutrients, contaminants, and organisms to the Bay; and bi-directional tidal flow intimately connects Delta and Bay environments.

In the Bay, actions addressing ecosystem processes are proposed to improve stream flows, natural floodplains and flood processes, and the aquatic foodweb. Restored or reestablished habitat benefitting aquatic species would include tidal perennial aquatic habitat, nontidal perennial aquatic habitat, sloughs, saline emergent wetland, seasonal wetlands, and riparian and riverine aquatic habitats. Species-specific actions would target delta smelt, longfin smelt, splittail, white and green sturgeon, chinook salmon, steelhead, striped bass, American shad, resident fish species, estuarine foodweb organisms, and marine and estuarine fishes and large invertebrates. The primary stressors reduced by Program actions would include water diversions, non-native species, predation and competition, contaminants, harvest, and human disturbance (for example, recreational boating).

Implementation of the Ecosystem Restoration Program would reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. The Program also would increase the abundance and distribution of desired estuarine and anadromous species, including delta smelt, sturgeon, chinook salmon, and steelhead. Phased implementation integrated with adaptive management would avoid or minimize adverse impacts on aquatic communities and desired species, and guide the type and intensity of actions needed to achieve Program targets.

Restoration of aquatic and adjacent communities, including riparian, shallow water, and tidal marsh, would increase productivity through the increased input of organic carbon. Increased production would result from the increased area available to support plants, including algae and vascular plants, and the increased density of plants in restored habitats. Increased inputs may result from reestablishing connections between terrestrial and aquatic habitats.

Restoration of aquatic areas also must consider contaminant concentrations in affected habitats and the potential for aquatic organisms to accumulate, magnify, transform, and mobilize contaminants to the detriment of aquatic communities or individual organisms. As for the Delta Region, effects of contaminants associated with habitat restoration in the Bay Region are considered potentially significant. Mitigation strategies are available to reduce this impact to a less-than-significant level by ensuring that problem areas are identified and that restoration plans avoid the problem area or incorporate design measures to minimize the problem.

The conversion of some managed wetlands to inundated tidal wetlands and open-water habitat would markedly increase the abundance of aquatic habitat for Bay species. The habitat value of newly inundated areas for Bay species would vary greatly, depending on the location and morphological characteristics of the restored areas. New spawning and rearing habitat may be provided for resident species in the Bay and Suisun Marsh, such as longfin smelt and striped bass. Anadromous species, such as chinook salmon, steelhead, and white sturgeon, also may benefit from the increased abundance of juvenile rearing and adult habitat. Newly created habitat also may increase the abundance and distribution of non-native species that compete with or prey on native and other target species. Although it is hoped that restoration would provide benefits to target species, this potentially significant impact may be unavoidable. Benefits to existing and reestablished habitat would be enhanced by actions to control non-native invasive species (although, specific actions are currently undetermined) and to increase the effectiveness of programs that reduce the introduction of invasive species.

Construction activities associated with habitat restoration could result in adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Bay species could be affected, depending on the timing and location of construction relative to species occurrence. Mitigation is available to reduce these potentially significant impacts to a less-than-significant level.

Artificial production targets in the Ecosystem Restoration Program include managing artificial fish propagation programs consistent with the rehabilitation of naturally producing populations, conserving ecological and genetic values, achieving recovery of special-status species, and maintaining healthy populations of other species. In general, these actions could benefit delta smelt, chinook salmon, steelhead, and other species in the Bay Region (primarily through reduced predation and competition effects).

Actions in the Ecosystem Restoration Program designed to reduce illegal harvest and improve sport harvest management for anadromous fish would increase the survival of adult fish and reduce impacts on self-sustaining natural populations. Additional actions include improving harvest regulations, supplementing existing law enforcement efforts and community outreach Delta-Bay Enhanced Enforcement Program, and developing additional cooperative programs to increase public awareness and provide additional means for reporting illegal-harvest violations. Species likely to benefit from such actions in the Bay Region include striped bass, chinook salmon, and sturgeon.

Water Quality Program

Program elements implemented in the Bay Region would address contaminants introduced from wastewater and industrial discharge, and from unknown origins (for example, toxicity events affecting aquatic organisms that cannot be attributed to specific causes). Beneficial impacts described above for the Delta would be similar for the Bay ecosystem and species. In addition, contaminants entering the Delta potentially flow to the Bay; therefore, the Bay would benefit from Water Quality Program elements implemented upstream in the Sacramento River and San Joaquin River Regions and in the Delta Region.

Levee System Integrity Program

Although the Levee System Integrity Program would not directly affect most Bay environments, the reduced likelihood of catastrophic breaching of Delta levees would reduce the likelihood of rapid hydrodynamic and salinity shifts caused by sudden change in Delta outflow. Although infrequently, species would benefit from the reduced frequency of sudden salinity shifts that could adversely affect habitat or delay transport to areas providing for specific species needs, such as spawning and rearing habitat. As in the Delta, setting back levees and constructing channel-side berm and levee remnants as part of levee maintenance and improvement in Suisun Marsh would allow development of natural marsh communities and produce beneficial effects on aquatic habitat characteristics. Levee reconstruction, dredging, and the installation of rock revetment would result in both short- and long-term adverse effects due to habitat encroachment and losses. Construction activities could result in potentially significant adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. These potentially significant impacts can be mitigated to a less-than-significant level.

Water Use Efficiency Program

Benefits described for Water Use Efficiency Program actions in the Delta Region also would apply to the Bay Region, primarily through contributions to reestablishing the natural seasonal variability in Delta outflow and salinity distribution.

Water Transfer Program

Impacts of Water Transfer Program elements in the Bay would be similar to impacts described for the Delta and primarily would be caused by actions affecting natural seasonal Delta outflow and salinity variability.

Watershed Program

As described for the Delta, benefits to the Bay would result from proposed activities in the watersheds flowing to the Bay. Many potential watershed actions that are expected to improve water quality and flows in watersheds also would improve water quality and flows in the Bay. Ecosystem-level benefits could include closer approximation of natural seasonal flow (and salinity) variability; closer approximation of natural sediment, transport, and delivery processes; reduced contaminant input; increased productivity; and restoration of natural ecosystem structure. Species benefits would primarily accrue from increased habitat abundance due to improved flow conditions and increased survival, growth, and reproduction in response to improved water quality.

Significant adverse impacts from construction for watershed actions would be similar to those described for the Delta Region.

Storage

New storage could change Delta outflow; however, relative to natural seasonal flow variability (pattern and magnitude), simulated flows with new storage were similar to flows under the No Action Alternative. As described for the Delta Region, actual effects will need to be determined for specific projects. The portion of new storage that may be allocated to environmental water supplies could provide beneficial impacts through enhancement of seasonal flow needs for biological communities and species in the Bay. Total annual Delta outflow, however, could be reduced because of additional export and could adversely affect Bay species.

The adverse effects of reduced annual outflow, including effects on estuarine salinity, would depend on the timing and reduction in magnitude relative to base outflow conditions. For some species, higher abundance is associated with higher Delta outflow. Delta outflow is the primary determinant of estuarine salinity distribution. Salinity affects a multitude of ecological processes, including those influencing the distribution and abundance of some aquatic organisms. Changes in Delta outflow that result in salinity distribution more closely approximating the natural seasonal pattern were assumed to restore salinity-related processes in the Bay and to benefit species through increased habitat, improved water quality, and other mechanisms. Mitigation is available to reduce these potentially significant impacts to a less-than-significant level, although mitigation potentially includes operational changes that could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."

6.1.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration Program

Actions addressing ecosystem processes are proposed to improve stream flows (including short-term flow fluctuations), natural sediment supply, stream meander, natural floodplains and flood processes, stream temperatures, and watershed processes (for example, wildfire; erosion; and management of timber harvest, grazing, and land use practices). Restored or reestablished habitat benefitting aquatic species would include seasonal wetlands and riparian and riverine aquatic habitats. Species-specific actions would target splittail, white and green sturgeon, chinook salmon, steelhead, striped bass, American shad, and resident fish species. The primary stressors reduced by Ecosystem Restoration Program actions would include water diversions; dams, weirs, reservoirs, and other structures; levees, bridges, and bank protection; gravel mining; non-native species; predation and competition; contaminants; harvest; artificial production; and human disturbance (for example, recreational boating).

Implementation of the Ecosystem Restoration Program would reactivate and maintain the ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Program actions would increase the abundance and distribution of desired anadromous species, including chinook salmon, steelhead, and splittail. Phased implementation integrated with adaptive management would avoid or minimize adverse impacts on aquatic communities and desired species, and guide the type and intensity of actions needed to achieve Program targets.

Reduced entrainment-related losses will increase species abundance and distribution. Approaches to reduce entrainment losses include the removal or relocation of high-impact diversions, changes in diversion timing to avoid periods of high species sensitivity, and construction of positive-barrier fish screens.

Ecosystem Restoration Program actions could lessen existing adverse stream water tem-perature conditions in the Sacramento River and San Joaquin River Regions. Increased riparian shading and natural channel configurations, especially on small tributary streams, would provide stream temperatures that approximate more natural conditions. On rivers where access to cool-water habitat has been blocked by dams, management actions will be required to maintain adequate cool-water habitat abundance within accessible reaches. Management actions may include revised carry-over storage requirements for upstream reservoirs, appropriate and enforceable water temperature requirements in downstream reaches, temperature control devices on reservoir outlets, and development of flexible short- and long-term flow management strategies. Chinook salmon and steelhead are the primary species that would benefit from improved water temperature conditions.

Restoration of the floodplain and floodplain processes would increase nutrient flows from terrestrial zones to the aquatic ecosystem, and increase biological productivity. Meander zones would increase the combined length of interfacing between terrestrial and aquatic zones, and restore the dynamic sediment movement processes that are critical to maintenance of diverse biological communities. Riparian restoration would increase the input of terrestrial invertebrates and nutrients into the stream system. Restoration of natural surface features would promote the development of additional channel complexity. Natural sediment input and movement processes also would benefit from reduced in-stream gravel extraction if these activities are relocated outside active stream channels and riparian zones. Introducing gravel into deficient areas (for example, below dams where natural sediment input cannot be restored) may reestablish sediment movement and habitat for desired species.

Construction of Ecosystem Restoration Program elements could cause short-term adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All aquatic species could be affected, depending on the timing and location of construction relative to species occurrence. Mitigation is available to reduce these potentially significant impacts to a less-than-significant level.

For chinook salmon, steelhead, and possibly other species, artificial production actions in the Ecosystem Restoration Program would be designed to avoid adverse effects on the fitness of natural spawning and rearing populations, ultimately increasing the abundance and distribution of target populations. Fish propagation programs would be consistent with rehabilitating the naturally producing populations, conserving ecological and genetic values, achieving the recovery of special-status species, and maintaining healthy populations of other species.

Chinook salmon and steelhead are the primary species targeted by actions to reduce illegal harvest and improve sport harvest management. Ecosystem Restoration Program harvest management elements would be consistent with maintaining the fitness of the natural spawning and rearing populations. Program elements may include additional actions improving harvest regulations, supplementing existing law enforcement efforts and community outreach (Delta-Bay Enhanced Enforcement Program), and developing additional cooperative programs to increase public awareness and provide additional means for reporting illegal-harvest violations.

Water Quality Program

In the Sacramento River and San Joaquin River Regions, the Water Quality Program relies on source control, increased enforcement of existing regulatory programs, and provision of incentives for action that exceed current regulatory programs. Potential actions would address contaminants from mine drainage, urban and industrial runoff, wastewater and industrial discharge, agricultural drainage and runoff, and unknown origins (for example, toxicity events affecting aquatic organisms that cannot be attributed to other causes). Water quality parameters potentially affecting beneficial uses include metals and toxic elements, organics and pesticides, ammonia, dissolved oxygen, chloride, nutrients, alkalinity, turbidity, temperature, and salinity.

The Water Quality Program would reduce contaminant delivery and movement within the system, reactivating and maintaining ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Reduced contaminants could substantially increase system productivity, reestablishing basic energy and material transfer mechanisms through increased survival, growth, and reproduction. Although available information is insufficient to develop specific impact conclusions for individual species, many species would benefit from reduced metabolic stress and increased survival.

Levee System Integrity Program

Actions included in the Levee System Integrity Program would minimally affect fisheries and the aquatic ecosystems in the Sacramento River and San Joaquin River Regions. The reduced frequency of catastrophic levee failure in the Delta could benefit these resources through reduced use of reservoir storage to restore the salinity balance in the Delta. Reservoir storage retained upstream would avoid the loss of operations flexibility, reducing the probability of unexpected adverse water temperature and flow effects.

Water Use Efficiency Program

The Water Use Efficiency Program could increase net water savings through implementation of conservation and water recycling actions. Net water savings could increase flexibility in reservoir operations, reduce diversions, improve water quality, delay the need for new water facilities, and increase the amount of water available for transfers.

Increased reservoir operation flexibility may allow flow management that more closely approximates the natural seasonal flow pattern and could increase the availability of cool-water releases to meet the needs of desired biological communities. Reestablishing natural seasonal flow pattern and magnitude could reactivate and maintain ecological processes and structures that sustain healthy fish, wildlife, and plant populations. Increased flexibility in flow management also may allow operations to minimize water level fluctuation. Improved habitat conditions (for example, improved water temperature and reduced stranding) could benefit all species, including chinook salmon and steelhead.

Diversions would be reduced in response to the reduced demands resulting from increased water use efficiency. Water use efficiency actions also are expected to alter the timing and pattern of diversions to avoid existing entrainment or other fisheries impacts. Lower diversions, depending on their timing relative to species occurrence, could reduce entrainment losses and benefit species abundance. Improved water quality would result from reduced contaminant delivery to the river system. Reduced contaminant delivery as a result of reduced applied water and the subsequent reduced runoff potentially would increase the productivity and survival of aquatic organisms. Delaying the need for new water facilities could avoid (1) additional adverse effects on seasonal flow variability; and (2) adverse impacts on natural structural features, including the loss of aquatic species habitat upstream of dams on currently unconstrained systems. Delaying the need for new water facilities also could avoid adverse impacts on species habitat.

Although increased water use efficiency generally would benefit the ecosystem processes and species in the Sacramento River and San Joaquin River Regions, adverse impacts may occur if the timing of reservoir releases is inconsistent with species needs or if runoff of applied water is reduced below the needs of existing wetlands and riparian habitats. These potentially significant impacts are expected to be avoided or mitigated through coordinated operations.

Water Transfer Program

Water transfers have the potential for both beneficial and adverse impacts on in-stream seasonal flows and on water temperature and quality. The transfer of water from storage facilities, if not appropriately timed, could adversely affect the immediate downstream habitat by reducing water available for release at a subsequent time during the season. However, the same transfer, if properly timed, could benefit downstream ecosystem conditions. This is especially true if the transfer is being executed for in-stream flow purposes.

Most water transferred for another consumptive use, regardless of the source of water being transferred, has the potential to be timed to provide a benefit to tributaries and main streams of the Sacramento and San Joaquin Valleys. Since most of these transfers need to be approved by state or federal agencies with mandates to ensure that environmental effects are minimized, the potential for adverse effects from transfers to fishery and aquatic ecosystems is generally not present. Mitigation strategies described in Section 6.1.11 are expected to reduce potentially significant adverse impacts from water transfers to a less-than-significant level. In addition, some of the actions described in the Water Transfer Program Plan (see Chapter 4 in the Water Transfer Program Plan), in conjunction with existing legal requirements placed on water transfers, are expected to protect against potentially significant adverse impacts on fisheries and aquatic resources.

Watershed Program

Watershed activities could affect all of the programs described above. The Watershed Program would focus on reducing stressors, encompassing natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Actions could include stream bank restoration, slope stabilization, meadow restoration, point source contaminant control, and aquatic habitat restoration. Implementation of actions could improve water quality, increase species habitat, increase water availability, and restore the natural stream structure.

Potential watershed activities are expected to improve water quality and flows in the Sacramento River and San Joaquin River Regions. Ecosystem-level benefits could include closer approximation of natural seasonal flow (and salinity) variability, restoration of basic heat transfer and storage mechanisms with beneficial effects on water temperature, restoration of natural sediment delivery and movement, reduced contaminant input, increased productivity, and restoration of the natural ecosystem structure. Species benefits primarily would accrue from increased habitat abundance (attributable to improved flow and water temperature conditions) and increased survival, growth, and reproduction in response to improved water quality.

Construction of Watershed Program elements could cause short-term adverse impacts though disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All aquatic species could be affected, depending on the timing and location of construction relative to species occurrence. These impacts are considered potentially significant but can be mitigated to a less-than-significant level.

Storage

New storage would provide the opportunity for additional flow management—potentially affecting the magnitude, timing, and duration of stream flow and diversion. New storage would be constructed and operated only after information clearly confirms that potentially significant adverse impacts on fish and aquatic species populations can be avoided.

Simulated hydrology with new storage indicated that Sacramento River flow would increase during August-September and that minimal changes in flow would occur on the San Joaquin River and its tributaries. Relative to natural seasonal flow variability (pattern and magnitude), however, simulated flows with new storage were similar to the flow timing, duration, and magnitude under the No Action Alternative. Actual effects will need to be determined for specific projects and will depend on location (for example, upstream of Delta, in-Delta, offstream, onstream, or enlargement of an existing reservoir) and operations rules. A portion of new storage may be allocated to environmental water supplies and could provide benefits through enhancement of seasonal flow needs for biological communities and species in the Sacramento and San Joaquin Rivers. Species could benefit from increased habitat abundance attributable to improved flow and water temperature conditions.

New surface storage reservoirs may be filled by diversions from the Sacramento and San Joaquin Rivers or their tributaries. Simulated diversions generally coincided with relatively high flow conditions, and the change in stream flow relative to conditions under the No Action Alternative was minimal. Diversions to off-stream storage, depending on the timing relative to species occurrence, could increase entrainment loss and adversely affect species populations, including chinook salmon and steelhead. These potentially significant impacts can be mitigated to a less-than-significant level, although mitigation potentially includes operational changes that could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."

Development of new surface storage would create additional aquatic reservoir habitat. New reservoirs would support sport fisheries. The species supported by reservoirs and targeted by anglers are primarily non-native (such as largemouth bass, spotted bass, red-ear sunfish, crappie, and catfish) or hatchery-supplemented fish populations (such as rainbow trout). Increased non-native species abundance in new reservoirs would result in less-than-significant impacts on native species because the non-native species that inhabit reservoirs currently are well established and the new reservoirs are relatively isolated from river and Delta habitats. Extreme fluctuations in water surface levels would be likely and, if they occur, they would limit the habitat values of the reservoirs for aquatic species.

Construction of storage facilities could cause short-term adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All aquatic species could be affected, depending on the timing and location of construction relative to species occurrence. These potentially significant impacts can be mitigated to a less-than-significant level.

6.1.7.4 OTHER SWP AND CVP SERVICE AREAS

All Programs

Implementation of the Program elements common to all alternatives most likely would minimally affect fisheries and aquatic resources in streams, reservoirs, and estuaries in the Other SWP and CVP Service Areas. Organisms transported with imported water and the destination of the water would be the same as under the No Action Alternative. Actions in the Ecosystem Restoration Program that address the introduction of non-native species into the Bay-Delta system also would limit their introductions into areas receiving SWP and CVP water. Improved water use efficiency (Water Use Efficiency Program) also may reduce the contribution of wastewater to southern California streams. Aquatic communities dependent on wastewater-augmented flows would be adversely affected by such a reduction. An accurate assessment of impacts requires detailed site-specific information on the delivery areas, potential for increased development, and vulnerable aquatic resources. Additional analysis will be conducted during environmental documentation for specific projects.

6.1.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For fisheries and aquatic ecosystems, the Conveyance element results in environmental consequences that differ among the alternatives, as described below. Changes in flow discussed in the following analysis are based on simulations used in Section 5.2, "Bay-Delta Hydrodynamics and Riverine Hydraulics."

