Final

BEL MARIN KEYS WETLAND RESTORATION PROJECT, PHASE I

Seasonal Wetland Preliminary Design Report

Prepared for
California State Coastal Conservancy

August 2017

ESA

Final

BEL MARIN KEYS WETLAND RESTORATION PROJECT, PHASE I

Seasonal Wetland Preliminary Design Report

Prepared for
California State Coastal Conservancy

August 2017

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900
www.esassoc.com

ESA

Bend	Oakland	San Francisco
Camarillo	Orlando	Santa Monica
Delray Beach	Pasadena	Sarasota
Destin	Petaluma	Seattle
Irvine	Portland	Sunrise
Los Angeles	Sacramento	Tampa
Miami	San Diego	

150011.00

OUR COMMITMENT TO SUSTAINABILITY | ESA helps a variety of public and private sector clients plan and prepare for climate change and emerging regulations that limit GHG emissions. ESA is a registered assessor with the California Climate Action Registry, a Climate Leader, and founding reporter for the Climate Registry. ESA is also a corporate member of the U.S. Green Building Council and the Business Council on Climate Change (BC3). Internally, ESA has adopted a Sustainability Vision and Policy Statement and a plan to reduce waste and energy within our operations. This document was produced using recycled paper.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

1. INTRODUCTION

The Bel Marin Keys Wetland Restoration – Phase 1 Project (Phase 1 Project), sponsored by the California State Coastal Conservancy (SCC), will enhance and create seasonal wetlands, reestablish habitat for special-status wildlife species, and protect existing inland development and habitats from increased risk of inundation due to climate change and sea level rise. The Phase 1 Project, which is part of the larger Hamilton Wetlands Restoration Project (HWRP), includes construction of a new bayfront levee, seasonal wetland restoration, modification to Novato Sanitary District infrastructure, site drainage modifications, and creation of PG&E access roads.

This report documents the preliminary design of the seasonal wetland restoration component of the Phase 1 Project. The proposed restoration will create 26.0 acres of seasonal ponds (wetlands), 18.0 acres of alkali meadow and lowland grassland between the ponds (mostly non-wetlands), and enhance 10.3 acres of alkali meadow (mostly wetlands) adjacent to 35.6 acres of existing wetlands. In total the proposed restoration will create a 44-acre seasonal pond complex and enhance a 46-acre area by creating new alkali meadow habitat adjacent to existing wetlands. Seasonal wetlands will be restored in the northern part of the Bel Marin Keys Unit V (BMKV) property and maintained with ongoing water and vegetation management. While the proposed restoration actions provide for direct modification to 36.3 acres, they provide indirect benefits over a larger, 90-acre area within the northwestern part of the site. The restoration serves as the first phase of a proposed larger seasonal wetland restoration with implementation of the full HWRP.

Relevant Prior Studies

The seasonal wetland preliminary design builds on previous work that has been completed including:

- Bel Marin Keys Unit V Expansion of the Hamilton Wetland Restoration Project, General Reevaluation Report (USACE 2003)
- Bel Marin Keys Unit V Expansion of the Hamilton Wetland Restoration Project, Supplemental Environmental Impact Report/Environmental Impact Statement (Jones and Stokes 2003)
- Bel Marin Keys Wetland Restoration Project Phase 1 Restoration Action Preliminary Design Report (Moffatt & Nichol et al. 2016)
- Draft Final Geotechnical Investigation, Bel Marin Keys Unit V Wetland Restoration New Bayfront Levee (Hultgren-Tillis 2016)
- Bel Marin Keys Wetland Restoration – Phase 1 Project, Supplemental Information Document for Joint Aquatic Resource Permit Application (ESA 2016)
- Bel Marin Keys – Field Data Collection for Seasonal Wetlands Restoration (ESA 2017)

Other site data collected in 2016 and 2017 and used in preparation of this preliminary design include verified wetland delineation maps, soils testing, and topographic survey data.

Project Goals and Objectives

The goal of the HWRP is to create a diverse array of wetland and wildlife habitats at the Hamilton Army Airfield, North Antenna Field, and Bel Marin Keys Unit V properties that will benefit endangered and other migratory and resident species.

Objectives for the seasonal wetland restoration are listed below. These objectives are based on the Supplemental Environmental Impact Report/Study (SEIR/S) and General Reevaluation Report, and more recent discussions with SCC staff.

1. Provide shallow ponds with adjacent upland/ruderal areas for shorebird and waterfowl foraging and roosting, as possible
2. Provide seasonal wetlands for other wildlife and plants
3. Provide mitigation opportunities for Phase 1 levee construction
4. Limit the need for operations, maintenance, and management, as possible
5. Maintain flexibility to implement long-term restoration activities
6. Maintain existing levels of flood protection for adjacent roadways and properties
7. Minimize mosquito production
8. Minimize planning, CEQA, permitting and implementation costs
9. Potentially maintain agricultural production until the full HWRP is implemented

2. SITE SETTING

Location and Land Use

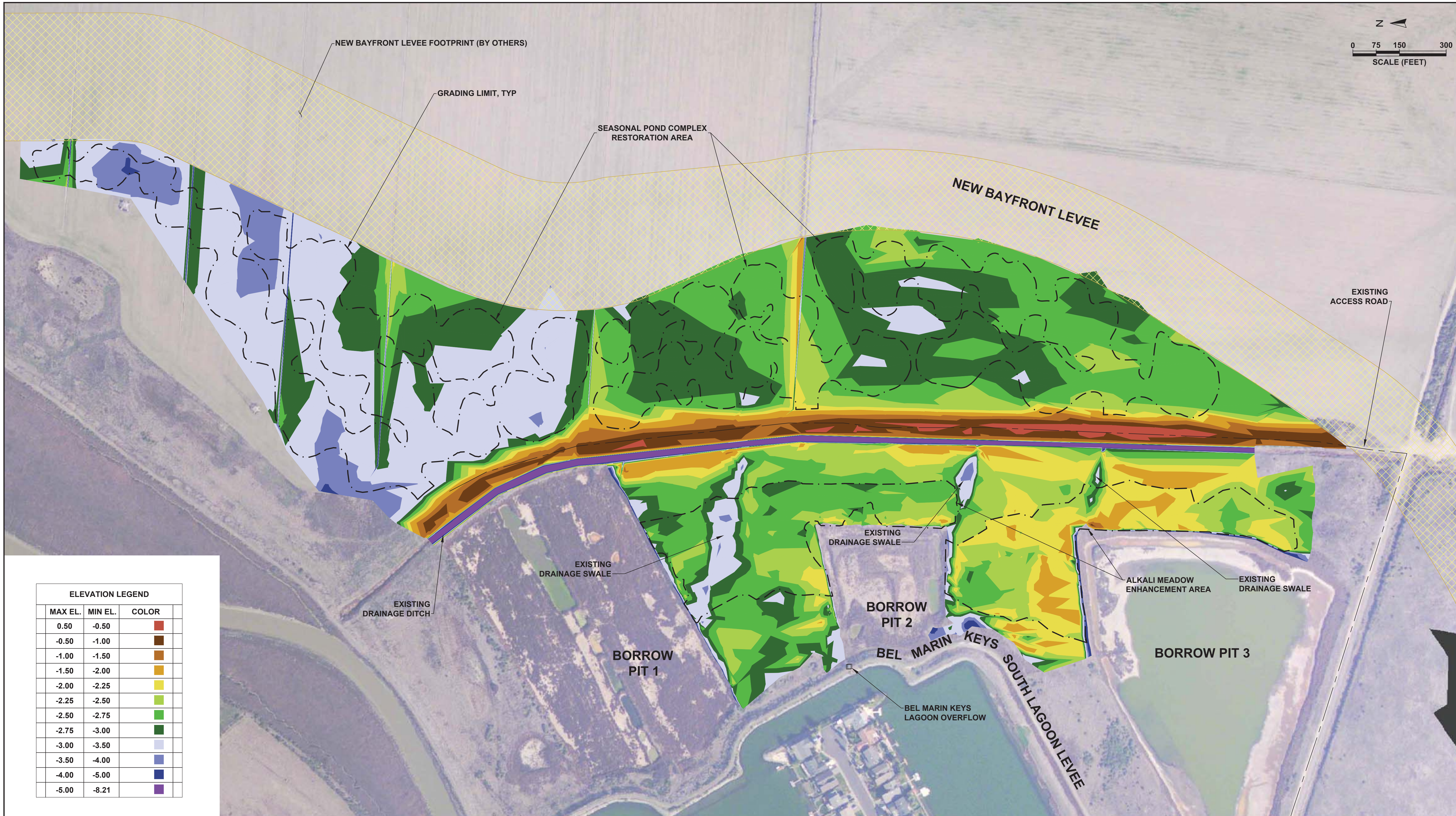
The Project site is located near the City of Novato, in Marin County, east of U.S. Highway 101 and south of CA Highway 37. The Phase 1 Project will occur entirely on the Bel Marin Keys Unit V (BMKV) property owned by the SCC. The seasonal wetland restoration focuses on creation of shallow seasonal wetlands and enhancement of alkali meadow within existing diked baylands (historical tidal marsh diked and drained for agriculture in the 19th century) along the northern portion of the BMKV site, between the proposed New Bayfront Levee and the existing Bel Marin Keys South Lagoon Levee.

The proposed seasonal pond complex is located within existing farmed baylands, currently under cultivation for oat hay, to the south of Novato Creek. The proposed seasonal wetlands are located east of shallow borrow pits adjacent to the Bel Marin Keys South Lagoon Levee that were created from Bel Marin Keys residential and lagoon development activities in the 1960s. The remnant borrow pits have become seasonally flooded saline basins supporting non-tidal pickleweed salt marsh and salt pans (barren saline flats in dry pond beds). Ruderal (weedy) fallow farmed baylands and levees in the vicinity are dominated by a mix of non-native Eurasian annual grasses and forbs, non-native salt and brackish marsh weeds, and elements of native perennial alkali grassland and salt marsh vegetation. An existing access road and drainage ditch separates the agricultural fields from the borrow pits (Figure 1).

Topography

Topography for the project is based on survey elevations collected by ESA in 2016 and 2017 using Real-Time Kinematic Global Positioning System (RTK-GPS) in North American Vertical Datum 88 (NAVD) (Figure 1). The restoration area is divided into two main areas by an existing access road and drainage ditch. The proposed seasonal wetland restoration area to the east of road/ditch generally slopes from south to north, towards Novato Creek. Existing elevations in the agricultural field vary from a low of approximately -5.0 ft NAVD at the northern end of the field to a high of -2.25 ft NAVD at the southern end, indicating that the former tidal baylands have subsided approximately 8.50 to 11.25 feet. The existing elevated access road that borders the field to the west is relatively flat with elevations ranging between -0.50 and 0.50 ft NAVD. Between the access road and the proposed alkali meadow enhancement areas is a drainage ditch with a relatively constant invert elevation of approximately -8.0 ft NAVD.

This page intentionally left blank



SOURCE: ESA 2017

ESA

BEL MARIN KEYS WETLAND RESTORATION . 150011

FIGURE 1

PROJECT AREA TOPOGRAPHY

This page intentionally left blank

Existing grades in the proposed alkali meadow enhancement area to the west of the existing road/ditch slope from a low of roughly -4.0 ft NAVD along the edges of the borrow pits to a high of roughly -1.5 ft NAVD along the eastern edge of the site, adjacent to the drainage ditch. Grades adjacent to the borrow pits are relatively gentle and mostly range between -2.75 and -2.0 ft NAVD. There are three shallow drainage swales within the proposed alkali meadow footprint, running in an east-west orientation, from the drainage ditch towards each of the borrow pits. Topographic data within the borrow pits is limited to the edges of the ponds due to the depth of standing water in the ponds and soft soil conditions at the time of survey. From the limited data collected, the side slopes of the borrow pits appear to vary between 2:1 to 5:1 (horizontal:vertical).

Soils

Subsurface conditions in the Project area consist of three strata: Bay Mud Crust, Young Bay Mud (upper soil horizons; Reyes series), and alluvium at depth (Moffatt and Nichol et al, 2016, NRCS 1985). Bay Mud Crust, derived from diked salt marsh soils, is found in upper soil horizons (topsoil layers), extending approximately 6 to 8 feet below grade. The crust has a stiff to very stiff consistency and has dried due to over a century of drainage and tillage for farming. When bay mud soils saturate, the clay component swells, and subsequently shrinks when it dries, causing development of deep cracks up to 2 inches wide and up to 2 feet below the ground surface (prior to discing for cultivation). The Bay Mud Crust overlays Young Bay Mud (older Holocene estuarine muds), which extends to depths of 40 to 50 feet below ground surface. Creation of the seasonal pond complex and the alkali meadow will be limited to the Bay Mud Crust strata.

Hydrology

The hydrology of the proposed seasonal wetland restoration area is influenced by a combination of precipitation, evapotranspiration, groundwater seepage, overflow from Bel Marin Keys South Lagoon, and agricultural water management through ditches, water control structures (e.g., the culvert that drains the north-south drainage ditch under the east-west access road) and pumping. The recent and historical hydrology of the diked, farmed baylands has been controlled primarily by diking and drainage activities for farming and flood control. Deep ditches, up to 6 feet deep below the subsided diked baylands in the Project Area, drain surface runoff and brackish shallow groundwater from adjacent farmed fields. Ditches are drained by pumping and discharge to the bay. Sloping groundwater surfaces are drawn down in relation to the lowered (pumped) surface water levels in ditches.

Agricultural Water Management

Water levels are managed by the lessee farmer to support production of oat hay in the project area. No irrigation occurs within the project area. Surface water (from precipitation) drains off of the farm fields into drainage channels which convey the water to a pump station located along the existing Bayfront levee, along the eastern perimeter of the site. The pump station is operated by Jens Kullberg, the lessee farmer. The ditch network allows groundwater levels to be lowered to below the root zone of oat hay crops during fall, winter and spring rainfall months. Surface runoff and groundwater are pumped out of the drainage channel and over the existing Bayfront levee into San Pablo Bay. As part of the existing water management regime, water is pumped off the BMKV property periodically during the winter to keep the farm fields from saturating and to maintain low water levels in the drainage channels which maintains lower groundwater elevations (Jens Kullberg, pers. comm. with C. Rogers). The pump operates automatically according to an elevation-based pump schedule. When water levels at the pump intake rise above a certain elevation, the pump turns on; when water levels fall, the pump turns off.

Precipitation

Precipitation at the Project site generally occurs principally during the wet season (Mediterranean climate) from October through May with December through March being the wettest months. From 2005 through 2015, annual rainfall averaged 22.0 inches and ranged from a low of 8.8 inches in 2005 to a high of 38.4 inches in 2010 (CIMIS, Black Point, Station 187). Annual evapotranspiration is more consistent, averaging 47.9 inches and ranging from 39.8 to 54.9 inches per year in the 2005 to 2015 period (CIMIS, Black Point, Station 187). Additional characterization of precipitation is available from the Hamilton Wetlands seasonal wetland preliminary design (PWA 2005).

Precipitation strongly influences seasonal patterns of wetland hydrology on site, as in other drained, diked baylands with artificially lowered groundwater. Generally, seasonal wetlands form in response to precipitation in Reyes clay loams (diked bayland soils) in shallow depressions (pools and swales) after rainfall saturates the clay-silt soils, causing clays to swell and seal cracks. After precipitation swells clay soils and seals cracks, subsequent precipitation begins to pond on the saturated surface. Shallow ponding occurs during periods of rapid, heavy rainfall, or passage of successive storms with high precipitation.

Seasonal wetlands in the North Bay generally are also strongly influenced by recurrent extreme precipitation events, such as severe multi-year droughts (low winter rainfall, often with long periods of significant soil drying and no precipitation during the normal rainfall season), and years of high rainfall, sometimes persisting through spring months. The precipitation-driven hydrology of seasonal wetlands, therefore, is expected to vary significantly in relation to the seasonal pattern and magnitude of highly variable annual rainfall.

Groundwater

Groundwater levels in the project vicinity are influenced by active year-round surface-water management (drainage) for farming. Groundwater levels at the site are controlled by evapotranspiration and a network of drainage ditches and an existing pump station at the eastern end of the site. Groundwater levels have been observed to drop in response to improved drainage for farming (see below) and would likely increase in the future, if drainage were modified to allow wetter conditions.

Elevation data for shallow groundwater in the project area is limited to observations made during geotechnical investigations for the project (HTE, 2016). In general, groundwater elevations within the BMKV site were observed between 6 to 8 feet below ground surface.

Groundwater levels in the proposed seasonal wetland area were anecdotally observed to drop between the 2015 and 2016 growing seasons, based on observed changes in vegetation, in response to drainage improvements in September 2015. The farmer lessee replaced the culvert at the south end of the existing drainage ditch in September 2015 which allowed the ditch to drain approximately 1.5 feet lower than in previous years (pers. comm. Jens Kullberg). This drainage improvement appears to explain an observed shift from wetland to upland vegetation in an existing pond along the Novato Creek levee. This pond supported wetland vegetation in 2015 (a drought year), as inferred by cover of dead plant material of rough cocklebur (*Xanthium strumarium*) observed in July 2016. In July 2016, after the drainage improvement was implemented, the pond bed was dry and supported no wetland vegetation.

Observations of dry pond beds at the two BMK reference sites (pond beds at -8.0 and -7.6 ft NAVD) confirm that groundwater levels at the reference sites were below -8.0 and -7.6 ft, respectively, in July 2016 which was during the drought and while pumping and farming operations were occurring.

The three borrow pits adjacent to the proposed alkali meadow enhancement area appear to have varying degrees of connection with the groundwater basin based on review of historic aerial photography in Google Earth. Borrow Pit 3 (South) has ponded water to varying degrees in all available photos, Borrow Pit 3 holds groundwater more consistently and frequently is likely deeper than Borrow Pits 2 and 3. Borrow Pit 2 (Middle) appears to have the most limited connection to groundwater, with only two small areas remaining ponded during the dry seasons. Borrow Pit 1 (North) appears to have more groundwater connection than Borrow Pit 2, but the extent of the groundwater influence appears to be limited to small, lower elevation areas towards the middle of the pit.

