Attachment E – Notice of Intent

**WATER QUALITY ORDER NO. 2013-0002-DWQ
GENERAL PERMIT NO. CAG990005**

STATEWIDE GENERAL NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT FOR RESIDUAL AQUATIC PESTICIDE DISCHARGES TO WATERS OF THE UNITED STATES FROM ALGAE AND AQUATIC WEED CONTROL APPLICATIONS

I. NOTICE OF INTENT STATUS (see instructions)

Mark only one item A. New Applicator B. X Change of Information: WDID# 2 APAP00050
C. ☐ Change of ownership or responsibility: WDID#

II. DISCHARGER INFORMATION

A. Name California Wildlife Foundation (coalition of Invasive *Spartina* Project partners)			
B. Mailing Address 428 13th Street, Suite 10A			
C. City Oakland	D. County Alameda	E. State CA	F. Zip 94612
G. Contact Person Amy Larson	H. E-mail address alarson@californiawildlifefoundation.org	I. Title Project Manager	J. Phone (510) 208-4438

III. BILLING ADDRESS (Enter information *only* if different from Section II above)

A. Name			
B. Mailing Address			
C. City	D. County	E. State	F. Zip
G. E-mail address	H. Title	I. Phone	

IV. RECEIVING WATER INFORMATION

A. Algaecide and aquatic herbicides are used to treat (check all that apply):

1. ☐ Canals, ditches, or other constructed conveyance facilities owned and controlled by Discharger.
   Name of the conveyance system: ______
2. ☐ Canals, ditches, or other constructed conveyance facilities owned and controlled by an entity other than the Discharger.
   Owner's name: ______
   Name of the conveyance system: ______
3. X Directly to river, lake, creek, stream, bay, ocean, etc.
   Name of water body: **Intertidal mudflats, marshes, and channels of San Francisco Bay Estuary**

B. Regional Water Quality Control Board(s) where treatment areas are located
(REGION 1, 2, 3, 4, 5, 6, 7, 8, or 9): **Region 2 – San Francisco Bay**
(List all regions where algaecide and aquatic herbicide application is proposed.)

V. ALGAECIDE AND AQUATIC HERBICIDE APPLICATION INFORMATION

A. Target Organisms: Non-native cordgrass (genus *Spartina*) including: *Spartina alterniflora* (and hybrids with native *S. foliosa*), *Spartina densiflora* (and hybrids with native *S. foliosa*)

B. Algaecide and Aquatic Herbicide Used: List Name and Active ingredients

Imazapyr (Habitat®, Polaris®)

C. Period of Application: Start Date **January 1** End Date **December 31, annually**

D. Types of Adjuvants Used: **Non-ionic surfactants (e.g. Competitor, Liberate). No nonylphenol-based adjuvants.**

VI. AQUATIC PESTICIDE APPLICATION PLAN

Has an Aquatic Pesticide Application Plan been prepared and is the applicator familiar with its contents?
X Yes ☐ No

If not, when will it be prepared? ______

VII. NOTIFICATION

Have potentially affected public and governmental agencies been notified? ☒ Yes ☐ No

VIII. FEE

Have you included payment of the filing fee (for first-time enrollees only) with this submittal?
☐ YES ☐ NO ☒ NA

IX. CERTIFICATION

"I certify under penalty of law that this document and all attachments were prepared under my direction and supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment. Additionally, I certify that the provisions of the General Permit, including developing and implementing a monitoring program, will be complied with."

A. Printed Name: Janet Cobb

B. Signature: Janet Cobb **Date:** March 26, 2014

C. Title: Executive Officer

XI. FOR STATE WATER BOARD STAFF USE ONLY

WDID:	**Date NOI Received:**	**Date NOI Processed:**
Case Handler's Initial:	**Fee Amount Received:** **$**	**Check #:**
☐ **Lyris List Notification of Posting of APAP**	**Date** ____________	**Confirmation Sent** ______

Olofson Environmental, Inc.
RECEIVED
APR 4 2014
Signed

CERTIFICATION
for 2014 ISP Aquatic Pesticide Application Plan
California Wildlife Foundation

In accordance with Attachment B, Section V.B.I. Standard Provisions - Reporting, Signatory and Certification Requirements, Water Quality Order No. 2013-0002-DWQ Statewide General National Pollutant Discharge Elimination System Permit for Residual Aquatic Pesticide Discharges to Waters of the United States from Algae and Aquatic Weed Control Applications, General Permit No. CAG 990005:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations." 40 C.F.R. § 122.22(d)

Signed and Agreed:

Janet Cobb
Executive Officer
California Wildlife Foundation

Drew Kerr
Treatment Program Manager
State Coastal Conservancy's Invasive *Spartina* Project

Peggy Olofson
Director
State Coastal Conservancy's Invasive *Spartina* Project

Aquatic Pesticide Application Plan
for the
San Francisco Estuary Invasive *Spartina* Project

This plan addresses herbicide application activities undertaken by
the coalition of ISP partner agencies in the effort to eradicate non-native, invasive *Spartina* from
the San Francisco Estuary.

Prepared by

Drew Kerr

Under contract to

Olofson Environmental, Inc.
1830 Embarcadero Cove, Suite 100
Oakland, CA 94606
510-536-4782

for the

State Coastal Conservancy
San Francisco Estuary Invasive *Spartina* Project
1330 Broadway, 13th Floor
Oakland, CA 94612

March 2014

Current funding for the San Francisco Estuary Invasive Spartina Project comes from the California State Coastal Conservancy and grants from the California Wildlife Conservation Board.

Table of Contents

List of Figures

Appendices

1. Chemical properties, degradation rates, environmental fate, and toxicity of imazapyr, glyphosate, and aquatic surfactants evaluated for *Spartina* control
2. Field Data Collection Form
3. Chain of Custody form
4. Laboratory Quality Assurance Plan, Pacific Agricultural Laboratory
5. General Site Safety & Materials Handling Guidelines and Procedures for *Spartina* Control Projects in the San Francisco Estuary
6. Adjacent Waterways for *Spartina* Treatment Sites (2014)

Introduction

The San Francisco Bay Estuary (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, but over the years many non-native species have been introduced, and some now threaten to cause fundamental changes in the structure, function, and value of the Estuary's tidelands. Among these threatening invaders are several species of salt marsh cordgrass (genus *Spartina*). In the 1970's, non-native *Spartina* was introduced to the Estuary and began to spread, slowly at first and then much more rapidly as their populations reached critical mass. Though valuable in their native habitats, non-native *Spartina* is often highly aggressive in its new environment, and routinely becomes the dominant plant species in areas they invade.

The California State Coastal Conservancy (Conservancy) and US Fish & Wildlife Service (USFWS) initiated the Invasive *Spartina* Project (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 stakeholders, with the ultimate goal of eradicating non-native *Spartina* from the Estuary. The geographic focus of the ISP includes the nearly 50,000 acres of tidally-influenced marshes, mudflats and brackish channels that comprise the estuarine shorelines of the nine Bay Area counties, including Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties.

The most problematic of the non-native cordgrass species is the hybrid between *Spartina alterniflora* (Atlantic smooth cordgrass) and the native *S. foliosa* (Pacific cordgrass), which was spreading rapidly throughout the southern Estuary at the beginning of ISP's control efforts. Based on international studies of comparable cordgrass invasions, these hybrids were likely to cause the eventual extinction of native *S. foliosa*, while choking tidal creeks, excluding native salt marsh vegetation and the fauna they support, dominating newly restored tidal marshes, and destroying thousands of acres of shorebird mudflat habitat. At the start of baywide implementation of ISP's treatment program in 2005, invasive *Spartina* dominated approximately 2,000 acres (806 net acres) of the Estuary and was spreading at a greater than exponential rate.

The purpose of the *Spartina* treatment program is to arrest and reverse the spread of invasive non-native cordgrass species in the Estuary to preserve and restore the ecological integrity of the intertidal habitats and estuarine ecosystem. This vegetation management is necessary to prevent further degradation and loss of the natural ecological structure and function of the system. In the absence of any coordinated treatment program, the naturally-unvegetated intertidal mudflats were likely to be replaced with dense, hybrid cordgrass marsh, and much of the diverse native salt marsh vegetation replaced with homogeneous stands of non-native *Spartina*. This ecological conversion would have altered the structure and function of the Estuary, affecting fisheries, migratory shorebirds and waterfowl, marine mammals, endangered fish, wildlife, and plants, as well as tidal sediment transport and the rate, pattern, and magnitude of tidal flows. In addition, invasive cordgrasses would have impeded the plans of the South Bay Salt Pond Restoration Project to restore up to 15,100 acres of diked baylands to native tidal systems.

Many endemic plant and animal species, including some that are rare or endangered, 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. Over 90% of the Estuary's tidal marshes have been destroyed to accommodate residential and commercial development and salt evaporator ponds. Degradation of a healthy, diverse native plant assemblage by a single dominant invader can push rarer species to local extinction.

1. Description of the Water System

Herbicide application for control of non-native *Spartina* is conducted within intertidal marshes and mudflats of the San Francisco Bay Estuary. This area includes salt marsh plains and channels, mudflats, newly-breached restoration sites, urbanized shorelines, manmade flood control channels, and some residential parcels on the shoreline of the nine Bay Area counties (San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, and Marin), all located within the geographic jurisdiction of the San Francisco Bay Regional Water Quality Control Board (Region 2). The majority of the remaining ~30 acres of non-native *Spartina* is located in the central and southern portions of San Francisco Bay in Alameda, San Mateo and Santa Clara counties.

The waters and wetlands within and adjacent to the treatment areas are brackish to saline (approximately 10-35 ppt salt, within the tolerance range of *Spartina*). Designated Beneficial Uses of these waters may include Wildlife Habitat (WILD), Preservation of Rare and Endangered Species (RARE), Shellfish Harvesting (SHELL), Water Contact Recreation (REC1), Noncontact Water Recreation (REC2), Commercial, and Sport Fishing (COMM), Marine Habitat (MAR), Fish Migration (MIGR), Fish Spawning (SPAWN), Estuarine Habitat (EST), and Navigation (NAV). No ISP site is located in or adjacent to where treatment may affect waters with Municipal Supply (MUN), Freshwater Replenishment (FRESH), Agricultural Supply (AGR), Groundwater Recharge (GRW), Industrial Service Supply (IND), or Industrial Process Supply (PROC).

Figure 1 shows the location of ISP treatment sites and Appendix 6 lists the adjacent or nearby waterways for each potential herbicide application area.

2. Treatment Area

The ISP Coalition may apply aquatic herbicide directly to non-native *Spartina* found growing in the intertidal portions of the water system described above in Section 1. The infestations to be treated in 2014 range in size from several acres to just a few square meters or less, with many areas approaching eradication. Manual removal will be used at a few locations where the target species and other conditions allow. Please refer to Sections 3.2 & 11.3 for more information on the ISP's Integrated Vegetation Management (IVM) strategies.

To facilitate planning, the ISP has delimited 25 site complexes (**Figure 1**) that contain a total of 177 sub-areas. Appendix 6 includes an approximate treatment area for each sub-area (based on 2013 data), and detailed maps of each site can be found on the ISP website at www.spartina.org/control/sites.htm.

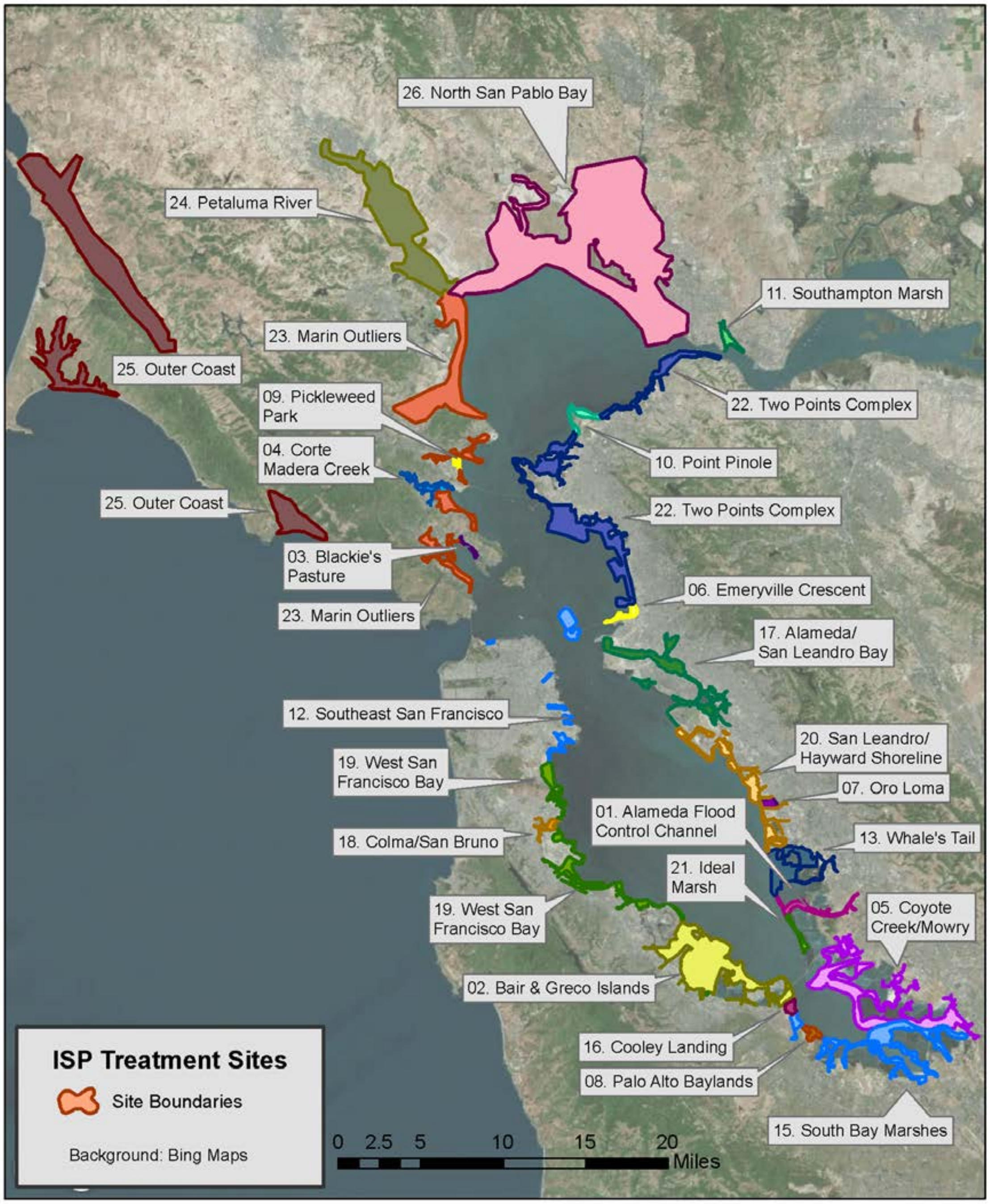

Figure 1. Locations of Invasive Spartina Project (ISP) treatment sites for 2014. Each site is comprised of 1-23 sub-areas, identified by letters (a through z) in project plans and documents.

3. Description of Target Weed Species

There is one native and four non-native species of cordgrass in the San Francisco Estuary. Pacific cordgrass (*Spartina foliosa*), the native species, is avoided during ISP's control efforts and is conserved by controlling the invasive, non-native species that can displace it. *Spartina foliosa* is particularly valued as habitat for the endangered California clapper rail (*Rallus longirostris obsoletus*), which spends most of its time foraging for food within or adjacent to the protective canopy of cordgrass. The non-native species are Atlantic smooth cordgrass (*S. alterniflora)*, English cordgrass (*S. anglica)*, Chilean cordgrass (*S. densiflora)*, and salt-meadow cordgrass (*S. patens).* Both the non-native Atlantic smooth cordgrass and Chilean cordgrass hybridize with the native Pacific cordgrass, and their offspring (referred to as hybrid *S. alterniflora* or hybrid *S. densiflora*) are highly invasive. Key aspects of the cordgrass species found in the Estuary are contrasted below. The roles these species play in their native habitats give ecologists an indication of their potential to alter the salt marsh ecosystem of San Francisco Bay.

3.1. Atlantic Smooth Cordgrass (*Spartina alterniflora*) and its Hybrids

Atlantic smooth cordgrass is unique among the world's cordgrass species in terms of its growth potential and ecological breadth. *Spartina alterniflora* is genetically very similar to *S. foliosa*, but the two species have significant differences. In size, growth rate, pollen and seed production, culm (stem) density and ecological tolerances, *S. alterniflora* is much more robust than *S. foliosa* (Smart and Barko 1978; Boyer, Callaway et al. 2000). The San Francisco Estuary population of *S. alterniflora* was introduced from seed collected in Maryland in the early-1970s to aid in a dredge spoils stabilization and marsh restoration experiment (Faber 2000). Genetic similarity to *S. foliosa* allowed multiple hybridization and eventual backcrossing events that produced the "hybrid swarm" that has posed the most widespread and intrusive threat to the Estuary (Daehler and Strong 1997). Pollen production, higher fertility, greater tolerance for both inundation and drought, and increased timeframe for flowering make these hybrids a prominent threat to native cordgrass through outcompetition, pollen swamping and hybrid assimilation (Rhymer and Simberloff 1996; Ayres, Garcia-Rossi et al. 1999; Anttila, King et al. 2000; Levin, Neira et al. 2006).

Hybrid *S. alterniflora* was well established and widely distributed in the Central and South Bay at the start of the ISP treatment program, but it was detected early and controlled more rapidly by ISP partners in the North Bay. Although a small population established on the shoreline of Southampton Marsh (Site 11) in Benicia State Recreation Area, hybrid *S. alterniflora* has not yet been detected further into Suisun Bay, despite intensive surveys. Over the years, North Bay outlier populations have been detected on the Petaluma River (Site 24), Sonoma Creek (26c), and Mare Island (26b), and single clones were found at both China Camp State Park (23o) and Sonoma Baylands (26d). Pioneering hybrid *S. alterniflora* populations have also been detected and managed at Drakes Estero, Limantour Estero and Bolinas Lagoon on the Point Reyes peninsula (Site 25). The abundance of hybrid *S. alterniflora* remains greatest in San Leandro Bay (Oakland), Robert's Landing (San Leandro), and outer Bair Island Ecological Reserve (Redwood City), but by 2013 it has been reduced by 96% baywide by the coalition of ISP partners, down to less than 33 net acres since its peak of 805 net acres in 2005.

3.2. Chilean Cordgrass (*Spartina densiflora*) and its Hybrids

Chilean cordgrass (also called dense-flowered cordgrass) is a distinctive cordgrass species native to South America that grows as a bunchgrass in the middle marsh plain, eventually forming tussocks and meadows (Spicher and Josselyn 1985; Kittelson and Boyd 1997). *Spartina densiflora* was introduced to Humboldt Bay, California in dry ship ballast containing propagules from South American ports that traded lumber (Spicher and Josselyn 1985). Believed to be a form of Pacific cordgrass for most of the 20th century, *S. densiflora* was deliberately transplanted to a salt marsh restoration at Creekside Park (ISP sub-area 4g) along Corte Madera Creek in Marin County in the 1970s. Within the salt marshes fringing Corte Madera Creek, it became a locally-dominant component of the middle and high salt marsh vegetation, displacing even robust pickleweed.

While the bulk of the *S. densiflora* invasion has been contained within Marin around the Corte Madera Creek watershed, other populations have been detected and largely eliminated in Redwood City (19s), Point Pinole Regional Shoreline (Site 10), Burlingame (19k & 19l), Tom's Point in Tomales Bay (25a), and the shoreline of San Pablo Bay National Wildlife Refuge (26b). Some of these novel population establishments appear to have been the result of active planting by anonymous parties. When established in close proximity to *S. foliosa*, *S. densiflora* has produced infertile hybrids with the native cordgrass that spread solely via vegetative growth (Ayres, Zaremba et al. 2008).

By 2012, the population of *S. densiflora* had been reduced to just 105 m^2 Estuary-wide, and only 9.8 m^2 of the hybrid between *S. foliosa* and *S. densiflora* remains, both reductions of more than 99% since the peak years for each. These successful reductions have been achieved through dedicated implementation of an adaptive Integrated Vegetation Management (IVM) strategy that includes multiple treatment methods. Because of the unique biology of this form of *Spartina*, any single-tool approach would have been ineffective. The efficacy of herbicide treatment (using imazapyr) varies widely between large plants and small plants, as well as between pioneering individuals and established stands. The seed bank viability of *S. densiflora* is estimated at 3-5 years (as compared to 1-1.5 years for *S. alterniflora*), which increases the time required for full eradication, even after an infestation is effectively reduced to just a few individuals. With these additional challenges, it is fortunate that *S. densiflora* appears to be somewhat limited in its ability to disperse around the San Francisco Bay ecosystem, and that the infestation has never approached the scale of hybrid *S. alterniflora*, which consistently responds well to imazapyr treatment and has shorter seed viability.

3.3. 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*). It was introduced to the San Francisco Estuary at Creekside Park (4g) along Corte Madera Creek in Marin County, along with Chilean cordgrass (*S. densiflora*), in 1976. Unlike Atlantic smooth cordgrass and Chilean cordgrass, this species failed to disperse from its point of introduction to expand the infestation beyond Creekside Park. It may be at or near its southern climatic limit on the Pacific Coast in the San Francisco Estuary.

Spartina anglica is nearly eradicated from San Francisco Bay, and it is not known to occur in any other location in California. The ISP mapped just 2 m^2 of *S. anglica* in 2012. There are several factors that contributed to this infestation lingering longer than might be expected given its relatively small size and presence at only a single ISP site. *Spartina anglica* flowers and sets seed in early summer, slightly later than *S. densiflora* but far ahead of hybrid *S. alterniflora*. This phenology did not allow for treatment ahead of seed dispersal prior to 2008, when ISP was first permitted to enter the sites before California clapper rail breeding season ends on September 1. In addition, there were several other years where either delayed permits (2011 and 2012 Biological Opinions) or political concerns (delays with Marin County finalizing its revised IPM Policy in 2009) caused the implementing ISP partner, Friends of Corte Madera Creek Watershed, to miss the optimal treatment window for that year. Finally, the remaining *S. anglica* at Creekside Park is often found growing as a short understory to the native *S. foliosa* that lines the main channel, which limited the full detection of the target plants, and the desire to preserve as much of the native cordgrass as possible further complicated the matter.

3.4. Salt-Meadow Cordgrass (*Spartina patens*)

In its native range on the Atlantic coast of the United States, salt-meadow cordgrass is naturally restricted to the well-drained high salt marsh and relatively moist sandy depressions at or above tidal influence. However, in the San Francisco Estuary, it has thrived along channel banks and on the pickleweed plain. *Spartina patens* arrived in the Estuary by the early 1960s in Southampton Marsh (Site 11; Benicia State Recreation Area), as evidenced by a sample present in the California Academy of Science's collection from circa 1962. At the initiation of treatment by ISP and the California Department of Parks and Recreation (State Parks), 0.65 net acre of salt-meadow cordgrass was present in large, discrete patches at Southampton Marsh. In 2012, the net cover was down to only 0.01 acre; however, the eradication work has been stalled because of complications related to the presence of three special status species.

Spartina patens has spread into an area of Southampton Marsh that supports a population of an endangered annual hemi-parasitic plant, soft bird's-beak (*Chloropyron molle* ssp. *molle,* formerly *Cordylanthus mollis ssp. mollis*). The treatment approach initially approved and used in this area of the marsh was to treat the *S. patens* stands with herbicide in the late fall, after the soft bird's beak had produced seed and senesced, so that the treatment would not negatively affect the soft bird's beak population. However, *S. patens* itself flowers in May at that location, and by the time herbicide was applied in October, the *S. patens* plants had also already produced seed and begun senescing. When a plant senesces it is no longer able to uptake and translocate the herbicide, processes that are necessary to kill the plant. It soon was clear that no additional headway was being made toward eradication of *S. patens*.

In 2011, the ISP worked with rare plant researcher Brenda Grewell (USDA-ARS) and State Parks to develop a new eradication plan to address the shortcomings of the earlier plan. The new plan would permit limited, temporary impacts to the soft bird's beak so that the *S. patens* could be treated effectively, and may include collecting and banking seed from the hemi-parasite to sow once *S. patens* has been eradicated and native host plants reestablish. Glyphosate is the herbicide used at this site to ensure that there is no residual effect on seed bank recruitment for the endangered annual plant, since glyphosate is inactivated by contact with the substrate.

