1.0 INTRODUCTION

The San Francisco Bay Estuary (San Francisco Estuary or Estuary) supports the largest and most ecologically important expanses of tidal mudflats and salt marshes in the contiguous western United States. This environment naturally supports a diverse array of native plants and animals. Over the years, many non-native species of plants and animals have been introduced to the Estuary, and some now threaten to cause fundamental changes in the structure, function, and value of the Estuary’s tidal lands. Among these threatening invaders are several species of salt marsh cordgrass (genus *Spartina*). In recent decades, populations of non-native cordgrasses were introduced to the Estuary and began to spread rapidly. Though valuable in their native settings, these introduced cordgrasses are highly aggressive in this new environment, and frequently become the dominant plant species in areas they invade.

One of the non-native cordgrass species, Atlantic smooth cordgrass (*Spartina alterniflora*), is rapidly spreading throughout the Estuary, particularly in the South San Francisco Bay (South Bay). Atlantic smooth cordgrass and its hybrids (formed when this species crosses with the native Pacific cordgrass, *Spartina foliosa*) are now threatening the ecological balance of the Estuary. Based on a century of international studies of comparable cordgrass invasions, they are likely to eventually cause the extinction of native Pacific cordgrass, choke tidal creeks, dominate newly restored tidal marshes, and displace thousands of acres of existing shorebird habitat. Once established in this estuary, invasive cordgrasses could rapidly spread to other estuaries along the California coast through seed dispersal on the tides. Non-native invasive cordgrasses currently dominate approximately 500 acres of the San Francisco Estuary in seven counties — on State, Federal, municipal, and private lands — and are spreading at a startling rate.

1.1 THE *SPARTINA* CONTROL PROGRAM

The *Spartina* Control Program is the “action arm” of the San Francisco Estuary Invasive *Spartina* Project (*Spartina* Project or ISP). The California State Coastal Conservancy (Conservancy) initiated the ISP in 2000 to stave off the invasion of non-native cordgrass and its potential impacts. The ISP is a regionally coordinated effort of Federal, State, and local agencies, private landowners, and other interested parties, with the ultimate goal of arresting and reversing the spread of non-native cordgrasses in the San Francisco Estuary. When fully implemented, the ISP will provide opportunities to maximize resources, effectively disseminate information, facilitate regional monitoring, and reduce the occurrence of cordgrass re-infestation. The geographic focus of the ISP includes the nearly 40,000 acres of tidal marsh and 29,000 acres of tidal flats that comprise the shoreline areas of the nine Bay Area counties, including Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties, and Sacramento County (Figure 1-1).

The ISP is comprised of a number of components including public education and outreach, scientific research, monitoring and mapping, regulatory coordination, and eradication (Figure 1-2). The eradication component of the ISP, under which on-the-ground treatment of vegetation will occur (and funding for such treatment will be allocated), is called the *Spartina* Control Program. The *Spartina* Control Program also is referred to in this document as the SCP or Control Program. The ISP is an existing, ongoing effort, while the *Spartina* Control Program is in the planning phases. The Control Program proposes to implement a number of treatment techniques to eradicate the four invasive non-native cordgrass species.
This page left intentionally blank.
Figure 1-1. Spartina Control Program Region

Sources: SEFI 1998; Bay Area EcoAtlas Ver. 1.50

S.E. ESTUARY

SUBREGIONS

Suisun Subregion
North Bay Subregion
Central Bay Subregion
South Bay Subregion

SAN FRANCISCO ESTUARY
BAYLANDS HABITATS
(Areas susceptible to non-native cordgrass invasion)

Intertidal Flat
Tidal Marsh
Salt Pond

Project Location

Scale
N
Miles
0 5 10

San Francisco
San Leandro Bay
San Leandro
Point
San Francisco
Bay

San Mateo

San Francisco
Bay

S.F. ESTUARY

SUBREGIONS

SAN FRANCISCO
COUNTY

SUISUN COUNTY

SOLANO
COUNTY

NAPA
COUNTY

CONTRA COSTA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUNTY

MARIN
COUNTY

SANTA CLARA
COUNTY

SONOMA
COUNTY

ALAMEDA
COUN
This page left intentionally blank.
1.0 Introduction

The proposed treatment techniques, ranging from mowing, pulling, or smothering plants to spraying with herbicides, are described in detail in Chapter 2, Program Alternatives. It is the potential impacts of the Spartina Control Program and the proposed treatment techniques that are the subject of this Programmatic Environmental Impact Statement/Report (EIS/R).

1.2 PURPOSE AND NEED

1.2.1 Statement of Purpose and Need

The purpose of the Spartina Control Program is to arrest and reverse the spread of invasive non-native cordgrass species in the San Francisco Estuary to preserve and restore the ecological integrity of the Estuary’s intertidal habitats and estuarine ecosystem.

The Control Program is needed to prevent further degradation and loss of the natural ecological structure and function of the San Francisco Estuary. In the absence of any coordinated and wide-ranging control program, within decades significant portions of the existing higher tidal flats are likely to be replaced with dense, invasive cordgrass marsh, and much of the native diverse salt-marsh vegetation replaced with nearly homogeneous stands of non-native cordgrass. This ecological conversion is likely to alter the structure and function of the Estuary, affecting fisheries, migratory shorebirds and waterfowl, marine mammals, endangered fish, wildlife, and plants, tidal sediment transport, and the rate, pattern, and magnitude of tidal flows. In addition, invasive cordgrasses may impede or preclude plans to restore up to 20,000 acres of diked baylands to native tidal marsh. Arresting and reversing the invasion of non-native cordgrasses may not be feasible once these species have spread and become established, due to the expansive scale of the invasion and the effects of hybridization. To avoid these consequences, the ISP proposes a rapidly implemented, regionally coordinated, long-term management program.