Each Program alternative includes a different suite of Conveyance elements. The facilities could substantially change the way water moves through the Delta and under Alternatives 1, 2, and 3 may result in potentially significant unavoidable adverse impacts on fish and aquatic resources.

Under the Preferred Program Alternative, construction and operation of Program elements depend on the ability to avoid adverse impacts on fish and other aquatic species populations. Consequently, some of the elements discussed may not be constructed.

6.1.8.1 PREFERRED PROGRAM ALTERNATIVE

The impacts will change as the Program moves forward, and the degree of impacts will depend on the extent to which each conveyance element is implemented.

The Preferred Program Alternative includes a description of consequences of a diversion facility on the Sacramento River and channel modifications along the Mokelumne River and in the south Delta. The contingent diversion facility may not be constructed because of uncertain species responses to the Program elements and subsequent potential for adverse impacts. The Program is committed to addressing uncertainty, and Program elements would be constructed and operated only after information clearly confirms that potentially significant adverse effects on fish and aquatic species populations can be avoided. Key to implementation of the Preferred Program Alternative is a strategy to address the uncertainty of species and ecosystem responses to Program elements. Ongoing activities to increase understanding of natural physical and biological processes and species habitats include the Strategic Plan, the CMARP, and the MSCS.

To minimize and avoid potential adverse effects of changes in flow and diversion, construction and operation of new facilities (such as barriers, fish screens, and conveyance channels) may be preceded by focused studies to determine the environmental effects, including species population response. Actions may be implemented progressively over the long term, and actions would be integrated with monitoring and evaluation to assess effects on the aquatic ecosystem, achievement of the Program objectives, and conform-ance to Program solution principles.

Although adverse aquatic species population effects would be avoided, harm to individual organisms could result from certain aspects of the Program elements (for example, entrainment loss and migration delay). For special-status species, such as species listed under federal and California ESAs, harm to individual organisms and their habitat is considered a significant adverse impact. The MSCS includes a framework for applying mitigation strategies during implementation to ensure that the Program avoids, minimizes, or compensates for its impacts on special-status species. Further, the Program has committed to implementing mitigation strategies that will minimize potentially significant adverse impacts prior to, or concurrent with, construction and operation of Program elements.

Delta Region

Delta Cross Channel. Under the Preferred Program Alternative, the DCC may be closed from September through July and possibly all months. Flexible operations would be considered, depending on demonstrated benefits. Based on DCC operations under the No Action Alternative, potential operations for the Preferred Program Alternative would increase juvenile salmon survival entering the Delta from the Sacramento River during October-January and May 20-June 30. Closure could benefit winter-, spring-, late fall-, and fall-run chinook salmon, although peak migration of juvenile chinook from the Sacramento River generally occurs after October, depending on occurrence of storm events.

Additional closure of the DCC relative to conditions under the No Action Alternative may increase the frequency and magnitude of net reverse flow conditions in the lower San Joaquin River, although the potential diversion channel on the Sacramento River would minimize or override the effects of DCC closure. If net reverse flow conditions are worsened, the reduced frequency of natural net flow conditions in Delta channels could reduce productivity, impair species movement, and increase entrainment in Delta diversions. Species adversely affected could include delta smelt, striped bass, and American shad. Mitigation strategies are available to reduce these potentially significant impacts to a less-than-significant level.

Delta Channel Capacity. Old River north of CCFB may be enlarged to reduce channel velocity. The enlarged channel potentially allows use of the full capacity of the SWP Delta export facility when all Bay-Delta standards are met. Simulated operations indicate that full use of the SWP pump capacity could increase the total annual exports by approximately 4%. In the absence of the other elements of the Preferred Program Alternative, increased exports could increase the magnitude of net reverse flow conditions in Old and Middle Rivers, and possibly in the lower San Joaquin River. Net reverse flow conditions are counter to natural net flow conditions in Delta channels and could reduce productivity, impair species movement, and increase entrainment in Delta diversions. Total Delta outflow also would be slightly reduced because of the additional export. The adverse effects of reduced outflow, including effects on estuarine salinity, would depend on the timing and reduction in magnitude relative to base outflow conditions. Species adversely affected could include chinook salmon, steelhead, delta smelt, striped bass, and American shad. These potentially significant adverse impacts can be avoided or reduced to a less-than-significant level with mitigation strategies.

Dredging to enlarge channels could cause adverse impacts. Dredging would increase the channel depth and further alter the natural structural features. In the short term, dredging would remove benthic communities and mobilize fine sediments. Maintenance dredging may be required over the long term, resulting in periodic short-term impacts. Dredging also may cause levee instability, which could require additional revetment and levee maintenance activities. Levee maintenance could remove tidal marsh communities and riparian vegetation. Contaminants may be mobilized to the detriment of aquatic communities or individual organisms. Dredging would adversely affect channel structure, productivity, water quality, and species habitat. Dredging also could release toxic substances into surface water. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern. All these potentially significant impacts can be mitigated to a less-than-significant level.

South Delta Intake Facilities. A new screened forebay intake may be constructed at the CCFB. The new facility potentially reduces entrainment losses relative to existing levels because fish entrainment into Clifton Court would be avoided and new state-of-the-art fish screens and associated facilities would increase screening efficiency. Reduced losses would benefit chinook salmon, steelhead, striped bass, delta smelt, splittail, and other Delta species.

Construction of new intake facilities could result in potentially significant adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All

Delta species could be affected, depending on the timing of construction relative to species occurrence. These impacts can be mitigated to a less-than-significant level.

South Delta Flow Control. An operable barrier may be constructed on the head of Old River at the confluence with the San Joaquin River near Mossdale. When closed, the barrier would direct San Joaquin River flow down the main San Joaquin River channel and past Stockton. The barrier potentially benefits juvenile chinook salmon from the San Joaquin River, by directing their movement along the San Joaquin River pathway and away from the CVP and SWP south Delta export intakes. The barrier also may benefit adult chinook salmon through the improved dissolved oxygen and water temperature conditions that result from increased net flow past Stockton.

Closure of the barrier, without a concomitant reduction in exports, would increase net flow toward the CVP and SWP south Delta export intakes, primarily through Turner Cut, Middle River, and Old River. Net flow toward the export facilities counters the natural net flow conditions in Delta channels and could reduce productivity, impair species movement, and increase entrainment in Delta diversions. Species adversely affected could include chinook salmon, steelhead, delta smelt, striped bass, and American shad. Benefits to San Joaquin River chinook salmon identified in the preceding paragraph could be partially negated by this increase. Because of the uncertainty of existing information on response of species to south Delta barriers, these impacts are considered potentially significant. These adverse impacts are expected to be reduced to a less-than-significant level through mitigation strategies, including monitoring and focused studies.

Implementation of actions to ensure the availability of water to agricultural diversions within the south Delta may include operable barriers, channel dredging, levee setbacks, and redesign and screening of agricultural diversion intakes. Construction of barriers on other south Delta channels, such as Middle River and Old River near the CVP's Tracy fish facility, or their functional equivalent may be necessary to alleviate the reduced water levels caused by closure of the head of Old River barrier in combination with CVP and SWP export operation. The barriers would diminish tidal flow, reducing connectivity to other Delta channels and altering basic hydraulic features that affect sediment and nutrient movement, water quality conditions (for example, water temperature and dissolved oxygen), and productivity. Barriers are expected to affect water quality because circulation would be reduced for the area bounded by the barriers. Reduced circulation could change stratification patterns and flow movement that potentially affect dissolved oxygen and water temperature. Species could be adversely affected by loss of habitat, change in water quality conditions (including water temperature and dissolved oxygen), and impeded access to resources and conditions that allow a species to survive and reproduce. Species potentially affected include juvenile chinook salmon, striped bass, delta smelt, and resident species. These impacts are considered potentially significant. These impacts are expected to be reduced to a less-than-significant level through mitigation strategies, including monitoring and focused studies.

Dredging to enlarge south Delta channels, including Middle River and Old River, would increase the channel depth and further alter the natural structural features. In the short term, dredging would remove benthic communities and mobilize fine sediments. Maintenance dredging may be required over the long term, resulting in periodic short-term impacts. Dredging also may cause levee instability, which could require additional revetment and levee maintenance activities. Levee maintenance could remove tidal marsh communities and riparian vegetation. Contaminants may be mobilized to the detriment of aquatic communities or individual organisms. Dredging would adversely affect channel structure, productivity, water quality, and species habitat. Dredging also could release toxic substances into surface waters. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern. All these potentially significant impacts can be mitigated to a less-than-significant level.

If channel enlargement is the result of setback levees, aquatic ecosystem area is potentially increased. Increased area, if associated with increased riparian and tidal marsh communities, may reestablish natural structural features that could increase productivity and provide habitat for aquatic species. Habitat created by levee setback also may increase the abundance and distribution of carp, inland silverside, or other non-native species that compete with or prey on native species.

Redesign and screening of existing agricultural diversion intakes in the south Delta could reduce entrainment-related losses of fish species. Consolidating and relocating diversions also could provide the opportunity to improve fish screen efficiency and to avoid diversions from areas where species vulnerability to entrainment is high.

Construction of flow control barriers, levee setbacks, diversion facilities, and fish screens could result in adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be adversely affected, depending on the timing and location of construction relative to species occurrence. These potentially significant impacts can be mitigated to a less-than-significant level.

Sacramento River to Mokelumne River Channel. A diversion facility structure may be constructed from the Sacramento River to the Mokelumne River, contingent on satisfactory resolution of fisheries concerns. The intake of the contingent facility on the Sacramento River may include fish screens and a fish ladder or equivalent to provide upstream migrants access to the Sacramento River. In combination with the new channel, the Mokelumne River channel (either the South or North Fork) may be enlarged to increase flow conveyance.

The fish screens potentially prevent juvenile and adult fish from entering the new channel with the flow diverted off the Sacramento River. Under no action conditions, the DCC would be closed at least from February through March 20—reducing flow from the Sacramento River into the Mokelumne River channels. With the construction and operation of the Sacramento River to Mokelumne River channel, flow from the Sacramento River would again enter the Mokelumne River channels. Existing relationships indicate that reduced flow in the Sacramento River (from flow exiting through the diversion) would cause an increase in the proportion of flow entering Georgiana Slough (see the March 1998 Affected Environment and Environmental Consequences Technical Reports for Fisheries and Aquatic Resources). Chinook salmon outmigration primarily occurs during February-May. The proportion of juveniles moving from the Sacramento River and into Georgiana Slough, therefore, is expected to increase with increased flow diverted through the Sacramento to Mokelumne River channel. As discussed under methods (Section 6.1.4, "Movement Relationships"), survival of chinook salmon that move into the DCC and Georgiana Slough is less than survival of fish that continue down the Sacramento River toward Rio Vista. USFWS studies indicate that the survival of fish following the Sacramento River route toward Rio Vista may be several times higher than survival of fish entering the DCC and Georgiana Slough. The actual magnitude of survival, however, is uncertain and depends on other factors, including water temperature and flow or salinity. In addition, abrasion, increased predation, impingement on fish screens or other diversion structures, stress from being handled, and movement to inappropriate habitat would reduce the survival of fish contacting the fish screens. The diversion could adversely affect winter-, spring-, late fall-, and fall-run chinook salmon and possibly other species (for example, steelhead, splittail, striped bass, and American shad).

A new channel would direct additional Sacramento River water into the Mokelumne River channels and the central Delta. In combination with reduced flow down the Sacramento River channel, migratory species destined for the Sacramento River may be attracted to the Mokelumne River channels and subsequently to the Sacramento River. The fish screen at the diversion facility on the Sacramento River would prevent movement of adult fish into the Sacramento River. Although fish ladders or other passage facilities are proposed, the efficiency of moving fish to the Sacramento River will depend on many factors, including species behavior. Some level of migration delay and blockage is likely, with subsequent adverse impacts on affected populations, including chinook salmon, steelhead, splittail, delta smelt, striped bass, sturgeon, and American shad. Adverse impacts may include mortality, reduced fecundity or reproductive success, and straying—potentially affecting the fitness of natural spawning and rearing populations in appropriated habitats.

The addition of Sacramento River flow to the Mokelumne River channels could confuse adult chinook salmon returning to the Mokelumne River to spawn and could delay outmigration of juveniles to the ocean. Although available information has not indicated responses of adult and juvenile chinook salmon to flow changes in the Mokelumne River channels, reduced survival of adults and juveniles could adversely affect the Mokelumne River chinook salmon population. CALFED recognizes the necessity to develop knowledge of species needs and understanding of the effects of Program elements relative to migration of adult and juvenile chinook salmon. Strategies to address this uncertainty are discussed in Section 6.1.2, "Areas of Controversy." Strategies will be identified in project-specific environmental documents that will provide detailed scientific analysis and implementation of an adaptive management strategy.

The diversion of additional Sacramento River water into the Mokelumne River channels and the central Delta would increase the frequency and magnitude of natural channel net flow direction in the Lower San Joaquin River. Natural net flow conditions in the Lower San Joaquin River channel could increase productivity, enhance species movement, and reduce entrainment in Delta diversions. Species beneficially affected could include chinook salmon, delta smelt, striped bass, and American shad.

Diversion of Sacramento River water at the diversion facility on the Sacramento River would reduce the magnitude of natural net channel flow in the Sacramento River below the diversion, primarily during February to June. The effects of reduced flow in the Sacramento River below the diversion could adversely affect habitat conditions—potentially reducing survival of chinook salmon, striped bass, and other species. The minimum flow criteria at Rio Vista and Sacramento River diversion operations criteria would reduce adverse effects. Implementation of the diversion facility on the Sacramento River is contingent on the satisfactory resolution of fisheries concerns. The scope of impacts on fish and aquatic species, and measures to avoid or mitigate these impacts, will be addressed in future documentation.

If Mokelumne River channel enlargement is the result of setback levees, aquatic ecosystem area is potentially increased. Increased area, if associated with increased riparian and tidal marsh communities, may reestablish natural structural features that could increase productivity and provide habitat for aquatic species. Channel enlargement with setback levees could benefit the aquatic ecosystem and Delta species. Habitat created by levee setbacks also may increase the abundance and distribution of carp, inland silverside, or other non-native species that compete with or prey on native species, as well as species with higher economic and social value (for example, chinook salmon, delta smelt, and striped bass). Construction of the levee setback could result in potentially significant adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. All Delta species could be affected in the short term, depending on the timing of construction relative to species occurrence. Mitigation is available to reduce these impacts to a less-than-significant level. Focused studies and monitoring of pilot projects, however, are needed prior to project implementation in order to provide additional information on potential changes in entrainment risk, predation, and habitat use by Delta species. Strategies to address this uncertainty are discussed in Section 6.1.2, "Areas of Controversy." Strategies will be identified in project-specific environmental documents that will provide detailed scientific analysis and implementation of an adaptive management strategy.

Enlarging Mokelumne River channels by dredging could cause potentially significant adverse impacts. Dredging would increase the channel depth and further alter the natural structural features. In the short term, dredging would remove benthic communities and mobilize fine sediments. Maintenance dredging may be required over the long term, resulting in periodic short-term impacts. Dredging also may cause levee instability, which could require additional revetment and levee maintenance activities. Levee maintenance could remove tidal marsh communities and riparian vegetation. Dredging would adversely affect channel structure, productivity, water quality, and species habitat. Dredging also could release toxic substances into surface waters. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern. Mitigation is available to reduce these potentially significant impacts to a less-than-significant level.

Bay Region

The Bay ecosystem would be affected by reduced Delta outflow. Revised upstream facility operations attributable to potential changes in Delta conveyance could increase average annual exports and potentially reduce Delta outflow by about 200-500 TAF relative to No Action Alternative conditions. The simulated reduction in outflow would be relatively small. Adverse impacts are considered less than significant because operations criteria are in place that will maintain minimum Delta outflow during the critical February-through- May period, the change in outflow is small relative to the variability in outflow from month to month and year to year, and the change in outflow is partially attributable to capture of flow during high-flow conditions that will minimize the effect on ecosystem processes.

Sacramento River and San Joaquin River Regions

Although conveyance facilities and channel modifications are located in the Delta, operations criteria affecting upstream reservoir operations potentially change with implementation of the Delta channel capacity and the diversion facility on the Sacramento River. The Delta channel capacity element could allow full use of the SWP export capacity. Simulated hydrology with full use of the SWP export capacity did not noticeably alter reservoir operations or stream flow in the Sacramento River or San Joaquin River Region.

Other SWP and CVP Service Areas

Conveyance facilities under the Preferred Program Alternative most likely would minimally affect fisheries and aquatic resources in the streams, reservoirs, and estuaries in the Other SWP and CVP Service Areas.

Reductions in entrainment at the pumping facilities attributable to improved fish screens could reduce the number of fish, eggs, and larvae that are diverted into the CVP and SWP water systems; and may reduce recruitment to fish populations in canals and reservoirs. These reductions are not expected to significantly reduce fishery resources in the canals and reservoirs supplied by exports.

6.1.8.2 ALTERNATIVE 1

Impacts in the Bay, Sacramento River, and San Joaquin River Regions, and in the Other SWP and CVP Service Areas would be the same as those described for the Preferred Program Alternative. The impacts associated with a change in Delta channel capacity, modified south Delta intake facilities, and south Delta flow control barriers would be similar to those described for the Preferred Program Alternative. Alternative 1 would not include a diversion facility on the Sacramento River or a change in DCC operations; therefore, conditions in the Sacramento River and Mokelumne River channels would be the same as under the No Action Alternative.

6.1.8.3 ALTERNATIVE 2

Impacts under Alternative 2 are similar to those described for the Preferred Program Alternative, except that adverse impacts attributable to change in Delta channel capacity, south Delta intake facilities, and south Delta flow barriers are potentially significant. Expansion beyond the 4,000-cfs capacity would worsen the impacts on anadromous fish in the Sacramento River. The increased facility size would increase mortality at the screens. Mortality of juvenile chinook salmon, and possibly other species, would increase for fish continuing down the Sacramento River because of a greater proportion of fish entering

Georgiana Slough. Increased flow into the Mokelumne River channels could cause additional straying and increased impacts through loss of fitness of natural spawning and rearing populations, increased adult fish mortality, and reduced fecundity. The effects of reduced flow in the Sacramento River below Hood could further adversely affect habitat conditions—potentially reducing survival of chinook salmon, striped bass, and other species. Because the capacity of the diversion facility on the Sacramento River would be 10,000 cfs, it is likely, given our present knowledge, that potentially significant adverse impacts would be unavoidable. The intake of the facility on the Sacramento River would include fish screens and a fish ladder or equivalent to provide upstream migrants access to the Sacramento River. In combination with the new channel from the Sacramento River to the Mokelumne River, the Mokelumne River channel (either the South or North Fork) would be enlarged to increase flow conveyance. The effects of channel enlargement are similar to those described for the Preferred Program Alternative.

6.1.8.4 ALTERNATIVE 3

Impacts in the Bay, Sacramento River, and San Joaquin River Regions, and in the Other SWP and CVP Service Areas would be similar to those described for the Preferred Program Alternative. Impacts of modified south Delta intake facilities would be similar to those described for the Preferred Program Alternative. Impacts of the Mokelumne channel enlargements would be similar to those described under the Preferred Program Alternative. Alternative 3 includes a diversion facility near Hood associated with an isolated facility with a capacity between 5,000 and 15,000 cfs. Revised operations criteria may allow simulated exports to increase by as much as 3% over levels simulated for the Preferred Program Alternative (an average annual increase in exports of 200 TAF) and possibly as much as 10% over the No Action Alternative, intensifying impacts on Delta outflow described for the Preferred Program Alternative. Given the substantial change in Delta flow conditions under Alternative 3, potentially significant adverse impacts may occur, although substantial benefits attributable to improved flow conditions in the central and south Delta are also probable.

Delta Cross Channel. Under Alternative 3, the DCC may be closed from September through July and possibly during all months. Flexible operations would be considered, depending on demonstrated benefits. Based on DCC operations under the No Action Alternative, potential operations for Alternative 3 would increase juvenile salmon survival entering the Delta from the Sacramento River during October-January and May 20-June 30. Closure could benefit winter-, spring-, late fall-, and fall-run chinook salmon; although peak migration of juvenile chinook from the Sacramento River generally occurs after October, depending on the occurrence of storm events.

