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2015 Quantitative Habitat Monitoring for the Salt River Ecosystem Restoration Project

Final Report

HTH Project# 3117-11
Ducks Unlimited Project# US-CA-478-1

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November 30, 2015

Executive Summary

The Salt River Ecosystem Restoration Project is a collaborative project designed to restore ecologic, geomorphic, and hydrologic function in the Salt River watershed and alleviate flooding problems. The Humboldt County Resource Conservation District is coordinating the project. As part of the project's habitat mitigation and monitoring plan (HMMP), a 10-year monitoring schedule was set up to determine whether the site is progressing along a trajectory that will meet projected habitat goals, with specific success criteria set as milestones for each monitoring year. The purpose of this report is to document quantitative habitat monitoring conducted in 2015, which involved (1) habitat mapping to determine acreage for salt marsh and riparian habitats and (2) percent cover assessment to determine plant species composition and percent cover for high marsh ecotone and Salt River wetland habitats.

Salt marsh habitat was created in the Salt River estuary by recontouring diked former tidelands and restoring tidal inundation in 2013. Two growing seasons following reintroduction of tidewater, native salt marsh plants have colonized much of the area that was formerly pastureland. We estimated that restored salt marsh habitat occupies 146 acres, or 45% of the targeted restoration goal of 322 acres. This vegetation response is considered favorable at this stage. The developing salt marsh is, however, threatened by invasive *Spartina* (*Spartina densiflora*), which is rapidly invading both open tidal flats and vegetated salt marsh. Immediate action is warranted to control this invasion.

Much of the riparian habitat present before restoration was retained. New areas were planted with riparian species in winter 2014–2015 and spring 2015 in designated planting zones as part of the project's Phase 1 restoration (Salt River estuary) and the first year of Lower Phase 2A restoration (extending upstream from Phase 1 to approximately 200 feet upstream of the Dillon Road Bridge). In 2015, we estimated 26 acres of retained riparian habitat and 23 acres of newly planted riparian areas in the Phase 1 project reach. The retained riparian habitat alone represents 60% of the restoration goal of 43 acres, and the combined habitat acreage for retained riparian habitat and riparian planting zones is 114% of the restoration goal. In the Lower Phase 2A (2014) project reach, we estimated 12 acres of retained riparian habitat and 10 acres of newly planted riparian areas. The retained riparian habitat alone represents 60% of the restoration goal of 20 acres, and the combined habitat acreage for retained riparian habitat and riparian and active berm planting zones is 110% of the restoration goal. Reed canary grass (*Phalaris arundinacea*) is invading riparian planting zones, primarily in the Lower Phase 2A project reach. Control actions are recommended to limit spread of the grass. We also recommend targeted weed control surrounding all riparian plantings to help these woody plants establish by reducing competition with weed species.

High marsh ecotone is a transitional habitat found at the upper margins of tidal inundation. In the area projected for restored high marsh ecotone habitat, cover by native plant species was found to be 40.9%, significantly greater than the minimum 15% cover set as a Year 2 success criterion for this habitat type. Total cover by invasive plants was 3.3%, of which 1.2% was attributable to invasive *Spartina,* and control efforts for this species

should include work in the high marsh ecotone, as well as the salt marsh. Total cover by non-native non-invasive plants was 15.7%, attributable primarily to two salt marsh colonizers that do not require action at this time.

Salt River wetland habitats are associated with the fluvial channel upstream of the project's salt marsh component. The Salt River wetland habitat type included in the first year of Lower Phase 2A restoration is brackish marsh. Native plant cover in brackish marsh was 37.5%, which was significantly greater than the minimum of 10% cover set as the HMMP Year 1 success criterion for Salt River wetlands. Cover by invasive plants was 7.6% for brackish marsh, with reed canary grass being the primary invasive species, and control efforts for this species should include work in brackish marsh, as well as the riparian planting zones. Non-native non-invasive cover in brackish marsh was 7.7%, which does not require action at this time.

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List of Preparers

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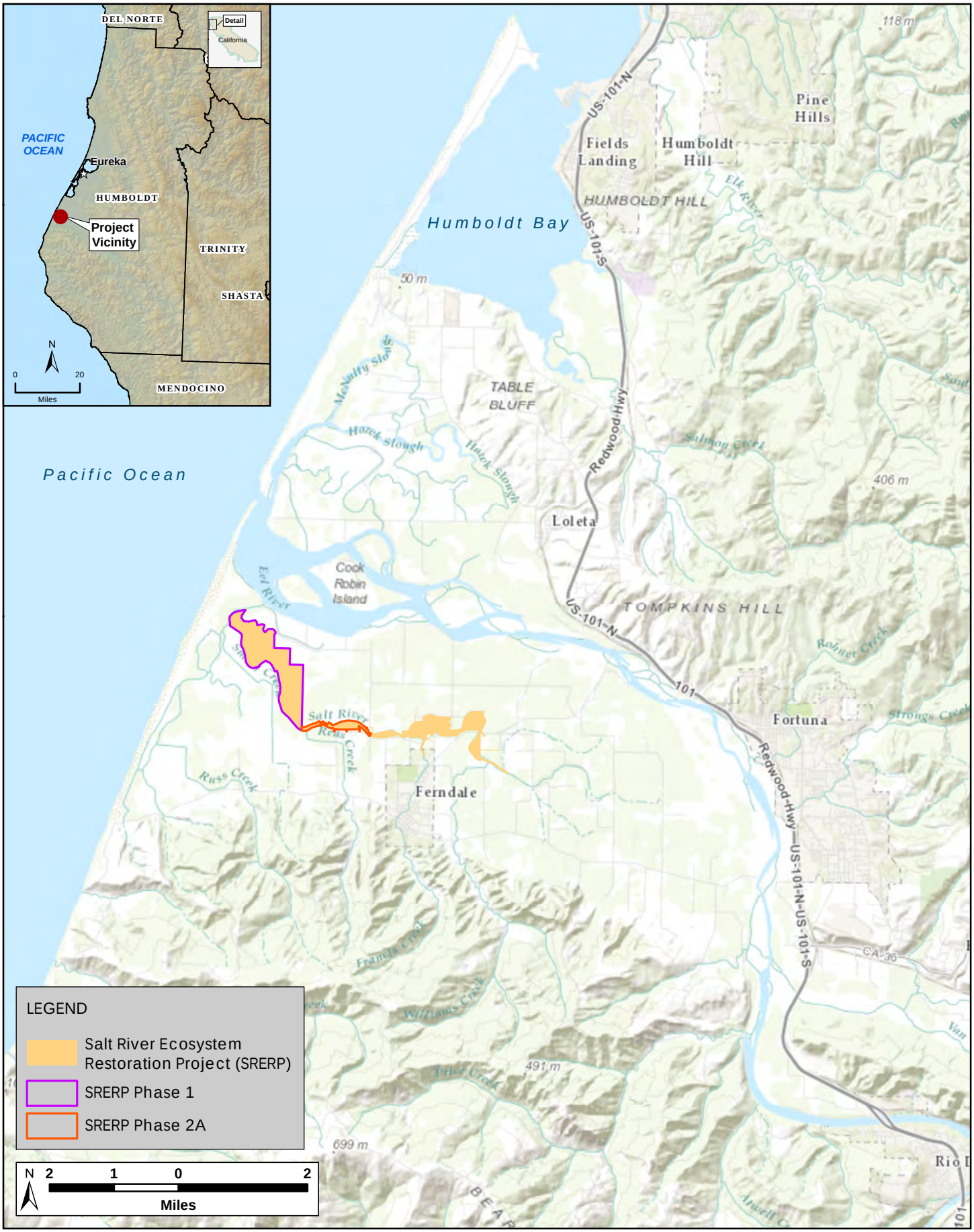
Section 1.0 Introduction

1.1 Project Background

The Salt River Ecosystem Restoration Project (SRERP) is a collaborative project designed to restore ecologic, geomorphic, and hydrologic function in the Salt River watershed and alleviate flooding problems. The Humboldt County Resource Conservation District (HCRCD) is coordinating the project, which encompasses 7.7 miles of the Salt River channel and more than 800 acres of adjacent land. SRERP is located in coastal Humboldt County, in northern California (Figure 1). The Salt River is a tributary of the lower Eel River. The project was needed because hydraulic function of the Salt River had been severely impaired by channel alteration and heavy siltation.

