Appendix 3.B
BDCP Tidal Habitat Evolution Assessment

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memorandum

date	August 27, 2012
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cc	Rebecca Sloan, ICF
from	Michelle Orr and Lindsey Sheehan
subject	BDCP Tidal Habitat Evolution Assessment

1. Introduction

This memorandum presents possible scenarios of tidal habitat evolution in Suisun and the Delta with and without the proposed BDCP restoration. Eleven types of tidal habitats are estimated for eight geographic regions and for three time periods: near-term (15 years), early long-term (25 years), and late long-term (50 years). This assessment was prepared to support the BDCP effects assessment.

2. Methods

Habitat evolution is estimated by: (1) defining initial site elevations (Section 2.2), (3) defining habitat types relative to the tidal frame (Section 2.3), (2) evaluating how the tidal frame will change over time due to sea-level rise and the breaching of hypothetical restoration sites (Section 2.4), and (4) evaluating how site elevations may change over time in response to sedimentation (Section 2.5) for With Project and Without Project scenarios (Section 2.1). The scenarios use tides as modeled by RMA.

2.1 Project Scenarios

Tidal habitats are estimated for the following scenarios and phases of implementation:

1. Existing Conditions
2. No Project early long term
3. No Project late long term
4. With Project near term
5. With Project early long term
6. With Project late long term

The No Project near term scenario is not modeled, since near term conditions assume no sea level rise and therefore the No Project near term scenario is the same as existing conditions.

Since the actual BDCP restoration areas have not been established and will not be known until later in project implementation, restoration areas are assumed for the purposes of this assessment and referred to as "hypothetical" footprints. Areas within the hypothetical restoration footprints are categorized by phase of implementation: near-term (15 years), early long-term (25 years), and late long-term (50 years). The hypothetical footprints and phasing were provided by RMA in GIS format. For simplicity, this assessment assumes that each phase of restoration is implemented at the beginning of the phase. In actuality, restoration will occur throughout each phase. The assumption that restoration occurs at the beginning of each phase tends to overestimate the extent of tidal emergent marsh and underestimate mudflat and subtidal habitat.

The With Project scenario assumes that the project is implemented with minimal grading. The scenarios assume no grading in Suisun Marsh or the Delta, with the exception of the West Delta. The restoration scenario assumes that subsided West Delta islands would be filled with imported material up to MLLW in all except the most deeply subsided areas (deeper than approximately nine feet below MLLW) and high filled areas lowered to MLLW. We assume the Dutch Slough restoration includes cut and fill to increase the restored intertidal acreage. The grading for this restoration scenario is consistent with the minimal fill scenario used in the 2009 BDCP cost estimate prepared by ESA PWA. This is a simplified grading scenario for initial broad-scale planning. The extent to which grading will be used to adjust the mix of intertidal emergent marsh and subtidal habitat has not been determined.

2.2 Initial Site Elevations

The model uses a composite elevation dataset comprised of DWR terrestrial LiDAR, IFSAR, and DWR and USGS bathymetry data collected from 2003-2008 (see Attachment A). The data were prepared by SAIC and received in GIS raster format by ESA PWA on October 30, 2009.

ESA PWA applied adjustments to the elevation data set for this assessment. ESA PWA applied adjustments to existing tidal marsh areas, which the LiDAR data often mapped as above the highest tides. The uncorrected LiDAR elevations are presumed to reflect top-of-vegetation elevations rather than ground elevations, a common error in using LiDAR-derived elevations in heavily-vegetated areas. ESA PWA applied elevation corrections specific to each tidal marsh type, using data from the BDCP vegetation map for marsh classification (Figure 1; see Attachment A for metadata). The existing marsh area in Suisun was categorized with the highest 18% of marsh as high marsh, the middle 50% as mid-marsh, and the lowest 32% of marsh as low marsh. These ratios are based on ESA PWA analysis of vegetation communities in the BDCP habitat map. The BDCP vegetation data identify Hill Slough West (in Suisun) and Prospect Island (Cache Slough area) as existing tidal marsh. ESA PWA adjusted these areas to map as managed marsh for this assessment, to match known field conditions.

We applied adjustments to known subtidal areas which are mapped as intertidal in the original data set. The uncorrected LiDAR data are presumed to show the water surface and not the actual bathymetry. ESA PWA adjusted the topography from intertidal elevations to subtidal elevations in the following locations: Little Hastings Tract, the southern tip of Liberty Farms, a small area west of the southern tip of Prospect Island, Discovery Bay, Little Mandeville Island, Mildred Island, and Little Holland Tract. The open water parts of Little Holland Tract were adjusted to a constant slope from subtidal up to higher elevations. Matlab processing was used for all elevation adjustments (more in Section 2.6).