Bel Marin Keys South Lagoon

The Bel Marin Keys South Lagoon lies to the west of the project area and is separated from BMKV by a levee. The Bel Marin Keys Community Service District (CSD) has a non-exclusive easement to discharge water from the South Lagoon onto the BMKV property when water elevations in the South Lagoon and Novato Creek are at or above 1.5 ft NGVD (4.1 ft NAVD) (Moffatt and Nichol et al, 2016). A water control structure allowing this discharge from the South Lagoon to BMKV is located near the northwest corner of Borrow Pit 2. The structure consists of three 16-inch or 24-inch diameter pipes fitted with flap gates.[1] Two of the flap gates appeared to be fixed in an open position, while the third was closed at the time of site survey work (April 2016). The inverts of the pipe outfalls are at approximately 3.0 ft NAVD. Water was observed to be flowing from the South Lagoon into the site during three site visits to this area (March 11, April 6, and April 26, 2017) and water was not flowing into the site during one site visit (June 10, 2016).

[1] Sources provide conflicting information on culvert diameters.

Biological Resources

Existing Habitats

Agricultural fields within the project area are farmed primarily for oat hay crops (*Avena sativa*), but support many weeds, including Italian rye grass (*Festuca perennis;* syn. *Lolium perenne;* also a hay crop and weed species), vetches (including, hairy vetch; *Vicia* spp.*, V. villosa*), annual mustards (*Brassica* spp.*, Raphanus sativa*) rabbit's-foot grass (*Polypogon monspeliensis*), brass-buttons (*Cotula coronopifolia*), bindweed (*Calystegia sepium*), sow-thistles (*Sonchus* spp.), ox-tongue (*Helminthotheca echioides*) and bird's-foot trefoil (*Lotus corniculatus*). Mature coyote brush shrubs (*Baccharis pilularis*) border the upland edge of the project area drainage channels and farm tract edges.

The borrow pits and steep drainage channels dividing the farm tracts contain elements of brackish and salt marsh vegetation, and are typically dominated by dense, tall alkali-bulrush (*Bolboschoenus maritimus*) stands in zones of summer saturation or flooding. Pickleweed (*Sarcocornia pacifica*), saltgrass (*Distichlis spicata*) and alkali-heath (*Frankenia salina*), are commonly abundant along winter-flooded, summer-drained areas such as upper ditch banks and at the edges of borrow pits. Upland, uncultivated areas between the borrow pits support mostly non-native annual grasses and forbs that are also sparsely distributed as weeds within the cultivated oat hayfields.

Special-status Species

Eight special-status wildlife species have the potential to occur in the vicinity of the Project area:

- California Ridgway's rail (*Rallus obsoletus*) (federally-listed as endangered)
- Western snowy plover (*Charadrius nivosus nivosus;* syn*. C. alexandrinus nivosus*) (federally-listed as endangered)
- Salt marsh harvest mouse (*Reithrodontomys raviventris halicoetes*) (federally-listed as endangered)
- California black rail (*Laterallus jamaicensis coturniculus*) (state-listed as threatened and a fully protected species)
- Burrowing owl (*Athene cunicularia*) (state species of special concern)
- San Pablo song sparrow (*Melospiza melodia samuelis*) (state species of special concern)
- Northern harrier (*Circus cyaneus*) (state species of special concern, nesting only)
- Short-eared owl (*Asio flammeus*) (state species of special concern, nesting only)

None of these species has been surveyed for or observed within the seasonal wetland restoration area, but have been observed or are likely to occur in adjacent areas such as the Hamilton Wetlands and Novato Creek. The U.S. Fish and Wildlife Service is likely to presume that diked salt marsh dominated by dense stands of pickleweed and associated halophytes may be occupied by populations of the salt marsh harvest mouse. Pickleweed presently occurs in narrow bands at the edges of the borrow pits, but there are no large dense stands of pickleweed within the project area. Black rails are unlikely to occur in diked salt marsh that is desiccated in summer. Snowy plovers are very unlikely to occur in areas dominated by either upland or wetland vegetation. California Ridgeway's rails are likely to be restricted to tidal salt marsh habitats with suitable structure.

Reference Sites

Two types of reference sites were used to inform the preliminary design: (1) onsite seasonal ponds and (2) natural, spontaneously-generated seasonal wetlands bordering San Pablo Bay. A third type of reference site, seasonal wetlands of diked farmed baylands, is discussed below for comparison though this type of seasonal wetland is not proposed at BMK.

Onsite seasonal ponds. ESA and Peter Baye identified two onsite seasonal ponds to use as reference sites. The ponds were analyzed for topography, soils, vegetation, and wildlife uses. Information gathered from these two wetland sites is shown in a technical memorandum (Appendix A, ESA 2017). One of the reference sites (Reference Site 1) contained some conditions the design will try to emulate, including the presence of wigeongrass (*Ruppia maritima*), an aquatic plant that is good food for ducks (Figure 2a).

Natural seasonal wetlands. Natural seasonal wetlands pond throughout the winter season and are generally dominated by perennial wetland vegetation. Natural seasonal wetlands near Bel Marin Keys were used as reference sites, drawing from the authors' prior professional experience. Modern examples of spontaneously regenerated natural seasonal wetlands bordering northwestern San Pablo Bay are found at China Camp Marsh, urban Novato floodplains landward of Bel Marin Keys, small valleys at Simmons Slough and Bahia Wetlands (North Novato), Ellis Creek baylands (Petaluma), Sears Point, and the non-tidal Tolay Creek delta. Natural seasonal wetlands bordering San Pablo Bay, in contrast with seasonal wetlands of farmed baylands (see more below), are generally dominated by perennial wetland vegetation, including assemblages that become senescent above-ground during the dry season (Figure 2b). Annual-dominated natural seasonal wetland assemblages are uncommon and localized in alkali grassland pools, or successional (unstable) features in stream deltas and alluvial fans contacting baylands.

Natural seasonal wetlands have at least temporarily established in fallow, undrained former farmed diked baylands in northern San Pablo Bay at Bahia, Sears Point, and Cullinan Ranch (Figure 2c). Historical botanical records near Ignacio Creek and Gallinas Creek also provide information on lowland seasonal wetlands bordering the bay. Natural seasonal wetlands, based on observations of existing seasonal wetlands and historical seasonal wetlands, are usually dominated by variable assemblages of perennial grass-like (graminoid) wetland vegetation, such as sedges, rushes, spike-rushes, creeping perennial grasses, and some annual wetland grasses. They also include stands of perennial forbs (broad-leaf plants) and some annual forbs. Natural seasonal wetlands develop dense sods (root-rhizome mats, with fabric-like shear strength and texture) under cover of dominant rhizomatous vegetation. They develop variable above-ground persistent standing and/or matted ("thatch") shoot litter that partially or fully covers soil and winter-flooded water surfaces. In addition, natural seasonal wetlands that established in fallow undrained diked baylands provide additional insights into the colonization of seasonal wetlands by native species (dispersing from nearby terrestrial lowlands and drainages) when they encounter the semi-artificial environments that form in diked baylands after cessation of tillage and drainage. Perennial vegetation and litter of natural seasonal wetlands sometimes limits exposure of ponded water surfaces to dabbling ducks, wading birds, and shorebirds.

The long-term dominant native vegetation of the restored seasonal wetlands at the Bel Marin Keys project site are designed to approximate the composition and structure of relict lowland natural seasonal wetlands adjacent to San Pablo Bay. These natural (but historically modified) seasonal wetlands differ from seasonal wetlands of farmed diked baylands and vernal pools, which are dominated by annual plants or very limited above-ground perennial vegetation.

Seasonal wetlands of farmed baylands. As noted above, this type of wetland is not proposed at the site, but is presented here for comparison. Traditional, familiar seasonal wetlands in farmed diked baylands (which resemble artificial vernal pools, and provide important winter high tide roost habitat for migratory shorebirds and waterfowl) depend on annual tillage or heavy grazing, both of which can cause some important trade-offs for ecological functions and maintenance costs. Annual tillage (discing) eliminates native perennial rhizomatous (creeping) sod-forming grassland and wet meadow vegetation, and selects for annual or short-lived perennial (weedy) vegetation (Figure 2d). Discing in farmed seasonal wetlands also removes above-ground biomass, beneficially maximizing exposure of shallow pool water surfaces to dabbling ducks and migratory shorebirds at high tides during winter rainfall months. The artificially maintained condition of farmed seasonal wetlands has historically provided valuable waterbird habitat, while limiting populations of amphibians, reptiles, invertebrates and small mammals that depend on intact soil structure and mammal burrows.

SOURCE: Peter Baye, June 2016

Figure 2a
Wigeongrass (*Ruppia maritima*) within the seasonal brackish pool at Reference Site 1 at Bel Marin Keys

SOURCE: Peter Baye, June 2013

Figure 2b
Two acre stand of creeping wildrye (*Elymus triticoides*) in perennial meadow within diked baylands at Sears Point

SOURCE: Peter Baye, June 2013

Figure 2c
Saltgrass meadow (*Distichlis spicata*) developed in hydrologically unmanaged seasonally flooded diked baylands at Cullinan Ranch

SOURCE: Peter Baye, January 2017

Figure 2d
Farmed diked baylands in oat hay cultivation at Sears Point

3. PRELIMINARY DESIGN

The proposed seasonal wetland restoration consists of the creation of a seasonal pond complex and enhancement of alkali meadow wetlands. The seasonal pond complex and alkali meadows are designed to require minimal operations and maintenance of the site hydrology (though still active management), while maintaining flexibility to support establishment of habitats, allowing drainage to address vector control issues, and reducing conditions that could promote undesirable soil and invasive species conditions. Details of the design elements for both the seasonal pond complex and alkali meadow and descriptions of the recommended revegetation, irrigation, water management, and wildlife value for the Project site are provided below.

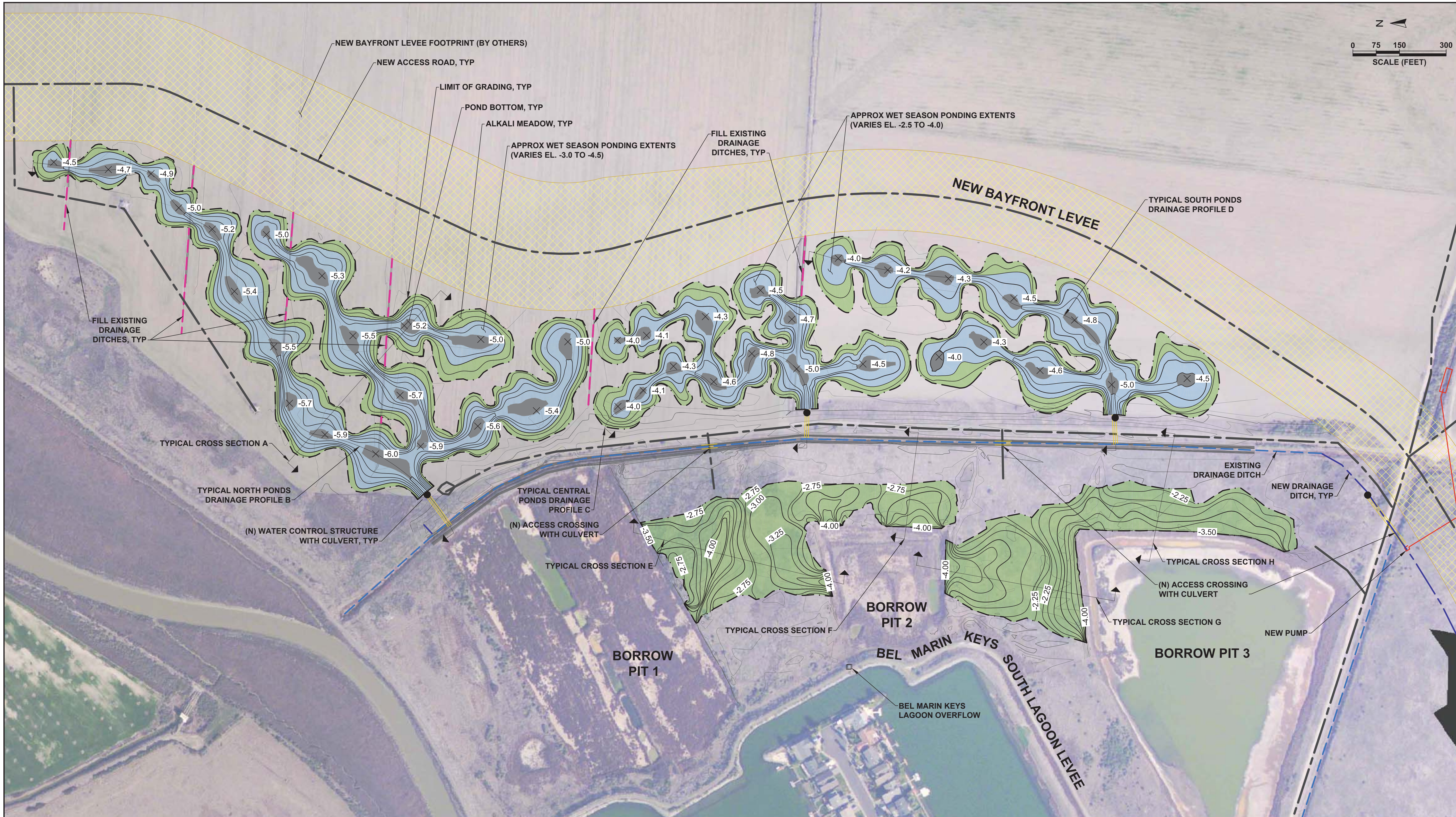
The seasonal wetland design for Bel Marin Keys is based primarily on natural seasonal wetlands of lowland valleys bordering San Pablo Bay. Small areas of seasonal wetlands present at BMKV also informed the design. See Section 2 for a discussion of reference sites used in the design.

The location of the seasonal wetland restoration within Bel Marin Keys was chosen for proximity to existing wetlands, providing a larger connected wetland complex. The area was also chosen because the hydrology can be managed separately from the rest of the site. This allows manipulation of hydrology to support the proposed restoration consistent with continued agricultural use of the rest of the site until the HWRP is fully implemented.

Seasonal Pond Complex

A seasonal pond complex comprised of a mix of seasonally-ponded open water, wetland, and upland/transitional habitats will be created in the northwest portion of the Project site, between the proposed New Bayfront Levee and the existing agricultural drainage ditch and access road (Figure 3). Approximately 26 acres of seasonal ponds with associated alkali meadow transitional slopes will be created within the 44-acre footprint between the New Bayfront Levee and the existing drainage ditch.

This page intentionally left blank



SOURCE: ESA 2017

NOTE: DESIGN CONTOUR INTERVALS VARY. SEASONAL POND COMPLEX GRADING IS SHOWN AT 0.5-FOOT CONTOURS. ALKALI MEADOW GRADING IS SHOWN AT 0.25-FOOT CONTOURS.

BEL MARIN KEYS WETLAND RESTORATION . 150011

FIGURE 2

SEASONAL POND COMPLEX AND ALKALI MEADOW PLAN VIEW

This page intentionally left blank

Seasonal Ponds

A network of seasonal ponds will be created by excavating below existing grade to create shallow depressions with the potential for ponding water up to an average depth of 1 to 2 feet. The network is divided into three hydrologically separate units (north, middle, and south) based on existing topography. The northern unit is located in an area of lower existing elevation, and has design pond invert elevations ranging from -6.0 to -4.5 ft NAVD. The middle and southern units are located in areas of slightly higher existing elevation and have design pond inverts ranging from -5.0 to -4.0 ft NAVD.

The units are designed as a series of small ponds and swales. The ponds will consist of shallow open water habitat, fringed by seasonal wetland vegetation along the side slopes. The ponds range in size from 0.25 to 1 acre, with pond bottom widths of 20 to 40 feet, and gentle side slopes varying between 20:1 to 50:1 (H:V) to the adjacent upland elevations. The ponds are connected by narrower swales, with bottom widths of 10 feet and side slopes of 10:1 (H:V). All three units of the pond network are sloped towards the drainage ditch to allow drainage of the ponds as needed. Contour grading for the seasonal pond complex are presented in Figure 3 and cross-sections are presented in Figure 4.

Seasonal wetlands on diked baylands can be prone to development of problematic acid sulfate soils. The design includes measures to reduce the potential for acid sulfate soils through the drawdown of water levels in spring (described in the Project Hydrology Section) and use of an inorganic soil cap, described below. Long periods of waterlogging in high organic material salt marsh soils during the warm growing season can release and accumulate excessive sulfides which oxidize to acid sulfates. By way of background, sulfides are generated by sulfur-reducing bacteria in anaerobic, saturated soil conditions fueled by organic matter (carbon source for metabolic activity). Extreme high concentrations of either soil sulfides (saturated conditions) or acid sulfates (drained, oxidized conditions) in the wetland root zone can cause significant plant growth inhibition, injury, or dieback. Some likely acid sulfate and sulfide barrens (plant-toxic sulfidic soils) have been observed at multiple locations on site, including some ditches and ditch spoils. Acid sulfate wetland soils also facilitate growth of some nuisance weed species.

To manage potential for problematic acid sulfate soils, and to promote the establishment of desirable vegetation, it is recommended that a 6-inch to 1-foot cap of fine sand or other mineral soil (such as old or new dredged sediment) with no biologically significant organic content, be placed within the footprint of the seasonal pond complex. Subsoils on site, obtained at depths close to the summer water table surface, are likely to contain high sulfide levels even if they have low organic matter content, and would likely be unsuitable. Pond areas would be over excavated 6 inches to 1 foot below grade and backfilled with a compacted layer of low-organic matter material (fine sand or other material).