Project implementation was initiated in 2013 and will be accomplished in phases over several years. In 2013, as part of Phase 1, the lower 2.5 miles of the Salt River channel were excavated and widened, and tidal connectivity was restored to approximately 300 acres of diked former tidelands on an agricultural parcel known as Riverside Ranch, now under ownership by the California Department of Fish and Wildlife. A new 2-mile setback levee was constructed to protect adjacent agricultural lands from tidal inundation. The tidal side of the levee was designed with a gradual slope to create a natural transition zone from wetland to upland, referred to as the high marsh ecotone. The high marsh ecotone was hydroseeded in September and October 2013 with a seed mix consisting of a sterile hybrid wheatgrass (*Elymus* X *Triticum*) and suitable native plant species (GHD 2014) to help prevent erosion and encourage establishment by native plant species. In the Phase 1 project reach, riparian planting was delayed because of unseasonably dry weather conditions in winter 2013/2014, but it was accomplished during the following year, in late winter 2014/2015 and early spring 2015, when moisture conditions were more conducive for planting (Tjarnstrom 2015).

The first year of Lower Phase 2A restoration involved excavating and recontouring the Salt River channel upstream of Phase 1 restoration work and extending approximately 200 feet upstream of the Dillon Bridge. Widening of the Salt River channel required removing mature riparian vegetation. The restoration plan was designed to retain as much riparian habitat as possible and to compensate for what was removed by planting riparian species in suitable locations. In addition to planting riparian species on the upper banks, the design included an ecologically valuable active channel edge riparian habitat element referred to as the active berm. Active berms are strips established immediately adjacent to the active channel and planted with riparian species. Active berms act as natural levees, providing bank stabilization and eventually channel shading.



N:\Projects3000\3117-01\11\Report\2015 Quantitative Habitat Monitoring\Fig 1 Vicinity Map.mxd

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Figure 1: Salt River Vicinity Map
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Salt River wetlands are a design component associated with the active bench. Flows exceeding the bankfull channel capacity will occupy the active bench. The active bench provides an area for sediment deposition, morphological diversity, and the establishment of wetland vegetation. Tidal influence is expected to produce brackish conditions in the lower channel reaches transitioning to freshwater conditions in the upper reaches. The Salt River wetland type associated with the first year of Lower Phase 2A restoration is brackish marsh. Additional Salt River wetlands that will be restored further upstream are freshwater wetlands and seasonal wetlands.

At the conclusion of Lower Phase 2A earthwork activities in fall 2014, seed and sterile straw mulch were applied to all disturbed ground. Channel banks were planted with a brackish seed mix between 6.5 and 9 feet North American Vertical Datum of 1988 (NAVD 88) and a freshwater seed mix above 9 feet. Woody riparian plants and wetland plugs were planted in late winter 2014/2015 and early spring 2015, with species composition varying among five designated planting zones: brackish riparian forest, freshwater riparian forest, brackish active berm, freshwater active berm, and brackish marsh (GHD 2015).

1.2 Project Purpose

H. T. Harvey & Associates (HTH) conducted 2015 quantitative habitat monitoring to assist HCRCD with fulfilling project monitoring requirements in accordance with the *Salt River Ecosystem Restoration Project Habitat Mitigation and Monitoring Plan* (HMMP) (HTH and Winzler & Kelly 2012). The HMMP established a 10-year monitoring schedule to determine whether the site is progressing along a trajectory that will meet projected habitat goals, with specific success criteria set as milestones for each monitoring year. Quantitative habitat monitoring, one of several types of monitoring prescribed by the HMMP, provides a means for assessing the following success criteria: (1) habitat acreage, (2) percent cover, and (3) average tree diameter. The HMMP monitoring schedule varies by target habitat type and by success criterion (Table 1) (HTH and Winzler & Kelly 2012).

This report documents quantitative habitat monitoring performed in 2015 to comply with the project's various permits that require implementation of the HMMP. Since SRERP is being implemented in phases, the project's implementation schedule needs to be considered when determining which monitoring tasks need to be performed each year. For example, monitoring performed in 2015 represented Monitoring Year 2 for habitats affected by restoration work implemented in 2013 (Phase 1 tidal wetland), whereas it represented Monitoring Year 1 for habitats affected by restoration work implemented in 2014 (Phase 1 riparian and Lower Phase 2A [2014] riparian and Salt River wetlands). The monitoring years represented by 2015 monitoring work performed are shown in bold in Table 1. The average tree diameter assessment criterion is included in Table 1 for completeness; however, no tree diameter assessments are needed until year 3 (2017 for Phase 1 riparian and Lower Phase 2A [2014] riparian).

Table 1. SRERP Quantitative Habitat Monitoring Schedule

	Success Criteria Assessed by Quantitative Habitat Monitoring		
Habitat	**Habitat Acreage**	**Percent Cover**	**Average Tree Diameter**
Tidal wetland			
High marsh ecotone	Years 1, 3, 5, 7, 10	Years 1, **2**, 3, 5, 7, 10	NA
Salt marsh	Years **1***, 3, 5, 7, 10	Years 3, 5, 7, 10	NA
Riparian	Years **1**, 3, 5, 7, 10	Years 2, 3, 5, 7, 10	Years 3, 5, 10
Salt River wetland**	Not required	Years **1**, 2, 3, 5	NA

Notes: Work performed in 2015 shown in bold.

NA = not applicable.

* Since salt marsh was not mapped in 2014 (Year 1), mapping/acreage assessment was performed in 2015 (Year 2) to comply as closely as possible with the intent of the habitat mitigation and monitoring plan.

** Salt River wetlands in the Lower Phase 2A (2014) project reach are represented by brackish marsh.

Section 2.0 Methods

HTH ecologists conducted quantitative habitat monitoring at the SRERP site in accordance with the project's HMMP. Vegetation data collection, assessment, and field mapping were conducted by plant ecologist Annie Eicher. Habitat maps were prepared by HTH Geographic Information System (GIS) specialists. Statistical analyses were performed by quantitative ecologist Ken Lindke. Project oversight was provided by principal restoration ecologists Maximiliano Busnardo and Daniel Stephens. Annie Eicher and HCRCD watershed coordinator Doreen Hansen visited the site on July 8, 2015. Field sampling for percent cover assessment was conducted August 4–20, 2015, and field mapping was performed August 25–September 15, 2015. The methods employed are summarized below.

2.1 Habitat Acreage

Habitat mapping was performed to determine habitat acreage for salt marsh and riparian habitats. Mapping was based on a combination of aerial photointerpretation and ground-truthing. We performed preliminary mapping in the office using GIS software (ESRI ArcGIS) and the most recent available true color satellite imagery (NAIP June 2014) as a map base. We consulted 1-foot contours of the as-built condition, provided by HCRCD in GIS format (converted from AutoCAD). Ground-truthing was performed in the field to verify habitat extents and revise the map as needed, using an IPad with Garafa GIS Pro software and true color satellite imagery (Google Earth 2014). For Phase 1, we used the "Riparian Planting Zone" GIS layer provided by HCRCD and did not attempt to verify these boundaries in the field. After mapping was completed, habitat acreage was calculated using GIS software. Assessment of riparian habitat acreage in the first growing season following planting involved consideration of the riparian forest and scrub habitat retained, as well as riparian and active berm planting zones.

2.2 Percent Cover Assessment

2.2.1 Field Sampling

Percent cover assessments were performed for two habitat types: high marsh ecotone and brackish marsh. Percent cover data were collected using plot-based field sampling methods. Plot locations were selected using GIS software to generate randomly distributed sample points. A total of 54 plots were sampled: 30 plots were placed in high marsh ecotone habitat bordering the setback levee in the project's Phase 1 reach, as defined by Year 1 habitat mapping (HTH 2014) (Figure 2), and 24 plots were placed in designated brackish marsh planting zones in the Lower Phase 2A (2014) project reach (GHD and HTH 2014) (Figure 3).

Sample plots were 10.8-square-foot (1-square-meter) square quadrats. In each plot, all plant species present were recorded, and the percent cover by species was visually estimated in cover classes using a modified Braun-Blanquet (1928) cover-abundance scale (Table 2). Taxonomic nomenclature used in this report follows Baldwin et al. (2012), and common names follow Calflora (2015).