1.2.2 Ecology of the San Francisco Estuary Tidal Lands

The tidal lands of the San Francisco Estuary include an intertidal zone at lower elevations, and a tidal marsh plain at higher elevations. Like most Pacific estuaries, the majority of the intertidal zone of the San Francisco Estuary naturally consists of unvegetated tidal flats, or mudflats. Native California tidal marsh vegetation is limited to the upper intertidal zones, above mean sea level in San Francisco and San Pablo Bays. Below mean sea level, waves erode and redeposit the upper layers of bay mud with each tidal cycle. Rich deposits of fine silt and clay from the Sacramento-San Joaquin Delta have accumulated in the Estuary to form highly productive mud-
flats, with abundant benthic invertebrates. The mudflats provide a critical source of nutrition and energy for migratory shorebirds and waterfowl, with more than one million shorebirds using the Estuary’s mudflats and salt ponds during migration, and over half of the west-coast migratory diving ducks making this estuary their winter home.

At elevations above the intertidal zone (in areas that have not been diked and removed from tidal action), are the Estuary’s tidal salt and brackish marshes. Pacific salt marsh vegetation is more diverse in plant species than its Atlantic counterpart. Until recent decades, the native Pacific cordgrass exclusively occupied the lower reaches of the Estuary’s tidal salt marshes. At slightly higher elevations, a relatively flat tidal marsh plain (reaching near the average level of the higher daily tides), is dominated by low-growing, mostly perennial plants such as pickleweed, saltgrass, and other salt-tolerant herbs. The tidal marsh plain is punctuated by salty shallow ponds (pans), and dissected by irregular tidal creeks. Above the tidal marsh plain, at the uppermost edges of the marsh, are an even greater number of plant species.

Many endemic (unique to the area) plant and animal species, including many rare or endangered species, survive only in the Estuary’s remaining tidal marshes. They remain at risk of extinction because of the severe decline over the past century in the abundance, distribution, and quality of tidal marshes. Most of the Estuary’s rare species have narrow or specific habitat requirements, and the health of their populations usually is sensitive to structural changes in their habitats – particularly the condition of the marsh vegetation. Strong dominance of the vegetation by one or more plant species necessarily results in lower overall species diversity, and can push rarer species to local extinction.

1.2.3 Characteristics of Native and Non-native Cordgrasses of the San Francisco Estuary

There are one native and four non-native species of cordgrass in the San Francisco Estuary. The native species is Pacific cordgrass (Spartina foliosa). The non-natives species are Atlantic smooth cordgrass (S. alterniflora), English cordgrass (S. anglica), Chilean cordgrass (S. densiflora), and salt-meadow cordgrass (S. patens). The non-native Atlantic smooth cordgrass hybridizes with the native Pacific cordgrass, and their offspring (referred to in this document as “Atlantic smooth cordgrass hybrids” or “hybrids”) are also invasive and considered non-native. Key aspects of the cordgrass species found in the Estuary are contrasted below. The biological contrasts among these species and their roles in their native habitats help to demonstrate how non-native cordgrasses are likely to alter the Estuary’s salt marsh ecosystem. First described is the native Pacific cordgrass, followed by the non-native species. Photographs of each of these species are shown immediately following the descriptions in Figure 1-3.

Pacific Cordgrass, Spartina foliosa (Native)

The historic range of Pacific cordgrass was confined to estuaries from Point Reyes to Baja California, with large gaps in between; for example, it is historically absent in Monterey Bay and Morro Bay. Most of the Pacific cordgrass population exists in San Francisco and San Pablo Bays. Its northern limit is now Bodega Bay, a small and recent natural population. It even more recently established in Tomales Bay, where its population surged following major flood and depositional events of the mid-1990s.

Pacific cordgrass is a perennial, salt-tolerant marsh grass, which spreads both sexually, by seed dispersal, and asexually, by long, creeping rhizomes (underground stems, or runners) that propagate small clusters of leafy shoots. Clonal (asexual) growth of rhizomes allows individual plants to form extensive colonies without being pollinated by another plant. A colony thus
1.0 Introduction

Pacific cordgrass is genetically very similar to Atlantic smooth cordgrass, but the two species also have significant differences. In size, growth rate, production, and ecological tolerances, Pacific cordgrass is much less robust than Atlantic smooth cordgrass (Smart and Barko 1978, Callaway 1990, Boyer, Callaway and Zedler 2000). Pacific cordgrass grows more luxuriantly in clayey mud than sand, but it naturally grows in substrates ranging from sand and mud to peat. Its leaves and stems wither in fall and are shed in winter, as the clones die back to young shoots and buds near the mud surface. The sparse remains of Pacific cordgrass stands in winter are relatively ineffective in trapping sediment.

Pacific cordgrass is generally restricted to a narrow portion of the intertidal zone, between an elevation just above mean sea level and an elevation near the level of the average higher daily tide (mean higher high water, “MHHW”). It tends to fail in competition with plants like pickleweed on the marsh plain, which, in California estuaries, approaches the elevation of the MHHW. This modest range in tidal elevation restricts Pacific cordgrass to the sloping banks of tidal creeks, and the gently sloping upper edges of mudflats where sediment accumulates. This leaves the vast acreages of Pacific tidal flats below mean sea level entirely free of emergent vegetation in natural historic conditions. The vegetated marsh plain (middle to high marsh zone) supports either sparse Pacific cordgrass in lower areas, or none at all.

Early experiments with Pacific cordgrass demonstrated that its slender, widely spaced leafy shoots and rhizomes are not as effective at stabilizing sediment compared with Atlantic smooth cordgrass, especially under exposed conditions at the bay’s edge (Newcombe et al. 1979). Seedlings of Pacific cordgrass are seldom found in established marshes, and appear only intermittently in sheltered upper mudflats.

Pacific cordgrass is particularly valued as habitat for the endangered California clapper rail, which spends most of its time foraging for food within, or close to, the protective canopy of cordgrass. Rails can move within Pacific cordgrass stands, and spend most of their time under cover of the cordgrass foliar canopy, usually selecting prey items such as invertebrates inhabiting the cordgrass stands and their edges. In contrast to the clapper rail of southern California tidal marshes, San Francisco Bay clapper rails generally do not construct “floating nests” in Pacific cordgrass; instead, they tend to build nests in gumplants or pickleweed in the higher marsh.