In order to create a surface of the tidally-connected areas, areas that are currently protected from tidal inundation, or are expected to be in the future, were removed from the topography raster. Excluded areas consist of agricultural areas, developed areas, and managed wetlands, as delineated by the BDCP vegetation map (Figure 1), as well as areas served by reclamation districts. For ease of processing, three types of topography rasters were created: areas within the hypothetical restoration footprints, areas outside the footprints, and existing marsh habitat areas. Areas of existing marsh were clipped from the topography to process elevation adjustments to existing marsh areas.

2.3 Habitat Categories

For a given position in the estuarine salinity regime, this assessment assumes the major determinant of habitat type – e.g, subtidal, intertidal mudflat, tidal emergent marsh, and upland – is position within the tidal frame. The areal extent of a habitat type is defined by its elevation range within the tidal frame. Suisun Marsh and Suisun Bay have different habitat types from the Delta due to their different salinity regimes. In addition, Cache Slough area habitats are slightly different from those in other areas of the Delta due to the specific geomorphic conditions at the base of the Yolo Bypass. The geographic areas are shown in Figure 2.

Habitat types by region and their associated elevation ranges relative to the tides are shown in Table 1. Table 2 presents the vegetation communities expected in each category. Habitat types by tide level for Suisun Marsh are shown schematically in Figure 3.

Habitat types, elevations, and vegetation communities for Suisun Marsh are based on work by the Suisun Ecological Workgroup (2001), surveys for the Hill Slough Restoration Project (PWA 2001), the Suisun Marsh Plan Final EIS/EIR (US Department of the Interior et al. 2011) and the Suisun Marsh Plan Draft Tidal Marsh and Aquatic Habitats Conceptual Model (Siegel et al. 2010). Habitat types, elevations, and vegetation communities for the Delta are based on surveys by Atwater (1980) and Simenstad et al. (2000), planning for the Dutch Slough Restoration Project (PWA et al. 2006), and work by other researchers (Watson and Byrne 2009; Witham and Kareofelas 1994).

The transition between emergent marsh vegetation and mudflat is not an exact function of position within the tidal frame and varies over even a short stretch of shoreline. In the Delta, for example, while emergent marsh vegetation has been observed to grow down to -1.5 feet below MLLW (Watson and Byrne 2009) and lower, it has also been observed transitioning to mudflat above MLLW. Simenstad et al. (2000) observed a range of elevations, typically averaging around MLLW.

The zone from extreme high water (EHW) to 9 ft NAVD88 is designated as sea level rise transition. This elevation band represents the transition between the typical upper limit of tidal inundation to non-tidally influenced uplands. The upper elevation limit of this habitat category is somewhat arbitrary, but was selected to be higher than EHW for LLT conditions with sea level rise. The acreage within the sea level rise transition band diminishes over the 50-yr planning period as sea level rises. The upland elevation zone is above the LLT high tides and does not change with sea level rise. It is included here for completeness of habitat mapping within each geographic region.

2.4 Tidal Datums

The assessment used spatially-varying tidal datums (EHW, MHHW, MHW, MTL, MLLW) [1] based on hydraulic modeling results provided by RMA for each scenario. The tide data used a 10 meter grid. RMA produced xyz data that ESA PWA converted to surfaces for each scenario and tidal datum.

Select assumptions for the hydraulic modeling scenarios are listed in Table 1. Ideally, all of the hydraulic modeling scenarios would have used a coupled model[2] and included sea-level rise. Because RMA was not able to model all the possible combinations, ESA PWA adjusted the tidal datums to approximate the desired scenarios. The adjustments for coupling ranged from 0.1 to 0.5 ft, with the adjustments varying spatially by scenario. RMA hydraulic model geometry for the Late Long-Term With Project scenario includes deepening and widening of the major tidal channels in Suisun Marsh, as these channels are expected to either be deepened as part of restoration implementation or scour in response to restoration (e.g., Williams et al. 2002).

The scenarios use a sea level rise of 15 cm for the early long term and 45 cm for the late long term, consistent with other BDCP analyses. The near term scenarios assume no sea level rise. These sea level rise assumptions are consistent with estimates in the Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (USFWS 2010) and at the high end of the range presented in the Suisun Marsh Plan (US Department of Interior et al., 2011). The rate of sea level rise is expected to accelerate over time. For example, using the National Research Council (NRC) III sea level rise curve to roughly estimate sea level rise acceleration (per USACE 2011), sea level rise is ~9 mm/yr by the ELT and ~13-15 mm/yr by LLT.

2.5 Accretion

The primary drivers of elevation change are accretion, both organic and inorganic, and regional subsidence. For the purposes of this assessment, we assume no regional subsidence. In the absence of an evaluation of sediment supply and maximum organic accretion rates, accretion assumptions are based on observed rates and professional judgment. Relatively sheltered conditions (little or no wind waves) are assumed. In Suisun, the habitat assessment considers both inorganic and, where marsh vegetation exists, organic contributions to accretion. In the Delta, the assessment assumes that significant accretion occurs only in vegetated areas. Accretion assumptions are described below.

