REPORT

Invasive/Exotic Vegetation Management Program

University of California, Berkeley
Richmond Field Station
Richmond, California

January 2004

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Table of Contents

1. Introduction

On September 4, 2003, the Untied States Army Corps of Engineers (USACE) issued a Nationwide Permit 38 ([NWP 38], File # 28135S) to the University of California, Berkeley (UC Berkeley) for remediation and restoration of wetland areas within Western Stege Marsh. Western Stege Marsh is a portion of the Richmond Field Station (RFS) property owned by UC Berkeley and is located at 1301 South 46th Street, Richmond, Contra Costa County, California. The location of the RFS is shown on Figure 1. Remediation and restoration activities are being conducted in compliance with the requirements of the Regional Water Quality Control Board (RWQCB), San Francisco Bay Region, Order Number 01-102. This report presents an invasive/exotic vegetation management program (the Program) that UC Berkeley is required to implement as a condition of the NWP 38.

The RFS currently occupies approximately 72 acres of marsh and mudflat and 90 acres of upland habitats. Included within these areas is a diversity of habitat types that support a number of native vegetation communities, including salt marsh, native and non-native grasslands, meadows and seeps, and coastal scrub (URS Corporation [URS], 2003). This report was prepared by Blasland, Bouck & Lee, Inc. (BBL) in coordination with URS and Aquatic Outreach Institute (AOI) on behalf of UC Berkeley to address potential impacts of invasive/exotic vegetation during the restoration of jurisdictional wetlands (i.e., less than 5 feet National Geodetic Vertical Datum [NGVD]) disturbed during remediation activities, as permitted by the NWP 38. The project area is the marsh and ecotone portion of Subunit 2. Subunit divisions are depicted on Figure 2; the project area is shown on Figures 3 through 5. A full description of the boundaries covered under the RWQCB Order is presented in Section 1.2.1.

1.1 Report Organization

- The remainder of Section 1 presents the site description, consultation background, and Program overview;
- Section 2 details the invasive/exotic vegetation management program; and
- Section 3 identifies references used to generate this report.

1.2 Project Setting

The following sections describe the physical and ecological setting of the project area that is affected by remediation and restoration activities authorized under the NWP 38.

1.2.1 Physical Description and RWQCB Area Designations

The RFS is currently owned by the UC Regents for use by the UC Berkeley campus and is located at 1301 South 46th Street in Richmond, California (Figure 1). The RFS occupies approximately 162 acres and consists of approximately 90 acres of upland, industrial-zoned land, used primarily for research and education, and approximately 72 acres of marsh and tidal mudflat. Of the 72 offshore acres, approximately 9.4 acres, located within the inner portion of Western Stege Marsh, are covered under the RWQCB order. The RFS is bounded by Meade Street off Interstate 580 to the north, by Meeker Slough/Regatta Boulevard to the west, and by South 46th Street to the east. The East Bay Regional Park District (EBRPD) Bay Trail transects the marsh portion of the RFS property known as Western Stege Marsh. Cherokee Simeon Ventures (CSV) owns the property

(formerly owned by Zeneca Inc. [Zeneca]) to the east of the RFS boundary, where it is in the process of redevelopment.

The RFS and adjacent Zeneca properties are identified as the Meade Street Operable Unit (MSOU). The MSOU was subdivided into two operable units identified as Subunits 1 and 2. Subunit 1 encompasses the Zeneca property and the eastern portion of Stege Marsh (Eastern Stege Marsh), and Subunit 2 encompasses the RFS property and the western portion of Stege Marsh (Western Stege Marsh). Subunit 2 was further divided into Subunits 2A and 2B. Subunit 2A includes the southeastern portion of the upland portion of the RFS and the eastern portion of Western Stege Marsh. Subunit 2B includes the remainder of the uplands and the western portion of Western Stege Marsh.

The project area is located in the marsh and ecotone portions of Subunit 2. Subunit divisions are depicted on Figure 2; the project area is shown on Figures 3 through 5. The project area is bounded to the west by the western shore of Meeker Slough, to the north by the developed portion of the RFS, to the east by Subunit 1, and to the south by the EBRPD Bay Trail. The NWP 38 permits activities below 5 feet NGVD in Western Stege Marsh.

1.2.2 Ecological Setting

Natural areas of the RFS, Stege Marsh, and Meeker Slough consist of a variety of habitat types that support a number of vegetation series and associations. The major natural habitat types occurring at the RFS include coastal scrub (California Natural Diversity Database [CNDDB] 32.000.00), native grasslands (CNDDB 41.000.00), non-native grasslands (CNDDB 42.000.00), meadows and seeps (CNDDB 45.000.00), and muted tidal marsh (CNDDB 52.000.00), tidal mudflats, and open slough channels. There are also several man-made landscaped habitats, such as herbaceous groundcovers and eucalyptus and other ornamental tree groves. Many habitats within the project area have been previously disturbed by human activities.

Major habitat types in the project area consist of coastal scrub and marsh habitats, as defined by the CNDDB. Figure 3 presents the location of existing habitat types in Western Stege Marsh prior to implementation of remedial activities authorized under the NWP 38. Figures 4 and 5 present habitat types as designed by remediation and restoration Alternatives 1 and 2, respectively, upon completion of restoration activities. Alternatives 1 and 2 are fully described in the Biological Assessment ([BA]; BBL, 2003a) submitted to the USACE, along with a copy to the United States Fish and Wildlife Service (USFWS), in July 2003.

Marsh habitat designed to exist within the project area following completion of restoration activities consists of high marsh, low marsh, tidal mudflat, and open-water slough habitats. The total area of marsh habitat within the project area is currently approximately 9.4 acres. Following completion of restoration activities, between 4.07 (Alternative 1) and 2.55 (Alternative 2) acres of additional marsh habitat will be created. High marsh is currently dominated by emergent vegetation consisting primarily of *Distichlis spicata* (salt grass), with some *Scirpus robustus* (alkali bulrush), *Grindelia stricta angustifolia* (marsh gum plant), and *Jaumea carnosa* (jaumea). Middle marsh areas are currently dominated by *Salicornia virginica* (pickleweed). Low marsh is currently dominated by *Spartina foliosa* (Pacific cordgrass), which has been confirmed by genetic testing. Tidal mudflat is primarily devoid of vegetation and is associated with slough channels that run through the project area.

Marsh habitat is currently separated from coastal scrub habitat on the northern boundary by a concrete riprap berm approximately 10 feet wide. The EBRPD Bay Trail forms the southern boundary of the inner portion of marsh habitat. Both areas create an abrupt transition zone between marsh and upland and are heavily vegetated with a mixture of native and non-native vegetation. On the outboard side of the EBRPD Bay Trail, marsh

habitat transitions from areas supporting pickleweed and cordgrass to tidal mudflats and open water habitats. Restoration plans for the project area include removal of the riprap berm on the northern boundary and subsequent creation of a gently sloping ecotone between marsh and upland habitats.

Coastal scrub habitat is present on the northern portion of the project area in a backfill area known as the "bulb" and along a small berm area in the southern portion of the project area (the island). Dominant vegetation is *Baccharis pilularis* (coyote brush), with large populations of *Foeniculum vulgare* (fennel). Other species associated with coastal scrub habitat in the project area include *Cortderia jubata* (pampas grass), *Cytisus scoparius* (Scotch broom), *Heteromeles arbutifolia* (toyon), various cotoneaster species, *Hordeum brachyantherum* (meadow barley), *Raphanus sativus* (wild radish), *Carduus pycnocephalus* (Italian thistle), *Avena sp.* (wild oats), *Bromus diandrus* (ripgut brome), *Toxicodendron diversilobum* (poison oak), and several invasive/exotic grasses (URS, 2003). Under Alternative 1 restoration plans, the bulb area is designated to be regraded to allow for creation of middle marsh habitat. Coastal scrub habitat is retained on the bulb in restoration plans for Alternative 2.

The main hydrologic feature of the project area is Meeker Slough, which is approximately 40 to 50 feet wide in the project area. The bottom elevation of Meeker Slough in the project area ranges from approximately 0 to -1.0 foot NGVD (URS, 2003).

Restoration plans for the project area call for vegetative dominance in each habitat type (e.g., high marsh) to remain similar to that which existed prior to remediation and restoration activities. Additionally, ecotone areas will be created to allow for a gradual transition between marsh and upland habitats. During restoration activities, UC Berkeley will implement a marsh restoration plan and an invasive/exotic species management program in the project area. The invasive/exotic vegetation management program is designed to reduce the presence of invasive/exotic species in the project area. This report presents the invasive/exotic vegetation management program.

1.3 Consultation Background

Phase 1 of the multiphase remediation program for the RFS was performed from September through December 2002 and included work in marsh and upland portions of Subunit 2A. The adjacent property (former Zeneca site) also performed their remedial work for the upland portion of Subunit 1 from September through December 2002. In preparation for this work, wetland areas were delineated, and Levine Fricke (LFR), on behalf of Zeneca, submitted a Joint Aquatic Resource Permit Application (JARPA) on September 11, 2001, for Subunit 1 and 2A on behalf of Zeneca. Based on additional characterization of the marsh by UC Berkeley, a modified excavation boundary was established. A revision to the work area and addition of UC Berkeley as a co-permittee were requested in a supplemental report provided to the USACE and the USFWS (URS, 2002). Zeneca and UC Berkeley used the same construction contractor to perform the Phase 1 work. However, subsequent work at the RFS, including Western Stege Marsh, will be performed by UC Berkeley construction contractors. Eastern and Western Stege Marsh are now independent projects. Western Stege marsh is contained within the boundaries of the UC Berkeley project area.

Two meetings were held with David Wooten of the USFWS to discuss results of California Clapper Rail (*Rallus longirostris obsoletus* [CCR]) surveys conducted during February 2002 by LFR and to discuss potential impacts of the remediation and restoration program on CCR. Following agreements reached to limit impact to CCR (i.e., work restricted outside of CCR habitat and a 150-foot buffer zone during breeding season), USACE issued a NWP 38 on September 17, 2002, for work within Subunit 2A. Under the Nationwide 38 permit, excavation and remediation of the upland portion of Subunit 1 was completed by Zeneca's contractor, along with a portion

of Subunit 2A in the fall of 2002. Due to the restricted work schedule, it was not possible to complete the full extent of work authorized under the permit.

In preparation for the second phase of work in 2003, URS performed additional CCR surveys on behalf of UC Berkeley in February 2003. BBL, on the behalf of UC Berkeley, submitted a request for modification to the NWP 38 (BBL, 2003b) to the USACE, along with a copy to the USFWS, in order to allow completion of remediation activities in the remaining authorized area and two additional areas within Western Stege Marsh.

Approval of the Nationwide 38 permit modification request required a Biological Opinion (BO) from the USFWS. Therefore, UC Berkeley submitted a BA (BBL, 2003a) to assist the USFWS with preparation of the BO evaluating potential impacts of the proposed remedial activities on sensitive species and habitats. The BA presented information regarding the project area, remedial alternatives, potential impacts to CCR, and a proposed mitigation plan. Following the USACE's and USFWS's review of the BA, the USACE issued a NWP 38 (File # 28135S) on September 4, 2003 to UC Berkeley for remediation and restoration of wetland areas within Western Stege Marsh. The NWP 38 stated that remediation and restoration activities must be implemented as described in the request for modification to the previous NWP 38 (BBL, 2003b) and the BA (BBL, 2003a). Additionally, terms and conditions imposed in the USFWS BO must also be implemented. The USFWS terms and conditions were as follows:

- UC Berkeley must develop a management plan for non-native plant species within the Stege Marsh area under UC Berkeley's jurisdiction; and

- UC Berkeley must develop a plan to manage feral animals in the vicinity of the project area.

A feral animal management program has been developed by UC Berkeley and will be submitted in compliance with the conditions of the NWP 38. This report details specifics of the invasive/exotic vegetation management program that UC Berkeley will institute on the RFS. A Program overview is provided in Section 1.4 and a detailed description of the program is provided in Section 2.

1.4 Program Overview

CCR are typically found in the intertidal zone and sloughs of salt and brackish marshes and adjacent upland refugia. These habitats are essential to the CCR for cover, foraging, and nesting habitat. Suitable CCR habitat has been significantly reduced in the San Francisco Bay Area due to urban encroachment, agricultural use, pollution, erosion, and the spread of invasive/exotic plant species. The spread of invasive/exotic plant species, specifically perennial pepperweed (*Lepidium latifolium*) and smooth cord grass (*Spartina alterniflora*), may reduce the quality of habitat available for CCR use on the RFS.

The Program outlined in this report is designed to reduce establishment and cover of priority invasive/exotic plant species (e.g., *L. latifolium*, *S. alterniflora*, *C. jubata*, *F. vulgare*, *Bassia hyssopifolia*) that may impact marsh and upland habitats used by CCR. The highest priority invasive/exotic species for control that have been observed, either on or adjacent to the RFS, are identified in Table 1 of Attachment 1. Of these highest priority species, the Program will focus particular attention on *S. alterniflora* and *L. latifolium*, as distinguished in the BO. Tables 2 and 3 of Attachment 1 list invasive/exotic plant species found on the RFS; however, these species pose less potential threat to habitat quality and restoration success. The Program will include the following two components:

- Actively monitor and control priority invasive/exotic vegetation within the project area to promote high quality marsh and upland habitat for CCR; and

- Enhance and increase ecotonal and upland refugia habitat for CCR.

Details regarding these two aspects of the program are presented in Section 2.

2. Invasive/Exotic Vegetation Management Program

The Program is designed to control the establishment of priority invasive/exotic vegetation that may reduce the quality of CCR habitat and/or reduce percent cover of native vegetation in the marsh and upland restoration areas. The Program is composed of two primary components: priority invasive/exotic vegetation control and monitoring, and ecotone and upland habitat enhancement and creation. These components are described in the sections below.