Closure of the DCC could increase the frequency and magnitude of net reverse flow conditions in the lower San Joaquin River relative to conditions under the No Action Alternative. Improved flow conditions associated with the isolated diversion channel near Hood, however, would override the effects of DCC closure. As discussed below for the isolated facility, net flow conditions are likely to improve under Alternative 3.

Delta Channel Capacity. Old River north of CCFB may be enlarged to reduce channel velocity. The enlarged channel potentially allows use of the full capacity of the SWP Delta export facility when all Bay-Delta standards are met. Simulated operations indicate that full use of the SWP pump capacity could increase the total annual exports by approximately 4%. In the absence of the other elements of Alternative 3, increased exports could increase the magnitude of net reverse flow conditions in Old and Middle Rivers, and possibly in the lower San Joaquin River. Improved flow conditions associated with the isolated diversion channel near Hood, however, could override the effects of enlarged channel capacity. As discussed below for the isolated facility, net flow conditions are likely to improve in all Delta channels under Alternative 3.

South Delta Flow Control Barriers. An operable barrier may be constructed on the head of Old River at the confluence with the San Joaquin River near Mossdale. When closed, the barrier would direct San Joaquin

River flow down the main San Joaquin River channel and past Stockton. The barrier potentially benefits juvenile chinook salmon from the San Joaquin River, by directing their movement along the San Joaquin River pathway and away from the CVP and SWP south Delta export intakes. The barrier also may benefit adult chinook salmon because of the improved dissolved oxygen and water temperature conditions that result from increased net flow past Stockton.

Closure of the barrier, without a concomitant reduction in exports, would increase net flow toward the CVP and SWP south Delta export intakes, primarily through Turner Cut, Middle River, and Old River. Improved flow conditions associated with the isolated diversion channel near Hood, however, would override the adverse effects of a barrier at the head of Old River. As discussed below for the isolated facility, net flow conditions are likely to improve in all Delta channels under Alternative 3.

Isolated Facility. A new isolated 5,000- to 15,000-cfs capacity channel would be constructed from Hood to CCFB. The intake of the facility on the Sacramento River would include fish screens. In combination with the new isolated facility, the south Delta intake, south Delta barriers, and Mokelumne River channel modifications also may be constructed, depending on need relative to flow exported through the south Delta. The impacts of the south Delta intake, south Delta barriers, and Mokelumne River channel modifications would be similar to those discussed above, although the magnitude of impact would be less. With a 15,000-cfs capacity isolated facility, barriers in the Middle River, Grant Line Canal, and Old River near the CVP Tracy fish facility would be unnecessary because overland irrigation supplies would be provided to the south Delta. The adverse impacts on aquatic species that are associated with the barriers would not occur, although impacts associated with the overland irrigation supply would need to be evaluated.

The fish screens at Hood would prevent juvenile and adult fish from entering the isolated channel with the flow diverted off the Sacramento River. Downstream of the near Hood intake, the proportion of Sacramento River flow entering Georgiana Slough (and the DCC, if open) would increase. Based on existing relationships, operation of the isolated facility diversion would increase juvenile salmon movement from the Sacramento River into the Mokelumne River channels, reducing their survival. Survival in the central Delta, although lower than for fish remaining in the Sacramento River, may improve in response to seasonal reductions in export from the south Delta. In addition, abrasion, increased predation, and other factors would reduce the survival of fish contacting the fish screens. The diversion could adversely affect winter-, spring-, late fall-, and fall-run chinook salmon and possibly other species (for example, steelhead, splittail, striped bass, and American shad).

The relocation of the intake for SWP and CVP exports from the south Delta to the Sacramento River near Hood would increase the frequency and magnitude of natural channel net flow in the south and central Delta, and in the lower San Joaquin River. The larger isolated facility would substantially intensify natural flow conditions. Although many complicating factors (such as water quality effects) may diminish any benefits of reducing exports from the south Delta, natural net flow conditions potentially increase productivity, enhance species movement, and reduce entrainment in Delta diversions. All species in the south, east, and central Delta would benefit, especially chinook salmon (including juveniles originating from the Mokelumne and San Joaquin Rivers), steelhead, delta smelt, splittail, striped bass, and American shad. The larger the isolated facility, the greater the reduction in flow diverted from the south Delta, and the larger the beneficial impact. Limiting May exports to 5,000 cfs would intensify the beneficial impact for the month of May.

Diversion of Sacramento River water near Hood would reduce the magnitude of natural net channel flow in the Sacramento River below Hood. Effects on Sacramento River flow below Hood would increase with an increase in the capacity of the isolated facility. Reduced net flow conditions in the lower Sacramento River could reduce fresh-water habitat (caused by an upstream shift in estuarine salinity in the Sacramento River channel), reduce productivity, and impair species movement (for example, transport of striped bass eggs). Migratory species are potentially adversely affected, including chinook salmon, delta smelt, and striped bass. The Rio Vista minimum net flow requirement of 3,000 cfs and isolated facility operations criteria would limit the magnitude of flow change.

Although the level of increased exports with the new storage elements would be small, the increase could slightly intensify the potentially significant adverse impacts and slightly reduce the beneficial impacts described above. Total Delta outflow also would be slightly reduced because of additional export. The adverse effects of reduced outflow, including effects on estuarine salinity, would depend on the timing and reduction in magnitude relative to base outflow conditions.

6.1.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents the comparison of the Preferred Program Alternative and Alternatives 1, 2, and 3. Given the programmatic level of analysis, what we know of existing conditions, and what we can predict to 2020, the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions are similar to impacts identified in Sections 6.1.7 and 6.1.8, which compare the Program alternatives to the No Action Alternative.

Although the Program elements common to all alternatives would improve and increase aquatic habitat and improve ecological processes in the Bay-Delta, potentially significant unavoidable impacts are associated with implementing the Conveyance Element under Alternatives 1, 2, and 3. Implementation of strategies to avoid potentially significant adverse impacts on fish populations would be incorporated under the Preferred Program Alternative.

Benefits of the Program alternatives would be less when compared to existing conditions because of the larger difference in increased water deliveries. Relative to existing conditions, additional annual water deliveries under the Program alternatives could range from 0.5 to 1.5 MAF in response to increased demands, new storage, and new conveyance elements (potential increased Delta channel capacity for all Program alternatives and the isolated facility for Alternative 3).

Although simulated operations and hydrology indicate similar flow variability for existing conditions and the Program alternatives, increased water deliveries would limit the ability of other Program elements (for example, actions included in the Ecosystem Restoration Program) to reestablish basic hydrologic features necessary to reactivate and maintain the ecological processes and structures that sustain healthy aquatic communities. Adverse impacts could include reduced productivity, reduced species habitat abundance, and degraded transport and attraction conditions. Impacts would depend on the change in flow, timing, and magnitude relative to species occurrence and needs. Additional diversions, including exports, could directly increase entrainment losses and contribute to net Delta flow conditions that may reduce productivity, impair species movement, and increase entrainment in Delta diversions. Most species are potentially affected, including chinook salmon, delta smelt, steelhead, and striped bass.

Although the Water Quality Program would reduce contaminant delivery relative to the No Action Alternative, increased contaminant input under the 2020 level of urban and industrial development for the Program alternatives may exceed input relative to existing conditions. Increased contaminant input could degrade ecosystem processes, reducing system productivity and adversely affecting species growth, survival, and reproduction.

For the Other SWP and CVP Service Areas, additional water deliveries under the Program alternatives may induce municipal, industrial, or agricultural development. Adverse impacts relative to existing conditions would exceed impacts relative to the No Action Alternative and may include greater loss of habitat, increased input of contaminants, and increased disturbance. Disturbance could include disruption of natural hydrology through increased seasonal runoff of applied water, potentially improving habitat for introduced species and adversely affecting native species in streams and estuaries. Improved water use efficiency (Water Use Efficiency Program) also may reduce the contribution of wastewater to streams relative to existing conditions. Aquatic communities dependent on wastewater-augmented flows would be adversely affected by such a reduction. An accurate assessment of impacts requires detailed site-specific information on the delivery areas, potential for increased development, and vulnerable aquatic resources. Additional analysis will be conducted during environmental documentation for specific projects.

In addition to actions discussed for the Program alternatives, activities unrelated to water deliveries and independent of the Program would be implemented under all Program alternatives and for the No Action Alternative (see Section 6.1.6, "No Action Alternative"). Potential benefits may occur from restoration associated with the Stone Lakes NWR and the SRFCP; improved flow management for the Yuba, Mokelumne, and Tuolumne Rivers; improved management of water temperature conditions in the Sacramento River attributable to the Shasta Temperature Control Device and interim reoperation of Folsom Reservoir; and reduced contaminant input from retirement of agricultural land in the San Joaquin River Region. Benefits could include increased productivity, increased spawning and rearing habitat abundance for riverine and Delta species, and reduced stress from contaminants. Potential adverse impacts may occur from construction associated with various projects, reoperation of Folsom Reservoir, and completion of the Coastal Aqueduct and MWD's Inland Feeder Project. Adverse construction impacts could include disturbance of existing biological communities, mobilization of sediments, and input of contaminants. Reoperation of Folsom Reservoir may reduce summer flows and the flexibility to manage cool-water releases in the lower American River, potentially reducing habitat abundance for steelhead and chinook salmon. Completion of the Coastal Aqueduct and Inland Feeder Project could introduce non-native species, adversely affecting native species communities.

6.1.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts. In doing so, those potentially significant adverse cumulative impacts for which the Program's contribution could be avoided or mitigated to a less than cumulatively considerable level are identified. If identified in the analysis, this section also presents any potentially significant adverse cumulative impacts that remain unavoidable regardless of efforts to avoid, reduce, or mitigate them. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For fisheries and aquatic resources, the analysis and conclusions regarding the significance of the Preferred Program Alternative's contribution to cumulative impacts are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This similarity is in part due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 6.1.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate them. At the programmatic level, the impact that cannot be avoided, reduced, or mitigated to a less-than significant level is noted on the list **in bold type**. Sections 6.1.7 and 6.1.8 elaborate on the long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on fisheries and aquatic resources in the Delta, Bay, Sacramento River, and San Joaquin River Regions: American River Watershed Project, American River Water Resource Investigation, CVPIA Anadromous Fish Restoration Program and other CVPIA actions not yet fully implemented, Delta Wetlands Project, Pardee Reservoir Enlargement Project, Sacramento Water Forum Process, Supplemental Water Supply Project, Sacramento County Municipal and Industrial Water Supply Contracts, and urbanization. At the programmatic level of analysis, the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 6.1.1 are expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level. The exception is the potential increase in non-native species to levels detrimental to native species. This outcome may result from the reestablishment of aquatic areas in the

Delta and Bay Regions, as discussed in Section 6.1.12. Mitigation strategies for this impact are identified (see Section 6.1.11) and will be implemented (see Chapter 9). However, this programmatic-level analysis cannot determine whether the Program's contribution to the potential increase in non-native species can be avoided, reduced, or mitigated to a less than cumulatively considerable level. Therefore, this analysis concludes that the impact is cumulatively significant and unavoidable. This conclusion is based on currently available information and the high level of uncertainty as to whether this impact can be avoided, mitigated, or reduced to a level that is less than cumulatively considerable.

Growth-Inducing Impacts. No impacts are anticipated. See the "Growth-Inducing Impacts" discussion in Chapter 4 and the discussion of growth-inducing impacts in Section 5.1.10.

Short- and Long-Term Relationships. Adverse short-term impacts on fisheries and aquatic resources are primarily related to construction activities. Their adverse effects, however, would be avoided, minimized, and mitigated as described previously, to the maximum extent possible. Implementation of BMPs, including a stormwater pollution prevention plan, a toxic materials control and spill response plan, and a vegetation protection plan would avoid and minimize most construction impacts. Limiting construction activities to windows of minimal species vulnerability would further avoid and minimize impacts. When impacts cannot be avoided or minimized, off-site development of comparable resources to at least an equivalent level may be required and may include Program actions contributing to long-term productivity through habitat restoration or facility construction.

Long-term ecological benefits is a primary objective of the Ecosystem Restoration Program. Implementation of the Ecosystem Restoration Program Plan within the guidelines of the Strategic Plan would ensure that design principles and criteria that affect fisheries and aquatic resources are selected on their ability to avoid short-term adverse impacts and to enhance and maintain long-term productivity. Selection of design principles and criteria for other resource plans, including the Levee System Integrity, Water Quality, Watershed, Storage, and Conveyance elements, that would affect fisheries and aquatic resources also would be based in part on their ability to avoid short-term adverse impacts and to enhance and maintain long-term productivity.

Flow conveyance facilities and operations can result in potentially significant adverse short- and long-term impacts. The possibility of adverse impacts increases from Alternative 1 to the Preferred Program Alternative and from the Preferred Program Alternative to Alternatives 2 and 3. The difference in impact intensity is due to reliance on larger facilities, greater changes in Delta channel structure, and change in facility location. The increasing structural and operational changes under Alternatives 2 and 3 and possibly under the Preferred Program Alternative, however, provide the increased opportunity for enhancement of long-term productivity relative to Alternative 1.

Irreversible and Irretrievable Commitments. Implementation of the elements included in the Program alternatives would result in some irreversible and irretrievable commitments of existing aquatic resources. Planned reestablishment of aquatic habitat types included in the Ecosystem Restoration Program would be difficult, if not impossible, to fully reverse once construction had commenced. After species communities are established, it would be even more difficult to restore preexisting conditions. Constructed components of the Storage and Conveyance elements, and the Levee System Integrity and Watershed Programs also could result in irreversible and irretrievable commitments of existing aquatic resources. The most significant commitment would occur in cases where aquatic ecosystem structure and connectivity is altered by reservoirs, levees, or conveyance facilities.

Irreversible and irretrievable commitments of aquatic resources, however, would be contingent on avoiding and minimizing adverse impacts through completion of screening and prioritization processes that incorporate:

- The best available understanding of natural physical and ecosystem processes and species habitat needs.

- Progressive implementation of Program elements over the long term.

- Integrated monitoring, research, and evaluation to assess achievement of the Program objectives and conformance to solution principles.

Activities would proceed based on confidence in the desirability of the results. Adaptive management would be employed during implementation of actions to allow early detection and minimization of undesirable results. In addition, mitigation measures would be employed to minimize any adverse impacts of such commitments.

6.1.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during specific project planning and development. Specific mitigation measures will be adopted, consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

Mitigation strategies proposed in this programmatic document are conceptual in nature. Final mitigation measures would need to be approved by responsible agencies as site-specific projects are approved by subsequent environmental review.

The impact assessment for fisheries and the aquatic ecosystem is based on currently available information. Detailed information on Program actions or responses to the actions are sometimes unavailable. Because of the uncertain results of actions affecting the ecosystem, Program actions will be implemented through adaptive management. Adaptive management includes an identification of the indicators of ecosystem health; phased implementation of substantial project actions; comprehensive monitoring of the indicators; and a commitment to remedial actions necessary to avoid, minimize, or mitigate immediate and future adverse impacts of project actions on ecosystem health.

The following potential mitigation strategies are proposed:

- Implementing BMPs, including a stormwater pollution prevention plan, toxic materials control and spill response plan, and vegetation protection plan.

- Limiting construction activities to windows of minimal species vulnerability.

- Creating additional habitat for desired species, including increasing aquatic area and structural diversity through construction of setback levees and channel islands.

- Controlling undesirable non-native species.

- Operating new and existing diversions to avoid and minimize effects on fish (that is, avoiding facility operations during periods of high species vulnerability). The operational changes could reduce water availability for other beneficial uses identified in Section 5.1, "Water Supply and Water Management."

- Locating the diversion point to avoid primary distribution of desired species.

- Controlling predators in the diversion facility (screen bays) and modifying diversion facility structure and operations to minimize predator habitat.

- Constructing a barrier to fish movement on Georgiana Slough. Adverse impacts of a flow barrier, however, would need to be considered (that is, reduced flow in the lower San Joaquin River), although benefits could occur if implemented concurrent with reduced south Delta exports. To date, effective fish barriers that could reduce the impact of increased movement from the Sacramento River with minimal flow effects have not been developed.

- Coordinating and maximizing water supply system operations flexibility consistent with seasonal flow and water temperature needs of desired species.
- Conducting core sampling and analysis of proposed dredge areas and engineering solutions to avoid or prevent environmental exposure of toxic substances after dredging.
- Capping exposed toxic sediments with clean clay/silt and protective gravel.
- Locating constructed shallow-water habitat away from sources of mercury until methods for reducing mercury in water and sediment are implemented.

6.1.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

Avoiding, minimizing, and mitigating potentially significant adverse impacts depend on developing knowledge of species needs and understanding the species response to specific actions. Where knowledge of species needs is limited and the species response to specific actions is uncertain, potentially significant adverse impacts may be unavoidable. Implementation programs that include adaptive management may provide information on species needs and species response to Program actions. The information then may be used to develop measures that avoid potentially significant adverse impacts.

For fisheries and aquatic ecosystems, it is possible that newly created habitat in the Delta and Bay Regions may increase the abundance and distribution of non-native species to levels that are detrimental to native species. While the Program includes actions to develop more scientific information on the needs and responses of native species and non-native species, this impact is considered significant and unavoidable at this programmatic level of analysis.

6.2 Vegetation and Wildlife

Terrestrial vegetation and wildlife would benefit from each of the CALFED Bay-Delta Program elements. An increase in target habitat supporting plant and wildlife species, including special-status species, is expected as a result of the Ecosystem Restoration Program.

6.2 Vegetation and Wildlife

6.2.1 SUMMARY

The Bay-Delta and other regions in the CALFED Bay-Delta Program (Program) study area contain some of the most varied natural terrestrial habitats and highest biodiversity anywhere in North America. In addition to biological importance, populations of plant and wildlife species are of great importance to the state's economy with respect to commercial and recreational interests. Many of these resources have been severely reduced or degraded by human settlement, population growth, and economic development since the mid-nineteenth century; but they remain a prominent part of California's natural landscape. Populations of diverse plant and animal species are the most healthy and therefore most valuable when the ecological processes that create and maintain habitat are functioning properly. The Program seeks to restore value by improving ecological functions in order to support sustainable plant and wildlife populations.

Preferred Program Alternative. Terrestrial vegetation and wildlife would benefit from many of the Program elements. The Ecosystem Restoration Program would result in net increases in area for target habitat supporting plant and wildlife species, including special-status species. Measures would protect natural habitats from future activities and would reconstruct the historical pattern of habitats in the Program regions. The Water Quality Program could reduce loading of organic and inorganic constituents, thus reducing bioaccumulation of those compounds in the food web. The Water Use Efficiency and Water Transfer Programs could result in increased quantity or quality of wetland and riparian habitats if water saved or transferred is allocated to restoration of habitat. Watershed restoration projects could improve habitat for target populations (including special-status species), increase habitat diversity, and improve water quality and flow conditions in streams and reservoirs and decrease erosion—thus benefitting vegetation and wildlife in downstream locations. Structural watershed improvements (for example, removing roadways and improving channels) could increase habitat area for natural vegetation and associated wildlife. Implementation of the Levee System Integrity Program would provide long-term protection for existing and restored wetland, riparian, upland, and agricultural habitats. Wildlife habitat on existing levees could be increased where upgraded levees are engineered to allow the establishment of natural habitat. Overall, the Preferred Program Alternative would increase the quantity and quality of terrestrial habitat compared to the No Action Alternative.