2.5.1 Suisun Marsh and Bay Accretion

Accretion in Suisun Marsh and Suisun Bay was simulated using ESA PWA's MARSH98 model, a model that has been used to examine marsh sustainability to sea-level rise across the saline and brackish parts of San Francisco Bay (e.g. Orr et al., 2003, Stralberg et al. 2011). The MARSH98 model uses the inorganic

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[1] EHW = Extreme High Water; MHHW = Mean Higher High Water; MHW = Mean High Water; MTL = Mean Tide Level; MLLW = Mean Lower Low Water

[2] In RMA's coupled Delta and Suisun model, density-driven flows are schematized to yield more accurate predictions of the contribution of salinity gradients on water surface elevations.

sediment mass balance calculations described by Krone (1987). This procedure assumes that the elevation of a marsh plain rises at rates that depend on the (1) availability of suspended sediment and (2) depth and periods of tidal inundation. When the level of an evolving marsh surface is low with respect to the tidal range, sedimentation rates may be high if the suspended sediment supply is sufficient. However, as the marsh surface rises through the tidal range, the frequency and duration of flooding by high tides is diminished so that the rate of sediment accumulation declines. MARSH98 implements these physical processes by calculating the amount of suspended sediment that deposits during each period of tidal inundation and sums that amount of deposition over the period of record. Accretion due to organic material is also added directly to the bed elevation at each tidal cycle.

A suspended sediment concentration of 50 mg/L and an organic accretion rate of 2 mm/yr were used for the Suisun area. These assumptions are consistent with regional sedimentation modeling for San Francisco Bay and Suisun by Stralberg et al. (2011). The suspended sediment assumption is consistent with estimates provided in the Suisun Marsh Tidal Marsh and Aquatic Habitats Conceptual Model (Siegel et al., 2010). The MARSH98 sedimentation curves used in this assessment are shown in Figure 4. Attachment B presents the accretion values used at each time step. For each cell in the topography raster, accretion was interpolated from values in Attachment B based on the elevation of the cell and then added to raise the cell elevation to a maximum of EHW.

2.5.2 Delta Accretion

For the Delta where emergent freshwater marsh is present, we assume that combined organic and inorganic accretion is sufficient to keep pace with sea-level rise (Simenstad et al. 2000, Orr et al. 2003). Where no emergent vegetation is present, we assume that there is insufficient inorganic sedimentation to significantly raise subtidal and intertidal mudflat areas; we assume no accretion in unvegetated areas.

2.6 Habitat Evolution Model

For each topography area (within the hypothetical footprints, outside the footprints, and marsh areas), tidal datum surfaces were created to match the topography shapes. The adjustments to the elevation data set for existing marsh topography and subtidal areas (described in Section 2.2) were completed using Matlab. In Suisun, each 10-meter cell of topography was accreted as described above (Section 2.5) and then categorized based on the tidal datums at that cell (
Table 1) using MatLab.

In the Delta, cells from the footprints and the No Project areas were categorized as marsh if they fell between existing conditions MLLW and the current time step MHHW. This assumes that the bottom edge of the marsh never drowns out, and the upper edge of the marsh migrates upslope with sea-level rise. The remaining areas were categorized per

Table 1. The existing marsh in the Delta is assumed to remain marsh in all future time steps.

For the No Project scenarios, the No Project topography and the existing marsh topography were merged in GIS with the existing marsh taking priority. For the With Project scenarios, the footprints that are breached by that time step, the areas outside the footprints, and the existing marsh were merged with the marsh taking the highest priority and the areas outside the footprints the lowest. The area for each habitat category for each scenario and each region was calculated in GIS.

3. Results

Areas by habitat type, region, and scenario are provided in Table 5 and Table 6, with Table 6 including areas within the hypothetical footprints only. Results for the no-project scenarios are mapped in Figure 5 - Figure 7. Results for the with-project scenarios are displayed graphically in Figure 8 - Figure 15.

3.1 Suisun Marsh and Bay

In Suisun Marsh with no project, model results show that the total amount of brackish tidal marsh remains relatively constant over the 50-year planning horizon, but transitions from high and mid marsh to mostly low marsh by late long term (Table 5 and Figure 16). With the project, the results show increases in low marsh areas, mudflat, and subtidal with restoration. The areas of low marsh, mudflat, and subtidal increase with each time step. High and mid marsh results show only temporary increases with restoration. The extent of high marsh peaks in the near term and the extent of mid marsh peaks in the ELT. The results show a net reduction in both high and mid marsh areas in the LLT compared to existing conditions, as sea level rise outpaces accretion. Over time, the sea level rise accommodation areas shrink and subtidal areas increase as sea levels rise and habitats migrate upslope, shown schematically in Figure 3.