Atlantic Smooth Cordgrass, Spartina alterniflora, and its Hybrids

Smooth cordgrass is the closely related sibling to Pacific cordgrass. In the United States, it occurs along both the Atlantic and Gulf Coasts (Gleason and Cronquest 1991). It is unique among the world’s cordgrass species in terms of its growth potential and ecological breadth, and it is the parent species of the other most invasive cordgrass species of hybrid origin, English cordgrass (Spartina anglica; Adam 1990). The San Francisco Estuary population of Atlantic smooth cordgrass was founded by seed from Maryland in the mid-1970s, introduced experimentally for one of the first tidal marsh restoration projects on the west coast (Faber 2000). We refer to the San Francisco Bay population of smooth cordgrass as Atlantic smooth cordgrass. 

Atlantic smooth cordgrass is a coarse perennial grass that, like its Pacific relative, spreads both by seed dispersal and by creeping rhizomes that form extensive clonal colonies. In parts of the San Francisco Estuary, the rate of lateral spread by rhizomes averages between 3.3 and 6.6 feet
per year, in contrast with native Pacific cordgrass, which spreads only 0.6 to 2.4 feet per year in the same marshes (Josselyn et al. 1993). Similar rates of lateral spread of this species and its hybrids have been recorded more recently in Cogswell Marsh on the Hayward Shoreline (K. Zaremba, M. Taylor, pers. comm.).

The size range of Atlantic smooth cordgrass is wide and highly variable, depending on its local genetics and environment. In nutrient-rich, well-drained marsh sediment, such as along tidal creek banks and on newly colonized tidal flats, extensive dense stands can reach nearly 10 feet in height. On poorly drained marsh flats, its vegetation is typically sparse and short, but its dense root and rhizome network maintains pure stands and effectively binds marsh sediments.

The “tall form” and “short form” of this species were so strikingly different that they were long assumed to be distinct varieties, rather than environmentally-caused variations. Modern research indicates that factors related to marsh drainage, such as waterlogged soil chemistry (especially accumulation of toxic soil sulfides), excessive salinity, and nutrient deficiency interact to cause the dramatic differences in growth-forms of Atlantic smooth cordgrass (Bradley and Dunn 1989, Mendelssohn and Seneca 1980, Valiela et al. 1978, Smart and Barko 1978). Genetic variations in height forms of Atlantic smooth cordgrass also have been confirmed in San Francisco Bay (Daecher et al. 1999).

In the salt marshes of the Atlantic coastal plain, Atlantic smooth cordgrass is dominant over most of the intertidal zone. Depending on local tidal range, it can grow to and below mean low water (McKee and Patrick 1988), and it can occupy, and even dominate, the marsh plain and the low marsh. Vast, homogeneous stands of Atlantic smooth cordgrass are the characteristic signature of the Atlantic region’s tidal marshes (Dame et al. 2000, Adam 1990, Chapman 1964, 1977).

In contrast with Pacific cordgrass, Atlantic smooth cordgrass freely establishes in relatively exposed shorelines with significant wave action, including estuarine sand beaches. It is planted in its native range to stabilize shorelines and to trap and accumulate sediments, and the high density of its tall stems is highly effective at reducing estuarine wave energy (Gleason et al. 1979, Knutson and Woodhouse 1988, Knutson et al. 1990).

In other environmental tolerances, Atlantic smooth cordgrass is also highly resilient. It can survive in salinity over 45 parts per thousand (well above ocean salinity), and grow luxuriantly in dilute brackish water. If buried, it can regenerate from up to about one foot of burial by deposited sediment (Zaremba 1978). Atlantic smooth cordgrass, like other low marsh species, can supply air to its roots in oxygen-free waterlogged mud, using porous air-filled chambers linking its foliage to roots and rhizomes. Atlantic smooth cordgrass can also tolerate the severe waterlogging and hypersalinity that develops in poorly drained depressions in the salt marsh, including salt marsh pans. Salt marsh pans are frequent and well-developed features of historic San Francisco Estuary marshes, and important habitat for migratory waterbirds (Goals Project 1999). Along the Hayward shoreline of San Francisco Bay, Atlantic smooth cordgrass has colonized many pre-existing pans, converting them to solid cordgrass marsh (P. Baye, D. Smith, pers. observ.).

In the San Francisco Estuary, Atlantic smooth cordgrass has displayed many of the ecological traits typical of its performance in its native salt marsh habitat, and some highly novel phenomena as well. Most colonies in the San Francisco Estuary are young, often forming nearly circular, discrete, expanding colonies, which merge into irregular patterns, resembling mold colonies in a petri dish. The edges of the colonies are tall and robust, while the centers often exhibit early symptoms of dieback or “short form” growth habits. The “donut” shape of colonies, in fact, is one of the species’ signatures for identification in aerial photographs of San Francisco Bay. This
trait is not typical of mature Atlantic salt marshes. In the mild Pacific winters, Atlantic smooth
cordgrass shoots tend to retain green leaves and persistent dead leaves through much of the
winter. This is an important contrast with native Pacific cordgrass: combined with the invader’s
much greater stem size and shoot density, year-round dense foliage gives Atlantic smooth
cordgrass exceptionally high potential to accumulate and trap estuarine sediment during winter
storms or floods.

The San Francisco population of Atlantic smooth cordgrass has generated some unusual
growth forms with strikingly atypical appearance. The dwarf form develops a profusion of short
lateral shoots instead of a tall main stem, forming pure stands with complete ground cover of
dense, low turf-like ankle-high vegetation on the marsh plain. The growth rate of the dwarf
form is, however, vigorous. The dwarf form is genetic, not environmentally induced; it occurs
in the same local environments that support luxuriant, tall stands of Atlantic smooth cordgrass,
often contiguous with the dwarf patches. It has established at multiple locations in San Fran-
cisco Bay (Daehler et al. 1999). A comparable dwarf form of its hybrid daughter species, Eng-
lish cordgrass, independently evolved in Britain and New Zealand (Chater 1965, Bascand 1970).