2.1 Priority Invasive/Exotic Vegetation Control and Monitoring

Active invasive/exotic vegetation plant control and monitoring will be undertaken within the project area. Additionally, UC Berkeley will encourage invasive/exotic vegetation control and monitoring activities in areas adjacent to the RFS that may directly impact invasive/exotic colonization in the project area. AOI, in partnership with the UC Berkeley Environmental Sciences Training Program (ESTP), is currently implementing an invasive/exotic plant control program under the direction of UC Berkeley. Since June 2003, UC Berkeley has worked with AOI to actively reduce establishment of newly colonizing priority species and reduce patch size of mature existing populations both within and adjacent to the project area. UC Berkeley and AOI have worked with Zeneca, EBRPD, and the Spartina Project to coordinate control activities, share resources, ensure implementation of effective techniques, and reduce edge effects by controlling targeted invasive/exotic vegetation surrounding the project area. Details of recent control efforts that have occurred over the past 8 months are discussed in Attachment 2 of this report. The Program is designed to build upon the successes of this ongoing effort in the project area. Table 1 in Attachment 1 presents priority invasive/exotic species that will be specifically targeted during Program implementation. Of these highest priority species, the Program will focus particular attention on *S. alterniflora* and *L. latifolium*, as distinguished in the BO.

2.1.1 Implementation Logistics

Following completion of remediation activities, UC Berkeley will install erosion control matting (e.g., jute matting) in the created ecotone if areas of bare ground are unable to immediately undergo initial restoration actions (i.e., natural revegetation and/or planting). Installation of erosion control matting will reduce potential colonization of invasive/exotic plant species within these areas and will enable UC Berkeley to focus limited personnel resources on controlling invasive plants within the remaining regraded habitat. Additionally, erosion control matting will reduce sediment erosion in regraded areas, thereby maintaining the integrity of the marsh regrading plan.

Due to the breeding and nesting season of CCR, all weed control activities that require the use of machinery (e.g., brush cutters or chain saws) or large groups (i.e., more than four persons) in or near the marsh will be conducted between September 1st and February 1st to minimize disturbance of CCR, in accordance with the NWP 38. Between February 1st and September 1st, weeders, trained by UC Berkeley contractors, will work only in small groups (i.e., fewer than four) without machinery in or within 200 feet of existing marsh habitat. Groups more than four people will only perform weed removal activities in areas greater than 200 feet from the existing marsh habitat during CCR breeding season.

Control of prioritized invasive/exotic plant populations will be implemented by UC Berkeley contractors. Contractors will lead UC Berkeley students and community volunteers during the Program. These activities will offer students and local community members the opportunity to learn about marsh ecology, the benefits of restoration, and the threat invasive/exotic species pose to marsh biodiversity.

Monitoring efforts will be overseen by UC Berkeley contractors (e.g., BBL or URS) and implemented by student and volunteer work crews. Volunteer monitoring will be primarily qualitative and will consist of site walks to identify locations of newly colonizing species or pioneer plants. Quantitative vegetation monitoring in the restoration area will provide data regarding progress of invasive/exotic species control and will be conducted by a UC Berkeley contractor (e.g., BBL or URS) and implemented as outlined in the wetland restoration monitoring section (i.e., Section 4.3.1) of the BA. Analysis of qualitative and quantitative data will occur in yearly restoration monitoring reports. Monitoring reports will assess effectiveness of the Program in controlling target species. Adaptive management strategies to increase chances for success of the restoration will be presented in annual monitoring reports.

2.1.2 Species Specific Management Recommendations

The invasiveness of exotic species can vary widely, from ornamentals that may persist but are sexually or vegetatively non-reproductive to species that can spread rapidly, hybridize with natives, and can invade intact native plant communities (e.g., *S. alterniflora*). Species-specific biology, history of invasiveness, and effectiveness of available control methods dictate which invasive/exotic species warrant immediate action and how to most effectively prioritize limited resources. The Program uses the California Invasive Plant Council (CalIPC) system of characterizing invasive/exotic species as a tool to prioritize which species warrant active control. The characterizations of species present on or adjacent to the project area are listed in Tables 1 through 3 in Attachment 1. Additional species-specific information is compiled in Attachment 3.

CalIPC classifications identify species that are wildland problems across habitats throughout the state. Prioritization of invasive species on and around the project area requires that specific site characteristics, such as the size of the invasive population, whether the invasive species habitat preferences are matched to the site conditions, and the proximity to sensitive or endangered species habitat, must be considered. The Program takes into account such information to prioritize the invasive/exotic species present on or adjacent to the project area. Table 1 identifies Priority I species, which are the highest priority species that should be monitored and removed in the project area prior to establishment and before going to seed. Table 2 identifies Priority II species, which are invasive/exotic species that should be monitored and may warrant removal if they could substantially reduce native revegetation efforts in the project area. Priority II species would only be removed after Priority I species have been addressed. Priority III invasive plants are of the lowest priority and would be locally controlled only when directly competing with establishing native species in the project area and reducing restoration success. Specific management recommendations for Priority I species are presented in the following paragraphs. It should be noted that the primary Priority I species of concern for the Program are *S. alterniflora* and *L. latifolium*, as was distinguished in the BO. Other Priority I species identified in this document will be addressed through the Program as they appear in the project area.

If the manual methods of control listed below are not effective in controlling establishment or regrowth of Priority I invasive/exotic species in the project area, chemical methods of control will be evaluated. Chemical methods of control will likely involve spot-spraying or wick application of a glyphosate pesticide, such as Rodeo®. Prior to implementing a chemical control program for invasive/exotic vegetation, UC Berkeley will consult appropriate agencies, such as EBRPD, Contra Costa County Vector Control, and USACE, to arrange logistics of implementation and to obtain any necessary permits.

2.1.2.1 Priority I Species of Highest Concern

Based on their historic presence in areas adjacent to the project area, their highly invasive nature, and their potential to severely disrupt the ability of native vegetation to establish in the project area, *S. alterniflora* and *L.*

latifolium are the two species of highest concern for the Program. Control methods that will be used for these species are described below.

Spartina alterniflora (smooth cordgrass)

Hand pulling is the simplest option for small propagules (i.e., one to a few plants less than 0.5 meters in diameter). On soft substrates, plants can be removed by gently pulling rhizomes and roots from the mud. Care should be taken to remove any rhizome pieces that may break off during removal of the larger plant portion. On harder substrates, a shovel may be needed, and some rhizomes may be easily missed. All plant material should be carried to an area above the high tide mark, where it can dry out and die. The growth site should be marked with stakes and revisited after a few months to be sure the entire propagule was removed.

If the infestation is small (i.e., one to a few patches 1 to 10 meters in diameter), burial of the plants under geotextile fabric or a black plastic tarp is an effective means of control. Stems can be mowed with a weed whacker or similar device and then covered with 100 percent shadecloth (e.g., geotextile fabric) or heavy-duty black plastic. Covering is best begun in spring. The area covered should exceed the plant diameter by at least one meter, and the covering must be well anchored to the mudflat with sandbags or boards and deep stakes to prevent movement during tidal flux. Completely covered patches may die within four months, but mortality rates substantially increase if covers are not removed for one year or more.

Lepidium latifolium (perennial pepperweed)

Mechanical methods to control perennial pepperweed require repeated follow-up, as new plants quickly regenerate from pieces of rootstock left in the soil. Segments much shorter than one inch (2.5 cm) are capable of resprouting. Due to the ability of pepperweed to regenerate from residual root stock, chemical control methods may be required to eliminate populations.

2.1.2.2 Priority I Species of Special Concern

Several additional Priority I species (i.e. *B. hyssopifolia*, *C. jubata*, and *F. vulgare*) are present in the project area and adjacent areas. These species have the potential to disrupt native vegetation establishment in the project area if they are not controlled. Therefore, the Program will monitor for these species and implement the control methods described below before they have a chance to become well established in the project area.

Bassia hyssopifolia (bassia, five-hook bassia)

Hand pulling is an effective control technique for discreet populations. Hand removal is accomplished most easily following rainfall when soil is loose. Plants should be pulled as soon as they are large enough to grasp and before they bolt or are able to produce seed. Pieces of root remaining in the soil will not sprout again if below the crown. Plants can be destroyed readily while they are still small by hand hoeing, either by cutting off the tops or by stirring the surface soil to expose seedlings to drying by the sun. Experience suggests that minimizing disturbance may allow more desirable plants to outcompete and replace this weed.

Cortaderia jubata (pampas grass)

Pulling or hand grubbing pampas grass seedlings is highly effective if seedlings are less than one-year old. For larger plants, however, a pulaski, mattock, or shovel are the safest and most effective tools for removing established clumps. To prevent resprouting, it is important to remove the entire crown and top section of the roots. Detached plants left lying on the soil surface may take root and reestablish under moist soil conditions. A

large chainsaw or brushcutter can expose the base of the plant, allowing better access for removal of the crown, making disposal of the detached plant more manageable.

Foeniculum vulgare (fennel, anise)

Manual methods of control are most effective when infestations are light and locally restricted. Digging out individual plants by hand is the most effective control, but it is labor-intensive, particularly in rocky soils. Cutting, mowing, and chopping temporarily reduce the height of fennel plants within a stand and prevent seed set, but are ineffective as methods of permanent removal.

In areas where fennel stands are already well established, management will require long-term management. Management efforts should focus on preventing or reducing soil disturbance, which favors spread, and reducing fennel density within dense stands that currently exist in the project area.

2.1.2.3 Additional Priority I Species

The following Priority I species have the potential to disrupt native vegetation establishment in the project area. Some of these species have been observed in areas adjacent to the project area (e.g., uplands on the RFS or on adjacent properties), but have not been observed in the project area (i.e., marsh and ecotone of the Western Stege Marsh). The Program will monitor for these species and will implement the control methods described below if they are observed in the project area.

Centaurea solstitialis (yellow starthistle)

It is important to prevent large-scale infestations by controlling newly established individuals or colonies. Spot eradication is the least expensive and most effective method of preventing establishment of yellow starthistle. At RFS, the population is sufficiently small that diligent monitoring in conjunction with timely hand pulling should effectively prevent spread of this species. Plants should be pulled before they bolt or are able to produce seed. Pieces of root remaining in the soil will not sprout again if below the crown. Plants can be destroyed readily while they are still small by hand hoeing, either by cutting off the tops or by stirring the surface soil to expose seedlings to drying by the sun.

Conium maculatum (poison hemlock)

This species has not been previously observed growing in the project area. However, it has been observed growing in adjacent areas. Hand pulling of poison hemlock is effective for small seedlings, especially prior to seed set, and easiest when the soil is wet. Because of the biennial nature of the plant, the entire root system does not need to be removed on second year (bolting) plants.

Spring mowing has proven effective in killing mature plants, yet regrowth may occur and new seedlings may continue to establish. A second mow in late summer is recommended to eliminate remaining or subsequent growth. Because poison hemlock seed has been shown to germinate up to three years following dispersal, a third year of mowing may be necessary if this plant becomes established.

Ehrharta erecta (ehrharta, panic veldt grass)

E. erecta control efforts are still new, and control methods are not yet proven. Manual removal of *E. erecta* must take care to remove the buried base of the plant, or resprouting will occur. Removal by hand is labor-intensive and will often stimulate germination from the seedbank. Extremely high densities of emerging

seedlings have been observed following manual removal. Due to this, manual removal must be repeated as plants emerge from the seedbank. Mulching the site following initial removal may be an effective control method. Due to uncertainty in control methods and the unknown persistence of *E. erecta* seedbanks, several years of treatment may be necessary if this species becomes established.

Phalaris aquatica (Harding grass)

Harding grass is currently present in the upland areas adjacent to the project area on the RFS. If this species begins to establish in ecotone habitats of the project area, then control methods may be needed. Harding grass produces an abundant seedbank and can regenerate from small rhizome pieces in the ground. Manual control methods should be repeatedly applied when plants are actively growing. Harding grass active growth occurs during periods of frequent rainfall. Hand removal can be accomplished through use of pulaskis, shovels, and hand picks. Close mowing or clipping late in the growing season can also greatly reduce the vigor of Harding grass. Mowing, when used, should be conducted when plants are still green, but seasonal soil moisture is almost exhausted. Once Harding grass plants have died back, new seedlings will soon establish if soil is left bare. However, young seedlings are susceptible to competition. To prevent re-establishment of Harding grass, desirable species should be planted, or the area should be heavily mulched or covered.

Rubus discolor (Himalayan blackberry)

Removing rootstock by hand digging is an effective method to control Himalayan blackberry, which can resprout from roots. Root pieces that remain in the soil will result in resprouting of the vegetation. Mechanical removal may be the most effective way to remove mature plants. Most mechanical control techniques, such as cutting trimming vines with loppers, clippers, shovels, or a weed wrench, are suitable for Himalayan blackberry. Care should be taken to prevent vegetative reproduction from cuttings, which may resprout if left in contact with the soil.

Perennial weeds such as Himalayan blackberry usually require several cuttings before underground plant parts exhaust their reserve food supply. If only a single cutting can be made, the best time to conduct this activity is when plants begin to flower. At this stage the reserve food supply in the roots is nearly exhausted, and new seeds have not yet been produced. Reestablishment of Himalayan blackberry may be prevented by planting fast-growing shrubs or trees, as the species is usually intolerant of shade.

Once again, it should be noted that if manual control methods for any of the species listed above do not effectively control their establishment or regrowth, then chemical methods of control will be evaluated. Chemical methods of control will likely involve spot-spraying or wick application of a glyphosate pesticide, such as Rodeo®.