Results show that the existing natural tidal marshes in Suisun Marsh such as Rush Ranch and Hill Slough transition from predominantly mid and high marsh to low and mid marsh by the LLT (Figure 16). Over time, sea level rise causes existing and restored marshes to lower or “drown” with respect to MHHW in the scenario modeled. The mid marsh plain lowers or “drowns” with respect to MHHW approximately 1ft for the scenario modeled. This increases the marsh inundation frequency from about 5-10% to about 20-30% (US Department of the Interior et al., 2011; Figure 2-3). This may result in reduced access to the marsh by terrestrial wildlife species and, as modeled, shifts in vegetation types to low-marsh dominate species such as cattails and tule.

Schematic of Suisun Marsh Habitats by Tide Levels and Transgression of habitats with Sea Level Rise

Figure 4. shows modeled marshplain and subtidal elevations over a period of 50 years compared to sea level rise. The top plot shows MHHW (blue dotted line) increasing over time at a faster rate than the marsh and subtidal flat can accrete (brown, light green, and dark green lines). The bottom plot shows marshplain and subtidal elevations relative to MHHW over time. A higher sediment supply or higher organic accretion would produce a curve that would allow the marshplain to keep up with sea level rise for longer. A decrease in available sediment or organic accretion would decrease the amount of time before a marsh drowns.

3.2 Delta

In the Delta, the results show an increase in tidal freshwater marsh acreage over time for both with and without project conditions. This is because freshwater marsh transgresses over higher areas and marsh accretion is assumed to keep pace with sea level rise. In the hypothetical restoration scenario, restoration significantly increases the extent of ecotone, freshwater marsh, and subtidal habitats. The areas of restored freshwater marsh and restored subtidal habitats are similar in magnitude. Intertidal mudflat areas (in the Cache Slough area) show a gradual decrease over time, as mudflats are squeezed between subtidal areas that transgress upslope and freshwater marshes that remain in place. Intertidal mudflat habitat drowns out significantly in the early long term and almost completely by late long term. As in Suisun Marsh, the sea level rise accommodation areas shrink and subtidal areas increase over time as sea levels rise.

According to model results, most of the restored emergent marsh, in fact most of the total restored area, occurs in Cache Slough and the South Delta. Results for the West Delta show large percentages of emergent marsh compared to the total area restored, a result of the assumption that fill will be imported to raise most subsided areas I the West Delta.

4. Discussion of Other Possible Restoration Scenarios

The restoration scenario assessed here represents only one of many possible restoration scenarios. Additional grading and growing tules for subsidence reversal prior to breaching can be use to increase ground elevations and area of intertidal habitat, if desired. On the other hand, intertidal habitat may be less than estimated here if the restoration does not include constructed features or adaptive management actions to ensure good tidal exchange to western Suisun Marsh. Restoration site selection also plays a significant role. These implementation considerations and others are discussed below.

Selection of restoration sites. The characteristics of restoration sites and where they are located on the landscape will have a significant effect on the resulting habitat. Restoration of less subsided sites will produce relatively more intertidal habitat, while restoration of more subsided sites will produce relatively more subtidal habitat.

Grading and use imported fill. Grading and fill placement to expand the intertidal area could be used to significantly increase the extent of intertidal marsh. For a gently-sloped upland edge (e.g., 100:1), borrowing from the upland edge (up to 1 ft above MHHW lowered to MHHW) and using the excavated material to raise shallow mudflat and subtidal areas up to marsh elevations could roughly double the intertidal marsh extent above the value estimated here. Growing tules to raise ground elevations (tule farming for subsidence reversal) prior to breaching could also increase the extent of intertidal marsh. Tule farming would need to be started early, since it requires on the order of decades to build up soils and measurably increase land elevations.

Tidal damping in western Suisun Marsh. The railroad tracks that cross western Suisun Marsh have the potential to limit tidal exchange west of the tracks, especially under LLT conditions. RMA modeling indicates that the extent of tidal damping may range from less than approximately 1 foot with existing channel geometry to over 4 feet with wider and deeper channels (ESA PWA 2011). The extent of restored intertidal marsh is sensitive to the extent of tidal damping. The wider and deeper channel configuration was used for the current assessment. The actual extent of tidal damping west of the railroad tracks will depend on how quickly tidal channels scour in response to increased tidal flows (with restoration and higher sea levels) and whether restoration measures such as dredging of sloughs are included to improve tidal exchange.