**Hybridization of Atlantic smooth cordgrass with native Pacific cordgrass.** Perhaps the most
novel and significant phenomenon of the San Francisco population of Atlantic smooth cord-
grass is the rapid evolution of an aggressively expanding hybrid swarm formed by cross pollina-
tion with the native Pacific cordgrass (Daehler and Strong 1997). The hybrid swarm includes
first-generation crosses between Atlantic smooth cordgrass and Pacific cordgrass with both
species acting as pollen-parents and seed parents. Because the two species’ pollination periods
overlap little, first-generation crosses are infrequent. Hybrids, however, have a wide range of
flowering times, and act as an effective reproductive bridge between the species. The hybrids
produce pollen in much greater abundance (21 times greater) and with higher fertility than the
native Pacific cordgrass. Superior hybrid pollen production and fertility so overwhelm popula-
tions of Pacific cordgrass (“pollen swamping”) that native stands of cordgrass produce mostly
hybrid back-cross seeds in the presence of flowering hybrid colonies, and fail to reproduce the
species sexually (Ayres et al. 1999, Antilla et al. 2000). This process alone, called hybrid assimili-
cation, can result in the extinction of the invaded species (Levin et al. 1996, Rhymer and Sim-
berloff 1996).

Genetic analysis has revealed that numerous large populations of presumed Atlantic smooth
cordgrass in the Estuary are predominantly hybrids and back-crosses (introgressants). The
ecologically invasive, dominant traits of Atlantic smooth cordgrass appear to be prevalent in the
hybrid swarm. “Pure” Atlantic smooth cordgrass is now a minority in most of the rapidly
evolving hybrid swarms, and trends suggest that hybrids will eventually replace both parent
species, as the hybrid-origin species English cordgrass did in Britain (see English Cordgrass,
below). This recently discovered threat of genetic extinction to a native cordgrass from an alien
cordgrass invasion is unique to the San Francisco Estuary. No native cordgrasses existed where
Atlantic smooth cordgrass invaded Washington and Oregon estuaries, and the cordgrasses
native to Europe are genetically isolated from their hybrids.

Atlantic smooth cordgrass, and its hybrids with similar appearance and behavior, are now
widely distributed in the Central and South Bay, but they have not yet been detected in the
North Bay or Suisun, despite intensive searches. The northern limit of its distribution in 2001
was the west shore bay of Point Pinole (Giant Marsh). The abundance of Atlantic smooth
cordgrass and hybrids remains greatest near the point of its original introduction circa 1977
(Pond 3, Hayward Shoreline, Alameda County), and sites of early transplanting (Colma Creek,
San Mateo County), early pioneer colonies (Oakland, San Leandro Bay, Hayward Shoreline),
and areas of subsequent transplanting (Cogswell Marsh, Hayward). It now is nearly the exclu-
sive marsh plant species of recently formed or restored tidal marshes along the San Leandro-
1.0 Introduction

Hayward shoreline, and this trend is expected to increase. Even as the Bay edge salt marshes and levees are eroding landward through wave action, Atlantic smooth cordgrass marsh is spreading in the opposite direction below the wave-cut marsh cliff. Its distribution becomes patchier south of the Dumbarton Bridge, decreasing in size and frequency to Alviso, where it is still relatively rare. It is well established as scattered, large but discrete colonies in the Dumbarton-Mowry Marsh, Newark, mostly in sloughs and disturbed marsh, or recently colonized mudflats. It is a common or dominant feature in marshes from San Bruno, the San Francisco Airport, south to Foster City, and is scattered in variable frequency along the Redwood City shoreline. The Napa-Sonoma and Petaluma Marshes are currently free from the Atlantic smooth cordgrass invasion, but young colonies have recently been detected in Bolinas Lagoon and Drakes Estero on the Point Reyes peninsula (K. Zaremba, pers. comm. 2001).

**English Cordgrass, Spartina anglica**

English cordgrass is an aggressive invader of mudflats and salt marshes in Britain, New Zealand, Australia, and the Pacific Northwest, and thrives in cool temperate climates. It originated in Britain as a fertile hybrid derived from introduced Atlantic smooth cordgrass and common cordgrass (S. maritima), a small, slow-growing creeping cordgrass native to European coasts, now greatly reduced in abundance. Within a century after its origin, English cordgrass became the dominant salt marsh grass in Britain (Lee and Partridge 1983, Gray et al. 1990). It is shorter and more grayish than Atlantic smooth cordgrass, but partly shares other traits of its parent, such as vigorously spreading rhizomes, ability to transform mudflats into vast stands of low marsh vegetation, and ability to dominate and displace associated plant species. It was introduced to the San Francisco Estuary at Creekside Park, Corte Madera, Marin County, along with Chilean cordgrass, in 1976. Unlike Atlantic smooth cordgrass and Chilean cordgrass, this species failed (so far) to disperse from its point of introduction. It may be at or near its southern climatic limit on the Pacific Coast in San Francisco Estuary.

**Chilean Cordgrass, Spartina densiflora**

Chilean cordgrass (also called dense-flowered cordgrass) is a distinctive cordgrass species native to South America. It has a bunchgrass growth habit, forming tight clumps or tussocks with short creeping rhizomes, and narrow, firm, in-rolled leaves (Spicher 1984), resembling European beachgrass (Ammophila arenaria). It is generally restricted to the middle marsh plain and high marsh zones where pickleweed, saltgrass, jaumea, and other low-growing herbs otherwise prevail. It does not spread into the low marsh where Pacific cordgrass and mudflats naturally dominate the Estuary (Kittleson and Boyd 1997). Chilean cordgrass lacks well-developed tissues specialized for transporting air from foliage to roots (Spicher 1984), a feature common to cordgrasses adapted to low marsh environments.