Implementation of the Preferred Program Alternative also would cause potentially significant adverse impacts. Adverse effects of the Ecosystem Restoration Program and Watershed Program could include the temporary loss, fragmentation, or disturbance of wetland, riparian, and agricultural wildlife foraging habitats as a result of construction and habitat management (for example, from noise, human activity, and removal of vegetation). These activities also could temporarily disturb special-status species habitat. The Levee System Integrity Program could result in temporary or permanent fragmentation of existing riparian corridors, or loss of adjacent habitat if levee bases are extended. Surface storage reservoirs and associated facilities would permanently inundate existing agricultural, wetland, riparian, annual grassland, woodland, and forest communities that support a variety of species, including special-status species. Storage reservoirs could fragment riparian corridors and wildlife use areas, and disrupt historical wildlife movement patterns. Reservoirs also could cause downstream impacts as a result of sediment supply interruption or alteration of hydrology. Levee setbacks that are associated with the Conveyance Element could result in habitat loss, as described for the Levee System Integrity Program. Channel dredging would cause temporary impacts in locations where dredged materials are drained. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern.

Alternatives 1, 2, and 3. Except for conveyance elements, Alternatives 1, 2, and 3 would result in similar beneficial impacts as those identified for the Preferred Program Alternative. With the option of no storage for Alternatives 1, 2, and 3, less water may be available for Ecosystem Restoration Program restoration and enhancement. Adverse impacts would be less under Alternatives 1, 2, and 3 if no new storage is developed because habitat loss from inundation would not occur, riparian corridors would not be fragmented, and downstream impacts would not occur. Potential impacts on special-status species from storage facilities also would be avoided. Because Alternative 1 would implement less improvements to channel conveyance in the north Delta, about 4,000-5,000 acres of agricultural habitat would remain unchanged and 3,500 acres of created natural habitat would not occur. Alternative 2 would involve similar conveyance facilities in the Delta Region and therefore similar impacts as those of the Preferred Program Alternative. As described for Alternative 1, Alternative 3 would involve fewer improvements to channel conveyance in the north Delta. However, an isolated open-channel conveyance would be constructed under Alternative 3, resulting in habitat loss of about 1,000 acres over that of the Preferred Program Alternative.

The following table presents a summary of the potentially significant adverse impacts and mitigation strategies that are associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact. See the text in this chapter for a more detailed description of impacts and mitigation strategies.

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Temporary or permanent loss or degradation of wetland and riparian communities (1,2,3,4,5,13,15).

Substantial temporary or permanent loss or disturbance of wintering waterfowl habitat (6).

Substantial decrease in important upland wildlife habitat and use areas (1,4,7).

Temporary or permanent fragmentation of riparian habitats and/or wildlife movement corridors (1,3,4, 5,8).

Temporary or permanent loss of habitat or direct impacts on special-status species (1,2,3,4,5,9,10,11,14).

Loss or degradation of portions of rare natural communities and significant natural areas (1,2,3,4).

Temporary disturbance or mortality of special-status species due to construction and habitat management activities (1,4,14).

Permanent loss of incidental wetland and riparian habitats that depend on agricultural inefficiencies (3).

Reduction in quantity or quality of forage for species of concern (11).

Summary of Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative (continued)

Mitigation Strategies

1. Avoiding direct or indirect disturbance to wetland and riparian communities, special-status species habitat, rare natural communities, significant natural areas, or other sensitive habitat.
2. Designing Program features to permit on-site or nearby restoration of wetlands, riparian habitat, special-status species habitat, rare natural communities, and significant natural areas that have been removed by permanent facilities.
3. Restoring or enhancing in-kind wetland and riparian habitat or rare natural communities and significant natural areas at off-site locations before, or at the time that, project impacts are incurred.
4. Restoring wetland and riparian communities, special-status species habitat, and wildlife use areas temporarily disturbed by on-site construction activities immediately following construction.
5. Phasing the implementation of Ecosystem Restoration Program habitat restoration to offset temporary habitat losses and to restore habitat (including special-status species habitat) before, or at the same time that, project impacts associated with the Ecosystem Restoration Program are incurred.
6. Restoring or enhancing waterfowl foraging habitat near existing use areas.
7. Enhancing or restoring upland habitat areas (including modification of existing land management practices) within affected watersheds or in other watersheds.
8. Phasing the implementation of modifications to levees that would be necessary to meet PL 84-99 standards in order to minimize the effects of fragmentation of riparian habitats and associated wildlife.
9. Avoiding construction or maintenance activities within or near habitat areas occupied by special-status wildlife species or in important wildlife use areas when species may be sensitive to disturbance.
10. Establishing additional populations of special-status species in protected suitable habitat elsewhere within their historical range for species for which relocation or artificial propagation is feasible.
11. Altering agricultural practices to improve habitat conditions for affected special-status species that use agricultural lands. This could include planting and managing crops to increase the availability or quantity of forage for affected species.
12. Implementing BMPs.
13. Maintaining sufficient outflow downstream of constructed off-stream reservoirs to maintain existing downstream wetland riparian communities.
14. Managing recreation-related activities on lands managed under the Program to reduce or avoid impacts on sensitive habitat, important wildlife use areas, and special-status species.
15. Avoiding creation of wetlands in areas with high concentrations of mercury in sediments.

Bold indicates a potentially significant unavoidable impact.

6.2.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that reflect differing opinions among technical experts. The opinions of technical experts can differ, depending on which assumptions or methodology they use. Below is a brief description of the areas of controversy for this resource category. Given the programmatic nature of this document, many of these areas of controversy cannot be addressed; however, subsequent project-specific environmental analysis will evaluate these topics in more detail.

The Program's position on ecosystem quality is contained in the Program mission statement and objective, contained in Chapter 1.

Success of Habitat Restoration Efforts. There is disagreement within the professional community regarding the potential for success of habitat creation and enhancement, and the ability of created or enhanced habitat to support special-status species. Several ongoing Program activities will address the uncertainty of species and ecosystem responses, including the Strategic Plan for the Ecosystem Restoration Program, the Comprehensive Monitoring and Research Program (CMARP), and the MSCS. Refer to Section 8.1.2 for a more detailed discussion of the MSCS.

Mitigation vs. Ecosystem Restoration Program Implementation. Confusion exists concerning the relationship of Ecosystem Restoration Program habitat restoration and the separate mitigation that will be necessary for implementation of other Program actions, such as those for water supply reliability and levee system integrity. Improvements and increases in aquatic and terrestrial habitats, and improvements in ecosystem function in the Bay-Delta are goals of the Ecosystem Restoration Program. These goals are aimed primarily at the rehabilitation of ecological processes throughout the Bay-Delta and watersheds to the Bay-Delta. The Ecosystem Restoration Program is not designed as mitigation for projects to improve water supply reliability or levee system integrity, or for other Program actions. Separate mitigation measures will be required for proposed actions to improve water supply reliability or levee system integrity, or implementation of other Program elements.

Conflicts with Current National and State Environmental Policies. Various commentors have identified certain elements in the Ecosystem Restoration Program that may conflict with national or state policy. For example, proposals for reduction of fuel loads in forests and therefore possible impacts on special-status species may conflict with federal or state special-status species protection. A second example is a comment from the Delta Protection Commission that relates to maintaining salinity standards if Delta islands are breached. These issues cannot be resolved at the programmatic level because proposals are not site specific and cannot address individual species' requirements. As specific projects are identified, compliance with existing policies will be addressed.

Potential for Change in the Salinity Regime of the San Francisco Estuary. The comment was made that the EIS/EIR should address impacts on biological resources that may result from increased salinity intrusion when large areas (approximately 10% of the Delta) are restored to tidal action, as proposed in the Ecosystem Restoration Program. The anticipated flow regime (reduced fresh-water inflow) and potential for increased salinity in Suisun Marsh also have been pointed out as issues that should be addressed.

Salinity standards in the Delta are set by the SWRCB. These standards will be met as long as they are in place, regardless of structural changes initiated under the Program.

Improvements to Water Supply and Reliability Leading to Induced Growth or Planned Growth. Several regional planning agencies disagree with the conclusion that improvements in water supply and reliability would lead to induced growth. While it is not certain that the Program would result in any growth-inducing impacts, for this programmatic level of analysis, it was assumed that any increased in water supplies and/or improvements in water supply reliability associated with the Program could stimulate growth. This assumption ensures that this document discloses the environmental consequences associated with growth in the event that the Program leads to this type of change. Projections by various planning agencies indicate, however, that growth would occur due to a variety of factors unrelated to water supply and other infrastructure. Planning documents produced by these agencies indicate that planned growth would require water as a mitigation measure. The difference in opinion between the conclusion reached in this document and various planning agencies remains unresolved. This difference in opinion is acknowledged but does not change the conclusion reached in the impact analysis—that potential future growth associated with adequate water supply and reliability would lead to potential adverse impacts on habitat and species.

Location of Storage Facilities. Various groups have commented that specific locations for storage facilities must be identified for an accurate discussion of environmental impacts. The Program needs additional site-specific information about each storage site before deciding on its preferred sites. This work is proceeding under the ongoing Integrated Storage Investigation.

6.2.3 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

The affected environment is described below for each of the regions in the study area. Natural and agricultural communities, as well as special-status species, are discussed for each region. Rare natural communities and significant natural areas are addressed in the March 1998 Affected Environment Vegetation & Wildlife Technical Report.

In the sections below, special-status species are defined as (1) plants or animals that are legally protected under the state and federal ESAs or other regulations, and (2) species that are considered sufficiently rare by the scientific community to qualify for such listing.

Rare natural communities include communities of plants and wildlife that are especially diverse, regionally uncommon, or of specific concern to state or federal agencies. More specifically, these communities include wetlands, riparian communities, and other communities that are tracked by DFG's Natural Diversity Data Base (NDDB). These natural communities are given special consideration because they provide important ecological functions, including water quality maintenance, stream bank stabilization, and essential habitat for wildlife and fisheries resources. In addition, because of land development activities, the existing distributions of rare natural communities is limited compared with their historical distributions. DFG has designated Significant Natural Areas (SNAs) to encourage recognition of the state's most significant natural areas and to seek perpetuation of these areas. SNAs have no legal status; however, they have been identified in response to a legislative mandate to raise the level of awareness about California's natural diversity and to identify opportunities for cooperative efforts in order to conserve important biological resources.

6.2.3.1 DELTA REGION

Agricultural lands and associated wildlife species dominate habitats in the Delta Region. Agricultural lands occupy approximately 72% of the total land area in the region. The remaining portions of the region contain mostly open-water, wetland, and riparian habitats. Years of agriculture and development in the Delta Region have resulted in the reduction or elimination of many natural habitats and species, especially those associated with native grasslands and tidal wetlands.

Natural and Agricultural Communities. Until the early 1800s, the Delta Region was dominated by approximately 400,000 acres of tidal marshland. The Delta's more than 60 islands were mostly marshy, with some riparian areas and upland shrubs.

Prior to the mid-1800s, agriculture in the Delta Region consisted primarily of dryland farming and irrigated agriculture from artesian wells, groundwater pumping, and some creek canals. By 1900, about one-half of the Delta's historical wetland areas had been reclaimed. Extensive reclamation continued through the 1930s and 1940s. As of 1985, it was estimated that of the original 400,000 acres of tidal marshland about 18,000 acres remained.

Historically, native grasslands and vernal pools occurred in the Delta Region but were not common. As leveed lands and agriculture increased, non-native grasslands emerged in unfarmed areas and abandoned agricultural fields.

Today, the Delta Region contains approximately 641,000 acres of agricultural land that dominate its lowland areas. Other dominant habitats in the region include valley foothill riparian and fresh and saline emergent wetlands. Hundreds of miles of waterways divide the Delta Region into islands, some of which are 25 feet below sea level. The Delta Region relies on more than 1,000 miles of levees to protect these islands. Many species occurring in the Delta Region have survived changes and reductions to their habitats, including reductions in their ranges and breeding populations. Many species have adapted to agricultural land uses, although agricultural lands often do not supply all life cycle requirements.

Major Delta Region crops and cover types in agricultural production include small grains (such as wheat and barley), field crops (such as corn, sorghum, and safflower), truck crops (such as tomatoes and sugar beets), forage crops (such as hay and alfalfa), pastures, orchards, and vineyards. Vegetable crops are the most abundant crops in the region. The distribution of seasonal crops in the Delta Region varies annually, depending on crop-rotation patterns and market forces. Recent agricultural trends in the Delta include an increase in the acreage of orchards and vineyards.

Grassland and ruderal habitats are present throughout the Delta Region. Although typically small, these habitats can provide relatively high wildlife values because intensive and extensive agriculture have greatly reduced the available natural upland habitats. The extent of use by wildlife depends on the type of vegetation present and the adjacent land uses. Vernal pools that occur in grasslands along the fringes of the Delta Region support a wide diversity of native plants and invertebrates. In particular, the Jepson Prairie Preserve contains vernal pools that support several special-status species.

Riparian scrub and woodland areas typically occur on channel islands on levees and along unmaintained, narrow channel banks of Delta Region creeks, waterways, and major tributaries. The major rivers of the Delta Region include the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras. Approximately 7,000 acres of riparian vegetation occur primarily on the levees of Delta islands and along the Cosumnes and Mokelumne Rivers. The riparian zone along leveed islands is usually very narrow, but more extensive riparian areas occur along the San Joaquin River just below its confluence with the Stanislaus River and along the Cosumnes River.

Seasonal fresh-water wetlands include inland fresh-water marshes that maintain surface water during only a portion of the year and vernal pools that are associated with grasslands. Seasonal wetland conditions also are created when harvested cornfields are flooded in the Delta Region during fall and winter to reduce soil salinity and control weeds. Large seasonal wetlands managed for waterfowl are located in the northwestern part of the Delta Region, west of the Sacramento Deep Water Ship Channel. These seasonal fresh-water wetlands are of great importance to migratory waterfowl and shorebird populations for the forage that they provide during fall, winter, and spring—when bird populations in the Delta increase dramatically.

Nontidal fresh-water marsh occurs on the landward side of Delta Region levees and in the interiors of Delta Region islands, mostly in constructed waterways and ponds in agricultural areas. Dominant nontidal fresh-water marsh species include tule (*Scirpus* sp.), bulrush (*Scirpus* sp.), cattail (*Typha* sp.), watergrass (*Echinochloa crusgalli*), and nutgrass (*Cyperus* sp.). Common floating aquatic species include pretty water smartweed (*Polygonum amphibium*) and water weed (*Elodea* sp.).

Tidal fresh-water and brackish-water emergent marsh habitat is dominated by tules (*Scirpus* spp.) and cattails (*Typha* spp.), with common reed (*Phragmites australis*), buttonbush (*Cephalanthus occidentalis*), sedges (*Carex* spp.), and rushes (*Juncus* spp.). This habitat occurs on in-stream islands and along mostly unleveed, tidally influenced waterways. Tidal emergent marsh provides habitat for many species, including the following special-status species: Mason's lilaeopsis (*Lilaeopsis masonii*), Delta mudwort (*Limosella subulata*), California hibiscus (*Hibiscus lasiocarpus*), Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*), California black rail (*Laterallus jamaicensis coturniculus*), and tricolored blackbird (*Agelaius tricolor*).

Open water in the Delta Region includes sloughs and channels in the Delta, flooded islands, ponds, and bays. Deep open-water areas are largely unvegetated; beds of aquatic plants occasionally occur in shallower open-water areas. Typical aquatic plant species include water hyacinth (*Eichhornia crassipes,* a non-native noxious weed) and water milfoil (*Myriophyllum* sp.). Open water provides resting and foraging habitat for water birds, including loons (*Gavia* sp.), pelicans (*Pelecanus* sp.), gulls (*Larus* sp.), cormorants (*Phalacrocorax* sp.), and diving ducks. These species forage primarily on invertebrates and fish.

Special-Status Species. Prior to agricultural development and reclamation of wetland habitats, the Delta Region contained diverse communities of wetland, riparian, and upland plant species. The relatively small portions of native grassland and upland areas were among the first areas of the Delta Region to be converted to agricultural lands.

The Delta Region once supported more than 250 species of wildlife, including large mammal species such as the grizzly bear and gray wolf. Several species that historically were present in the Delta Region are now extinct from the region. The Ecosystem Restoration Program would evaluate the appropriateness of restoring experimental populations of extirpated species.

Generally, the existing distribution of plant and animal species in the Delta Region is closely linked with the distribution of one or more habitat types on which a species depends. Dozens of special-status plants and wildlife occur in the Delta Region. Most of the special-status species occur in grassland and vernal pools. The remaining special-status plants occur in the region's other habitat types.

Most of the special-status wildlife species are associated with fresh-water emergent wetlands, marshes, open water, and agricultural lands.

Vernal pools and other fresh-water seasonal wetlands support several special-status crustaceans, including tadpole shrimp (*Lepidurus packardi*) and fairy shrimp (*Branchinecta lynchi*). Although severely declining due to a dramatic shrinkage of suitable habitat, the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*, which is federally listed as threatened) has been found in the Delta Region on McCormack-Williamson and New Hope Tracts. Several special-status invertebrates occur in the Antioch Dunes area.

See the MSCS for more detail on special-status species.

Waterfowl and Shorebirds. Resident and migratory waterfowl and shorebirds suffered perhaps the largest declines resulting from development and agriculture in the Delta Region. The declines in resident and migratory waterfowl populations before the early twentieth century have been attributed to hunting and the large-scale reclamation of tidal marshes that occurred between 1860 and 1910. Loss of wetlands in other portions of the state also contributed to these declines.

Changes in agricultural cropping patterns since the 1970s have increased the quality of waterfowl and shorebird habitat in the Delta Region. As a result, populations of waterfowl and shorebirds in the Delta have been increasing.

Waterfowl and shorebirds forage primarily in natural and artificial wetlands and agricultural lands. The Delta supports approximately 10% of the Central Valley's wintering waterfowl and shorebird populations. Several waterfowl species are particularly dependent on the Delta, including tundra swans (*Cygnus columbianus*), white-fronted geese (*Anser albifrons*), snow geese (*Chen caerulescens*), greater sandhill cranes (*Grus canadensis*), northern pintails (*Anas acuta*), and mallards (*Anas platyrhynchos*).

More than 30 species of shorebirds regularly use the Delta Region. Six species nest in the Delta Region, and the rest overwinter there or pass through during spring and fall migration. During the 1992-93 winter, 28,500 shorebirds were counted in the Delta Region, primarily dunlins (*Calidris alpina*) and long-billed dowitchers (*Limnodromus scolopaceus*). Shorebirds prey extensively on invertebrates. Important foraging habitats include permanent saline, brackish, and fresh-water marshes; seasonal wetlands; and agricultural cropland.

6.2.3.2 BAY REGION

The Bay Region includes the entire watershed for the San Francisco Bay (exclusive of the Delta and its tributary watersheds). Proposed actions associated with the Program would occur primarily in the area of Suisun Marsh, Suisun Bay, and northern San Pablo Bay. Therefore, the description of existing conditions focuses on these areas.

Suisun and San Pablo Bays support large areas of tidal flats that provide important foraging habitat for shorebirds. Suisun Marsh supports saline emergent wetland, which provides habitat for salt marsh species that prefer infrequently flooded salt marsh habitat, and coastal brackish marsh, which provides habitat for species that prefer tidal marshes with lower salinity.

The Bay Region is dominated by open water; tidal flats; diked managed wetlands; and some non-leveed lowlands, which support wetlands that change in character from salt marsh (in the western portions) to brackish marsh (in the eastern portions). The sections below describe the vegetation and wildlife resources for the entire watershed of the Bay Region.

Wetland and terrestrial habitats in the Bay Region have undergone changes over time as a result of marsh reclamation, water diversions, industrialization, and the effects of sedimentation caused by hydraulic mining. Marsh reclamation and water diversions have not been as severe in the Bay Region as in the Delta Region, but extensive hydraulic mining upstream during the late 1800s resulted in the deposition of millions of cubic yards of sediment and debris into low-lying areas and channels in the Bay Region.

Natural and Agricultural Communities. Until the early nineteenth century, the Bay Region was dominated by very large, productive wetlands and tidal flats, with deeper channels and open-water areas that drained over 40% of the state. Although these communities are still present in the region, they have been reduced in size by agricultural development and industry.