2.2 Ecotone and Upland Enhancement/Creation

The presence of an ecotonal edge between marsh and upland habitats is an important physical attribute that influences CCR survival. During high tides, CCR are forced into ecotone edges adjacent to marsh habitat. Therefore, dense vegetation in these areas creates refugia for CCR from predators until tides recede. Ecotone areas between marsh and upland habitats that contain appropriate vegetation density and height may reduce the impact of predation upon CCR (Goals Project, 2000).

The restoration designs in Alternatives 1 and 2, as presented in the BA, call for creation of gradually sloping ecotone edges between the high marsh and upland habitats. Ecotonal edges will be created through removal of steep riprap areas, where appropriate (e.g., northern edge of Western Stege Marsh), and proper regrading of the

project area following remediation. The marsh, ecotone, and upland areas disturbed during remediation activities will be revegetated with native species. Final revegetation goals are for each habitat type to be dominated by native species similar to those species present prior to disturbance. Ecotone edges should be dominated by tall (i.e., 3 to 4 feet) herbaceous native species, interspersed with small shrubs, to provide cover from predators for CCR during high tides. The Program will also supplement the feral animal management program by preventing the establishment of large woody growth in ecotone areas that could be used as perching areas for large raptors that may potentially prey on CCR.

Ecotone areas will be monitored during the invasive/exotic species control program to create a diverse habitat and to prevent the dominance of non-native species that may decrease the value of these habitats for CCR use. Establishing a native plant community is the most effective long-term method to reduce invasive/exotic vegetation presence in the restoration area. Native plants established through revegetation of upland and ecotone habitats will compete with invasive/exotic species. Effective establishment of native vegetation and active management of invasive/exotic vegetation will prevent bare ground present following final grading from becoming quickly dominated by aggressive invasive/exotic species.

2.3 Implementation Schedule

Control of Priority I invasive/exotic vegetation in the project area and in surrounding areas has been implemented since the summer of 2003. These activities were performed at the behest of UC Berkeley, and were performed by AOI and ESTP. Details of these activities are presented in Attachment 2. Control of invasive/exotic vegetation will continue in the project area as outlined in this report as various stages of remediation are completed.

The following bullets outline a general timeline for invasive/exotic vegetation management activities:

- Creation/enhancement of ecotone areas is dictated by remediation schedules. As remediation and final grading is completed in the project area, ecotone creation/enhancement will be addressed.

- The invasive/exotic species control program, which will help create densely vegetated ecotones, will continue in the eastern portion of the project area during the first quarter of 2004 following completion of remediation and regrading activities in this area.

- Removal of riprap areas and creation of additional ecotone will occur in accordance with future remediation schedules (2005 through 2007).

- Quantitative invasive/exotic species monitoring will be performed semi-annually during restoration monitoring events, and invasive/exotic vegetation control efforts will be implemented semi-annually or more frequently as needed. Activities related to these aspects that may potentially disturb CCR during the breeding season will be implemented in accordance with the NWP 38 and as presented in Section 2.1.1.

- Invasive/exotic vegetation monitoring and control efforts will be documented and submitted to the agencies as a portion of the annual restoration monitoring report.

UC Berkeley will continue implementation of the Program through conclusion of the restoration monitoring program for Western Stege Marsh, as outlined in the BA.

3. References

Blasland, Bouck & Lee, Inc. 2003a. *Richmond Field Station Remediation Project Biological Assessment Report.* July, 2003.

Blasland, Bouck & Lee, Inc. 2003b. *Nationwide Permit 38 Modification Request (ACOE File No. 26417S), Western Stege Marsh Remediation and Restoration Project at Richmond Field Station, Richmond, California.* July, 2003.

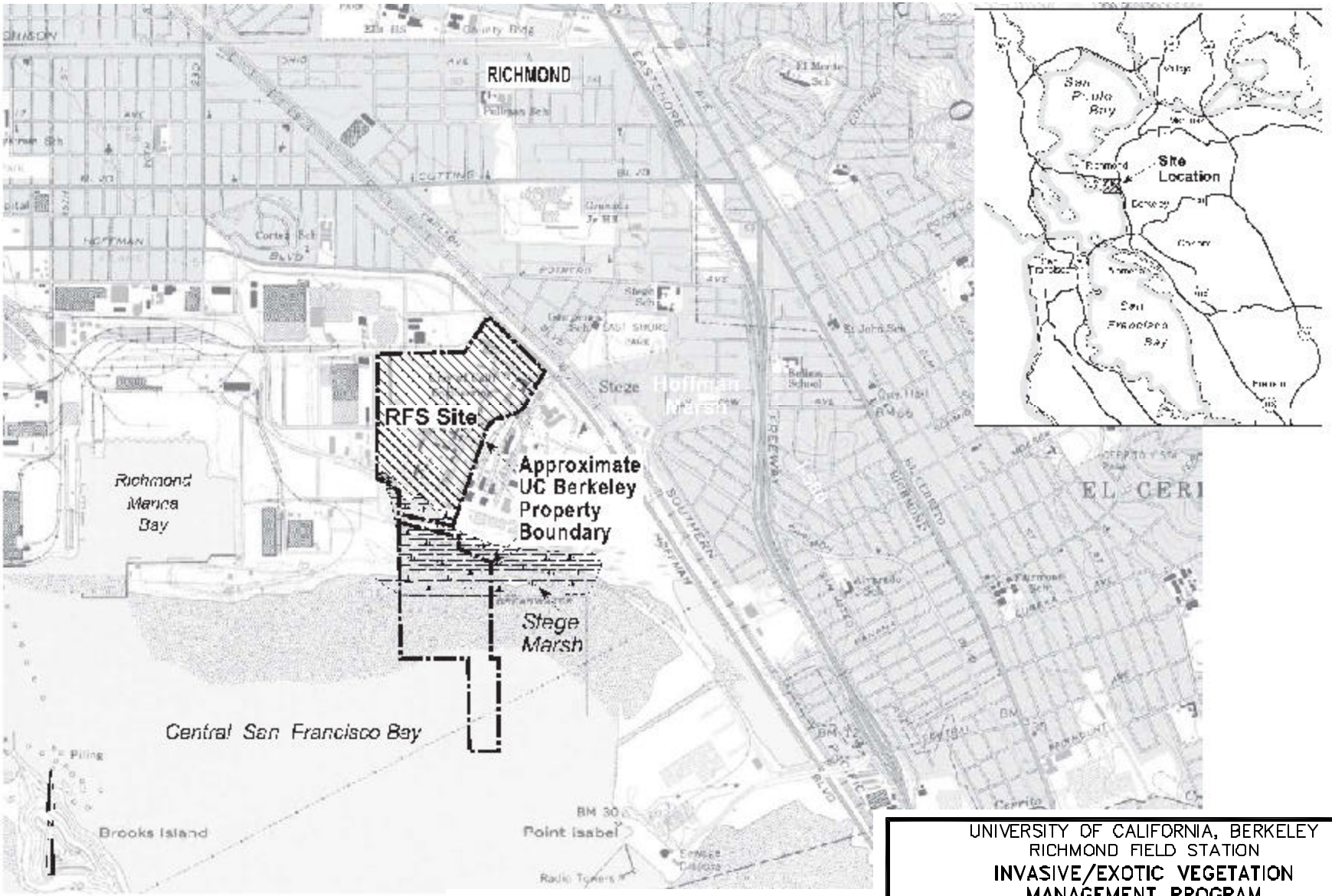
Goals Project. 2000. *Baylands Ecosystem Species and Community Profiles: Life Histories and Environmental Requirements of Key Plants, Fish, and Wildlife.* Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P.R. Olofson, editor. Oakland, California: San Francisco Bay Regional Water Quality Control Board.

URS. 2002. Meade Street Operable Unit, Subunits 1 and 2A, U.S. Army Corps of Engineers File Number 26417S (June 5, 2002).

URS. 2003. *Richmond Field Station Remediation Project, Initial Study, California Environmental Quality Act.* May, 2003.

Figures

BLASLAND, BOUCK & LEE, INC.
engineers & scientists



Map Source: USGS, 7.5 min. Quadrangle map, Richmond, California, 1980 revised

NOTE:
MAP WAS PREPARED FROM A USGS TOPOGRAPHIC 7.5 MIN QUADRANGLE PROVIDED BY URS ON 7/8/03

X: FIGURE_1 SITE LOC MAP.TIFF
L: OFF=REF
P: PAGESET/PLT-AL
1/22/04 RV-BG-JNS
F:/IBM/CAD/2004PROJ/24210.410/IEWMPP/24210SL1.DWG

UNIVERSITY OF CALIFORNIA, BERKELEY
RICHMOND FIELD STATION
INVASIVE/EXOTIC VEGETATION MANAGEMENT PROGRAM

SITE LOCATION MAP

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

FIGURE
1

LEGEND:

ZENECA PROPERTY (SUBUNIT 1)

RICHMOND FIELD STATION PROPERTY (SUBUNIT 2 & OFFSHORE PROPERTY)

NOTE:

FIGURE PROVIDED BY URS CORPORATION.

UNIVERSITY OF CALIFORNIA, BERKELEY
RICHMOND FIELD STATION
INVASIVE/EXOTIC VEGETATION MANAGEMENT PROGRAM

SUBUNITS 2A AND 2B LOCATIONS AND BOUNDARIES

BLAGBURN, BOUCK & LEE, INC.
engineers, scientists, economists

FIGURE 2

L: DFF=REF
P: PAGESET/PLT-BL
1/22/04 IRV-80-JMS
F:/BW/CAD/2004PROJ/2421D.410/IEVMPP/2421GC01.DWG

LEGEND

- PAMPAS GRASS
  0.2 ACRES
- WALKING PATH
  0.25 ACRES
- SURFACE WATER (ORANGE POND)
  0.1 ACRES
- DISTRESSED/DEAD HIGH SALT MARSH (SALT GRASS)
  0.2 ACRES
- COYOTE BRUSH/CONCRETE RUBBLE
  0.3 ACRES
- MIXED RUDERAL SCRUB
  2.5 ACRES
- LOW SALT MARSH (PACIFIC CORDGRASS)
  3 ACRES
- MIDDLE SALT MARSH (PICKLEWEED)
  1.4 ACRES
- HIGH SALT MARSH (SALT GRASS)
  3.7 ACRES
- SURFACE WATER/SLOUGH
  1.1 ACRES
- ALKALI BULRUSH
  0.1 ACRES
- FENCE LINE
- BOUNDARY BETWEEN UPLAND AND MARSH (~ 5' NGVD)

0 100' 200'
GRAPHIC SCALE

NOTES:

1) SOME PORTIONS OF THE HIGH SALT MARSH (SALT GRASS) AREAS ALONG THE EBRPD BAY TRAIL ALSO CONTAIN INTERMITTENT PATCHES OF PICKLEWEED.

2) 14 ACRES TOTAL WATER AND WETLANDS IN PROJECT AREA.

3) BASE MAP SUPPLIED BY URS ON 7/9/03 AT A SCALE OF 1"=100'.

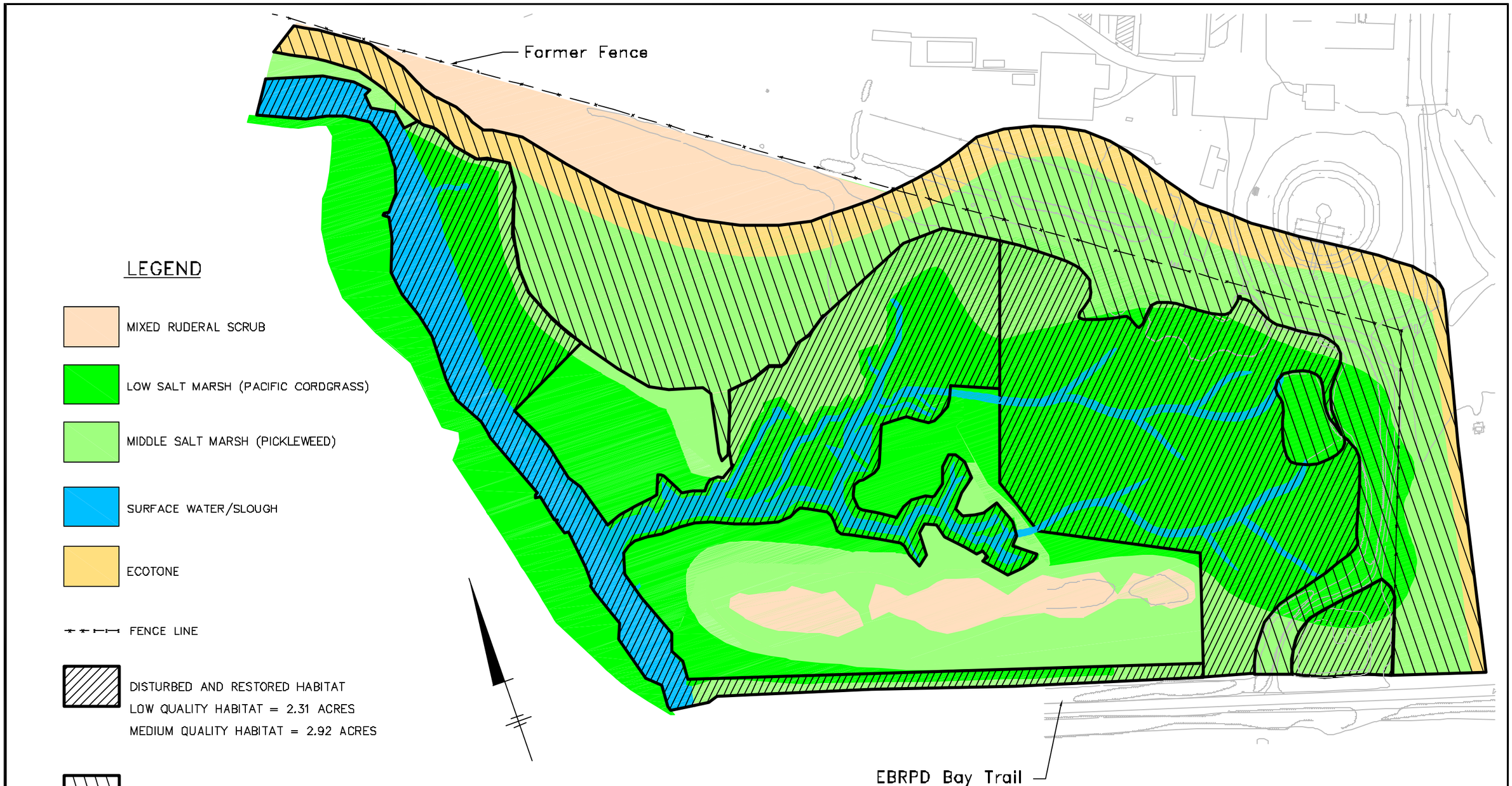
UNIVERSITY OF CALIFORNIA, BERKELEY
RICHMOND FIELD STATION
INVASIVE/EXOTIC VEGETATION MANAGEMENT PROGRAM

PROJECT AREA
PRE-CONSTRUCTION HABITATS

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

FIGURE 3

X: (XREF)
L: OFF=REF
P: PAGESET/PLT-BL
1/29/04 IRV-80-JMS
F:/BM/CAD/2D04PROJ/24210.410/IEVMPP/24210C02.DWG



NOTES:

1) SOME PORTIONS OF THE HIGH SALT MARSH (SALT GRASS) AREAS ALONG THE EBRPD BAY TRAIL ALSO CONTAIN INTERMITTENT PATCHES OF PICKLEWEED.