Mixed sediment textures, ranging from clay, silt, to fine sand, would be suitable for a thin cap in different pools. Variable sediment texture would contribute to variation in the relative abundance, density, and canopy thickness of seasonal wetland vegetation. Fine sands over impermeable clays would promote more prostrate vegetation, with larger vegetation gaps corresponding with greater shallow open water areas most years.

Dredge material present on the State Lands Parcel, immediately adjacent to in the BMKV site, could potentially provide material for the cap. Sediment from maintenance dredging of the BMK Lagoon is another potential source. The BMK Community Services District recently applied for permits to carry out maintenance dredging of the BMK Lagoon and a limited area of Novato Creek and to place the dredged material at an upland disposal site immediately north of Pacheco Pond (USACE 2017). This dredge material would be tested, and additional testing is likely to indicate suitability for placement as a cover (cap) of low-organic fine sediment on the constructed seasonal wetlands. All feasible options for cap material should be explored in order to find proper material while also ensuring that the use of that material would also be consistent with existing project documents and permits.

Upland Habitats and Drainage Ditches

The ground surface adjacent to the seasonal ponds will remain at existing grade. Shallow, seasonal, existing, agricultural drainage ditches within the seasonal pond complex will be abandoned and filled. The existing large drainage ditch between the seasonal pond complex and alkali meadow will be used to manage water levels. It is recommended, to the extent possible to maintain water levels in the ditch near bank full during winter and spring and maintain water in the ditch perennially which would support alkali-bulrush vegetation. It is recommended that the ditch be stocked with native three-spine stickleback (*Gasterosteus aculeatus*) to manage mosquito production, and to provide a prey base for wading birds. On-site ditches are expected to currently be fishless, since they are not connected to terrestrial freshwater drainages or tidal backwater flows.

Alkali Meadow

The Phase 1 Project uses grading and revegetation to expand and enhance existing alkali meadow habitats along the banks of the three existing saline wetland/open water borrow ponds immediately east of the Bel Marin Keys South Lagoon. The alkali meadow enhancement area covers approximately 10.3 acres (Figure 3). The alkali meadow enhancements create gentle, less regular slopes along the edges of the existing ponds to increase the extent of the wetland and transition habitat and sculpt more natural, less linear habitat edges. The alkali meadow enhancements will be located in proximity to and complement existing wetlands that occur within the shallow borrow pits.

Design grades for the alkali meadow are based on elevations where native saltgrass and alkali-heath have been observed to grow under the existing conditions during surveys in July 2016 and April 2017 (Appendix A). Contour grading for the alkali meadow enhancements are presented in Figure 3 and cross-sections are presented in Figure 5.

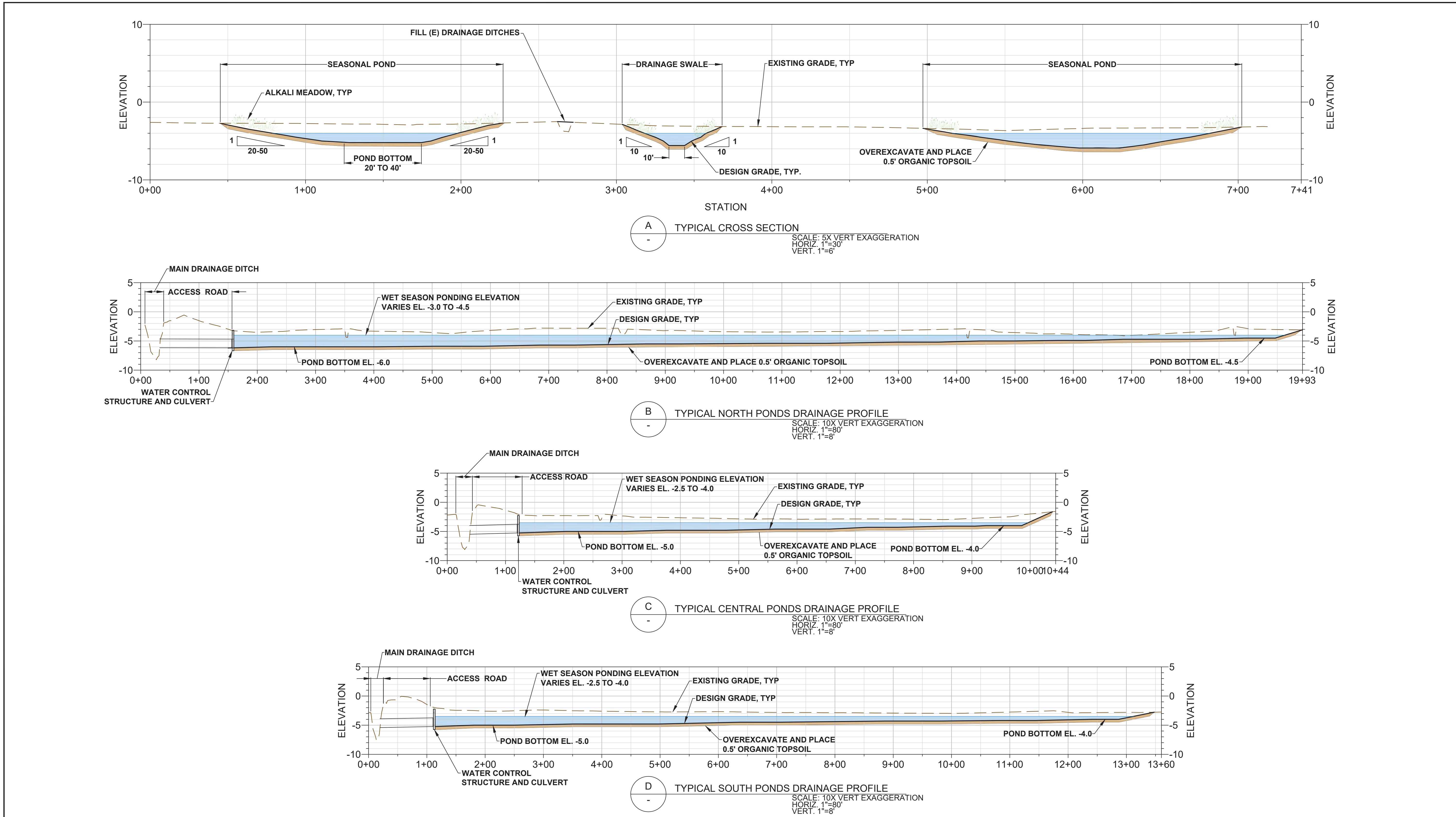
Along the banks of Borrow Pit 1, saltgrass and alkali-heath are found between -4.5 and -2.3 ft NAVD (Appendix A). To expand and enhance this existing habitat, a flatter slope ranging from

100:1 to 50:1 will be excavated along the southern edge of this borrow area from about -4.0 to -2.75 ft NAVD. Excavation adjacent to Borrow Pit 1 also incorporates and enhances an existing shallow swale which currently bisects the area in an east-west direction towards the existing drainage ditch.

Adjacent to Borrow Pit 2, saltgrass is growing along the banks between -4.5 and -1.8 feet. Along this borrow area, a flat transitional slope that ranges from existing grade (-2.75 and -2.25) down to -4.0 feet NAVD will be excavated to expand the area of native alkali grassland vegetation. Borrow Pit 2 appears to receive much of the overflow discharged from the Bel Marin Keys South Lagoon discharge structure that outfalls into the north end of this area. If wetter conditions are needed to support the alkali meadow adjacent to Borrow Pit 2, increasing discharges from the lagoon should be considered.

Adjacent to Borrow Pit 3, saltgrass is currently established between -3.0 and -2.0 NAVD along the east edge of the borrow area and between -4.5 and -2.25 NAVD along the north edge. To help expand this band of native transitional vegetation, a gentle 100:1 to 60:1 slope will be excavated from existing grade at -2.25 ft down to -3.5 ft NAVD along the east edge of the pond and down to -4.0 feet NAVD along the north edge.

This page intentionally left blank



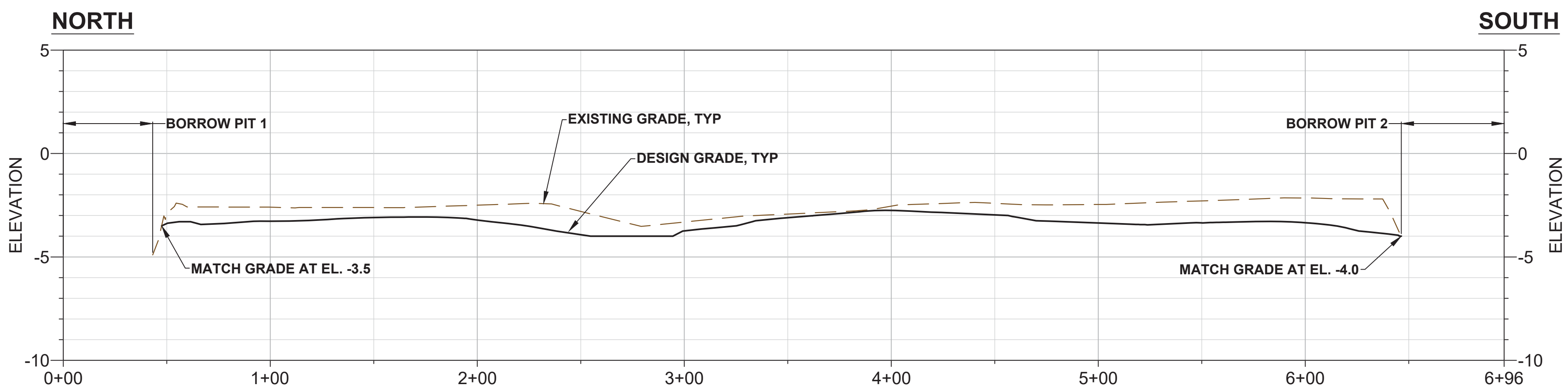
SOURCE: ESA 2017

ESA

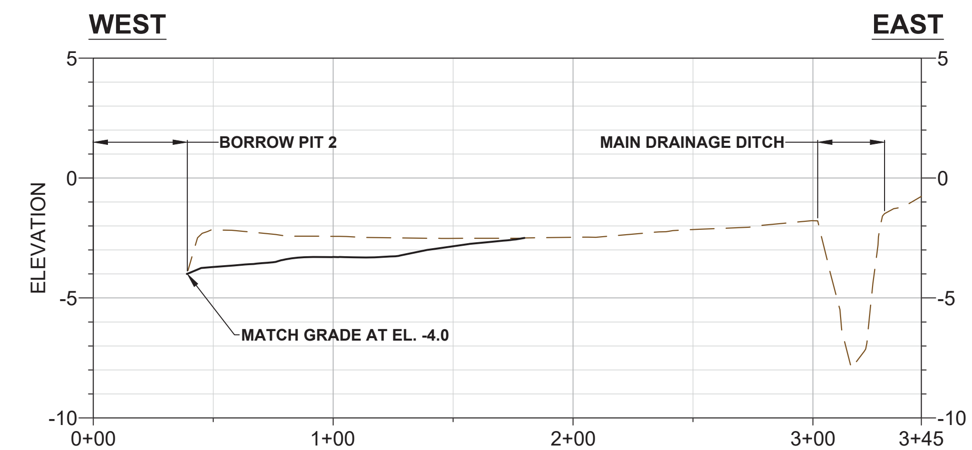
BEL MARIN KEYS WETLAND RESTORATION . 150011

FIGURE 3

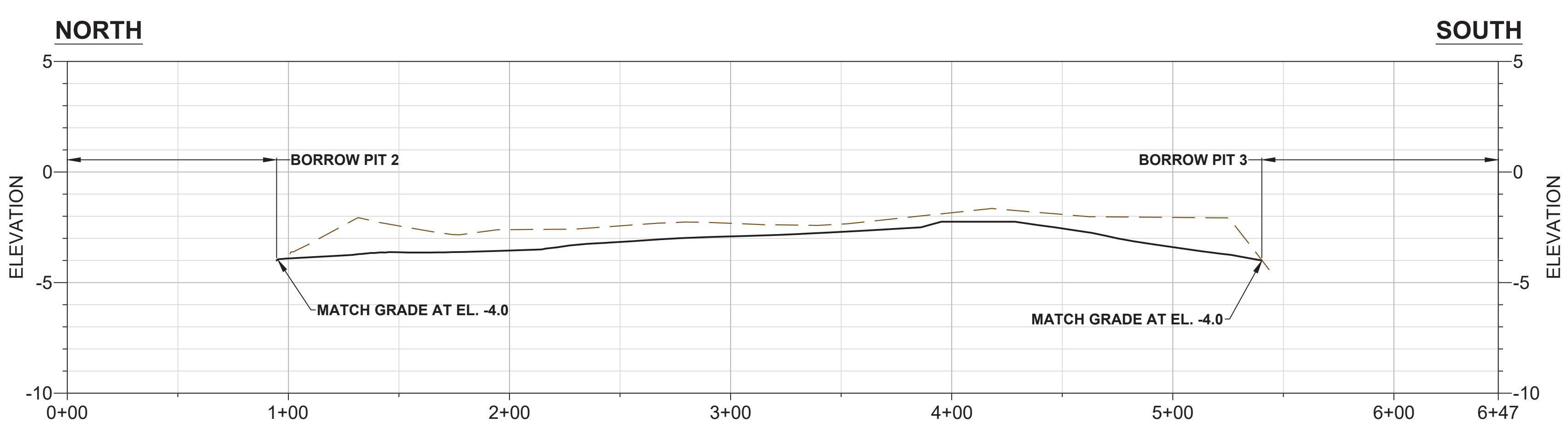
SEASONAL POND COMPLEX
TYPICAL CROSS SECTIONS AND PROFILES



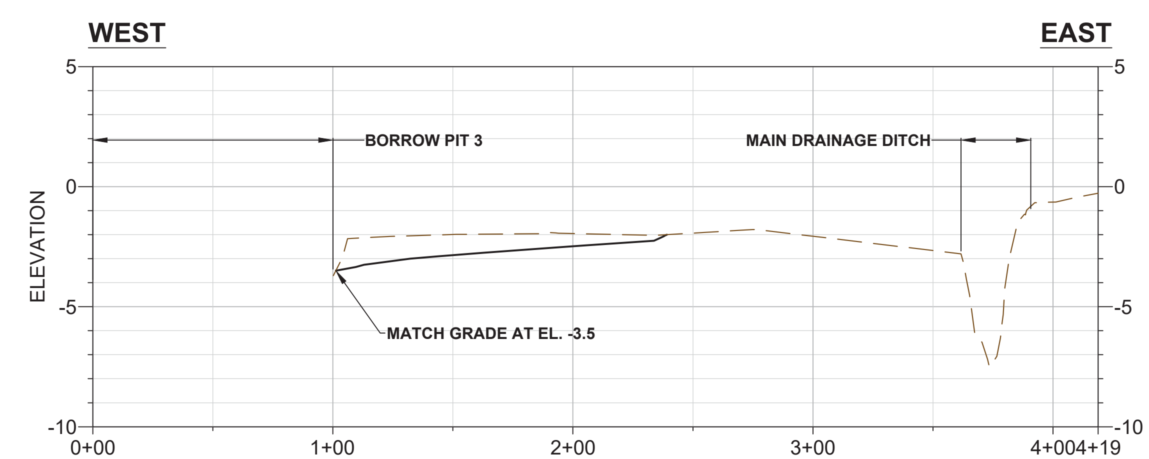
E
-
TYPICAL CROSS SECTION
SCALE: 10X VERT EXAGGERATION
HORIZ. 1"=40'
VERT. 1"=4'



F
-
TYPICAL CROSS SECTION
SCALE: 10X VERT EXAGGERATION
HORIZ. 1"=40'
VERT. 1"=4'



G
-
TYPICAL CROSS SECTION
SCALE: 10X VERT EXAGGERATION
HORIZ. 1"=40'
VERT. 1"=4'



H
-
TYPICAL CROSS SECTION
SCALE: 10X VERT EXAGGERATION
HORIZ. 1"=40'
VERT. 1"=4'

SOURCE: ESA 2017

ESA

BEL MARIN KEYS WETLAND RESTORATION . 150011

FIGURE 4

ALKALI MEADOW
TYPICAL CROSS SECTIONS

Revegetation

Long-term native vegetation objectives and reference conditions

The seasonal wetland vegetation at ideal reference sites generally include the assemblages of dominant or abundant species listed in Table 1. The assemblages vary with local hydrology and soil conditions, ranging from drier seasonal wetlands (desiccated in summer, like vernal pools and alkali grassland; saturated or very shallowly flooded in winter) to wet meadows and seasonal marsh (wet or flooded in winter, mesic to moist in summer). In the constructed seasonal wetlands, these assemblages would vary in extent and position across topographic, soil, and drainage/flooding/saturation gradients of constructed basins (pools) swales, and flats. These assemblages are not completely discrete; they would also intergrade, since populations of each species can independently respond to variable environmental gradients over fluctuating annual conditions.

The preliminary planting list for the alkali meadow and seasonal pond complex is shown in Table 2. The vegetation zones are divided into three elevation zones within the seasonal ponds (low, mid, and high elevation zones). The pond edges (alkali meadow) and non-graded areas between the ponds (lowland grassland) will also be revegetated within the seasonal pond complex. The vegetation is expected to be similar in the alkali meadow west of the drainage ditch, alkali meadow around the pond edges, and lowland grassland within the non-graded areas between the ponds. Because of these similarities, all alkali meadow and lowland grassland areas are grouped into one vegetation zone called alkali grassland flats. Though the site will not support natural alkali flats, which occur on alkali soils (basic pH) that are not present at the site, it will support similar vegetation to natural alkali flats.[2] Created bayland alkali flats support abundant halophyte forbs and grasses, especially saltgrass and alkali-heath.

[2] Created alkali flats within diked salt marsh (bay mud) or dredged material (partially drained bay mud) contain significant residual salinity and non-sodium salts, which may be acidic due to acid sulfate soil conditions.