Salt River
Eel River
Morgan Slough
Camp Weott Rd
Salt River
Port Kenyon Rd

LEGEND
2015 Sample Plots
High Marsh Ecotone Habitat

N 650 325 0 650
Feet

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Figure 2. Sample Plot Layout for High Marsh Ecotone Habitat

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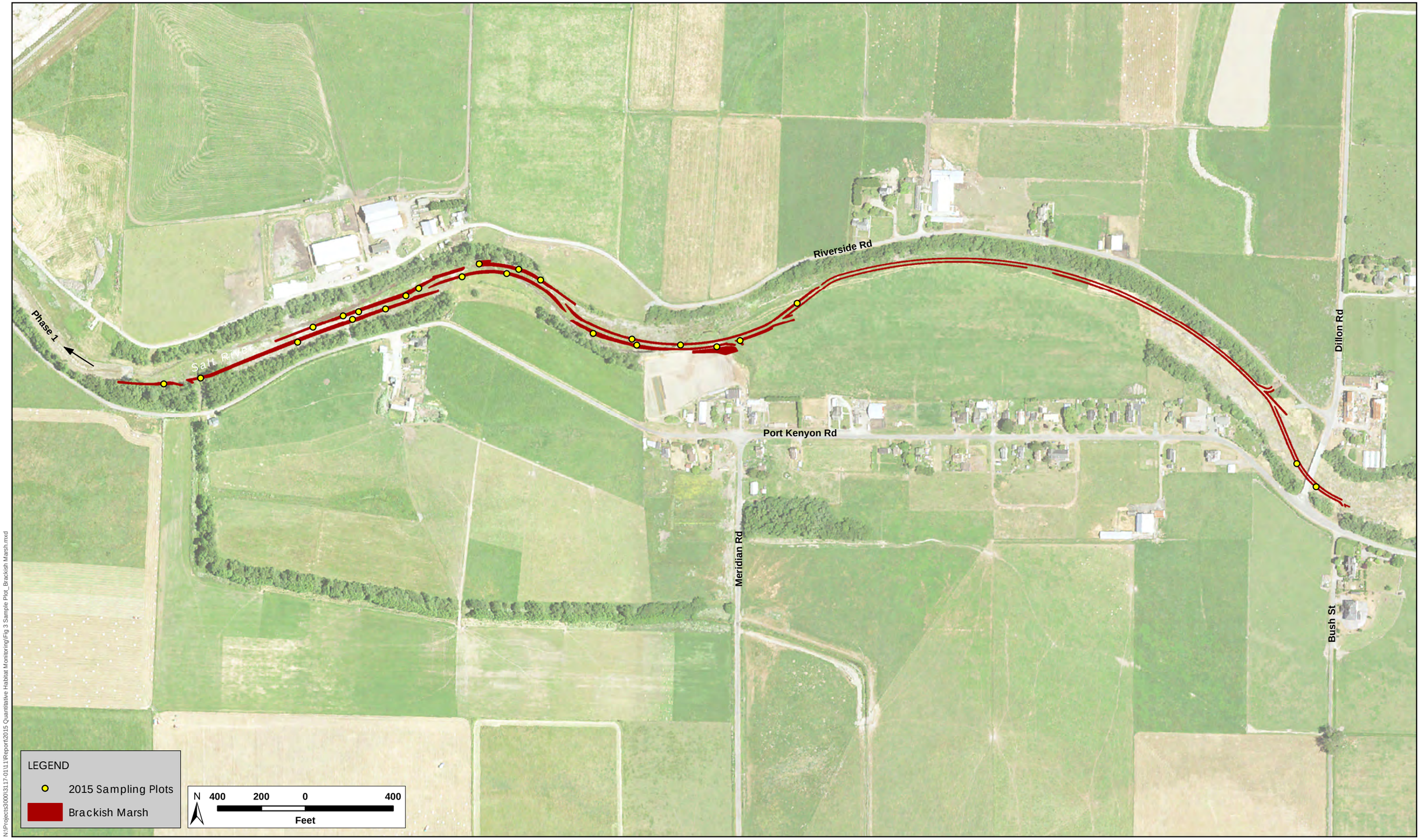

N:\Projects3000\3117-01111\Report\2015 Quantitaitve Habitat Monitoring\Fig 3 Sample Plot_Brackish Marsh.mxd

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Figure 3. Sample Plot Layout for Brackish Marsh Habitat

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Table 2. Modified Braun-Blanquet (1928) Plant Cover-Abundance Scale

Cover Class	Range of Percent Cover	Median (%)
r	<1 (single individual)	0.1
+	<1 (sporadic or few)	0.5
1	1–5	3.0
2	>5–25	15.0
3	>25–50	37.5
4	>50–75	62.5
5	>75–95	85.5
6	>95-100	97.5

2.2.2 Plant Species Categorization

All plant species encountered in sample plots were categorized as native, invasive, or non-native non-invasive. The purpose of the categorization was to serve as a basis of comparison of current site conditions with the HMMP's success criteria for minimum cover by native plants and maximum cover by invasive plants and non-native non-invasive plants. Native plants are defined as plants that are believed to occur in the region naturally. Non-native plants have been introduced either as a direct or indirect result of human activity. Invasive plants are defined by the California Invasive Plant Council (Cal-IPC) as non-native plants that threaten wildlands by displacing native species, hybridizing with native species, altering biological communities, or altering ecosystem processes (Cal-IPC 2015).

Cal-IPC maintains an online database called the California Invasive Plant Inventory, which includes ratings for non-native invasive plants that threaten the state's wildlands (Cal-IPC 2015). Cal-IPC ratings represent the best available knowledge of invasive plant experts in the state. The Cal-IPC evaluation considers cumulative statewide impacts of each plant based on an assessment of the plant's ecological impacts, invasive potential, ecological amplitude, and distribution (Table 3). Cal-IPC recognizes that the impact of invasive plants in specific geographic regions or habitats in California may be greater or lesser than the statewide rating of the species indicates, and it suggests that management actions for a species should be considered on a local and site-specific basis. Therefore, we also considered ratings by the Humboldt County Weed Management Area (HWMA) (2010), which emphasize regional strategic management priorities. Additional sources were consulted containing information on local levels of invasiveness (Pickart 2006, Leppig and Pickart 2013, Pickart pers. comm. 2014). For the current assessment, all plants having either a Cal-IPC or an HWMA rating of "High" were categorized as invasive. Other plants were categorized as either invasive or non-native non-invasive based on available information on the ecological impacts and/or level of threat to wildlands locally (Appendix A). None of the plants are listed as federal noxious weeds (USDA 2015).

Table 3. California Invasive Plant Council Ratings and Definitions

Cal-IPC Rating	Definition
High	These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
Moderate	These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
Limited	These species are invasive, but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

Source: Cal-IPC 2015.

2.2.3 Data Analysis

For each habitat type, we examined the data using a power analysis to determine whether the sample size (i.e., number of plots/quadrats) provided sufficient statistical power, defined as 80% power, to detect a significant difference in cover between the observed state and the relevant success criterion, at an 80% confidence level. First, observations of total percent cover by native plant species for each plot (defined as the sum of the median cover classes for all native plant species) (Table 2) were arcsine square root transformed, and power analysis was conducted on these transformed values. This data transformation results in values that are on a continuous unbounded scale and may give a closer approximation to normality, a key assumption for the power analysis. We conducted a one-sample, two-sided *t*-test on the difference between the mean of the transformed observations and the arcsine square root of the success criteria for each habitat type, with a significance level of 0.20, power of 0.80, and standard deviation of the transformed observations. This approach yielded the sample size that would be necessary to determine whether the observed means were significantly different from the criteria, with sufficient power. If the necessary sample size was less than the number of plots that were sampled, then we determined there to be sufficient power.

To assess plant species composition, we used the median percent cover by cover class (Table 2) to calculate mean percent cover for each plant species observed. For each plot in each habitat type, total cover by native plant species was calculated as the sum of the percent plant cover for each native species observed in the plot. Mean percent cover by native plants for the survey area was then calculated as the mean of total native plant cover for all plots in each habitat type. Nonparametric bootstrap methods were used to construct approximate 95% confidence intervals for the mean percent cover by native plants in the survey area. Nonparametric methods were used because the data are not normally distributed (Manly 2007). Traditional parametric methods assume that mean values are normally distributed and use student's *t* distribution to give symmetric intervals. Percent cover data are inherently bounded by zero and 1 (when expressed as a proportion), whereas the normal

distribution is unbounded, and correct confidence intervals are often asymmetric except when mean values of percent cover are near 50%.