2) BASE MAP SUPPLIED BY URS ON 7/9/03 AT A SCALE OF 1"=100'.

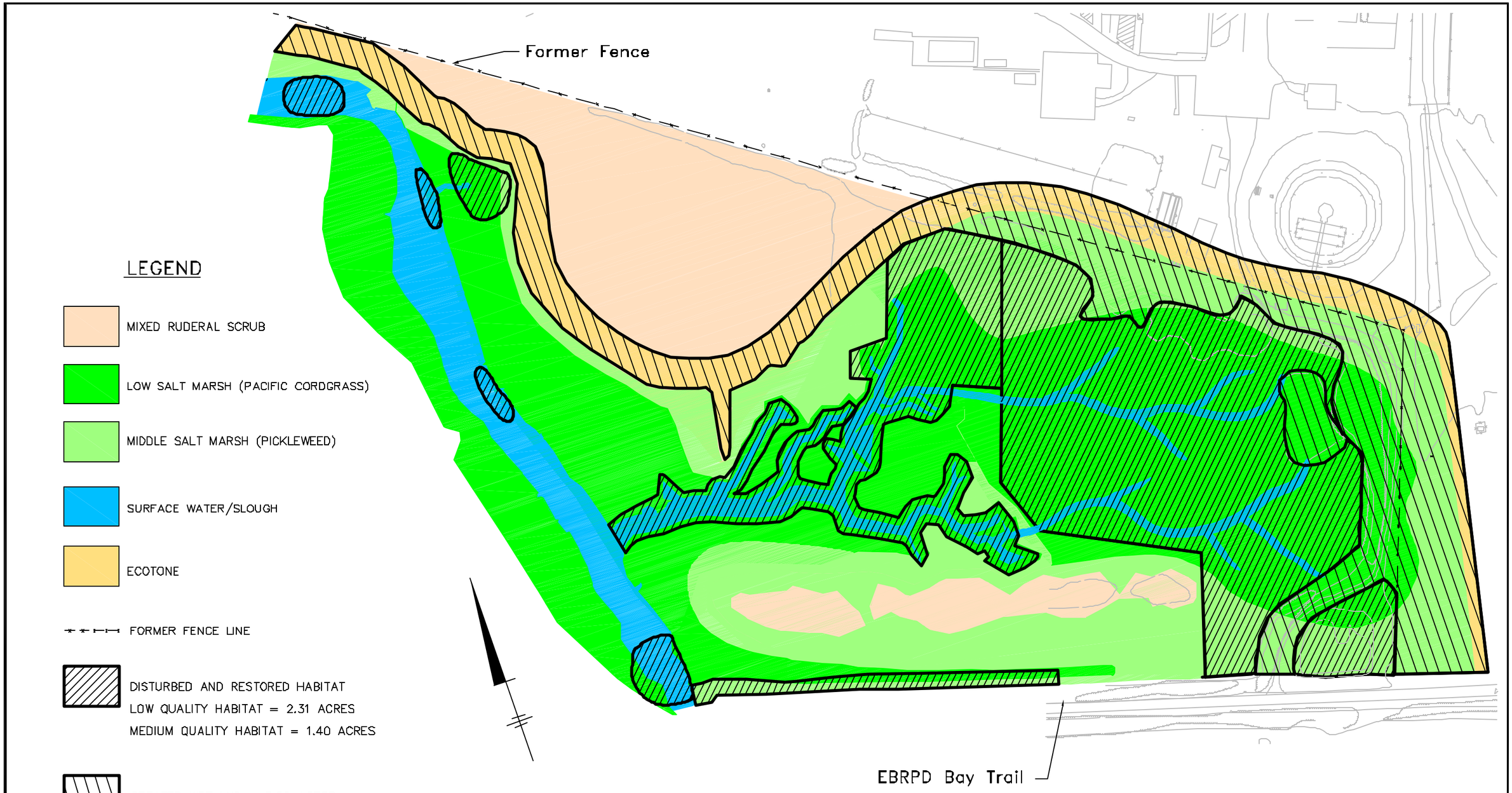
UNIVERSITY OF CALIFORNIA, BERKELEY
RICHMOND FIELD STATION
INVASIVE/EXOTIC VEGETATION MANAGEMENT PROGRAM

PROJECT AREA - ALTERNATIVE 1 CONCEPTUAL RESTORATION PLAN

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

FIGURE 4

L: DFF=REF
P: PAGESET/PLT-BL
1/29/04 IRV-80-JMS
F:/BM/CAD/2D04PROJ/2421D.410/IEVMPP/2421GC03.DWG



NOTES:

1) SOME PORTIONS OF THE HIGH SALT MARSH (SALT GRASS) AREAS ALONG THE EBRPD BAY TRAIL ALSO CONTAIN INTERMITTENT PATCHES OF PICKLEWEED.

2) BASE MAP SUPPLIED BY URS ON 7/9/03 AT A SCALE OF 1"=100'.

UNIVERSITY OF CALIFORNIA, BERKELEY
RICHMOND FIELD STATION
INVASIVE/EXOTIC VEGETATION MANAGEMENT PROGRAM

PROJECT AREA - ALTERNATIVE 2 CONCEPTUAL RESTORATION PLAN

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

FIGURE 5

L: DFF=REF
P: PAGESET/PLT-BL
1/29/04 IRV-80-JMS
F:/BW/CAD/2D04PROJ/24210.410/IEVMMP/24210CD4.DWG

Attachment 1

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Priority I Invasive Non-Native Plant Species

Table 1 identifies the highest priority invasive plant species that will be monitored, and controlled to prevent establishment. Priority I species will be removed to the greatest extent feasible prior to developing viable seed.

Table 1.

Scientific Name	Common Name	Sub-site location within West Stege Marsh restoration area				CalIPC rating
		Marsh	Upland	Bulb	Staging Area	
Bassia hyssopifolia	mustard	X	X			B
Centaurea solstitialis	yellow star-thistle		X			1A
Conium maculatum*	poison hemlock					B
Cortaderia jubata	pampas grass		X		X	1A
Cynara cardunculus*	artichoke thistle					1A
Ehrharta erecta	Stebbins' grass		X			B
Foeniculum vulgare	sweet fennel		X	X	X	1A
Genista monspessulana*	French broom					1A
Lepidium latifolium	pepperweed		X			1A
Phalaris aquatica	Harding grass		X	X	X	B
Rubus discolor	Himalayan blackberry		X			1A
Spartina alternaflora	Atlantic cordgrass	X				A2

Identification of sub-site locations, where invasive non-native species currently occur or could establish within natural habitats, are based upon field observations, species ecology, and recent plant inventories conducted by URS (2003).

* Non native species not currently present within restoration areas, however observed growing directly adjacent to marsh habitat

List A: documented as aggressive invaders that displace natives and disrupt natural habitats. This includes two sub-lists: list 1-A: Widespread invasives across the state of California and list A-2: invasives that are currently distributed regionally.

List B are wildland pest plants of lesser invasiveness; invasive pest plants that spread less rapidly and cause a lesser degree of habitat disruption; that maybe widespread or regional.

Priority II Invasive Non-Native Plant Species

Table 2 identifies priority II invasive non-native plant species which will be monitored and controlled if deemed an impact on the survivorship of revegetation plantings or the integrity of sensitive wildlife habitat, and if community volunteer and student resources are available for implementing control strategies.

Table 2.

Scientific Name	Common Name	Sub-site location within West Stege Marsh restoration area				CalIPC rating
		Marsh	Upland	Bulb	Staging Area	
Acacia melanoxylon	blackwood acacia		X		X	No Rating
Brassica rapa				X		No Rating
Carduus pycnocephalus	Italian thistle		X	X		B
Carpobrotus chilensis	iceplant	X		X	X	No Rating
Carpobrotus edulis	iceplant			X		1A
Centranthus ruber	red valerian		X			No Rating
Cirsium vulgare	bull thistle		X			B
Contoneaster pannosa				X	X	A2
Contoneaster sp.	contoneaster		X			A2
Cynodon dactylon	Bermuda grass			X		No Rating
Eucalyptus globulus	blue gum eucalyptus			X	X	1A
Lactuca serriola	prickly lettuce		X	X		No Rating
Lotus corniculatus	birdsfoot trefoil		X		X	No Rating
Melilotus alba			X			No Rating
Melilotus indica			X			No Rating
Oxalis pes-carpae	Bermuda buttercup			X	X	No Rating
Polypogon monspeliensis	rabbitfoot grass	X	X			No Rating
Raphanus sativus	wild radish		X	X		No Rating

Scientific Name	Common Name	Sub-site location within West Stege Marsh restoration area				CalIPC rating
		Marsh	Upland	Bulb	Staging Area	
Salsola soda	alkali Russian thistle		X	X		No Rating
Salsola tragus	Russian thistle	X				No Rating
Silybum marianum	milk thistle		X	X		No Rating

Identification of sub-site locations, where invasive non-native species currently occur or could establish within natural habitats, are based upon field observations, species ecology, and recent plant inventories conducted by URS (2003)

List A: documented as aggressive invaders that displace natives and disrupt natural habitats. This includes two sub-lists: list 1-A: Widespread invasives across the state of California and list A-2: invasives that are currently distributed regionally.

List B are wildland pest plants of lesser invasiveness; invasive pest plants that spread less rapidly and cause a lesser degree of habitat disruption; that maybe widespread or regional.

Priority III Invasive Non-Native Plant Species

Table 3 identifies priority II invasive non-native plant species are the lowest priority for control. Control activities will only occur if species substantially affect revegetation survivorship or the integrity of sensitive wildlife habitat. It is no anticipated that these species will have significant impacts.

Priority III: These species are of lowest priority and can be locally controlled where competing with native species establishment.

* non-native species observed on adjacent areas
(sub-site, non native species observations from URS, 2003)

Table 3.

Scientific Name	Common Name	Sub-site location within West Stege Marsh restoration area				CalIPC rating
		Marsh	Upland	Bulb	Staging Area	
Allium triquetrum*						
Anthemis cotula*	mayweed					
Bellardia trixago*	Mediterranean lineseed					
Chamaesyce maculate*	spotted spurge					
Cichorium intybus	chicory		X			
Coronopus didymus	wart cress		X			
Cotula australis			X		X	
Euphorbia peplus*	petty spurge					
Gastridium ventricosum*	nit grass					
Geranium molle					X	
Hirschfeldia incana	short pod mustard		X	X	X	
Linum bienne					X	
Lythrum hyssopifolium*	hyssop loosestrife					
Parapholis incurva	sickle grass	X	X			
Paspalum dilatatum	Dallis grass				X	
Schinus molle*	Peruvian pepper tree					B
Tragopogon porrifolius*	Salsify					
Trifolium dubium	hop clover		X		X	
Trifolium fragiferum*	strawberry clover					

Scientific Name	Common Name	Sub-site location within West Stege Marsh restoration area				CalIPC rating
		Marsh	Upland	Bulb	Staging Area	
Trifolium subterraneum	subterranean clover				X	
Vicia villosa ssp. varia	winter vetch		X			
Aira caryophyllea	silver hairgrass		X	X	X	
Anagallis arvensis	scarlet pimpernel		X		X	
Avena barbata	slender wild oats		X	X	X	
Avena fatua	wild oats		X	X	X	
Briza major	rattlesnake grass		X			
Briza minor	little rattlesnake grass				X	
Bromus diandrus	ripgut brome		X	X	X	
Bromus hordeaceus	soft chess	X	X	X	X	
Bromus madritensis ssp. Madritensis*						
Bromus madritensis ssp. Rubens	red brome	X	X	X		A2
Bromus stamineus			X	X	X	
Chamomilla suaveolens	pineapple weed		X			
Conyza bonariensis*	South American horseweed					
Cotula coronopifolia	brass-buttons		X			
Dactylis glomerata*	orchard grass					
Dipsacus sativus*	teasel			X		
Eucalyptus polyanthemos*	silver dollar eucalyptus					
Geranium dissectum	cutleaf geranium		X	X	X	
Hordeum marinum ssp. gussoneanum	Mediterranean barley			X		
Hordeum murinum ssp. Leporinum	foxtail barley		X	X	X	
Hordeum vulgare*	common barley					
Hypochaeris glabra*	smooth cat's-ears					
Hypochaeris radicata	rough cat's-ears				X	
Lolium multiflorum	Italian ryegrass	X	X	X	X	

Scientific Name	Common Name	Sub-site location within West Stege Marsh restoration area				CalIPC rating
		Marsh	Upland	Bulb	Staging Area	
Medicago polymorpha	California burclover			X	X	
Picris echioides	bristly ox-tongue		X	X	X	
Plantago coronopus*						
Plantago lanceolata	English plantain		X	X	X	
Poa annua			X		X	
Polygonum arenastrum	common knotweed		X		X	
Portulaca oleracea*	common purslane					
Prunus armeniaca*	apricot					
Pyracantha sp.	firethorn		X		X	
Ricinus communis	castor bean		X			B
Rumex acetosella	sheep sorrel				X	
Rumex crispus	curly dock	X	X	X	X	
Senecio vulgaris	common groundsel		X			
Silene gallica*						
Sonchus asper ssp. Asper	prickly sow thistle		X	X		
Sonchus oleraceus	common sow thistle		X	X	X	
Spergula arvensis ssp. Arvensis*	stickwort					
Taraxacum officinale*	dandelion					
Tetragonia tetragonioides	New Zealand spinach		X			
Vicia sativa ssp. Sativa	spring vetch			X	X	
Vulpia bromoides		X	X			
Vulpia myuros	zorro grass			X	X	
Vulpia myuros var. myuros*						

Identification of sub-site locations, where invasive non-native species currently occur or could establish within natural habitats, are based upon field observations, species ecology, and recent plant inventories conducted by URS (2003).