TABLE 1
NATIVE PLANT SPECIES OF SEASONAL WETLAND VEGETATION TYPES IN SAN PABLO BAY

Scientific Name	Common Name
Alkali grassland (summer dry; significant but low residual soil salinity) [1]	
Amsinckia intermedia	Fiddleneck
Centromadia pungens	Spikeweed
Cressa truxillensis	Alkali-weed
Distichlis spicata	Saltgrass
Elymus triticoides	Alkali wildrye or creeping wildrye
Elymus x *gouldii*	Giant alkali wildrye
Frankenia salina	Alkali-heath
Hemizonia congesta subsp. *lutescens*	Yellow hayfield tarweed
Lowland (alluvial) grassland and wet meadow	
Carex praegracilis	Field sedge
Carex barbarae	Basket sedge
Elymus triticoides	Alkali wildrye or creeping wildrye
Elymus x *gouldii*	Giant alkali wildrye
Juncus arcticus var. *balticus* (syn. *J. balticus*)	Baltic rush
J. mexicanus	Mexican rush
Seasonal marsh	
Carex barbarae	Basket sedge
Eleocharis macrostachya	Common spikerush
Juncus arcticus var. *balticus* (syn. *J. balticus*)	Baltic rush
Juncus phaeocephalus var. *paniculatus*	Brown-head rush
Perennial marsh –mesohaline (brackish)	
Bolboschoenus maritimus	Alkali-bulrush (emergent flooded and lower margins of seasonal
Distichlis spicata	Saltgrass
Sarcocornia pacifica	Pickleweed (upper margins of seasonal flooding)
Perennial marsh –oligohaline (marginally brackish to fresh)	
Bolboschoenus maritimus	Alkali-bulrush
Eleocharis macrostachya	Common spikerush
Typha latifolia, T. domingensis	Cattails
Seasonal pond bed	
Eleocharis macrostachya	Common spikerush
Eleocharis parvula	Dwarf spikerush
Ruppia maritima	Wigeongrass (submerged aquatic)
Sesuvium verrucosum	Sea-purslane

NOTES: [1] Other vegetation that could be found in gaps or openings within alkali grassland include: *Downingia pulchella, Eryngium aristulatum, Glyceria occidentalis, Lasthenia glaberrima, Lasthenia glabrata* subsp. *glabrata, Lepidium oxycarpum, Plagiobothrys bracteatus*, *Pleuropogon californicus, Triglochin scilloides*, *Triphysaria versicolor* subsp. *faucibarbata*.

SOURCE: Peter Baye, 2017

TABLE 2
PRELIMINARY PLANT LIST FOR RESTORED SEASONAL WETLANDS

Scientific Name	Common Name	Seasonal Pond Basin/Pool Zone	Alkali Grassland Flat	Propagule Type	Target Range Propagule Density (yd^2)	Ecological Management and Function
Ambrosia psilostachya	Western ragweed	High zone (incidental)	Yes	Dormant root fragment/ sod	1-10	Persistent clonal perennial Stress tolerant Soil stabilization Weed competition Gap colonization
Amsinckia intermedia	Fiddleneck	No	Yes	Seed	100-200	Post-grading native winter annual cover crop Weed competition Insect pollinator host Gap colonization
Bolboschoenus maritimus	Alkali-bulrush	Low zone and deep ditch	No	Corm	<< 0.1 (rare, local)	Aggressive dominant clonal perennial Survives drought Weed competition Waterfowl food Primary production
Carex barbarae	Basket sedge	High zone (incidental)	Yes	Dormant sod fragment	0.1-1.0	Persistent clonal perennial Soil stabilization Weed competition Gap colonization
Carex praegracilis	Clustered field sedge	High zone	Yes	Dormant sod fragment	0.1-1.0	Persistent clonal perennial Soil stabilization Weed competition Gap colonization
Centromadia pungens	Spikeweed	No	Yes	Seed	10-100	Summer- fall annual Insect pollinator host Weed competition Gap colonization
Cressa truxillensis	Alkali-weed	No	Yes	Dormant rhizome or sod fragment	0.1-1.0	Persistent prostrate clonal perennial Gap colonization Insect pollinator host
Distichlis spicata	Saltgrass	High zone	Yes	Dormant sod fragment	1-10	Persistent clonal perennial Soil stabilization Weed competition Gap colonization
Downingia pulchella	Downingia	Low zone	No	Seed	100-1000	Winter-spring annual Insect pollinator host Gap colonization
Eleocharis macrostachya	Common spikerush	Low zone	No	Dormant sod fragment	1-10	Persistent clonal perennial Soil stabilization Weed competition Gap colonization Waterfowl food
Eleocharis parvula	Dwarf spikerush	Low zone	No	Seed	100-1000	Facultative annual/ perennial Turf-forming Gap colonization Weed competition Waterfowl food
Elymus triticoides	Alkali-wildrye, Creeping wildrye	No (will colonize)	Yes	Dormant sod fragment	1-10	Persistent clonal perennial Soil stabilization Weed competition Gap colonization Mallard nest habitat Small mammal habitat
Frankenia salina	Alkali-heath	No (will colonize)	Yes	Dormant sod fragment	1-10	Persistent clonal perennial Soil stabilization Insect pollinator host Weed competition Gap colonization

TABLE 2
PRELIMINARY PLANT LIST FOR RESTORED SEASONAL WETLANDS (CONTINUED)

Scientific Name	Common Name	Seasonal Pond Basin/Pool Zone	Alkali Grassland Flat	Propagule Type	Target Range Propagule Density (yd^2)	Ecological Management and Function
Glyceria occidentalis	Manna grass	Low zone	No	Seed	1-10	Winter annual Gap colonization Floating mat canopy
Hemizonia congesta subsp. *lutescens*	Yellow hayfield tarweed	No (will colonize)	Yes	Seed	10-100	Summer- fall annual Insect pollinator host Weed competition Gap colonization
Iva axillaris	Poverty-weed	No	yes	Dormant rhizome fragment	0.1-1.0	Prostrate clonal perennial Gap colonization
Juncus balticus	Baltic rush	Mid zone	No	Dormant rhizome fragment	0.1-1.0	Persistent clonal perennial Soil stabilization Weed competition Gap colonization
Lasthenia glaberrima	Rayless goldfields	Low zone	No	Seed	1-10	Winter annual Gap colonization Insect pollinator host
Lasthenia glabrata	Smooth goldfields	High zone	Yes	Seed	10-100 pool 1-10 flat	Winter annual Gap colonization Insect pollinator host
Plagiobothrys spp. (P. bracteatus and *P. stipitatus)*	Bracted and stalked popcorn flower	Low zone	No	Seed	10-100	Winter annual Gap colonization Insect pollinator host
Plantago elongata	Bigelow's plaintain	Low zone	No	Seed	1-10	Winter annual Gap colonization Insect host Waterfowl foraging
Pleuropogon californicus	Semaphore grass	Low zone	No	Seed	10-100	*Winter annual* *Gap colonization* *Floating mat canopy*
Ruppia maritima	Wigeongrass	Low zone	No	Live or dormant rhizome, turion	0.1-1.0	Clonal perennial Waterfowl foraging Gap colonization
Symphyotrichum chilense	Common aster	High zone	Yes	Dormant rhizome and crown fragment	0.1-1.0	Persistent clonal perennial Insect pollinator host
Triglochin scilloides	Flowering quillwort	low	No	Seed	0.1-1.0	Winter annual Gap colonization Waterfowl foraging
Triphysaria versicolor subsp. *faucibarbata*	Butter-and-eggs	High	No	Seed	10-100	Winter annual Gap colonization Insect pollinator host

SOURCE: Peter Baye, 2017

The relative extent and distribution patterns of these plant assemblages in the established seasonal wetlands is expected to vary dynamically among rainfall years, in relation to depth and duration of submergence and soil saturation. It is likely that relative dominance of most species will increase or decrease across wet and drought precipitation cycles, and patchy zonation patterns are likely to shift upslope or downslope within constructed basins. This process is facilitated by the clonal growth habit (creeping vegetative spread) of most perennial dominant species, which allows them to spatially track, or "forage" changing position of environmentally favorable patches or zones, into which they move by rhizome growth.

The diversity of different functional groups of native plants in the seasonal wetlands is essential to the dynamic ability of the vegetation they comprise to adapt to natural extremes of hydrological conditions. For example, the most drought-tolerant species in the assemblages, such as alkali/creeping wildrye, and the more salt-tolerant species, such as saltgrass and alkali-heath, are likely to expand distribution and relative abundance into lower, wetter zones (shift lower down in pool inundation and elevation gradients) during droughts. Conversely, "wetter" marsh and wet meadow species, such as sedges, rushes, and spikerushes, are likely to decline in density and abundance during droughts, and expand vertically within the pool inundation and elevation gradients during wet years with prolonged, deep flooding that drowns out less flood-tolerant species. Stable or "quasi-equilibrium" vegetation patterns or elevation ranges are very unlikely to develop over decade-scale rainfall cycles. Therefore, stable zonation patterns and relative abundance of species are not expected or set as objectives for seasonal wetlands. The overall species composition, however, is likely to stabilize as persistent, resilient clones of stress-tolerant perennial species. Table 3 shows the prescribed dominant, common, and post-disturbance abundant plant species within the different vegetation zones within the design.

TABLE 3
PRESCRIBED DOMINANT NATIVE VEGETATION FOR RESTORED SEASONAL WETLANDS

Vegetation Type or Zone	Dominant to Subdominant Species	Frequent to Uncommon Species	Intermittent or Post-disturbance Abundant Species
Alkali grassland flats (Includes alkali meadow and lowland grassland)	*Distichlis spicata* *Elymus triticoides* *Frankenia salina*	*Ambrosia psilostachya* *Carex barbarae* *Carex praegracilis* *Cressa truxillensis* *Euthamia occidentalis* *Iva axillaris* *Symphyotrichum chilense*	*Amsinckia intermedia* *Centromadia pungens* *Hemizonia congesta* *Juncus bufonius* *Lasthenia glabrata*
Seasonal wetland pool – high zone (frequent early emergence)	*Distichlis spicata* *Elymus triticoides* *Frankenia salina* *Juncus balticus*	*Carex barbarae* *Carex praegracilis*	*Juncus bufonius* *Lasthenia glabrata* *Triphysaria versicolor*
Seasonal wetland pool – middle zone	*Distichlis spicata* *Elymus triticoides* *Frankenia salina* *Juncus balticus*	*Carex barbarae* *Carex praegracilis* *Elymus triticoides* (drought) *Eleocharis macrostachya* *Juncus balticus*	*Bolboschoenus maritimus*
Seasonal wetland pool – low zone (pool bed; late emergence)	*Eleocharis macrostachya* *Eleocharis parvula* - *OR* - *Bolboschoenus maritimus*	*Glyceria occidentalis* *Pleuropogon californicus* *Ruppia maritima*	*Downingia pulchella* *Lasthenia glaberrima* *Plagiobothrys* spp. *Plantago elongata* *Sesuvium verrucosum* *Triglochin scilloides*
Perennial fresh-brackish marsh (flooded deep remnant ditch)	*Bolboschoenus maritimus*	*Typha latifolia* *Ruppia maritima*	*N/A*

SOURCE: Peter Baye, 2017

Episodic droughts and disturbances causing dieback patches in perennial vegetation will likely create vegetation gaps in which opportunistic annual species (both native alkali vernal pool plants, and non-native weeds) are likely to colonize temporarily, until perennial dominant species recapture the gaps. Extirpation (local population extinction) of some of the least salt-tolerant wetland plant species may occur, however, if progressive increases in soil salinity occur in some closed, undrained seasonal wetland basins.

Non-native vegetation management

Vegetation will need to be established on barren, newly graded soils that will likely be heavily loaded with accumulated weed seed banks from prior oat hay farming and adjacent dirt roads and levees. Some of the most abundant short-term primary weed successional species expected at Bel Marin Keys seasonal wetlands, all of which are present in oat hay farmed areas and adjacent levees, include fat-hen (*Atriplex prostrata*), brass-buttons (*Cotula coronopifolia*), rabbit's-foot grass (*Polypogon monspeliensis*), and bird's-foot trefoil (*Lotus corniculatus*).

These seasonal wetland weeds are expected to become transiently abundant during disturbed, post-grading soil conditions for 1-3 years, before significant competition from clonal perennial native dominant vegetation occurs. They are likely to be displaced when dense leaf litter, live closed canopies, and perennial sods develop. They may persist locally in vegetation gaps or areas with low or thin vegetation cover, especially in alkali grassland flats, but are not expected to persist as dominants to any significant extent.

Weed seed density in seasonal wetlands may be managed by scraping and stockpiling the uppermost soil layers (top 6 inches) prior to grading. The uppermost soil layers contain the highest density of persistent, dormant weed seeds, and transient (short-lived) weed seeds. Stockpiled surface soils may be placed in pond beds, ditch bottoms (flooding depth and duration environments exceeding physiological tolerances of seasonal wetland weeds). Alternatively, weed-rich soils may be capped (minimum thickness approximately 6 inches) with subsoil with lower weed seed density.

In contrast, one invasive non-native perennial clonal forb, perennial pepperweed (*Lepidium latifolium*) has potential to establish in sub-dominant or even dominant persistent, spreading populations early in succession. Its seed rain on the site may be significant in years before grading occurs if populations increase in nearby Novato Creek tidal marshes. Perennial pepperweed, however, is also probably unlikely to maintain dominance in competition with dense, tall stands of alkali-wildrye, field sedge, and basket sedge. It may persist and require short-term, multiple-year management in lower vegetation of alkali grassland. Management of perennial pepperweed would require selective spot-applications of wetland/aquatic formulations of glyphosate in spring, during bolting (rapid shoot elongation) or earliest flowering stages, over a period of 2-3 years, while populations are young and small. If herbicide treatment is not allowed, small infestations may be able to be removed successfully by removing (shoveling out) the entire plant. Delay of treatment would risk potentially explosive and unmanageable spread and widespread establishment in wet years, before native vegetation is fully established.

Plant salvage, propagation, native plant stock production, and translocation

The large acreage of seasonal wetlands requiring revegetation imposes a very high demand for vegetative planting stock of perennial species, and seed stock for a few selected native annual species needed as a transitional native “cover crop” to stabilize graded soils and resist rapid weed invasion.

Direct seeding of graded seasonal wetlands is recommended only for strong colonizing native annual species that naturally establish exclusively by seed; these are important to sow in bulk, at high density, to provide early seedling competition with weedy non-native annuals prevalent in diked baylands. Native annuals are needed to temporarily occupy the gaps between slower-growing, spreading clones of perennial grass-like plants and grasses that are expected to dominate the vegetation in the long term. Fast-colonizing native annuals and slow-colonizing native perennials together compose the foundation for a dynamic, successional vegetation strategy. In the absence of native annual seeding at high density, the niche of rapid, opportunistic colonizers will be dominated exclusively by weeds, some of which may retard the development of the primary target perennial dominant plant species. Heavy seeding by robust native annuals known to thrive in diked bayland soils (and past levee seeding projects) is a prudent method of resisting high weed invasion rates. In addition, the native winter and summer annual forbs recommended also provide significant pollen and nectar sources for insect pollinators, including native bees.

Commercial native plant nurseries can provide custom-grown seed stock from local founder populations. A lead time of two years (two growing seasons) is generally needed to allow time to amplify seed populations from limited small founder populations.[3] A lower-cost option for producing abundant seed stock is to cultivate native annuals as “weed crops” using the same or similar farming methods currently used to produce oats on site. Modification of cultivation in rows to allow for manual bulk seed harvesting over short seed production periods (*Amsinckia*) and long production periods (*Centromadia, Hemizonia*) would be incorporated in on-site cultivation designs. It is recommended to use similar bulk propagation and translocation methods used for the Oro Loma Horizontal Levee Project and use the skills, knowledge, and close proximity of the Hamilton Nursery Manager, as available, to implement the revegetation strategy including on-site plant salvage, propagation, plant stock production, and translocation. Existing native vegetation (mostly salt grass and alkali health) along the banks of the borrow pits should be salvaged prior to excavation and cultivated on-site away from the grading area or at the Hamilton Nursery. This vegetation will be replanted within the alkali grassland flats.

Native perennial grass-like plants and grasses of Bay Area seasonal wetlands, especially those with slow creeping (rhizomatous, clonal) growth habits, naturally establish infrequently and very slowly from seed; though they are included in commercial seed mixes for native revegetation in California, their seedling establishment rate is inherently low, uneven, and unpredictable, even in

[3] Preliminary schedule is for revegetation work to begin in September 2017 with planting in newly-graded areas to occur in fall 2019.

years of favorable rainfall patterns. For the perennial species, mass translocation of dormant vegetative propagules into graded soils is recommended as the primary method for rapidly establishing pioneer perennial clonal plant populations over large areas. As clones expand radially (by creeping) and coalesce, they form a closed perennial grassland/wet meadow or seasonal marsh vegetation.

Bulk translocation of dormant vegetative propagules (rhizome fragments, sod fragments containing rhizome and bud masses, shoot crowns with buds) using mechanical equipment is recommended for the very large seasonal wetland acreages designed (comparable to small farm plots), which are probably too large for cost-efficient, labor-intensive manual transplanting. Alternatively, a large dedicated volunteer group and/or use of an AmeriCorps team could keep costs down while providing significant outplanting results. When dry and fully dormant in cool temperatures in mid/late fall, sods of clonal perennial grasses and grass-like plants (sedge, spikerush, grasses) can be mechanically harvested (scraped or excavated with small equipment) in bulk, broken or shredded to fragments mechanically, and shallowly disked into soil. Dormant sod fragments will retain high viability as long as they are buried and sheltered from desiccation and heating. Track-walking or moderately compacting them into the soil increases rooting contact and minimizes air gaps. When soils are moistened with fall/winter rains, rhizome buds rapidly produce roots and shoots that grow during the wet winter-spring season. Careful timing of translocation with the onset of fall-winter rains replaces the role of artificial irrigation, and ensures a long root growth season needed to establish plants that can resist moisture stress of the first summer.