Planting and vegetation management. Vegetation establishment is not explicitly addressed in this assessment. If wetland vegetation is not present prior to tidal restoration, either through managing water level to encourage desired vegetation or through planting, it will take time to establish through natural recruitment. In Suisun Marsh, mid marsh vegetation may colonize relatively quickly, on the order of five years. Low marsh vegetation establishes more slowly, particularly within the lower part of its elevation range. These rates of marsh colonization are based on limited sources available for San Francisco Bay marshes (Siegel 1998, P. Faber, pers. comm., Williams & Orr 2002) and assume sufficiently quiescent conditions for seeds to germinate (Friedrichs and Perry, 2001). In the Delta, freshwater emergent marsh has been observed to colonize within a few years in the upper end of its elevation range. Colonization is slower at the lower end of the tide range (USFWS and USACE 1990, Simenstad et al. 2000). Planting is expected to be required to establish high-marsh native plant communities in Suisun Marsh (Table 2).

Timing of implementation. Restorations that occur earlier start accreting sediments earlier and develop relatively more high-elevation habitat types. Perhaps equally important, restorations that occur earlier may have less of an elevation deficit by the time restoration occurs. Ongoing subsidence through existing land use practices may result in ground elevations below those used in this assessment. The supply of inorganic sediments available for deposition may also decrease over time (Wright and Schoellhamer 2004).

5. Limitations and Uncertainty

The tidal habitats model is a planning-level tool that uses simplifying assumptions to represent complex natural processes. Models possess inherent limitations and uncertainties; those pertinent to this model are discussed below.

- This habitat evolution assessment uses a series of assumptions based on professional judgment. Additional assessment and input from Delta scientists and restoration practitioners would refine the assessment approach.
- Sediment supply and maximum potential rates of organic accretion are variable and uncertain processes. The ability of marshes to keep pace with higher rates of sea level rise is not yet well understood.
- Future sea level rise is also uncertain. The BDCP sea level rise scenarios are on the high end of the range of current estimates. Lower sea level rise than assumed for this assessment will result in relatively greater areas of those habitats higher in the tidal frame.
- Landscape factors in habitat evolution have been considered at a coarse scale. Additional habitat evolution is expected downstream of the restored sites, as the major tidal channels scour in response to restoration (Williams et al. 2002), and at the bay-marsh edge as wind-waves erode the

shoreline. High wind wave exposure may delay or stall sedimentation (and vegetation establishment). Changes in salinity will occur with sea level rise, shifting the locations of brackish marsh. These processes were not considered in this assessment.

- The topography and habitat mapping data used in this assessment were corrected for known inaccuracies. Additional inaccuracies may exist.
- Marsh transgression and sea level rise accommodation space is shown in some areas upslope of leveed areas (e.g. east of Montezuma Slough, edge of eastern Delta) which would not actually be subject to transgression. This limitation affects a relatively small acreage.
- Some aquatic habitats outside RMA's model grid boundaries are misclassified as uplands because of the way the boundary was extrapolated in GIS. This limitation affects the Stone Lakes area (in the eastern Delta) and other areas near the mapping border.
- The existing marsh area south of Prospect Island (fewer than 100 acres) is incorrectly mapped as leveed under the Existing Conditions and No Project scenarios.

6. Memorandum Preparers

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Stacie Grinbergs, P.E., and Richard Rachiele of RMA provided hydrodynamic modeling results for use in this assessment.

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8. Tables & Figures

8.1 Tables

8.2 Figures

9. Attachments

Table 1. Elevation-Based Habitat Categories

Habitat	Suisun	Cache Slough	Delta, Excluding Cache Slough
Upland	> 9 ft NAVD	> 9 ft NAVD	> 9 ft NAVD
Sea-Level Rise Transition	EHW – 9 ft NAVD	EHW – 9 ft NAVD	EHW – 9 ft NAVD
High Tidal Brackish Marsh	MHHW – EHW	NA	NA
Mid Tidal Brackish Marsh	MHW – MHHW	NA	NA
Low Tidal Brackish Marsh	MLLW+1 ft – MHW	NA	NA
Freshwater Ecotone	NA	MHHW - EHW	MHHW - EHW
Tidal Freshwater Marsh	NA	MLLW+1 ft – MHHW	MLLW - MHHW
Intertidal Mudflat	MLLW – MLLW+1ft	MLLW – MLLW+1ft	
Subtidal 1	MLLW-3ft – MLLW	MLLW-3ft – MLLW	MLLW-3ft – MLLW
Subtidal 2	MLLW-6ft – MLLW-3ft	MLLW-6ft – MLLW-3ft	MLLW-6ft – MLLW-3ft
Subtidal 3	< MLLW-6ft	< MLLW-6ft	< MLLW-6ft

Source: Suisun Ecological Workgroup (2001), PWA (2001), Simenstad et al. (2000), PWA et al. (2006), Watson and Byrne (2009), Siegel et al. (2011).