However, implementation of the new plan has now been postponed because of the reappearance of California clapper rail in Southampton Marsh in 2011, after years of absence at the site. In an effort to nurture the potential new clapper rail population, State Parks and USFWS set up extensive marsh exclusion zones, including areas of *S. patens* populations, and again restricted entry for treatment until after October 1. The 2012 and 2013 breeding season surveys did not detect any clapper rail at the site, but the exclusion zones were still in effect, so it is uncertain what treatment will be conducted on *S. patens* in 2014.

4. Aquatic Herbicides, Adjuvants and Application Methods

4.1. Aquatic Herbicides Used for *Spartina* Treatment

Herbicides have proven highly effective in controlling populations of non-native cordgrasses (*Spartina* spp.). The aquatic formulation of imazapyr (Habitat® or Polaris®) was registered for use in the State of California on August 30, 2005. San Francisco Bay land managers that were engaged in their own independent *Spartina* control efforts prior to the inception of the ISP Treatment Program used aquatic glyphosate-based herbicides (Aquamaster®, Rodeo®). Imazapyr and glyphosate are the only two aquatic herbicides registered by U.S. EPA for use in the sensitive estuarine system. Although all ISP partners have since switched to imazapyr for their *Spartina* treatment, glyphosate may be utilized at a single Suisun Bay site (Southampton Marsh {Site 11] in Benecia State Recreation Area) that has special considerations discussed in Section 3.4 and in more detail below.

There are a number of qualities that make imazapyr ISP's preferred choice over the previous alternative, glyphosate. Glyphosate tends to strongly adsorb to sediment and salt particles accumulated on the *Spartina*, rendering the herbicide inactive, while imazapyr does not have these issues that can reduce its efficacy. It is common for the tides to deposit abundant sediment from turbid San Francisco Bay onto the leaves and stems of invasive *Spartina* in the adjacent mudflats and salt marshes. Glyphosate also requires significantly longer dry times to fully penetrate the cuticle of the plant and begin translocation, but the available application windows on the tidal mudflats and marsh are relatively short and don't allow for these processes to occur before the target plants are flooded again. In addition, imazapyr can be applied at lower concentrations than glyphosate, which allows for low volume applications and both reduces the amount of herbicide required as well as the amount that may run off of the plants and reach the water. For a comprehensive review of the literature regarding all aspects of these two herbicides, as well as their use to control invasive *Spartina*, please refer to Use of Imazapyr Herbicide to Control Invasive Cordgrass (*Spartina* spp.) in the San Francisco Estuary: Water Quality, Biological Resources, and Human Health and Safety (Leson & Associates 2005). This document is available on ISP's website at www.spartina.org/referencemtrl/SF-Imazapyr-EA.pdf.

4.1.1. Imazapyr.

Habitat® (EPA Reg. No. 241-426) or Polaris® (EPA Reg. No. 228-534) are solutions of 28.7% or 27.7% (respectively) isopropylamine salt of imazapyr in water, equivalent to 2 lbs. acid per gallon, and contain a small amount of an acidifier. Because Habitat® is purportedly a similar formulation to Arsenal® and this product contains acetic acid, the acidifier in Habitat® is likely also acetic acid, but this is proprietary business information that is not disclosed on the label (Leson & Associates 2005).

Imazapyr inhibits an enzyme (acetolactate synthase [ALS]) required for the biosynthesis of the three branched-chain aliphatic amino acids valine, leucine, and isoleucine. Because animals do not synthesize branched-chained aliphatic amino acids but rather obtain them from eating plants, the engineered mechanism for plant toxicity (*i.e.* the interruption of protein synthesis due to a deficiency of the amino acids valine, leucine, and isoleucine) is not generally relevant to birds, mammals, fish or invertebrates. This explains the very low toxicity presented by imazapyr to these potential receptors that is reported throughout the literature, and its U.S. EPA rating of toxicity to aquatic organisms as Category V (practically non-toxic), the lowest level on the scale.

Imazapyr is relatively slow-acting, taking several weeks for the plants to show lethal effects. However, plants cease growth within 24 hours of a successful application (Shaner and O'Connor 1991). On *Spartina*, it normally takes 2-4 weeks after treatment to see visible effects such as yellowing of the leaves, and complete plant death can take several months. In the San Francisco Estuary, with the relatively late-season applications to invasive *Spartina* (mainly because of endangered species issues that affect access to the marshes), the treated plants may not reveal much of a response before the time of natural senescence, but will simply not emerge in the spring of the following year if fully impacted by the treatment.

4.1.2. Glyphosate.

Aquamaster® (EPA Reg. No. 524-343) is an aqueous solution containing 53.8% glyphosate in its isopropylamine salt form or 4 lbs. acid per gallon, and contains no inert ingredients other than water. Glyphosate inhibits an enzyme needed to synthesize an intermediate product in the biosynthesis of the aromatic amino acids, essential for protein synthesis and to produce many secondary plant products such as growth promoters, growth inhibitors, phenolics, and lignin. Animals do not synthesize these aromatic amino acids and glyphosate therefore has low toxicity to these potential receptors (Schuette 1998). In general, glyphosate herbicides are somewhat faster acting than imazapyr herbicides. On *Spartina*, complete brown-down occurs within 7 to 21 days.

Glyphosate may be utilized at a single site in Suisun Bay (Southampton Marsh [Site 11] in Benecia State Recreation Area) for treatment of *Spartina patens*. As described above in Section 3.4, this marsh contains a population of the endangered annual plant soft bird's beak (*Chloropyron molle molle*), a portion of which is growing near or interspersed with the target *S. patens*. Although not normally an issue in the salt marsh, with rapid degradation by photolysis and twice daily tidal inundation to accelerate dilution, imazapyr does have a longer half-life in terrestrial soils and can inhibit seedling recruitment through this residual action. In order to minimize the potential for impacts to soft bird's beak, glyphosate has been used at this site as an alternative to imazapyr since it strongly and irreversibly binds to sediment, inactivating its herbicidal activity.

4.2. Degradation Byproducts

4.2.1. Imazapyr Degradation

The degradation of imazapyr in water largely mimics the pathway by which the herbicide would be mobilized at high tide after application to *Spartina* during low tide. Residual imazapyr on the plants that has not completely dried or did not penetrate the leaf cuticle will be inundated by the incoming tide and presumably solubilized. Aquatic degradation studies under laboratory conditions demonstrated rapid initial photolysis of imazapyr with reported half-lives ranging from 3 to 5 days (SERA 2004). Scientists at American Cyanamid Company, who discovered imidazolinone herbicides in the 1970s, identified four degradation products from the photolysis of imazapyr: quinolinic acid, quinolinimide, furo[3,4-*b*]pyridine-5(7*H*)-one, and 7-hydroxy-furo[3,4-*b*]pyridine-5(7*H*)-one (Shaner and O'Connor 1991). The two primary photodegradation products were rapidly degraded with half-lives less than or equal to 3 days, and eventual mineralization to carbon dioxide [CO_2] (Entrix 2003). Due to its very low vapor pressure (1.8×10^{-11} mmHg) and its ionic state in water, imazapyr is not expected to volatilize from water or soil. Imazapyr's octanol/water partition coefficient (K_{ow}) has been reported at 0.22 (log K_{ow}), reflecting its high solubility in water and low solubility in lipids, and hence low propensity to bioconcentrate. A low bioaccumulation factor (BAF) of 3 was calculated for imazapyr, which suggests a low potential for bioconcentration in aquatic organisms (Leson & Associates 2005). U.S. EPA considers compounds with a BAF less than 100 to have low bioaccumulation potential.

Degradation rates in turbid and sediment-laden waters, common to estuarine environments, are expected to be lower than those determined under laboratory conditions. In controlled field dissipation studies in two freshwater pond systems with application of 1.5 lb imazapyr a.e./acre, imazapyr rapidly dissipated from the water with first-order half-lives of 1.9 days and 12.8 days. No detectable residues of imazapyr were found in the water and sediment after 14 and 59 days, respectively (Entrix 2003). The ISP's NPDES water quality monitoring at treatment sites from 2005-2013 has found an average reduction in imazapyr in the adjacent surface water of 92-99% just one week post-treatment over the amount present in the adjacent surface water immediately after the application.

In estuarine systems, dilution of imazapyr by the incoming tide will contribute to its rapid dissipation and removal from the area where it has been applied. Studies in estuaries in Washington State examined the fate of imazapyr applied at a standard rate of 1.5 lb imazapyr a.e./acre directly to sediment. The study design was conservative because imazapyr was applied to bare mudflats with no algal or emergent vegetation intercepting the herbicide. The study measured immediate maximum concentrations of imazapyr in intertidal waters and sediment less than three hours after application and short-term concentrations between 24 and 72 hours after application. Sediment samples collected three hours after application were retrieved immediately after the first tidal wash over the area. Maximum concentrations in water and sediment were detected at 3.4 mg/L and 5.4 mg/kg, respectively. Measurable concentrations of imazapyr declined exponentially in both water and sediment, approaching the zero-asymptote at 40 and 400 hours with half-lives of <0.5 and 1.6 days, respectively. Water collected 20 and 200 feet outside the spray zone with the first incoming tide was 99% lower than the maximum water concentration at the edge of the spray zone (Leson & Associates 2005). Application of the same amount of herbicide to a stand of 5.5-foot tall *Spartina* resulted in a 75% reduction in concentrations in sediment through interception by the canopy (Patten 2003). In sum, this research suggests that imazapyr quickly dissipates in estuarine environments.

In addition, Patten observed that native salt marsh vegetation rapidly colonizes the plots treated with imazapyr after the *Spartina* plants have died, which supports the conclusion of very low persistence of imazapyr in estuarine environments. The ISP has routinely observed this phenomenon of rapid native plant colonization of treated areas at many sites around San Francisco Bay since 2005, usually involving passive revegetation by either annual pickleweed (*Salicornia europaea*), perennial pickleweed (*Sarcocornia pacifica*), or *Jaumea carnosa*.

4.2.2. Glyphosate Degradation

Under typical environmental conditions of pH 5-9, glyphosate is ionized and is readily soluble in water with a solubility of about 12,000 mg/L. Laboratory and field studies indicate that glyphosate is strongly and irreversibly adsorbed by soil, sediment, and suspended sediment, inactivating its herbicidal properties. Because glyphosate adheres strongly to particles, it does not readily leach to waters (Sprankle *et al.*, 1977 cited in Albertson, 1998), and potential movement of glyphosate to groundwater is unlikely. Glyphosate bound to the sediment in estuarine systems such as San Francisco Bay is biodegraded by microorganisms, with the primary decomposition product being aminomethylphosphonic acid (AMPA); the potential effects of AMPA are encompassed by the available toxicity data on glyphosate and glyphosate formulations (SERA 1996). Due to its negligible vapor pressure (7.5×10^{-8} mmHg) and its ionic state in water, glyphosate is not expected to volatilize from water or soil. Glyphosate's K_{ow} has been reported at 0.00033, indicating its high solubility in water, low solubility in lipids, and thus low potential to bioaccumulate.

Energetic tidal cycles and tidal currents effectively disperse bound (adsorbed) glyphosate and surfactants and dilute them in microbially-active suspended sediment. Studies of the fate of glyphosate and surfactants applied in tidal marshes and mudflats have reported that concentrations of both substances dropped below detection levels as soon as two tidal cycles (one day) to seven days (Kroll 1991, Paveglio *et al.* 1996) after application.

The photolytic half-life of glyphosate in deionized water exposed outdoors to sunlight was approximately five weeks at 100 ppm and three weeks at 2000 ppm. Glyphosate shows little propensity toward hydrolytic decomposition. Its hydrolysis half-life is greater than 35 days. It is also stable to photodegradation under visible light but photolyzes when exposed to UV radiation. Glyphosate's loss from water occurs mainly through sediment adsorption and microbial degradation. The rate of microbial degradation in water is generally slower because there are fewer microorganisms in water than in most soils. Other studies using water from natural sources determined glyphosate's half-life ranges from 35 to 63 days (Leson & Associates 2005). For all aquatic systems, sediment appears to be the major sink for glyphosate residue. A review of the literature on glyphosate dissipation applied under estuarine conditions suggests that 24 to 48 hours after applications, glyphosate concentrations in water were reduced by more than 60-fold.

4.2.3. Water Quality Impacts Relative to Degradation

These independent lines of research into the fate of imazapyr or glyphosate applied with a surfactant in tidal and other aquatic habitats suggest that potential impacts to water quality and beneficial uses of waters of the U.S. caused by spraying these herbicide mixtures in intertidal environments are likely be small and temporary. Therefore, controlled applications (i.e. following the product label instructions) of herbicides registered for use in the estuarine environment are not expected to degrade water quality, except to a very limited temporal and spatial extent.

In summary, the use of imazapyr or glyphosate combined with an aquatic surfactant to treat infestations of non-native *Spartina* results in less than significant impacts on water quality due to the rapid degradation rate and controlled application of herbicides to the target plants. Since application of herbicide would take place during low tide and low wind conditions, the herbicide would likely be absorbed by plants for a minimum of several hours following application (up to several weeks in high marsh and at certain tidal cycles), resulting in less than significant quantities of imazapyr, glyphosate or surfactants entering the water.

4.3. Herbicide Applications Methods for Invasive *Spartina*

Herbicide applications to invasive *Spartina* by the coalition of ISP partners will follow the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) label for all products employed, and the herbicide/surfactant mixture will be applied directly to *Spartina* foliage for control of this noxious weed. Treatment is timed to achieve the longest possible tidal exposure of the *Spartina* to allow the herbicide to penetrate the leaf cuticle so it is not washed off by the incoming tides (referred to as “dry time”). Therefore, ISP partners usually begin treatment on a low (ebb) or receding tide just after sunrise during the active growing season of the cordgrass (which varies by species). These measures not only maximize efficacy but also provide protection for the water quality adjacent to the treatment area, and minimize the disturbance to endangered tidal marsh species such as the California clapper rail (*Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris*). The primary route by which herbicide solution may directly contact water during invasive *Spartina* treatment is by overspray onto areas that will be covered by water on the next tide. Herbicide may also be washed off plants by subsequent tidal inundation, or potentially by precipitation (although the *Spartina* treatment occurs during the dry season for San Francisco Bay where there is little to no measurable rainfall). Applications are postponed if there is rain predicted or experienced during the necessary dry time window for the herbicide (generally 4-6 hours). Several other key aspects are factored into the timing equation. According to the California Department of Pesticide Regulation (CDPR) and the ISP Programmatic Environmental Impact Report (PEIR), herbicide applications should only be conducted when sustained winds are less than 10 mph. Hence, ISP partners emphasize the need to begin treatment at dawn on appropriate days because the afternoon winds may halt the work prematurely.

Herbicides may be applied to non-native *Spartina* from manually-transported devices (normally 3-5 gallon backpack sprayers, or smaller handheld sprayers), or from spray equipment mounted on an airboat, truck, amphibious tracked vehicle, or helicopter. The spray equipment on the airboat, truck or amphibious vehicle are essentially identical, utilizing a pump to draw the herbicide mixture from a tank reservoir (normally 25-50 gallons in capacity) through a length of hose to a spray gun where it can be dispersed onto the target plants or used to fill a backpack sprayer. Spot applications may be conducted directly from these platforms (such as in areas of soft mudflat where only an airboat can provide access) or can be performed similarly to a backpack treatment with the applicator walking out onto the marsh hauling the spray gun and hose to the location of the target plant.

Aerial application is conducted by helicopter (the imazapyr label does not allow for fixed-wing aircraft to be used) from a boom sprayer (a horizontal pipe with spray nozzles along its length, mounted to the bottom of the helicopter). Aerial broadcast application will only be employed at one ISP site in 2014, a portion of outer Bair Island Ecological Reserve known as B2 Northeast (2c.1b). The helicopter flies at a height of approximately 20-30 feet over the marsh, using on-board GPS to carefully lay down the herbicide mixture in side by side swaths over the target *Spartina* meadow. USFWS has only permitted ISP the use of seed suppression at this site to maintain high tide refugia for resident California clapper rails. A seed suppression application utilizes a dilute solution of imazapyr (normally 32 oz. per acre or less) that won't produce mortality but rather will arrest the development of the target *Spartina* so it cannot expand or disperse viable seed. ISP only conducts aerial applications when the target infestation is more than a quarter mile from sensitive receptors.

4.4. Surfactants

For most foliar applications of aquatic herbicide formulations, adjuvants must be added to spray solutions to improve the performance and minimize the variability of herbicide efficacy. Surfactants are designed to improve the spreading, dispersing/emulsifying, sticking, absorbing, and/or pest-penetrating properties of the spray mixture (Tu *et al.* 2001). The pure herbicide formulation mixed with water will stand as a droplet on the leaf surface and the small area of contact therefore provides little potential for uptake of the active ingredient into the foliage. Water droplets containing a surfactant will spread in a thin layer over a leaf surface and improve herbicide uptake by maximizing herbicide distribution and forcing the fluid into the plant. Both of the aquatic imazapyr formulations Habitat® and Polaris®, as well as the glyphosate herbicide Aquamaster®, require the addition of a surfactant for post-emergent applications such as the treatment of invasive *Spartina*.

The coalition of ISP partners evaluated a suite of potential surfactants labeled for aquatic use at the start of the Estuary-wide Treatment Program in 2005, following the recommendations of the herbicide manufacturers, Washington State University researchers, licensed California Pest Control Advisors (PCAs), and other professional vegetation managers. The resulting efficacy on hybrid *Spartina* varied widely across the spectrum of these adjuvants approved for aquatic use.

Please refer to Table A-2 (in Leson & Associates 2005; www.spartina.org/referencemtrl/SF-Imazapyr-EA.pdf) for the full list of formulations that ISP investigated.

Two surfactants labeled for aquatic use, Competitor® and Liberate®, were chosen to be used by the coalition of ISP partners, with either imazapyr or glyphosate, for applications to invasive *Spartina.* Competitor® (Wilbur-Ellis Co.) is an esterified seed oil (ESO) containing a non-ionic emulsifier system, and was recommended for use with imazapyr by the original manufacturer of the herbicide (BASF). The ingredients include ethyl oleate, sorbitan alkylpolyethoxylate ester, and dialkyl polyoxyethylene glycol. Toxicity studies classified this surfactant as a toxicity category of 3-4 ('Caution' signal word). This product strikes a good balance by combining one of the lowest relative toxicities to aquatic life of the available surfactants while consistently yielding high efficacy results. One study from Washington State concluded that the esterified seed oil surfactant tested, Competitor®, performed better than the other surfactants tested (*i.e.* Agri-Dex®, a crop oil-based surfactant, and R-11®, a non-ionic surfactant). This finding is also supported by Patten (2002) in which the author recommended using a methylated seed oil surfactant for aerial applications and for unfavorable conditions such as less than six hours of drying time before tidal inundation, or also on moist leaves.

Liberate® (Loveland Industries, Inc.) is a non-ionic, low foam penetrating adjuvant. Its active ingredients are lecithin (phosphatidylcholine, a naturally occurring lipid derived from soybeans that biodegrades readily), methyl esters of fatty acids, and alcohol ethoxylate. This product also acts as a drift retardant which aids in high-pressure hose applications, has a relatively low toxicity to aquatic life, and has been highly effective on hybrid *Spartina*. Toxicity studies classified this surfactant as a toxicity category of 3-4 ('Caution' signal word). A non-toxic blue marker dye (e.g. TurfTrax or similar) is also included in the tank mix for ground-based treatment to help the applicator get full coverage without re-treating, which ensures maximum efficacy while helping to reduce the amount of chemical entering the tidal marsh environment.

Recent studies have raised concern over a group of surfactants containing nonylphenol ethoxylate due to their moderate toxicity and suspected endocrine disruption in fish and aquatic organisms. Consequently, the ISP partners do not use any nonylphenol products, such as R-11® and ProSpreader®, for invasive *Spartina* control, although they are commonly used by other vegetation managers and are known to perform well by improving herbicide efficacy.

5. Factors influencing choice to use herbicide

The non-native *Spartina* invasion of the San Francisco Estuary is especially threatening to its native mudflats and tidal marsh systems because of hybridization of Atlantic smooth cordgrass and the native Pacific cordgrass (referred to as hybrid *S. alterniflora*). This ability to hybridize, and the documented exponential expansion rates of the population of hybrid forms throughout the Estuary, defines the need for a zero tolerance threshold on invasive *Spartina* in San Francisco Bay. The Invasive *Spartina* Project is a regionally-coordinated eradication effort that ultimately will only be fully successful if all infestations are effectively controlled and monitored down to eradication.

In comparison with ongoing annual noxious weed control programs, an eradication program such as ISP does not depend on approaching or reaching a threshold exceedance to determine whether treatment (chemical or otherwise) should be implemented in a given year. Since hybrid *S. alterniflora* is currently found nowhere else in the world, if it can be eradicated from the San Francisco Estuary there is no direct pathway for reinvasion. It also has relatively short seed viability, on the order of 1-1.5 years, allowing for a reasonable timeline to eradication over other noxious weeds that can remain viable for decades. Hybrid *S. alterniflora* is an ecosystem engineer, capable of significantly altering the hydrologic and physical structure of tidal areas where it becomes established. These impacts were readily visible throughout entire regions of the Estuary at the inception of ISP. Mudflats and channels were converted to dense *Spartina* meadows, tidal marsh plants and the fauna that depend on them were excluded by the invader, and flood control channels both large and small were clogged by the dense vegetation. Eradication is essential to protect the Estuary from these impacts and to ensure that the hybrid *S. alterniflora* does not disperse through the Golden Gate to begin these transformations of the native ecosystem at other locations along the West Coast of the U.S.

A single small, expanding clone of hybrid *Spartina* within an otherwise native *S. foliosa* matrix has the capability of 'swamping' *S. foliosa* flowers with its superior quantity of hybrid pollen, effectively converting the native stand into a hybrid-producing population. Within a couple of growing seasons, the majority of new seedlings establishing in and around that clone's footprint will be of hybrid origin, resulting in the eventual extirpation of the native *S. foliosa* from the stand. Repeated throughout the Estuary, this progression threatens the population stability of native *S. foliosa* stands while covering naturally-unvegetated areas (mudflats and tidal channels) with tall, dense stands of hybrid *Spartina*.

Therefore, where hybrid forms of *Spartina* are identified, efforts must be directed at removing ***all*** of the plants in the area. There is no acceptable level of hybrid presence in an otherwise native marsh, as the inevitable result of even a small amount of hybrid *S. alterniflora* will be the relatively rapid conversion to a non-native stand capable of infesting adjacent marshlands. Rhizomatous perennial plants such as hybrid *S. alterniflora* cannot be effectively controlled through digging. Breaking the rhizome actually stimulates vegetative growth, and without large-scale mechanical excavation of the entire soil profile to a depth of at least three feet, it is virtually impossible to remove all the roots except from seedlings that have not yet established. Proper application of an aquatic herbicide is far less damaging than any of the mechanical or cultural methods available, especially on the scale at which the coalition of ISP partners operates. Section 11 of this APAP goes into much greater detail on the full suite of treatment methods evaluated for *Spartina* eradication, as well as the development of ISP's IVM strategies that incorporate non-chemical tools where appropriate and effective.

6. Gates and Control Structures

There are no applicable gates or control structures important to the logistics of the treatment of non-native *Spartina* in the Estuary. *Spartina* is an emergent plant so herbicide applications are made directly to the leaves and stems, normally at a low or receding tide when tidal waters are not present and the plant is fully exposed.

7. Section 5.3 Exception

This APAP element in General Permit #CAG990005 does not apply to the coalition of ISP partners working on non-native *Spartina* eradication. Neither acrolein nor copper is used in the treatment of *Spartina*.

8. Water Quality Monitoring Plan (WQMP)

8.1. Monitoring Site Selection

The Water Quality Monitoring Plan (WQMP) is designed to answer the two key questions articulated by the Permit:

1. Does the residual aquatic herbicide discharge cause an exceedance of receiving water limitations?
2. Does the discharge of residual aquatic herbicide, including active ingredients, inert ingredients, and degradation byproducts, in any combination cause or contribute to an exceedance of the "no toxics in toxic amount" narrative toxicity objective?

The final list of sites for ISP's 2014 Treatment Season, and for its WQMP, can only be determined after inventory monitoring is conducted during the active growing season, since numerous sites are approaching eradication and some may not require treatment if no plants are found. ISP will collect samples from a minimum of six imazapyr application events for imazapyr in 2014. All ISP applications to non-native *Spartina* occur in the same environmental setting (tidally-influenced waters of the Estuary), which is considered flowing water. Pursuant to General Permit #CAG990005, if the results from six consecutive sampling events show concentrations that are less than the applicable receiving water trigger in an environmental setting, the ISP will reduce the sampling frequency for imazapyr to one per year in that environmental setting. If the annual sampling shows exceedances of the applicable receiving water trigger (refer to Section 8.5), the ISP will be required to return to sampling six applications the next year. Glyphosate may be used at a single site in 2014 as described above in Sections 3.4 and 4.1.2, and would therefore be monitored for that single event.