Non-native species not currently present within restoration areas, however observed growing directly adjacent to marsh habitat.

REFERENCES

URS. 2003. *Richmond Field Station Remediation Project, Initial Study, California Environmental Quality Act* May, 2003.

Attachment 2

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Summary of Current Weed Control Activities

Work controlling invasive plant populations within the project area and on adjacent lands started in summer 2003. Efforts focused on the control of *Spartina alterniflora*, (smooth cordgrass), *Lepidium latifolium* (perennial pepperweed), *Bassia hyssopifolia* (fivehook bassia), *Foeniculum vulgare* (fennel), *Cortaderia jubata* (pampas grass), and *Centaurea solstitialis* (yellow starthistle). These species were chosen due to their high CalIPC rating (see Appendix I for prioritized species lists and CalIPC ratings) and their ability to quickly colonize habitats and disturbed areas.

Two populations of *Spartina alterniflora* were observed south of the Bay trail. Samples from these populations and were genetically tested by the Spartina Project for verification. UC Berkeley, BBL and AOI worked directly with the Spartina Project and in coordination with EBRPD to quickly implement a control strategy. This was accomplished by cutting back the above ground portions of the *Spartina* and covering the populations with a weed fabric to reduce the plants ability to photosynthesize. The weed fabric will remain in place until the populations have died back. AOI began monitoring the site biweekly to ensure that the integrity of the weed fabric covering is maintained and that no new shoots are emerging. The Spartina Project staff maintain the weed barrier when required.

In July, AOI actively controlled a newly colonizing bassia, which had reached densities over 50% cover in some portions of the marsh ecotone. A seedbank of bassia and other non-native plant species was imported with the fill materials from Martinez during the first phase of the remediation efforts. Control efforts included brush cutting the bassia on the soil stock pile to prevent seed set, as well as hand removing dense stands and pioneering individuals from the mid and high marsh habitats. Removal efforts required approximately 400 hours of hand labor. Bassia plants were removed off site in green waste containers or composted until removed.

Three isolated patches of *Lepidium latifolium* (perennial pepperweed) were removed by hand, which included grubbing out root material.

Dense stands of *Foeniculum vulgare* (sweet fennel) have established in the rocky fill material along the Bay trail on EBRPD's land, on the bulb area within the project site (Figure 3), and on the marsh upland islands. Due to fennel's deep roots and the nature and composition of the rocky fill soils along the Bay trail, digging out the roots was not a viable option, as it could result in slope instability. AOI staff and UC Berkeley students removed the seed heads and most of the above ground portions this fall to prevent further spread.

Cortaderia jubata (pampas grass) has been growing along the Bay trail and within the marsh ecotone and upland habitats for several decades. Mature plants were greater than 6-8 feet in diameter. Initial monitoring indicated that more than 145 mature plants were growing either within or on the windward side of the project area. Approximately 120 mature plants have been cut to the ground with chainsaws, with root balls grubbed out for more than 50%. Additional work was completed in January 2004 to complete initial control of these populations.

One hundred and twelve Centaurea solstitialis (yellow star thistle) individuals were found and removed from upland areas within the marsh and the area adjacent to 46th Ave. along Zeneca's property line.

Attachment 3

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Bassia hyssopifolia
(bassia, five-hook bassia)
Listed: CalIPC List B

Description: Bassia (*Bassia hyssopifolia*) is a grayish annual up to three and one third feet tall; with inconspicuous flowers and younger stems that are densely covered with long, soft, straight hairs. Branches angle out at thirty to sixty degrees from the stem. The small fruit has five distinctive hooked structures on each seed, looking and adhering like a five-legged tick. Overall, this plant looks similar to lambs' quarters (Chenopodium album), but it has smaller, elongated, pointed leaves. Bassia is sometimes confused with other members of the Chenopodiaceae, such as Russian thistle (Salsola tragus) or kochia (generally Kochia scoparia). Russian thistle is more profusely branched and spiny than bassia. Bassia more closely resembles plants of the genus Kochia, within which some taxonomists believe it should be included. Bassia is hairier than kochia, produces a pronounced, woolly-looking flowering spike unlike kochia's small clusters of flowers, and has a characteristic five-spined fruit. In the family *Chenopodiaceae* its leaves are linear to lanceolate; largest leaves, found toward base of plant, are 1.6-2.4 in (40-60 mm) long, 0.04-0.14 in (1-3.5 mm) wide, flat, untoothed, and alternate. Bassia flowers between July and October. Inflorescence: spike 0.2-2 in (5-50 mm) long, with oblong, leaf-like bracts 0.08-0.2 in (2-5 mm) long that often wither in fruit. Flowers: tiny, without petals, in axillary groups of one to a few; 5 stamens and 2 or 3 stigmas. Calyx is tan, densely woolly, becoming leathery; attached to the calyx are 5 incurved, hooked spines about 0.04 in (1 mm) long. Fruit: including the persistent calyx, is 0.04-0.06 in (1-1.5 mm) in diameter, containing a single dark brown seed about 0.04 in (1 mm) long.

Distribution and Habitat Preference: Bassia occurs widely in California, except in the Klamath and northern Coast Ranges and in the Sierra Nevada above 1,200 meters (about 3,900 ft). It appears to do well on basic or saline soils. It is also common in abandoned agricultural fields in the Owens Valley, the Mojave Desert (Lancaster), the Colorado (Imperial Valley) Desert, the South Coast (Santa Ana River), and northward through the Sacramento Valley

Origin: Bassia is native to parts of Europe and Asia, particularly around the Caspian Sea. It was first recorded in North America near Fallon, Nevada, about 1915. It probably was introduced as a seed contaminant, possibly with Turkestan alfalfa (Medicago sativa) seed. It was found as early as 1921 near Los Banos in the San Joaquin Valley. By 1940 it could be found in spiny saltbush (Atriplex confertifolia) and mixed lowland associations of the San Joaquin, Owens River, Santa Ana River, Imperial, Coachella, and Palo Verde valleys.

Dispersal: Considering the external structure of the fruit, bassia seeds probably disperse by attaching to the fur or feathers of passing animals. Human disturbances, such as road building or ditch clearing, help to establish bassia and likely contribute to dissemination as well. The seeds do not survive well in fresh water for extended periods.

Invasiveness: Bassia occasionally may displace native species, but there is no evidence that it alters other ecosystem processes (e.g., fire cycles, hydrological cycles, soil chemistry, etc.). On The Nature Conservancy's Kern River Preserve, in the southern Sierra, bassia covers five to ten acres (2 to 4 ha) in a multitude of small clusters, becoming a monospecific stand in the densest areas. Once established, it is somewhat persistent, although it does not appear to be on the increase at the Kern River Preserve. In some areas native species are replacing bassia, suggesting that it is possibly ruderal or stress-tolerant rather than competitive. Because it is toxic to sheep, bassia can be a threat to livestock.

Reproduction: Bassia is an annual, reproducing by seeds. Its germination and growth patterns have not been extensively studied. However, the following can be inferred from the plant's environmental preferences and from the habits of its close relatives: seed dormancy is relatively short; germination requires warm, high-light

conditions; germination and seedling growth are not hindered by moderately saline/alkaline conditions; and initial growth is rapid, especially below ground.

Centaurea solstitialis
(yellow starthistle)
Listed CalIPC List A-1

Description: In California, yellow starthistle (Centaurea solstitialis) grows as a deep-taprooted winter annual, or rarely as a short-lived perennial. It produces one to many solitary, spiny, yellow flower-heads during late spring, summer, and fall. Seeds begin to germinate soon after fall rains, and young plants grow as prostrate to ascending taprooted rosettes until bolting occurs in late spring or early summer. Stem leaves of bolted plants extend downward, giving the stems a winged appearance. Flowering plants range from ankle to shoulder height and change color from green to bluish green in summer. Flowerheads are generally produced from June through September. The heads are initially produced on branch tips, but robust plants may produce heads in the branch axils later in the season. The main phyllaries (flowerhead bracts) are palmately spined with a single stout, apical spine and a few much smaller, lateral spines. Some individuals produce shorter apical spines. The heads contain two types of fruits or achenes. Most are cream to tan with a white pappus or plume; achenes in the outer ring are darker and lack a pappus.

This annual from the *Asteraceae* family has stems from 6-72 in (15-200 cm) in height. Leaves: basal, earliest, entire to slightly toothed; subsequent, lobed to deeply lobed; bright green and scabrous-bristly in seedling and rosette stages; 2-6 in (5-15 cm) long; cauline leaves long, entire, narrow, decurrent; initially green, becoming bluish green and densely covered with cobwebby hairs later in the season; leaf blades 0.4-1.2 in (1-3 cm) long. Inflorescence: produced late May-December; heads 1 to many, always solitary; involucre 0.5-0.7 in (13-17 mm) tall, ovoid; outer phyllaries with apical appendages palmately spiny, central spine 0.4-1 in (10-25 mm) long, generally stout; tips of inner phyllaries with membranous winged tips about 1 mm wide. Flowers: many; corollas 0.5-0.8 in (13-20 mm) tall, unusually equal, yellow; marginal florets sterile, corollas 2-4 lobed, spreading to ascending; inner florets fertile, 5 lobed. Fruits: achenes 0.08-0.12 in (2-3 mm) long; those produced by outer ring of flowers dull, dark brown to blackish, without pappus; those produced by interior flowers glossy, grayish to mottled light brown; pappus white with bristles 0.08-0.166 in (2-4 mm) long, pappus bristles covered with rows of minute barbs; achene attachment scar obtuse, achene base broad.

Distribution and Habitat Preference: Yellow starthistle is most widely distributed in the Sacramento and northern San Joaquin valleys, Inner North Coast Ranges, northern Sierra Nevada foothills, Cascade and Klamath ranges, and the central-western regions of the state. It is currently spreading in mountain regions of the state below 7,500 feet (2,250 m) and in the central-western region. Primarily it is a problem in moderately warm, exposed areas on fertile, drier soils, including disturbed sites, grasslands, rangeland, hay fields, pastures, roadsides, and recreational areas.

Origin: Yellow starthistle is native to southern Europe and western Eurasia and was first collected in Oakland, California, in 1869. It was most likely introduced after 1848 as a contaminant of alfalfa seed. Introductions prior to 1899 were most likely from Chile, while introductions from 1899 to 1927 appear to be from Turkestan, Argentina, Italy, France, and Spain. By 1917 it had become a serious weed in the Sacramento Valley and was spreading rapidly along roads, trails, streams, ditches, overflow lands, and railroad rights-of-way. Yellow starthistle had spread to over a million acres of California by the late 1950s and nearly two million acres by 1965. In 1985 it was estimated to cover eight million acres in California (Maddox and Mayfield 1985) and perhaps ten to twelve million acres a decade later.

Dispersal: Human activities are the primary mechanisms for the long-distance movement of yellow starthistle seed. Seed is transported in large amounts by road maintenance equipment and on the undercarriage of vehicles. The movement of contaminated hay and uncertified seed is also an important long-distance transportation

mechanism. Once at a new location, seed is transported in lesser amounts and over short to medium distances by animals and humans. The short, stiff, pappus bristles are covered with microscopic, stiff, appressed, hair-like barbs that readily adhere to clothing and to hair and fur. The pappus is not an effective long-distance wind-dispersal mechanism as wind moves seeds only short distances, with maximum wind dispersal being sixteen feet (<5 m) over bare ground with wind gusts of twenty-five miles per hour (40 km/hr).

Invasiveness: Dense infestations of yellow starthistle displace native plants and animals, threatening natural ecosystems and nature reserves. Yellow starthistle also significantly depletes soil moisture reserves in annual grasslands in California and in perennial grasslands in Oregon. Long-term ingestion by horses causes a neurological disorder known as chewing disease, a lethal lesion of the nigropallidal region of the brain. This disease is expressed as a twitching of the lips, tongue flicking, and involuntary chewing. Permanent brain damage is possible, and affected horses may starve to death. Yellow starthistle interferes with grazing and lowers yield and forage quality of rangelands, thus increasing the cost of managing livestock. It can also reduce land value and limit access to recreational areas.