Table 2. Tidal Habitat Categories

Habitat Category	Tidal Elevations	Vegetation Community
Upland	9 ft NAVD+	Primarily non-native annual grasses, coyote bush (*Baccharis* spp.), forbs
Sea-Level Rise Transition	EHW to 9 ft NAVD	Similar to "Upland", may have some populations of clonal perennial graminoids such as creeping wildrye (*Leymus triticoides*)
Brackish - tidal emergent marsh, high	MHHW to EHW (Suisun)	pickleweed (*Sarcocornia virginica*), saltgrass (*Distichlis spicata*), Pacific silverweed (*Argentina egedii*), alkali heath (*Frakenia salina*), Baltic rush (*Juncus articus* spp. *Balticus*), jaumea (*Jaumea carnosa*), saltgrass (*Distichlis spicata*), salt marsh dodder (*Cuscuta salina*), sea milkwort (*Glaus maritime*), western goldenrod (*Euthamia occidentalis*), and gumplant (*Grindelia stricta*)
Brackish - tidal emergent marsh, mid	MHW to MHHW (Suisun)	variable mixture of species including Baltic rush (*Juncus articus spp. balticus*), Pacific silverweed (Argentina egedii), and American bulrush (*Schoenoplectus americanus*)
Brackish - tidal emergent marsh, low	MLLW+1 ft to MHW (Suisun)	hardstem bulrush (*Schoenoplectus acutus*) and California bulrush (*S. californicus*)
Freshwater Ecotone	MHHW to EHW (Delta, Cache Slough Area)	For the north Delta, assume: saltgrass (*Distichlis spicata*); creeping wildrye (*Leymus triticoides*); alkali heath (*Frenkenia salina*); sea blight (*Suada* spp.); Baltic rush (*Juncus balticus*); pale spike rush (*Eleocharis macrostachya*); yerba mansa (*Anemopsis californica*); Suisun Marsh aster (*Symphyotrichum lentum*), and; coyote thistle (*Eryngium aristulatum*). For the other Delta areas, assume: sedges (*Carex spp.*); rushes (*Juncus* spp.); spikerushes (*Eleocharis* spp.); creeping wildrye (*Leymus triticoides*); swamp smartweed (*Polygonum hydropiperoides*), and; water plantain (*Alisma plantago aquatica*).
Fresh - tidal emergent	MLLW to MHHW (Delta, Cache Slough Area)	Dominated by tule/bulrush (*Schoenoplectus* spp.) and cattails (*Typha* spp.) with higher in-channel islands dominated by California rose (*Rosa californica*), arroyo willow (*Salix lasiolepis*), and redosier dogwood(*Cornus sericea*)
Intertidal mudflat	MLLW to MLLW+1 ft (Suisun and Cache Slough area)	Mix of unvegetated and vegetated with native and non-native submerged aquatic vegetation. Notable native species include sago pondweed (*Stuckenia pectinata*) and widgeongrass (*Ruppia maritima*); non-natives include Brazilian waterweed (*Egeria densa*) and water hyacinth (*Eichhornia crassipes*).
Subtidal 1	0 to 3 ft below MLLW	See intertidal mudflat.
Subtidal 2	3 to 6 ft below MLLW	See intertidal mudflat.
Subtidal 3	6+ ft below MLLW	See intertidal mudflat.

Sources: Suisun Ecological Workgroup (2001), PWA (2001), Simenstad et al. (2000), PWA et al. (2006), Watson and Byrne (2009), US Department of Interior *et al*. (2011), Siegel et al. (2011).

Table 3.Tidal Habitat Modeling Scenarios

Scenario	Time Period	Hypothetical Restoration Footprints	Coupled with San Francisco Bay	Sea-Level Rise	Suisun Scour
No Project	Existing Conditions	No	Modeled	None	No
	Early Long Term	No	Estimated	Modeled (15 cm)	No
	Late Long Term	No	Estimated	Modeled (45 cm)	No
With Project	Near Term	Yes	Modeled	None	No
	Early Long Term	Yes	Modeled	Modeled (15 cm)	No
	Late Long Term	Yes	Estimated	Estimated (45 cm)	Yes

Note: "Estimated" indicates that coupling / sea level rise was not included in the RMA model run so was estimated using a post-model adjustment.