Chilean cordgrass, along with other South American coastal species, was probably accidentally introduced to Humboldt Bay, California by ship ballast containing seeds from South American ports that traded lumber (Spicher 1984). For most of the 20th Century, Chilean cordgrass was erroneously treated as an “ecotype,” or minor geographic variation, of the native Pacific cordgrass, despite the lack of diagnostic traits matching this species. In the late 1970s, the presumed native “Humboldt Bay form” of Pacific cordgrass was deliberately transplanted to salt marsh restoration and landscaping sites at Creekside Park, Corte Madera, Marin County (Faber 2000). Within the salt marshes fringing Corte Madera Creek, it has since become a locally dominant component of the middle and high salt marsh vegetation, displacing even robust pickleweed.

A second population of Chilean cordgrass spontaneously established across the Bay from Creekside Park in the ancient marsh plain at Point Pinole (Whittell Marsh), Contra Costa County. The Point Pinole population was discovered in the mid-1990s, and has been largely
1.0 Introduction

Salt-Meadow Cordgrass, *Spartina patens*

Salt-meadow cordgrass is another rhizome-forming creeping cordgrass of Atlantic salt marshes, but unlike Atlantic smooth cordgrass, it has fine stems with narrow, soft, in-rolled leaves, and is intolerant of waterlogged mud. It is naturally confined to the well-drained high salt marsh and relatively moist sandy depressions at or above tidal influence. Two distinctive geographic and ecological types have been recognized, and in the past have been treated as distinct taxonomic varieties. In peaty high salt marshes of the northeastern Atlantic coast, a relatively low form with lax, slender stems forming dense matted turfs with “cowlicks” was once treated as *S. patens* var. *monogyna* (Fernald 1950). These dense salt marsh turfs are often nearly pure stands of salt-meadow cordgrass crowding out most potentially associated species that occupy gaps in the cover caused by winter ice or drifted wracks. In sandy marshes associated with large barrier beaches and wash-over fans from Cape Cod through the Atlantic coastal plain, a coarser, erect type, formerly recognized as *S. patens* var. *juncea*, is prevalent. Intermediate forms are common.

Between the 1959 publication of *A California Flora* (Munz and Keck 1959) and its 1970 supplement (Munz 1970), salt-meadow cordgrass was reported in Southampton Bay, Benicia, Solano County. The time and mode of introduction is unclear. Salt-meadow cordgrass at Southampton occupies large, discrete patches in pure and exceptionally thick stands compared with its native marshes. The patches are distributed close to tidal sloughs, a pattern suggesting local transport by currents. One large stand is spreading into a high marsh site (pickleweed-saltgrass vegetation) that supports a population of an endangered annual plant, soft bird’s-beak (*Cordylanthus mollis* ssp. *mollis*). The Southampton Bay cordgrass population appears to match the type description of “variety monogyna,” the fine-stem type of northeastern Atlantic marshes. (P. Baye, S. Klohr, unpubl. data 2000).

A population of salt-meadow cordgrass was reported in San Bruno, but was not detected in recent intensive searches. It is possible that a relatively unfamiliar native salt marsh grass, *Puccinellia nutkaensis*, could be mistaken for vegetative salt-meadow cordgrass. However, salt-meadow cordgrass was confirmed from a batch of grasses collected as unknowns from tidal marshes in the vicinity of Tolay Creek, Tubbs Island, Sonoma County, in 2001 (H. Spautz, pers. Comm.). The exact location of the collection has not been recovered, but this observation indicates that some spread to San Pablo Bay has occurred (P. Baye, unpubl. data 2001).
This page left intentionally blank.
1.0 Introduction

Figure 1-3. Cordgrass Species

Native Pacific cordgrass meadow at Blackie’s Pasture, Marin County.

A tall stand of Atlantic smooth cordgrass hybrids invading a native pacific cordgrass meadow near Tiburon, Marin County.

Figure 1-3. Cordgrass Species
1.0 Introduction

Figure 1-3. Cordgrass Species

A patch of English cordgrass at Creekside Park, Marin County.

Robust stands of Chilean cordgrass along Corte Madera Creek in Marin County.

Hummocks of Salt-meadow cordgrass at Southampton Marsh, Solano County.
1.0 Introduction

This Page Left Intentionally Blank
Table 1-1. Net and Gross Area Invaded by Non-native Cordgrass Species (2000-2001)

<table>
<thead>
<tr>
<th>Species</th>
<th>Net* Acreage (acres)</th>
<th>Gross* Acreage (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic Smooth Cordgrass (and hybrids)</td>
<td>469</td>
<td>5,016</td>
</tr>
<tr>
<td>English Cordgrass</td>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>Chilean Cordgrass</td>
<td>13</td>
<td>263</td>
</tr>
<tr>
<td>Salt-meadow Cordgrass</td>
<td>0.6</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>483</td>
<td>5,287</td>
</tr>
</tbody>
</table>

* "Net area" is area with 100% cover by non-native cordgrass
* "Gross area" is area in which non-native cordgrasses occur

Table 1-2. Net Area (in Acres) of Non-native Cordgrass Species by Bay Subregion (2000-2001)

<table>
<thead>
<tr>
<th>Species</th>
<th>Suisun Bay</th>
<th>North Bay</th>
<th>Central Bay</th>
<th>South Bay: Dunbarton Bridge North</th>
<th>South Bay: Dunbarton Bridge South</th>
<th>Total Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic Smooth Cordgrass (and hybrids)</td>
<td>0</td>
<td>0</td>
<td>111</td>
<td>361</td>
<td>11</td>
<td>483</td>
</tr>
<tr>
<td>English Cordgrass</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Chilean Cordgrass</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Salt-meadow Cordgrass</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.6</td>
</tr>
</tbody>
</table>