When nonparametric bootstrap methods are used, the sampling error can be quantified by resampling the observed data many times, thus providing a method for constructing confidence intervals. Total percent cover values of native plant species for individual plots were resampled with replacement n times, where *n* is equal to the number of plots sampled in each habitat type, and the mean of these n new sample values was calculated. This process was repeated 1,000 times to yield 1,000 bootstrap replicates of mean percent cover of native species. The 95% confidence limits were defined as the 2.5th and 97.5th percentiles of these 1,000 bootstrap replicates. Mean cover by invasive species, non-native non-invasive species, sterile wheatgrass, and all plants was assessed in the same manner and for each habitat type.

Section 3.0 Results

3.1 Habitat Acreage

3.1.1 Habitat Mapping

Projected habitat types from the SRERP's HMMP are shown in Figure 4. In 2015, we found that salt marsh plants have colonized much of the restored tidal area (Figure 5). No quantitative data for plant species composition were collected during this monitoring year; however, it is apparent that the salt marsh is dominated by native plant species. Most of the salt marsh is dominated by perennial pickleweed (*Salicornia pacifica*) (Photo A), whereas some salt marsh areas are dominated by saltgrass (*Distichlis spicata*) (Photo B).

Other habitats found in the area projected to be salt marsh also were mapped (Figure 5). Mudflats were found at lower elevations than salt marsh. For mapping purposes, mudflats were defined as areas with less than 5% cover by vascular plant species. Deeper areas of mudflat ponded water, and shallow areas supported *Vaucheria longicaulis* var. *macounii*, a species of macroalgae commonly found regionally in tidal sloughs and on high tidal flats associated with salt marshes (Photo C). At elevations higher than salt marsh were areas of high marsh ecotone, mostly dominated by tufted hairgrass (*Deschampsia cespitosa*) (Photo D) and some areas of wet grassland dominated by creeping bentgrass *(Agrostis stolonifera*) (Figure 5). A small elevated area appeared to support a predominance of upland plants (mapped as "upland"); however, no quantitative sampling was conducted, and no jurisdictional determination was performed.

Most of the riparian habitat at SRERP is forest bordering the Salt River channel. The riparian forest is dominated by tree species, mostly willows (*Salix* spp.), and also has red alder (*Alnus rubra*) and black cottonwood (*Populus trichocarpa*). In the project's Phase 1 reach, some riparian habitat present before restoration was retained by the project (Photo D). In addition, riparian species were planted to augment this habitat type, mapped as the "Riparian Planting Zone" (Figure 5). In the interior of the tidal area, some channels are bordered by riparian scrub, dominated by the shrub species coyote brush (*Baccharis pilularis* var. *consanguinea*) and willow shrubs. Some of the riparian forest and scrub has died off in response to inundation by tidewater. Where the stands contained mostly live trees or shrubs, they were mapped as riparian habitat. Stands that were predominantly dead were mapped as "standing dead" (Photo E) (Figure 5). In the project's Lower Phase 2A (2014) reach, some riparian habitat was retained on the banks of the newly excavated channel (Photo F). In addition, riparian species were planted in the riparian and active berm planting zones (Figure 6).

Photo A. Pickleweed-Dominated Salt Marsh, September 2015

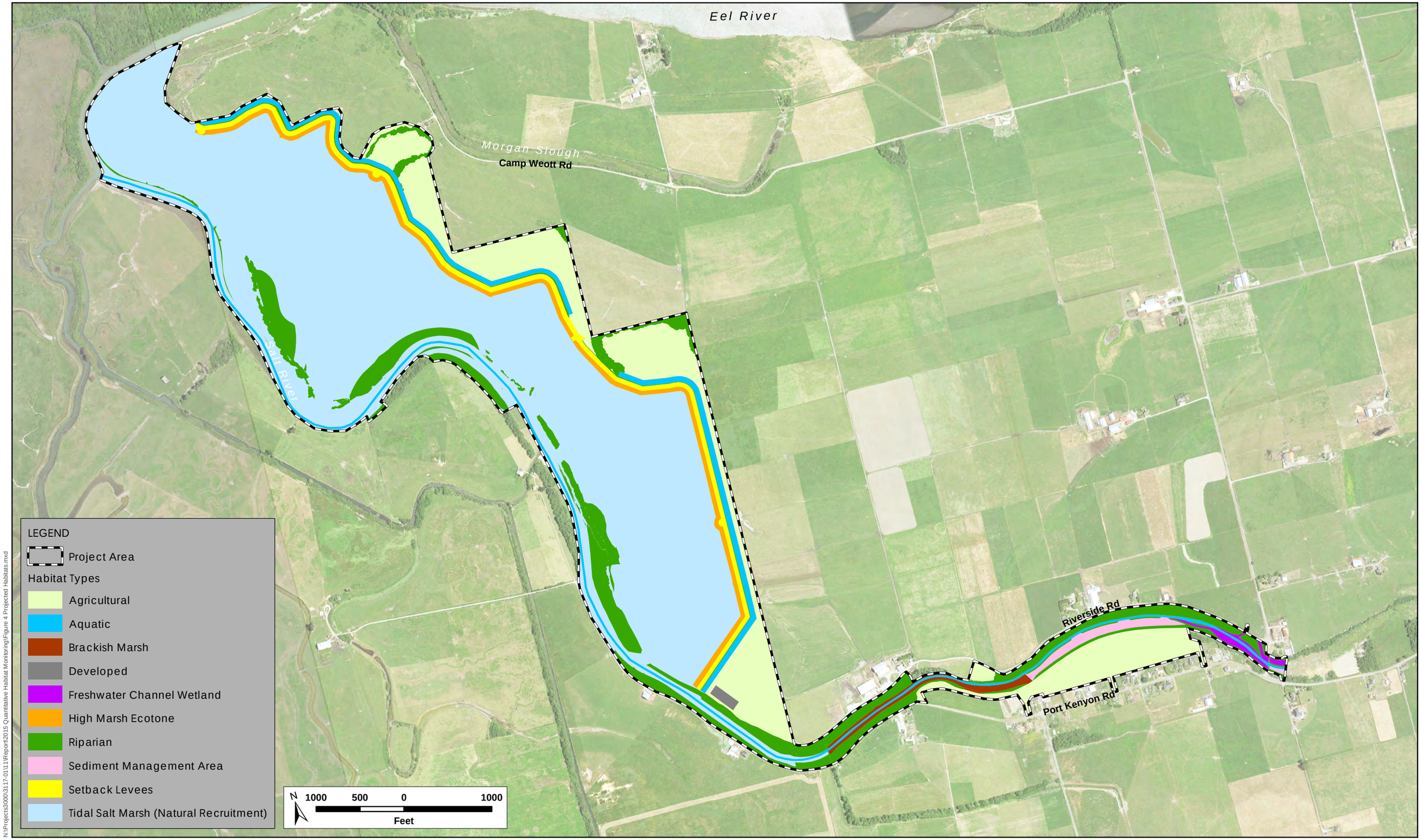
Photo B. Saltgrass-Dominated Salt Marsh, September 2015

Photo C. Mudflat, with Ponded Water and Macroalgae, August 2015

Photo D. Hairgrass-Dominated High Marsh Ecotone (front) and Riparian Habitat (back), September 2015

Photo E. Standing Dead Riparian Vegetation in Restored Tidal Area, August 2015

Photo F. Riparian Habitat Retained on Salt River Channel Banks, August 2015



N:\Projects3000\3117-01111\Report\2015 Quantitative Habitat Monitoring\Figure 4 Projected Habitats.mxd

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Figure 4. Projected Habitat Types for SRERP