The greatest adverse effect on natural communities in the Bay Region was the removal of tidal influence. The placement of levees between many wetland areas and the channels prevented water from reaching communities at the higher elevations in the wetlands as it had before when the waters advanced and subsided. Many species in these natural communities could no longer survive and perished. Some of these areas now support agricultural grain production.

The hydraulic mining practices in upstream watersheds in the Bay Region resulted in the deposition of millions of cubic yards of sediment and debris. In addition to adversely affecting the numerous wetlands in the region, this sedimentation reduced channel depths, making dredging necessary to keep the waterways navigable.

Today, the Bay Region contains extensive areas of tidal flats remaining from pre-settlement eras. Tidal flats include shoals, sandy mud bars, and portions of stream beds that are exposed at low tide. Tidal flats are largely unvegetated, although some emergent vegetation may be present. Bay Region tidal flats provide resting and foraging habitat for several bird groups. California (*Larus californicus*) and ring-billed gulls (*Larus delawarensis*) use tidal flats as resting areas. During spring and fall migration, large numbers of shorebirds congregate to forage on invertebrates in and on tidal flat substrates. Mammals such as raccoons (*Procyon lotor*) and skunks (*Spilogale* and *Memphitis* sp.) also forage on Bay Region tidal flats.

Saline emergent wetland is confined to the Suisun Bay/Marsh boundaries and along the northern shore of San Pablo Bay. Common plant species associated with saline emergent wetland include cordgrass (*Spartina* sp.), pickleweed (*Salicornia* sp.), and saltgrass (*Distichlis spicata*). Each plant species typically occupies a specific elevational band in relation to the mean tidal water level. Unmanaged coastal brackish marsh occurs along sloughs and channels of Suisun Marsh, and is dominated by tules and cattails. The largest extent of wetlands in Suisun Marsh consists of fresh-water and brackish marshes that are managed mostly as waterfowl habitat.

Upland communities exist on hills and plateaus that surround the Bay Region lowlands. The dominant community in these areas is non-native grassland, with a varied shrub and oak overstory. Agricultural uses in these areas include cattle grazing and vineyards.

Special-Status Species. Prior to agricultural development and settlement in the Bay Region, diversity of plant species was higher than it has been since, but was never as high as in the Delta Region (although the two regions shared many of the same species). Many species were dependent on the tidally influenced lowlands.

Many, if not all, of the large mammals once present in the Delta Region also historically were present in the Bay Region. These species met similar fates. Habitat fragmentation and destruction, as well as subsistence and market hunting, combined to eliminate many species from the Bay Region. Some species that used the higher upland and cliff parts in the region lingered for some time into the twentieth century but eventually were driven off by activities associated with continued industrial and residential development.

Dozens of special-status wildlife and plants occur in the Bay Region. The saline and brackish emergent marsh habitat of Suisun Marsh supports populations of plant species that are federally listed as endangered, including the Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*) and soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*). Mason's lilaeopsis (*Lilaeopsis masonii*) (state listed as rare, no federal listing status) occurs in brackish or fresh-water tidal marshes of Suisun Bay/Marsh.

The majority of special-status wildlife species are associated with upland grasslands and fresh-water emergent wetlands, and are restricted in their range because of the fragmentation and low diversity of habitats. Species such as the bald eagle (*Haliaeetus lencocephalus*) and peregrine falcon (*Falco mexicanus*) are seasonal visitors to the Bay Region. Recent reports indicate that the peregrine falcon has nested at various locations in the region (for example, on the Bay Bridge). Two federally listed and state-listed endangered species occur in saline emergent wetlands in the Bay Region: the salt marsh harvest mouse (*Reithrodontomys raviventris*) and the California clapper rail (*Rallus longirostris obsoletus*). The salt marsh harvest mouse is known from occurrences in Suisun Marsh, islands in Suisun Bay, and saline emergent marshes south of Suisun Bay. The California clapper rail is known from occurrences in Suisun Marsh and islands in Suisun Bay. California black rails (*Laterallus jamaicensis coturniculus*) occur in saline emergent wetlands of Suisun Marsh, islands of Suisun Bay, and saline emergent marshes along the Contra Costa shoreline. California black rails are state listed as threatened. The salt marsh common yellowthroat (*Geothlypis trichas sinuosa*) uses the tall emergent vegetation that grows in the more brackish areas.

See the MSCS for more detail on special-status species.

Waterfowl and Shorebirds. The Bay Region has always been a major waterfowl and shorebird area due to the presence of its wetlands and the extensive open-water habitats. As with the Delta Region, the Bay Region suffered losses of wetlands and subsequently waterfowl and shorebirds, beginning in earnest during the 1800's. Development, agriculture, and water diversions were not as extensive as those in the Delta Region. Therefore, losses of waterfowl and shorebirds in the Bay Region, although severe at times, never reached the extent that occurred in the Delta Region. Much of the decline in waterfowl numbers in the Bay Region during the nineteenth and twentieth centuries can be attributed to losses incurred in other portions of the state.

Today, the Bay Region is an important waterfowl area for the Pacific Flyway and may contain more than 1 million birds as they migrate through the area. Mid-winter waterfowl surveys in 1991 estimated nearly 268,700 waterfowl in the entire Bay Region, including approximately 265,000 ducks—primarily scaups (*Aythya* sp.), scoters (*Melanitta* sp.), canvasbacks (*Aythaya valisineria*), ruddy ducks (*Oxyura jamaicensis*), and northern pintail (*Anus acuta*).

The Bay Region is a particularly important area for shorebirds, supporting more shorebirds than all other California coastal wetlands combined. An estimated 300,000-400,000 shorebirds in fall, and from 600,000 to 1 million shorebirds in spring, can be found in the region.

6.2.3.3 SACRAMENTO RIVER REGION

The Sacramento River Region contains the watershed of the Sacramento River and its tributaries, and extends from Collinsville in the south to the Oregon border in the north. The Sacramento River Region contains a large diversity of both lowland and upland habitats and species. Along most of the Sacramento River and its tributaries remnants of riparian communities are all that remain of once very productive and extensive riparian areas. However, along the upper reaches of the Sacramento River more riparian vegetation is still intact. Wetlands occupy many areas along Sacramento River Region waterways but are not as extensive as wetlands found in the Delta Region. On the other hand, grasslands and wooded upland communities are more abundant in this region than in the previously described Delta and Bay Regions. Agricultural lands also occupy a significant portion of the Sacramento River Region. Open-water areas occur mainly on the larger waterways, where waterways converge, and in reservoirs. The sections below describe the vegetation and wildlife resources for the upper and lower watershed areas in the region.

See the MSCS for more detail on special-status species.

Natural and Agricultural Communities. Perhaps the most drastic difference between historical and existing conditions in the Sacramento River Region is the reduction of lush, unbroken riparian areas. Development, dams, agriculture, and fuel needs removed and fragmented most riparian areas, especially between the early nineteenth and mid-twentieth centuries. Native perennial grasslands covered vast areas in the region but have since been farmed or invaded by non-native annuals.

Low-lying areas in the region once were routinely flooded, replenishing nutrients and providing water to many portions of the region not situated along waterways. However, diking and construction of levees to protect agricultural lands and residential areas have changed this, and many former communities dependent on regular floods perished. Marshes and emergent wetlands were never as abundant in the Sacramento River Region as in the Delta and Bay Regions due to inherent differences in the geomorphology of the regions. Vernal pools are important wetland resources that were historically abundant and have decreased dramatically with agriculture and development in the last two centuries.

The higher elevations in the Sacramento River Region are dominated by conifers and hardwoods. These areas have sustained some development and logging but have suffered less of a decline than the other communities in the region.

Special-Status Species. Prior to the habitat and community changes resulting from settlement and development of the Sacramento River Region, several plants and animals were present that have since been extirpated from the region. Over 100 special-status wildlife and plants occur in the Sacramento River Region. The largest number of special-status plant species in this region occurs in grassland, which includes vernal pools. The next-largest number of special-status plant species occurs in chaparral and montane hardwood.

The majority of the special-status wildlife species are associated with grasslands, fresh-water emergent wetlands, lakes, and rivers on the valley floor. Many of these species have been listed by federal and state wildlife agencies because of habitat loss associated with agricultural development and water projects.

See the MSCS for more detail on special-status species.

Waterfowl and Shorebirds. Waterfowl in the Sacramento River Region outnumber shorebirds. Populations of both groups have fluctuated over the last two centuries due to market hunting, conversion of natural habitat to agricultural and urban uses, weather conditions, and conditions on breeding grounds. Market hunting until the 1920s affected many waterfowl populations in the Sacramento River Region. Conversion of natural habitats to agricultural and urban uses, and drought conditions contributed to declines in numbers of waterfowl and shorebirds using the Sacramento River Region. After the mid-1930s, waterfowl populations increased in the Sacramento River Region. Favorable weather patterns on the Canadian breeding grounds and a reduction in hunters during World War II may have contributed to these increases. Also, labor shortages extended the time required for harvesting rice and other grains, which provided additional forage for waterfowl. Declines in Sacramento River Region waterfowl and shorebird populations due to unfavorable conditions on their breeding grounds occurred during the late 1950s and during the mid-1980s. Populations recovered appreciably after these periods of decline.

Today, private duck clubs and state and federal refuges in the Sacramento River Region provide essential habitat for wintering waterfowl and shorebirds in the Sacramento River Region. Approximately 60% of the Pacific Flyway waterfowl population winters in the Sacramento River Region.

Sacramento River Region wetlands also provide important habitat for shorebirds. The Sacramento River Region is particularly important to shorebirds in spring, when shorebirds use wetlands in the valley as staging areas during migration to northern breeding grounds.

6.2.3.4 San Joaquin River Region

The San Joaquin River Region has many similarities to the Sacramento River Region, including terrain, climate, habitats, and species. Historical and present differences between the two regions do exist, however. For example, the San Joaquin River Region's riparian regions are not and have never been as extensive as those found in the Sacramento River Region; the San Joaquin River Region holds more land devoted to agriculture. Many riparian communities in the region were lost when historical waterways ran dry as water was diverted through irrigation channels and artificial drainages. Isolated riparian communities exist in the lower portions of the San Joaquin River Region, and more intact communities can be found along the eastern reaches in the region. Wetlands are situated in the northern and western reaches in the region but are less abundant in other parts of the region. The section below describes the vegetation and wildlife resources for the upper and lower watershed areas in the San Joaquin River Region.

Natural and Agricultural Communities. As with the Sacramento River Region, the San Joaquin River Region has lost most of its historical riparian areas, mostly due to agriculture. Agriculture developed early and quickly in the region and has remained the dominant land use. Historically, the lowlands were a large floodplain of the San Joaquin River that supported vast expanses of permanent and seasonal marshes, lakes, and riparian areas. Almost 70% of the lowlands have been converted to irrigated agriculture, with wetland acreage reduced to 120,300 acres.

Upland shrubs and oak woodlands that surround the San Joaquin River Region to the east, west, and south are less intact today than they were prior to the twentieth century. Development and water diversions adversely affected some communities in these areas. Wetland areas were once very common in the northern, southern, and parts of the western reaches of the San Joaquin River Region; but since the mid-nineteenth century wetlands have been reduced to a fraction of their historical acreage by minerals, salts, pesticides, diversions, and reclamation activities.

Special-Status Species. Similarly to all of the other Program regions, changes in the natural landscape of the San Joaquin River Region took their toll on plant and wildlife species. Over 100 special-status wildlife and plants occur in the San Joaquin Rive Region. The largest number of special-status plant species occurs in grassland and valley foothill woodland.

Most of the special-status wildlife species are associated with grasslands, fresh-water emergent wetlands, lakes, and rivers that occur on the valley floor. Many of the species have been listed by federal and state wildlife agencies because of habitat losses associated with agricultural development and water projects.

See the MSCS for more detail on special-status species.

Waterfowl and Shorebirds. Waterfowl and shorebird numbers in the San Joaquin River Region historically were greater than those for the Sacramento River Region. In addition to the factors that reduced waterfowl and shorebird populations in the Sacramento River Region, the loss of additional wetlands in the San Joaquin River Region due to the accumulation of minerals and pesticides resulted in a compounded detrimental effect on waterfowl and shorebird numbers. Initially, waterfowl and shorebird recovery in the San Joaquin River Region was not as successful as in the Sacramento River Region. Recent efforts to restore damaged wetlands, prevent harmful runoff from entering the wetlands, and manage agricultural lands to favor waterfowl and shorebirds during winter have aided the recovery of these species in the region. The San Joaquin River Region supports approximately 25% of the Central Valley waterfowl and shorebird populations, and up to 30% of the wintering duck population.

6.2.3.5 OTHER SWP AND CVP SERVICE AREAS

The Other SWP and CVP Service Areas region includes two distinct, noncontiguous areas: in the north, are the San Felipe Division's CVP service area and the South Bay SWP service area; to the south, are the SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

The Other SWP and CVP Service Areas contain a large diversity of both lowland and upland habitats and species. Urban growth has reduced the area and connectivity of important habitats that are critical to sustaining a wide variety of unique plants and animals. The conflict between urban growth and conservation of native habitat has resulted in the listing of a number of plants and animals that were threatened with extinction. In response, local land use agencies working with state and federal fish and wildlife agencies, and development and environmental stakeholders have initiated and begun to implement large-scale conservation planning efforts to reduce the conflicts between development and recovery of listed species.

The most dramatic difference between historical and existing conditions is the fragmentation of what were once large contiguous blocks of habitat, such as chamise-redshank chaparral, coastal sage scrub, grassland, oak woodland, oak savanna, southern oak woodland-forest, riparian woodland-forest, succulent scrub, sand dune habitat, alkali desert scrub, desert riparian habitat, desert wash, fresh-water/salt-water marsh, and coastal strand. These habitats were located in three subareas: the Central Coast Service Area, South Coast Service Area, and Southern Deserts Service Area.

Natural and Agricultural Communities. Significant changes to the natural landscape in the region occurred in the late 1800s and early 1900s with land conversions to agriculture, a pattern similar to the San Joaquin River Region. That pattern shifted dramatically compared to the San Joaquin River Region, as urban growth in the region that started in the 1900s began to displace agricultural lands and convert large areas of remaining native habitats.

Special-Status Species. Similarly to the San Joaquin River Region, changes in the natural landscape in the Other SWP and CVP Service Areas took a toll on plant and wildlife species. The California condor, light-footed clapper rail, California least tern, least Bell's vireo, Belding's savannah sparrow, southwestern willow flycatcher, California gnatcatcher, Mohave ground squirrel, Morro Bay kangaroo rat, Santa Ana River woollystar, and Santa Ynez false-lupine are examples of species that have been listed.

6.2.4 ASSESSMENT METHODS

The assessment methods described below are intended to address the broad range of environmental consequences to vegetation and wildlife that are associated with implementing all elements of the CALFED Program. Additional detailed information on existing conditions and individual species can be found in the March 1998 Environmental Consequences Vegetation & Wildlife Technical Report. The MSCS and its appendices present additional detailed information on special-status species and their habitats. The MSCS has been prepared for programmatic compliance with the state and federal endangered species laws. Although the MSCS complements the impact analysis in this section, it is not intended to serve as the impact analysis for CEQA/NEPA purposes.

During the implementation phase of the Program, second-tier or site-specific environmental documents will be prepared for individual projects. The documents will identify specific locations for Program actions and the site-specific mitigation measures that will be required to mitigate the impacts of the actions. Site-specific environmental documents will identify the existing land uses in the project area and, where appropriate, will evaluate the socioeconomic effects of implementing the Program action.

The plant community classification system that is used is a modified Holland system. Generally, impacts are assessed at the community level. This community approach assumes that those species dependent on a plant community generally would be affected in the same direction by a particular Program action; that is, if a plant community is adversely affected, the associated plants and animals most likely would be similarly affected.

Some Program actions could directly affect specific environmental variables, such as flow, water quality, and substrate. Changes in these environmental variables could affect plant communities by changing rates of erosion, sedimentation, or water availability; by directly creating new plant communities; or by removing, converting, or fragmenting existing communities. These impact mechanisms may cause changes in the quality or quantity of plant communities and associated wildlife. Changes also may affect the number of wildlife special-status species or the area or quality of rare natural communities by altering existing foraging and breeding areas. These changes in quality and quantity are the measures used to determine impacts of the alternatives being considered. At the next level of analysis (site specific) the interactions between quantity and quality, or habitat and temporal scale and disturbance regimes that are associated with habitat quality will be evaluated. The programmatic impact analysis focuses on the direct effects of conveyance elements. Although indirect impacts, such as noise or human disturbance, also can affect habitat quality, these impacts cannot be used to differentiate between alternatives at the programmatic level.

Several general categories of impact measures were used to assess the level of impact of the Program alternatives on vegetation, wildlife, and special-status species, including:

- Area of natural plant communities, including associated wildlife and plant species.

- Quality of natural plant communities, including the associated wildlife and plant species, and changes in non-indigenous and introduced species.

- Area and quality of agricultural land providing habitat value.
- Habitat patterns for plant communities (for example, spatial orientation of habitats, connectivity, and landscape-level diversity).
- Number of known special-status species or areas with a critical habitat designation.
- Area and quality of plant communities occupied by special-status species.
- Area and quality of rare natural communities or significant natural areas.

Two types of analysis have been included to address plant communities and associated wildlife species: (1) changes in areal extent due to direct increase, loss, or conversion; and (2) changes in quality. Changes to the areal extent of vegetation have been defined and analyzed using various tools in geographic information system (GIS) and hard-copy mapping that focus primarily on spatial analysis of a plant community area. The change in acreage of each plant community is used as the quantitative measure of impacts on wetland and terrestrial habitats, associated vegetation and wildlife, or species groups. The assessment of qualitative impacts on plant communities considers geographic extent, distribution, quality, and spatial configuration. A project that affects the continuity of a linear riparian plant community or drainage patterns in wetlands, for example, may result in a greater impact than those resulting from changes in areal extent. The severity of impacts is determined by the magnitude of changes in quality or condition of the plant communities.

Geographic comparisons have been made using electronic databases and hard-copy maps of plant community distributions. Results of this analysis provided information on the likelihood of affecting a given plant community or special-status species with the implementation of a particular alternative.

This analysis uses DFG's NDDB location information on special-status plants and animal species. Approximate impact footprints corresponding to proposed alternative features were generated using GIS and the NDDB. A list of special-status plant and animal species potentially occurring within these footprints was produced.

The habitat requirements of each species, as defined in the literature (NDDB and California Native Plant Society data bases 1997), were used to evaluate the effect of changes resulting from alternative features on these special-status species. Each species was identified as potentially being either positively affected, negatively affected, or not significantly affected (more information can be found in the March 1998 Environmental Consequences Vegetation & Wildlife Technical Report). Mitigation strategies are presented that would minimize or eliminate these negative impacts.

The document assumes that the distribution and abundance of special-status species is proportional to the amount and quality of habitat available. Assessment of impacts is based on the potential of a Program action to affect a special-status species, its critical habitat, or its range.

Rare natural communities and significant natural areas were treated qualitatively, in part because specific data on the location of the project features in relation to specific areas or communities were not generally available. DFG mapping of vernal pools, and the NDDB and files were used to obtain some quantitative information regarding effects on rare natural communities.

6.2.5 SIGNIFICANCE CRITERIA

The significance of any of the Program actions would vary, depending on the environmental setting in which the activity occurs. Significance criteria may be qualitative or quantitative. The general nature of the planning and the broad range of settings and impacts dictate the use of qualitative significance criteria at this programmatic stage. The criteria will be made more definitive and more quantitative at the project-specific level.

The significance criteria identified for evaluation of impacts on vegetation and wildlife resources are:

- Temporary or permanent removal, filling, grading, or disturbance of wetlands and riparian communities (for criteria related to agricultural land conversion, refer to Section 7.1, "Agricultural Land and Water Use").

- Substantial decreases in the size of important native upland wildlife habitats (upland habitat areas that generally are declining and that are important to maintaining populations of some species) or wildlife use areas (for example, traditional deer winter ranges or fawning habitat) in watersheds of major tributaries to the Sacramento and San Joaquin Rivers.