* "Net area" is area with 100% cover by non-native cordgrass

1.2.4 Long-term Effects of Non-native Invasive Cordgrass

Recent cordgrass monitoring and mapping efforts by the ISP and University of California, Davis, have concluded that over 5,000 acres of the Estuary’s tidal flats and marshes have been invaded by stands of non-native cordgrass (including hybrids), with total area coverage of nearly 500 acres (Ayers et al., In Press). The area invaded by stands of non-native cordgrass is referred to as “gross area,” while the actual area covered by the stands (i.e., with greater than 90% coverage) is referred to as “net area.” Table 1-1 shows the net and gross area of each cordgrass species, and Table 1-2 shows the net area of each cordgrass species by subregion. The current gross invaded area accounts for less than eight percent of the total area of existing tidal flats and marshes in the San Francisco Estuary (Ayers et al., In Press); however, the gross invaded area in the South Bay accounts for greater than 15 percent of the existing tidal flats and marshes. Figure 1-4 shows the current distribution of non-native cordgrass in the San Francisco Estuary. The rate of expansion of each of the species varies. English cordgrass has not spread beyond its original 1970s introduction site, Chilean cordgrass has spread to cover 13 acres at three sites in the Central Bay, salt-meadow cordgrass has expanded from two plants in 1970 to 42 plants at one site, and Atlantic smooth cordgrass and its hybrids has spread from two sites planted in Fremont and Alameda Island in the 1970s to cover nearly 500 net acres (5,000 gross acres) today.

Based on the characteristic cordgrass behavior described in the previous section, the spread of non-native invasive cordgrasses could have tremendous long-term effects on the natural ecology of the San Francisco Estuary. Left uncontrolled, these effects would likely include the following long-term consequences:
1.0 Introduction

- **Genetic assimilation and extinction of native Pacific cordgrass (*Spartina foliosa*).**
  Native Pacific cordgrass cannot effectively reproduce by seed in the presence of Atlantic smooth cordgrass hybrids. The much larger pollen loads and the greater fertility of the pollen of hybrids results in “swamping” of the native species. Thus, seeds produced by native plants that are in the vicinity of Atlantic smooth cordgrass hybrids are themselves hybrid. The net result is continued and accelerated formation of hybrid seeds, and progressive decline in native cordgrass seed reproduction. Pacific cordgrass, though not previously threatened, may now be endangered due to aggressive hybridization and outright displacement by the competitively superior invader. This process has already been scientifically documented at many sites in the Estuary (D. Ayres, pers. Comm.).

- **Extensive regional loss of tidal flats.** Native Pacific cordgrass, with rare exceptions, doesn’t tend to colonize open tidal flats that are subject to high wind and wave energy. Atlantic smooth cordgrass and its hybrids do, and they would likely eventually invade a significant portion of existing higher tidal flats in the Central and South Bays. This potential was demonstrated in an area of San Leandro, where in 10 years, non-native cordgrass invaded and completely covered large segments of a half-mile-wide stretch of tidal flat along the shoreline. Extensive invasion of tidal flats by Atlantic smooth cordgrass is also occurring on a larger scale in the channel off of Alameda Island (Figure 1-5a).

- **Elimination of critical foraging habitat for migratory shorebirds.** During the spring and fall, the Estuary is an important feeding stopover on the Pacific Flyway for many migrating birds. These birds require extensive open intertidal mudflats for foraging. The invasion of the Estuary by Atlantic smooth cordgrass and its hybrids would transform these feeding areas into dense meadows, with no foraging value. This process is already underway (Figure 1-5b).

- **Failure of efforts to restore native tidal marsh vegetation in diked baylands.** Attempts to restore naturally diverse native tidal marsh vegetation and structure in the San Francisco Estuary would result instead in establishment of persistent stands of hybrid Atlantic smooth cordgrass, as has already occurred at several marsh restoration sites on the eastern San Francisco Bay shoreline. Greater than 10,000 acres of diked baylands (former commercial salt ponds) are slated for restoration to tidal marsh in the coming decade, and these areas would be lost to non-native cordgrass (Figure 1-5c).

- **Alteration of natural sedimentation processes to support restoration of diked baylands.** Abundant sediment supply will be critical for restoring the Estuary’s thousands of acres of deeply subsided diked baylands. The Bay waters typically carry large amounts of fine sediment suspended in the water column, which naturally deposits in calm areas and forms the marsh plains. Because the dense foliage of Atlantic smooth cordgrass and its hybrids readily trap and retain sediment suspended in the Bay water, the presence of these plants in vast acreage would trap and “lock up” suspended sediments that would otherwise nourish restored tidal marsh. Stabilization of mudflats by extensive invasion of smooth cordgrass could significantly retard salt marsh restoration in tidally restored salt ponds.

- **Regional loss of tidal sloughs and channels.** Small tidal sloughs, essential to the movement of wildlife and habitat for native estuarine fish, would become choked with
This Page Left Intentionally Blank
Figure 1-5. Effects of Non-native Cordgrass on the San Francisco Estuary

Elsie Romer Bird Sanctuary, Alameda Shoreline, in 1991, 1998, and 2000. These infrared photographs show the progression of Atlantic smooth cordgrass from the shoreline down onto the tidal flats and up onto the adjacent upper shoreline, over a nine year period.
These shorebirds are shown foraging in the tidal flat that has been invaded by a flourishing Atlantic smooth cordgrass clone. Clones have been documented to spread at a rate of greater than six feet per year.

Atlantic smooth cordgrass hybrids (circular growth pattern on mudflat) colonized this 49 acre restoration site near Whale's Tail Marsh in Hayward soon after restoration. (Photo: Stephen Joseph)

Cogswell Marsh, Hayward, was restored beginning in 1980, and is now almost completely invaded by Atlantic smooth cordgrass hybrids. These infrared photographs show the marsh in 1996 and 1998 - the red circular patterns are Atlantic smooth cordgrass.

Figure 1-5. Effects of Non-native Cordgrass on the San Francisco Estuary
1.0 Introduction

This Page Left Intentionally Blank
Small and medium channels being invaded by Atlantic smooth cordgrass hybrids, which have a tendency then to trap sediment and fill the channel. The phot at rightf shows a stand of Atlantic smooth cordgrass colonizing a tidal channel. Note the wrack (accumulated debris) on top.