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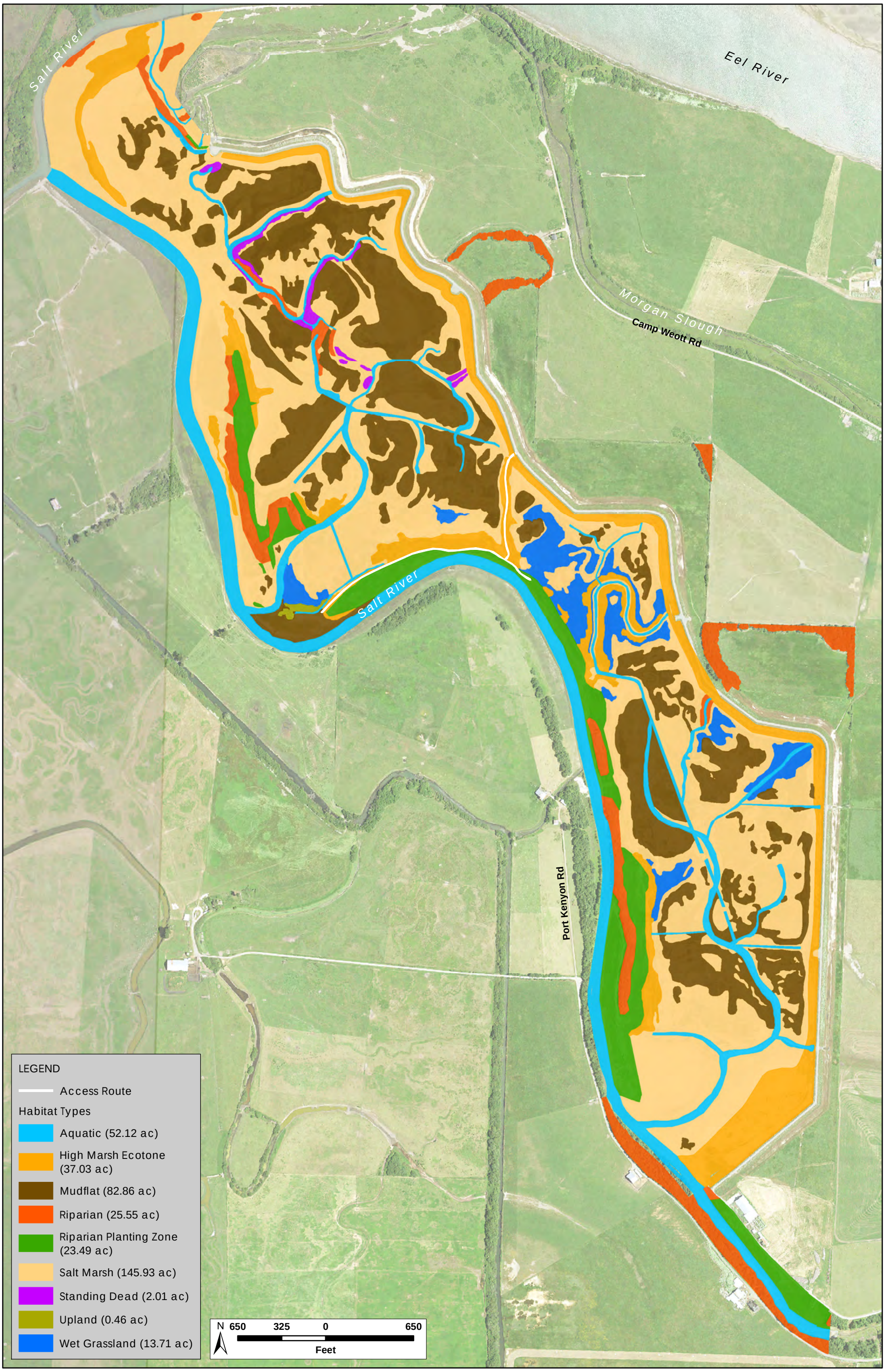

N:\Projects3000\3117-01\11\Report\2015 Quantitative Habitat Monitoring\Fig 5 Phase 1 Habitat Map.mxd

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Figure 5. 2015 Salt Marsh and Riparian Habitat Map for SRERP Phase 1

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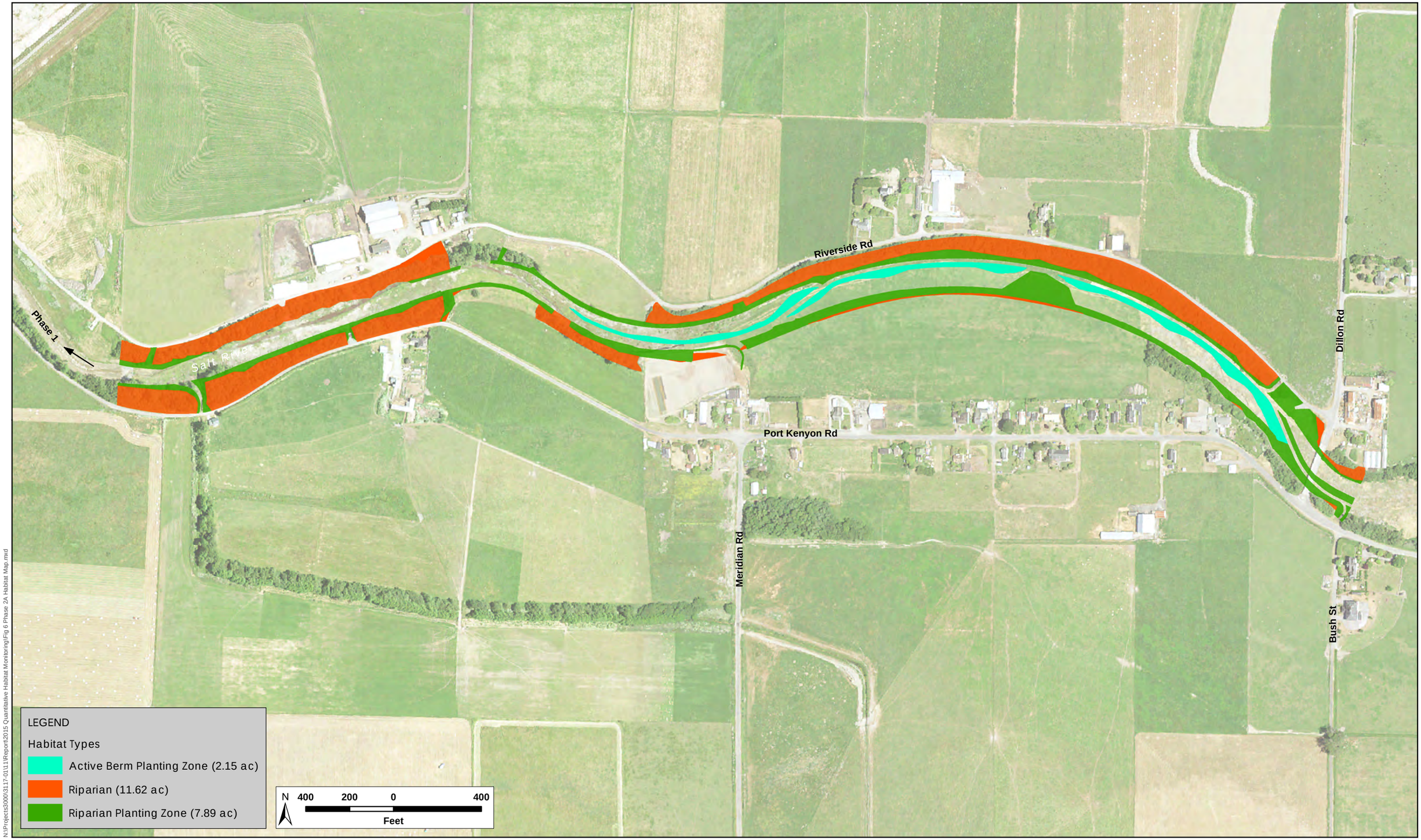

N:\Projects3000\3117-01\11\Report\2015 Quantitative Habitat Monitoring\Fig 6 Phase 2A Habitat Map.mxd

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Figure 6. 2015 Riparian Habitat Map for SRERP Lower Phase 2A (2014)
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3.1.2 Habitat Acreage Success Criterion

Habitat acreage has a final success criterion at least 90% of the projected acreage for each habitat type by Year 10. No habitat acreage success criteria were set by the HMMP for individual monitoring years; however, by Year 5, deviations greater than 10% from projected values may trigger more detailed evaluations of specific project reaches to evaluate potential remedial or adaptive management actions (HTH and Winzler & Kelly 2012).

Table 4 compares the 2015 habitat type acreages to the HMMP success criterion. The HMMP projected the restoration of 322 acres of salt marsh (Figure 4) (HTH and Winzler & Kelly 2012). In 2015, we mapped 146 acres of salt marsh (Figure 5).