Table 4. Representative Tidal Datums By Region, With and Without Project (ft NAVD88)

		Without Project		With Project	
	Tidal Datum	Existing Conditions	Late Long Term	Near Term	Late Long Term
Suisun Marsh	EHW	7.29	8.81	6.98	8.42
	MHHW	6.58	8.09	6.33	7.71
	MHW	5.93	7.46	5.71	7.11
	MLLW	1.44	2.85	1.81	3.33
Suisun Bay	EHW	6.98	8.52	6.81	8.22
	MHHW	6.29	7.80	6.15	7.51
	MHW	5.65	7.17	5.53	6.92
	MLLW	1.52	2.95	1.69	3.41
Cache Slough	EHW	7.13	8.65	6.72	7.70
	MHHW	6.39	7.91	6.07	7.13
	MLLW	2.13	3.54	2.38	4.36
Mokelumne	EHW	6.75	8.21	6.37	7.50
	MHHW	6.00	7.48	5.7	6.91
	MLLW	2.51	3.78	3.21	4.82
North Delta	EHW	7.20	8.63	6.84	7.90
	MHHW	6.47	7.9	6.19	7.29
	MLLW	3.62	4.80	3.7	5.13
South Delta	EHW	6.47	7.91	6.27	7.12
	MHHW	5.74	7.21	5.58	6.56
	MLLW	2.27	3.55	2.38	4.21
Western Delta	EHW	6.63	8.12	6.43	7.70
	MHHW	5.91	7.41	5.76	7.06
	MLLW	2.19	3.5	2.34	4.02
Yolo Bypass	EHW	7.01	8.48	6.7	7.76
	MHHW	6.23	7.74	6.03	7.16
	MLLW	2.74	3.98	2.86	4.58

Source: Hydraulic modeling results from RMA with coupling and sea level rise adjustments by ESA PWA (see text), averaged by region by ESA PWA.

Table 5. Tidal Habitat Areas by Time Step and by Region With and Without Project (Acres)

Region	Habitat Type	Max Elevation	Without Project: Existing Conditions	Without Project: Early Long Term	Without Project: Late Long Term	With Project: Near Term	With Project: Early Long Term	With Project: Late Long Term
Suisun Marsh	Upland		14,150	14,140	14,140	14,160	14,170	14,180
Suisun Marsh	SLR Accommodation	9 ft NAVD	1,130	1,020	840	1,220	850	780
Suisun Marsh	High Tidal Brackish Marsh	~EHW	1,410	820	360	1,440	950	470
Suisun Marsh	Mid Tidal Brackish Marsh	~MHHW	3,700	3,670	3,140	3,720	3,860	3,210
Suisun Marsh	Low Tidal Brackish Marsh	~MHW	2,810	3,460	4,500	4,640	5,420	7,160
Suisun Marsh	Intertidal Mudflat	MLLW + 1 ft	270	250	240	1,380	1,880	2,020
Suisun Marsh	Subtidal 1	MLLW	1,020	1,020	990	2,200	2,810	7,470
Suisun Marsh	Subtidal 2	MLLW - 3 ft	780	810	840	820	930	1,550
Suisun Marsh	Subtidal 3	MLLW - 6 ft	2,360	2,430	2,580	2,330	2,510	2,700
Suisun Marsh	Hypothetical footprint not yet restored		-	-	-	7,600	6,130	-
Suisun Marsh		Subtotal	27,620	27,620	27,620	39,520	39,520	39,530
Suisun Bay	Upland		3	3	3	3	3	3
Suisun Bay	SLR Accommodation	9 ft NAVD	20	20	7	30	20	10
Suisun Bay	High Tidal Brackish Marsh	~EHW	150	80	20	140	80	20
Suisun Bay	Mid Tidal Brackish Marsh	~MHHW	580	560	200	580	560	460
Suisun Bay	Low Tidal Brackish Marsh	~MHW	600	670	1,050	610	650	760
Suisun Bay	Intertidal Mudflat	MLLW + 1 ft	140	110	80	160	100	60
Suisun Bay	Subtidal 1	MLLW	1,760	1,480	1,000	1,850	1,350	750
Suisun Bay	Subtidal 2	MLLW - 3 ft	7,230	6,640	5,360	7,430	6,230	4,150
Suisun Bay	Subtidal 3	MLLW - 6 ft	11,040	11,970	13,820	10,740	12,540	15,320
Suisun Bay	Hypothetical footprint not yet restored		-	-	-	-	-	-
Suisun Bay		Subtotal	21,530	21,530	21,530	21,530	21,530	21,530

Table 5. Tidal Habitat Areas by Time Step and by Region With and Without Project (Acres) (Continued)