Atlantic smooth cordgrass hybrids will establish in high-energy environments along open bay shoreline. Here it has established at the tip of sand bars along the San Leandro shoreline, and is altering the natural beach-forming processes.

(Photo: Stephen Joseph)

Figure 1-5. Effects of Non-native Cordgrass on the San Francisco Estuary
non-native cordgrass and trapped sediment. Larger sloughs and the mouths of larger
creeks would eventually become clogged, causing slowed river discharge and upstream
flooding. Choking and infilling of tidal creeks by Atlantic smooth cordgrass has been
observed at many sites in the East Bay (Figure 1-5d).

- **Increased need for dredging and flood control.** Atlantic smooth cordgrass may in-
vade sloughs and channels, trapping sediment and eventually causing significant reduc-
tion in channel capacity. The need for maintenance dredging of tidal reaches of flood
control and navigational channels probably would increase significantly, particularly
where channels cross what are now broad intertidal flats, where the cordgrass can easily
invade the channel. Invasive smooth cordgrass also attracts endangered clapper rails
during early stages of colonization, which could affect regulatory requirements for
dredging (Figure 1-5d).

- **Alteration of estuarine beaches and beach-forming processes.** Atlantic smooth cord-
grass freely establishes along exposed shorelines and in sandy substrates, and it has
colonized tidal flats in front of beaches and along sand spits in the Estuary. The pres-
ence of cordgrass precludes the natural beach-forming processes along the shoreline
(Figure 1-5e). Today, there are few remaining sand beach areas in the Estuary that have
not established rapidly growing stands of Atlantic smooth cordgrass and its hybrids.

- **Marginalization of endangered California clapper rail habitat.** In the early stages of
Atlantic smooth cordgrass invasion, habitat alterations appear to favor the California
clapper rail by providing additional nesting and foraging habitat in the young, tall cord-
grass stands. However, in long-term succession of the cordgrass in its native range, the
tall, robust plants are eventually replaced by short, sparse stands, which have little or no
value for clapper rails – except along the fringes of the stand where the young, tall
plants continue to grow (Meanley 1985). In addition, cordgrass meadows would eventu-
ally spread to cover much of the remaining mudflat and eliminate foraging opportunities
for the bird. Thus, the habitat structure and distribution of the clapper rail in future the
San Francisco Estuary’s marshes may be radically altered and reduced by long-term in-
vasion of smooth cordgrass

- **Reduction or elimination of salt marsh harvest mouse habitat.** Pickleweed habitat
essential to the endangered salt marsh harvest mouse would be replaced in lower tidal
reaches by “short form” hybrid Atlantic smooth cordgrass, and upper tidal reaches by
Chilean cordgrass and salt-meadow cordgrass. At best, this would reduce the mouse’s
potential for recovery in its native ecosystem, and at worst, it could push the species to
local extinction in the remaining tidal marshes it inhabits.

- **Precluded Recovery of California sea-blite and other endangered plants.** The recov-
ery of federally endangered Californian sea-blite depends on the species’ reestablish-
ment in the San Francisco Estuary. Reestablishment of independent populations in the Estu-
ary depends on protection and restoration of local sandy high tide lines between sandy
beaches and salt marsh. These important features cannot be established or sustained in
the presence of wave-damping, sediment-trapping Atlantic smooth cordgrass. Salt
meadow cordgrass threatens local populations of another endangered plant, soft bird’s-
beak.

- **Production of massive deposits of vegetative debris.** Atlantic cordgrass produces
large amounts of standing biomass and leaf litter, which becomes floating “wrack”
(rafted tidal debris) in the winter. Massive wrack deposition can interfere with operation
of water intake structures (tidegates), smoother and induce large barren areas in high salt
1.0 Introduction

• **Spread of invasive cordgrasses to other California estuaries.** The San Francisco Estuary would become a dispersal source of invasive hybrid Atlantic cordgrass, threatening vulnerable and relatively pristine estuaries of the central California coast. Pioneer colonies of invasive cordgrass species have already been discovered in all of the estuaries along the Marin County shoreline, and are believed to be spread from the San Francisco Estuary (Figure 1-6).

Figure 1-7 shows examples of locations that non-native invasive cordgrasses are typically found in the Estuary, and contrasts the characteristics of native Pacific cordgrass with Atlantic smooth cordgrass.

1.3 PURPOSE AND USE OF THIS PROGRAMMATIC EIS/R

The California State Coastal Conservancy (Conservancy), as the lead agency under the California Environmental Quality Act (CEQA), and the U.S. Fish and Wildlife Service (Service), as the lead agency under the National Environmental Policy Act (NEPA), have jointly prepared this EIS/R to address the environmental impacts of the proposed *Spartina* Control Program. This
Generalized composite illustration of SF Bay tidal habitats invaded by Atlantic Smooth Cordgrass.

Generalized conceptual model of consolidated tidal marsh subsequently invaded by smooth cordgrass, compared with intact native tidal marsh vegetation. Not to scale.

Figure 1-7. Typical San Francisco Estuary habitats invaded by Atlantic Smooth Cordgrass.

(Illustrations by Peter Baye)
document satisfies the procedural, analytical, and public disclosure requirements of CEQA and the U.S. Fish and Wildlife Service (Service), as the lead agency under the National Environmental Policy Act (NEPA), have jointly prepared this EIS/R to address the environmental impacts of the proposed *Spartina* Control Program. This document satisfies the procedural, analytical, and public disclosure requirements of CEQA and NEPA. The Conservancy and the Service have prepared this document pursuant to the National Environmental Policy Act (NEPA) (42 United States Code Secs. 4321 et seq.) Sections 1506.2 and 1506.4 of the President’s Council on Environmental Quality (CEQ) regulations on implementing NEPA (40 Code of Federal Regulations 1500 et seq.) and the California Environmental Quality Act Statutes (Public Resources Code Sections 21000, et seq.) and implementing Guidelines (14 California Code of Regulations Sections 15000 et seq.). Guidelines and regulations for implementing both CEQA and NEPA encourage the preparation of joint documents. Because NEPA and CEQA are somewhat different with regard to procedural and content requirements, the document has been prepared to comply with the more stringent requirements.