Table 4. Comparison of 2015 Habitat Acreages with HMMP Success Criterion

Phase	Habitat Type	HMMP Projected Acreage	HMMP Success Criterion[1]	2015 Acreage Mapped
1	salt marsh	322	290	146
1	riparian	43	39	26 acres retained; 23 acres planted
Lower 2A (2014)	riparian	20	18	12 acres retained; 10 acres planted

[1] HMMP success criterion is ≥90% of HMMP's projected acreage by habitat type.

The total projected acreage for restored riparian habitat for Phase 1 (referred to as Riverside Ranch in the HMMP) is 43 acres (Figure 4) (HTH and Winzler & Kelly 2012). In 2015, we mapped 26 acres of riparian habitat in the Phase 1 project reach. In addition, 23 acres were planted with riparian species in riparian planting zones in winter 2014 through spring 2015 (Figure 5, Table 4).

The total projected acreage for restored riparian habitat for the entire Phase 2 reach is 85 acres (HTH and Winzler & Kelly 2012), and the portion contained in the Lower Phase 2A (2014) project reach is 20 acres (Figure 4). In 2015, we mapped 12 acres of riparian habitat in the Lower Phase 2A (2014) project reach. In addition, in winter 2014 through spring 2015, 8 acres were planted with riparian species in riparian planting zones and 2 acres in active berm planting zones (Figure 6, Table 4).

3.2 Percent Cover Assessment

3.2.1 Overview

Plant species composition for the high marsh ecotone and brackish marsh habitats is presented in Appendix B. The mean percent cover shown for each species represents the mean of the medians of the cover classes observed in sample plots. The range shown for each species represents the minimum and maximum percent cover values in the plots in which that species occurred, again based on cover class median values. Percent frequency estimates shown in Appendix B represents the proportion of sample plots in which a given species occurred.

Both the restored habitats sampled had more than 50% total vegetation cover, and both were dominated by native plant species. Plant species composition by plant species category is summarized in Table 5 and discussed in more detail in the following sections.

Table 5. Percent Cover Assessment for SRERP High Marsh Ecotone and Brackish Marsh, 2015

	Mean Percent Cover (95% Confidence Intervals)	
Plant Species Category	**High Marsh Ecotone**	**Brackish Marsh**
Native species	40.9 (31.2, 51.7)	37.5 (26.2, 48.7)
Invasive species	3.3 (1.4, 5.7)	7.6 (3.7, 12.2)
Non-native non-invasive species	15.7 (10.0, 21.7)	7.7 (3.8, 12.7)
Sterile hybrid wheatgrass	0.0	1.7 (0.4, 3.6)
All Species	60.0 (50.3, 69.1)	54.5 (43.1, 65.7)

3.2.2 Habitat Descriptions

3.2.2.1 High Marsh Ecotone

Photo G. High Marsh Ecotone, August 2015

Total vegetation cover in the high marsh ecotone was 60.0% (Table 5) (Photo G), an approximate 30% increase from the total cover of 46.5% estimated in 2014 (HTH 2014). As in 2014, the most common species were two native grasses: tufted hairgrass and meadow barley (*Hordeum brachyantherum*), both found in nearly 80% of the plots. Tufted hairgrass showed a dramatic increase in mean cover, from 9.4% to 27.0%, whereas meadow barley declined from 9.7% to 4.0%. The native salt marsh species perennial pickleweed was found in 50.0% of the plots with a mean cover of 5.6%, a slight increase compared with last year. Salt marsh sand spurry (*Spergularia marina*) also was found in nearly half the plots, with a mean cover of 3.0%. Other native salt marsh species that were present with low cover (<1.0%) included saltgrass and gumplant (*Grindelia stricta*). Fat-hen (*Atriplex prostrata*), a non-native species that colonizes open areas in salt marshes, remained frequent (60.0% frequency), but mean cover dropped from 16.2% in 2014 to 3.9% in 2015, whereas the mean cover of another non-native colonizer, brass buttons (*Cotula coronopifolia*), increased from 0.9% to 11.7%, with 63.3% frequency (Appendix B). The sterile hybrid wheatgrass planted in the high marsh ecotone in fall 2013 to help provide erosion control through the 2014 growing season did not reproduce and thus was not present this year (Table 5).

3.2.2.2 Brackish Marsh

Total vegetation cover in the brackish marsh was 54.5% (Table 5) (Photo H). The dominant plant species was tufted hairgrass (present in 91.7% of the plots with mean cover of 21.2%), and meadow barley was common (present in 83.3% of the plots with mean cover of 8.1%). Both of these native grasses were included in the seed mix planted in the brackish marsh planting zone. Another native included in the planting mix that was frequent in sample plots was gumplant (present in 41.7% of the plots with mean cover of 1.0%). The sterile hybrid wheatgrass that was planted also was frequent (58.3% frequency) with low cover (1.7% mean cover). Other frequent species were fat-hen (present in 54.2% of the plots with mean cover of 3.7%) and the highly invasive reed canary grass (*Phalaris arundinacea*) (present in 54.2% of the plots with mean cover of 4.7%) (Appendix B).

Photo H. Brackish Marsh, August 2015

3.2.3 Percent Cover Success Criteria

3.2.3.1 Native Plant Percent Cover Success Criteria

Native plant cover in high marsh ecotone was estimated to be 40.9%, significantly greater than the minimum of 15% cover set as the Year 2 success criterion in the HMMP. Native plant cover in brackish marsh was 37.5%, significantly greater than the minimum of 10% cover set as the HMMP Year 1 success criterion for Salt River wetlands. Most of the native plant cover was attributable to tufted hairgrass.

Sufficiency of sample size as determined by power analysis is a function of both the variability of the dataset and the degree to which the estimated value is close to the expected value—in this case, the success criterion. Our power analysis results indicated that the sample size in the high marsh ecotone and brackish marsh was sufficient to determine that the mean percent cover of native plants was greater than the relevant success criteria, with 80% power and 80% confidence. In fact, we sampled more than three times the minimum number of plots necessary as determined by the power analysis. The power analysis yielded low sample size estimates for high marsh ecotone and brackish marsh habitats primarily because the observed percent cover of native plants in these habitats was high relative to the success criteria.

3.2.3.2 Invasive Plant Percent Cover Success Criterion

A maximum of 5% cover by invasive plant species by Year 10 has been set as a success criterion for all restored SRERP habitats (HTH and Winzler & Kelly 2012). No milestone criteria were set for individual monitoring years. In 2015, the high marsh ecotone had a total cover by invasive plants of 3.3%, and the two primary

invasive plants were invasive *Spartina* (*Spartina densiflora*) (present in 20% of the plots with 1.2% mean cover) and rabbitsfoot grass (*Polypogon monspeliensis*) (present in 50% of the plots with 1.7% mean cover). Adjacent to the high marsh ecotone, *Spartina* is invading tidal habitats, although no quantitative sampling for percent cover was required by the HMMP in tidal habitats as part of this year's monitoring. While mapping, we observed *Spartina* to be pervasive throughout tidal habitats, invading both open areas (Photo I) and densely vegetated salt marsh. Brackish marsh had 7.6% cover by invasive plant species. The primary invasive plant present in the brackish marsh was reed canary grass (Photo J), with 54.2% frequency and 4.7% mean cover. Creeping bentgrass was present in 29.2% of the plots with 1.4% mean cover, and all other invasive plants each had <1.0% mean cover (Table 5) (Appendix B).

Photo I. Invasive *Spartina* Invading Open Tidal Habitat, August 2015

Photo J. Reed Canary Grass Patch in Brackish Marsh, August 2015

3.2.3.3 Non-Native Non-Invasive Plant Percent Cover Success Criterion

A maximum of 15% cover by non-native non-invasive plant species by Year 10 has been set as a success criterion for all restored SRERP habitats (HTH and Winzler & Kelly 2012). No milestone criteria were set for individual monitoring years. In 2015, high marsh ecotone had 15.7% cover by non-native non-invasive plant species, attributable primarily to brass buttons and fat-hen. Brackish marsh had 7.7% cover by non-native non-invasive plant species, attributable primarily to fat-hen and clustered dock (*Rumex conglomeratus*) (Table 5) (Appendix B).

Section 4.0 Discussion

The objectives of periodic monitoring are to assess whether habitat restoration is progressing along a trajectory that will meet project goals and to note management actions that might contribute toward meeting those goals. Success criteria are useful as a quantitative way to define goals and measure progress.