Reproduction: Plants reproduce only by seed and generally flower from May to September. When adequate moisture is available, yellow starthistle can survive as a short-lived perennial and flower throughout fall, winter, and spring. However, the flowers produced during winter are often killed by frost. Almost all plants are self-incompatible and require pollen from a genetically compatible plant to produce seed.

Seeds produced per head (30-80) and flowerhead production per plant (1-1,000) are variable, depending on soil moisture levels and intensity of competition). Large plants can produce nearly 75,000 seeds. Seed production in heavily infested areas varies between fifty to 200 million seeds per acre. Studies of seed survival in soil have found significant survival to ten years. Seeds typically germinate in late fall or early winter, when soil moisture is present and overwinter as basal rosettes.

Germination responses in yellow starthistle are greatly reduced in dark environments and by exposure to light enriched in the far-red portion of the spectrum. During early seedling establishment, root growth is vigorous and can extend deeper than one meter (3.3 ft), providing plants with access to deep soil moisture reserves during dry summer months. Reduced light levels cause the rosettes to produce fewer but larger leaves and to assume a more upright growth form. Reduced light levels also significantly reduce root growth and flower production. Consequently, survival and reproduction are significantly reduced in shaded areas, and the plant is probably less competitive in dense stands of established perennials. Bolting occurs from late spring to early summer, and spiny flowerheads generally are produced from early summer to late summer or fall. The spines on the flowerheads may protect them from herbivory by large animals, but they do not prevent significant herbivory by grasshoppers or seed predation by birds.

Conium maculatum
(poison hemlock)
Listed Cal IPC List B

Description: Poison hemlock (*Conium maculatum*) is a member of the carrot family. It is usually a biennial, with first-year plants producing ground-level rosettes. During the second year plants grow from two to ten feet tall with a stem that is ribbed, hollow, and has purplish streaks or splotches. Small, white flowers grow in many umbrella-shaped clusters, each supported by a stalk. Leaves have a somewhat fern-like appearance and are finely pinnately divided. When crushed, they have a rank odor.

This biennial in the family *Apiaceae* has stems that are hollow, ribbed with purple spots. Leaves: opposite, ovate, tapered, serrate, and finely pinnately divided. Inflorescence: umbels terminal and lateral. There are 4-6 bracts, brown in color, and 5-6 bractlets present. Pedicels abundant. Flower: petals white or yellowish, usually wide with narrow tips. Ray flowers number 10-20, 0.6-2 in (1.5-5cm). Fruit: 0.08-0.12 in (2-3mm) wide, ovate with distinctively wavy ribs.

Distribution: Poison hemlock has spread throughout California in areas below 5,000 feet (1,500 m) elevation, excluding the Great Basin and Desert provinces. It is commonly found in dense patches along roadsides and fields. It also thrives in meadows and pastures and is occasionally found in riparian forests and flood plains. It does best in disturbed areas where soil is moist with some shade. Poison hemlock is also able to form stands in dry, open areas.

Origin: Poison hemlock is native to Europe, North Africa, and Asia. It was brought to the United States as a garden plant sometime in the 1800s and sold as a "winter fern". The earliest poison hemlock collections were made in 1893 and 1897 in Berkeley and Truckee, respectively. Poison hemlock has spread throughout the United States, Canada, Australia, New Zealand, and South America.

Dispersal: Poison hemlock reproduces only by seed, which is dispersed by water, mud, wind, animal fur, human clothing, boots, and machinery. It has no means of vegetative reproduction.

Invasiveness: Poison hemlock can spread quickly after the rainy season in areas that have been cleared or disturbed. Once established, it is highly competitive and prevents establishment of native plants by overshading. In agricultural areas it interferes with crops and production of feed for livestock. Poison hemlock is best known for its toxicity to vertebrates, causing death primarily by respiratory paralysis after ingestion. The alkaloids in poison hemlock depress the central nervous system. Symptoms include nausea, vomiting, convulsions, loss of muscle power, dilation of pupils, slowing of heartbeat, and eventual death from respiratory failure. In livestock, symptoms appear immediately after ingestion, and death occurs within two to three hours. The recommended treatment is the same as that for nicotine poisoning: tannic acid followed by a purgative. Wildlife is also susceptible to the toxic effects of poison hemlock. Ten percent of an elk population on Grizzly Island, California, died from ingesting poison hemlock in 1985.
Field experiments have not established any allelopathic effects of poison hemlock. Ancient Greeks used poison hemlock to carry out judicial executions, including the execution of Socrates. Most human poisonings occur when the leaves are eaten by people confusing them with edible seeds used as spices, or when children use the hollow stems as flutes. Seeds and young leaves are the most toxic parts of the plant. It is recommended that gloves be worn when handling the plant, as some people develop dermatitis, and that inhalation of particles be minimized.

Reproduction: Reproductive plant parts develop in mid-April, usually one year after germination. In summer, once plants have set seed, they dry up and die leaving tall stalks to shade out other plants. The seed of poison hemlock is fully developed by mid-June. Plants disperse about 90 percent of their seed in September through December, with the remainder dispersed by late February. This lengthy dispersal period allows poison hemlock to produce new seedlings continuously for several months. Poison hemlock has a large range of conditions in which it can germinate. It can germinate at temperatures greater than 9.4 C and lower than 33.8 C. It can germinate in darkness as well as in light. About 85 percent of seed produced is able to germinate as soon as it leaves the parent plant. The remainder is dormant and requires certain environmental conditions (thought to be summer drying) in order to germinate. This ensures that some seed will remain in the seedbank until the following growing season. Seed can remain viable in the soil for up to three years. It germinates most readily in soil, but can also germinate in sand. The combination of long seed dispersal period, seed dormancy, and non-specific germination requirements enable poison hemlock seedlings to emerge in almost every month of the year. Germination takes place in all months of the year except April, May, and July, with late winter and early spring being the periods of greatest germination. Most vegetative growth occurs in winter months, with plants developing a deep taproot that is sometimes branched.

Cortaderia jubata

(pampas grass)

Listed Cal IPC List A-1

Description: Jubata grass (*Cortadaria jubata*) is a perennial grass six to twenty-three feet tall with long leaves arising from a tufted base or tussock. The inflorescence or flower cluster is a plumed panicle at the end of a long stem. Stems generally are at least twice as long as the tussock. Plumes consist of hairy female flowers, deep violet when immature, turning pinkish or tawny cream-white at maturity. Jubata grass is easily confused with, and often called, pampas grass (Cortaderia selloana). The two species are distinguished by stem height, leaf, plume, and spikelet color, florets, leaf tip, and presence of viable seed. The tussocks of jubata grass are less erect and more spreading and not fountain-like, when compared to tussocks of Cortaderia selloana. Stem (culm) height 2-2.5 times longer than tussock equal to or slightly longer than tussock in female plants; two times longer in male plants. Leaf color bright to deep green glaucous-green. Plume color pinkish to deep violet light violet to silvery white; female plants with lighter plumes than males. Spikelet color glumes purple glumes white; males sometimes purplish near base. Florets hairy at base; awn slightly extending beyond hairs males sparsely or not at all hairy; female densely hairy at base, awns twice the length of hairs, Leaf tip not bristly or curled bristly and curled. Viable seed - yes only when male and female plants are present

It is a perennial grass in the family *Poaceae.* Its leaves have blades 3-5 ft (1-1.5 m) long, 0.8-4 in (2-10 cm) wide, flat or slightly V-shaped in cross-section, deep green, upper and lower surfaces glabrous, occasionally with hairs near collar on upper surface, tips not setaceous (bristly) or curled, margins scabrous and sharp. Sheath: densely hairy. Inflorescence: dense panicle, 1-3 ft (3-10 dm) long, flexuous, deep violet when immature, pinkish turning cream-white or tawny at maturity. Spikelets: numerous, all female, 0.6 in (14-16 mm) long, 3-5 florets in each. Florets: 0.12-0.2 in (3-5 mm) long, glumes purple, lemma long-hairy, awns short <0.04 in (<1 mm), stigmas not exerted. Caryopsis: numerous seeds produced apomictically (without pollen transfer), easily separated from rachilla.

Distribution and Habitat Preference: In California jubata grass occurs only in coastal areas. It has become common in disturbed ditch banks, road cuts, cliffs, and cut-over areas, and eroded or exposed soil below 2,600 feet (800 m) elevation in the coastal fog belt from Santa Barbara County to Humboldt County, and less frequently in open habitats of southern California. Jubata grass nearly always occurs on open sites, such as roadside cuts, forest clearcuts, mudslides, or burned areas. Although typically found on sandy soils, jubata grass can survive on other soil types, including serpentine.

Origin: Jubata grass is native to northern Argentina and the Andes of Bolivia, Peru, Chile, and Ecuador. In its native range it can be found from sea level to elevations greater than 11,000 feet (3,400 m). It was first cultivated in France and Ireland from seed collected in Ecuador. It is not clear how or when it was introduced into California, but it may have come through France via the horticultural trade.
Jubata grass was first reported as a weed in California in logged redwood forests of Humboldt County in 1966. Since infestations exist only in coastal areas of California, it is likely that the origin of this weed is a low-elevation biotype from South America. Because all seed production occurs without pollen transfer (apomictic), little genetic diversity exists within these plants. This would explain its limited range in California. Spread occurs by wind-blown seed or by humans using mature inflorescences in decorative arrangements or using plants in landscaping. Seeds have been reported to disperse over twenty miles under windy conditions. Movement throughout the state also occurs when nurseries mistakenly sell this weedy species instead of *Cortaderia selloana*.

Invasiveness: Large infestations threaten California's native coastal ecosystems by crowding out native plants, particularly in sensitive coastal dune areas. In addition to its effect on native plant diversity, jubata grass can reduce the aesthetic and recreational value of natural areas. In cut-over coastal redwood forests in northern California, jubata grass suppresses reestablishment of seedling conifers. It is a significant weed problem in forestry operations and conservation areas in other countries, particularly New Zealand and Australia. In forests, jubata grass can outcompete seedling trees and retard their establishment and growth. It creates a fire hazard with excessive build-up of dry leaves, leaf bases, and flowering stalks. Large clumps can complicate fire management activities by blocking vehicle and human access and by becoming fire hazards themselves. The sawtoothed leaves can cause injury to humans.

Reproduction: Jubata grass reproduces by asexual means only. Flowers typically are produced from late July to September, even in the first year of growth. Plants can flower twice during the same season. Although all plants produce only female flowers, viable seeds develop from unfertilized ovules (apomixis). No pollination is necessary. All seedlings are genetically identical to the parent plant. This unusual form of reproduction is probably the most important characteristic responsible for the weediness of jubata grass, as well as its limited range. An individual inflorescence can produce 100,000 minute seeds, and large clumps can produce a million or more seeds. Like Cortaderia selloana, jubata grass can also reproduce vegetatively from fragmented tillers that produce adventitious roots in moist soils.

Germination generally occurs in spring and requires sandy soils, ample moisture, and light. The temperature range for germination is 55 to 70 degrees F (13-21 degrees C), with an optimum temperature of 63 degrees F (17 degrees C)
Seeds do not appear to survive long in the soil, although no detailed studies have yet been conducted. Seedling growth and establishment are most rapid on bare, sandy soil and exposed road cuts, but typically require cool, foggy climate and moist soil. Seedling survival is low in shaded areas or in competition with grasses or sedges. Growth initially is slow, but once established, plants grow rapidly. Roots are clustered in a shallow crown and can be fine to fairly thick. Technically, the roots are considered fibrous. Jubata grass does not tolerate winter frost, hot summer temperatures, intense sunlight, or drought. This may account for its inability to become established in the Central Valley of California. Plants are capable of surviving about fifteen years.

Ehrharta erecta

(ehrharta, panic veldt grass)

Listed Cal IPC List B

Description: Ehrharta (Ehrharta erecta) is perennial grass, distinct from E. calycina in having a crabgrass-like habit with decumbent as well as ascending jointed stems. The sterile lemmas of E. erecta are without awns. Ehrharta erecta (ehrharta). Poaceae. Perennial grass. Stems: culms erect or ascending from decumbent base, branching, 12-24 in (30-60 cm) tall. Leaves: flat leaf blades 2-5 in (5-12 cm) long, 0.2-0.4 in (4-9 mm) wide. Inflorescence: 2-6 in (6-15 cm) long, contracted to open panicle. Laterally compressed sessile to subsessile spikelets, 0.1 in (3-3.5 mm), falling as one unit. Glumes 0.06-0.1 in (1.5-3 mm), about equal, longer than sterile florets. Three florets per spikelet, lower two sterile and without palea; upper floret fertile with palea. Sterile lemmas awnless, glabrous.

Distribution: Ehrharta erecta (ehrharta) became established in northern California about 1930. It has been reported from the greater San Francisco Bay Area and from La Jolla Shores in San Diego County. Populations have been reported from the San Francisco Bay Area, as well as San Diego, Santa Barbara, Los Angeles, and Ventura counties. E. erecta is thought to be more invasive in the northern portion of its range, but more information is needed to verify this.

Habitat Preferences: In its native range it is widespread in winter-rainfall and tropical regions but does not extend into arid regions. It has been observed it in a wide variety of habitats in both exposed and shady areas in the San Francisco Bay Area, including sand, heavy soils, and thin, rocky soils. This species is still vigorously expanding its range, and that the degree of threat it poses may not yet be apparent.

Origin: All three species of Ehrharta present in California are native to southern Africa. E. erecta became established as an adventive near Berkeley around 1930. The former Soil Conservation Service (now Natural Resources Conservation Service) promoted E. calycina for forage improvement and erosion control during the 1950s and 1960s, and it was planted on ranches and sowed on controlled burns in coastal San Luis Obispo and Santa Barbara counties.

Dispersal: The three species of Ehrharta spread primarily by wind-borne seed. Invasions of E. calycina spread primarily in the direction of prevailing wind and are enhanced by disturbance. E. erecta can also spread vegetatively.