This document is a Programmatic EIS/R (NEPA Regulations Section 1508.18 and CEQA Guidelines Section 15168) in that it analyzes the potential effects of implementing treatment methods for a regional program, rather than the impacts of an individual project. This program-level EIS/R identifies mitigation measures that will be applied to reduce or eliminate impacts at treatment locations. The Conservancy will use this document to evaluate the Control Program for approval, and the Service will use it to evaluate any necessary Incidental Take Permits under Section 7 of the Federal Endangered Species Act. The National Marine Fisheries Service (NMFS) may use this EIS/R when considering Federal Endangered Species permits for take of protected marine species under its jurisdiction. The US Army Corps of Engineers also may use this document as NEPA documentation for any required permits under Section 404 of the Clean Water Act.

The Regional Water Quality Control Board (RWQCB) may use this document for any necessary National Pollutant Discharge Elimination System (NPDES) Permits for application of herbicides, and the California Department of Fish and Game may use it for its Streambed Alteration Agreements and any permits required under the State Endangered Species Act. The San Francisco Bay Conservation and Development Commission (BCDC) may use this document if BCDC permits are required for the project. Approval and permitting requirements are described in detail in Chapter 5.0, Environmental Compliance.

This EIS/R also is intended to address cumulative effects of specific cordgrass control activities throughout the Estuary. It may be used by other local agencies for CEQA compliance for local decisions and permits required to implement subsequent non-native cordgrass control activities. CEQA lead agencies intending to use this document for future site-specific projects will prepare Initial Study checklists to determine if there could be site-specific impacts beyond those identified in this document. Provided the environmental impacts of future activities are adequately addressed in this document, additional CEQA documentation may not be required for some individual projects. If additional environmental analysis is required for future activities and newly identified impacts, or to introduce new mitigation measures, subsequent environmental documents would be tiered from the analyses contained herein (CEQA Guidelines Section 15168 [c] and Section 15177).

Responsible Agencies under CEQA must consider the EIR prior to reaching their own conclusions on whether and how to approve a project. Those agencies may, at their discretion, follow the responsible agency requirements found in Section 15096 by considering the document (15096(f)), mitigating or avoiding only the direct or indirect environmental effects of those parts of the project which it decides to carry out, finance, or approve (15096(g)), adopting findings...
1.0 Introduction

(15096(h)), and filing a Notice of Determination (15096(i)). Responsible agencies also may prepare a subsequent or supplemental EIR as provided for in CEQA Guidelines Sections 15162 and 15163, respectively. Since this EIS/R is a programmatic document, in addition to adoption of the EIS/R, the Responsible Agency will also have to determine whether further tiered environmental documentation, such as a mitigated negative declaration, is required for the site-specific project. See CEQA Guidelines section 15168(c) and (d).

1.4 DOCUMENT ORGANIZATION

The Final EIS/R consists of a revised Draft EIS/R that incorporates changes in response to comments on the draft, as well as the Comments and Responses, and two new appendices: Appendix J, the US Fish and Wildlife Service Biological Opinion and NOAA Fisheries concurrence letter, and Appendix K, the CEQA-mandated Mitigation Monitoring and Reporting Program. The Final EIS/R is published in two volumes; Volume 1 is the revised EIS/R text, including comments and responses, and Volume 2 is the complete set of appendices. Contents of each chapter and appendix are outlined below.

Chapter 1, Introduction, describes the project background, and EIS/R purpose, need, and organization.

Chapter 2, Alternatives, describes the process used to develop alternatives to the SCP, as well as descriptions of each alternative, and the alternatives that were not carried forward for further analysis in this document.

Chapter 3, Environmental Setting, Impacts, and Mitigation Measures, includes descriptions of the environmental setting, and the impacts that may occur on each resource as a result of implementation of the SCP. Mitigation measures for potentially significant impacts are identified, and residual impacts (following application of mitigation measures) are discussed.

Chapter 4, Evaluation of Alternatives, This section provides a comparison of the impacts or effects of each alternative analyzed in the document, and identifies the NEPA “environmentally preferred” and the CEQA “environmentally superior” alternative. It also summarizes any unavoidable significant adverse impacts.

Chapter 5, Environmental Compliance, summarizes applicable federal, state, and local regulations, and describes permits and approvals that may be required. A discussion of relevant regional invasive species policies is also included.

Chapter 6, Public Involvement, discusses public involvement that has occurred to date and is expected to occur prior to certification of the EIR by the Conservancy and the Record of Decision on the EIS by the Service.

Chapter 7, List of Preparers, identifies the preparers of this document.

Chapter 8, Definitions, defines words used in the document.

Chapter 9, References, is the list of references cited in the document.

Chapter 10, Comments and Responses on the Draft EIS/R

Volume 2: Appendices. The appendices provide additional information on the environmental review process and technical information that was used in the EIS/R analyses. Pursuant to CEQA requirements, materials and literature referenced in the EIS/R, but not included in Appendices, are maintained at the Conservancy offices in Oakland, California.
1.0 Introduction

1. Appendix A – Notice of Intent (NOI)
2. Appendix B – Notice of Preparation (NOP)
3. Appendix C – CEQA Initial Study
4. Appendix D – NOP/NOI Public Comment Letters
5. Appendix E – Herbicide and Surfactant Information
6. Appendix F – Sensitive Species Table
7. Appendix G – Best Management Practices for the California Clapper Rail
8. Appendix H – List of Document Recipients
9. Appendix I – *Spartina* Control Program Possible First Year Pilot and Demonstration Projects
10. Appendix J – Biological Opinion
11. Appendix K – Mitigation Monitoring and Reporting Program