An Herbicide Application Log Form will be completed for every herbicide application to non-native *Spartina* by an ISP coalition partner, whether or not it is one of the sites to be monitored for water quality. The application log shall include the date, location, applicator name, type and amount of herbicide used, application details (e.g. start and stop times, concentration and rate), visual monitoring assessment, and certification that the applicators followed the APAP.

At the outset of ISP's water quality monitoring in 2005, four different treatment site types were identified to assist with sampling site selection to ensure monitoring was representative of the entire treatment program:

I. Tidal Marsh, Microtidal Marsh, Former Diked Bayland, Backbarrier Marsh

II. Fringing Tidal Marsh, Mudflats, and Estuarine Beaches

III. Major Tidal Slough, Creek or Flood Control Channel

IV. Urbanized Rock, Rip-Rap, Docks, Ramps, etc.

ISP will select at least one representative site from each of these marsh site types to be sampled for water quality in 2014 under NPDES General Permit # CAG990005. Sites will also be selected to represent the range of herbicide delivery systems present in the work program of the coalition of ISP partners. The 2014 Treatment Calendar will be regularly updated throughout the season as inventory is completed and work is scheduled. The calendar is posted on ISP's website at www.spartina.org for viewing by the public.

8.2. Sampling Design

The sampling events are designed to characterize the potential risk involved with herbicide applications to non-native *Spartina* relative to adjacent surface waters. Consistent with permit requirements, the monitoring program will include background/pre-treatment sampling up to 24 hours prior to the application, application event monitoring immediately post-treatment, and one-week post-application event monitoring. During background sample collection, the point will be recorded using GPS to aid ISP staff in locating the point for future sampling events. The application event samples will be collected immediately adjacent to the treatment area after sufficient time has elapsed such that treated water will be present the adjacent area on the incoming tide. Since it is standard protocol for the ISP partners to treat *Spartina* on a low or receding tide whenever possible, application event samples will often be taken 0.5-5 hours post-treatment when the tide has again flooded the site. Finally, the one-week post-treatment monitoring will be conducted when sufficient water is present at the site on the seventh day after the application. To enhance quality assurance, the ISP will be submitting at least one duplicate and one field blank to the lab over the course of the season. These will be added to either the treatment event or one-week post-treatment event since the herbicide levels in the pre-treatment samples are usually ND (not detected). It is standard for the lab to also include blanks as part of their quality control.

8.3. Field Sampling Procedures

In 2014, the Invasive *Spartina* Project will continue to conduct water quality monitoring on behalf of the coalition, as it has since 2005. Water samples will be collected using a sampling rod and pre-cleaned amber glass one-liter bottles. To collect the sample, the bottle is attached to the sampling rod with a clamp, inverted and extended out over the water at the application site, lowered to approximately 50% of the water depth (which is normally less than 6 feet), and turned upright to collect the sample. When the bottle is full it is pulled back out of the water and the cap is affixed to the mouth of the bottle. The sample is labeled in permanent ink with the sample ID number, date, time, and initials of the sampler.

The sample ID number is assigned by the following protocol: a four-letter code unique to the site, followed by the site visit number (*e.g.* 01 for pre-treatment, 02 for treatment, or 03 for one-week post-treatment), followed by the time since the application (*e.g.* "pre" for the baseline sample, the number of hours since the application for the treatment sample, or "1w" for the one-week post-treatment).

8.3.1. Equipment Calibration

Temperature, electrical conductivity, salinity, and dissolved oxygen will be measured in the field with a portable YSI Model 85 (Yellow Springs Instruments Inc., Ohio, USA), while pH will be measured with an Oakton waterproof pHTestr1 (Oakton Instruments, Illinois, USA). To assure accurate and reliable temperature, electrical conductivity, salinity, and dissolved oxygen measurements, the YSI Model 85 meter will be calibrated, operated, and maintained in accordance with the manual specifications found at http://www.ysi.com/media/pdfs/038503-YSI-Model-85-Operations-Manual-RevE.pdf. To assure accurate and reliable pH measurement, the pHTester 1 meter will be calibrated, operated, and maintained in accordance with the manual specifications found at http://www.4oakton.com/Manuals/pHORPIon/WPpHTestr1_2mnl.pdf.

8.3.2. Field Data Sheets

At each sampling location, the sample ID number, the time of the sampling, the sample depth, and the water temperature, pH, dissolved oxygen, conductivity, and salinity measurements, will be entered on a Field Data Collection Form ("FDCF", **Appendix 2**). Also recorded on the FDCF will be site information, including the site ID number, the station location (application point, upstream, downstream), station type (reference, treated), wind conditions, tidal cycle, water color, and the type of herbicide and surfactant that might be present. Any other unusual conditions or concerns will be noted, and any fish, birds, or other wildlife present will be recorded. The FDCFs will be dated and numbered consecutively for each site on that date. Data from these field forms will be entered into an electronic spreadsheet for processing, and the FDCFs will be compiled into a data log and kept permanently in the ISP office.

8.3.3. Sample Shipment

Following collection, water samples will be stored on ice packs and shipped for priority overnight delivery to the Pacific Agricultural Laboratory in Portland, OR. If samples are not shipped until the following day, they will be stored in a cooler on ice until they can be transferred to a refrigerator, and subsequently transferred back into a cooler for shipping. A chain of custody (COC) form is completed by the ISP biologist and included in the shipping cooler. Upon receipt of the cooler the laboratory sends an email to ISP listing the samples that were received and documenting any problems such as a broken bottle, if applicable.

8.4. Sample Analysis

Sample analyses will be conducted at a laboratory certified by the California Department of Public Health in accordance with California Water Code section 13176. The ISP anticipates that it will continue to utilize the analytical services of Pacific Agricultural Laboratory that has conducted their analyses since 2010. The samples will be analyzed within the appropriate holding times for imazapyr (extracted within seven days, analyzed within 21 days of extraction) or glyphosate (within 14 days). Results are reported as parts per billion (ppb), equivalent to μg/L. The analytical method used for imazapyr is EPA 8321B in which the extracts are analyzed using liquid chromatography with mass spectroscopy (LC/MS) detection, with a Limit of Quantitation (LOQ) of 0.1 ppb (the minimum detectable level of the analytical method). Glyphosate is analyzed using EPA method 547 (High Performance Liquid Chromatography with post column derivatization using orthophthalaldehyde [OPA] and fluorescence), with a reporting limit of 5ppb, and for its primary metabolite AMPA, 10ppb. The lab runs one blank each time it conducts an analysis (minimum of one sample tested per batch, maximum of three). Results will be reported at the end of the season to the State Water Quality Control Board and placed on the ISP's website for public viewing.

8.4.1. Assessment of Field Contamination

To help assess contamination from field equipment, ambient conditions, sample containers, transit, and the laboratory, a field blank will be collected and submitted for analysis on a regular basis. Field blank samples will be obtained by pouring distilled water into a sampling container at the sampling point.

8.4.2. Lab Quality Control & Data Quality Indicators

Each season, the contracted analytical laboratory (lab) is required to provide a Quality Assurance Plan (QAP) that meets USEPA standards prior to initiating analysis. The lab plan specifies the method of analysis to be used, and describes any variations from standard protocol. ISP staff will review the lab QAP and determine if it is adequate.

At a minimum, the following DQIs will be required for the lab:

Criteria	*Method*	*Indicator Goal*
Accuracy of measurement	Analyze matrix spikes and spike duplicates	1 matrix spike per 10 samples (10%) > 65% @ 2.0 ug/L
Agreement between measurements	Analyze lab duplicates and/ or matrix spike duplicates	Relative percent difference < 25%
Completeness	Percent of usable data (completed/submitted)	95% return
Comparability of results	Standard reporting units	All data reported in micrograms per liter (ug/L) or parts per billion (ppb)
	Use of standardized analysis methods	Standard method used if possible, any modifications identified, described, and supported.
Detection Limits	Limit of Quantitation	LOQ </= 0.1 ppb

The lab QAP submitted for 2014 is attached as **Appendix 4**.

8.5. Receiving Water Monitoring Triggers

In the new Statewide General NPDES Permit for Aquatic Weed Control (#CAG990005), the State Water Resources Control Board describes new Receiving Water Monitoring Triggers. In the absence of Receiving Water Limitations or other adopted criteria, objectives or standards for imazapyr, the State Water Board used data from the U.S. EPA Office of Pesticides Ecotoxicity Data-base to develop Receiving Water Monitoring Triggers to protect all beneficial uses of the receiving water. Toxicity studies were reviewed and a monitoring trigger was set at one-tenth of the lowest LC_{50} (lethal concentration that killed 50% of a test species in laboratory toxicity tests) for the most sensitive freshwater aquatic species. The most sensitive species in this review of the literature by the Water Board was rainbow trout, with a 96 hour LC_{50} of 112 mg/L; consequently, the monitoring trigger was set at 11.2 mg/L (11,200 ppb). However, according to the language in the proposed permit, exceeding the monitoring trigger does not constitute a violation of this General Permit but rather requires the Discharger to perform certain specified actions including additional investigations and enhanced Best Management Practices (BMP's). Based on the past nine years of water quality monitoring, the coalition of ISP partners does not anticipate that residues from applications of imazapyr to eradicate invasive *Spartina* will ever reach this new trigger. The four-year mean imazapyr concentration found in a treatment event sample from 2007-2010 was 0.06 mg/L (60 ppb), more than two full orders of magnitude below this new standard, and results from the past three treatment seasons have been consistently lower yet. Glyphosate only has a receiving water limitation (700 ppb) for municipal or domestic water supplies, which do not apply to the salt water of the open Estuary where *Spartina* grows.

9. Procedures to Prevent Sample Contamination

The collection of water samples for analysis of herbicide concentration will never be conducted by one of the applicators but rather by an ISP biologist after the treatment equipment has left the site. New disposable gloves will be worn for each sample collection. All reusable sampling equipment (e.g. sampling pole, clamp, etc.) will be thoroughly rinsed after each collection and air dried. In the unlikely event that more than one sampling event must occur in a given day, the reusable sampling equipment will be rinsed with distilled water before travelling between sites, and new gloves will be worn. The one-liter amber glass bottles are shipped to ISP directly from the lab and are certified clean.

10. Applicable Water Quality Best Management Practices

10.1. Spill Prevention and Containment

The following mitigations were identified in the ISP's Programmatic Environmental Impact Report/Statement (PEIR/S). These mitigations will be implemented at all herbicide treatment sites and verified by ISP staff.

IMPACT WQ-1: Degradation of Water Quality Due to Herbicide Application

MITIGATION WQ-1: Herbicides shall be applied directly to plants and at low or receding tide to minimize the potential application of herbicide directly onto the water surface, as well as to ensure proper dry times before tidal inundation. Herbicides shall be applied by a certified applicator and in accordance with application guidelines and the manufacturer label. Applications will not be conducted when sustained winds are greater than 10 mph to minimize drift. The Treatment Program shall use adaptive management strategies to refine herbicide application methods to increase control effectiveness and reduce impacts.

IMPACT WQ-2: Herbicide Spills

MITIGATION WQ-2: Herbicides shall be applied by or under the direct supervision of trained, certified or licensed applicators. Storage of herbicides and adjuvants/surfactants on-site shall be allowed only in accordance with an approved spill prevention and containment plan; on-site mixing and filling operations shall be confined to areas appropriately bermed or otherwise protected to minimize spread or dispersion of spilled herbicide or surfactants into surface waters. Mixing and filling normally occurs on a levee or other upland area adjacent to the marsh.

No containers of herbicide larger than the standard 2.5 gallon jugs are used by ISP partners. A spill response plan must be in place in the event of an accidental discharge, to ensure that herbicide does not reach the marsh or surface waters.

IMPACT WQ-3: Fuel or Petroleum Spills

MITIGATION WQ-3: Fueling operations or storage of petroleum products shall be maintained off-site, and a spill prevention and management plan shall be developed and implemented to contain and clean up spills. Transport vessels and vehicles, and other equipment (e.g., mowers, pumps, etc.) shall not be serviced or fueled in the field except under emergency conditions; hand-held gas-powered equipment shall be fueled in the field using precautions to minimize or avoid fuel spills within the marsh.

In addition to these water quality mitigation measures, each ISP coalition partner agency and its contractors are required to have an acceptable Site Safety and Materials Handling Plan (**Appendix 5**). Spills will be cleaned up according to the FIFRA label instructions for the herbicide, and all equipment used to remove spills (e.g. absorbent pads, kitty litter, etc.) will be properly disposed.

10.2. Ensuring an Appropriate Application Rate

The ISP worked with the original manufacturer of imazapyr (BASF), as well as Pest Control Advisors (PCA) licensed by the California Department of Pesticide Regulation (CDPR), to identify the most effective herbicide concentrations and rates for use on the various forms of non-native *Spartina* from the available herbicide delivery systems (e.g. backpack, truck, etc.). A PCA prepares an annual written Pest Control Recommendation (PCR) based on the FIFRA product label (imazapyr or glyphosate) for the coalition of ISP partners to follow for their treatment. All herbicide applications to non-native *Spartina* by the coalition of ISP partners will be conducted by trained personnel under the supervision of a person holding a CDPR Qualified Applicator License (QAL) with an aquatic endorsement. ISP biologists accompany all treatment crews to track back to the previously mapped non-native *Spartina* displayed on their GPS unit, to ensure thorough herbicide coverage on the target plants, to assist with hybrid identification to preserve the native cordgrass, and to enhance sensitivity around endangered species such as the California clapper rail.

10.3. Educating Applicators in Avoidance of Potential Adverse Effects

All applicators for the coalition of ISP partners are trained in the safe mixing and application of herbicides, and follow the FIFRA product label requirements for the Personal Protective Equipment (PPE) that should be worn to reduce exposure. Applications are not conducted when sustained winds exceed 10 mph, and it is routine for trained applicators to be cognizant of the wind direction to avoid drift onto themselves, other people present in the marsh, or onto non-target vegetation.

Fortunately, both imazapyr and glyphosate (the only two herbicides available for use on non-native *Spartina* in an estuarine system) have excellent toxicology profiles with regards to human health and safety. All relevant exposure pathways have been studied including dermal, inhalation, oral ingestion and ocular. A comprehensive review of the available literature on both herbicides was synthesized in Use of Imazapyr Herbicide to Control Invasive Cordgrass (*Spartina* spp.) in the San Francisco Estuary: Water Quality, Biological Resources, and Human Health and Safety (Leson & Associates 2005). The review includes the exhaustive human health risk assessment for application of imazapyr in forestry applications that was contained in the 2004 SERA report. This document is available on ISP's website at www.spartina.org/referencemtrl/SF-Imazapyr-EA.pdf. Mild eye irritation can result from accidental splashing during mixing, but this effect can be minimized or avoided by wearing the proper eye protection.

10.4. Coordination to Protect Water Supplies

Treatment of non-native *Spartina* by the coalition of ISP partners occurs entirely within the salt water environment of the Estuary. *Spartina* is by nature an estuarine species and does not grow in fresh water. There are no diversions for irrigation, drinking water, or domestic stock water that could be impacted by *Spartina* treatment in the Estuary.

10.5. Preventing Fish Kill from Aquatic Herbicide Applications

Both imazapyr and glyphosate are very low toxicity to fish, posing virtually no risk of resulting in a fish kill. In addition, these herbicides are normally applied to non-native *Spartina* on a low or receding tide when water is not present, so residual amounts that may reach the water on the returning tide are small and rapidly diluted. The application to species of submersed aquatic plants in a closed system (pond or lake) can cause indirect fish kills through depletion of dissolved oxygen used up by decomposers breaking down the treated plant material. This is not possible for emergent plants such as *Spartina*, and the Estuary is an open system with twice daily tidal exchange of its waters.

11. Evaluation of Alternate, Non-Chemical Control Methods

The Conservancy and USFWS evaluated a no action alternative and a full range of treatment methods as part of the CEQA and NEPA project review (USFWS & SCC 2003). The evaluation considered the effects of the treatment methods on water quality, hydrology, biological resources, air quality, human health and safety, visual resources, cultural resources, socioeconomics, and cumulative impacts, as well as the expected effectiveness, cost, and feasibility of applying the method under the specific conditions of this project. Several non-chemical treatment methods, including hand-pulling, manual and mechanical excavation, dredging, mowing, burning, pruning, flaming, crushing, and covering/tarping were evaluated along with herbicide treatment[1]. The evaluation assessed three alternative approaches for achieving regional eradication of invasive *Spartina*, including a "no action" alternative, a "no chemical" alternative, and an alternative that used all available control methods in an Integrated Vegetation Management approach. The integrated management approach was selected as the preferred alternative, as the strategic use of herbicide was considered necessary to achieving control and eradication of invasive *Spartina*, and because in many situations, herbicide was determined to be less damaging to the environment than manual or mechanical control, as discussed below.

11.1. No Action Alternative

Under the no action alternative evaluated under CEQA, the Conservancy and USFWS would not implement regionally-coordinated treatment to control invasive *Spartina* in the San Francisco Bay Estuary, and instead, local agencies and landowners would continue, as they had been, to implement control measures on their own properties. This alternative was not selected due to the overwhelming evidence of the threat posed by uncontrolled non-native *Spartina* in the Estuary. The loss of mudflat from the conversion to monotypic hybrid *Spartina* marsh destroys intertidal foraging habitat for shorebirds (Stralberg et. al., 2004). It also shifts the benthic invertebrate group from surface feeders available to birds and other consumers to belowground feeders that are unreachable (Neira et. al. 2005). The domination of both tidal marsh and mudflat alike by hybrid *S. alterniflora* results in a loss of biodiversity, both in terms of native marsh plants and the wildlife they support, as well as reducing the benthic invertebrate biomass (foundation for the estuarine food web in mudflats) by greater than 70% (Levin et.al., 2006; Brusati and Grosholz, 2006).

Destruction of habitat can have ripple effects throughout the system; loss of perennial pickleweed (*Sarcocornia pacifica*) directly impacts species that depend on this plant, such as the endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) for which pickleweed is both the primary food source and preferred habitat. There are several other special status species that are vulnerable to these same changes in the composition of the tidal marsh plant community, including California black rail (*Laterallus jamiacensis coturniculus*), three subspecies of song sparrow (*Melospiza melodia pusillula, M.m. maxillaris* and *M.m.samuelis*) and saltmarsh common yellowthroat (*Geothlypis trichas sinuosa*) all of which are year-round tidal marsh residents. Established stands of hybrid *Spartina*, widely recognized as ecosystem engineers, are also capable of altering the hydrology within marshes as the dense vegetation accretes sediment over time, clogging channels used as foraging corridors for clapper rails and other animals. The potential impacts of inaction detailed above are clearly unacceptable outcomes, especially when

1 At the time of the initial Programmatic EIS/EIR, the only herbicide evaluated for use was an aquatic formulation of glyphosate, as that was the only herbicide permitted for use in the estuarine environment. A subsequent addendum in 2005 evaluated the use of imazapyr herbicide (e.g., Habitat®, Polaris®), and found it to have lower potential environmental impacts than glyphosate.

effective tools to combat these issues have been developed and the substantial investment in ISP has shown so much progress towards accomplishing the goal of eradication.

As detailed in Section 5 of this APAP, the ability of the non-native cordgrass to hybridize with the native, and the documented exponential expansion rates of the population of hybrid forms throughout the Estuary, defines the need for a zero tolerance threshold on invasive *Spartina* in San Francisco Bay. A single small, expanding clone of hybrid *Spartina* within an otherwise native *S. foliosa* matrix has the capability of 'swamping' *S. foliosa* flowers with its superior quantity of hybrid pollen, effectively converting the native stand into a hybrid-producing population. Within a couple of growing seasons, the majority of new seedlings establishing in and around that clone's footprint will be of hybrid origin, resulting in the eventual extirpation of the native *S. foliosa* from the stand. Therefore, where hybrid forms of *Spartina* are identified, efforts must be directed at removing *all* of the plants in the area. There is no acceptable level of hybrid presence in an otherwise native marsh, as the inevitable result of even a small amount of hybrid *S. alterniflora* will be the relatively rapid conversion to a non-native stand capable of infesting adjacent marshlands.

11.2. Prevention

The four species of non-native *Spartina* that are the targets of the treatment efforts of the coalition of ISP partners are long-established in the San Francisco Estuary. One species was introduced in the 1960s (*S. patens*), while all three of the others were introduced in the mid-1970s. Only *S. densiflora* is present in any other location in California (Humboldt Bay), so there is currently no direct invasion pressure for any of the four species, and once eradicated there is consequently little chance of reinvasion. The best way to prevent new invasions is to successfully reach the goal of eradication by implementing the treatment described throughout this APAP and in other ISP planning documents. In addition, ISP biologists, partners and contractors take great care to ensure that they are not vectors dispersing the infestations from one site to another. This mainly entails thorough washing of all gear and treatment equipment upon leaving a site to eliminate the possibility that seeds or other propagules are transported to areas free of infestation.

11.3. Mechanical Methods

11.3.1. Hand-pulling and manual excavation

Manual removal methods are the simplest technology for removal of cordgrass. Manual removal includes pulling cordgrass seedlings out of soft marsh sediments or using hand tools such as spades, trowels, mattocks, or similar tools to excavate larger plants. Manual removal methods are effective primarily at removing aboveground plant parts, or the discrete root system of *Spartina densiflora*, but are much less effective at removing rhizomes (the horizontal underground stem that sends out roots and shoots from buds) from perennial species like hybrid *Spartina alterniflora* that rapidly regenerate shoots. Unless digging removes the entire marsh soil profile containing viable rhizomes and buds, its effect is equivalent to pruning (see Section 11.3.3). The vigor with which remaining rhizomes resprout and regrow is often proportional to the severity of the disturbance. Frequent re-digging and maintenance is needed to attempt to exhaust rhizome reserves of energy and nutrients, and reduce the population of buds capable of resprouting.

For hybrid *Spartina alterniflora*, the main target plant, manual removal is only effective on isolated seedlings, or very young discrete clones (asexually reproducing colonies of cordgrass). Manual excavation in tidal marshes is extremely labor-intensive. Most cordgrass colonies occur in soft mud, where footing needed for digging is impossible or hazardous. Dug plants with roots left in contact with moist soil may retain viability and regenerate in place or disperse on high tides to establish new populations, so heavy bags of the removed vegetation and substrate must be hauled manually from the site for proper disposal. This would entail repeatedly traversing the marsh plain carrying or otherwise transporting the material, which would be damaging to the native marsh plant community and increase the potential disturbance to the wildlife at the site. In addition, it would be prohibitively expensive.

As the invasive *Spartina* populations are reduced, the ISP has increased its use of manual removal methods as part of an IVM strategy that reduces reliance on herbicide where other methods are found to be effective. Manual removal is really only practicable on *Spartina densiflora*, the second most common invasive cordgrass species in the Estuary, which behaves as a discretely-rooted bunchgrass as opposed to the deeply-rooted rhizomatous clones of the main problem species, hybrid *Spartina alterniflora*. The infestations of *S. densiflora* occur mainly in Marin County with the exception of a few outlier populations in Contra Costa and San Mateo Counties. Many tons of *S. densiflora* have been removed manually over the years, and as of 2014 virtually all of the *S. densiflora* infestations that remain around the Bay are managed with purely manual methods to complete the eradication.

11.3.2. Mechanical excavation, maceration and dredging

Mechanical removal in marshes uses equipment specially designed for working in semi-terrestrial, semi-aquatic wetland environments. Excavation and dredging are accomplished using (1) amphibious dredges fitted with excavators, clamshells, or cutterhead dredges, or (2) excavators working from mats (large wood pile supports placed flat on geotextile fabric placed over the marsh surface). Some locations could allow use of conventional shallow-draft, barge-mounted dredging equipment working within reach of the marsh from the margins of navigable channels, particularly at high tide.

Mechanical excavation working to the full depth of the rhizome system (up to three feet) in tidal marshes has the potential to be significantly more effective than manual excavation. Similarly, maceration techniques that almost completely destroy both aboveground and belowground living mass of cordgrass have high potential effectiveness. However, both techniques also have significant limitations in the San Francisco Estuary. Excavators working from levees have an inherent limitation of short reach or access distance, usually a working distance of less than 20 feet for the size equipment that typical levees could bear. Floating barges with clamshell or cutterhead dredges, in contrast, would need to work at high tides within about 70 feet of the leading edge of cordgrass vegetation, but treatment in the endangered clapper rail and salt marsh harvest mouse habitat is supposed to be conducted at low tide to reduce the potential for disturbance. Excavators have sufficient reach to dispose of excavated marsh soil and biomass in non-wetland areas, on levees, or in aquatic habitats such as salt ponds, which lack vegetation.