- Substantial fragmentation or isolation of wildlife habitats or movement corridors, especially riparian and wetland habitats.

- Substantial decrease in the amount of available forage, including forage from agricultural lands for wintering waterfowl.

- Substantial increase in the potential for outbreaks of wildlife diseases.

- The temporary or permanent loss of occupied special-status species habitat or indirect or direct mortality of special-status species.

- Reduction in the area or geographic range of rare natural communities and significant natural areas.

- Reduction in the area or habitat value of critical habitat areas designated under the federal ESA.

6.2.6 NO ACTION ALTERNATIVE

Future potential projects considered in the assessment of impacts on vegetation and wildlife under the No Action Alternative are described in Attachment A, "Information about the No Action Alternative; Modeling Assumptions for Existing Conditions, the No Action Alternative, and the Program Alternatives; and Actions That May Contribute to Cumulative Impacts."

6.2.6.1 DELTA REGION

Although project operations and surface water and groundwater storage would change under the No Action Alternative, Delta inflow and outflow most likely would be similar to flows under existing conditions. Project operations rules and demands, similar under both the No Action Alternative and existing conditions, would limit the ability to change flow patterns and the associated salinity distribution in the Delta. The quantity and quality of wetland and riparian vegetation in the Delta would diminish over time as other non-Program projects (see Attachment A) are implemented, despite likely small increases in wetland and riparian vegetation due to increased productivity that could occur. Changes that could occur are not quantifiable at a programmatic level of analysis.

Sediment supply and movement could be affected by the Delta Levees Subvention Project and actions upstream of the Delta, including land retirement and the Sacramento River Flood Control Project (SRFCP). None of the projects would substantially change the structure of the existing ecosystem, and change in sediment supply and movement most likely would be minimal. Any changes to the quantity or quality of habitat cannot be quantified at this programmatic level of analysis.

Contaminant input and movement could be reduced by land retirement from the San Joaquin drainage problem lands and, possibly, by restoration that is associated with the Stone Lakes National Wildlife Refuge (NWR). Contaminant input under the 2020 level of development, however, could increase or decrease. Relative to existing sources of contaminants, the change in contaminant input most likely would be small. Change in flow also could affect the movement and dilution of contaminants; however, information on flow change is currently unavailable.

Biological productivity and nutrient input are affected by the processes discussed above and the changes in structural characteristics described below. Relative to existing conditions, projects under the No Action Alternative that could increase biological productivity, nutrient input, and movement in the terrestrial ecosystem include changes in wildlife refuge operations and restoration that is associated with the Stone Lakes NWR, Delta Levees Subvention Project, and SRFCP. Restoration of riparian, shaded riverine aquatic, and tidal marsh areas could slightly increase productivity through increased production and input of organic carbon, and could provide a small benefit to Delta species.

Structural characteristics of the Delta would be similar for both the No Action Alternative and existing conditions. Projects that could affect structural characteristics of the Delta ecosystem and species habitat include the Delta Levees Subvention Project and Stone Lakes NWR. Change in structural characteristics is considered a beneficial effect when the change moves toward a natural condition. Restoration of tidal marsh and connecting sloughs in the Stone Lakes NWR, and changes in levee maintenance practices to allow development of natural riparian and marsh communities would result in a small beneficial effect relative to the existing Delta system. For example, an additional 1,300 acres of habitat added to the Stone Lakes NWR under the No Action Alternative would benefit several plant communities (including wetlands) by assisting the recovery of special-status species and adding linkage between refuge habitats.

6.2.6.2 BAY REGION

Under the No Action Alternative, effects on vegetation and wildlife communities in the Bay Region primarily would depend on the movement of contaminants, sediment, nutrients, and production from the Delta Region. The small increase in productivity and nutrient input identified for the Delta could be transported to the Bay and provide small benefits to the wetlands and adjacent upland habitats surrounding waters in the Bay Region.

6.2.6.3 SACRAMENTO RIVER REGION

Although operations and surface water and groundwater storage would change under the No Action Alternative, Sacramento River and tributary flows most likely would be similar to flows under existing conditions. Project operations rules and demands, similar under both the No Action Alternative and existing conditions, would limit the ability to change flow patterns. Changes to the quality and quantity of riparian and wetland communities would be small, and not measurable at a programmatic level of analysis.

The SRFCP could affect structural characteristics of the Sacramento and American Rivers. Change in structural characteristics is considered a beneficial effect when the change moves toward a more natural condition. Changes in levee maintenance practices to allow development of natural riparian and shaded riverine aquatic communities would result in small benefits relative to the existing levee system. The structural changes could result in a slight increase in the quantity and quality of habitats that support species (including special-status species) that are associated with riparian and shaded riverine terrestrial habitats.

6.2.6.4 SAN JOAQUIN RIVER REGION

San Joaquin River and tributary flows most likely would be similar to flows under existing conditions. Mokelumne River and Tuolumne River flows could be altered to improve spawning and rearing conditions, providing a benefit primarily to chinook salmon but also potential small benefits to riparian vegetation.

Water quality conditions in most rivers in the San Joaquin River Region under the No Action Alternative would be similar to water quality conditions under existing conditions. Retirement of approximately 45,000 acres of agricultural lands in drainage problem areas could reduce the input of contaminants (primarily selenium and salts) to the San Joaquin River, and benefit the plant and animal species that obtain materials and food supply from areas affected by contaminants.

The water supplies to 10 NWRs, 4 Wildlife Management Areas (WMAs), and private wetlands in the Grasslands Water District would be at Level 4 under the No Action Alternative. Level 4 is the amount of water required for full development of the land lying within the 1988 refuge boundaries, in contrast to Level 2 under existing conditions, which is the average amount of water the refuges had received for approximately 10 years. In general, Level 4 water supplies would allow for greater flexibility and consistency in providing water for full development of wetlands, and water to support waterfowl and other species relying on refuge habitat. The increasing quantity and quality of habitat supported by Level 4 water supplies are not quantifiable at a programmatic level of detail.

6.2.6.5 OTHER SWP AND CVP SERVICE AREAS

The impact of the 2020 level of development on upland, wetland, and riparian habitat in the Other SWP and CVP Service Areas cannot be quantified with available information.

In general, the projects proposed consist of new water conveyance (for example, the Coastal Aqueduct), water storage (for example, the Diamond Valley Reservoir Project), and groundwater storage/groundwater recharge (for example, the Semitropic Groundwater Banking Project). Projects such as the Diamond Valley Reservoir Project would displace up to 4,500 acres of habitat but would support smaller acreages of wetlands bordering the reservoir. Groundwater storage/recharge projects, such as the Semitropic Groundwater Banking Project, would retain terrestrial habitat as a result of conveyance groundwater wells and pumps but also could provide benefits to vegetation communities able to tap groundwater, particularly near springs. Groundwater recharging involving spreading basins also would add open-water habitat and small wetland areas that could be used by waterfowl and other species.

6.2.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For vegetation and wildlife resources, the environmental consequences of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs and the Storage element are similar under all Program alternatives as described below. The environmental consequences of the Conveyance element vary among Program alternatives, as described in Section 6.2.8. Chapter 4 describes the area of land that could be affected with implementation of all Program elements.

The discussion below provides a programmatic evaluation of the impacts on special-status plant and wildlife species and their habitats. The potential impacts on special-status species and their habitats are considered potentially significant based on the significance criteria. The mitigation strategies in Section 6.2.11 will reduce most potentially significant impacts to a less-than-significant level. Depending on the location of certain Program actions, the fragmentation of riparian habitats or wildlife movement corridors, or the loss or degradation of portions of rare natural communities or significant natural areas may be significant and unavoidable (see Section 6.2.12).

The MSCS provides additional discussion of the potential impacts of the Preferred Program Alternative on special-status plant and wildlife species. The MSCS also presents additional detail on methods for avoiding, minimizing, and compensating for the Program's impacts on special-status species and their habitats, termed "conservation measures" in the report. The MSCS analysis builds on the analysis in this document and serves as the basis for programmatic compliance with the federal and state laws regarding endangered species.

6.2.7.1 DELTA REGION

Ecosystem Restoration Program

Ecosystem Restoration Program actions proposed for the Delta Region that could affect vegetation and wildlife resources are summarized in the Ecosystem Restoration Program (Volumes 1, 2, and 3). The Ecosystem Restoration Program could result in a net increase in the following natural plant community types: tidal fresh-water emergent wetland, nontidal fresh-water emergent wetland, tidally influenced channels and distributary sloughs, shallow-water habitat, shoals, open-water areas in restored fresh-water emergent wetland areas, seasonal wetlands, riparian habitat, perennial grassland, and inland dune scrub habitat. The program also would improve habitat values of agricultural lands for waterfowl and other wildlife through cooperative management agreements with landowners.

Measures to restore and enhance natural habitats would result in a net increase in the area of natural habitats supporting plant and wildlife species, including special-status species. Species that would benefit from these measures and the magnitude of the benefits would depend on where measures are implemented and the specific habitat restoration designs (for example, the restored habitat patch size) or habitat management prescriptions employed. Ecosystem Restoration Program measures will include provisions to protect natural habitats from future activities that could result in their loss or degradation.

Restoration of combinations of shallow-water, wetland, and riparian habitats would reconstitute a historical pattern of habitats to the Delta Region. These habitats would be established along an elevational gradient from open water at lower elevations, gradually transitioning to wetland, and then to riparian habitat at higher elevations. Restoration of large tracts of wetlands within existing agricultural lands would create a habitat pattern that could result in a more uniform distribution in the Delta of wildlife that breed or rest in wetlands and forage in nearby agricultural habitats.

Implementation of the Ecosystem Restoration Program could cause temporary impacts on wetland and riparian communities and special-status species and their habitats. These impacts would result primarily from construction- and habitat management-related disturbances that are associated with restoration activities, such as noise, human activity, and removal of vegetation. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate these potentially significant impacts to a less-than-significant level.

Permanent impacts of implementing the Ecosystem Restoration Program on vegetation and wildlife resources, including rare natural communities, significant natural areas, and special-status species and their habitats, primarily would result from conversion of existing habitats to different habitat types and changes in land management practices (for example, changes in cropping patterns on agricultural lands or vegetation management practices). Most habitat restoration acreage would be created by restoring existing agricultural lands to natural habitats. Relatively small acreages of some natural plant communities would be converted to open-water or other natural plant communities. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate these potentially significant impacts to a less-than-significant level.

The adverse impacts of implementing the Ecosystem Restoration Program could include the temporary loss, fragmentation, or disturbance to wetland, riparian, and agricultural wildlife foraging habitats. Construction- and habitat management-related activities could result in temporary disturbance to, or mortality of, special-status species that may be present on or near areas where program measures are implemented. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate these potentially significant impacts to a less-than-significant level.

Implementation of the Ecosystem Restoration Program could result in conversion of up to approximately 112,000 acres of agricultural lands (Table 4-4) to natural habitats, and conversion of annual grassland and ruderal habitat areas to other natural habitat types. A portion of agricultural lands that could be affected by the program is expected to be lands currently farmed to crops that provide important forage (corn and wheat) for some species. The loss of agricultural lands that provide high wildlife forage values could result in a reduction in available forage for such species as Swainson's hawks, greater sandhill cranes, and wintering waterfowl—if natural and agricultural habitats restored or enhanced under the program provide less forage than is provided by the affected agricultural lands. Restoration or enhancement of natural and agricultural foraging habitats for these species, in conjunction with proposed mitigation strategies (Section 6.2.11, "Mitigation Strategies), are expected to reduce this potentially significant impact to a less-than-significant level.

Ecosystem Restoration Program actions that could substantially increase the availability of waterfowl forage (for example, managing agricultural lands to increase forage availability) could potentially concentrate large numbers of wintering waterfowl and increase the likelihood for transmission of waterfowl diseases. Because the Ecosystem Restoration Program would be enhancing the availability of waterfowl forage over a large area (throughout the Delta), implementation of these actions most likely would serve to disperse foraging waterfowl and potentially reduce the likelihood for transmission of waterfowl diseases. Therefore, this potential impact is considered less than significant. The potential impact of the Ecosystem Restoration Program on agriculture (for example, loss of agricultural acreage) is discussed further in Section 7.1, "Agricultural Land and Water Use," Section 7.2, "Agricultural Economics," and Section 7.3, "Agricultural Social Issues."

Implementation of the Ecosystem Restoration Program also could make certain contaminants in sediments, such as mercury, more available in the water column. Although mercury mobilization is not well understood, discussion in Section 5.3, "Water Quality," indicates that under anaerobic conditions mercury is methalyzed by anaerobic bacteria and thus mobilized in the water column. Consequently, in areas with a mercury source, the combination of restored wetlands and anaerobic conditions may enhance the formation of methyl mercury. Methyl mercury in the water column then would be available to fish and other members of the food chain, including special-status wildlife. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate these potentially significant impacts to a less-than-significant level. Further discussion of methyl mercury impacts and mitigation is included in the March 1998 Environmental Consequences Water Quality Technical Report.

Water Quality Program

Implementation of the Water Quality Program could reduce the loadings of organic and inorganic constituents (such as metals and insecticides) to the Delta and its tributaries from mine drainage, urban and industrial runoff, wastewater and industrial discharge, and agricultural drainage. Loadings in these constituents would be reduced through source control and treatment.

In general, improvements in water quality would benefit Delta habitats and associated plant and wildlife species. Implementation of best management practices (BMPs) for application of insecticides could reduce drift to adjacent habitats. (BMPs are described in the Water Quality Program Plan.) Reduction of insecticide drift could increase the availability of prey for species that feed on invertebrates and could reduce the likelihood for bioaccumulation of compounds in the food web. Reduction in loadings of organic and inorganic constituents in the aquatic ecosystem would reduce bioaccumulation of these compounds in the Delta's food web and, consequently, in wildlife that feed directly on aquatic organisms or on terrestrial organisms that feed on aquatic species.

Actions to improve water quality may require changes in agricultural practices (for example, changes in cropping patterns), relocation or construction of new facilities, or reduction in agricultural drainage. Changes in agricultural practices could result in a loss of habitat for some wildlife, including special-status species, that use agricultural lands (for example, wintering waterfowl) if such changes reduce the amount or availability of forage on affected lands. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate this potentially significant impact to a less-than-significant level.

Measures that may result in ground disturbance, such as relocating water intakes, could cause localized and temporary disturbances to habitats and associated vegetation and wildlife, including special-status species, in some locations. These impacts are considered potentially significant and can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). The reduction in selenium loadings to the Delta from agricultural drainage that would be achieved through increased water use efficiency could result in localized loss of wetland or riparian habitat areas that depend on existing drainage practices (see discussion below for "Water Use Efficiency Program").

Levee System Integrity Program

Implementation of the Levee System Integrity Program would provide long-term protection of existing wetland, riparian, and upland habitats, as well as agricultural lands with high wildlife habitat value, from flooding that could result from levee failures. The program also would protect habitats enhanced or restored on Delta islands under the Ecosystem Restoration Program from levee failure. The quantity of wildlife habitat associated with existing levees could be increased, and adverse effects of the program on vegetation and wildlife resources could be reduced, where upgraded levees are engineered to allow establishment of wetland and riparian habitats.

Depending on specific project design, levee land bases and heights may be increased. Increasing the land bases of levees, including setting back levees, could remove up to 35,000 acres of agricultural land and some grassland and wetlands adjacent to existing levees. Temporary and permanent losses of levee and adjacent habitats would reduce available habitat for associated plant and wildlife species, including special-status species and wintering waterfowl. Wetland and riparian habitats, however, are expected to be naturally reestablished along the waterside of levee setbacks. The overall benefits of increasing wetland and riparian habitat that is associated with construction of setback levees, in conjunction with implementing proposed mitigation strategies (Section 6.2.11, "Mitigation Strategies"), are expected to reduce these potentially significant impacts to a less-than-significant level.

Depending on the type of levee upgrade design, implementation of the program also could result in temporary or permanent fragmentation of existing riparian corridors that provide cover for some species during migration or local movements. Some long-term activities that are associated with maintaining upgraded levees (for example, periodic control of vegetation) also could result in impacts on levee habitats and associated plants and wildlife, including special-status species. Construction- and levee management-related activities also could result in temporary disturbance to or mortality of special-status species that may be present or near where program actions are implemented. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate these potentially significant impacts to a less-than-significant level.

Water Use Efficiency Program

The Water Use Efficiency Program could result in increased quantity or quality of wetland and riparian habitats, and would benefit associated plant and wildlife species if water saved under the program is allocated to environmental uses (for example, restoration of wetlands). In some instances, tailwater return systems would be built as an efficiency measure. Tailwater ponds included in the return systems can be designed to incorporate beneficial habitat areas (for example, fresh emergent wetlands). Implementation of the Water Use Efficiency Program also could lessen adverse impacts that are associated with constructing and operating new storage facilities, if the amount of water conserved under the program results in reducing the amount of new storage capacity that is needed to meet water supply objectives.

Adverse impacts of the program would be associated with measures to increase the efficiency of water used for agriculture. Generally, efficiency measures could result in temporary losses or degradation of wetland and riparian communities (for example, from land grading and construction activities adjacent to habitat areas). Construction-related activities also could result in disturbance to special-status species present or near where program actions are implemented. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate these potentially significant impacts to a less-than-significant level.

Increasing water use efficiency also could result in permanent losses of natural habitats (for example, from reduced or lost flows to habitats, including on-farm flows and flows in district-level delivery canals). Increasing irrigation and drainage efficiencies, for example, could result in less water available to incidental habitats that depend on existing inefficiencies. Incidental habitats include wetlands at the end of a field, or riparian vegetation in a drainage ditch or channel. Many seasonal wetlands, riparian corridors, and other habitats have developed as a result of water losses leaving a field and traveling to another field or to a surface stream or drain. Locally, these habitat areas can provide significant habitat value; and their loss could adversely affect wildlife, including special-status species, that depend on them. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate these potentially significant impacts to a less-than-significant level.

The area of agricultural lands that provides relatively high wildlife habitat value could be reduced in some years if cropland is fallowed or could be permanently lost if cropland that provides relatively high wildlife values is converted to produce crops that provide lower wildlife values. Changes in cropping patterns, depending on the location and types of cropland that would be affected, could result in a reduction in the quantity or quality of forage for wintering waterfowl, Swainson's hawks, and greater sandhill cranes. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate this potentially significant impact to a less-than-significant level.

Water Transfer Program

The Water Transfer Program would not generate new sources of water but would provide the mechanisms necessary to reallocate water among uses and users, including beneficial uses for wildlife and their habitats. Transfers of water for environmental uses could include water necessary to enhance or restore wetland and riparian habitats, which could improve the quantity and quality of habitat available for associated plants and wildlife, including special-status species—especially if the transfer is directed at such needs (for example, water transferred to state or federal wildlife refuges). Some transfers of water could locally reduce the availability of wetland, riparian, and other habitats for some species, including special-status species (for example, transfer of irrigation water used to farm crops with high wildlife forage value). Impacts on vegetation and wildlife could be less than significant or potentially significant, depending on the species or communities that are affected by a particular water transfer. Potentially significant impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). Actions in the Water Transfer Program, in conjunction with existing legal requirements placed on water transfers, will protect against potentially significant adverse impacts on vegetation and wildlife resources (see Chapter 4 in the Water Transfer Program Plan).

Watershed Program

The watershed areas in the Delta encompass the entire drainage basin of the Sacramento River and San Joaquin River watersheds. Therefore, the upper watershed areas for the Delta Region are discussed under the Sacramento River and San Joaquin River Regions. Implementation of the Watershed Program is not expected to adversely affect vegetation and wildlife resources in the Delta Region. Many of the proposed activities are expected to improve water quality and flows in the watershed areas, and could improve water quality in the Delta. Improvements in water quality could benefit Delta habitats and associated plant and wildlife species, including special-status species, if contaminant loadings are sufficiently reduced.