Like annuals, production of perennial dominant species requires two years of lead time before grading, to ensure adequate volumes of planting stock in the form of sod and rhizome fragments. The production of open field-grown (farmed) stock, or planting stock produced in lined raised beds, is relatively lower than nursery production of container grown plants, and provides more robust and resilient transplanting units. The project site, as well as adjacent farmed baylands, supports ample areas suitable for small-scale native plant farming of the project's target species, commensurate with the acreage of the project. Approximately one acre of irrigated farmed native plant stock area should produce enough propagules in two years to supply the entire project area. The project area, in turn, may in the future provide abundant, renewable (self-regenerating after harvest) planting stock supplies for future Bel Marin Keys levee revegetation.

Local founder population sources for the most dominant target species are also ample. Derelict floodplain and riparian lands between Highway 101 and Bel Marin Keys support large stands of basket sedge, alkali-wildrye, and rushes. Saltgrass and alkali-heath occur along ditches and levees on site. Other reference sites for seasonal wetland vegetation (Ellis Creek, Petaluma, Sears Point, Bahia, Simmons Slough) also support feasible sources for founder populations, with landowner permission (Sonoma Land Trust, City of Petaluma, Marin Audubon Society, California State Parks, San Pablo Bay National Wildlife Refuge). A list of founder population sources for different plant species within the preliminary planting list are shown in Table 4.

TABLE 4
ABUNDANCE AND AVAILABILITY OF SOURCE POPULATION STOCK FOR FOUNDER POPULATION PROPAGULES

Species	Bel Marin Keys-101 Floodplain	Bel Marin Keys On-Site Diked Baylands	Marin Audubon Olive-Atherton	San Pablo Bay NWR Sonoma Land Trust Sears Point	Tolay Creek Delta CDFW	China Camp State Park	Other Sites
Ambrosia psilostachya	-	-	-	Sonoma Baylands	-	Beach	-
Amsinckia intermedia	-	-	-	Present and propagated	-	-	Ellis Creek oat hayfield, Petaluma
Bolboschoenus maritimus	-	Abundant in ditches	-	Abundant in ditches	-	-	-
Carex barbarae	Abundant	-	-	-	-	San Pedro Road ditches	-
Carex praegracilis	-	-	-	-	-	San Pedro Road ditch	Richardson Bay to San Rafael
Centromadia pungens	-	-	-	Levees Sears Pt Sonoma Baylands	-	-	-
Cressa truxillensis	-	-	-		Locally common	-	Ellis Creek to Alman Marsh Petaluma
Distichlis spicata	-	Abundant	-	Locally abundant	Limited	Limited	Limited
Eleocharis macrostachya	?	-	Locally abundant	-	Locally abundant	-	-
Eleocharis parvula	-	-	-	-	-	-	SW Cullinan Ranch (tidal)
Elymus triticoides	Abundant	Local	Trace	Abundant	Abundant	Local	-
Frankenia salina	-	Locally abundant	-	Locally abundant	Limited	Limited	-
Glyceria occidentalis	-	-	-	Intermittent	-	-	Bahia seasonal wetland pond
Hemizonia congesta subsp. *lutescens*	-	-	-	Abundant	-	Locally abundant	-
Iva axillaris	-	-	-	-	-	-	Richardson Bay Audubon
Juncus balticus	Locally abundant	?	-	-	-	-	-
Lasthenia glaberrima	-	-	-	Locally common in pools, swales Sears Pt	Locally common in pools	-	-
Lasthenia glabrata	-	-	-	-	-	-	Lakeville Petaluma Marsh 1 location
Pleuropogon californicus	-	-	-	Locally abundant	?	-	-

TABLE 4
ABUNDANCE AND AVAILABILITY OF SOURCE POPULATION STOCK FOR FOUNDER POPULATION PROPAGULES (CONTINUED)

Species	Bel Marin Keys-101 Floodplain	Bel Marin Keys On-Site Diked Baylands	Marin Audubon Olive-Atherton	San Pablo Bay NWR Sonoma Land Trust Sears Point	Tolay Creek Delta CDFW	China Camp State Park	Other Sites
Ruppia maritima	-	Locally abundant in ditches, lagoon	Limited	Limited	-	Limited	-
Symphyotrichum chilense	?	?	?	Limited	?	?	
Triglochin scilloides	-	-	-	Locally, intermittently abundant	Limited, intermittent	-	
Triphysaria versicolor subsp. *faucibarbata*	-	? [limited]	-	Locally, seasonally abundant	? [limited]	-	
Typha latifolia	Limited	Locally abundant	Limited	Locally abundant	Locally abundant	Limited	

SOURCE: Peter Baye, 2017

Irrigation

Irrigation of constructed seasonal wetlands is not recommended because irrigation generally provides an unfavorable competitive advantage to fast-growing annual and short-lived perennial wetland weed growth and reproduction, which could persist after drought and irrigation. Irrigation should not be considered unless extreme drought conditions occur after grading and initial seedling and perennial bud emergence (with risk of high mortality). Irrigation of seasonal wetlands should not be performed unless actual flooding and saturation of seasonal wetlands (not drained moist-soil irrigation) can be achieved. Irrigation providing moist-soil drained conditions (like agriculture) after the first growing season is not recommended under any circumstances because of the high risk of counter-productive weed growth. Target native seasonal wetland vegetation is composed of relatively slow-growing perennial species with low reproductive output.

Irrigation with freshwater sources (potentially including recycled wastewater), in contrast, is recommended for relatively small areas of on-site cultivation of high volume native perennial planting stock and seed, starting two years before grading. The lead time and irrigation is needed to ensure capacity for rapid revegetation of large acreage seasonal wetlands, and offset uncertainty of variable growth of propagated stock under unpredictable rainfall and evapotranspiration conditions in the growing seasons before grading.

Project Hydrology

Groundwater and surface water in the Project area will be managed to support the seasonal pond complex and the alkali meadow. The hydrology of the project site will be managed to have ponded to saturated conditions from late November to the end of March. In early April, water levels in the Project area will be drawn down, with the goal of creating dry pond-bed conditions by the end of April.

Water levels in the Project area will be managed using water control structures installed at the south end of the existing drainage ditch and at each of the connections between the seasonal pond complex and the drainage ditch. The drainage ditch water control structure will be used to raise groundwater to a target elevation of -3.5 ft NAVD. The goal is to create ponded depths of 0.5 to 2.5 ft in the seasonal pond complex and saturated soils (no surface ponding) to 0.5 ft ponded depths in the alkali meadow. The wetland water control structures will be used to control and adjust water levels in each seasonal wetland to help manage the wetland habitat. Additional information on the proposed water control structures is provided below.

The target water levels have been developed to support target native vegetation and soil quality within the ponds. Target water levels take into account the high soil organic matter and sulfur-rich nature of the soil within the project site. These soils have the potential to produce and accumulate excessive sulfide and acid sulfate if ponded water or saturated soil conditions extend into or beyond the late spring/early summer.

The water management regime described here may need to be adjusted to best meet the project objectives. For example, changes to the water management approach may be needed to address vector control issues. The site manager will coordinate water management with Marin/Sonoma Mosquito and Vector Control District staff. Section 5 provides a discussion of potential adjustments in long-term water management.

Water Control Structures

We recommend the use of twin-track, precast concrete flashboard weir boxes for both the seasonal wetland water control structures and the drainage ditch water control structure.

For the three seasonal wetland water control structures, we recommend that the project team consider weir boxes approximately 3-ft wide by 3-ft deep by 4-ft tall by Briggs Manufacturing or equal. The recommended weir boxes incorporate flashboard tracks sized for 2-inch flashboards. Flashboards will be redwood (or other approved material). The use of twin-tracks on the weir boxes will limit seepage and water loss through the flashboards. Earth can be packed between the tracks to additionally seal off outflows. The weir boxes would connect to an 18-inch diameter high-density polyethylene (HDPE) stormdrain pipe which would drain each pond complex to the adjacent drainage ditch. The pipe outfall will be supported by treated wood piles or a precast concrete headwall. The foundation below the weir boxes and headwalls (if needed) will be constructed with compacted aggregate base rock as recommended by the project geotechnical engineer. At minimum, we assume that a spread foundation would incorporate over excavation and backfill with engineered fill to a depth of 2 feet below and extend aerially 2 feet beyond the footprint of each structure. The area around the boxes will be backfilled with native soil placed in lifts and compacted as recommended by the project geotechnical engineer.

For the drainage ditch water control structure, we recommend use of an overflow weir with a canal gate. This downstream structure would be similar to seasonal wetland water control structures – incorporating a larger twin-track weir box (approximately 5-ft wide by 5-ft deep by 6-ft tall) with a canal gate. The flashboards and canal gate would be used to control water levels in the drainage ditch and groundwater elevations in the seasonal pond complex and alkali meadow area to/near the ground surface elevation.

Wildlife Value

The seasonal ponds, when flooded, will provide foraging habitat for dabbling ducks and high tide roost habitat for migratory shorebirds. Seasonal flooding of wetland basins is not expected to occur to a significant extent or duration in drought years, or in years of infrequent large winter storms. Significant long-duration ponding attractive to waterfowl and shorebirds is likely to occur in wet years (frequent winter storms), particularly following growing seasons when management reduces above-ground biomass (mowing, grazing, burning). Perennial wetland areas such as the drainage ditch, may provide foraging habitat for wading birds (herons, egrets) if populations of native three-spine stickleback are introduced. In seasonal wetlands with low salinity in winter pools, Pacific tree frogs (*Pseudacris sierra*) may establish and provide a prey base for snakes and wading birds.

The vegetative cover of alkali wildrye and sedge meadows close to seasonal ponds will also provide suitable nesting habitat for dabbling ducks, particularly mallards. Natural recruitment and establishment of some shrub patches may occur in drained bay mud soils around seasonal wetlands (California rose, *Rosa californica*; coyote-brush, *Baccharis pilularis*; poison-oak, *Toxicondendron diversilobum*; elderberry, *Sambucus nigra*) and are likely to support songbird foraging and nesting habitat. Substantial populations of small mammals (voles, mice, shrews) and lagomorphs (brush rabbit, California hare) are likely to establish in dense, stable perennial grassland and wet meadow vegetation. These, in turn are likely to provide a terrestrial prey base for avian predators (including raptors such as red-tail hawks, harriers, black-shouldered kites, and golden eagles) great horned owls, egrets, herons, foxes, raccoons, skunks, and coyotes. Deer from adjacent oak woodland and scrub habitats may be attracted to browse in dense perennial seasonal wetland vegetation that remains green late in summer in many years.

4. PROJECT CONSTRUCTION

While the seasonal wetlands could be constructed during the first or second year of construction of the Phase 1 Project, seasonal wetland construction is recommended for the second year in order to provide time for plant propagation and establishment prior to construction. Recommended construction elements and sequencing for each wetland type being created are specified below.

Site Access

Access to the seasonal pond complex will occur from the New Bayfront Levee to the east and via the existing access road along the west side of the seasonal pond complex area and will not impact existing wetland habitat. Within the site's interior, construction access will generally occur within the New Bayfront Levee footprint and will not traverse existing wetland habitat. Following construction of the New Bayfront Levee, access to the seasonal pond complex area will occur via the levee crest and along the existing access road west of the seasonal pond complex.

Access to the alkali meadow areas for construction will be primarily from the existing access roads to the south and east of the alkali meadow creation area. Up to two new access road lateral connections crossing the drainage ditch adjacent to the existing access road will be created to serve the alkali meadow enhancement area. At these locations, culverts up to 60-feet long will be installed along the drainage ditch to maintain conveyance within the ditch. These culvert crossings will be backfilled with compacted fill to support access by construction and revegetation equipment and personnel. A third access route will connect the existing access road south of the alkali meadow creation area.

If required to ensure safe access for vehicles and heavy equipment, existing and proposed access roads may be upgraded by adding gravel and widening the road as necessary. Upon project completion, these areas could remain or be restored to pre-construction conditions.

Schedule and Phasing

Excavation and grading of the seasonal wetlands complex and alkali meadow areas are anticipated to likely require eight to twelve weeks depending upon the number of crews employed by the construction contractor. The excavation period will occur during the dry season of Year 1 or Year 2 of construction. Revegetation will occur in the fall and, depending on the size of the planting crews, would require an additional four to eight weeks between mid-October and late December.

Construction Methods

Construction equipment will include excavators, low ground pressure dozers, low ground pressure dump trucks, graders, and possibly a sheep's foot compactor to compact the base of the seasonal wetlands ponds. Excavated material will be placed in dump trucks and used as top soil on the stability berms along the new Bayfront Levee. Staging for the seasonal wetland creation will be within the common staging area for the larger Phase 1 Project.

Wetlands excavation will occur during the dry season to limit the need for dewatering and/or rerouting of water during construction. Access routes that cross existing ditches will incorporate culverts to convey runoff and groundwater seepage towards the project pump station. Excavation of deeper areas within the seasonal wetlands ponds could occur in stages to help manage groundwater allowing saturated soils to dry via evaporation between excavation stages. Active dewatering is not anticipated with the relatively shallow excavation depths and dry season work.

We recommend compaction of the seasonal pond bottoms and slopes. Excavated pond bottom and slopes below the anticipated maximum ponding level shall be over excavated by a minimum of 6-inches. The subgrade shall be moisture conditioned to 1 to 5% over optimum, and compacted to a minimum of 90% R.C. (as per ASTM D1557). Following compaction, a shallow three to four-inch lift of low-organic matter material (sand or other suitable dredge material) shall be placed on the prepared subgrade and the material shall be disked to blend the low organic matter cap material with the subgrade material. The intermediate cap layer shall be moisture conditioned and compacted to 90% RC. The final cap layer shall be placed, disked to blend with the surface of the underlying layer, moisture conditioned and compacted. A final shallow disk and track walk with a dozer to finish the completed surface.

Erosion is expected to be minimal during and following construction. The seasonal wetland creation areas are comprised of cohesive bay mud that has a low erosion potential. Additionally, the wetland grading includes flat slopes for habitat enhancement. Post construction best management practices for erosion control will include revegetation of native plant species along the seasonal wetland pond slopes and alkali meadow areas and hydroseeding with a native upland/transitional plant mix within adjacent upland areas. Silt fences will be installed within the existing drainage ditch at the downstream limit of the seasonal pond complex and alkali meadow area and just upstream of the new pump station to help trap any eroded sediments during the first wet season following construction. The silt fence will be removed from the drainage ditches upon adequate establishment of plants to control site erosion. After the first wet season, it is anticipated that the plantings and seeding will be sufficient to control erosion within the area.

Construction Volumes and Opinion of Probable Costs

Table 5 below provides the estimated construction volumes and opinion of probable cost for the project. Excavation and fill cost estimate was provided by Moffatt & Nichol, while ESA developed the cost estimate for all other project elements. These opinions of probably cost are intended to provide an approximation of total project costs appropriate for the preliminary level of design and include a 25% contingency to account for project uncertainties. Total costs are $2,178,250, consisting of $1,869,438 for the 44-acre seasonal pond complex and $308,812 for the 10.3-acre alkali meadow west of the drainage ditch.

TABLE 5
CONSTRUCTION VOLUMES AND OPINION OF PROBABLE COSTS

Project Element	Unit	Quantity	Unit Cost	Total Cost
Excavation				
Seasonal Pond Complex	CY	59,900	$10	$599,000
Alkali Meadow	CY	8,740	$10	$87,400
Fill				
Seasonal Pond Complex 6-in sand cap	CY	12,900	$10	$129,000
Other Elements				
Precast Twin Track Concrete Flashboard Weirs and Risers	EA	3	$380	$1,140
Precast Concrete Overflow Weir and Risers	EA	1	$960	$960
18-inch diameter HDPE pipe	FT	325	$70	$22,750
18-inch diameter canal gate	EA	1	$2,500	$2,500
Precast Concrete Headwalls	EA	4	$300	$2,500
Aggregate Base Rock	CY	20	$250	$2,500
Revegetation				
Seasonal Ponds	AC	26	$17,500	$455,000
Alkali Meadow West of Drainage Ditch	AC	10.3	$15,500	$159,650
Alkali Meadow and Lowland Grassland East of Drainage Ditch (Surrounding Seasonal Ponds)	AC	18	$15,500	$279,000
		Subtotal		$1,742,600
		Contingency	25%	$435,650
		Total		$2,178,250

In providing opinions of probable construction costs, ESA has no control over the actual costs at the time of construction. The actual cost of construction may be impacted by the availability of construction equipment and crews and fluctuation of supply prices at the time the work is bid. ESA makes no warranty, expressed or implied, as to the accuracy of such opinions as compared to bids or actual costs. Quantities and unit costs are based on existing data and current level of design and are intended for planning purposes only. Values will be refined and updated through subsequent phases of site survey, technical analysis and design. Unit costs area based on recent relevant project experience, bid prices from similar projects, consultation with suppliers, and cost estimating references (RSMeans 2015).

5. ONGOING MANAGEMENT

Operations and Maintenance

The SCC is currently responsible for long-term site management, although site management may eventually be transferred to another entity. Initially, the SCC expects to enlist the farmer lessee to provide the necessary on-site management. The SCC will identify roles and responsibilities for long-term site management, reporting requirements, schedule, and adaptive management decision-making.

Water Management

Surface water and groundwater in the Project area will be managed by the Site Manager to support the seasonal pond complex and the alkali meadow. The Site Manager will be appointed by the California State Coastal Conservancy.

The following activities, based on our existing site understanding and proposed design parameters, should be used to manage the seasonal pond complex and alkali meadow hydrology.

- In late fall, install flashboards in the ditch water control structure to desired water elevation (design target elevation -3.5 ft NAVD). Canal gate may also need to be adjusted/closed to achieve desired water elevations.
- In late fall, install flashboards in each wetland water control structure to desired maximum ponded elevation.
- During the wet season, monitor water levels within the seasonal wetlands pond complex, alkali meadow, and borrow ponds on a monthly basis. Adjustments to wetland water control structure flashboard elevations and/or ditch water control structure flashboards elevations and gate opening should be made accordingly.
- Monitor project site after large storm events to ensure there is no damage to the structures or excessive ponding.
- In late spring, remove flashboards in wetland water control structures to allow seasonal pond complex to drain. Flashboards should be removed over a two-week period to allow a gradual drawdown of the ponds and wetlands.
- In late spring, remove flashboards and/or open canal gate to lower groundwater and facilitate drainage.