Heavy equipment often is used within the Estuary's tidal marshes for purposes other than eradication of cordgrass, including removal of large debris hazards and contaminated materials, and construction or maintenance of ditches or canals. Most of this work is done on mats, to distribute the weight of equipment and protect underlying vegetation. These actions are usually aimed at operations that are highly localized (points or narrow alignments) in the marsh, and usually on the relatively firm marsh plain. Even there, equipment may become mired in soft substrate, and removal of mired equipment can damage the marsh. In contrast to this maintenance work, removal of invasive cordgrass involves a randomized, mosaic pattern, and occurs most often in the low marsh and mudflats which do not easily support mats and geotextile fabrics. Thus, control methods based on excavators working on mats would be most applicable to localized, large patches of invasive cordgrass on the marsh plain. Some tidal flats invaded by cordgrass occur on sandy deltas with intertidal sand bars (e.g., San Lorenzo Creek) where equipment could be staged, but this situation is unusual. The feasibility of using mechanical excavation or dredging methods at a particular location would be determined based on site-specific conditions.

Aside from the feasibility of these scenarios listed above, excavation or maceration with heavy equipment has been evaluated by ISP partners as simply too damaging to the sensitive estuarine ecosystem, resulting in long-term alterations and scars. If the marsh plain is excavated down to the full depth of the rhizome system of hybrid *S. alterniflora*, the micro-elevation of that area has been reduced for many years until sufficient sediment can accrete and native plants can establish at an appropriate level of tidal inundation. The disturbance from excavation is also likely to increase erosion by removing the anchoring effects of the vegetation, and can have short-term water quality impacts from the suspended sediment released. When large-scale invasive *Spartina* control is evaluated for the most appropriate method, the use of aquatic herbicide presents a far lower impact than excavation or maceration.

11.3.3. Mowing, burning, pruning, and flaming

Cordgrasses (as well as most other perennial grasses) are well adapted to disturbances that "crop" or otherwise remove aboveground biomass because they have evolved with a variety of herbivores. A single event that removes living aboveground cordgrass biomass generally stimulates cordgrass growth, and as soon as a cordgrass stand can generate leaves and resume photosynthesis, it begins to recharge its roots and rhizomes with new food reserves. If vegetation is removed with frequency, roots and rhizomes may be prevented from regenerating reserves of energy and nutrition and eventually cordgrass may be killed as its organs of regeneration and storage become exhausted, however this could take many applications throughout the growing season to be successful. If the cordgrass is mown close to the mud surface, it also severs the connections in the leaves (the aerenchyma) that transport oxygen down to roots growing in anoxic, waterlogged sediment, and this could further stress the plant.

Repeated close mowing may be used to increase physiological stress to a point that cordgrass cannot regenerate; frequent burning would have similar effects. The use of pruning, burning, and mowing for cordgrass eradication in open mudflats and marshes would require very frequent treatment of all aboveground growth until the cordgrass rhizome/root systems become exhausted. It is really not practicable, given the challenging conditions found in the tidal ecosystem and entry restrictions to protect breeding endangered species, to return multiple times throughout the growing season to repeatedly implement these measures frequently enough to result in eradication.

For robust stands of hybrid *S. alterniflora*, mowing has never been found to be an effective eradication tool, so there is no way to know how many times the technique would have to be implemented to reach the goal. However, mowing has been effectively implemented by ISP as part of their IPM strategy for the eradication of *S. densiflora*. Unlike the other native and non-native *Spartina* present in the Estuary, this species of cordgrass does not lose all of its above-ground biomass each year during senescence, so stands that were previously treated with herbicide but did not die fully are restricted from producing enough new green growth to accept another application the following year. Mowing was used to stress the plants and to remove the standing biomass so the status of each plant could be evaluated and an appropriate follow-up treatment implemented where necessary. This method was implemented on several meadow infestations of *S. densiflora* from 2008-2011, and was so successful that it could be discontinued entirely in 2012 in favor of manual removal of the remnants of the greatly-depleted infestation.

Controlled burning could be used in some situations to remove vegetation prior to other treatments, or to prevent pollen and seed dispersal in founder colonies invading new sites. Burning would be used only in suitable locations, and only during periods of low-wind conditions (normally early morning), when fire hazards in succulent vegetation of tidal pickleweed marshes would be manageable. Ignition, however, may be difficult in cordgrass stands on mudflats, and there is likely to be significant collateral damage to other marsh vegetation and potentially to endangered species that call these systems home.

Selective pruning (partial mowing with weed-whackers or flaming with hand torches) may be used to remove flowerheads and seedheads of discrete clones of hybrid *S. alterniflora* to prevent flow of pollen from contaminating seed production of native cordgrass, and to prevent seed production within founding colonies. However, pruning would have little or no effect on the clone's growth rate and must be followed up with other methods to control spread. Mown vegetation without viable seeds or propagules may be left in place or removed from the site. Vegetation containing viable seeds or propagules would require removal from the treatment site and disposal in a suitable area not conducive to cordgrass growth.

11.4. Cultural Methods

11.4.1. Tarping (Solarization)

Tarping (solarization) is intended to exhaust the energy reserves in perennial cordgrass roots and rhizomes and increase the environmental and disease stress on the plants. This typically involves securing opaque geotextile fabric completely over a patch of cordgrass with long wooden stakes. This excludes sunlight essential to photosynthesis and bakes the covered cordgrass under a tent of high temperature and humidity. The geotextile fabric chosen for *Spartina* treatment must be very thick and composed of a material that is inert to biological degradation (e.g. Mirafi FW 700). Lighter woven fabrics are readily degraded by ultraviolet light, salt water, and the physical action of the tides, shredding the material into many smaller fragments that can be dispersed on the tides.

This technique may be used for discrete clones on relatively firm substrates where the geotextile fabric can be fastened to the marsh plain securely with stakes for a sufficiently long period of time (up to two years if maintained continually in place). High tides, high winds, and tide-transported debris common in tidal marshes often make this method difficult or impossible to implement. Care must be taken to cover the entire clone, as well as an additional buffer around this footprint to account for vegetative expansion. If rhizomes spread beyond the reach of the blanketing cover, rhizome connections to exposed, healthy stems can translocate nutrients and oxygen to the starving connected portions of the clone under the fabric, and increase overall survival. Tarps must be visited regularly to be repaired and re-secured, which is not feasible or economical on a large scale. Securely staking geotextile on soft mudflats is virtually impossible, making this method infeasible for most situations at this elevation.

Unlike the judicious use of an aquatic herbicide, or small-scale manual removal, tarping hybrid *Spartina* has greater impacts to the immediate area of the tidal ecosystem where it is employed. Restricting photosynthesis and heating the plants and the wet substrate not only kills the target plant but inflicts collateral damage to all of the other plants in that footprint, destroys the native seed bank in the sediment, and kills beneficial soil organisms such as mycorrhizal fungi. Once the tarps are removed it may take years for the area to be sufficiently recolonized to resemble the marsh plant and soil community present before the treatment.

11.4.2. Flooding and draining

Flooding and draining techniques entail constructing temporary dikes or other structures (or in some cases simply closing existing flood control gates) to impound standing water or remove water to kill emergent vegetation. Cordgrasses are intolerant of permanent flooding as well as dry conditions, and are generally absent in the diked nontidal salt marshes of the Estuary. Salt evaporation ponds, managed waterfowl ponds, and completely diked pickleweed marsh exclude cordgrasses, native and non-native alike. Atlantic smooth cordgrass and English cordgrass are capable of invading tidal marsh pools (salt pans) subject to irregular tidal influence (Campbell et al. 1990), but they are not likely to survive in typical diked wetlands.

When tidal marshes are diked and drained rather than flooded, they undergo rapid physical and chemical changes. Organic matter decomposes when microbes are exposed to air; clays shrink when dewatered; and sulfides formed in oxygen-free mud transform to sulfates forming strong acids (Portnoy 1999). Therefore, diking and draining, although conceivably effective for killing cordgrass, would adversely impact marsh soil chemistry and structure, and the longer salt marsh soils are dike/drained the more difficult these adverse soil changes would be to reverse. For these reasons, diking and draining only would be used in a critical situation where no other method is feasible, and only after careful evaluation and planned mitigation. Diked salt marsh soils that remain permanently flooded undergo relatively slower and less significant changes. Diked flooded salt marshes would eliminate existing standing vegetation, but are readily re-colonized by young salt marsh vegetation if the diking is brief.

Isolating the treatment area for flooding or draining may be accomplished by constructing temporary dikes or by closing openings in existing dikes. Temporary constructed dikes need not be large to accomplish this form of treatment. Low earthen berms (about one foot above marsh plain elevation), constructed using low-ground pressure amphibious excavators, could be built around large colonies of cordgrass within open marsh plains. Alternatively, water-filled geotextile tubes ("inflatable dams"), analogous with inflatable cofferdams used in aquatic construction/dewatering operations, may be used. Upon completion of treatment, berms would be graded down to marsh surface elevation, and inflatable dams removed. Temporary dike structures may be difficult to construct in tidal mudflats. Mudflat sediments are usually too soft to "stack" into berms, and firmer material placed on fluid or plastic muds simply subsides into the flats. Similarly, inflatable dams may not be feasible for softer tidal flats.

Many populations of non-native cordgrasses have invaded marshes restored by breaching dikes. In these situations, a dike-enclosed tidal marsh could be temporarily re-closed ("choked") by placing a sheetpile barrier in the existing breach, thus creating a temporary lagoon and effecting mass cordgrass eradication. Water control structures (adjustable tidegates) may be installed to enable marsh managers to maintain water depths lethal to cordgrass, suitable diving duck habitat, and adequate water quality. Marsh recolonization is expected to proceed rapidly following restoration of tidal flows.

An alternative form of treatment, intermediate between flooding and draining, would be to combine impoundment of water with deliberate solar evaporation, creating hypersaline lagoons. Hypersaline conditions would make the habitat transformation even more rapidly lethal for invasive cordgrass, but also for all of the native tidal marsh plants. In addition, restoring tidal flows to temporary salt ponds would require dilution of brines so they would not poison the Estuary after breaching, which could increase the already high cost of these methods, making them infeasible for ISP.

11.5. Biological Control

There are two main reasons why biological control agents are not an option for incorporation into ISP's IVM strategy. As described above, ISP is an eradication program and even the most effective biological agents simply control the population of the target plant. It is not in the best interest of the biocontrol to remove the entire noxious weed population lest it lose its only food source. The populations of the biocontrol and noxious weed normally reach a balance and then cycle up and down, keeping the target plant in check but never fully eliminating it. Second, biocontrols are not normally so specific that they won't feed on other plant species in the same genus as the target. There are thousands of acres of native *Spartina foliosa* throughout the Estuary, and the primary target of the coalition of ISP partners is actually a hybrid with the native cordgrass and the introduced *Spartina alterniflora*. If a biocontrol was determined to be effective on the hybrid, it would likely feed on the native too, presenting an unacceptable scenario for tidal marsh conservation in the Estuary.

Biocontrol agents were fully investigated to manage non-native *Spartina* in Washington State where there is no native cordgrass. The planthopper *Prokelisia marginata* showed some promise but researchers were never able to maintain sufficient populations from year to year to achieve widespread control. Interestingly, *Prokelisia* found on *S. foliosa* in the San Francisco Estuary were introduced to Willapa Bay in 2000 and Puget Sound in 2003. Obviously this insect was already present in the Estuary and did not apparently have any significant impact on the rapidly expanding hybrid *Spartina* population.

11.6. Herbicide

The application of aquatic herbicide (specifically imazapyr) was evaluated in ISP's Programmatic Environmental Impact Report against the full suite of available treatment methods for *Spartina* and was identified as having the lowest impact to the tidal ecosystem while also having the highest efficacy. The unacceptable impacts of implementing the various other treatment methods on an Estuary-wide scale have been addressed above in Sections 11.3 and 11.4. Imazapyr is very effective on hybrid *Spartina alterniflora*, *S. anglica*, *S. patens* and hybrid *S. densiflora*, often resulting in 100% elimination of individual plants (up to moderate-sized clones) in a single application. When successful, the results are permanent and no further follow-up treatment is required to maintain the eradication of a given plant. Herbicide is also the most cost-effective alternative, especially on the scale required by the coalition of ISP partners to tackle the non-native *Spartina* problem.

While imazapyr was found to be effective on previously-untreated mature *S. densiflora*, efficacy was extremely variable on established meadows, previously-treated plants, and especially on seedlings and small plants. The reasons for this variable efficacy are still unclear, but ISP learned to adapt its treatment in response, and developed an IVM strategy using a combination of methods to achieve *S. densiflora* eradication. Herbicide was then only used at two sites to arrest the development of the plant and stop seed dispersal until after California clapper rail breeding season had ended and mowing or digging could be implemented with reduced disturbance.

11.7. Least Intrusive Treatment Method

The ISP was created by the State Coastal Conservancy and USFWS to preserve native tidal wetlands and mudflats, and to enable large-scale restoration, such as the South Bay Salt Pond Restoration, to proceed. The choice of treatment methods and development of adaptive IVM strategies place a high value on minimizing or eliminating negative impacts to the tidal ecosystem. The presence of endangered species such as the clapper rail or salt marsh harvest mouse at many ISP sites necessitates that the least intrusive treatment method, that is also effective, be chosen. A great deal of effort goes into reducing potential disturbance to these endangered species, including a variety of conservation measures required by USFWS in ISP's Section 7 Biological Opinion. The application of imazapyr directly to the target vegetation at low tide is normally the best solution for balancing these objectives.

11.8. Selecting the Most Appropriate Herbicide Formulation

Once all available treatment methods were identified and a decision matrix was used to determine that the application of aquatic herbicide was both the most effective and least intrusive choice, the decision on which herbicide formulation to use was relatively simple. There are only two herbicides approved by U.S. EPA for use in the sensitive estuarine environment, imazapyr and glyphosate. As described earlier in ISP's Aquatic Pesticide Application Plan (Section 4), prior to the California Department of Pesticide Regulation's registration of the aquatic formulation of imazapyr, invasive *Spartina* control in San Francisco Bay was attempted with glyphosate-based products. Since glyphosate adsorbs strongly to the sediment and salt deposited on the leaves of the target plant by the tides, its herbicidal properties are inactivated resulting in very poor efficacy even at higher concentrations and rates. Imazapyr does not have these issues of inactivation, and is very effective on invasive *Spartina*, making it the clear choice for the coalition of ISP partners.

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Appendix 1

Chemical properties, degradation rates, environmental fate, and toxicity of imazapyr, glyphosate, and aquatic surfactants evaluated for *Spartina* control

Invasive *Spartina* Project
2014 Aquatic Pesticide Application Plan

Table A-1: Chemical description; degradation rates, products, and pathways; bioaccumulation ratings; and advantages and disadvantages of imazapyr and glyphosate herbicides for estuarine use

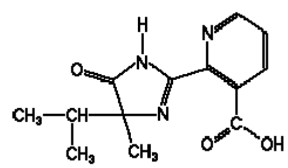
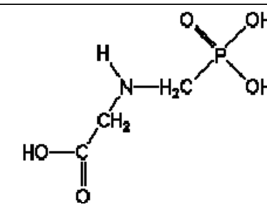
	Imazapyr	**Glyphosate**
Trade Name (Company)	Habitat® (Bayer Corporation)	Rodeo® (Dow Chemical Company) Aquamaster® (Monsanto Corporation)
Registration No.	81334-34-1	1071-83-6
Formulation	Aqueous solution of isopropylamine salt of imazapyr plus acidifier; active ingredient: 28.7% isopropylamine salt of imazapyr; equivalent to 22.6% imazapyr	Aqueous solution of isopropylamine salt of glyphosate; technical formulation contains 2,4-nitrosoglyphosate ("NNG") impurity; active ingredient: 53.8% glyphosate isopropylamine salt; equivalent to 48.0% glyphosate
Chemical name	IUPAC: (*RS*)-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid CAS: 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylic acid	IUPAC: *N*-(phosphonomethyl)glycine CAS: *N*-(phosphonomethyl)glycine
Chemical formula		
Formula	$C_{13}H_{15}N_3O_3$	$C_3H_8NO_5P$
Herbicide family	Imidazolinone	Organophosphorus
Mode of action	Systemic, broad-spectrum (non-selective); amino acid synthesis inhibitor, specifically, inhibits acetohydroxyacid synthase ("AHAS") aka acetolactase synthase ("ALS"), the first enzyme in the synthesis of branched-chain aliphatic amino acids (valine, leucine, and isoleucine) and as a result inhibits protein synthesis and cell growth	Systemic, broad-spectrum (non-selective); amino acid synthesis inhibitor; inhibits 5-enolpyruvylshikimate-3-phosphate synthase, needed by plants to synthesize chorismate, an intermediate metabolic product in the synthesis of aromatic amino acids
Molecular weight	261.28 g/mole imazapyr 320.42 g/mole imazapyr isopropylamine salt	169.08 g/mole glyphosate 228.22 g/mole glyphosate isopropylamine salt

Table A-1 contd.: Chemical description; degradation rates, products, and pathways; bioaccumulation ratings; and advantages and disadvantages of imazapyr and glyphosate herbicides for estuarine use

	Imazapyr	**Glyphosate**
Specific gravity	1.04–1.07	0.5
Minimum drying time	1 hour	6 hours
Highest proposed application rate	1.5 lb a.e./acre	10.8 lb/acre
Rate of kill	Very slow	Relatively slow
Volatility	Vapor pressure = 1.8×10^{-11} mm Hg Henry's Law constant of 7.1×10^{-17} atm m^3/mole No volatilization from dry soil surfaces; low volatilization of imazapyr from water or moist soil surfaces.	Extremely low vapor pressure, thus, negligible risk of movement through volatility
Solubility	Water: 11,272 mg/L	Water: ~12,000 mg/L
Soil organic carbon adsorption coefficient	K_{oc} = 8.81 Very low K_{oc} indicates low sorption potential.	K_{oc} = 24,000 Very high K_{oc} indicates tight sorption to most soils, suspended solids, and sediments in the environment.
Octanol/water partition coefficient	K_{ow} = 0.22, 1.3	K_{ow} = 0.0003
Degradation pathways	Slow anaerobic microbial degradation. No degradation under anaerobic conditions. Rapid photolysis in water.	Primarily degraded by microbes and fungi in soil or water, under both aerobic and anaerobic conditions. Photodegradation in water and soil are not expected to contribute significantly to glyphosate degradation.
Degradation products	Quinolinic acid	Aminomethylphosphonic acid ("AMPA"); further degraded to carbon dioxide and phosphate.
Half-life in soil	$t_{½}$ = 25–141 days	Average $t_{½}$ = 32 days, based on 47 agricultural and forestry studies. In most cases, >90% degraded within six months after application.
Half-life in benthic sediment	$t_{½}$ = <2 to 7 days	$t_{½}$ = >3 to 12 months

Table A-1, page 2/3

Table A-1 contd.: Chemical description; degradation rates, products, and pathways; bioaccumulation ratings; and advantages and disadvantages of imazapyr and glyphosate herbicides for estuarine use

	Imazapyr	Glyphosate
Half-life in water	No detectable degradation due to hydrolysis up to 30 days, pH 5-7 Average $t_{½}$ = 1-4 days (photolysis)	$t_{½}$ = 7–14 days
Bioaccumulation	BCF = 3; Low potential for bioaccumulation	BCF in fish after 10-14 day exposure period = 0.2 to 0.3 Low potential for bioaccumulation in aquatic animals; poorly absorbed when ingested by terrestrial mammals; any absorbed glyphosate is rapidly eliminated resulting in minimal tissue retention.
Advantages for estuarine use	– Rapid photolysis in water – Shorter minimum drying time than glyphosate – No adsorption to particles – Formulation can be mixed with salt water – Aerial applications require an order of magnitude lower spray volumes than glyphosate – Application is more cost-effective than application of glyphosate – Does not require use of non-ionic surfactants	– Low leaching potential due to strong sorption to soil/sediment particles
Disadvantages for estuarine use	– Increased adverse effects to non-target emerged vegetation due to higher efficacy on vascular plants	– Efficacy hindered by minimum drying time – Inactivated by adsorption to sediment particles – Formulation requires mixing with freshwater, which is not readily available – Aerial applications require large spray volumes, which require frequent refilling of helicopter tanks – Application is expensive – Requires use of non-ionic surfactants

Table A-1, page 3/3

Table A-2: Chemical properties, environmental fate, general toxicity rating, and toxicity of adjuvants

Adjuvant (Manufacturer)	Ingredients[1]	Chemical Properties	Degradation Pathways	General Toxicity Rating	Toxicity (lowest reported)
Non-ionic Surfactants ("NIS")					
R-11® (surface activator) (Wilbur-Ellis Company)	80% octylphenoxy polyethoxyethanol, 20% butanol and compounded silicone	– soluble in lipid and water – flammable – specific gravity = 1.0	Slowly biodegraded by progressive shortening of ethoxylate chain; intermediate breakdown products of polyethylene glycol (anti-freeze) and short-chain ethoxylates	Mammals: practically non-toxic orally, mild skin irritation possible Fish: Moderately toxic Other aquatic biota: slightly toxic	96-hr LC_{50}, rainbow trout 3.8 ppm[2] 96-hr LC_{50}, bluegill sunfish 4.2 ppm[2] 96-hr LC_{50}, juvenile rainbow trout 6 ppm[5] 48-hr LC_{50}, *Daphnia* spp. 19 ppm[3] LD_{50} oral, rabbit >5,840 mg/kg[2] LD_{50} dermal, rabbit >5,000 mg/kg[2]
X-77® (spreader activator) (Valent Corp.)	Alkylarylpoly (oxy-ethylene) glycols, free fatty acids, isopropyl alcohol	– soluble in lipid and water – flammable	Slowly biodegraded by progressive shortening of ethoxylate chain; intermediate breakdown products of polyethylene glycol (anti-freeze) and short-chain ethoxylates	Mammals: practically non-toxic orally Fish and other aquatic biota: moderately toxic	96-hr LC_{50}, rainbow trout 4.2 ppm[2] 96-hr LC_{50}, bluegill sunfish 4.3 ppm[2] 48-hr LC_{50}, *Daphnia* spp. 2 ppm[2] LD_{50} oral, rabbit >5,000 mg/kg[2] LD_{50} dermal, rabbit >5,000 mg/kg[2]
Liberate® (penetrating surfactant, deposition and drift control agent) (Loveland Industries, Inc.)	Phosphatidylcholine (lecithin), methyl esters of fatty acids, alcohol ethoxylate	– emulsifiable – specific gravity = 0.976	Biodegradation presumed rapid due to natural lecithin ingredients	Mammals: practically non-toxic orally, moderate skin irritation possible	96-hr LC_{50}, rainbow trout 17.6 ppm[1] NOEC, rainbow trout 12.5 ppm[1] 48-hr LC_{50}, *Daphnia magna* 9.3 ppm[1] NOEC, *Daphnia magna* 7.5 ppm[1] LD_{50} oral, rat >5,000 mg/kg[1] LD_{50} dermal, rat >5,000 mg/kg[1]
LI-700® (wetting and penetrating surfactant) (Loveland Industries, Inc.)	Phosphatidylcholine (lecithin), methylacetic acid, alkyl polyoxyethylene ether	– emulsifiable – not flammable – specific gravity = 1.03	Biodegradation presumed rapid due to natural lecithin ingredients	Mammals: practically non-toxic orally, causes skin and eye irritation Fish and other aquatic biota: practically non-toxic	96-hr LC_{50}, rainbow trout 17 ppm[2] 24-hr LC_{50}, rainbow trout 22 ppm[2] 96-hr LC_{50}, juv. rainbow trout 700 ppm[5] 96-hr LC_{50}, bluegill sunfish 210 ppm[2] 48-hr LC_{50}, *Daphnia* spp. 170 ppm[3] LD_{50} oral, rat >5,000 mg/kg[2] LD_{50} dermal, rat >5,000 mg/kg[2]
Cygnet Plus (Cygnet Enterprises)	75% d-limonene and related isomers, 15% methylated vegetable oil, 10% alkyl hydroxypoly oxyethylene; manufactured from natural limonene	– flammable – specific gravity = 0.87		Mammals: causes skin and eye irritation; Fish: slightly toxic Other aquatic biota: moderately toxic	NOEC, Ceriodaphnia dubia 3.0 ppm[4] 96-hr LC50 Ceriodaphnia dubia 6.6 ppm[4] NOEC, rainbow trout 30 ppm[4] 96-hr LC50, rainbow trout 45 ppm[4] NOEC, fathead minnow 15 ppm[4] 96-hr LC50, fathead minnow ppm[4]
Esterified Seed Oils ("ESOs") or Mehylated Seed Oils ("MSOs")					
Competitor® Wilbur-Ellis Company)	Ethyl oleate, sorbitan alkyl polyethoxylate ester, dialkyl polyoxy-ethylene glycol	– soluble in water – combustible – specific gravity = 0.9		Fish: slightly toxic Other aquatic biota: practically non-toxic	96-hr LC_{50}, rainbow trout 95 ppm[3] 48-hr LC_{50}, *Daphnia* spp. >100 ppm[3]

Table A-2 contd.: Chemical properties, environmental fate, general toxicity rating, and toxicity of adjuvants

Adjuvant (Manufacturer)	Ingredients[1]	Chemical Properties	Degradation Pathways	General Toxicity Rating	Toxicity (lowest reported)
Crop Oil Concentrates ("COC")					
Agri-Dex® (wetting and penetrating agent) (Helena Chemical Company)	Proprietary; heavy range paraffin-based petroleum oil with polyol fatty acid esters and polyethoxylyated derivatives	– dispersible in water as micelles – moderately flammable	Biodegradation presumed rapid	Mammals: practically non-toxic through oral ingestion, mild skin and eye irritant; Fish and other aquatic biota: practically non-toxic	96-hr LC_{50}, rainbow trout 271 ppm[2] 24-hr LC_{50}, rainbow trout 386 ppm[2] 96-hr LC_{50}, juv. rainbow trout 271 ppm[5] 48-hr LC_{50}, *Daphnia* spp. >1,000 ppm[3] LD_{50} oral, rat 5,010 mg/kg[2] LD_{50} dermal, rabbit >2,020 mg/kg[2]
Silicone-based Surfactants					
Dyne-Amic® (activator, spreader-sticker, wetting and penetrating agent, buffer) (Helena Chemical Company)	Organosilicone , methylated vegetable oil			Fish and other aquatic biota: slightly toxic	96-hr LC_{50}, rainbow trout 23.2 ppm[3] 48-hr LC_{50}, *Daphnia* spp. 60 ppm[3]
Kinetic® (spreader-sticker, wetting agent) (Helena Chemical Company)	Organosilicone , polyoxypropylene-polyoxyethylene copolymer			Fish and other aquatic biota: slightly toxic	96-hr LC_{50}, rainbow trout 13.9 ppm[3] 48-hr LC_{50}, *Daphnia* spp. 60.7 ppm[3]
Colorants					
Blazon® Spray Pattern Indicator "Blue" (Milliken Chemical)	Proprietary; 30% non-ionic polymeric colorant, 70% water	– pH = 7.0 – completely soluble in water – specific gravity = 1.07 – mildly acidic		Mammals: practically non-toxic orally; mild skin irritant; not mutagenic	LD_{50} rat >5,000 mg/kg[1]

[1] Manufacturer specimen labels
[2] Referenced in Entrix 10/03.
[3] Erik Johansen, Washington State Department of Agriculture, Memorandum Re: Summary of Acute Toxicity Data for Five Spray Adjuvants, February 4, 2004.
[4] Pacific Ecorisk, An Evaluation of the Acute Toxicity of "CYGNET PLUS" to *Ceriodaphnia dubia* (water flea), *Oncorhynchus mykiss* (rainbow trout), and *Pimephales promelas* (fathead minnow), December 10, 2004.
[5] King *et al.* 2004.