Invasiveness: There is no quantitative information available on the impacts of Ehrharta erecta. However, it has been observed to spread rapidly in wildland areas. E. erecta is able to penetrate adjacent vegetation with decumbent stems and by going over it with ascending stems, as well as by spreading vegetatively. The dense turf that develops makes it difficult for seeds of other species to germinate.

Reproduction: E. erecta (ehrharta) reproduces both sexually and vegetatively by means of tillers. As an annual, E. longiflora (annual veldt grass) reproduces only by seed. E. erecta can create a continuous turf in moist areas, with plants spreading both vegetatively and by seed.

Foeniculum vulgare
(fennel, anise)
Listed CalIPC List A-1

Description: Fennel (Foeniculum vulgare) is an erect perennial herb, four to ten feet tall, with finely dissected, almost feathery leaves and characterized by a strong anise scent originating from stems and leaves. The flowers are yellow and small (one-quarter inch across), and are clustered in large, rounded, umbrella-like groups (compound umbels), roughly four inches across, that are conspicuous from April through July. During the growing season plants usually include a mixture of living and dead hollow stems (canes). Branches arise from the stems at conspicuously jointed nodes, and leaves arise both from the root crown and from the stems. Leaves sheath the stems where they meet. Seeds of wild fennel look like the fennel seed commonly used as a flavoring in foods: they are oblong, dorsally compressed, and ribbed. It is a perennial herb in the family Apiaceae. It is 3.3-12 ft (1-3.5 m) high with a characteristic anise or licorice scent. Roots: mature plants have a thick, deep taproot from which erect, solid glaucous-green stems arise. Stems: 10-20 stems originate from a basal cluster in late winter, then die back the following September-November. Leaves: petioles 2.8-5.6 in (7-14 cm) long sheaths hug the stem; leaf blades triangular-ovate in outline and 0.3-2 ft (10-60 cm) long, 1-1.3 ft (30-40 cm) wide, finely dissected into nearly thread-like segments. Inflorescence: compound umbel with 15-40 spreading-ascending rays, each 0.4-1.6 in (1-4 cm) long. Flowers: no sepals, yellow petals with narrowing tips, 5 small stamens, inferior ovary topped by two short styles. Fruits: 0.1-0.2 in (2.5-4.5 mm), oblong-ovate, dorsally compressed, with thick, prominent ridges.

Origin: Fennel is native to southern Europe and the Mediterranean region, where it has been used for centuries as a spice and for medicinal purposes. Although details about its introduction are unknown, it has occurred in California for at least 120 years and is presumed to have escaped from cultivation repeatedly.

Reproduction and Dispersal: Fennel reproduces from both root crowns and seeds. Flower production generally begins when individuals are eighteen to twenty-four months old. Flowering stems begin to be produced in late winter to early spring, and flowers appear by early May. Seed production is prolific and can begin as early as May and continue through early November. Generally, seed production peaks in August and September. Seeds may persist in soil for several years without germinating. Germination can occur almost any time of the year. Vegetative growth begins in mid-winter and peaks in July to August. Initial growth during winter and spring is slow, then becomes rapid in early summer. Flowering stems die during late fall and early winter, although some remain alive and begin to produce new leaves with the onset of rains. Plants have a thick taproot. Seeds are dispersed by water, by animals, and by humans by clinging to clothing or mud on vehicles. Birds and rodents eat the seeds and may disperse them as well.

Habitat Preference: In California fennel is found in mesic locations with a Mediterranean climate from sea level to 2,000 feet. It usually colonizes disturbed areas, especially weedy sites adjacent to fresh or brackish water, and pastures, abandoned lots, and roadsides. Common in open habitats such as grasslands, coastal scrub, savannas, and the banks of creeks, estuaries, and bays. Dense local populations have been reported from Santa Cruz Island, in fields around the San Francisco Bay region. It is widely scattered in fields and ditches throughout the Sacramento, Salinas, and San Joaquin valleys and foothills, and in hillside pastures of most coastal counties from Mendocino south to San Diego. Fennel is particularly aggressive in areas subjected to plowing or medium-heavy grazing and recently abandoned. Fennel occurs in soils with pH ranging from 4.8 to 8.3, but appears to prefer more acidic than alkaline conditions. The preferred soil type appears to be well drained, sandy soils, but it has been observed to thrive in sites with a high clay content.

Invasiveness: Fennel will invade areas where the soil has been disturbed and can exclude or prevent reestablishment of native plant species. It can drastically alter the composition and structure of many plant communities, including grasslands, coastal scrub, riparian, and wetland communities. It appears to do this by outcompeting native species for light, nutrients, and water and perhaps by exuding allelopathic substances that inhibit growth of other plants. It develops dense, uniform stands. On Santa Cruz Island fennel can achieve 50 to 90 percent absolute cover and reach heights of ten feet. Once established, fennel is tenacious and difficult to control. Because of its prolific seed production and seed viability, a long-lived seedbank can build up rapidly. Most impact assessment for fennel has focused on native plants, but fennel's value to animals is unknown. Grazers will feed on early-season regrowth, and feral pigs will seek out and eat the roots, but mature stems are generally not used as food. Birds and rodents eat the seeds.

Fennel stand development and successional patterns are poorly understood, especially with regard to persistence. It is unclear whether fennel stands are an edaphic climax, or whether another plant community will replace them after several decades. In parks and preserves where fennel removal is part of a restoration program, transitional communities will occur after fennel is removed, but these may be dominated by other non-native species found there was a significant increase in native herbaceous species shortly after removal of fennel, but the areas quickly became dominated by non-native grasses.

Lepidium latifolium
(perennial pepperweed)
Listed Cal IPC List A-1

Description: Perennial pepperweed (Lepidium latifolium) is a multi-stemmed herb that grows three to eight feet tall with a heavy, sometimes woody, crown and a spreading underground root system. Stems and leaves are dull gray-green and waxy, sometimes with reddish spots. The tiny white flowers are borne in dense clusters at the tops of the stems. Flowering from May to July, plants produce many small, roundish, light brown fruits. Perennial pepperweed is somewhat similar to whitetop (Cardaria draba), but perennial pepperweed is much taller. The upper leaves do not clasp the stem as do those of whitetop.
It is a perennial herb in the family *Brassicaceae*. Roots: deep and spreading. Stems: 1 to many above-ground stems 3-8 ft (1-2.7 m) tall. Stems and leaves glabrous, with gray waxy coating, appearing dull gray-green, sometimes with small reddish spots. Leaves: young plants have petioled leaves 1-2 in (2.5-5 cm) wide and 4-12 in (10-30 cm) long, arising near base of stem; older stems have alternate, sessile leaves, reduced in size upward. Leaf margins smooth or with rounded shallow teeth. Inflorescence: a panicle, 5-6 in (25-27.5 cm) wide. Flowers: white, 0.1 in (3 mm) wide; 4 sepals, white, oval, <1 mm long; 4 petals, white, spatulate, 0.06 in (1.5 mm) long; 6 stamens. Fruit: a silicle, round-ovate, about 2 mm long, with 2 flattened ellipsoid seeds.

Origin: Perennial pepperweed is native to Eurasia where it grows in a wide variety of habitats, including fresh, brackish, and saltwater wetlands, in and around agricultural fields, in waste places, and even on stony slopes, from sea level to above 10,000 feet (3,049 m) elevation. The first published record of perennial pepperweed in California is from 1936, when it was collected on a ranch north of Oakdale in Stanislaus County. Recent localized infestations along State Highway 50 may have been initiated from seed or plant fragments that were contaminants in rice straw bales, since these infestations are found in areas of recent construction where straw bales were used for erosion control.

Dispersal: Perennial pepperweed can be distributed by seeds or by pieces of the underground stems. The small seeds have no special adaptations for long-distance dispersal. They are capable of being transported by wind, water, and possibly waterfowl.

Reproduction: Perennial pepperweed reproduces from seed, as well as vegetatively from intact root systems or from pieces of rootstock. Flowering time varies from May to July in different parts of California. Peak bloom lasts for several weeks. Seeds mature by June or July. Each mature plant has the capacity to produce thousands of seeds each year. Seeds typically germinate in spring in wet sand or mud. Germination studies have shown high germination rates (64-100 percent) under a variety of conditions. Highest rates occurred under alternating temperature regimes yielding germination rates as high as 64 to 96 percent in laboratory studies. Seedlings grow rapidly and can produce flowering stems the first year. In fall and winter aerial stems die back to the ground, creating a thick thatch of dead stems in heavily infested areas. In early spring new shoots begin to form from the rootstocks. A single intact root crown can produce several flowering stems. New plants readily grow from pieces of rootstock less than one-third of an inch (0.8 cm) in diameter and less than one inch (2.5 cm) long.

Habitat Preference: Perennial pepperweed invades brackish to saline or alkaline wetlands throughout California, from the coast to the interior and north and eastward into the Great Basin and Columbia Basin. It is also found in native (unplanted) hay meadows and as a weed in agricultural fields where the soil is slightly alkaline or saline. It has been found in all counties in California except Del Norte, Humboldt, and Imperial and is well established in marshes of the San Francisco Bay and Delta, including at Benicia State Park. Large infestations occur in Suisun Marsh, especially at Grizzly Island Wildlife Area. According to observations of

wildlife area managers and others, within the last fifteen years perennial pepperweed populations in California have expanded, and the plant has significantly increased its overall range. In California the plant typically grows in full sun in heavy, moist soils that are often saline or alkaline, but it also grows in drier sites and on other soil types

Invasiveness: Perennial pepperweed is an aggressive invader of coastal and interior wetlands throughout California. It forms dense monospecific stands that exclude other plants, including natives. At Grizzly Island Wildlife Area in Suisun Marsh it is encroaching on several rare plant populations, including soft bird's-beak (Cordylanthus mollis ssp. mollis), Suisun Marsh thistle (Cirsium hydrophi-lum var. hydrophilum), and Suisun Marsh aster (Aster lentus). In most areas it prefers habitat slightly higher than that dominated by pickleweed (Sali-cornia spp.), but it has invaded Salicornia-dominated marshes in the Al-viso Slough area, and thus poses a threat to the habitat of the endangered salt marsh harvest mouse, California black rail, and California clapper rail. In waterfowl nesting areas it outcompetes grasses that provide food for waterfowl.

Phalaris aquatica

(Harding grass)

Listed Cal IPC List B

Description: Harding grass (Phalaris aquatica) is an erect, waist-high, stout perennial grass with grayish to bluish green leaves. Flowering heads are dense, spike-like, and usually two to five inches long. It is slow to develop from seed, but can form large bunches after several years. Harding grass is similar to three other species: littleseed canary grass (Phalaris minor), canary grass (P. canariensis), and reed canary grass (P. arundinacea). Unlike these other species, the base of the Harding grass stem often produces a reddish sap when cut. The other three species have winged glumes, although the wing is widest in the upper third of the glumes of littleseed canary grass and canary grass. The wing margins of littleseed canary grass usually have tiny teeth, whereas the margins are entire in the other two species. Both littleseed canary grass and canary grass differ in that they are annuals, they commonly have shorter inflorescences, and they lack the tuberous swelling often found at the base of the stem of well established Harding grass plants. Reed canary grass (P. arundinacea) differs from Harding grass in having more distinct rhizomes and an inflorescence that is compact at first but later becomes more open as the branches spread. Hybrids of Harding grass and reed canary grass have been produced.

This perennial tufted, erect, deep-rooted, rather stout grass is in the family *Poaceae* and grows to 3-4 ft (1-1.3 m) tall. Leaves: blades grayish to bluish green, rolled at emergence, 4-15 in (10-40 cm) long, 0.25 to 0.75 in (6-18 mm) wide, hairless, with membranous ligules 0.10 to 0.40 in (3-10 mm) long and no true auricles. Inflorescence: dense, cylindrical, spike-like, 2-5 in (5-12 cm) long and 0.6 in (1.5 cm) broad, becoming narrower toward the tip. Primary and secondary panicle branches very contracted, with numerous short-pediceled spikelets. Spikelets 0.20-0.25 in (5.5-6.5 mm) long, laterally flattened, all similar, and at maturity not falling entire but disarticulating above persistent glumes. Three florets per spikelet, only the uppermost fertile, lower two reduced to sterile lemmas.
Glumes almost equal, membranous, the length of the spikelet and enclosing it, 3-nerved, strongly keeled along the mid-nerve with a row of short spines on the back in the upper half; lateral nerves also prominent, green, margins papery and white. Two sterile lemmas reduced, narrow, pointed, curved, and hairy, about 0.06 in (1.5 mm) long, not supporting paleas. Upper lemma 5-nerved, rounded, and fairly densely hairy on the back, becoming shiny at maturity, about 3/4 the length of glumes. Palea faintly 2-nerved, nerves close together along the mid-line, hairy in upper half on back between nerves. Three anthers, 0.10 in (2.5 mm) long.

Distribution: Harding grass is widespread in California because it has been used as a forage species and for revegetating after fires. It is most common in coastal valley and foothill grasslands from Oregon to the Mexican border. It is also found in the Sacramento and San Joaquin valleys at elevations below 4,000 feet (1,200 m). Harding grass is typically found along roadsides that are seldom defoliated, allowing this tall, erect, leafy plant to dominate neighboring vegetation. It is also frequently found beside ditches and streams because it tolerates wet soil conditions. However, it also tolerates dry conditions because of its deep root system. It can be found on a wide range of soil types, growing best in high-fertility conditions but tolerating low-fertility soils.

Origin and Dispersal: Native to the Mediterranean region, it has been dispersed throughout the world by agronomists and farmers for its value as forage in pastures. Its main agronomic value is its ability to tolerate conditions of low moisture, heavy grazing, and winter pugging by livestock. Once planted widely for forage, it

continues to colonize new areas through spread by seed. Seeds are disseminated short distances primarily by wind and by animals, while long-distance spread is through human activity.