There will need to be a period (number of years) to experiment with weir settings (flashboard riser heights) to adaptively manage the seasonal wetlands and alkali meadows immediately following construction. The following activities should be implemented in the first several wet seasons, in addition to the normal management described above:

- Check water levels following rainfall events and during prolonged dry periods between storms.
- Monitor drawdown duration in spring through early summer.

- Compare water levels and drawdown to hydrologic water years (i.e. wet vs. dry years) to determine target flashboard elevations in each seasonal wetland network and in the ditch water control structure.

Settings for the water control structures are designed to be flexible and allow fine tuning of water management. Once a desired control structure setting has been identified and refined through use, it should be possible to decrease the level of ongoing active management required. For example:

- Flashboard elevations can be adjusted at each pond network to control ponded depth following rainfall events and to trap elevated ground water. Through monitoring of ponded depth and drawdown during dry to normal years, the flash board elevations can be fine-tuned to allow for the ponds to drawdown through percolation and evaporation (versus active management) by late spring during dry to normal years.
- At the ditch water control structure, flashboard elevations can be adjusted to manage groundwater levels and ponding within the borrow ponds and alkali meadow enhancement areas and seasonal pond complex.
- Additionally, the canal gate at the ditch water control structure may be closed or nearly closed to limit drainage of stormwater and groundwater from the seasonal wetlands areas.
- Flashboards may be doubled in the twin track weirs and backfilled with clay material if leakage is limiting ponding duration. Alternatively, commercially available flashboards that provide a positive seal may be utilized to limit leakage.

Water management in the alkali meadow may be accomplished via management of the ditch water control structure. Additionally, if conditions in the meadow are too dry to support native alkali meadow vegetation, it may be possible to increase discharges from the Bel Marin Keys South Lagoon to Borrow Pit 3.

Soils Management

Two potentially significant changes in soil conditions may develop after grading and modification of drainage: soil salt accumulation in closed seasonal wetland basins, and acid sulfate soil problems resulting from exposure of sulfidic subsoils to near-surface soil horizons and emergent pond beds.

Soil salts may accumulate in some subsoils below farmed topsoil horizon layers, and salt-enriched soils may be graded into surface areas that drain to seasonal wetland basins. Salts may rise with capillary movement, leach and concentrate by evaporation in closed basins. If excessive salt accumulations occur in constructed seasonal wetlands, their most likely impact would be to increase dominance of the most salt-tolerant species in the plant assemblages (likely pickleweed, saltgrass, alkali-heath, and alkali-bulrush), and decline or loss of salt-sensitive species such as Baltic rush and common spikerush. This may be an acceptable outcome, but if site managers decide to mitigate salt accumulation, it can be achieved by partially or fully draining seasonally flooded basins before they evaporate. Drainage may occur by removing flashboards from weirs, and draining the basins to primary ditches.

Although the design includes measures to reduce the potential for acid soils (water management and capping with inorganic soils; see Section 3), the potential exists for acid sulfate soils to develop. If severe acid sulfate soils were to develop, the impact is likely to be expressed as local barren patches. Most severe acid sulfate soils in North Bay diked baylands resolve themselves over about 5-7 years, unless the sulfide sources are regenerated by annual flooding and draining of organic-enriched soils. Amendment of acid sulfate barren patches with agricultural lime, especially in wet years, may accelerate mitigation of acid sulfate soil conditions.

Vegetation Management

Long-term vegetation management will include reduction of above-ground standing biomass to increase exposure of shallow water and emergent pool beds, making pool habitat more accessible to dabbling ducks and shorebirds. In prehistoric times, Coast Miwok people annually or at least intermittently burned perennial grassland vegetation to maintain favorable hunting conditions and grassland grain or textile production. Modern methods for perennial grassland/wet meadow management include episodic controlled patch burns, mowing with haying (biomass removal), and some specific grazing prescriptions suitable for seasonal wetlands.

Controlled late fall burning, rotated through the seasonal wetlands in patches over multiple years, would be the most desirable method for long-term vegetation management from a habitat perspective. The practical difficulties of conducting controlled burns next to a residential development with oak woodlands adjacent, and with strict air quality permit regulations, may make this option less feasible and predictable than grazing or mowing with haying.

Dry-season grazing for vegetation management, using livestock that do not degrade soil structure or integrity of native sods (rhizome mats), is a potentially viable option for selective reduction of above-ground biomass. Sheep are recommended because they tend to avoid flooded pools and saturated ground even in the wet season, and sheep trampling is less destructive to rhizomatous native grassland sods than heavier cattle, which prefer to graze and trample moist soils. Cattle are not recommended for grazing in clonal perennial-dominated seasonal wetlands because of the high risk of degrading sods and increasing weed invasions. Goats could also be used for grazing, but they are more expensive than sheep and are therefore not recommended.

Sheep can be rotated through seasonal wetlands by realigning mobile solar electric fences. Sheep grazing leases would require leaseholders to provide water to sheep. Sheep grazing occurs along Lakeville Highway grasslands (including some baylands), and have grazed seasonal wetlands along Atherton Avenue in recent decades. Sheep flocks may require deterrent “guard” llamas or sheepdogs to protect against coyote predation. Sheep grazing may be compatible and economically feasible if a willing grazing lease can be secured.

Mowing, with hay harvest and removal, is another potential method for long-term management and enhancement of the seasonal pond complex. Mowing would need to be timed in late summer, after nesting season and before fall rains. Mowing would not be needed for all pools each year, but it would be recommended to rotate the mowing to cover one quarter to one third of the seasonal pond complex each year and therefore each patch would be mowed every three to four years. One option to implement mowing with haying would be to arrange this responsibility with the lessee farmer. Mowing with haying may be difficult due to undulating, depressional topography and would likely be a higher maintenance cost than sheep grazing.

Considerations for Implementation for Future Phases

The BMKV-envisioned restoration includes the construction of new levees, beneficial reuse of dredged material (to raise subsided marsh plane elevations), reestablishment of the site's tidal connection, and creation of seasonal wetlands. The Project is envisioned as occurring in phases, with implementation spanning a period of 13 or more years, as dredge material became available. The new outboard levee constructed in Phase 1 of the project will provide continued and improved flood protection to the Bel Marin Keys Community and other developments landward of the BMKV property, while also allowing for the future breaching of the existing levee and reestablishment of tidal wetlands between the new outboard levee and the existing levee. Subsequent phases of the BMKV Wetland Restoration Project are reasonably foreseeable, but not presently in the active planning stages.

Developing large native perennial grassland resources through the revegetation planned in Phase 1 would develop plant capital for future Bel Marin Keys levee and transition area revegetation. Native grass sod could be borrowed from the alkali meadow and seasonal pond complex for bulk translocation during future phases of the project. Developing large native perennial grassland during Phase 1 could make revegetation in future phases most cost effective.

In the long-term, the Phase 1 Project will result in an increase in aquatic habitat, wetland habitat, and wetland-upland interface. Overall effects of the Phase 1 Project combined with future restoration phases (restoration of tidal salt marsh habitat) will contribute to the recovery of tidal marsh species including salt marsh harvest mouse, Ridgway's rail, and California black rail. Future restoration phases may also restore additional seasonal wetlands in other areas landward of the new bayfront levee. Additional seasonal wetlands combined with seasonal wetlands created during Phase 1 will create a vast seasonal pond complex which will provide a larger habitat network for shorebirds, ducks, and other wildlife.

As discussed above, the hydrology of the seasonal pond complex and alkali meadow areas will be managed using a combination of flashboard weirs, canal gates, and pumping to capture surface water runoff and raise and lower groundwater elevations seasonally. The ability to manage this hydrology is dependent on the ability of the pumps to discharge water from the subsided elevations in the project area to San Pablo Bay. As sea levels rise, more frequent and higher capacity pumping may be needed to maintain the design water surface elevations and durations to support seasonal wetlands. If the operational requirements to maintain seasonal hydrology become infeasible, the site could be adaptively managed allow evolution from a seasonal wetland to a near-perennial or perennial wetland.

6. NOTES AND CONSIDERATIONS FOR DESIGN REFINEMENT

Notes and considerations for design refinement:

- For the purposes of the preliminary design, we infer existing groundwater hydrology based on limited available information and assume little or no change in groundwater hydrology with the project. This approach allows us to be fairly certain of meeting the seasonal ponding targets. However, it may be possible under with-project water management to achieve higher groundwater levels, providing cost and sustainability benefits. Designing for higher groundwater would require less excavation (the ponds would be shallower) and may lower ongoing pumping costs. Since groundwater will rise with future sea-level rise, designing to a higher groundwater level would also increase resilience. We recommend that the Conservancy consider collecting groundwater and surface water data at the site and completing a water balance model to more accurately estimate with-restoration hydrology. Groundwater could be manipulated this fall and winter by installing a small field experiment to partially block the existing drainage ditch and the smaller agricultural ditches in the seasonal pond complex area. This should raise ground water levels which could then be measured to see how groundwater responds.

- To revegetate the site using the methods outlined in this report, revegetation efforts should begin immediately, in September 2017. We recommend preparation of a propagation and translocation plan by a qualified professional as soon as possible. Time will be required for plant collection (on and off site) and for propagation on site. To further develop the revegetation implementation strategy, discussions should be had with the lessee farmer (Jens Kullberg), the Hamilton Nursery Manager (Christina McWhorter), Peter Baye, and other institutions that could implement the revegetation plan such as Save the Bay and Students and Teachers Restoring A Watershed (STRAW).

- Low-organic fine sediment seasonal wetlands cap material should be identified as soon as possible in order to coordinate permission of use, soil testing, and delivery of the material.

- Coordination should also continue with Marin/Sonoma Mosquito and Vector Control District during design refinement in order to confirm their requirements for site management.

7. REFERENCES

ESA, 2017. Bel Marin Keys – Field Data Collection for Seasonal Wetlands Restoration Memorandum. Prepared for California State Coastal Conservancy.

ESA, 2016. Bel Marin Keys Wetland Restoration – Phase 1 Project, Supplemental Information Document for Joint Aquatic Resource Permit Application. Prepared for California State Coastal Conservancy.

Hultgren-Tillis Engineers, 2016. Draft Final Geotechnical Investigation – Bel Marin Keys Unit V Wetland Restoration – New Bayfront Levee. Marin County, California. March 14, 2016.

Jones & Stokes, 2003. Final supplemental environmental impact report/environmental impact statement (SEIR/S) Bel Marin Keys Unit V expansion of the Hamilton Wetland Restoration Project. April. Oakland, CA. Prepared for the California State Coastal Conservancy and U.S. Army Corps of Engineers.

Moffatt & Nichol, Hultgren Tillis, ESA, WRA, RMC, 2016. Bel Marin Keys Wetland Restoration Project Phase 1 Restoration Action Preliminary Design Report. Prepared for the California State Coastal Conservancy. February 2016.

Natural Resources Conservation Service (NRCS), 1985. Soil Survey of Marin County. United States Department of Agriculture, Soil Conservation Service.

PWA (Philip Williams & Associates, Ltd.), 2005. Hamilton Wetlands Restoration Project Seasonal Wetlands Preliminary Design. Prepared for The California State Coastal Conservancy. December. PWA REF. # 1764.

RSMeans. 2015. Site Work and Landscape Cost Data. 34th annual edition.

USACE, 2003. US Army Corps of Engineers (USACE), Bel Marin Keys Unit V Expansion of the Hamilton Wetland Restoration Project, General Reevaluation Report (GRR) and Technical Appendices. Prepared by the U.S. Corps of Engineers, San Francisco District in cooperation with the California State Coastal Conservancy and the San Francisco Bay Conservation and Development Commission (April 2003).

USACE, 2017. SPN-2006-22397N Bel Marin Keys Maintenance Dredging. Available at: http://www.spn.usace.army.mil/Missions/Regulatory/Public-Notices/Article/1205480/spn-2006-22397n-bel-marin-keys-maintenance-dredging/

Appendix A
Field Data Collection Memorandum

ESA

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

www.esassoc.com

memorandum

date February 24, 2017

to Jeff Melby, SCC, Dilip Trivedi and Neil Nichols, Moffatt & Nichol

from Michelle Orr, Stephanie Bishop

cc Peter Baye

subject Bel Marin Keys - Field Data Collection for Seasonal Wetlands Restoration

Background

This memorandum provides information on the field data collected by ESA to support seasonal wetland design concepts for Phase 1 of the Bel Marin Keys Wetland Restoration Project.

Data Collected

Data were collected on July 12, 2016, at two seasonal pond reference sites within the Bel Marin Keys site and at the two areas where potential wetland creation and expansion are proposed. See Figure 1 for data collection locations.

Soils

A total of 11 soil samples were collected at five different soil pit locations (Figure 1). Four samples were collected at each seasonal pond reference site. Two soil pits were dug at each reference site, one at the edge of the pond and one in the center of the pond. Two soil samples were taken at each soil pit location, one between 2-3 cm depth and one at a depth of 10 cm. The pit was then dug to 1 foot depth and a photo taken of the soil profile. Photos of the reference pond sites and their soil profiles are shown in Attachment 1. Within the proposed wetland creation area one soil pit was dug in an area that has not been recently tilled and three soil samples were taken at a depth of 6 inches, 1 foot, and 1 ft and 10 cm. Soil sample analysis is shown in Attachment 2.

Topography

Elevation survey points were collected using Real-Time Kinematic GPS (RTK-GPS) in horizontal datum NAD83 California State Plane 3 and vertical datum NAVD88. Two elevation cross-sections were completed at each seasonal pond reference site and elevations were taken at existing salt grass (*Distichlis spicata*) and alkali heath (*Frankenia salina*) patches (Figure 1). Vegetation type was recorded for each elevation point collected within the seasonal pond reference sites and salt grass and alkali heath patches. Key elevation results are shown in Table 1.

Elevation data within areas planned for wetland creation and expansion were compared to the 2009-2011 California Coastal Conservancy Lidar Hydro-flattened bare earth Digital Elevation Model (DEM) to spot check the LiDAR data (Attachment 3). On average RTK-GPS elevations are 0.75 ft below the elevations from the Lidar elevations within areas supporting transitional and upland vegetation. The RTK-GPS elevations at the two seasonal pond reference sites were several feet below the Lidar elevations (Figure 2). The large difference in elevations at the seasonal pond reference site 1 is expected, as the pond was excavated after the Lidar was flown. The difference in elevations at seasonal pond reference site 2 is hypothesized to be because the pond contained water during the Lidar flight.

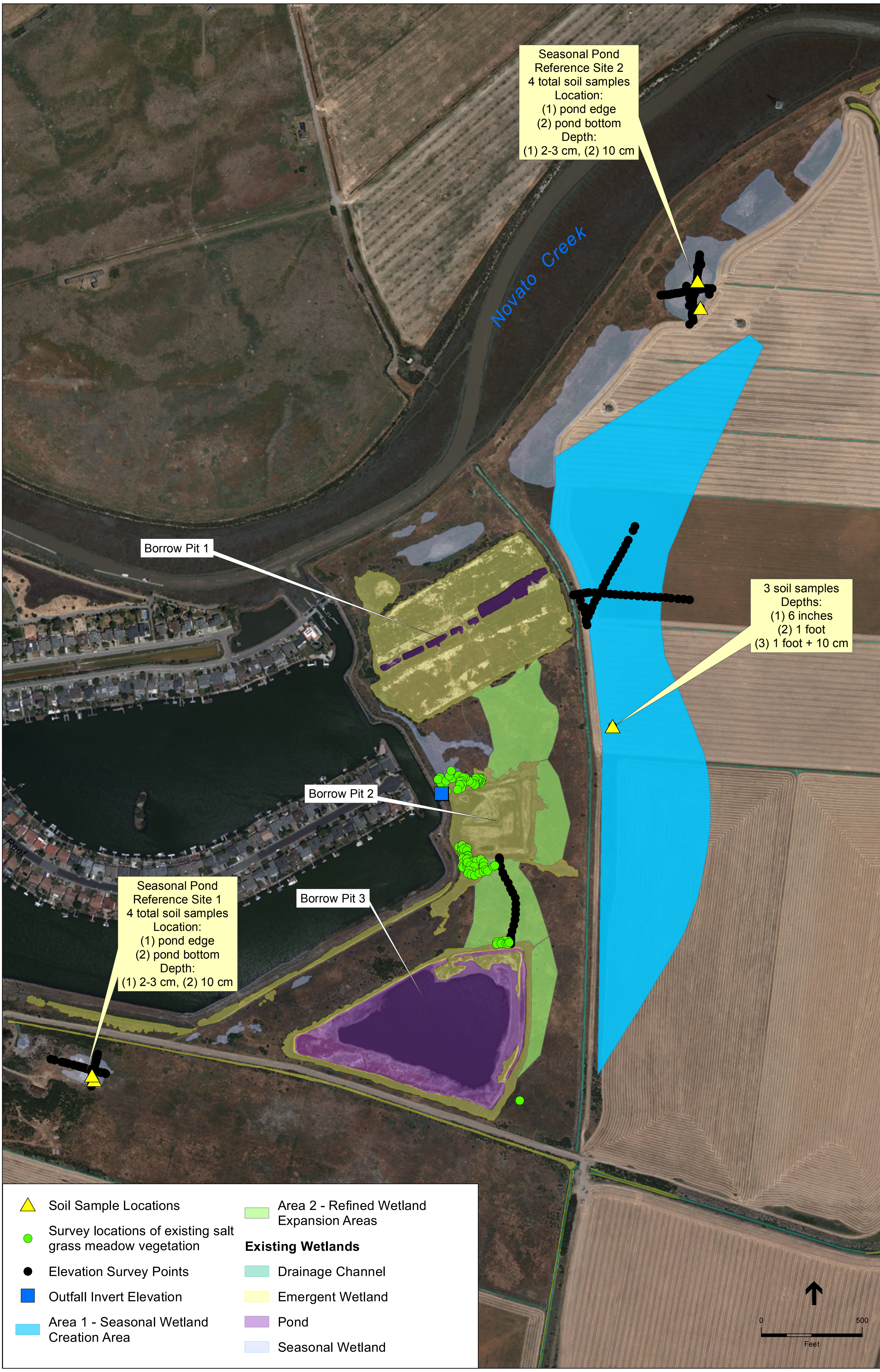
Vegetation and Wildlife

Vegetation and wildlife was noted within the areas data was collected. At seasonal pond reference site 1 the pond was dry and no vegetation was growing within the pond bottom (Photo A in Attachment 1). Seasonal pond reference site 1 and its adjacent wetlands cover approximately 0.5 acre. At the pond edges vegetation consists of rabbitsfoot grass (*Polypogon monspeliensis*) and brass button (*Cotula coronopifolia*). At the upland edge of the pond this vegetation transitions to a mix of rabbitsfoot grass and Bird's foot trefoil (*Lotus corniculatus*).