Table A-2, page 2/2

Table A-3a: Imazapyr herbicide mixture component concentrations and application rates for treatment of non-native *Spartina* in San Francisco Estuary

Application Method	Spray Volume	Formulation	Active Ingredient[1]	Surfactant[2]	Colorant
High volume handheld sprayer	100 gal/acre	0.52-0.75% solution 4-6 pints/100 gal	1-1.5 lb a.e./acre	0.25% v/v NIS with ≥70% a.i.; ~1% v/v MSO, ESO, or VOC; SBS according to label	3 qt/100 gal
Low-volume directed sprayer	20 gal/acre	0.75-1.5% solution 1.2-2.4 pints/20 gal	0.3-0.6 lb a.e./acre	0.25% v/v NIS with ≥70% a.i.; ~1% v/v MSO, ESO, or VOC; SBS according to label	3 qt/100 gal
Broadcast sprayer/ Aerial application	10-30 gal/acre	2.5-7.5% solution 6 pints/10-30 gal	0.5-1.5 lb a.e./acre	0.25% v/v NIS with ≥70% a.i.; ~1% v/v MSO, ESO, or VOC; SBS according to label	0.5-1.5 qt/acre

[1] Active ingredient in Habitat® is imazapyr isopropylamine salt; values expressed as imazapyr acid equivalent
[2] NIS = non-ionic surfactant; MSO = methylated seed oil; ESO = esterified seed oil; VOC = vegetable oil concentrate, SBS = silicone-based surfactant, %v/v = percentage based on volume by volume

Table A-3b: Glyphosate herbicide mixture component concentrations and application rates for treatment of non-native *Spartina* in San Francisco Estuary

Application Method	Spray Volume	Formulation	Active Ingredient[1]	Surfactant[2]*	Colorant
High volume handheld sprayer	100 gal/acre	1-2% solution 1-2 gal/100 gal	4-8 lb a.e./acre	≥0.5% v/v NIS with ≥50% a.i.	3 qt/100 gal
Low-volume directed sprayer	25-200 gal/acre	1-8% solution 1-8 gal/100 gal	1.35-10.8 lbs a.e./acre	≥0.5% v/v NIS with ≥50% a.i.	3 qt/100 gal
Broadcast sprayer/ Aerial application	7-40 gal/acre/ 7-20 gal/acre	4.5-7.5 pints/acre	2.25-3.75 lb a.e./acre	≥0.5% v/v NIS with ≥50% a.i.	0.5-1.5 qt/acre

[1] The active ingredient in Rodeo® and Aquamaster® is glyphosate isopropylamine salt; values are expressed as glyphosate acid equivalent
[2] NIS = non-ionic surfactant, %v/v = percentage based on volume by volume

Table A-4: Worst-case concentration of imazapyr herbicide dissolved in leading edge of incoming tide

Assumptions

Worst-case occurs on the leading edge of lateral flow from overtopped channel through an herbicide-treated marsh
Herbicide was uniformly sprayed across the entire marsh surface (but not in channels) at an application rate r = 15.6 mg a.e./sqft
The herbicide applied on a unit area (1 sqft) is therefore mass m = 15.6 mg a.e.
The herbicide dissolves completely in the incoming water
A percentage, p, of the herbicide sticks to the vegetation canopy, and does not dissolve in the first one foot of flow depth
Incoming tidal water overbanks channel and flows laterally across the surface of the marsh to a maximum distance D
Water flow across marsh (after it leaves channel) has a uniform depth d = 1ft
A percentage, s, of the active herbicide that was deposited onto the sediment surface dissolves into the water column
The dissolved herbicide is instantly fully dissolved in the first unit volume that flows through
No evaporation
No rain or other input of fresh water

Application rate

Habitat® label application rate: 4-6 pints per acre			Label indicates 2 pounds imazapyr acid equivalents per gallon Habitat®		
	6	pints/acre		1.5	lb a.e./acre
=	0.75	gal/acre	=	15.61	mg a.e./ft^2

Variables (p, D, and s can be varied):

r =	15.61	mg a.e./ft^2	Herbicide application rate
m =	15.61	mg a.e.	Initial mass of herbicide per unit area (per 1 ft^2)
p =	0%		Percentage of applied herbicide that is absorbed into vegetation canopy
d =	1	ft	Depth of water flow across marsh (1 ft allows unit volume calculations)
D =	100	ft	Distance of lateral flow across the marsh surface[a]
s =	60%		Percentage of herbicide reaching the sediment that resuspends into water column
C =	?		Concentration of herbicide in water column (mg a.e./ft^3)

Equation[b]

C = m × (1-p) × D × s = (mass per unit area) × (1-percent absorbed by plant canopy) × (percent dissolved in water column) × (number of units through which water flows)

Computed Concentration

C =	m	1-p	D	s	=	
	15.61	100%	100	60%		937 mg/ft^3
						33.1 mg/liter

Notes

a) Most *Spartina* infested marshes in the San Francisco Estuary that will become inundated by tidal water in the days following imazapyr application have a multitude of channels throughout the marsh that will transport water directly from the San Francisco Bay before overbanking and causing lateral flow across the marsh. In these marshes there would be a maximum of 100 feet of lateral flow through sprayed marsh before meeting with another flow.

b) Calculation does not take into account potential decay during period of time between spraying and water inundation nor any decay that might occur in water column once the herbicide is resuspended from sediment.

Table A-5: Ecotoxicity categories for acute toxicity of pesticides to wildlife[1]

Toxicity Category	Mammals: Acute Oral or Dermal LD_{50} (mg/kg)	Mammals: Acute Inhalation LC_{50} (ppm)	Birds: Acute Oral LD_{50} (mg/kg)	Birds: Acute Inhalation LC_{50} (ppm)
Very highly toxic	<10	<50	<10	<50
Highly toxic	10-50	51-500	10-50	50-500
Moderately toxic	51-500	501-1000	51-500	501-1,000
Slightly toxic	501-2,000	1001-5000	501-2,000	1,001-5,000
Practically non-toxic	>2,000	>5,000	>2,000	>5,000

Table A-6: Ecotoxicity categories for acute toxicity of pesticides to aquatic organisms[1]

Toxicity Category	Fish or Aquatic Invertebrates Acute Concentration LC_{50} (mg/L)
Very highly toxic	<0.1
Highly toxic	0.1-1
Moderately toxic	>1-10
Slightly toxic	>10-100
Practically non-toxic	>100

Table A-7: Ecotoxicity categories for acute toxicity of pesticides to insects[1]

Toxicity Category	Concentration (μg/bee)
Highly toxic	<2
Moderately toxic	2 - 11
Practically non-toxic	>11

[1] U.S. EPA, Technical Overview of Ecological Risk Assessment, Analysis Phase: Ecological Effects Characterization, September 28, 2004.

Table A-8: Toxicity of imazapyr to mammals

Test Substance	Animal Species	Administration Route	Gender	LD_{50} or ED_{50}	Effect[3]	Testing Facility (Reporting Year)
Imazapyr technical	Rat	oral	♂	>5,000 mg/kg b.w.	NOEL	American Cyanamid Company (1983)[1]
			♀	>5,000 mg/kg b.w.	NOEL	
	Rabbit	dermal	♂	>2,000 mg/kg b.w.	NOEL	
			♀	>2,000 mg/kg b.w.	NOEL	
	Rat	inhalatory	♂	>1 ppm	ND	Food and Drug Research Laboratories (1983)[1]
			♀	>1 ppm (analytical)	ND	
AC 243,997 (93% pure)	Rat	inhalation	♂+♀	>1.3 ppm	L	Voss *et al.* (1983)[2]
Imazapyr isopropylamine technical (49.3% a.i.)	Rat	oral	♂	>10,000 ppm diet	DA	Medical Scientific Research, Laboratory (1983)[1]
			♀	>10,000 ppm diet	DA	
		intraperitoneal	♂	4,200 mg/kg b.w.	DA, B, A, S, CY, C, DBW	
			♀	3,700 mg/kg b.w.	DA, B, A, S, CY, C, DBW	
		subcutaneous	♂	>5,000 mg/kg b.w.	DA	
			♀	>5,000 mg/kg b.w.	DA	
		dermal	♂	>2,000 mg/kg b.w.	NOEL	
			♀	>2,000 mg/kg b.w.	NOEL	
	Mouse	oral	♂	>10,000 mg/kg b.w.	DA	
			♀	>10,000 mg/kg b.w.	DA	
		intraperitoneal	♂	3,450 mg/kg b.w.	DA, B, A, S, CY, C, DBW	
			♀	3,000 mg/kg b.w.	DA, B, A, S, CY, C, DBW	
		subcutaneous	♂	>5,000 mg/kg b.w.	DA, B, S	
			♀	>5,000 mg/kg b.w.	DA, B, S	

Table A-8 contd.: Toxicity of imazapyr to mammals

Test Substance	Animal Species	Administration Route	Gender	LD_{50} or ED_{50}	Effect[3]	Testing Facility (Reporting Year)
Imazapyr isopropylamine (25% a.i.)	Rat	oral	♂	>5,000 mg/kg b.w.	DA	American Cyanamid Company (1983)[1]
			♀	>5,000 mg/kg b.w.	DA	
	Mouse	oral	♂	>5,000 mg/kg b.w.	DA	American Cyanamid Company (1986)[1]
			♀	>5,000 mg/kg b.w.	DA	
	Rabbit	dermal	♂	>2,148 mg/kg b.w.	NOEL	American Cyanamid Company (1983)[1]
			♀	>2,148 mg/kg b.w.	NOEL	
	Rat	inhalatory	♂	>0.2	NOEL	Food and Drug Research Laboratories (1983)[1]
			♀	>0.2 (analytical)	NOEL	
Arsenal® 4-AS	Rat	inhalatory	♂+♀	>4.62 ppm	L	Hershman & Moore (1986)[2]
Chopper®RTU (NOS)	Rat	inhalatory	♂+♀	>3.34 ppm	L	Werley (1987)[2]

[1] cited in Entrix 10/03.
[2] cited in SERA 12/04, Appendix 1
[3] Acronyms: A = ataxia (loss of ability to coordinate muscular movement); B = blepharoptosis (drooping of upper eyelid); b.w. = body weight; C = convulsion; CY = cyanosis (bluish discoloration of skin and mucous membranes resulting from inadequate oxygenation of blood); DA = decreased activity; DBW = decreased body weight; ED_{50} = dose causing 50% inhibition of a process; L = lethality; LD_{50} = lethal dose, 50% kill; ND = nasal discharge; NOEL = no-observable-effect level (no toxic signs); NOS = not otherwise specified; S = sedation

Table A-9: Toxicity of imazapyr to birds

Test Substance	Species	Test (Observed Effect)	Result*
Arsenal® (identical with Habitat®)	Northern bobwhite quail	LD_{50}, 18-weeks dietary	>1890 mg/kg diet ~200 mg/kg b.w.
		NOEL, 18-weeks dietary	1890 mg/kg HDT ~200 mg/kg b.w.
		LD_{50}, 5-day acute dietary	>5000 mg/kg diet ~674 mg/kg b.w.
		NOEL, 5-day acute dietary	5000 mg/kg HDT ~674 mg/kg b.w.
	Mallard duck	LD_{50}, 18-weeks dietary	>1890 mg/kg diet ~200 mg/kg b.w.
		NOEL, 18-weeks dietary	1890 mg/kg diet ~200 mg/kg b.w.
		LD_{50}, 5-day acute dietary	>5000 mg/kg diet ~674 mg/kg b.w.
		NOEL, 5-day acute dietary	5000 mg/kg HDT ~674 mg/kg b.w.

* Fletcher 1983a, 1983b, Fletcher *et al*. 1984a, 1984b, 1984c, 1984d, 1995a, 1995b; all in SERA 12/04, Appendix 3

Table A-10: Toxicity of imazapyr and imazapyr herbicide/surfactant mixtures to fish

Test Substance + Surfactant	Animal Species	Test	Result	Reference
Arsenal® Herbicide (28.7% imazapyr) + Hasten	Rainbow trout, juvenile (*Oncorhynchus mykiss*)	96-hr LC_{50}	113 ppm surfactant	Smith *et al.* 2002[1]
Arsenal® Herbicide (28.7% imazapyr) + Agri-Dex®		96-hr LC_{50}	479 ppm surfactant	
Arsenal® Herbicide (28.7% imazapyr)		96-hr LC_{50}	77,716 ppm of concentrate 22,305 mg imazapyr a.e./L	Grue 2003[1] King *et al.* 2004
Arsenal® Concentrate (53.1 a.i. imazapyr)		96-hr LC_{50}	43,947 ppm of concentrate 23,336 mg imazapyr a.e./L	Grue 2003[1]
AC 243,997 with isopropylamine in water	Bluegill sunfish (*Lepomis macrochirus*)	96-hr LC_{50}	>1000 mg/L	Cohle & McAllister 1984a[2]
Arsenal® Herbicide (22.6% purity)		96-hr LC_{50}	180 mg/L	Cohle & McAllister 1984b[2]
AC 243,997 (99.5% purity)		96-hr LC_{50}	>100 mg/L	Kintner & Forbis 1983a[2]
Imazapyr NOS	Rainbow trout (*Salmo gairdneri*) Channel catfish (*Ictaluras punctatis*) Bluegill sunfish (*Lepomis macrochirus*)	96-hr LC_{50}	>100 mg/L	Peoples 1984[2] Gagne *et al.* 1994[2]
Arsenal® Herbicide (22.6% purity)	Rainbow trout (*Salmo gairdneri*)	96-hr LC_{50}	110 mg/L	Cohle & McAllister 1984c[2]
Arsenal® Herbicide (21.5% purity)		96-hr LC_{50}	>110 mg a.e./L	Drotter *et al.* 1995[2]

Table A-10 contd.: Toxicity of imazapyr and imazapyr herbicide/surfactant mixtures to fish

Test Substance + Surfactant	Animal Species	Test	Result	Reference
AC 342,997 (purity NOS)	Fathead minnow (*Pimephales promelas*)	NOEC LOEC MATC	120 mg a.i./L >120 mg/L >120 mg/L	Drotter *et al.* 1998[2]
AC 342,997 (99.6% purity)	Fathead minnow (*Pimephales promelas*)	28-day NOEC LOEC MATC	>118 mg a.i./L >118 mg a.i./L >118 mg a.i./L	Drotter *et al.* 1999[2]
AC 243,997 (99.5% purity)	Atlantic silverside (marine) (*Menidia menidia*)	96-hr LC_{50}	184 mg/L	Manning 1989a[2]
Imazapyr NOS	Nile tilapia (*Tilapia nilotica*)	24-hr LC_{50} 48-hr LC_{50} 72-hr LC_{50} 96-hr LC_{50}	4,670 µg/L 4,630 µg/L 4,610 µg/L 4,360 µg/L	Supamataya *et al.* 1981[2]
Imazapyr NOS	Silver barb (*Barbus genionotus*)	24-hr LC_{50} 96-hr LC_{50}	2,706 µg/L 2,706 µg/L	Supamataya *et al.* 1981[2]

[1] cited in Entrix 10/03
[2] cited in SERA 12/04

Abbreviations: LC_{50} = lethal concentration, 50% kill; LOEC = lowest-observable-effect concentration; MATC = maximum allowable toxicant concentration; NOEC = no-observable-effect concentration (no toxic signs); NOS = not otherwise specified

Table A-11: Toxicity of imazapyr and imazapyr/surfactant mixtures to aquatic invertebrates

Test Substance	Species	Test (observed effect)	Result	Reference
Arsenal® Applicator's Concentrate (479 g imazapyr a.e./L)	Freshwater benthic macroinvertebrates	In-situ microcosm NOEC, (D, BM)	>18.4 mg/L (HDT)	Fowlkes *et al.* 2003
Arsenal®Herbicide (22.6% purity)	Freshwater water flea (*Daphnia magna*)	NOEC 48-hr LC_{50}	180 mg/L 350 mg/L	Forbis *et al.* 1984[2]
Arsenal® + unidentified surfactant	Freshwater water flea (*Daphnia magna*)	48-hr LC_{50}	79.1 mg imazapyr a.e./L	Cyanamid 1997[1]
Arsenal®	Freshwater water flea (*Daphnia magna*)	NOEC	40.7 mg imazapyr a.e./L	Cyanamid 1997[1]
Arsenal®	Freshwater water flea (*Daphnia magna*)	48-hr EC_{50} (?)	373 mg imazapyr a.e./L	Cyanamid 1997[1]
Arsenal®	Eastern oyster (*Crassostrea virginica*)	EC_{50} (G) NOEC	>132 mg imazapyr/L >132 mg imazapyr/L (HDT)	Mangels & Ritter 2000[1]
Arsenal®	Pink shrimp (*Penaeus duorarum*)	EC_{50} (S)	>132 mg imazapyr/L >132 mg imazapyr/L (HDT)	Mangels & Ritter 2000[1]
AC 243,997 (technical)	Freshwater water flea (*Daphnia magna*) (<24 hours old)	24-hr LC_{50} 48-hr LC_{50}	>100 mg imazapyr a.e./L >100 mg imazapyr a.e./L	Kintner & Forbis 1983[2]
AC 243,997 (99.5% a.i.)	Freshwater water flea (*Daphnia magna*)	7, 14, 21-day NOEC (S/R/G)	97.1 mg/L (HDT, MATC)	Manning 1989[2]
AC 243,997 (purity NOS)	Grass shrimp (*Paleomonetes pugio)*	BCF	<1 (not calculable)	Drotter *et al.* 1996[2]
AC 243,997 (purity NOS)	Eastern oyster (*Crassosstrea virginica*)	BCF	<1 (not calculable)	Drotter *et al.* 1996[2]
AC 243,997 (99.6% purity)	Eastern oyster (*Crassosstrea virginica*)	EC_{50} (G)	>132 mg/L	Drotter *et al.* 1997[2]
AC 243,997 (99.5% purity)	Eastern oyster (*Crassosstrea virginica*)	96-hr EC_{50} (G)	>173 mg/L	Ward 1989[2]

[1] cited in Entrix 10/03
[2] cited in SERA 12/04, Appendix 4

Abbreviations: BM = biomass, D = deformity, S = survival; R = reproduction; G = growth; HDT = highest dose tested; MATC = maximum allowable toxicant concentration

Table A-12: Toxicity of imazapyr and imazapyr/surfactant mixtures to non-target aquatic vegetation

Test Substance	Species	Test (Observed Effect)	Result	Reference
Technical grade imazapyr	Green algae (*Selenastrum capricornutum*)	EC_{50} (G) EC_{25} (G)	71 mg/L 78 mg/L	Hughes 1987[2] Mangels & Ritter 2000[1]
	Freshwater diatom *(Navicula pelliculosa)*	EC_{50} (G) EC_{25} (G)	>59 mg/L >59 mg/L	Mangels & Ritter 2000[1]
	Saltwater diatom (*Skeletonema costatum*)	EC_{50} (G) EC_{25} (G)	85 mg/L 42.2 mg/L	Hughes 1987[2]
	Blue-green algae (*Anabaena flos-aquae*)	EC_{50} (G) EC_{25} (G)	117 mg/L 7.3 mg/L	Mangels & Ritter 2000[1]
	Green algae (*Chlorella emersonii*)	EC_{50} (G)	0.2 mg/L	Landstein *et al.* 1993[2]
	Duckweed (*Lemna gibba*)	EC_{50} (G) EC_{25} (G)	0.024 mg/L 0.013 mg/L	Hughes 1987[2]
Arsenal®+ unidentified surfactant	Common water milfoil (*Myriophyllum sibiricum*)	EC_{25} (G shoots) EC_{50} (G shoots) EC_{25} (# roots) EC_{50} (# roots) EC_{25} (G roots) EC_{50} (G roots)	0.013 mg/L 0.032 mg/L 0.022 mg/L 0.029 mg/L 0.0079 mg/L 0.0099 mg/L	Roshon *et al.* 1999[2]
	Green algae (*Selenastrum capricornutum*)	EC_{50} (G) EC_{25} (G)	14.1 mg/L 8.36 mg/L	Mangels & Ritter 2000[1]
	Duckweed (*Lemna gibba*)	LC_{50} EC_{50} (G) EC_{25} (G)	24 ppb 0.0216 mg/L 0.0132 mg/L	Mangels & Ritter 2000 Mangels & Ritter 2000[1]

[1] cited in Entrix 10/03.
[2] cited in SERA 12/04, Appendix 4.

Abbreviations: S = survival; R = reproduction; G = growth; HDT = highest dose tested; MATC = maximum allowable toxicant concentration

Table A-13: Toxicity endpoints for risk quotient calculation and levels of concern for interpretation of risk quotients

	Aquatic animals	Mammals	Birds	Aquatic vascular plants and algae	Non-endangered plants	Endangered plants
Assessment						
Acute	EC_{50} or LC_{50} acute toxicity	LD_{50} oral	LD_{50} oral	EC_{50}	EC_{25} seedling emergence and vegetative vigor	EC_{25} seedling emergence and vegetative vigor or NOEC
Chronic	NOEC early-life stage or full life-cycle tests	NOEC 2-generation reproduction	NOEC 21-week reproduction			
Levels of concern (risk quotient greater than)						
Acute risk	0.5	0.5	0.5	1.0	1.0	1.0
Acute restricted use	0.1	0.2	0.2			
Acute risk endangered species	0.05	0.1	0.1			
Chronic risk	1.0	1.0	1.0			

U.S. Environmental Protection Agency, Technical Overview of Ecological Risk Assessment, Analysis Phase: Ecological Effects Characterization and Risk Characterization, September 28th, 2004.