Construction activities associated with the Watershed Program could result in potentially significant adverse impacts through disturbance of existing biological communities, mobilization of sediments, and input of contaminants. These impacts can be mitigated to a less-than-significant level.

Storage

If an in-Delta storage facility is constructed on one or more Delta islands, up to approximately 15,000 acres of open-water habitat of varying depth would be created, increasing the quantity of open-water habitat area in the Delta for associated wildlife. Seasonal wetland and mudflat habitats also could develop in the facility during reservoir drawdown periods, which could provide temporary foraging habitat for shorebirds, waterfowl, and other water birds.

A storage facility and its water diversion and conveyance components would permanently remove approximately 15,000 acres of primarily agricultural habitat and could remove or disturb existing emergent wetland, riparian, and grassland and ruderal habitat on affected islands. Specific affected acreages of natural communities would depend on the size and location of the storage facility and its water diversion and conveyance components. Inundation of various habitats and removal of associated habitat values are considered potentially significant impacts. These impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

In-Delta storage could potentially cause seepage to adjacent properties that could saturate soils and change vegetation composition if occurring on natural vegetation types. This potentially significant impact can be mitigated to a less-than-significant level (see Section 5.4, "Groundwater Resources").

Construction of storage facilities could result in potentially significant impacts on special-status plants and animals as a result of construction-related activities and inundation of existing occupied habitats. For most species, these impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). General mitigation strategies include avoidance of temporary or permanent impacts on special-status species (Section 6.2.11, "Mitigation Strategies"). The MSCS includes a more detailed and specific conservation measure that requires avoiding implementing actions, including construction of storage facilities, that could result in the mortality of certain specified special-status species. These species are characterized by populations that are rare and/or localized such that loss of individuals of these species could substantially diminish the species viability. Consequently, for species addressed by this conservation measure in the MSCS, these potentially significant impacts would be reduced to a less-than-significant level through avoidance.

Depending on where storage facilities are located and specific project design, avoiding impacts on rare natural communities and significant natural areas may not be feasible. Site-specific evaluations of potential storage facilities will be coordinated through CALFED's Integrated Storage Investigation. Because of this uncertainty, this document concludes that some storage sites could result in significant unavoidable impacts on rare natural communities and significant natural areas.

6.2.7.2 BAY REGION

Ecosystem Restoration Program

Ecosystem Restoration Program actions proposed for the Bay Region that could affect vegetation and wildlife resources are summarized in the Ecosystem Restoration Program Plan (Volumes 1, 2, and 3). The Ecosystem Restoration Program could result in a net increase in the following natural plant community types: shallow tidal perennial aquatic habitat, tidally influenced saline and brackish emergent wetland, tidally influenced sloughs and deep open-water areas adjacent to nontidal wetlands, seasonal wetlands, riparian scrub, and perennial grassland. The Ecosystem Restoration Program also would enhance existing, degraded, and seasonal wetlands, including vernal pools.

Implementation of the program would result in the loss of agricultural lands and conversion of existing diked nontidal saline and brackish emergent wetlands to tidal saline and brackish emergent wetlands. Saline emergent wetland communities and associated wildlife, however, would benefit from reestablishment of tidal flows to historical saline emergent wetland areas. An unpredictable quantity of tidal flats also could be associated with restoration of saline emergent wetlands. Some existing wetland, riparian, and grassland habitats could be lost or converted to open water or other natural plant communities. The types and significance of impacts on vegetation and wildlife resources in the Bay Region, including special-status species, resulting from implementation of the program would be similar to those described for the Delta Region. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate the potentially significant impacts on vegetation and wildlife that are associated with implementing the Ecosystem Restoration Program in the Bay Region to a less-than-significant level.

Water Quality Program

The types and significance of impacts on vegetation and wildlife resources from implementing the Water Quality Program in the Bay Region would be similar to those described for the Delta Region. Potentially significant impacts on vegetation and wildlife that are associated with implementing the Water Quality Program in the Bay Region can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Levee System Integrity Program

The Levee System Integrity Program could result in improving and providing long-term maintenance on approximately 155 miles of existing levees in the Suisun Marsh to reduce the potential for levee failures. Activities to rehabilitate levees could disturb an estimated 300-750 acres of natural and agricultural habitat. The types and significance of impacts on vegetation and wildlife resources from implementing the Levee System Integrity Program in the Bay Region would be similar to those described for the Delta Region. The potentially significant impacts on vegetation and wildlife that are associated with implementing the

Levee System Integrity Program in the Bay Region can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

The Levee System Integrity Program would directly affect vegetation and wildlife resources only in the Delta and Bay Regions and is not discussed further in the region-specific discussions that follow.

Water Use Efficiency and Water Transfer Programs

The types and significance of impacts on vegetation and wildlife resources from implementing the Water Use Efficiency and Water Transfer Programs in the Bay Region would be similar to those described for the Delta Region. Potentially significant impacts on vegetation and wildlife that are associated with implementing the Water Use Efficiency Program in the Bay Region can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Water transfers would affect water quality primarily through changes to river flow and water temperatures. In addition, the source of water for a transfer and the timing, magnitude, and pathway of each transfer would determine the potential for significant impacts. Potential beneficial water quality impacts are a function of the ability of a transfer to decrease the concentration of various contaminants through both increased streamflow and the potential for obtaining higher quality water from several sources. Because specific transfers can invoke both beneficial and adverse impacts, at times on the same resource, net effects must be considered on a case-by-case basis. Nevertheless, actions in the Water Transfer Program, in conjunction with existing legal requirements placed on water transfers, will protect against potentially significant adverse impacts on vegetation and wildlife resources (see Chapter 4 in the Water Transfer Program Plan).

Watershed Program

The types and significance of impacts on vegetation and wildlife resources from implementing the Watershed Program in the Bay Region would be similar to those described below for the Sacramento River and San Joaquin River Regions, but to a lesser degree. The potentially significant impacts on vegetation and wildlife that are associated with implementing the Watershed Program in the Bay Region can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). As described for the Delta Region, improvements in water quality resulting from implementation of the Watershed Program in the Sacramento River and San Joaquin River Regions also could benefit wetland and aquatic habitats and associated species, including special-status species, in the Bay Region if contaminant loadings are sufficiently reduced.

Impacts from construction activities associated with the Watershed Program would be similar to those described for the Delta Region. These impacts can be mitigated to a less-than-significant level.

Storage

No storage facilities are proposed in the Bay Region; therefore, no impacts on vegetation and wildlife that are associated with the Storage element are anticipated in the region.

6.2.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration Program

Ecosystem Restoration Program actions proposed for the Sacramento River and San Joaquin River Regions that could affect vegetation and wildlife resources are summarized in the Ecosystem Restoration Program Plan (Volumes 1, 2, and 3).

The primary objective of the Ecosystem Restoration Program in the Sacramento River and San Joaquin River Regions is to improve ecological processes and habitat conditions that are critical to sustaining and improving anadromous fish populations. Proposed program activities include restoring and protecting stream meander belts; maintaining or improving the floodwater and sediment detention and retention capacity of important hydrologic basins; restoring floodplain processes, such as overbank flooding of floodplains and stream channel migration; and restoring, enhancing, or protecting riparian vegetation to provide shaded riverine aquatic cover. Partial restoration of the ecological processes that sustain healthy riverine ecosystems on affected streams would result in more natural patterns of stream channel migration, bank erosion, and overbank flooding that are important factors in maintaining healthy riparian and other associated floodplain habitats.

Implementation of the Ecosystem Restoration Program could increase the area of open-water and wetland communities that are associated with stream courses and flood basins. Actions that restore channel meander could result in the creation of oxbow lakes in future years as channels migrate across their floodplains. Increasing the area over which floodwaters are detained, the amount of floodwater detained, or the frequency of floodwater detention in overflow basins could increase the area of seasonal wetland and open-water habitats.

Implementation of the program also would enhance existing seasonal wetlands and the wildlife values that are associated with agricultural lands through cooperative programs with landowners. These actions could improve the quantity and availability of forage for species such as wintering waterfowl, greater sandhill cranes, and shorebirds that use seasonal wetlands and agricultural lands in the Central Valley.

The Ecosystem Restoration Program would result in the direct and/or indirect protection, enhancement, and restoration of riparian and associated floodplain habitats along the San Joaquin and Sacramento Rivers and their major tributaries, including habitat areas occupied by the riparian brush rabbit along the Stanislaus River. Implementation of the program is expected to result in substantial increases in the quantity and quality of riparian habitats, and in increased connectivity among existing fragmented riparian habitat areas that are associated with the San Joaquin and Sacramento Rivers and their major tributaries.

Restoration of floodplain habitats could result in the loss of agricultural lands adjacent to streams and rivers, potentially reducing foraging habitat area for wintering waterfowl and associated special-status wildlife species. This impact is considered potentially significant and can be mitigated to a less-than-significant level with implementation of program actions that enhance forage values on agricultural lands and implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

A relatively small area of wetland and riparian communities could be temporarily or permanently affected by floodplain habitat improvements, depending on the type of improvement actions that are implemented. Types of actions that could beneficially or adversely affect these communities include levee setbacks, modification of levee maintenance practices to increase the area and quality of riparian vegetation, modification of stream flows, and exclusion of livestock from stream channels and adjacent banks. Implementation of the Ecosystem Restoration Program, however, is expected to result in an overall increase in the quality and quantity of these communities. These potentially significant impacts can be mitigated to a less-than-significant level with implementation of program actions that restore or enhance wetland and riparian communities and implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Construction- and habitat management-related activities that are associated with implementing the program could result in temporary disturbance to, or mortality of, special-status species that are present or near where program actions are implemented. These potentially significant impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Water Quality Program

The types and significance of impacts on vegetation and wildlife resources in the Sacramento River and San Joaquin River Regions from implementing the Water Quality Program would be similar to those described for the Delta Region. Agricultural land conversion in the San Joaquin River Region is included as a potential measure to improve water quality by reducing discharges from drainage lands with selenium problems. Program policies do not include conversion of land uses to reduce water demands. However, depending on water supply and water transfer opportunities available under the various alternatives, farmers may choose to change cropping patterns, temporarily fallow land, or permanently remove land from agricultural production. The types and significance of impacts on vegetation and wildlife resources in the Sacramento River and San Joaquin River Regions from conversion of cropland would be similar to those identified for the Water Use Efficiency and Water Transfer Programs in the Delta Region. Potentially significant impacts on vegetation and wildlife associated with implementing the Water Quality Program in the Sacramento River and San Joaquin River Regions can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Water Use Efficiency and Water Transfer Programs

The types and significance of impacts on vegetation and wildlife resources in the Sacramento River and San Joaquin River Regions from implementing the Water Use Efficiency and Water Transfer Programs would be similar to those described for the Delta Region. Potentially significant impacts on vegetation and wildlife in the Sacramento River and San Joaquin River Regions that are associated with implementing the Water Use Efficiency and Water Transfer Programs can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Watershed Program

A conceptual description of the types of watershed activities that might take place and their potential impacts follows. Impacts are characterized as local (those occurring in the general vicinity of project construction) and regional (those extending beyond the immediate project area).

Habitat enhancement and restoration activities undertaken as part of the Watershed Program would restore or improve habitat types—such as oak woodland, wetland, or riparian habitat—or improve specific habitat values targeted at specific plant or wildlife species, including special-status species. Temporary impacts on vegetation and wildlife resources could include displacement of resident species, local erosion and siltation of nearby streams and waterways, and disturbance of resident species as a result of construction activities. These impacts could be less than significant or potentially significant, depending on the species or communities that are affected by habitat restoration. Potentially significant impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Permanent impacts on vegetation and wildlife that are associated with habitat restoration could include the loss of occupied special-status species habitat as a result of converting an existing habitat to a different habitat type. This potentially significant impact can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

The types of beneficial impacts could include, but would not be limited to, improved habitat for target species populations; increased habitat diversity in the region; and an increase in the quality or quantity of limiting factors, such as nesting or feeding habitat for target species. These effects may occur locally, such as improved feeding areas for deer; or may extend outside the region if the restoration would affect migratory species, such as improved habitat for neotropical migratory birds.

Improving wastewater and stormwater treatment, controlling mine waste, implementing erosion control, and improving forest and land use management practices would result in improved water quality conditions in streams and reservoirs. Some activities, such as land use management, may increase stream flows and would directly benefit riparian vegetation. These water quality and quantity changes also may benefit vegetation and wildlife in downstream areas. Potentially significant adverse impacts could include temporary disturbances to wildlife, temporary erosion and siltation, and temporary losses of vegetation as a result of construction activities. Implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies") can mitigate these potentially significant impacts to a less-than-significant level.

Structural watershed improvement activities might include improved maintenance of roadways; removal of old roadways; installation of erosion control structures; and channel improvements, such as realignment, bank stabilization, and revegetation. Removal of roadways would increase natural vegetation and associated wildlife, and would minimize access, thereby reducing human disturbance to wildlife resources. Depending on the location and type of action implemented, these activities could result in temporary or permanent losses of natural habitats, including rare natural communities and significant natural areas, and construction-related disturbance to special-status species. Where improvements are implemented in areas already heavily disturbed, it is anticipated that these actions would result in little or no permanent impact on vegetation and wildlife resources. Temporary impacts on vegetation and wildlife also could include increased erosion and siltation during construction. These temporary and permanent impacts on vegetation and wildlife could be less than significant or potentially significant, depending on the species or communities that are affected by a particular program action. Potentially significant impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Storage

Surface storage reservoirs and associated facilities (for example, conveyance facilities to and from off-stream storage facilities) could inundate up to an estimated 16,600 acres in the San Joaquin Valley and up to 32,000 acres in the Sacramento Valley. Surface storage could be increased by either enlarging existing reservoirs or constructing new off-stream storage facilities. Off-aqueduct storage reservoirs and associated facilities also could be constructed in the San Joaquin Valley. Creation of storage pools would increase the availability of habitat for wildlife that use lake habitats and reduce habitat for plant and wildlife species that use the habitats that would be inundated. Habitats most likely to be affected by increasing surface storage capacity include wetland, riparian, annual grassland, chaparral, woodland, and forest communities. The actual areas and habitat types that would be affected by construction of off-aqueduct storage facilities depends on the siting, design, and operations of facilities. Increase in storage capacity also may make more water available for Ecosystem Restoration Program actions.

Construction of storage facilities would inundate various habitats, such as wetlands, riparian, annual grasslands, chaparral, woodland, and forest communities. These impacts are considered potentially significant and can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). If off-stream and off-aqueduct reservoirs are located in watersheds that support riparian vegetation, reservoirs also could lead to the loss or degradation of riparian habitat downstream of the reservoirs as a result of sediment supply interruption to the stream channel and alteration of stream hydrology. Habitat values of lands adjacent to surface storage reservoirs could be degraded for some wildlife species if public access and levels of recreation substantially increase as a result. These potentially significant impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Construction of off-stream and off-aqueduct storage facilities could potentially fragment riparian corridors and disrupt historical movement patterns of some wildlife. This impact is considered potentially significant and unavoidable. Construction of storage facilities also could result in potentially significant impacts on some special-status plants and animals, rare natural communities, and significant natural areas. For most species and communities, these impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). Avoidance of temporary or permanent impacts on special-status species, rare natural communities, and significant natural areas are included as general mitigation strategies (Section 6.2.11, "Mitigation Strategies"). The MSCS includes a more detailed and specific conservation measure that requires avoiding implementing actions, including construction of storage facilities, that could result in the mortality of certain specified special-status species. These species are characterized by populations that are rare and/or localized such that loss of individuals of these species could substantially diminish species viability. Consequently, for species addressed by this MSCS conservation measure, these potentially significant impacts would be reduced to a less-than-significant level through avoidance.

Depending on where storage facilities are located and specific project design, it may not be feasible to avoid impacts on rare natural communities and significant natural areas. Site-specific information will be determined through the ongoing Integrated Storage Investigation. Because of the uncertainty that is inherent for the current programmatic analysis, this document concludes that some reservoir sites under consideration could result in potentially significant unavoidable impacts on rare natural communities and significant natural areas if these areas are not avoided.

If groundwater storage is achieved by percolating water through water-spreading grounds, construction of water-spreading grounds and associated facilities could result in the temporary or permanent loss of annual grassland and agricultural habitat types, assuming that they are constructed in lowland areas in the San Joaquin and Sacramento Valleys. The actual habitat area and habitat types that would be affected by construction and operation of groundwater recharge facilities depend on the siting, design, and operations of the facilities. Impacts on vegetation and wildlife in the Sacramento River and San Joaquin River Regions could be less than significant or potentially significant, depending on the species or communities that are affected by a recharge facility. Potentially significant impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Shallow open-water habitat could be created when surface water is retained on spreading grounds. Mudflats and bare ground could be created as surface water is drawn down. To maintain percolation efficiency, however, spreading grounds likely would be maintained devoid of vegetation. Exposed mudflats could provide suitable foraging habitat for shorebirds but likely would provide only low forage and cover values for other wildlife that typically are associated with wetlands.

Changes in project operations are not anticipated to adversely affect vegetation and wildlife resources in the Sacramento River or San Joaquin River Region. Flows and timing of flows may be changed in the Sacramento River and Feather River as a result of reservoir release changes made in response to operations changes at the water export pumps in the Delta. These changes are not expected to adversely affect vegetation and wildlife and, therefore, are considered less than significant. Variations in water storage levels at San Luis Reservoir may occur due to changes in the amounts of water exported at the pumping plants, but these changes are not expected to adversely affect vegetation and wildlife resources.

6.2.7.4 Other SWP and CVP Service Areas

All Programs

Less-than-significant impacts on vegetation and wildlife resources in the Other SWP and CVP Service Areas are anticipated. For example, as discussed for the other Program regions, implementation of the Water Use Efficiency Program could result in decreases of wetlands or riparian areas that are associated with return flows. Changes in urban or rural landscaping could result from changes in water use patterns. Mitigation strategies are available to reduce impacts to a less-than-significant level. Future site-specific environmental documentation will be required as site-specific project actions are identified.

6.2.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For vegetation and wildlife resources, the Conveyance element results in environmental consequences that vary among the alternatives, as described below. These consequences affect only the Delta Region.

6.2.8.1 Preferred Program Alternative

This section includes a description of the consequences of a diversion facility on the Sacramento River. If the diversion facility is not built, these consequences would not occur.

South Delta modifications could result in the temporary or permanent loss of an estimated 100-700 acres of wetland, riparian, grassland, ruderal, and agricultural habitats. Loss of wetland and riparian habitat is considered a potentially significant impact. This impact can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). The potential loss of a relatively small areas of grassland, ruderal, and agricultural habitats is considered less than significant. The flow and stage control facilities would disrupt tidal flow sufficiently to result in the loss of tidal wetlands or cause a change in the plant species composition of wetlands upstream of the barrier. Construction-related activities and operation of barriers also could result in disturbance to or mortality of special-status species and loss or degradation of their habitats. These impacts are considered potentially significant and can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Conveyance capacity in the Old River and other Delta channels could be increased through channel dredging or construction of levee setbacks. Dredged materials will be analyzed, dredged, and handled in accordance with permit requirements. Permits will incorporate mitigation strategies identified in Section 5.3.11 to prevent release of contaminants of concern.

Construction of setback levees could result in the loss of wetland, riparian, and grassland and ruderal habitats, if existing levees are removed; and would result in the loss of agricultural habitats. Construction-related activities also could result in disturbance to or mortality of special-status species and loss or degradation of their habitats. Impacts on riparian, wetland, and agricultural habitats and on special-status species are considered potentially significant. These impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). The potential loss of grassland and ruderal habitats is considered a less-than-significant impact. The types and amount of habitat area that would be affected depend on the location and design of levee setbacks. The quantity of wildlife habitat associated with setback levees could be increased, and the adverse impacts that are associated with constructing levee setbacks on vegetation and wildlife resources could be reduced—if setback levees are engineered during project design to allow the establishment of wetland and riparian habitat.