Invasiveness: In wildland habitats Harding grass outcompetes and displaces native plant species. Tall stands of its dry foliage can present a fire hazard in summer. Although valued as a forage plant, it can cause a condition known as “staggers” in sheep. Staggers is characterized by respiratory distress, poor muscle coordination, and even death in some animals. Harding grass is less palatable to animals when plants are mature.

Reproduction: Harding grass reproduces by seed. Flowering occurs in May and June, as soils dry after winter rains, with viable seed formed between May and September. A significant amount of seed is produced each year by established plants, up to 40,000 seeds per square meter under some conditions. However, seed production varies considerably with plant density, soil type, and weather conditions. It is not known how long seed remains viable in the soil. Seeds will germinate whenever moisture is available, although germination rates decrease as temperatures drop below 50 degrees F (10 degrees C) or rise above 85 degrees F (30 degrees C). Seedlings will establish successfully only if there is minimal competition. Although Harding grass is an aggressive competitor once established, it has weak growth as a seedling. Harding grass can tolerate some shade but prefers open ground. Although it can tolerate dry conditions, it typically goes dormant over summer if moisture is limited, as in most areas of California, then recommences active growth with fall rains. Plants grow actively through autumn, winter, and spring, producing much new seed in spring before the onset of dry conditions. Individual plants can spread laterally by production of short rhizomes (underground stems), allowing clumps to form, but this spread is minimal compared with reed canary grass, which has a much more extensive rhizome system.

Rubus discolor

(Himalayan blackberry, Himalayaberry)

Listed Cal IPC List A-1

Description: Himalayan blackberry (*Rubus discolor*) grows as a dense thicket of long, bending branches (canes), appearing as tall, ten-foot mounds or banks, particularly along watercourses. Canes have hooked prickles. Flowers are white, yielding black berries that usually ripen later than native blackberries. This sprawling, essentially evergreen, glandless, robust shrub is from the family *Rosaceae*. The shrubs appear as "great mounds or banks". Stems: some canes to 10 ft (3 m) tall, others decumbent, trailing, or scandent to 20-40 ft (6-12 m) long (Bailey 1923), frequently taking root at tips. Primocanes pilose-pubescent, becoming nearly glabrous with age, very strongly angled and furrowed, bearing well spaced, heavy, broad-based, straight or somewhat curved prickles 0.24-0.4 in (6-10 mm) long. Leaves: 5 foliolate, glabrous above when mature and cano-pubescent to cano-tomentose beneath. Hooked prickles on petioles and petiolules. Leaflets large and broad; terminal leaflet roundish to broad-oblong. Leaflets abruptly narrowed at the apex, unequally and coarsely serrate-dentate. Floricane leaflets 3-5 foliolate and smaller than on primocanes. Inflorescence: a large terminal cluster with branches in lower axils. Peduncles and pedicels cano-tomentose and prickly. Flowers: white or rose, 0.8-1 in (2-2.5 cm) across, with broad petals. Sepals broad, cano-tomentose, conspicuously pointed and soon reflexed, +/- 0.28-0.32 in (7-8 mm) long. Fruit: roundish, black, and shiny, up to 0.8 in (2 cm) long, with large succulent drupelets. Fruit ripens late compared with native blackberries and over a considerable interval, from mid-summer to fall.

Distribution and Habitat Preferences: Himalayan blackberry occurs in California along the coast in the Coast Ranges, Central Valley, and the Sierra Nevada (Dudley and Collins 1995). It forms impenetrable thickets in wastelands, pastures, and forest plantations. It grows along roadsides, creek gullies, river flats, fence lines (Parsons and Amor 1968), and right-of-way corridors. It is common in riparian areas, where it establishes and persists despite periodic inundation by fresh or brackish water. Periodic flooding can produce long-lived early seral communities conducive to the growth and spread of blackberries. Himalayan blackberry is one of few woody plants that pioneer certain intertidal zones of the lower Sacramento River.

Blackberries grow well on a variety of barren, infertile soil types. These shrubs tolerate a wide range of soil pH and texture, but do require adequate soil moisture. Himalayan blackberry prefers disturbed and wet sites even in relatively wet climates. It prefers areas with an average annual rainfall greater than 76 cm on both acidic and alkaline soils. It appears to be tolerant of periodic flooding by brackish or fresh water.

Origin: Himalayan blackberry is native to western Europe. There is no botanical evidence to show that it is native to the Himalayan region. It may have found its way there as a cultivar. Himalayan blackberry probably was introduced to North America in 1885 as a cultivated crop. By 1945 it had become naturalized along the West Coast. It seeds heavily, and seeds are readily dispersed by mammals and birds. It also spreads vegetatively by rooting of cane tips.

Invasiveness: Himalayan blackberry colonizes areas initially disturbed and then neglected by humans and can dominate range and pasture lands if not controlled. Himalayan blackberry is a strong competitor, and it rapidly displaces native plant species. Blackberries are highly competitive plants. Thickets produce such a dense canopy that the lack of light severely limits the growth of other plants. Because plants are prickly, livestock, particularly sheep and cattle, avoid grazing near them, effectively decreasing the usable pasture area. Young sheep and goats that get tangled up in the canes have been known to die of thirst and hunger. In wet areas blackberries may hinder medium-sized to large mammals from gaining access to water. The impenetrable nature of blackberry

thickets reduces access for maintenance of fence lines and for forestry practices, as well as recreational pursuits. Dense thickets around farm buildings and fence lines are a considerable fire hazard.

Reproduction: Reproductive versatility is well represented in the genus Rubus, with sexual reproduction, parthenogenesis (development of the egg without fertilization), pseudogamy (a form of apomixis in which pollination is required), and parthenocarpy (production of fruit without fertilization) occurring widely. These modes of asexual reproduction contribute to the aggressive spread of blackberries.

Flowering begins in May and continues through July. Fruit is produced from July to September. Most blackberries produce good seed crops nearly every year. Immature fruit of Himalayan blackberry is red and hard, but at maturity fruit becomes shiny black, soft, and succulent.
Blackberry seeds have a hard, impermeable coat and a dormant embryo Consequently, germination is often slow. Most blackberries require, at a minimum, warm stratification at 68 to 86 degrees F (20 to 30 degrees C) for ninety days, followed by cold stratification at 36 to 41 degrees F (2 to 5 degrees C) for an additional ninety days (Brinkman 1974). These conditions are frequently encountered naturally as seeds mature in summer and remain in the soil throughout the cold winter months.

In Australia Himalayan blackberry seedlings receiving less than 44 percent of full sunlight did not survive. The slow growth of seedlings and their intolerance of shading suggest that few seedlings would be expected to survive in dense pastures or forest plantations. Blackberry thickets are also poor sites for seedling development. Establishment of Himalayan blackberry seedlings depends on the availability of open habitats such as land neglected after cultivation, degraded pastures, and eroded soils along streams. Although seedlings show the potential for rapid growth under laboratory conditions, they grow much more slowly in the field and are easily surpassed by the more rapid growth of daughter plants.

Himalayan blackberry can form roots at cane apices. Canes were observed growing to a height of 40 cm before they arched over and trailed on the ground. Daughter plants developed where these canes rooted, forming only on first-year canes. All canes produced berries in the second year and then died, senescence commencing near the middle and at the apices of canes without daughter plants. Reentry of canes into the center of the thicket resulted in an impenetrable mass of prickly canes within two and a half years. Individual canes may live only two to three years yet reach a density of 525 canes per square meter. A large quantity of litter and standing dead canes develops in old thickets. Canes of Himalayan blackberry can grow to twenty-three feet (7 m) long in a single season. At one site the mean horizontal projection of fifty first-year canes was eleven feet (3.3 m). Ninety-six percent of these canes had daughter plants at their apices. Lateral branches on some canes had also formed daughter plants.
The root crown on Himalayan blackberry, from which many lateral roots grow at various angles, can be up to eight inches (20 cm) in diameter. One root had a maximum depth of almost 3 feet (90 cm) and was more than thirty-three feet (10 m) long. Adventitious shoots (suckers) are occasionally formed on the roots and may emerge from a depth of 45 cm. Blackberries also readily propagate from root pieces and cane cuttings. In less than two years a cane cutting can produce a thicket sixteen feet (5 m) in diameter.

Dispersal: Himalayan blackberry thickets can produce 7,000 to 13,000 seeds per square meter. When grown in dense shade, however, most species of blackberry do not form seeds. Seeds of blackberries are readily dispersed by gravity and by many species of birds and mammals. The large, succulent fruits are highly favored and, after they mature, rarely remain on the plant for long. A hard seed coat protects the embryo even when seeds are ingested. Passing through animal digestive tracts appears to scarify seeds and may enhance germination. Prompt invasion of cut-over lands by Himalayan blackberry suggests that dispersed seeds can remain viable in the soil for several years. Seeds germinate mainly in spring.

Spartina alterniflora
(smooth cordgrass)
Listed Cal IPC List A-2

Description: Smooth cordgrass (Spartina alterniflora) is a perennial, spreading grass from one foot tall in spring to six or eight feet tall in fall. It grows naturally only in intertidal estuarine habitats, and is often found in large, nearly monospecific stands in coastal or bayside marshes. Its large, round stems are hollow in cross section. Leaves are hairless, and leaf tips are sharply pointed. Young, healthy green shoots and leaf sheaths are often streaked with red or purple just below the sediment surface. This species is easily confused with the closely related native California cordgrass (S. foliosa), which is usually less than four and a half feet tall in fall and lacks red pigment in green, healthy shoot tissues (it may have red pigment on decaying tissues). Smooth cordgrass is highly variable in size, depending on growing conditions, and may hybridize with native California cordgrass.

Its in the family *Poaceae* with rhizomes from 1/8-1/4 in (4-7 mm) wide, fleshy, whitish. Stems: typically <6 ft (2 m) but occasionally exceeding 8 ft (2.5 m), width at base to 1 in (25 mm), round, hollow, over .3 in (8 mm) diameter. Ligules <0.2 in (4mm) long. Leaves: to 1 in (25 mm) wide, glabrous, generally flat when fresh. Upper leaf surface ribbed, lower leaf surface smooth. Inflorescences: 4-18 in (10-45 cm) long, 1/4-7/8 in (5-22 mm) wide; 3-30 branches (spikes) per inflorescence, with 5-35 spikelets per branch. Flowers (spikelet): 3/8-9/16 in (8-15 mm) long, keels and glume glabrous to hairy. A clonal patch may live >100 years.

Distribution: In California smooth cordgrass currently is found in Marin County and south San Francisco Bay, where it is rapidly spreading across open intertidal mud flats. Smooth cordgrass also invades established salt marsh communities, where it is likely to be found in the company of pickleweed (Salicornia) and California cordgrass (Spartina foliosa). In Washington smooth cordgrass is rapidly invading Willapa Bay and Puget Sound (Padilla Bay). Smooth cordgrass may be expected in other Pacific Coast estuaries in the future. A small patch was found in Humboldt Bay in the early 1980s, but it has since been eradicated. Smooth cordgrass does not grow on wave-swept Pacific Coast beaches and does not invade freshwater marshes that lack saltwater influence.

Origin: Smooth cordgrass is native to the Atlantic and Gulf Coast marshes of North America. It is a dominant component of Atlantic Coast salt marshes, where it forms extensive monospecific stands (Adam 1990). Introductions to San Francisco Bay and Padilla Bay, Washington, were associated with salt marsh restoration and erosion control projects. The introduction in Willapa Bay, Washington, appears to have been in association with oyster shipments during the nineteenth century.

Invasiveness: Open intertidal mudflats are characteristic of Pacific Coast estuaries and provide important feeding grounds for many shorebird species. Smooth cordgrass transforms open intertidal habitats into monospecific stands of tall grass, reducing shorebird feeding areas. The dense growth of smooth cordgrass also traps and holds sediments and can clog flood control and navigation channels and alter hydrology. The spread of smooth cordgrass threatens productive oystering grounds in Willapa Bay, Washington. Oystering grounds in other estuaries, such as Tomales Bay, California, would likely also be threatened if smooth cordgrass were introduced there. Smooth cordgrass can invade and replace native California cordgrass stands, and the genetic integrity of native California cordgrass is threatened by hybridization with smooth cordgrass.

Reproduction: Vegetative fragments may break off from established plants on eroding banks of tidal sloughs. Dredging an area infested with smooth cordgrass can promote the spread of vegetative fragments. A viable

vegetative fragment must contain either root or rhizome material and can be transported with tides. Seeds can float and may also be transported with tides. Smooth cordgrass grows most rapidly from April-September. Winter dieback of large flowering stems begins around October, and large, dead culms are usually washed away by tides in winter. Young, green shoots remain on most plants throughout the winter in California. During the early stages of mudflat invasion, plants grow as isolated, circular patches (clones). Clones spread laterally by vegetative shoots, often three andone-thirdfeet(>1 m) per year. Over time, circular patches fuse together, and mudflats are transformed into meadows of smooth cordgrass. Smooth cordgrass can become reproductive as early as the first year, but more often plants first flower after two to three years. Flowering occurs in late July-September. Copious inflorescences but few seeds are produced in most plants. Most clones require cross-pollination for good seed set, and cross-pollination (by wind) is rare in isolated patches. A few plants with high self-fertility have consistently high seed output. Ripe seeds fall from inflorescences from October-January. Seeds trapped in mud or wrack germinate in February-May. Most seedlings do not survive the first winter because of winter storms and burial by algae; however, those seedlings that do survive can grow rapidly the following spring. Seeds remain viable for only one year, and they do not tolerate desiccation. Vegetative fragments may be spread year round at sites prone to erosion.