Appendix 2

2014 Field Data Collection Form

Invasive *Spartina* Project
2014 Aquatic Pesticide Application Plan

Page ___ of ___ on this date

NPDES Field Data Collection Form

San Francisco Estuary Invasive *Spartina* Project, Aquatic Pesticide Application Plan, 1830 Embarcadero Cove, Suite 100-C, Oakland, CA 94606

Site ID (XXXX) (e.g. DEAD): ____________ Date: ____________ Collected By: ____________

Monitoring Area Description: ____________

Water Color (circle): green green-brown brown blue (dye) Other waterway observations: ____________

Station Location (circle): at application point upstream downstream Station Type (circle): Reference Treated

Wind (circle): low high Weather (circle): fog rain Tidal Cycle (circle): high low slack

Herbicide: imazapyr glyphosate Surfactant (circle): Liberate Competitor

Field Measurements

Water Depth	pH	Dissolved Oxygen	Water Temp	Conductivity	Salinity	Turbidity
Meters	Number	mg/L	^{O}C	mS	ppt	NTU

Samples Collected

Sample ID (XXXX-YY-Ab)*	Time	Sample Depth (m)	Notes

*** XXXX-YY-Ab** (e.g. DEAD-01-pre, ZIPY-02-0.5h) = **XXXX:** Site, **YY:** site visit number (01-1st, 02-2nd, 03-3rd, etc.), **A:** time to application (either pre, increments thereafter in half hours – 0.5), **b:** time increment (h=hour, w=week (for 1 week post-treatment))

Additional Notes or Comments: ____________

Wildlife Presence: ____________

Appendix 3

Chain of Custody for Pacific Agricultural Laboratory

Invasive *Spartina* Project
2014 Aquatic Pesticide Application Plan

APPENDIX 3. CHAIN OF CUSTODY FORM

Pacific Agricultural Laboratory

Analytical Request/Chain of Custody

Pacific Agricultural Laboratory, LLC
12505 N.W. Cornell Rd., Ste. 4 • Portland, OR 97229
Tel 503.626.7943 • Fax 503.641.0644 • www.pacaglab.com

Page 1 of 1

PAL Project # ____

CLIENT INFO

Name: Invasive Spartina Project
Contact: Drew Kerr
Address: 2612-A 8th Street
City: Berkeley State: CA Zip: 94710
Telephone: 510.548.2461 Fax: 510.548.2460
Email: drew@spartina.org Cell Phone: 510.292.8406
Project # ____ Purchase Order # ____
Method of Shipment: FedEx

Requested Turnaround Time
☑ Standard (10 working days)
☐ Rush ____ please specify

PAL ID	Client Sample ID	Sample Date	Sample Time	Sample Type	Container Type	No. of Containers	Requested Analysis: Imazapyr					Comments
				Water	Amber (1L)	1	X					

Relinquished by: ____ (SIGNATURE) DATE ____ TIME ____ Received by ____ (SIGNATURE) DATE ____ TIME ____

Relinquished by: ____ (SIGNATURE) DATE ____ TIME ____ Received by ____ (SIGNATURE) DATE ____ TIME ____

Lab Comments: ____

All services performed by PAL are subject to the Standard Terms and Conditions on reverse side of this form.

Pacific Agricultural Laboratory, LLC Standard Terms and Conditions

Unless otherwise agreed in a separate contract, services provided by Pacific Agricultural Laboratory, LLC (PAL) are expressly limited to the terms and conditions stated herein. ***Submission of samples is deemed acceptance of these terms and conditions.***

Limits of Liability: All analytical services provided by PAL are made on a best effort basis. Established methods of analysis will be followed whenever possible; however every sample has unique properties that may require deviation or adaptation of established methodologies. The total liability of PAL will be limited to retesting or refund of the paid for services provided, at the option of PAL. Use of PAL constitutes acceptance of these limitations of liability.

Confidentiality: Pacific Agricultural Laboratory is zealously protective of customer information and uses its best business practices to maintain strict and absolute customer confidentiality. Confidentiality can be obtained, to the fullest extent allowed by the law, by placing written, mutual confidentiality agreements into force, upon request. Information is released to third parties only upon the authorization of the customer, by court order, or otherwise as required by law, and taking precautions to ensure confidential transfer of information between PAL and its customers by courier or mail, facsimile, email (internet), and/or telephone as the customer may direct. PAL shall not be responsible for any disclosure of any information of customer unless PAL specifically agrees to keep such information confidential by separate agreement.

Billing: All fees are billed directly to the client. Third party billing will not be accepted without prior arrangement and consent by PAL and agreement of the third party to all standard terms and conditions.

Payment Terms: For clients without approved credit from PAL, payment must be received prior to the release of final project report. For clients with approved credit, terms are net 30 days from the date of invoice unless otherwise stated on that invoice. Any changes from these terms must be agreed upon prior to sample submission. A service charge of 1 _% per month (18% annual rate) will apply for outstanding balances that are past due. In the event of default of payment for analytical services rendered, the client is responsible for reasonable collection charges including court costs and attorney's fees incurred by PAL. There is an additional $25.00 charge for any returned checks.

Litigation: All fees and costs associated with compliance by PAL to any subpoena for documents, for consultation in preparation for or testimony in any deposition or proceeding, or for any other purpose relating to the work of PAL, in connection with work performed for a client, shall be paid by the client. Such costs include, but are not limited to, fees for persons responsible for responding to subpoenas, reproduction of reports and data in support of reports, mileage and other travel expenses, attorney preparations for testimony, court testimony, attorney fees, and any other expenses associated with PAL's participation in the litigation.

Hazardous Materials/Samples: Unused portions of samples found or suspected to be hazardous according to state or federal laws will either be returned to the client at the expense of the client, or properly disposed of as hazardous waste at the expense of the client. Samples are the property of the client at all times, even while in the possession or under the control of PAL for analysis. All other samples will be properly and anonymously disposed of as nonhazardous waste after expiration of sample retention time. Samples subject to USDA foreign soil or plant permits shall be disposed of in accordance with applicable permit conditions.

Sample Retention/Disposal: Samples submitted for analysis are retained and stored under proper conditions and security for a period of time after the issuance of the final report. Retention times are generally as follows:

Sample Type	Retention Time
Surface Water, Wastewater	30 days
Nonhazardous Soil and Sludge	60 days
Food Commodities, Plant Tissue	60 days
Other Nonhazardous Materials	60 days
Hazardous Materials	30 days

Report and Document Retention: PAL shall retain final reports and all supporting documentation and analytical data used to generate reports for eight years following the generation of the report, after which time PAL shall be free to destroy the information.

Sample Containers and Shipping Materials: PAL will provide appropriate sample containers, shipping containers and packing materials at no additional charge upon prior arrangement. Standard shipping will be UPS Ground, and the client will be charged for expedited container shipping and the shipping of samples to PAL for analysis.

Analytical Service Requests: Requests for analytical Services can be made by telephone, fax, email or in writing. The client must confirm requests for service in writing, using a PAL chain of custody form prior to the commencement of work by PAL, and following directions for sampling as provided by PAL. It is very important that the analytical services to be provided by PAL be clearly understood by both PAL and the client prior to commencement of projects. PAL will not be responsible for delays caused by incomplete information provided by the client including missed hold times and delayed report generation.

Appendix 4

Quality Assurance Plan (QAP)
Pacific Agricultural Laboratory (PAL)

Invasive *Spartina* Project
2014 Aquatic Pesticide Application Plan

Extraction of Imidazolinone Herbicides in Water

1.0 Scope and Application

1.1 This procedure describes the extraction of imidazolinone herbicides from aqueous samples. This method is applicable to all types of water including, but not limited to, drinking water, storm water, surface water, and groundwater.

2.0 Summary of Method

2.1 A 500mL aliquot of sample is acidified to pH 2 and 12.5g sodium chloride is added. Sample is shaken in a separatory funnel with three 50mL portions of dichloromethane. Organic layers are drained **[through acidified sodium sulfate]** into a round bottom flask, and concentrated by rotary evaporation (SOP-AM-027).

3.0 Interferences

3.1 Potential interferences may include contamination from glassware and solvents, and co-extracted materials from the sample matrix. Care must be taken to avoid and/or minimize these potential interferences.

4.0 Sample Handling and Preservation

4.1 Samples should be taken in 1-L amber glass bottles with a PTFE lined cap.

4.2 Samples are taken at neutral pH, and stored at 4°C prior to extraction.

4.3 All water samples shall be extracted within seven (7) days of sampling.

5.0 Apparatus and Instrumentation

5.1 1000 mL glass separatory funnel

5.2 500 mL graduated cylinder

5.3 600 mL beaker

5.4 250 mL round bottom flask

5.5 Large glass funnel

5.6 pH meter

5.7 Top-loading balance, accurate to ±0.01g

5.8 Magnetic stir bar

5.9 Magnetic stir plate

5.10 Rotary evaporator, Rotavap; Yamato RE50

6.0 Reagents and Supplies

6.1 Organic-free water, DI H_2O

6.2 Methanol (MeOH) w/0.5% Formic Acid

6.3 Pesticide-grade Dichloromethane, DCM

6.4 6 N Hydrochloric Acid, HCl

6.5 Sodium chloride, ACS grade

6.6 Glass beads

6.7 **[Glass wool]**

6.8 **[Acidified sodium sulfate, Na_2SO_4]**

7.0 Procedure

7.1 For each sample, the necessary glassware items (separatory funnel, 600 mL beaker, and flat-bottom flask) are obtained, rinsed with Dichloromethane if necessary, and labeled with sample number. Beakers contain a magnetic stir bar, and two glass beads are added to each flat-bottom flask. Using a graduated cylinder, measure 500 mL of organic-free water for QC and transfer to a beaker with a stir bar. Likewise, measure and transfer 500 mL of sample into a beaker with a stir bar.

7.2 **[Sodium sulfate funnels are prepared by placing a small plug of glass wool into a glass powder funnel, to which ~25g *acidified* Sodium Sulfate is added. Funnels are rinsed with ~10mL DCM, and solvent is drained into waste. A funnel is placed on each labeled collection flask.]**

7.3 Using a 500 mL graduated cylinder, a 500 mL aliquot of sample is measured and transferred to the labeled 600 mL beaker.

7.4 Method Blank (BLK) consists of 500 mL deionized water in a 600mL beaker. This sample will be the negative control (QC) for the analysis.

7.5 Lab Control Sample/Lab Control Sample Duplicate (LCS/LCSD) each consist of 500 mL DI water in a 600mL beaker. Project specific spike compounds are added to each, and the standard log number and spike volume are recorded on extraction bench sheet. These samples will be the positive control (QC) for the analysis.

7.6 The pH of each sample and QC is adjusted to 2.0 by dropwise addition of 6N hydrochloric acid.

7.7 12.5 g of sodium chloride is added to each beaker, stirring until salt is completely dissolved.

7.8 The contents of each beaker are transferred into the appropriately labeled separatory funnel. Samples and QC are extracted by shaking three times with 50mL DCM. The lower (DCM) layers are drained **[through the acidified sodium sulfate funnel]** into the corresponding flat-bottom round flask.

7.9 **[After all solvent is collected, Na_2SO_4 funnels are rinsed with ~20mL Dichloromethane, to optimize recovery of analytes.]**

7.10 Extracts are concentrated to ~0.5 mL using rotary evaporation (SOP-AM-027), and remaining solvent is evaporated to dryness under a steady stream of nitrogen gas.

7.11 Extract is transferred to labeled culture tubes as per SOP-AM-XXX (Rotavap) using MeOH w/0.5% Formic acid as final solvent. Final volume is 2mL for most Imidazolinone extractions.

7.12 Extracts should be stored in refrigerator until analysis.

8.0 Calculations

8.1 N/A

9.0 Quality Control

9.1 At a minimum, batch QC will include a method blank (MB), and a Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD). Additional QC will be performed if there are project and/or method specific requirements. An extraction batch consists of a batch of 20 consecutive samples extracted within 7 days.

9.2 Spike recoveries are calculated after analysis to evaluate extraction efficiency.

10.0 Reporting

10.1 N/A

11.0 References

11.1 American Cyanamid Method 2261

11.2 American Cyanamid Method M1900

Imidazolinone Herbicides in Water by EPA 8321B

1.0 Scope and Application

1.1 This procedure is used to determine the concentrations of Imidazolinone herbicides in liquid matrices.

2.0 Summary of Method

2.1 A measured volume of sample is extracted using AM-033, Extraction of Imidazolinone Herbicides in Water.

2.2 Extracts are analyzed using liquid chromatography with mass spectroscopy (LC/MS) detection.

3.0 Interferences

3.1 Potential interferences may include contaminated solvents and extraction glassware, dirty chromatographic equipment, and co-extracted materials from the sample matrix. Care must be taken to avoid and/or minimize these interferences.

4.0 Sample Handling and Preservation

4.1 Store samples at 4^{o}C out of direct sunlight. Water samples should be extracted within 7 days of sampling and analyzed within 40 days of extraction

4.2 Personal protection measures should be taken while handling solvents and samples.

5.0 Apparatus and Instrumentation

5.1 Analytical balance, Sartorius model CP124S, accurate to 0.0001g. Calibration of balance shall be checked daily (SOP EQ-001).

5.2 N-EVAP evaporation manifold with heated water bath

5.3 HPLC System

5.3.1 Agilent 1100 HPLC system equipped with binary pump, autosampler, solvent degasser, and single quadrapole mass spectrometer.

5.3.2 Agilent Chemstation software

5.3.3 Analytical Column – C18 reverse phase column, 100mm x 3.0mm ID, 2.5 µm particle size, Agilent Zorbax SB-C18 or equivalent.

6.0 Reagents and Supplies

6.1 Organic-free reagent water

6.2 Methanol, Chemsolve, HPLC Grade

6.3 Acetonitrile (ACN), Chemsolve, HPLC Grade

6.4 Formic Acid, EMD, ACS Grade

6.5 Luer lock tipped syringe

6.6 Screw capped tubes with Teflon lined lids

6.7 13mm 45 µm nylon syringe filters

6.8 Auto sampler vials with PTFE lined caps

6.9 Volumetric flasks, class A

6.10 Gas tight syringes with PTFE tipped plungers

6.11 HPLC/MS Tuning Standard – Aglient ES Tuning Mix G2421A

7.0 Procedures

7.1 Sample Extraction:

7.1.1 Extract waters via the procedure outlined in Pacific Agricultural Laboratory SOP AM-033 “Extraction of Imidazolinone Herbicides in Water”.

7.1.2 Store extracts in refrigerator until analysis.

7.2 Solvent exchange of water extracts:

7.2.1 Transfer a 1 ml aliquot of the sample extract to a culture tube. Mark the meniscus of the liquid in the tube.

7.2.2 Evaporate the solvent under a steady stream of nitrogen using the N-Evap evaporation manifold.

7.2.3 Reconstitute the extract as follows: add 500 uL methanol, then 500 uL Mobile Phase A (95% organic free water, 5% ACN, 0.05% formic acid). .

7.2.4 Filter the sample extract into an autosampler vial through a 45 µm 13 mm syringe filter using a luer tipped syringe.

7.2.5 Cap the vial and label with appropriate moniker.

7.3 Preparation of HPLC mobile phase:

7.3.1 The mobile phase is contained in two reservoirs, one containing the aqueous portion (Mobile Phase A) and one containing the organic(Mobile Phase B) portion.

7.3.2 Prepare Mobile Phase A by combining 950 mL of organic free water, 50 mL ACN, and 0.5 mL formic acid.

7.3.3 Prepare Mobile Phase B by combining 950 mL of ACN, 50 mL organic free water, and 0.5 mL formic acid.

7.4 Chromatographic conditions:

7.4.1 Flow rate: 0.40 mL/minute

7.4.2 Injection volume: 10 ul

7.4.3 Column Temperature: 45 ^{o}C

7.4.4 Solvent Gradient:

Time	%A	%B
0.0	80	20
1.5	80	20
8.0	30	70
10	30	70

7.4.5 Re-equilibration time: 3 minutes, 80% A/20% B

7.5 Mass Spectrometer Conditions:

7.5.1 Ionization Mode: API-Electrospray

7.5.2 Drying Gas: N_2, 11.0 L/min, 250 ^oC

7.5.3 Nebulizer Pressure: 30 psig

7.5.4 Capillary Voltage: 1500 V

7.6 Mass Spectrometer Detector settings:

7.6.1 Settings for use in MS data acquisition (SIM ions and fragmentor voltages) vary by analyte and are displayed in Table 2 of the Appendix (12.2).

7.7 If the peak areas of the sample signals exceed the calibration range of the system, dilute the extract as necessary and reanalyze the diluted extract.

7.8 Calibration:

7.8.1 Electrospray MS System: The MS system is calibrated for accurate mass assignment, sensitivity, and resolution using the Agilent ES Tuning Mix G2421A. The following masses are calibrated in positive and negative ionization modes:

MASS	POSITIVE	NEGATIVE
1	118.09	112.99
2	322.05	431.98
3	622.03	601.98
4	922.01	1033.99
5	1521.97	1633.95

Tune parameters are adjusted to ensure ions are present at each of the masses with counts >50000 and peak widths within the range of 0.60 – 0.70 amu.

7.8.2 Stock Standards: Individual analyte stock standards are made at concentrations between 500-1000 μg/ml by transferring 25-50 mg neat standard to a 50 mL class A volumetric flask, dissolving the neat standard in acetonitrile or methanol, and diluting to the mark with acetonitrile or methanol. Stock standards prepared from neat standards may be used for a maximum of two years. Alternatively, a solution containing 1000 μg/ml of analyte may be obtained from ChemService or other reputable manufacturer and used as a stock standard. In this case, the stock standard may be used until the expiration date provided by the manufacturer.

7.9.3 Working Standards: A 10 μg/ml working standard is made by transferring appropriate amounts, depending on initial concentrations, of stock standards to a 10 mL class A volumetric flask and diluting to the mark with methanol or acetonitrile. The amount of stock standard to transfer will range between 100-200 μL and is calculated using the formula:

$$\text{Amt. Stock Std.}(\mu L) = \frac{[\text{Final Conc. } (10\mu g/ml)] \times [\text{Final Vol. } (10ml)}{\text{Initial Stock Conc. } (\mu g/\mu L)}$$

The working standard solution is transferred to an appropriately labeled screw cap tube and may be used for a maximum of one year.

7.9.4 Preparation of external standard calibration curve: an appropriate aliquot of the working standards are added to an autosampler vial and diluted to 1 ml with Mobile Phase A. A minimum of 5 standards are prepared at the following suggested levels: 0.005 ug/ml, 0.010 ug/ml, 0.020 ug/ml, 0.05 ug/ml, and 0.10 ug/ml. The calibration range can be adjusted to meet expected levels in the samples. The calibration standards are prepared as follows:

Calibration level	Aliquot volume	Concentration of aliquot(s)	Volume of buffer	Final volume
100 ng/ml	100 μl	1000 ng/ml	900 μl	1.0 ml
50 ng/ml	50 μl	1000 ng/ml	950 μl	1.0 ml
20 ng/ml	200 μl	100 ng/ml	800 μl	1.0 ml
10 ng/ml	100 μl	100 ng/ml	900 μl	1.0 ml
5 ng/ml	50 μl	100 ng/ml	950 μl	1.0 ml

7.9.5 The system is calibrated prior to the injection of a set of sample extracts. After injecting a set of standards, a linear calibration curve is prepared. Exclude the origin as a point. The R value of the generated curve should be 0.99 of better. If the calibration fails to meet these criteria, the cause of the deviation should be rectified and the system recalibrated.

7.9.6 The calibration is verified by injecting a CCV at the mid point concentration of the calibration curve after no more than twenty samples. If the response deviates by more than +/- 15% from the initial calibration, the system should be recalibrated and the samples bracketed by the either the initial calibration or the prior passing CCV and the failing CCV should be reanalyzed. If the CCV is >15% of initial calibration, the samples bracketed by the either the initial calibration or the prior passing CCV and the failing CCV can be used if the sample contains no detectable residues.

8.0 Calculations

8.1 Water Samples:

$$\frac{\text{amount f/curve (ng/ml) x final volume (ml) x dilution factor}}{\text{sample volume (ml)}} = \text{result (ug/liter, ppb)}$$

9.0 Quality Control

9.1 Initial Demonstration of Proficiency – the laboratory shall demonstrate initial proficiency with each sample preparation technique, by generating data of acceptable accuracy and precision for target analytes in a clean matrix. The laboratory must also repeat the demonstration whenever new staff is trained or significant changes in instrumentation are made.

9.1.1 Calculate the average recovery and the standard deviation of the recoveries of the four QC reference samples. Refer to Section 8.0 of EPA Method 8000 for procedures in evaluating method performance.

9.2 Method Reporting Limits (MDLs)

9.2.1 The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

9.2.2 The extraction and analysis of seven replicates of a spiked sample determine the MDL.

9.2.3 Multiply the standard deviation of the seven replicate results by the one sided 99%t-statistic (3.14) to obtain the MDL for each analyte.

9.2.4 These results are kept on file and should be re-evaluated annually, when significant changes in instrumentation are made, or when new staff are added.

9.3 Sample Quality Control for Preparation and Analysis

9.3.1 The laboratory will have procedures for documenting the effect of matrix on method performance.

9.3.2 Water matrix – minimum QC samples shall include a method blank (MB), Laboratory Control Sample (LCS), and a Laboratory Control Sample Duplicate (LCSD). A matrix spike may be prepared and analyzed provided there is adequate sample.

9.4 QC Frequency – an analytical batch is defined as a set of no more than 20 samples extracted within 14 days. The QC frequency for each analytical batch is as follows:

Method blank – 5%

Matrix Spike/Matrix Spike Duplicate – 5%

Laboratory Control Sample/Laboratory Control Sample Duplicate – 5%

9.4.1 In house method performance criteria for spike and surrogate compounds should be developed using guidance found in Section 8.0 of EPA Method 8000.

9.4.2 If the recovery data is outside acceptance limits, the samples should be re-extracted and/or the data flagged as necessary.

10.0 Reporting

10.1 If all QC criteria have been met, the data is then compiled and a report is generated, including sample raw analytical results and QC data, and submitted to the client.

11.0 References

11.1 EPA Method 8321B, SW-846 Revision 2, December 2007.

11.2 Pacific Agricultural Laboratory Quality System Manual.

11.3 EPA Method 8000B, SW-846 Revision 2, December 1996.

11.4 SW-846, Chapter One, Revision 1, 1992.

12 Figures and Appendices

12.1 Table 1 - Analyte list and reporting limits

12.2 Table 2 – Mass Spectrometer Data Acquisition Settings

Approved: ________________________________

Date: ________________________________

TABLE 1	
ANALYTE LIST AND LIMIT OF QUANTITATION (LOQ)	
Analyte	**LOQ, ug/L**
Imazamox	0.02
Imazapic	0.02
Imazapyr	0.02
Imazethapyr	0.02

TABLE 2 – MASS SPECTROMETER DATA ACQUISITION SETTINGS

Time	**SIM Ions**	**Fragmentor Voltage**	**Capillary Voltage**
0.00	220,222,234, 248,262,277, 278,290,293, 306,307	200	2000 V

TABLE 3 – SIM IONS FOR IDENTIFICATION/QUANTIFICATION

Analyte	Quantification Ion	Qualifier Ions	Ionization Mode	Fragmentor Voltage
Imazamox	306	307,278	positive	200
Imazapic	293	277,220	positive	200
Imazapyr	262	234,222	positive	200
Imazethapyr	290	262,248	positive	200

Appendix 5

General Site Safety & Materials Handling Guidelines and Procedures for Spartina Control Projects in the San Francisco Estuary

Invasive *Spartina* Project
2014 Aquatic Pesticide Application Plan

General Site Safety & Materials Handling Guidelines and Procedures for *Spartina* Control Projects in the San Francisco Estuary

Invasive *Spartina* Control Plan

ATTACHMENT 1

IMPORTANT DISCLAIMER AFFECTING LEGAL RIGHTS. *The San Francisco Estuary Invasive Spartina Project (ISP) compiled this document to provide a suggested set of general guidelines and procedures that are consistent with the mitigation measures required by the ISP EIR [spelled out](“PEIR”). These guidelines may be used by ISP partners and contractors as a minimal baseline, consistent with the PEIR, for planning and implementing site-specific Spartina control work in the San Francisco Estuary.*

These general guidelines are not intended to cover all safety procedures and precautions that may be necessary, nor are they intended to substitute for a comprehensive set of safety procedures and precautions for any particular control work or site. The ISP and the Conservancy make no warranties, assurances or representations of any kind with respect to the scope, extent, propriety or effectiveness of the suggested procedures that are described in these guidelines. Each ISP partner is responsible for and should independently develop and implement all appropriate safety precautions and procedures needed for the control work it undertakes. As a condition to use of these guidelines, each ISP partner and any of its contractors agree that the ISP and the State Coastal Conservancy (“Conservancy”) shall not be responsible for the acts or omissions of any ISP partner, or its contractors or volunteers, and agree to release and hold harmless the ISP and the Conservancy from any claims or liability, in connection with the development or implementation of site-specific safety procedures and precautions.