Seasonal pond reference site 2 is much larger than reference site 1, the pond and its adjacent wetlands cover approximately 2.0 acres. Seasonal pond reference site 2 was also dry at the time of the survey, however unlike reference site 1, the pond bottom was covered by dead plant material, which consisted mostly of cocklebur (*Xanthium strumarium*) (Photo D in Attachment 1). There was some swamp grass (*Crypsis* sp.) growing within the dry pond and some patches of pickleweed (*Salicornia pacifica*). Within the lowest area within the pond there was a patch of bulrush (*Bolboschoenus maritimus*). At the upland edges of the pond, vegetation consisted of fat-hen (*Atriplex prostrata*), Bird's foot trefoil, Russian thistle (*Salsola* sp.), non-native annual grasses, and some alkali heath (*Frankenia salina*).

While at the saltgrass meadow reference areas, two black-necked stilts and ten great egrets were observed foraging in borrow pit 2, while five black-necked stilts were observed foraging in borrow pit 3. No other birds were seen utilizing the borrow pits or seasonal wetland areas.

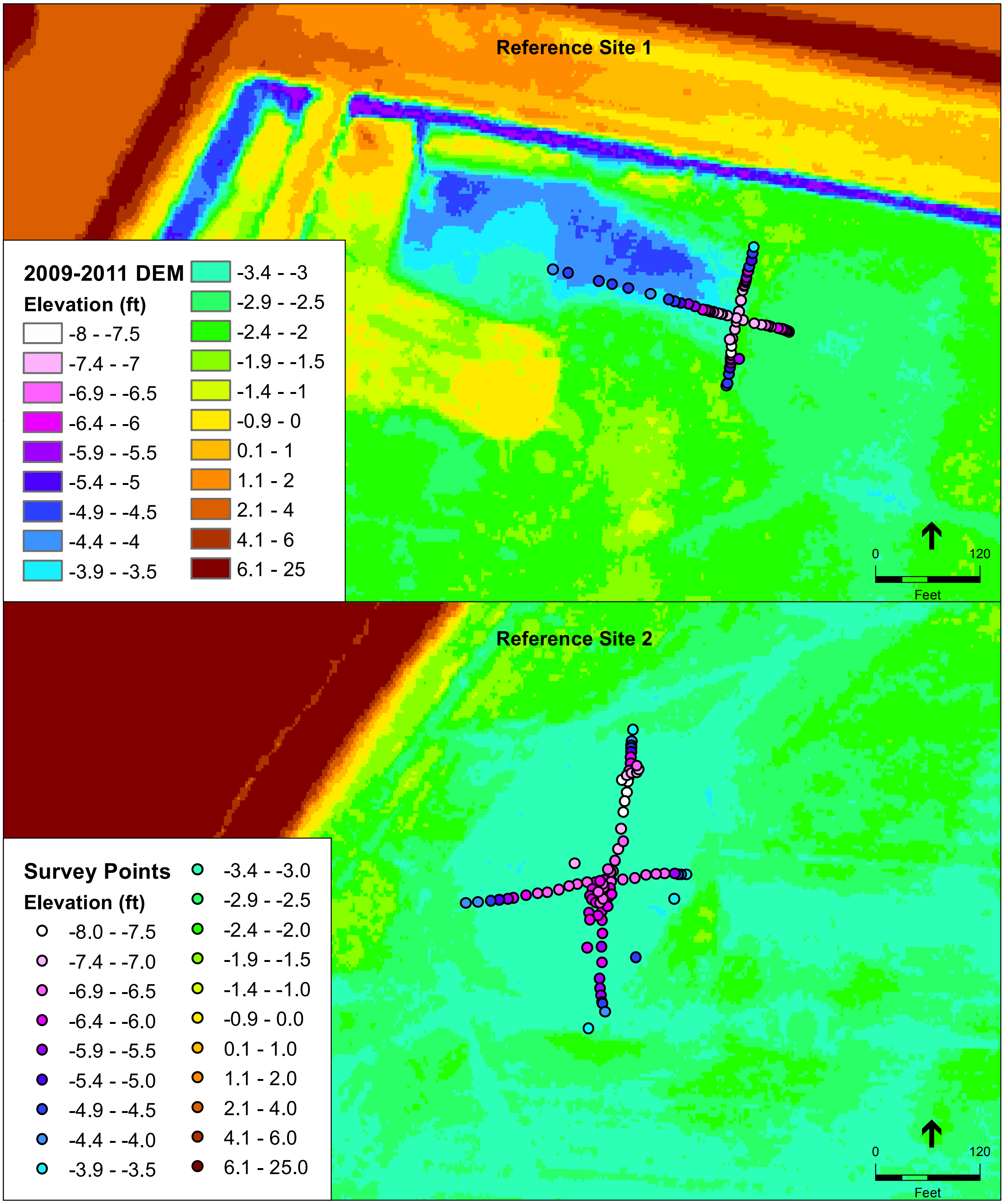
Tables and Figures



SOURCE: USDA, 2014; ESA, 2016

Bel Marin Keys Wetland Restoration Project - Phase 1. 150011.00

Figure 1
Data Collected for Seasonal Wetland Design



SOURCE: ESA, Coastal Conservancy Lidar 2009-2011, ESA 2016

Bel Marin Keys Wetland Restoration Project . 150011

Figure 2
Reference Site Elevations
DEM vs. Survey Points

TABLE 1
SUMMARY OF KEY ELEVATIONS

VEGETATION TYPE/FEATURE	MINIMUM ELEVATION (FT)	MAXIMUM ELEVATION (FT)	NOTES
Reference Site 1 (Cross-Sections)			
Other vegetation (upland/transition)	-6.1	-3.9	Dominated by bird's foot trefoil
Pool edge	-5.8	-5.1	
Rabbitsfoot grass	-7.2	-5.1	
Brass button	-7.2	-6.0	
Pool bottom/bare ground/pond crust	-7.6 (bottom)	-7.1	
Approximate maximum ponding depth	1.8 ft		Calculated as difference between -7.6 and -5.8 ft.
Reference Site 2 (Cross-Sections)			
Pool edge	-4.5	-3.8	
Other vegetation (upland/transition)	-6.5	-3.8	Dominated by bird's foot trefoil, fat-hen, and annual grasses
Russian thistle	-5.8	-4.5	
Rabbitsfoot grass	-4.4	-3.8	
Pickleweed	-6.6	-6.1	
Alkali bulrush	-7.5	-6.3	
Pool bottom/bare ground/dead vegetation	-8.0 (bottom)	-5.7	
Approximate maximum ponding depth	3.5 ft		Calculated as difference between -8.0 and -4.5.
Area 2 (Vegetation and Hydraulic Structure Elevations)			
Other vegetation (upland)	-3.0	-2.0	
Alkali Heath	-3.4	-2.6	
Saltgrass (borrow pit 2)	-4.7	-2.4	
Saltgrass (borrow pit 3, steeper gradient than borrow pit 2)	-5.4	-2.0	
Pickleweed	-5.7	-2.1	
One small patch of Russian thistle	-2.2		
One small patch of perennial pepperweed	-2.6		
Invert of BMK Lagoon Overflow Structure	3.1		
Area 1 (Spot Checks)			
Farm Field	-3.7	-3.0	
Low ridge between ditch and farm field	-2.9	-0.7	

Attachment 1

Site Photos

Bel Marin Keys Wetland Restoration Project – Phase 1. D150011.00

Photo A

Reference Site 1 Seasonal Pond

Bel Marin Keys Wetland Restoration Project – Phase 1. D150011.00

Photo B

Reference Site 1 Soil Profile – Seasonal Pond Edge

Bel Marin Keys Wetland Restoration Project – Phase 1. D150011.00

Photo C

Reference Site 1 Soil Profile – Seasonal Pond Bottom

Bel Marin Keys Wetland Restoration Project – Phase 1. D150011.00

Photo D

Reference Site 2 Seasonal Pond

Bel Marin Keys Wetland Restoration Project – Phase 1. D150011.00

Photo E

Reference Site 2 Soil Profile – Seasonal Pond Edge

Bel Marin Keys Wetland Restoration Project – Phase 1. D150011.00

Photo F

Reference Site 2 Soil Profile – Seasonal Pond Bottom

Bel Marin Keys Wetland Restoration Project – Phase 1. D150011.00

Photo G

Area 1 Soil Profile – Farm Field

Bel Marin Keys Wetland Restoration Project – Phase 1. D150011.00

Photo H

Reference Site 3 – Saltgrass Meadow

Attachment 2

Soil Analysis

E T S

975 Transport Way, Suite 2
Petaluma, CA 94954
(707) 778-9605 / FAX 778-9612

Environmental Technical Services

-Soil, Water & Air Testing & Monitoring
-Analytical Labs
-Technical Support

Serving people and the environment so that both benefit.

CALCULATED CEC & ITS APP. RELATIONSHIP to SOIL TEXTURE
0-8 -> SAND
8-12 -> LOAMY SAND
12-20 -> SANDY LOAM
20-28 -> LOAM
28-40 -> CLAY LOAM
>40 -> CLAY

CLIENT: Environmental Science Associates, 1425 N.McDowell Blvd., Suite 200, Petaluma, CA
ATTN: Stephanie Bishop
SITE: Bel Marin Keys, Novato, California – vernal pools, habitat restoration

RECEIVED & PROCESSED	DATE of REPORT
7/18/2016	7/27/2016

SOIL/SEDIMENT EXTRACTABLE MINERAL CONTENT REPORT

LAB SAMPLE NUMBER	THE SAMPLE ID	AREA &/or TYPE of SAMPLE	PERCENT ORGANIC MATTER	NITRATE N ppm	AMMONIA N ppm	PHOSPHOROUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SULFUR S ppm	SODIUM Na ppm	SULFIDES S= ppm
06961-1	BMK1/N	Ref 1, Edge, 2-5 cm	**10.5**	**6**	**37**	**20**	**1000**	**2703**	**1925**	**675**	**5869**	**0.27**
06961-2	BMK2/N	Ref 1, Edge, 10 cm	**8.2**	**7**	**58**	**20**	**900**	**2612**	**1950**	**650**	**4808**	**0.39**
06961-3	BMK3/N	Ref 1, Bottom, 2-3 cm	**9.3**	**5**	**49**	**5**	**800**	**3174**	**2750**	**1150**	**15304**	**0.30**
06961-4	BMK4/N	Ref 1, Bottom, 10 cm	**8.5**	**4**	**33**	**18**	**700**	**1929**	**1650**	**200**	**3056**	**0.27**
06961-5	BMK5/N	Ref 2, Edge, 2-3 cm	**13.5**	**5**	**35**	**45**	**410**	**1929**	**1775**	**240**	**2596**	**0.92**
06961-6	BMK6/N	Ref 2, Edge, 10 cm	**9.9**	**6**	**83**	**40**	**300**	**1671**	**1800**	**115**	**2054**	**0.72**

ZINC Zn ppm	COPPER Cu ppm	MANGANESE Mn ppm	IRON Fe ppm	SOLUBLE SALTS mS/cm	EXCESS CARBONATE (Qual)	SOIL pH/ BUFFER INDEX -log[H+]	ACTUAL PERCENT of TOTAL CEC %K [1-7%]	%Mg [15-30%]	%Ca [50-75%]	%Na [<10-25%]	%H [0-20%]	CALC TOTAL CEC
-	-	-	**194.4**	**9.81**	**N**	**3.8 / 5.16**	**3.2**	**28.0**	**12.1**	**32.2**	**24.4**	**59.9**
-	-	-	**291.7**	**5.89**	**N**	**3.7 / 5.18**	**3.1**	**29.2**	**13.2**	**28.4**	**26.1**	**54.5**
-	-	-	**291.6**	**12.84**	**N**	**3.8 / 5.62**	**1.7**	**21.2**	**11.2**	**54.0**	**12.0**	**108.5**
-	-	-	**208.3**	**3.74**	**N**	**3.7 / 5.28**	**3.1**	**27.7**	**14.4**	**23.2**	**31.7**	**39.2**
-	-	-	**222.2**	**3.66**	**N**	**4.8 / 6.06**	**2.2**	**33.4**	**18.7**	**23.8**	**21.9**	**37.1**
-	-	-	**271.7**	**2.21**	**N**	**4.6 / 5.95**	**1.7**	**31.3**	**20.5**	**20.3**	**26.2**	**32.4**

SAMPLE #	SAMPLE ID		P S A TEST RESULTS			SOIL TEXTURE	USDA CLASSIFICATION
06961-1	BMK1/N	TEXTURAL ANAL->	**43.2% Sand**	**33.4% Silt**	**23.4% Clay**	**Sandy Mud**	**Loam**
06961-2	BMK2/N	TEXTURAL ANAL->	**39.6% Sand**	**35.0% Silt**	**25.4% Clay**	**Sandy Mud**	**Loam**
06961-3	BMK3/N	TEXTURAL ANAL->	**44.4% Sand**	**32.6% Silt**	**23.0% Clay**	**Sandy Mud**	**Loam**
06961-4	BMK4/N	TEXTURAL ANAL->	**21.4% Sand**	**46.4% Silt**	**32.2% Clay**	**Sandy Mud**	**Clay Loam**
06961-5	BMK5/N	TEXTURAL ANAL->	**17.8% Sand**	**38.0% Silt**	**44.2% Clay**	**Sandy Mud**	**Clay Loam**
06961-6	BMK6/N	TEXTURAL ANAL->	**6.4% Sand**	**34.2% Silt**	**59.4% Clay**	**Mud**	**Clay**

COMMENTS

These six soils do divide up into two groups as suggested by the labeling with Ref 1 soils being generally more saline and sodic than the Ref 2 soils. In addition, the shallower soil samples tended to be more saline and sodic as compared to the deeper samples indicating that the salts are concentrating and staying in the upper root zone. The Ref 1 soils generally have somewhat greater acidity than the Ref 2 soils, although all soils at these sites have horrendously high acidities with pHs being at 3.7-3.8 for Ref 1 soils, and at 4.6-4.8 for the Ref 2, Edge soils. The CEC distributions are greatly perturbed by the relatively high Mg levels and the absolutely high Na levels. The Ca:Mg ratios are very low indeed being at just over 1 (BMK6) down to about 0.7 (BMK1). One sample in particular, BMK3, has an unusually high Na level (@ >40% greater than seawater!). The CEC totals are more like salt marsh soils for the Ref 1 soils, except Ref 1 @ 10 cm, while the Ref 2 soils have total CEC values more consistent with clayey terrestrial soils. Sulfides are only mildly elevated, but extractable Fe levels are very high indeed. Soils grade from loam to clay with clay loam in between in both directions, i.e., in depth and also laterally going from Ref 1 to Ref 2.

E T S
975 Transport Way, Suite 2
Petaluma, CA 94954
(707) 778-9605 / FAX 778-9612

Environmental Technical Services
-Soil, Water & Air Testing & Monitoring
-Analytical Labs
-Technical Support

Serving people and the environment so that both benefit.