Dredging Old River and other Delta channels could affect riparian and emergent wetland vegetation. Dredged material would be disposed of on agricultural lands, beneficially reused for levee improvements, used for shallow-water habitat restoration, or disposed of by other methods available that meet regulation requirements. If dredged material is assumed to be held on agricultural lands for 2 years for draining and settling, affected agricultural habitats could be temporarily lost until those lands were returned to production after removal of the dredged material. These impacts are considered less than significant. To the extent that dredging reduces the amount of land that setback levees require, dredging could result in a lesser impact. Dredging would not provide opportunities for habitat creation that setback levees may offer. Beneficial and adverse impacts that are associated with levee improvements and creation of shallow-water habitat are discussed in Section 6.2.7.1.

Dredging may mobilize contamination to the detriment of riparian and wetland vegetation and individual organisms. Effects of contaminants associated with dredging are considered potentially significant. Mitigation strategies described in Section 5.3 would reduce this impact to a less-than-significant level.

Improvements to the CVP and SWP include construction of an intertie between the Tracy Pumping Plant and CCFB. Construction of the intertie could result in the permanent loss of wetland, riparian, grassland and ruderal, and agricultural habitat areas. Construction-related activities also could result in disturbance to or mortality of special-status species and loss or degradation of their habitats. Impacts on riparian, wetland, and agricultural habitats and on special-status species are considered potentially significant but can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). The potential loss of grassland and ruderal habitats is considered less than significant. The types and amounts of habitats that would be affected depend on the location and design of the intertie.

Construction of a diversion facility on the Sacramento River could remove or disturb wetland, riparian, grassland and ruderal, and agricultural habitat areas. The type and amount of habitat affected would depend on facility design and location. Construction-related activities could result in disturbance to or mortality of special-status species or loss or degradation of their habitats. Impacts on riparian and wetland habitat and on special-status species are considered potentially significant. These impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). A relatively small area of grassland, ruderal, and agricultural habitat is likely to be affect; therefore, potential impacts on these habitats are considered less than significant.

The conveyance capacity of channels along the southwestern portion of Glanville Tract and along McCormack-Williamson Tract would be increased through dredging channels or constructing levee setbacks. Effects of dredging would be similar to those described for enlarging the channel capacity in the Old River. Constructing setback levees would remove and disturb wetland, riparian, agricultural, and grassland and ruderal habitat, and could result in the temporary or permanent loss of up to approximately 1,800-2,000 acres of habitat. Constructing the setback levees, however, could create approximately 1,900-2,100 acres of open-water, wetland, riparian, and grassland habitats. Construction-related activities could result in disturbance to or mortality of special-status species or loss or degradation of their habitats. Impacts on riparian and wetland habitat and on special-status species are considered potentially significant. These impacts can be mitigated to a less-than-significant level with construction of setback levees and implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). Although wetland and riparian plant communities would be created, the diversion facility nevertheless would result in a net loss of agricultural habitat that supports wintering wildlife. This potentially significant impact can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

North Delta channel modifications could include enlarging channel capacity through dredging or constructing setback levees. Effects of dredging would be similar to those described for enlarging the channel capacity in the Old River. Setback levees along the North Mokelumne River from I-5 to the San Joaquin River could result in the loss of an estimated 1,000-1,200 acres of agricultural habitat area. The loss of agricultural foraging habitat is considered potentially significant and can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). Some acreage of existing wetland, riparian, and grassland and ruderal habitat also could be temporarily lost or disturbed in locations where levees are breached. Setting back the levees would create approximately 1,200-1,400 acres of habitat that would include open-water and emergent wetland habitats; and would create riparian scrub and woodland along the levees, and grassland and ruderal vegetation on levee slopes. The created acreage of wetland and riparian plant communities is expected to exceed the affected existing acreage. Construction-related activities could result in disturbance to or mortality of special-status species or loss or degradation of their habitats. Impacts on riparian and wetland habitat and on special-status species are considered potentially significant. These impacts can be mitigated to a less-than-significant level with construction of setback levees and implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

Changes in project operations are not anticipated to adversely affect vegetation and wildlife resources in any Program region. Flows and timing of flows may be changed within Delta waterways due to changes in pumping patterns at the export pumps, but these changes are not expected to adversely affect vegetation and wildlife under any alternative. This topic is not discussed again for the Program alternatives.

6.2.8.2 ALTERNATIVE 1

Impacts that are associated with south Delta modifications would be the same as those described for the Preferred Program Alternative. Beneficial and adverse impacts that are associated with levee setbacks or dredging are the same as those discussed for the Preferred Program Alternative.

Other north Delta improvements to conveyance capacity described for the Preferred Program Alternative would not occur. Therefore, the beneficial and adverse effects of channel dredging and levee setbacks would not occur. About 4,000-5,500 acres of habitat (primarily agricultural lands) affected by the Preferred Program Alternative would be affected under Alternative 1. About 3,500 acres of created open-water, wetland, riparian, and grassland habitat under the Preferred Program Alternative would not be realized under Alternative 1.

Impacts that are associated with the diversion facility on the Sacramento River would not occur under Alternative 1.

6.2.8.3 ALTERNATIVE 2

Conveyance improvements would result in the same impacts on vegetation and wildlife resources as those described for the Preferred Program Alternative. The increased capacity of a new diversion facility compared to the Preferred Program Alternative would not result in additional potentially significant impacts because it is assumed that the construction/operational footprint would be the same for canal capacities under this alternative.

6.2.8.4 ALTERNATIVE 3

Most conveyance improvements would result in the same impacts as those described for the Preferred Program Alternative, except that the diversion facility from the Sacramento River to the Mokelumne River and improvement of channel conveyance downstream to the San Joaquin River would not occur. Beneficial and adverse effects of channel dredging and levee setbacks on the Mokelumne River described for the Preferred Program Alternative would not occur.

In addition to conveyance improvements discussed for the Preferred Program Alternative, an isolated open-channel facility would be constructed along the east side of the Delta. Construction of the isolated conveyance facility could remove and disturb an estimated 100-200 acres of wetland, riparian, and grassland and ruderal habitats; and could result in the loss of an estimated 700-900 acres of agricultural habitat. The loss of agricultural foraging habitat is considered potentially significant and can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). Permanent direct impacts on large riparian areas and associated wetlands at major stream crossings would be avoided by properly designed siphons, but construction of the siphons could result in temporary impacts on riparian and wetland habitats and associated wildlife. Construction-related activities also could result in disturbance to or mortality of special-status species and loss or degradation of their habitats. Impacts on riparian and wetland habitat and on special-status species are considered potentially significant. These impacts can be mitigated to a less-than-significant level with construction of setback levees and implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies").

6.2.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents the comparison of the Preferred Program Alternative and Alternatives 1, 2, and 3. This programmatic analysis found that the potentially beneficial and potentially significant adverse impacts from implementing any of the Program alternatives when compared to existing conditions were the same impacts as those identified in Sections 6.2.7 and 6.2.8, which compare the Program alternatives to the No Action Alternative.

The analysis indicates that an overall benefit to vegetation and wildlife resources would result when the Program alternatives are compared to existing conditions.

At the programmatic level, the comparison of the Program alternatives to the existing conditions did not identify any additional potentially significant environmental consequences than were identified in the comparison of Program alternatives to the No Action Alternative.

The following potentially significant impacts are associated with the Preferred Program Alternative:

- Temporary or permanent loss or degradation of wetland and riparian communities.
- Substantial temporary or permanent loss or disturbance of wintering waterfowl habitat.
- Substantial decrease in important upland wildlife habitat use areas.
- **Temporary or permanent fragmentation of riparian habitats and/or wildlife movement corridors.**
- Temporary or permanent loss of habitat or direct impacts on special-status species.
- **Loss or degradation of portions of rare natural communities and significant natural areas.**
- Temporary disturbance or mortality of special-status species due to construction and habitat management activities.
- Permanent loss of incidental wetland and riparian habitats that depend on agricultural inefficiencies.
- Reduction in quantity or quality of forage for species of concern.

Bold indicates a potentially significant unavoidable impact.

6.2.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. This section identifies where Program actions could contribute to potentially significant adverse cumulative impacts. In doing so, those potentially significant adverse cumulative impacts for which the Program's contribution could be avoided or mitigated to a less than cumulatively considerable level are identified. If identified in the analysis, this section also presents any potentially significant adverse cumulative impacts that remain unavoidable regardless of efforts to avoid, reduce, or mitigate them. Refer to Chapter 3 for a summary of cumulative impacts. Refer to Attachment A for a list and description of the projects and programs considered in concert with the Preferred Program Alternative in this cumulative analysis.

For vegetation and wildlife resources, the analysis and conclusions regarding the significance of the Preferred Program Alternative's contribution to cumulative impacts are essentially the same as the analysis and conclusions regarding the Preferred Program Alternative's long-term impacts. This is partially due to the long-term nature of the Program and the wide range of actions that falls within the scope of the Program's potential future actions. Section 6.2.1 lists in summary form the potentially significant adverse long-term impacts and the mitigation strategies that can be used to avoid, reduce, or mitigate them. At the programmatic level of analysis, the impacts that cannot be avoided, reduced, or mitigated to a less-than-significant level are noted on the list in **bold type**. Sections 6.2.7 and 6.2.8 elaborate on long-term impacts.

The impact of the Preferred Program Alternative, when added to the potential impacts of the following projects, would result in potentially significant adverse cumulative impacts on vegetation and wildlife resources in the Delta, Bay, Sacramento River, and San Joaquin River Regions: American River Watershed Project, American River Water Resource Investigation, CVPIA Anadromous Fish Restoration Program and other CVPIA actions not yet fully implemented, Delta Wetlands Project, Pardee Reservoir Enlargement Project, Sacramento Water Forum Process, Supplemental Water Supply Project, Sacramento County Municipal and Industrial Water Supply Contracts, and urbanization. At the programmatic level of analysis, most of the CALFED Program's contribution to cumulative impacts resulting from environmental consequences listed in Section 6.2.1 is expected to be avoided, reduced, or mitigated to a less than cumulatively considerable level. The exceptions are the temporary or permanent fragmentation of riparian habitats and/or wildlife movement corridors that is associated with surface storage in the Sacramento River and San Joaquin River Regions and the loss or degradation of portions of rare natural communities and significant natural areas (as discussed in Section 6.2.12). At the programmatic level of analysis, it is not anticipated that the CALFED Program's contribution to these cumulative impacts can be avoided, reduced, or mitigated to a less than cumulatively considerable level. Therefore, this analysis concludes that these impacts are cumulatively significant and unavoidable. This conclusion is based on currently available information and the high level of uncertainty as to whether these impacts can be avoided, mitigated, or reduced to a level that is less than cumulatively considerable.

Growth-Inducing Impacts. See Section 5.1.10 for a general discussion of the Program's potential to induce growth. Population growth could lead to increased urban and industrial development and contribute to losses of important habitats, such as coastal sage scrub, riparian vegetation, and wetlands. Increased contaminant inputs and increased human-caused disturbance from population growth also could result in the loss or degradation of habitats. The nature and extent of these impacts would depend on the type and location of growth and on how it is managed.

Short- and Long-Term Relationships. Construction activities would cause some unavoidable short-term adverse impacts on vegetation and wildlife resources in local areas. However, their adverse effects would be mitigated to the maximum extent possible. Mitigation would be accomplished through minimization of adverse effects; containment of impacts; application of best on-site land, vegetation, habitat, and wildlife management practices during construction; and off-site development of comparable resources to at least an equivalent level. Adaptive management would be used to measure and readjust actions implemented to provide for long-term productivity. The overall benefits to the long-term productivity of vegetation and wildlife generally would outweigh short-term adverse impacts. If the reverse were true, the proposed action would be eliminated from consideration during screening.

Production of long-term ecological benefits is a primary objective of the Ecosystem Restoration Program. During implementation of the Ecosystem Restoration Program Plan, design principles and criteria that would affect vegetation, habitat, and wildlife resources or their resources would be selected on the basis of their ability to avoid short-term adverse impacts and to enhance and maintain long-term productivity. The vision for the program is that important water-dependent vegetation and habitat resources in the state be restored to conditions approaching their historically rich levels of biological productivity in targeted areas.

Selection of design principles and criteria for all Program elements would be based in part on their ability to avoid short-term adverse impacts, and to enhance and maintain long-term productivity with respect to vegetation and wildlife resources.

Irreversible and Irretrievable Commitments. Implementation of the Ecosystem Restoration Program would result in some irreversible and irretrievable commitments of existing vegetation, habitats, and wildlife population resources. Short-term direct habitat losses would result from construction activities. Vegetation and habitat conversions included in the Ecosystem Restoration Program design specifications would be difficult, if not impossible, to fully reverse once earth moving and construction had commenced. After the new species, habitats, and ecosystems had become established, it would be even more difficult to restore converted areas to pre-existing conditions. However, restoration activities would not proceed until the designers are confident of the desirability of the results. Moreover, adaptive management would be used during the course of the Program to identify situations that could lead to undesirable or less-than-optimum results. In this way, potential mistakes could be identified early, and plans altered to minimize any unintentional adverse results.

The biologic environment is complex, with many unique inter-relationships about which little is known. Uncertainty is involved in anticipating the effect of Program actions on the ecosystem. Because of the lack of knowledge on how the ecosystem may respond to Program actions, it is possible that restoration actions may fail to achieve the Program objectives. It also is possible that individual projects may cause some negative impacts in achieving their ultimate objective. The adaptive management program is intended to address these uncertainties. Adaptive management is a key component of the Program, as it provides a decision support system for stakeholders and resource managers. Adaptive management addresses risks and uncertainties by increasing opportunities to redirect management with new information. More information on adaptive management can be found in the Phase II Report.

Constructed components of the Water Quality, Levee System Integrity, and Watershed Programs, and the Storage and Conveyance elements could result in irreversible and irretrievable commitments of existing vegetation, habitats, and wildlife population resources. The most pertinent examples would occur in cases where lands and resources are converted to new or increased reservoir storage, levees, or conveyance facilities. Mitigation strategies would be used to reduce the adverse impacts of such commitments to a less-than-significant level.

6.2.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during specific project planning and development. Specific mitigation measures will be adopted, consistent with the Program goals and objectives and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

This section summarizes potential mitigation strategies by impact. Additional conservation measures that could be implemented to offset potential adverse impacts on special-status species are described in the MSCS. Where the Ecosystem Restoration Program would cause adverse impacts, the program would be phased to help mitigate potential adverse impacts resulting from restoration actions. The Ecosystem Restoration Program will not provide mitigation or compensation for the adverse impacts on vegetation and wildlife resources from implementing other Program element actions, or the effects of construction and operation of storage and conveyance facilities. All adverse impacts caused by other programs will need to be mitigated separately.

Potential mitigation strategies include:

- Avoiding direct or indirect disturbances to wetland and riparian communities.
- Restoring or enhancing sufficient in-kind wetland and riparian habitat areas at off-site locations (near project sites) before, or when, project impacts are incurred to offset habitat losses.
- When feasible, designing Program features to permit on-site mitigation of wetland and riparian communities. For example, levee or conveyance improvements could be designed to allow for the establishment and long-term maintenance of wetland or riparian habitat areas.
- Initially implementing Ecosystem Restoration Program habitat restoration (to the extent feasible) to offset temporary habitat losses and to restore sufficient wetland and riparian habitats before, or when, project impacts associated with the program are incurred.
- Restoring wetland and riparian communities temporarily disturbed by construction activities onsite immediately following construction. Types of actions could include planting native plants, controlling non-native plants to improve conditions for the natural reestablishment of native plants, or enhancing or restoring the original site hydrology to allow for the natural reestablishment of the affected plant community.
- Avoiding restoration of wetlands in areas characterized by high concentrations of mercury in sediments.
- Phasing the implementation of modifications to levees that would be necessary to meet PL 84-99 standards over a sufficient period to minimize the effects of fragmentation of riparian habitats and associated wildlife.

- Implementing BMPs, such as avoiding disturbance to highly erodible soils or installing siltation barriers or detention basins, to reduce the potential for siltation of nearby wetlands.

- Maintaining sufficient outflow downstream of constructed off-stream storage reservoirs to maintain existing wetland and riparian communities downstream of reservoirs.

- Restoring or enhancing sufficient waterfowl foraging habitat near existing use areas to offset impacts on the abundance, quality, and availability of waterfowl forage. Types of restoration and enhancement actions could include restoring and managing seasonal wetlands for wintering waterfowl, increasing the area of land farmed to produce crops with high forage value (such as corn or rice), or modifying farming practices to increase forage availability (for example, leaving a portion of forage crops unharvested through winter or shallowly flooding fields).

- Avoiding important wildlife habitat use areas, such as critical deer winter range and fawning habitat.

- Planting and maintaining native species to restore important wildlife habitat use areas temporarily disturbed by on-site construction activities immediately following construction.

- Enhancing or restoring upland habitat areas within affected watersheds or in other watersheds when sufficient habitat for enhancement is unavailable within the affected watershed. This could include modifying existing land management practices (for example, grazing and fire management practices) to improve conditions for the natural reestablishment and long-term maintenance of affected plant communities and habitats.

- Avoiding direct and indirect disturbances to habitat areas occupied by special-status species.

- Avoiding construction or maintenance activities within or near occupied special-status species habitat areas or important wildlife use area when species may be sensitive to disturbance, such as during the breeding season.

- Restoring habitat areas occupied by special-status species that are temporarily disturbed by construction activities onsite immediately following completion of construction.

- Restoring or enhancing suitable habitat areas that are occupied by, or are near and accessible to, special-status species that have been adversely affected by the permanent removal of occupied habitat areas.

- Phasing habitat restoration actions to restore sufficient suitable habitat to minimize the adverse affects of impacts on occupied special-status species habitats before impacts are incurred.

- For species for which relocation or artificial propagation is feasible, establishing additional populations of special-status species adversely affected by the Program in protected suitable habitat areas elsewhere within their historical range.

- Altering agricultural practices to improve habitat conditions for affected special-status species that use agricultural lands. This could include planting and managing crops to increase the availability or quantity of forage for affected species.

- Avoiding direct or indirect disturbances to rare natural communities and significant natural areas.

- Restoring or enhancing disturbed rare natural communities or significant natural areas at off-site locations before, or when, Program actions that could affect these communities are incurred.

- Restoring rare natural communities or significant natural areas at or near affected locations after Program activities are completed.

- Managing recreation-related activities on lands managed under the Program to minimize or avoid potential adverse effects of recreational activities on sensitive habitats, important wildlife use areas, and special-status species.

6.2.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

If off-stream reservoirs are built in the Sacramento River and San Joaquin River Regions, existing riparian habitat corridors on the small or ephemeral tributaries could be permanently fragmented as a result of inundation, potentially blocking the movement and interchange of populations of some wildlife species from upper to lower watershed locations. This impact cannot be mitigated to a less-than-significant level and is considered potentially significant and unavoidable.

If surface water storage facilities are built, potentially significant impacts on rare natural communities and significant natural areas could occur. These impacts may be unavoidable, depending on where storage facilities are located. Site-specific evaluations of potential storage facilities will be coordinated through CALFED's Integrated Storage Investigation. Because of the uncertainty that is inherent for the current programmatic analysis, this document concludes that some reservoir sites under consideration could result in significant unavoidable impacts on these resources. This impact cannot be mitigated to a less-than-significant level.

Construction of storage facilities also could result in potentially significant impacts on special-status plants and animals as a result of construction-related activities and inundation of existing occupied habitats. For most species, these impacts can be mitigated to a less-than-significant level with implementation of mitigation strategies (Section 6.2.11, "Mitigation Strategies"). Avoidance of temporary or permanent impacts on special-status species are included as general mitigation strategies (Section 6.2.11, "Mitigation Strategies"). The MSCS includes a more detailed and specific conservation measure that requires avoiding implementing actions, including construction of storage facilities, that could result in the mortality of certain specified special-status species. These species are characterized by populations that are rare and/or localized such that loss of individuals of these species could substantially diminish species viability. Consequently, for species addressed by this MSCS conservation measure, these potentially significant impacts would be reduced to a less-than-significant level through avoidance.