May 2005

Updated June 2011

Table of Contents

Emergency Information

Emergency Phone Numbers

- **In case of any emergency, call 9-1-1, and follow dispatcher instructions**
- **Pesticide Emergency:**
  - Call the ChemTrec (Chemical Transportation Emergency Center) emergency number, 1-800-424-9300, for instructions on how to handle any pesticide emergency
  - Emergency involving the BASF product (Habitat): 800-832-HELP (800-832-4357)
  - Emergency involving the Nufarm product (Polaris AQ): 877-325-1840
  - Emergency involving Monsanto products (Aquamaster): 314-694-4000
  - Emergency involving Dow products (Rodeo): 800-369-2436 or 979-238-2112
- **Chemical Spill into Marsh or other Waters:**
  - Report all spills within 24 hours to the San Francisco Regional Water Quality Control Board: 510-622-2369

Nearest Hospital

The following space is provided for the ISP grant recipient or its contractor(s) to provide the location and directions to the closest hospital.

Name: ____

Address: ____

____

Phone: ____

Directions to hospital: ____

____

____

____

____

A map should be attached or otherwise made available on site.

Sensitive Receptors

When applying herbicides for non-native *Spartina* control, care must be taken to protect human health, and particularly "sensitive receptors" that may be located near the application area.

Sensitive receptors include hospitals, schools, and residences near the Bay margin that are in close proximity (e.g., within 0.25 mile) to areas being treated with herbicide. The potential presence of sensitive receptors must be evaluated on a site-specific basis. The *Adjacent Land Uses* section in the site-specific Invasive *Spartina* Control Plan contains some information regarding potential sensitive receptors at each sub-area. In general, sensitive receptors are most likely to occur at sites located in the Corte Madera Creek watershed in Marin County, and along the shorelines of Alameda, Hayward and San Leandro in Alameda County. Birders, bicyclists, joggers, pedestrians, and users of recreational facilities (including parks, marinas, launch ramps, fishing piers, and beaches) that surround the Bay also could be sensitive receptors. The ISP grant recipient(s) and their contractors are responsible for fully identifying and protecting sensitive receptors.

To minimize risks to the public, mitigation measures for herbicide treatment methods must be implemented by entities engaging in treatment activities. Such measures include, but are not limited to, the following:

1. *Post signs for sensitive receptors within 500 feet*. At least one week prior to application, post signs informing the public of impending herbicide treatment at prominent locations within a 500-foot radius (approximately 1/10 mile) of treatment sites where homes, schools, hospitals, or businesses could be affected. Schools and hospitals within 500 feet of any treatment site should be separately noticed at least one week prior to the application.

2. *Avoid aerial spraying near sensitive receptors*. Do not conduct aerial spraying within 0.25 mile (1,320 feet) of a school, hospital, or other sensitive receptor location.

3. *Minimize drift*. Manage herbicide application to minimize potential for herbicide drift (See *Spray Drift Reduction*, page 11 of this document). Herbicide must not be applied when winds are in excess of 10 miles per hour or when inversion conditions exist, or when wind could carry spray drift into inhabited areas.

4. *Post signs at access points.* Post colored signs at and/or near any public trails, boat launches, or other potential points of site access 24 hours prior to treatment. The signs should inform the public that the area is to be sprayed with glyphosate and/or imazapyr herbicide for weed control, and that the spray is harmful if inhaled. The signs should advise "no entry" for humans and animals until eight (8) hours after treatment, and the treatment date and time should be stated. A 24-hour ISP contact number may be provided.

5. *Avoid high use areas*. Avoid application of herbicides near areas where the public is likely to contact water or vegetation. For example, avoid applying herbicide in or adjacent to high use areas within 24 hours of high use times, such as weekends or certain holidays. If a situation arises that makes it necessary to treat high-use areas during such times, the areas should be closed to the public before, during, and after treatment.

Listing of Sensitive Receptors

The following spaces are provided for the ISP grantee and its contractors to list sensitive receptors within 0.25 mile of the herbicide treatment site. This information should be made available in advance to herbicide application contractors.

	Schools	Hospitals
Name		
Address		
Contact		
Phone		
Name		
Address		
Contact		
Phone		
Name		
Address		
Contact		
Phone		

Residences

Name		
Address		
Contact		
Phone		
Name		
Address		
Contact		
Phone		
Name		
Address		
Contact		
Phone		

Site Safety Protocols for Working in Marshes, Mudflats, and other Tidal areas of the San Francisco Estuary

Tidal lands of the San Francisco Estuary present many unique hazards to workers who must access intertidal areas during the performance of their activity. The following is a summary of some of the hazards one may encounter when accessing these areas, and suggested precautions. There is no assertion made here, either stated or implied, that this list is comprehensive of all hazards that could possibly be encountered while in intertidal areas of the Estuary. Caution should be exercised at all times while in these areas, and common-sense danger avoidance techniques should be employed.

Teams

Always travel with a partner when entering or working in marshlands. There are many hidden hazards associated with marshland travel and work that are not readily discernable at first glance. A team of at least two individuals adds a necessary level of safety for any work or activity taking place in the marsh.

Supervisors should provide daily worker safety briefings prior to commencing work on site. These briefings need not be exhaustive, but should include any new information the supervisor may have obtained about the work conditions on the site, weather conditions, team assignments, equipment condition, or other pertinent issues.

Channels

Watch for hidden channels and holes in the marsh plain as you traverse the marsh. Often smaller channels in the marsh are obscured by vegetation. These channels can be quite deep, and may result in a sprain or pulled muscle, or possible fractures. Use a probe, like a stick or staff to check ahead of your path for unseen channels. Keep alert for vegetation changes, like *Grindelia* sp. (Gumplant), which grows along channel edges and may indicate a hidden channel.

Channel banks can sometimes be quite soft, and the mud that lines the channel can often be unstable. It is not unusual to sink deeply into these muds. This could be dangerous during an incoming tide. Always probe the mud within channels to test its ability to support your weight before stepping forward.

Channels often block direct routes through the marsh. These channels can be quite small or very large. Great caution should be observed when considering crossing these channels. It may seem worthwhile in most cases to leap across the channel to get to the other side. This should only be done on the smaller channels, when your partner is able to follow, when you have surveyed the route for alternate paths around the channel, and at low tide. Large channels should be avoided entirely, and placing driftwood bridges over these channels is not advised. Workers may fall from unstable bridges into larger channels and risk injury, drowning, hypothermia, or equipment destruction. It is best in these situations to find a way around the channel.

Mudflats

Mudflats at low tide can be quite dangerous to the unprepared. Often these flats are extremely soft, making travel over them slow and messy. Without proper footwear made for travel over mudflats (called “mudders”), workers may sink up to their thighs in mud.

If stuck deeply in a mudflat or channel bottom, you can often extract yourself by spreading out your weight over the mud by, in effect, laying or crawling on the muddy surface. Rocking your boots or waders back and forth to open space around your boot can also work to extract your feet from the mud. Assistance from your partner in the marsh can be essential during these situations. If feet sink into soft mud or quicksand, do not make violent movements in an attempt to get free. If boots or waders become stuck, slip one foot out gradually, rest the leg on the surface and gradually free the other leg. Lying on the surface and spreading the weight can avoid sinking. Move to firm ground using a “leopard crawl” (spread eagled, face down, keeping the maximum area of the body in contact with the ground at all times).

Chemical or Physical Hazards

Many marshland areas have been historic sites of dumping or disposal. Many marshes have accumulated debris or wrack that contains all manner of refuse. As a result, some areas have large amounts of this waste material, and in some cases, toxic waste or hazardous chemicals. Supervisors should be made aware of any known chemical or toxic waste issues associated with a site and take appropriate precautions. Workers should be notified prior to the beginning of operations within the marsh what the condition of the marsh is relative to toxic or hazardous substances, and be appropriately equipped.

Wear footwear capable of resisting puncture by sharp objects. Nails, glass, chunks of concrete, rusty metal and other debris can severely injure workers without appropriate footwear. Ideally, workers should wear hip or chest waders with reinforced soles, that are resistant to puncture, tearing or chemicals.

In areas where there are known concentrations of toxic or hazardous substances, a site-specific safety plan should be prepared and an appropriately trained hazardous materials expert should supervise work. At a minimum, workers should wear protective gloves and eyewear, long-sleeve shirts, and thoroughly wash all clothing subsequent to work in the marsh. Workers should also thoroughly wash themselves with soap and water following work activities.

If potentially toxic or hazardous materials are discovered during work activities, the area should be marked and reported to the appropriate authorities (the County Hazardous Materials Office and/or the Regional Water Quality Control Board). The area should be avoided until the material has been assessed and/or removed from the site.

Tides

All workers in the marsh shall be made aware of the tidal schedule prior to work in the marsh. Work shall commence on an ebb tide and cease on the incoming tide or earlier. Allow ample time to return to non-tidal areas before the incoming tide starts to advance across the work site. This general rule may be modified in higher marsh habitats where tidal action is lessened, but workers should always be alert and mindful of working in situations where the incoming tides may trap them, and allow ample time for exiting the marsh prior to an incoming tide. *If in doubt, get out*. Tides can rise extremely quickly in some areas, and it is possible that rising tides may outpace the ability of workers to out-run the increasing water levels, especially in soft muds or heavily vegetated marsh plains.

Weather

It is always important to monitor weather conditions prior to and during work activities within the marsh. Wind, rain, fog or other inclement weather can mean the difference between a safe work site and an extremely dangerous one. Winds usually occur in the early afternoon or late morning during the summer months, though dangerous weather patterns can occur at any time of the year. Rainfall may subject workers to hypothermia if unprepared, or may result in potentially dangerous floodwaters. Winds can increase wave action, whip up salt spray or dust. Fog can decrease workers ability to communicate or discern potential hazards in the marsh. It is ill advised to go into marshland terrain in bad visibility. For all work performed in the intertidal areas of the Estuary, workers or supervisors should check weather forecasts prior to commencing work on the site, should monitor weather conditions for any changes while on site and should modify work plans accordingly to insure the safety of all personnel.

Communication

Open lines of communication between workers in the marsh must be maintained. When more than one team will be working in the marsh at any one time, it is advisable to have a communication link to a land base and between individual teams for safety. In the case of injury, discovery of hazardous materials, endangered species, or cultural artifacts, or for other reasons, land-based assistance can be contacted from the field for immediate help or first aid. On the ground coordination via phone or walkie-talkie when crews are spread out over the marsh can help to avoid dangerous situations.

Herbicide Handling, Spill Prevention and Spill Response

The following information and practices are to be incorporated into herbicide-based *Spartina* control operations associated with the San Francisco Estuary Invasive Spartina Project (ISP).

Herbicide Use

- All herbicides shall be applied by or under the direct supervision of trained, certified or licensed applicators and in accordance with the product label
- On-site mixing and filling operations shall be confined to areas appropriately bermed or otherwise protected to minimize spread or dispersion of spilled herbicide or surfactant into surface waters

Herbicide Storage

Proper herbicide storage is one of the keys to using herbicides safely. Always wear rubber gloves when handling herbicides in storage, and review product labels for specific storage instructions.

General rules for herbicide storage include:

- Keep all herbicides in their original containers.
- Store herbicides in a locked shelter away from children and animals.
- Store herbicides in a dry, cool and well- ventilated area.
- DO NOT subject herbicides to freezing or extremely high temperatures.
- Store herbicides separately from seed, fertilizer, insecticides and food.
- Make periodic inspections of storage facilities and storage containers. Check for possible leaks, spills and other similar problems.
- Keep appropriate absorbent material in the storage area at all times as well as a plastic container for storing damaged material.
- Reject any broken or leaking containers when herbicides are delivered.
- Do not store herbicides in office or break areas where employees congregate.

Container Disposal

Empty herbicide containers must be disposed of according to government regulations or be returned to the manufacturer for disposal. Empty containers not returned to the manufacturer can be handled according to the procedures below, as long as local, state and federal laws are followed:

- Triple rinse containers with water at the application site. Always pour the rinsewater into an appropriate receptacle.
- Rinsed containers should be disposed of in a landfill approved for pesticide disposal or in accordance with applicable government procedures. Check with your

supervisor to find out if and when herbicide containers may be handled in this manner.

Spill Response

Under all circumstances, it is the responsibility of the applicator to assure that all precautions are taken prior to initiating work to assure protection of water quality and the environment. The applicator is also responsible for the provision of a Spill Response Kit that is appropriate for the work being undertaken.

The following procedures should be followed in the case of a non-petroleum chemical spill:

- Put on protective gloves, eyewear, a long-sleeved shirt and pants before cleanup
- If a container is leaking, immediately transfer the remaining herbicide to another appropriate container to prevent further spillage
- If the herbicide was spilled on a person, remove the contaminated clothing and rinse the product from the body. If necessary, perform appropriate first aid.
- Cover the spill area with an absorbent material to soak up the herbicide. Common cat litter, sawdust, soil or sand can all be used for this purpose. Consult the manufacturer for more specific clean up recommendations.
- Remove any contaminated items from the spill area to prevent further contamination
- Remove the absorbent material with a broom and or shovel after the spill has been absorbed. Make sure all contaminated soil is removed from the spill area as well.
- Place the contaminated soil and absorbent material into a suitable container, and dispose of the container in an approved landfill area
- ***Do not wash down the area with water*** using a high pressure hose. You may spread the spill and make the herbicide more difficult to contain and clean up.
- When a spill occurs on a site, or is large enough that you need help to contain or clean it up, contact a supervisor immediately. In case of a major spill, call the manufacturer or ChemTrec (Chemical Transportation Emergency Center), 1-800-424-9300.

Spill Response Kit

A Spill Response Kit should provided at the work site and be immediately accessible to all personnel. Some or all of the following items may be included in a Spill Response Kit. Consider site-specific conditions and the chemicals to be used to determine which of the following items are appropriate**.**

- PVC Gloves or equivalent (to mid forearm)
- PVC boots or equivalent
- Chemical resistant splash goggles
- Vice grip pliers

- Phillips head screwdriver (2)
- Shovels
- Brooms, dustpan
- Clay granules or a sawdust
- Activated charcoal or other appropriate absorbent material
- First aid kit
- Tyvek coveralls (2 pair) or neoprene coveralls
- Recovery drums
- DOT triangular reflector kit
- Source of clean water and soap
- In the case of refueling or mixing activities planned on open mudflats the spill response kit should include a portable wet vacuum or other pumping equipment

Preventing Spills

The following procedures will help to minimize the risk of spills occurring:

- Keep bags and cardboard containers dry at all times
- Prevent or correct leaks in herbicide containers and application equipment
- Properly dispose of all empty pesticide containers
- Tie down or otherwise secure containers when transporting pesticides to prevent them from falling from a vehicle
- Store herbicides only in their original containers or properly labeled service containers
- Stay alert and attentive when handling or using herbicides
- Where on-site or in-field transfer of liquid chemicals (herbicide mixtures, fueling operations) is planned, the transfer will occur at an appropriate upland site (staging area) to avoid contamination of the marsh or adjacent surface waters. A closed transfer system with a dry lock is preferred for these operations.

Procedures for Liquid Spill Response

The following procedures should be followed in the case of a non-petroleum spill:

- Put on protective gloves, eyewear, a long-sleeved shirt and pants before cleanup
- If a container is leaking, immediately transfer the remaining herbicide to another appropriate container to prevent further spillage
- If the herbicide was spilled on a person, remove the contaminated clothing and rinse the product from the body. If necessary, perform appropriate first aid or seek immediate medical attention.
- Cover the spill area with an absorbent material to soak up the herbicide. Common cat litter, sawdust, soil or sand can all be used for this purpose. Consult the manufacturer for more specific clean up recommendations.

- Remove any contaminated items from the spill area to prevent further contamination
- Remove the absorbent material with a broom and or shovel after the spill has been absorbed. Make sure all contaminated soil is removed from the spill area as well.
- Place the contaminated soil and absorbent material into a suitable container, and dispose of the container in an approved landfill area
- ***Do not wash down the area with water*** using a high pressure hose. You may spread the spill and make the herbicide more difficult to contain and clean up.
- When a spill occurs on a site, or is large enough that you need help to contain or clean it up, contact a supervisor immediately. In case of a major spill, call the manufacturer or ChemTrec (Chemical Transportation Emergency Center).

Under all circumstances it is the responsibility of the applicator to assure that all precautions are taken prior to initiating work to assure protection of water quality and the environment. The applicator is also responsible for the provision of a Spill Response Kit that is appropriate for the work being undertaken.

Spray Drift Reduction

Definition of pesticide drift	The Department of Pesticide Regulation (DPR) defines pesticide drift as the pesticide that moves through the air and is not deposited on the target area at the time of application. Drift does NOT include movement of pesticide and associated degradation compounds off the target area after application (e.g., translocation, volatilization, evaporation, or the movement of pesticide dusts or pesticide residues on soil particles that are windblown after application.)
The pesticide drift issue	Pesticide drift, particularly from agricultural fields, has been known to impact adjacent residential areas, cause damage to non-target crops, and contaminate the environment.
How does pesticide drift occur?	Low levels of pesticide drift may occur from all types of pesticide applications. Pesticide drift becomes unacceptable when pesticides are applied by imprecise methods or under environmental conditions that prohibit the applicator from maintaining control over the path the pesticide takes once it leaves the application equipment.

The San Francisco Estuary Invasive *Spartina* Project (ISP) has identified the use of herbicide as a critical component of its *Spartina* Control Program. The herbicide used for *Spartina* Control is imazapyr (Polaris™ or Habitat®) a product with exceptionally low toxicity, approved by U.S. EPA and the State of California for use in sensitive aquatic and estuarine environments. The human health risks associated with imazapyr are very low, and it requires no special personal protection measures for handling and application beyond those on the FIFRA label. In any case, it is desirable to minimize exposure of humans or non-target plants to pesticide drift.

The ISP requires that all herbicide application under the Control Program be managed to minimize spray drift to protect human health and the environment. Application of herbicide and surfactants in accordance with product labels (including the Supplemental Labeling for Aerial Application in California) will minimize spray drift. In addition, the ISP recommends the following:

1. For ground application of herbicide mixture by vehicle-mounted or towed ground equipment:
    a. Herbicide should be applied only when wind speed is 10 miles per hour or less at the application site, as measured by an anemometer positioned four feet above the ground.
    b. Discharge should start after entering the target site; discharge should be shut off before exiting the target site.
2. For aerial application of herbicide mixtures:
    a. Application should be by helicopter; no airplane application should be used.
    b. Nozzle orifices of broadcast sprayers should be directed backward.
    c. Flow of liquid from each nozzle should be controlled by a positive shutoff system.

d. Spray nozzles should be adjustable to allow control of droplet size. Use up to 1500 microns for windy conditions.
e. Boom pressure should not exceed the manufacturer's recommended pressure for the nozzles being used.
f. Herbicide should be applied only when wind speed is three to 10 miles per hour at the application site, as measured by an anemometer positioned four feet above the ground.
g. Discharge should start only after entering the target site; discharge height should not exceed 10-15 feet above the target vegetation; discharge should be shut off whenever necessary to raise the equipment over obstacles; discharge should be shut off before exiting the target site.

Petroleum Fuel Spill Prevention and Response

Spills of gasoline or other petroleum products, required for operation of motorized equipment, into or near open water could degrade water quality, with potential for bioaccumulation of contaminant toxicity. Several types of equipment used for treatment of *Spartina* may present opportunities for petroleum spills. Equipment used in *Spartina* control activities include:

- Amphibious tracked vehicles
- Spray trucks
- Water-based excavators (e.g. Aquamog)
- Gas-powered mowers (e.g. Weed-Whackers)
- Air boats and outboard motor boats

Fueling

Fueling of amphibious tracked vehicles, spray trucks or land-based excavators should be done offsite at fueling stations or suitable staging areas. A suitable staging area shall be equipped with sufficient protection to prohibit a petroleum spill from migrating beyond the immediate fueling area (e.g., an impermeable plastic tarp set between raised berms, a catch basin or similar portable device).

Water-based excavators, airboats and outboard motor boats shall be fueled offsite at commercial fueling stations or designated locations such as equipment maintenance yards. When fueling is done on or adjacent to treatment sites, a spill prevention and response plan must be prepared and implemented. A copy of this plan shall be provided to the Invasive *Spartina* Project at fieldops@spartina.org.

Gas powered, hand held machinery (e.g., weed whackers) shall be refueled on a non-absorbent tarp or mat placed under machinery to catch any spills.

In addition to spills during refueling operations, small amounts of oil or fuel may leak from improperly maintained equipment. Before using any equipment in the marsh, check to make sure that it is in good working order with no signs of leakage or corrosion that might indicate the potential for inadvertent spills on the work site.

Transport vessels and vehicles, and other equipment (e.g., mower, pumps, etc.) shall not be serviced or fueled in the field except under emergency conditions.

> ***Under all circumstances, it is the responsibility of the applicator to assure that all precautions are taken prior to initiating work to assure protection of water quality and the environment. The applicator is also responsible for the provision of a Spill Response Kit that is appropriate for the work being undertaken.***

Herbicide Information

This section provides product labels and Material Safety Data Sheets (MSDS) for herbicides and adjuvants that have been evaluated and approved for use in controlling non-native *Spartina* in the San Francisco Estuary. Product labels and MSDSs contain important information to help protect human health and the environment, and they should be included as a part your Site Safety Plan. Included in this section are the following products:

Imazapyr Herbicide:

Polaris™ (imazapyr-based herbicide) – Product label and MSDS. The product label and MSDS for **Habitat®** are essentially identical and it is approved by ISP.

Surfactants:

1. **Liberate®** (non-ionic surfactant/drift retardant) - Product label and MSDS.
2. **Competitor®** (methylated seed oil) – Product label and MSDS.

Colorants:

3. **Turf Trax® or Hi-Light®,** (spray pattern indicator) - Product label and MSDS.

Please note that ONLY the aquatic herbicides and surfactants that are listed here are approved for use in *Spartina* control in the San Francisco Estuary. There are other drift retardants and anti-foaming agents that may be used, provided the ISP Partner has reviewed the product information and found the product to pose no significant risk to human health or the estuarine environment.

It is the responsibility of the applicator to obtain product labels and MSDSs for any products not included in this document.

It is the responsibility of the applicator to assure that the most current product labels are obtained and followed.