CALCULATED CEC & ITS APP. RELATIONSHIP to SOIL TEXTURE
0-8 -> SAND
8-12 -> LOAMY SAND
12-20 -> SANDY LOAM
20-28 -> LOAM
28-40 -> CLAY LOAM
>40 -> CLAY

CLIENT: Environmental Science Associates, 1425 N.McDowell Blvd., Suite 200, Petaluma, CA
ATTN: Stephanie Bishop
SITE: Bel Marin Keys, Novato, California – vernal pools, habitat restoration

RECEIVED & PROCESSED: 7/18/2016
DATE of REPORT: 7/27/2016

SOIL/SEDIMENT EXTRACTABLE MINERAL CONTENT REPORT

LAB SAMPLE NUMBER	THE SAMPLE ID	AREA &/or TYPE of SAMPLE	PERCENT ORGANIC MATTER	NITRATE N ppm	AMMONIA N ppm	PHOSPHOROUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SULFUR S ppm	SODIUM Na ppm	SULFIDES S= ppm
06961-7	BMK7/N	Ref 2, Bottom, 2-5 cm	6.4	11	62	38	1000	1747	1425	1300	5797	0.23
06961-8	BMK8/N	Ref 2, Bottom, 10 cm	18.1	12	59	15	900	1215	1550	1300	3001	0.21
06961-9	BMK9/N	Area 1, @ 6 in	10.3	5	36	28	800	2126	2125	27	238	0.32
06961-10	BMK10/N	Area 1, @ 1 ft	9.7	5	10	8	700	2096	2175	40	420	0.48
06961-11	BMK11/N	Area 1, @ 1'10"	10.9	8	13	15	410	1883	1775	36	443	1.77

ZINC Zn ppm	COPPER Cu ppm	MANGANESE Mn ppm	IRON Fe ppm	SOLUBLE SALTS mS/cm	EXCESS CARBONATE (Qual)	SOIL pH/ BUFFER INDEX -log[H+]	ACTUAL PERCENT of TOTAL CEC: %K [1-7%]	%Mg [15-30%]	%Ca [50-75%]	%Na [<10-25%]	%H [0-20%]	CALC TOTAL CEC
-	-	-	238.1	4.69	N	5.9 / 6.71	4.8	27.0	13.4	47.3	7.5	49.3
-	-	-	226.2	3.46	N	5.9 / 6.83	6.4	27.9	21.6	36.4	7.6	33.1
-	-	-	285.7	0.39	N	4.4 / 5.55	4.4	37.4	22.7	2.2	33.2	31.2
-	-	-	285.7	0.50	N	4.4 / 5.29	3.6	34.6	21.8	3.7	36.3	31.7
-	-	-	244.1	0.37	N	4.7 / 5.28	2.3	34.1	19.5	4.2	39.9	27.3

SAMPLE #	SAMPLE ID		P S A TEST RESULTS			SOIL TEXTURE	USDA CLASSIFICATION
06961-7	BMK7/N	TEXTURAL ANAL->	21.8% Sand	50.7% Silt	28.0% Clay	Sandy Mud	Clay Loam
06961-8	BMK8/N	TEXTURAL ANAL->	30.8% Sand	45.4% Silt	23.8% Clay	Sandy Mud	Loam
06961-9	BMK9/N	TEXTURAL ANAL->	9.8% Sand	38.8% Silt	51.4% Clay	Mud	Clay
06961-10	BMK10/N	TEXTURAL ANAL->	13.8% Sand	58.1% Silt	28.1% Clay	Sandy Silt	Silty Clay Loam
06961-11	BMK11/N	TEXTURAL ANAL->	12.8% Sand	36.4% Silt	50.8% Clay	Sandy Mud	Clay

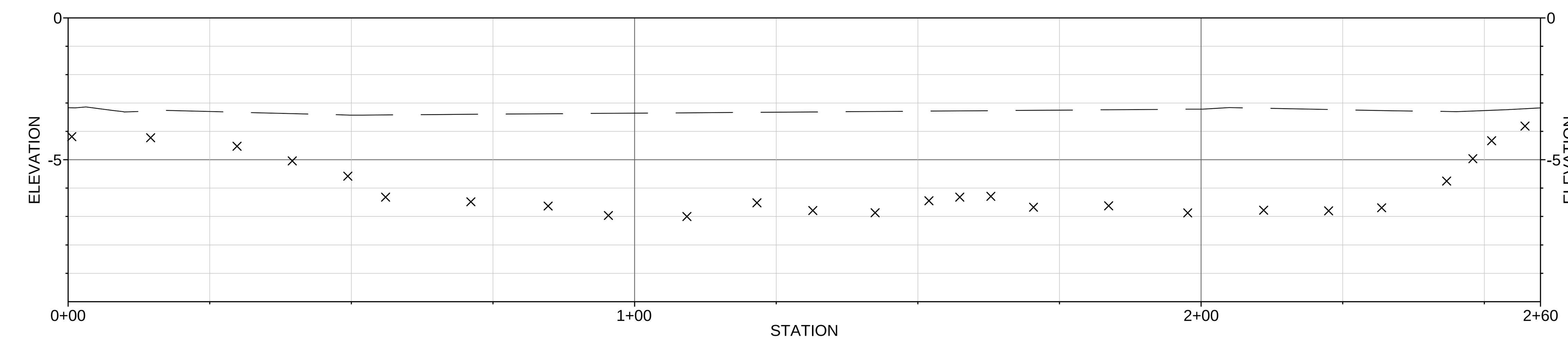
COMMENTS

These five soils do divide up into two groups as suggested by the labeling with Ref 2 soils being generally more saline and sodic than the Area 1 soils. In addition, the shallower Ref 2 Bottom soil sample tended to be more saline and sodic as compared to the deeper sample in that location, again, indicating that the salts are concentrating and staying in the upper root zone. In this case, the Area 1 soils generally have somewhat greater acidity than the Ref 2 soils; Ref 2 Edge soils contrast somewhat with Ref 2 Bottom soils in this property as the latter have less acidity, i.e., higher pHs, less pronounced buffer indexes. The CEC distributions are greatly perturbed by either the relatively high Mg levels and the absolutely high Na levels in the Ref 2 Bottom soils or by the much higher CEC acidities in the Area 1 soils; (please note: CEC acidities for BMK1 thru BMK8 "seem" more normal due to the extreme Na levels in these samples). The Ca:Mg ratios are very low, again, running from roughly 0.8 (BMK7) to about 1.3 (BMK8); other soils are in between. All CEC distributions are highly perturbed, but the Area 1 soils are perturbed in a different way due to their much more normal Na levels. The Ref 2 Bottom soil total CECs are more "normal" (i.e., more like terrestrial soils) than the other reference soils, and Area 1 soils are very normal. Sulfides are mildly elevated in all except BMK11 which is moderately high; extractable Fe levels are very high again.

Attachment 3

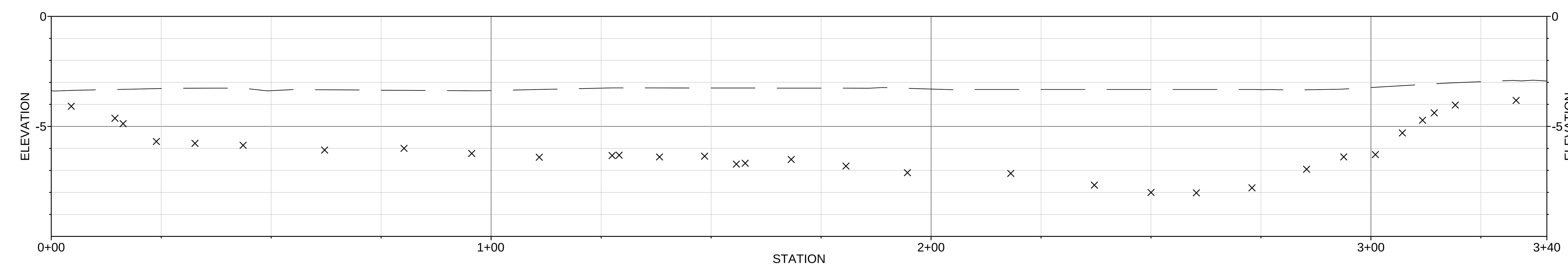
LiDAR and RTK GPS Elevation Comparisons

Print Date: 10/5/2016



1 SECTION

SCALE:
HORIZ. 1"=20'
VERT. 1"=4'

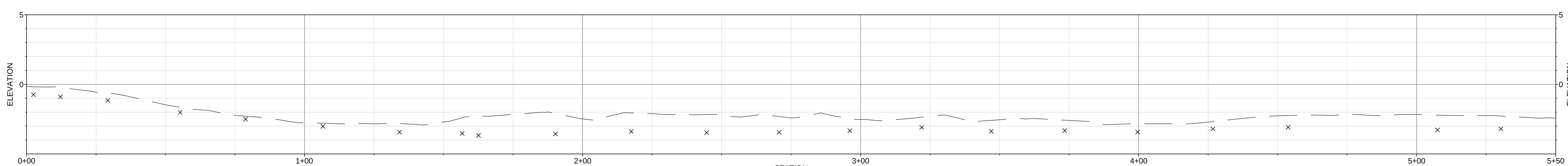


2 SECTION

SCALE:
HORIZ. 1"=20'
VERT. 1"=4'

3 SECTION

SCALE:
HORIZ. 1"=20'
VERT. 1"=4'



4 SECTION

SCALE:
HORIZ. 1"=20'
VERT. 1"=4'

File: K:\projects_2015\D150011.00 - Bel Marin Keys Wetland Restoration Project\09 CAD\Dwgs\Xref\XREF_Survey.dwg

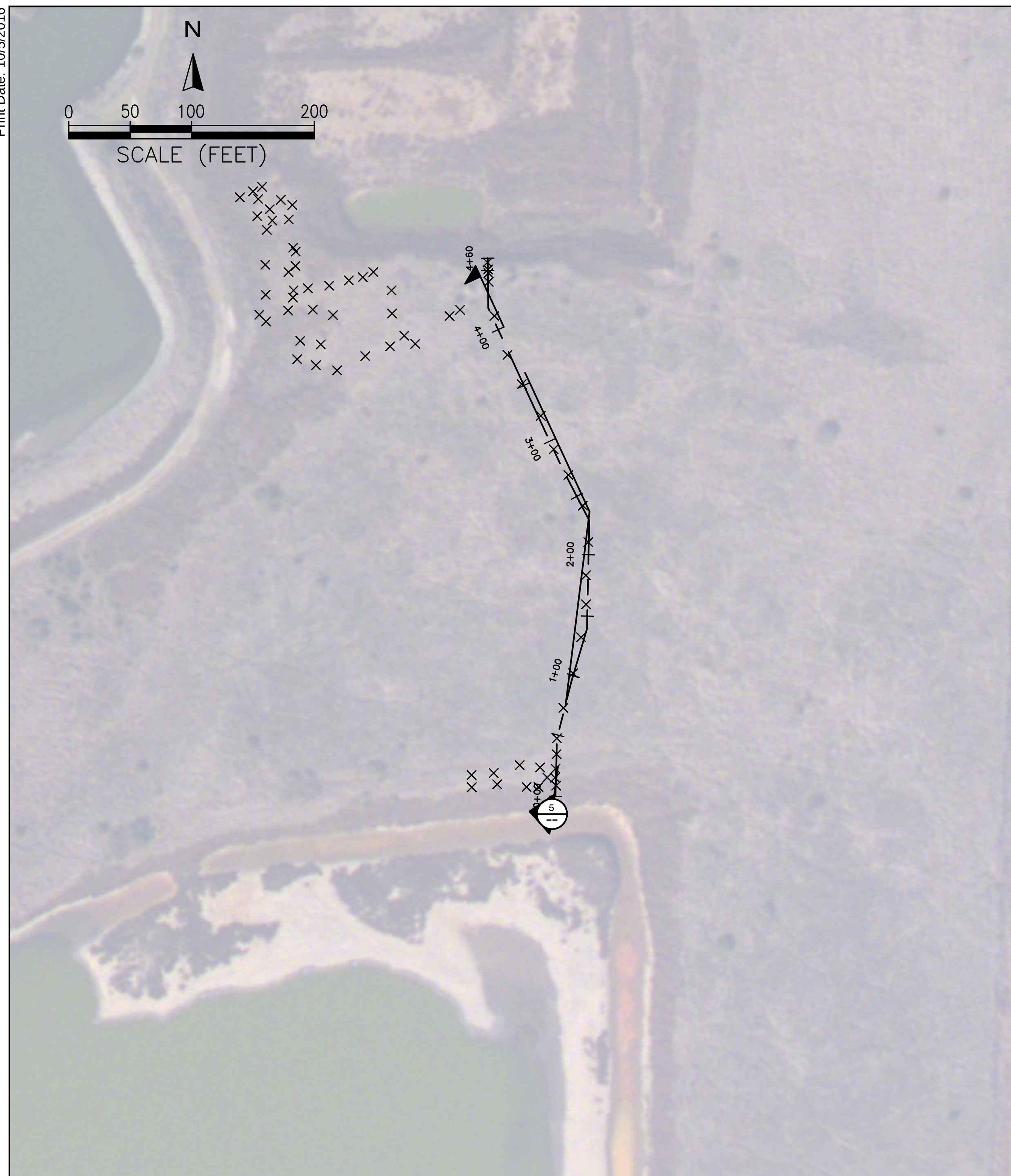
Figure 1

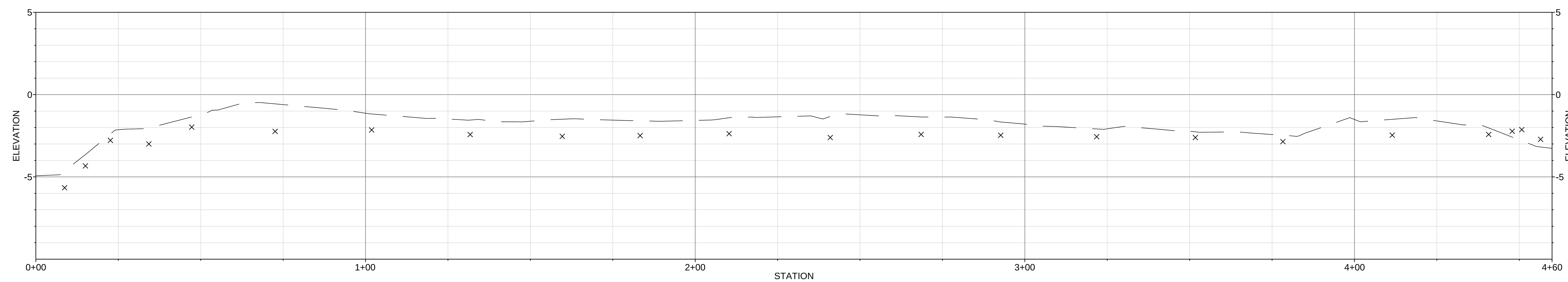
dashed line = elevation from LiDAR (2009-2011 California Coastal Conservancy Lidar Hydro-flattened bare earth Digital Elevation Model)

x = elevation from ESA field survey (RTK GPS, July 2016)

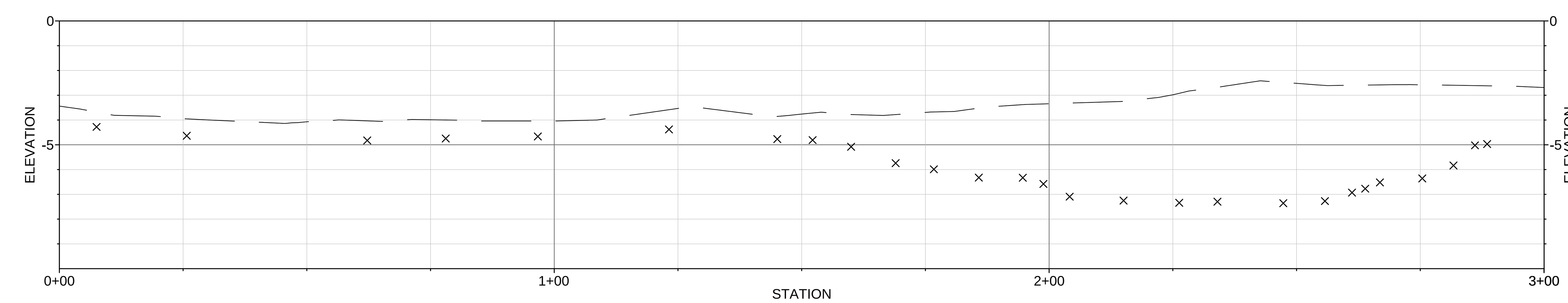
ESA

Print Date: 10/5/2016

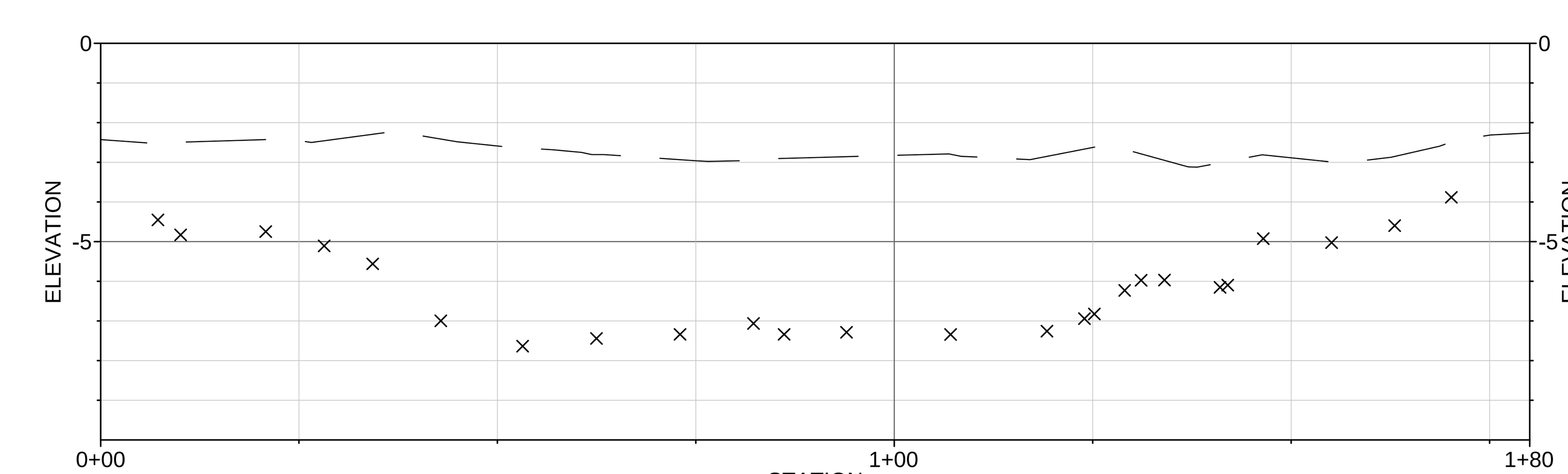




5 SECTION
SCALE:
HORIZ. 1"=20'
VERT. 1"=4'



6 SECTION
SCALE:
HORIZ. 1"=20'
VERT. 1"=4'



7 SECTION
SCALE:
HORIZ. 1"=20'
VERT. 1"=4'

File: K:\projects_2015\D150011.00 - Bel Marin Keys Wetland Restoration Project\09 CAD\Dwgs\Xref\XREF_Survey.dwg

SOURCE: SOURCE:

Bel Marin Keys Wetland Restoration - D150011.00

Figure 2

SURVEY SECTIONS

ESA

dashed line = elevation from LiDAR (2009-2011 California Coastal Conservancy Lidar Hydro-flattened bare earth Digital Elevation Model)

x = elevation from ESA field survey (RTK GPS, July 2016)