4.1 Success Criteria

Restoration of the Salt River estuary (SRERP Phase 1) was designed to create suitable abiotic conditions for the establishment of salt marsh that would provide ecological benefits for numerous fish, wildlife, and wetland plant species. A system of sinuous channels was excavated to simulate natural drainage patterns, and the marsh plain was contoured to create microtopography for the development of marsh habitat zones. Two growing seasons following reintroduction of tidewater, native salt marsh plants have colonized much of the area that was formerly pastureland. The estimated 146 acres of salt marsh habitat represent 45% of the targeted restoration goal of 322 acres. This vegetation response is considered highly favorable at this stage. The developing salt marsh is, however, threatened by invasive *Spartina*, which is rapidly invading both open tidal flats and vegetated salt marsh. Immediate action is warranted to control the invasion, as discussed in Section 4.2, "Management Recommendations."

In general, the tidal areas that had the best colonization by salt marsh were between approximately 6 feet and 7.5 feet NAVD 88 and appeared to have good tidal exchange. Open mudflat generally was found at slightly lower elevations and in areas that were less well-drained, where prolonged inundation and ponding at low tide are less conducive to colonization by vascular plants. It is possible that salt marsh will expand into areas that are now mudflat, though it is difficult to predict to what extent or at what rate such expansion might occur. High marsh ecotone dominated by tufted hairgrass was found at elevations higher than the salt marsh. In general, these were areas that were disturbed during restoration and planted with the high marsh ecotone seed mix. In other areas at similarly high elevations, we found wet grassland dominated by creeping bentgrass. Creeping bentgrass was common in the pastureland before restoration (HTH 2010). It is highly invasive regionally in brackish diked former tidelands (Pickart 2006), but it cannot withstand full tidal inundation, so it is unlikely to be a serious threat to restored salt marsh at SRERP. The creeping bentgrass dominated areas (mapped as wet grassland in Figure 5), total approximately 13.7 acres or 4% of the HMMP's projected 322 acres of restored salt marsh. This surface area could contribute to future failure to attain the HMMP's required minimum restored salt marsh acreage (at least 290 acres), if the current mudflat habitat is not substantially colonized by salt marsh vegetation. The persistence of creeping bentgrass in portions of the restored tidal area is either an indication that these areas may be receiving less than full tidal inundation or that additional time is needed for replacement of bentgrass dominated areas by native salt marsh species via natural recruitment. Therefore, no management actions are currently recommended. Rather, we recommend two years of additional monitoring (Years 3 and 5 per the HMMP) to determine the likely future trajectory of vegetation in the wet grassland areas, along with assessment of the rate of conversion of mudflat to salt marsh. At Year 5, these

additional years of vegetation monitoring should then be used to determine whether management actions are needed in either the wet grassland or mudflat areas to meet the HMMP's salt marsh habitat acreage requirements. Another type of monitoring prescribed in the HMMP is tidal exchange verification. Integration of tidal and vegetation data analyses would help to better understand the relationship between physical conditions and vegetation response in the tidal restoration area.

Assessment of riparian habitat acreage in the first growing season following planting involved consideration of the established riparian forest and scrub retained, as well as riparian and active berm planting zones. In the Phase 1 project reach, established riparian habitat alone represents 60% of the restoration goal of 43 acres, and the combined habitat acreage for retained riparian habitat and riparian planting zones is 114% of the restoration goal. In the Lower Phase 2A (2014) project reach, established riparian habitat alone represents 60% of the restoration goal of 20 acres, and the combined habitat acreage for retained riparian habitat and riparian and active berm planting zones is 110% of the restoration goal. An additional three years of monitoring (Years 2, 3, and 5 per the HMMP) can be used to determine whether riparian establishment in the planting zones appears to be sufficient to meet project goals. Reed canary grass is invading riparian planting zones, especially in the Lower Phase 2A project reach. Control actions are recommended to limit the spread of reed canary grass, as discussed in Section 4.2, "Management Recommendations."

The native plant success criteria were clearly met for high marsh ecotone and brackish marsh habitats. Overall, the high native plant cover was largely attributable to the successful establishment of two native grasses, tufted hairgrass and, to a lesser extent, meadow barley, both of which were components of the hydroseed mix applied as part of the restoration effort.

4.2 Management Recommendations

Two invasive plant species warrant immediate management action in SRERP restored areas. Invasive *Spartina* is rapidly invading restored tidal habitats, both open tidal flats and vegetated salt marsh. HCRCD has removed some *Spartina*, but much more work is needed to prevent this invasive grass from further invasion. The plants that have established are producing seed, and it is expected that *Spartina* will spread rapidly wherever it is not actively controlled. The cost of *Spartina* control will increase quickly the longer that the invasion is allowed to progress. The need for ongoing management actions to control *Spartina* in SRERP restored areas was recognized as a high priority in the HMMP (HTH and Winzler & Kelly 2012). Eradication of invasive *Spartina* is the target of a coastwide eradication effort (Boe et al. 2010), and a regional *Spartina* eradication program also is in place (HTH 2013), with the Humboldt Bay Harbor, Recreation, and Conservation District serving as regional coordinator. An effective method of control developed by the Humboldt Bay National Wildlife Refuge involves mechanical removal using handheld brush cutters to penetrate the substrate surface and cut out *Spartina* rhizomes. Additional control options, guidelines for site-specific evaluation of *Spartina* infestation, estimation of the resources needed for control, and selection of appropriate control methods are provided in the *Humboldt Bay Regional Spartina Eradication Plan* (HTH 2013).

The second invasive species that warrants control is reed canary grass, which is invading brackish marsh and riparian planting zones. Additionally, there are isolated patches of reed canary grass at higher elevations in the restored tidal area. In restored riparian habitats, the hope is that shade cover eventually will provide long-term control of reed canary grass. In the meantime, until canopy cover can become established, efforts to keep reed canary grass in check are advised. Hydroseeding the restored riparian areas was observed to achieve good cover this first growing season, which is helpful in providing competition; however, reed canary grass is an aggressive invader and good competitor. Young plants that have not yet developed extensive root systems can be manually removed, and herbicide approved for use in aquatic environments may be an option for larger patches. Other invasive weeds observed in riparian and active berm planting zones included Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), poison hemlock (*Conium maculatum*), and bristly ox-tongue (*Helminotheca echioides*). Targeted weed control surrounding riparian plantings is recommended to help these woody plants establish by reducing competition with weed species.

4.3 Future Monitoring

The 2015 habitat mapping provided good postrestoration base maps for Phase 1 and Lower Phase 2A (2014) project reaches. Future mapping efforts can build on these maps to track vegetation changes over time. Quantitative habitat monitoring needs for 2016 include mapping salt marsh and high marsh ecotone habitats (monitoring year 3 for Phase 1) and mapping riparian habitat (monitoring year 1 for Lower Phase 2A [2015]).

In 2016, percent cover assessments will be needed for salt marsh and high marsh ecotone habitats (monitoring year 3 for Phase 1). The first 2 years of monitoring high marsh ecotone have focused on the region bordering the setback levee that was projected to be restored to high marsh ecotone. During 2015 mapping of salt marsh, additional areas of high marsh ecotone were identified in the tidal area, and these areas should be incorporated into future percent cover assessments. Also in 2016, percent cover assessments will be needed for riparian habitats (monitoring year 2 for Phase 1 and Lower Phase 2A [2014]) and for Salt River wetlands (monitoring year 2 for Lower Phase 2A [2014] and monitoring year 1 for Lower Phase 2A [2015].