Appendix 6

Adjacent Waterways for Invasive *Spartina* Treatment Sites

Invasive *Spartina* Project 2014 Aquatic Pesticide Application Plan

Adjacent Waterways for Spartina Treatment Sites (4014)

ISP Site #	ISP Site Name	ISP Sub-Area Number	ISP Sub-Area Name	2013 Estimated Treatment Area (Sq Meters)	Adjacent or Nearby Waterways
1	Alameda Flood Control Channel	01a	Channel Mouth	36.01	San Francisco Bay, Alameda Flood Control Channel
1	Alameda Flood Control Channel	01b	Lower Channel (not including mouth)	521.39	San Francisco Bay, Alameda Flood Control Channel
1	Alameda Flood Control Channel	01c	Upper Channel	191.32	San Francisco Bay
1	Alameda Flood Control Channel	01d	Upper Channel - Union City Blvd to I-880	326.93	San Francisco Bay, Alameda Flood Control Channel
1	Alameda Flood Control Channel	01e	Strip Marsh No. of Channel Mouth	23.42	San Francisco Bay, Alameda Flood Control Channel
1	Alameda Flood Control Channel	01f	Pond 3-AFCC	17.73	San Francisco Bay, Alameda Flood Control Channel
2	Bair/Greco Islands	02a.1a	Belmont Slough Mouth	5036.10	San Francisco Bay, Belmont Slough, Bay Slough
2	Bair/Greco Islands	02a.1b	Belmont Slough Mouth South	2037.11	San Francisco Bay, Belmont Slough
2	Bair/Greco Islands	02a.2	Upper Belmont Slough and Redwood Shores	15488.07	San Francisco Bay, Belmont Slough, Bay Slough, Redwood Shores Lagoons, Steinberger Slough
2	Bair/Greco Islands	02a.3	Bird Island	621.28	San Francisco Bay, Belmont Slough, Bay Slough
2	Bair/Greco Islands	02b.1	Corkscrew Slough	3190.32	San Francisco Bay, Corkscrew Slough, Redwood Creek, Steinberger Slough, Deepwater Slough
2	Bair/Greco Islands	02b.2	Steinberger Slough South, Redwood Creek Northwest	4176.97	San Francisco Bay, Corkscrew Slough, Redwood Creek, Steinberger Slough, Smith Slough
2	Bair/Greco Islands	02c.1a	B2 North Quadrant West	17399.45	San Francisco Bay, Steinberger Slough
2	Bair/Greco Islands	02c.1b	B2 North Quadrant East	47292.20	San Francisco Bay, Steinberger Slough
2	Bair/Greco Islands	02c.2	B2 North Quadrant South	34447.05	San Francisco Bay, Corkscrew Slough, Deepwater Slough, Redwood Creek
2	Bair/Greco Islands	02d.1a	B2 South Quadrant West	5225.34	San Francisco Bay, Redwood Creek
2	Bair/Greco Islands	02d.1b	B2 South Quadrant East	268.28	San Francisco Bay
2	Bair/Greco Islands	02d.2	B2 South Quadrant (2)	1460.23	San Francisco Bay, Corkscrew Slough
2	Bair/Greco Islands	02d.3	B2 South Quadrant (3)	478.41	San Francisco Bay, Redwood Creek, Corkscrew Slough
2	Bair/Greco Islands	02e	West Point Slough NW	977.44	San Francisco Bay, Redwood Creek, Westpoint Slough, First Slough
2	Bair/Greco Islands	02f	Greco Island North	10198.96	San Francisco Bay, Redwood Creek, Westpoint Slough, First Slough
2	Bair/Greco Islands	02g	West Point Slough SW and East	763.16	San Francisco Bay, Redwood Creek, Westpoint Slough, First Slough
2	Bair/Greco Islands	02h	Greco Island South	3188.40	San Francisco Bay, Westpoint Slough, First Slough, Ravenswood Slough
2	Bair/Greco Islands	02i	Ravenswood Slough & Mouth	16352.60	San Francisco Bay, Ravenswood Slough
2	Bair/Greco Islands	02j.1	Ravenswood Open Space Preserve (N of Hwy 84)	1141.38	San Francisco Bay
		02j.2	Ravenswood Open Space Preserve (S of Hwy 84)	108.31	San Francisco Bay
2	Bair/Greco Islands	02k	Redwood Creek and Deepwater Slough	5580.42	San Francisco Bay, Corkscrew Slough, Redwood Creek, Smith Slough, Deepwater Slough
2	Bair/Greco Islands	02l	Inner Bair Island Restoration	303.44	San Francisco Bay, Redwood Creek, Smith Slough, Steinberger Slough
2	Bair/Greco Islands	02m	Pond B3 - Middle Bair Island Restoration	3611.44	San Francisco Bay, Corkscrew Slough, Steinberger Slough

Adjacent Waterways for Spartina Treatment Sites (4014)

ISP Site #	ISP Site Name	ISP Sub-Area Number	ISP Sub-Area Name	2013 Estimated Treatment Area (Sq Meters)	Adjacent or Nearby Waterways
		02n	SF2	15.54	San Francisco Bay
3	Blackie's Pasture	03a	Blackie's Creek (above bridge)	0.16	San Francisco Bay, Blackie's Creek
3	Blackie's Pasture	03b	Blackie's Creek Mouth	26.43	San Francisco Bay, Blackie's Creek
4	Corte Madera Creek Complex	04a	Corte Madera Ecological Reserve (CMER)	13.34	San Francisco Bay, San Rafael Bay, Corte Madera Creek
4	Corte Madera Creek Complex	04e	Larkspur Ferry Landing Area	3.43	San Francisco Bay, San Rafael Bay, Corte Madera Creek
4	Corte Madera Creek Complex	04f	Riviera Circle	78.97	San Francisco Bay, San Rafael Bay, Corte Madera Creek
4	Corte Madera Creek Complex	04g	Creekside Park	111.84	San Francisco Bay, San Rafael Bay, Corte Madera Creek, Tamalpais Creek
4	Corte Madera Creek Complex	04h	Upper Corte Madera Creek (Above Bon Air Road)	25.86	San Francisco Bay, San Rafael Bay, Corte Madera Creek, Tamalpais Creek, Murphy Creek
4	Corte Madera Creek Complex	04i	Lower Corte Madera Creek (between Bon Air Rd & HWY 101)	137.55	San Francisco Bay, San Rafael Bay, Corte Madera Creek
4	Corte Madera Creek Complex	04j.1	Corte Madera Creek Mouth - North Bank	339.30	San Francisco Bay, San Rafael Bay, Corte Madera Creek
4	Corte Madera Creek Complex	04j.2	Corte Madera Creek Mouth - South Bank	40.02	San Francisco Bay, San Rafael Bay, Corte Madera Creek
5	Coyote Creek/Mowry Complex	05a.1	Mowry Marsh & Slough	3497.55	San Francisco Bay, Mowry Slough
5	Coyote Creek/Mowry Complex	05a.2	Calaveras Marsh	10937.77	San Francisco Bay, Coyote Creek, Alviso Slough
5	Coyote Creek/Mowry Complex	05b	Dumbarton/Audubon	2656.89	San Francisco Bay, Newark Slough, Plummer Creek
5	Coyote Creek/Mowry Complex	05c.1	Newark Slough West	448.23	San Francisco Bay, Newark Slough
5	Coyote Creek/Mowry Complex	05c.2	Newark Slough East	370.24	San Francisco Bay, Newark Slough
5	Coyote Creek/Mowry Complex	05d	LaRiviere Marsh	1063.81	San Francisco Bay, Newark Slough
5	Coyote Creek/Mowry Complex	05e	Mayhew's Landing	417.53	San Francisco Bay, Newark Slough
5	Coyote Creek/Mowry Complex	05g	Cargill Pond (W Hotel)	33.51	San Francisco Bay, Newark Slough
5	Coyote Creek/Mowry Complex	05h	Plummer Creek Mitigation	56.02	San Francisco Bay, Plummer Creek
		05i	Island Ponds	286.07	San Francisco Bay, Coyote Creek, Mud Slough, Guadalupe River
6	Emeryville Crescent	06a	Emeryville Crescent East	161.86	San Francisco Bay
6	Emeryville Crescent	06b	Emeryville Crescent West	18.58	San Francisco Bay
7	Oro Loma Marsh	07a	Oro Loma Marsh-East	674.12	San Francisco Bay
7	Oro Loma Marsh	07b	Oro Loma Marsh-West	4702.87	San Francisco Bay
8	Palo Alto Baylands	8	Palo Alto Baylands	3654.37	San Francisco Bay
9	Pickleweed Park/ Tiscornia Marsh	9	Pickleweed Park / Tiscornia Marsh	1.13	San Francisco Bay, San Rafael Bay, San Rafael Creek
10	Point Pinole Marshes	10b	Southern Marsh	36.97	San Francisco Bay
10	Point Pinole Marshes	10c	Giant Marsh	75.86	San Francisco Bay
11	Southampton Marsh	11	Southampton Marsh	389.78	San Francisco Bay
12	Southeast San Franciso	12a	Pier 94	0.38	San Francisco Bay, Islais Creek Channel
12	Southeast San Franciso	12b	Pier 98/Heron's Head	458.35	San Francisco Bay, Lash Lighter Basin

Adjacent Waterways for Spartina Treatment Sites (4014)

ISP Site #	ISP Site Name	ISP Sub-Area Number	ISP Sub-Area Name	2013 Estimated Treatment Area (Sq Meters)	Adjacent or Nearby Waterways
12	Southeast San Franciso	12c	India Basin	0.48	San Francisco Bay, India Basin
12	Southeast San Franciso	12e	Yosemite Channel	14.32	San Francisco Bay, South Basin, Yosemite Slough
12	Southeast San Franciso	12f	Candlestick Cove	0.39	San Francisco Bay, Brisbane Lagoon, South Basin, Yosemite Channel
12	Southeast San Franciso	12g	Crissy Field	0.09	San Francisco Bay, Crissy Field Marsh
12	Southeast San Franciso	12h	Yerba Buena Island	0.18	San Francisco Bay, Clipper Cove, Bar Channel, Oakland Outer Harbor
12	Southeast San Franciso	12i	Mission Creek	0.08	San Francisco Bay, Mission Bay, China Basin Water Channel
13	Whale's Tail Complex	13a	Old Alameda Creek North Bank	0.84	San Francisco Bay, Alameda Creek, North Creek
13	Whale's Tail Complex	13b	Old Alameda Creek Island	382.96	San Francisco Bay, Alameda Creek, North Creek
13	Whale's Tail Complex	13c	Old Alameda Creek South Bank	43.60	San Francisco Bay, Alameda Creek, North Creek
13	Whale's Tail Complex	13d	Whale's Tail North Fluke	45.44	San Francisco Bay, Alameda Creek, Mt. Eden Creek
13	Whale's Tail Complex	13e	Whale's Tail South Fluke	29.42	San Francisco Bay, Alameda Creek
13	Whale's Tail Complex	13f	Cargill Mitigation Marsh	74.00	San Francisco Bay, Alameda Creek
13	Whale's Tail Complex	13g	Upstream of 20 Tide Gates	2.93	San Francisco Bay, Alameda Creek, Ward Creek
13	Whale's Tail Complex	13h	Eden Landing-North Creek	0.59	San Francisco Bay, North Creek
13	Whale's Tail Complex	13i	Eden Landing-Pond 10	7.76	San Francisco Bay, Mt. Eden Creek
13	Whale's Tail Complex	13j	Eden Landing-Mt Eden Creek	29.69	San Francisco Bay, Mt. Eden Creek
13	Whale's Tail Complex	13k	Eden Landing Reserve South-North Creek Marsh	13.48	San Francisco Bay, Mt. Eden Creek, North Creek
13	Whale's Tail Complex	13l	Eden Landing Reserve North-Mt Eden Creek Marsh	33.91	San Francisco Bay, Mt. Eden Creek
15	South Bay Marshes	15a.1	Charleston Slough to Mountainview Slough	602.01	San Francisco Bay
15	South Bay Marshes	15a.2	Stevens Ck to Guadalupe Sl	152.13	San Francisco Bay
15	South Bay Marshes	15a.3	Guadalupe Slough	637.31	San Francisco Bay, Guadalupe Slough, Moffett Channel
15	South Bay Marshes	15a.4	Alviso Slough	8013.04	San Francisco Bay, Alviso Slough, Coyote Creek, Guadalupe River
15	South Bay Marshes	15a.5	Coyote Creek to Artesian Slough	220.61	San Francisco Bay, Coyote Creek, Mud Slough, Guadalupe River
15	South Bay Marshes	15b	Faber/Laumeister Marsh	662.24	San Francisco Bay, San Francisquito Creek
15	South Bay Marshes	15c	Shoreline Regional Park	1506.79	San Francisco Bay, Charleston Slough, Stevens Creek
16	Cooley Landing Salt Pond Restoration	16.1	Cooley Landing Central	4946.19	San Francisco Bay
16	Cooley Landing Salt Pond Restoration	16.2	Cooley Landing West	12885.16	San Francisco Bay
17	Alameda/San Leandro Bay Complex	17a	Alameda Island South (Elsie Roemer Bird Sanctuary, Crown Memorial State Beach, Crab Cove)	1153.58	San Francisco Bay, Tidal Channel, Airport Channel, San Leandro Bay, East Creek
17	Alameda/San Leandro Bay Complex	17b	Bay Farm Island	21.97	San Francisco Bay, San Leandro Bay
17	Alameda/San Leandro Bay Complex	17c.1	Arrowhead Marsh West	14475.42	San Francisco Bay, San Leandro Bay, Airport Channel, San Leandro Creek, Elmhurst Creek, Damon Slough
17	Alameda/San Leandro Bay Complex	17d.1	MLK Regional Shoreline - Fan Marsh Shoreline	395.30	San Francisco Bay, San Leandro Bay, Airport Channel, San Leandro Creek, Elmhurst Creek, Damon Slough
17	Alameda/San Leandro Bay Complex	17d.2	Airport Channel - MLK Shoreline	75.99	San Francisco Bay, San Leandro Bay, Airport Channel, San Leandro Creek, Elmhurst Creek, Damon Slough

Adjacent Waterways for Spartina Treatment Sites (4014)

ISP Site #	ISP Site Name	ISP Sub-Area Number	ISP Sub-Area Name	2013 Estimated Treatment Area (Sq Meters)	Adjacent or Nearby Waterways
17	Alameda/San Leandro Bay Complex	17d.3	East Creek -MLK Shoreline	306.31	San Francisco Bay, San Leandro Bay, Tidal Canal, Colisuem Channels, Damon Slough
17	Alameda/San Leandro Bay Complex	17d.5	Damon Sl/Elmhurst Cr - MLK Shoreline	146.36	San Francisco Bay, San Leandro Bay, Airport Channel, San Leandro Creek, Elmhurst Creek, Damon Slough
17	Alameda/San Leandro Bay Complex	17e.1	San Leandro Creek North	6.75	San Francisco Bay, San Leandro Bay, Airport Channel, San Leandro Creek, Damon Slough
17	Alameda/San Leandro Bay Complex	17e.2	San Leandro Creek South	140.68	San Francisco Bay
17	Alameda/San Leandro Bay Complex	17f	Oakland Inner Harbor	178.72	San Francisco Bay, Oakland Inner Harbor, Oakland Middle Harbor, Lake Merritt, Lake Merritt Channel, Brooklyn Basin, Tidal Canal, Fortmann Basin, Alaska Basin
17	Alameda/San Leandro Bay Complex	17g	Coast Guard Island	4.54	San Francisco Bay, Oakland Inner Harbor, Brooklyn Basin, Fortmann Basin
17	Alameda/San Leandro Bay Complex	17i	Coliseum Channels	185.15	San Francisco Bay, Coliseum Channels, East Creek Slough, San Leandro Creek, Damon Slough
17	Alameda/San Leandro Bay Complex	17k	Airport Channel	41.34	San Francisco Bay, San Leandro Bay, Airport Channel, San Leandro Creek, Elmhurst Creek, Damon Slough
17	Alameda/San Leandro Bay Complex	17l	Doolittle Pond	21.93	San Francisco Bay, San Leandro Bay, Airport Channel, Tidal Canal, San Leandro Creek, Elmhurst Creek, Damon Slough
17	Alameda/San Leandro Bay Complex	17m	Alameda Island (East: Aeolian Yacht Club & Eastern Shoreline)	364.96	San Francisco Bay, San Leandro Bay, Airport Channel, Tidal Canal, San Leandro Creek, Elmhurst Creek, Damon Slough
18	Colma Creek/San Bruno Marsh Complex	18a	Colma Creek	11.39	San Francisco Bay, Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor
18	Colma Creek/San Bruno Marsh Complex	18b	Navigable Slough	13.35	San Francisco Bay, Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor
18	Colma Creek/San Bruno Marsh Complex	18c	Old Shipyard	1.40	San Francisco Bay, Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor
18	Colma Creek/San Bruno Marsh Complex	18d	Inner Harbor	0.43	San Francisco Bay, Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor
18	Colma Creek/San Bruno Marsh Complex	18e	Sam Trans Peninsula	8.52	San Francisco Bay, Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor
18	Colma Creek/San Bruno Marsh Complex	18f	Confluence Marsh	2.23	San Francisco Bay, Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor
18	Colma Creek/San Bruno Marsh Complex	18g	San Bruno Marsh	69.16	San Francisco Bay, Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor
18	Colma Creek/San Bruno Marsh Complex	18h	San Bruno Creek	92.84	San Francisco Bay, San Bruno Creek, Colma Creek, Navigable Slough, Old Shipyard Harbor, Inner Harbor
19	West San Francisco Bay	19a	Brisbane Lagoon	4.46	San Francisco Bay, Brisbane Lagoon, Oyster Cove
19	West San Francisco Bay	19b	Sierra Point	3.41	San Francisco Bay, Oyster Cove, Brisbane Lagoon
19	West San Francisco Bay	19c	Oyster Cove	20.60	San Francisco Bay, Oyster Cove, Brisbane Lagoon

Adjacent Waterways for Spartina Treatment Sites (4014)

ISP Site #	ISP Site Name	ISP Sub-Area Number	ISP Sub-Area Name	2013 Estimated Treatment Area (Sq Meters)	Adjacent or Nearby Waterways
19	West San Francisco Bay	19d	Oyster Point Marina	0.60	San Francisco Bay, Oyster Cove, Brisbane Lagoon
19	West San Francisco Bay	19e	Oyster Point Park	3.46	San Francisco Bay, Oyster Cove,
19	West San Francisco Bay	19f	Point San Bruno	9.45	Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor, Seaplane Harbor
19	West San Francisco Bay	19g	Seaplane Harbor	5.47	Colma Creek, Navigable Slough, San Bruno Creek, Old Shipyard Harbor, Inner Harbor
19	West San Francisco Bay	19h	SFO	2494.21	San Francisco Bay, Seaplane Harbor, Mills Creek
19	West San Francisco Bay	19i	Mills Creek Mouth	26.42	San Francisco Bay, Easton Creek, Mills Creek
19	West San Francisco Bay	19j	Easton Creek Mouth	12.15	San Francisco Bay, Easton Creek, Mills Creek
19	West San Francisco Bay	19k	Sanchez Marsh	2571.35	San Francisco Bay, Sanchez Marsh, Bay Front Channel, Burlingame Lagoon
19	West San Francisco Bay	19l	Burlingame Lagoon	72.76	San Francisco Bay, Sanchez Marsh, Bay Front Channel, Burlingame Lagoon, Anza Lagoon
19	West San Francisco Bay	19n	Coyote Point Marina / Marsh	17.54	San Francisco Bay, Coyote Point Marina/Marsh, San Mateo Creek
19	West San Francisco Bay	19o	San Mateo Creek / Ryder Park	18.16	San Francisco Bay, San Mateo Creek, Seal Slough
19	West San Francisco Bay	19p.1	Seal Slough Mouth - Central Marsh	1825.82	San Francisco Bay, San Mateo Creek, Seal Slough
19	West San Francisco Bay	19p.2	Seal Slough Mouth - Peripheral Marshes	1673.46	San Francisco Bay, San Mateo Creek, Seal Slough, Foster City Lagoon
19	West San Francisco Bay	19q	Foster City	0.57	San Francisco Bay, Foster City Lagoon, Belmont Slough
19	West San Francisco Bay	19r	Anza Lagoon	1.12	San Francisco Bay, Sanchez Marsh, Bay Front Channel, Burlingame Lagoon, San Mateo Creek
20	San Leandro / Hayward Shoreline	20a	Oyster Bay Regional Shoreline	698.83	San Francisco Bay, Oyster Bay, Golf Links Channel, San Leandro Small Boat Lagoon, Estudillo Creek Channel
20	San Leandro / Hayward Shoreline	20b	Oakland Metropolitan Golf Links	1228.93	San Francisco Bay
20	San Leandro / Hayward Shoreline	20c	Dog Bone Marsh	27.29	San Francisco Bay
20	San Leandro / Hayward Shoreline	20d.1	Citation Marsh South	18.07	San Francisco Bay, San Lorenzo Creek Tidal Tributaries
20	San Leandro / Hayward Shoreline	20e	East Marsh	12.28	San Francisco Bay, San Lorenzo Creek Tidal Tributaries
20	San Leandro / Hayward Shoreline	20h.2	San Lorenzo Creek & Mouth South	302.90	San Francisco Bay, San Lorenzo Creek, Bockman Channel
20	San Leandro / Hayward Shoreline	20i	Bockmann Channel	2.86	San Francisco Bay, Bockman Channel
20	San Leandro / Hayward Shoreline	20j	Sulphur Creek	3.18	San Francisco Bay
20	San Leandro / Hayward Shoreline	20k	Hayward Landing	0.06	San Francisco Bay
20	San Leandro / Hayward Shoreline	20l	Johnson's Landing	8.10	San Francisco Bay
20	San Leandro / Hayward Shoreline	20m	Cogswell Marsh, Quadrant A	81.12	San Francisco Bay
20	San Leandro / Hayward Shoreline	20p	Hayward Shoreline Outliers	7.44	San Francisco Bay, Estudillo Creek Channel
20	San Leandro / Hayward Shoreline	20q	San Leandro Shoreline Outliers	1005.59	San Francisco Bay, San Leandro Flood Control Channel
20	San Leandro / Hayward Shoreline	20r	Oakland Airport Shoreline and Channels	879.14	San Francisco Bay, Oyster Bay

Adjacent Waterways for Spartina Treatment Sites (4014)

ISP Site #	ISP Site Name	ISP Sub-Area Number	ISP Sub-Area Name	2013 Estimated Treatment Area (Sq Meters)	Adjacent or Nearby Waterways
20	San Leandro / Hayward Shoreline	20s	H.A.R.D. Marsh	27.52	San Francisco Bay
20	San Leandro / Hayward Shoreline	20t	San Leandro Marina	0.34	San Francisco Bay, Estudillo Creek Channel
20	San Leandro / Hayward Shoreline	20u	Estudillo Creek Channel	20.45	San Francisco Bay, Estudillo Creek Channel
20	San Leandro / Hayward Shoreline	20v	Hayward Landing Canal	173.04	San Francisco Bay
21	Ideal Marsh	21a	Ideal Marsh North	1217.68	San Francisco Bay
21	Ideal Marsh	21b	Ideal Marsh South	1198.27	San Francisco Bay
22	Two Points Complex	22a	Wildcat Marsh	175.90	San Francisco Bay, San Pablo Strait, San Pablo Bay, Wildcat Creek
22	Two Points Complex	22b.1	San Pablo Marsh East	874.32	San Francisco Bay, San Pablo Bay
22	Two Points Complex	22b.2	San Pablo Marsh West	1890.76	San Francisco Bay, San Pablo Bay, San Pablo Creek
22	Two Points Complex	22c	Rheem Creek Area	731.32	San Francisco Bay
22	Two Points Complex	22d	Stege Marsh	72.19	San Francisco Bay, Richmond Inner Harbor
22	Two Points Complex	22e	Hoffman Marsh	0.30	San Francisco Bay, Richmond Inner Harbor
22	Two Points Complex	22f	Richmond/ Albany /Pinole Shoreline	72.89	San Francisco Bay, San Pablo Strait, San Pablo Bay
23	Marin Outliers	23b	Beach Drive	84.77	San Francisco Bay, San Pablo Bay
23	Marin Outliers	23c	Loch Lomond Marina	8.87	San Francisco Bay, San Pablo Bay
23	Marin Outliers	23d.2	San Rafael Canal Mouth West	11.39	San Francisco Bay, San Rafael Creek
23	Marin Outliers	23e	Muzzi & Martas Marsh	104.91	San Francisco Bay, San Clemente Creek, Corte Madera Ecological Reserve Pond
23	Marin Outliers	23i	Strawberry Cove	49.67	San Francisco Bay, Richardson Bay, Strawberry Cove, Pickleweed Inlet
23	Marin Outliers	23j	Bothin Marsh	1.72	San Francisco Bay, Richardson Bay, Strawberry Cove, Pickleweed Inlet, Tennessee Creek
23	Marin Outliers	23k	Sausalito	0.66	San Francisco Bay, Richardson Bay
23	Marin Outliers	23m	Novato	3.66	San Francisco Bay, San Pablo Bay, Novato Creek, Bel Marin Lagoon, Miller Creek, Gallinas Creek
24	Petaluma River	24a	Upper Petaluma River-Upstream of Grey's Field	399.07	San Francisco Bay, San Pablo Bay, Petaluma River, Lynch Creek
24	Petaluma River	24c	Petaluma Marsh	40.68	San Francisco Bay, San Pablo Bay, Petaluma River, Tule Slough, Schulz Slough, Mira Slough, Mud Hen Slough, Donahue Slough, San Antonio Creek
26	North San Pablo Bay	26b	San Pablo Bay NWR & Mare Island	730.87	San Francisco Bay, San Pablo Bay, Sonoma Creek, Mare Island Strait, Second Napa Slough, Dutchman Slough, South Slough
26	North San Pablo Bay	26c	Sonoma Creek	137.87	San Francisco Bay, San Pablo Bay, Sonoma Creek, Tolay Creek, Second Napa Slough, Third Napa Slough, Dutchman Slough, South Slough