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Appendix A. Suggested Categorization of Non-Native Plant Species as Invasive or Non-Invasive

Non-Native Plant Species	Invasive Status: Suggested Category[1]	Invasive Status: Cal-IPC Rating[2]	Invasive Status: HWMA Rating[3]	Regional Notes for Species
Agrostis stolonifera	Invasive	Limited	High	Highly invasive in brackish marshes and agricultural wetlands
Atriplex prostrata	Non-inv	Not listed	Moderate	Colonizer of disturbed saline marshes
Bromus hordeaceus	Non-inv	Limited	Not listed	Associated with persistent disturbance
Cirsium vulgare	Invasive	Moderate	High	Pest on agricultural land and in wildlands
Cotula coronopifolia	Non-inv	Limited	Not listed	Colonizer of disturbed saline marshes
Cynosurus cristatus	Non-inv	Not listed	Not listed	Not common
Festuca arundinacea	Non-inv	Moderate	Monitor	Associated with persistent disturbance
Festuca perennis	Non-inv	Moderate	Not listed	Commonly planted as a pasture grass; not aggressive in wildlands
Glyceria declinata	Invasive	Moderate	Not listed	Potential threat in disturbed wet areas
Holcus lanatus	Invasive	Moderate	Moderate	Invasive in fresh to brackish marshes and agricultural wetlands
Hordeum marinum ssp. *gussoneanum*	Invasive	Moderate	Not listed	Generally associated with disturbance
Lotus corniculatus	Invasive	Not listed	Monitor	Invasive in fresh to brackish marshes and agricultural wetlands; persistent seedbank stimulated by disturbance
Lythrum hyssopifolia	Non-inv	Limited	Not listed	Not aggressive
Phalaris arundinacea	Invasive	Not listed	High	Highly invasive in freshwater and brackish wetland and riparian habitats; high-priority control concern for SRERP
Plantago major	Non-inv	Not listed	Not listed	Not aggressive
Polypogon monspeliensis	Invasive	Limited	Monitor	Common in disturbed areas at upper marsh margins
Ranunculus repens	Invasive	Limited	Not listed	Invades disturbed areas; toxic to livestock and people
Rumex conglomeratus	Non-inv	Not listed	Not listed	Occurs in fresh to brackish marshes and agricultural wetlands, usually with low abundance
Sonchus asper ssp. *asper*	Non-inv	Not listed	Not listed	Associated with persistent disturbance
Spartina densiflora[4]	Invasive	High	High	Highly invasive in salt marshes; target of regional eradication program; high-priority control concern for SRERP
Trifolium fragiferum	Non-inv	Not listed	Not listed	Commonly planted for forage
Trifolium repens	Non-inv	Not listed	Not listed	Commonly planted for forage

[1] Suggested categories for non-native plants: invasive and non-invasive (non-inv).

[2] California Invasive Plant Council (Cal-IPC 2015) statewide ratings for invasive weeds.

[3] Humboldt County Weed Management Area (HWMA 2010) county ratings for invasive weeds.

[4] *Spartina densiflora* is listed as a noxious weed by the California Department of Food and Agriculture (CDFA 2015).

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Appendix B. Plant Species Composition in SRERP High Marsh Ecotone and Brackish Marsh, 2015

Scientific Name Common Name	Native Status[1]	Mean Percent Cover/Percent Frequency (Range) [2,3] High Marsh Ecotone	 Brackish Marsh
Herbs			
Agrostis stolonifera Creeping bentgrass	INV	0.3/20.0 (0.1–3.0)	1.4/29.2 (0.1–15.0)
Atriplex prostrata Fat-hen	NN	3.9/60.0 (0.1–37.5)	3.7/54.2 (0.1–37.5)
Bolboschoenus maritimus ssp. *paludosus* Alkali bulrush	N	—	<0.1/4.2 (0.5–0.5)
Bromus carinatus California bromegrass	N	—	1.6/8.3 (0.1–37.5)
Bromus hordeaceus Soft chess	NN	—	<0.1/12.5 0.1–0.5
Carex lyngbyeii Lyngbye's sedge	N (rare)[4]	—	0.1/4.2 (3.0–3.0)
Cirsium vulgare Bull thistle	INV	—	0.3/12.5 (0.5–3.0)
Cotula coronopifolia Brass buttons	NN	11.7/63.3 (0.1–37.5)	—
Cynosurus cristatus Crested dogtail	NN	—	0.1/16.7 (0.1–0.5)
Cyperus eragrostis Tall flatsedge	N	—	0.2/12.5 (0.1–3.0)
Deschampsia cespitosa Tufted hairgrass	N	27.0/76.7 (0.5–97.5)	21.2/91.7 (0.5–62.5)
Distichlis spicata Saltgrass	N	0.7/13.3 (0.1–15.0)	—
Elymus glaucus Blue wildrye	N	—	0.6/4.2 (15.0–15.0)
Elymus X *Triticum* Sterile hybrid wheatgrass	NA	—	1.7/58.3 (0.1–15.0)
Epilobium ciliatum ssp. *watsonii* Fringed willowherb	N	—	<0.1/8.3 (0.5–0.5)
Festuca arundinacea Tall fescue	NN	—	<0.1/4.2 (0.1–0.1)
Festuca perennis Italian ryegrass	INV	0.1/20.0 (0.1–0.5)	0.1/12.5 (0.5–0.5)
Glyceria declinata Waxy mannagrass	INV	—	<0.1/4.2 (0.5–0.5)

Scientific Name Common Name	Native Status[1]	Mean Percent Cover/Percent Frequency (Range) [2,3] High Marsh Ecotone	 Brackish Marsh
Grindelia stricta Gumplant	N	0.6/6.7 (3.0–15.0)	1.0/41.7 (0.1–15.0)
Holcus lanatus Velvet grass	INV	—	<0.1/4.2 (0.5–0.5)
Hordeum brachyantherum Meadow barley	N	4.0 /80.0 (0.1–62.5)	8.1/83.3 (0.1–37.5)
Hordeum marinum ssp. *gussoneanum* Mediterranean barley	INV	—	0.5/37.5 (0.1–3.0)
Juncus bufonius Toadrush	N	<0.1/3.3 (0.1–0.1)	0.3/16.7 (0.1–3.0)
Lotus corniculatus Birdsfoot trefoil	INV	0.1/10.0 (0.1–3.0)	0.1/4.2 (3.0–3.0)
Lythrum hyssopifolia Hyssop loosestrife	NN	—	<0.1/4.2 (0.5–0.5)
Oenanthe sarmentosa Water parsley	N	—	<0.1/8.3 (0.5–0.5)
Phalaris arundinacea Reed canary grass	INV	<0.1/3.3 (0.1–0.1)	4.7/54.2 (0.5–37.5)
Plantago major Common plantain	NN	—	0.9/16.7 (0.5–15.0)
Polypogon monspeliensis Rabbitsfoot grass	INV	1.7/50.0 (0.1–15.0)	0.4/25.0 (0.1–3.0)
Potentillla anserina ssp. *pacifica* Pacific silverweed	N	—	0.3/20.8 (0.5–3.0)
Pseudognaphalium stramineum Cottonbatting plant	N	—	<0.1/8.3 (0.1–0.1)
Ranunculus repens Creeping buttercup	INV	—	0.1/8.3 (0.5–3.0)
Rumex conglomeratus Clustered dock	NN	—	2.0/33.3 0.1–37.5
Salicornia pacifica Perennial pickleweed	N	5.6/50.0 (0.5–62.5)	0.6/4.2 (15.0–15.0)
Scirpus microcarpus Panicled bulrush	N	—	2.8/12.5 (15.0–37.5)
Sonchus asper ssp. *asper* Prickly sow thistle	NN	<0.1/3.3 (0.1–0.1)	<0.1/4.2 0.5–0.5
Spartina densiflora Dense-flowered cordgrass	INV	1.2/20.0 (0.1–15.0)	—

Scientific Name Common Name	Native Status[1]	Mean Percent Cover/Percent Frequency (Range)[2,3] High Marsh Ecotone	 Brackish Marsh
Spergularia marina Sand spurry	N	3.0/46.7 (0.1–15.0)	—
Trifolium fragiferum Strawberry clover	NN	—	0.6/4.2 (15.0–15.0)
Trifolium repens White clover	NN	—	0.2/29.2 (0.1–3.0)
Shrubs			
Baccharis pilularis ssp. *consanguinea* Coyote brush	N	—	<0.1/4.2 (0.1–0.1)
Trees			
Salix lasiandra Pacific willow	N	—	0.6/4.2 (15.0–15.0)
Total Vegetation Cover		**59.9**	**54.5**

[1] N = native; NN = non-native non-invasive; INV = invasive; NA = not applicable (see Table 3 and Appendix A for more information).

[2] — = not present.

[3] Range = minimum and maximum percent cover values for plots in which the species was present.

[4] Lyngbye's sedge has a California Rare Plant Rank of 2B.2: Fairly Endangered in California, but More Common Elsewhere (California Native Plant Society. 2015. Inventory of Rare, Threatened, and Endangered Plants of California. Version 8-02. <http://www.rareplants.cnps.org>. Accessed September 19, 2015).