Region	Habitat Type	Max Elevation	Without Project: Existing Conditions	Without Project: Early Long Term	Without Project: Late Long Term	With Project: Near Term	With Project: Early Long Term	With Project: Late Long Term
Cache Slough	Upland		7,320	7,320	7,300	7,500	7,690	7,770
	SLR Accommodation	9 ft NAVD	2,130	1,450	740	3,570	3,300	1,630
	Ecotone	EHW	720	800	450	1,430	1,890	1,610
	Tidal Freshwater Marsh	MHHW	3,460	4,060	5,120	7,030	10,840	14,420
	Intertidal Mudflat	MLLW + 1 ft	840	440	0	800	240	2
	Subtidal 1	MLLW	1,730	1,860	1,750	1,840	3,270	4,100
	Subtidal 2	MLLW - 3 ft	1,600	1,810	2,030	1,700	2,260	3,870
	Subtidal 3	MLLW - 6 ft	2,990	3,060	3,380	3,050	3,250	6,480
	Hypothetical footprint not yet restored		-	-	-	12,920	7,130	-
		Subtotal	20,780	20,790	20,770	39,850	39,860	39,880
Mokelumne	Upland		3,090	3,090	3,090	3,100	3,210	3,430
	SLR Accommodation	9 ft NAVD	1,850	1,580	320	2,040	1,530	1,150
	Ecotone	EHW	350	290	350	300	310	210
	Tidal Freshwater Marsh	MHHW	1,570	1,800	3,090	2,730	3,050	3,730
	Subtidal 1	MLLW	280	230	170	1,530	1,380	920
	Subtidal 2	MLLW - 3 ft	510	480	450	780	880	1,080
	Subtidal 3	MLLW - 6 ft	3,210	3,290	3,370	3,280	3,320	3,580
	Hypothetical footprint not yet restored		-	-	-	370	370	-
		Subtotal	10,850	10,760	10,850	14,120	14,050	14,110
North Delta	Upland		2,960	2,960	2,960	2,960	3,060	3,040
	SLR Accommodation	9 ft NAVD	1,180	1,110	190	1,220	1,070	890
	Ecotone	EHW	80	70	340	70	70	80
	Tidal Freshwater Marsh	MHHW	280	350	1,000	250	330	670
	Subtidal 1	MLLW	210	170	120	190	170	100
	Subtidal 2	MLLW - 3 ft	290	290	310	290	290	240
	Subtidal 3	MLLW - 6 ft	2,890	2,930	2,960	2,910	2,920	3,080
	Hypothetical footprint not yet restored		-	-	-	230	230	-
		Subtotal	7,880	7,890	7,890	8,120	8,140	8,110

Table 5. Tidal Habitat Areas by Time Step and by Region With and Without Project (Acres) (Continued)

Region	Region and Habitat Type	Max Elevation	Without Project			With Project		
			Existing Conditions	Early Long Term	Late Long Term	Near Term	Early Long Term	Late Long Term
South Delta	Upland		12,280	12,280	12,280	12,290	12,470	12,550
South Delta	SLR Accommodation	9 ft NAVD	2,090	1,740	1,070	2,280	1,690	1,410
South Delta	Ecotone	EHW	840	670	470	820	700	1,330
South Delta	Tidal Freshwater Marsh	MHHW	3,560	4,070	4,960	3,390	3,990	15,090
South Delta	Subtidal 1	MLLW	1,090	880	700	1,030	810	4,380
South Delta	Subtidal 2	MLLW - 3 ft	2,310	2,170	1,980	2,260	2,070	7,570
South Delta	Subtidal 3	MLLW - 6 ft	12,090	12,440	12,810	12,200	12,600	14,360
South Delta	Hypothetical footprint not yet restored		-	-	-	22,410	22,410	-
South Delta	Subtotal		34,260	34,250	34,260	56,690	56,730	56,700
Western Delta	Upland		6,250	6,250	6,250	5,930	5,950	5,920
Western Delta	SLR Accommodation	9 ft NAVD	830	660	290	940	710	270
Western Delta	Ecotone	EHW	180	200	220	190	220	200
Western Delta	Tidal Freshwater Marsh	MHHW	5,100	5,250	5,590	6,330	7,470	8,020
Western Delta	Subtidal 1	MLLW	1,200	980	710	1,230	1,030	350
Western Delta	Subtidal 2	MLLW - 3 ft	3,300	3,040	2,710	3,380	3,080	1,890
Western Delta	Subtidal 3	MLLW - 6 ft	19,040	19,530	20,120	19,300	19,800	21,660
Western Delta	Hypothetical footprint not yet restored		-	-	-	1,010	50	-
Western Delta	Subtotal		35,900	35,900	35,900	38,310	38,320	38,310
Yolo Bypass	Upland		7,180	7,180	7,180	7,180	7,210	7,190
Yolo Bypass	SLR Accommodation	9 ft NAVD	750	720	200	770	700	490
Yolo Bypass	Ecotone	EHW	40	40	480	20	50	160
Yolo Bypass	Tidal Freshwater Marsh	MHHW	270	280	370	270	290	400
Yolo Bypass	Subtidal 1	MLLW	2	2	1	2	1	1
Yolo Bypass	Subtidal 2	MLLW - 3 ft	2	2	2	2	2	2
Yolo Bypass	Subtidal 3	MLLW - 6 ft	40	40	40	40	40	40
Yolo Bypass	Hypothetical footprint not yet restored		-	-	-	-	-	-
Yolo Bypass	Subtotal		8,290	8,280	8,290	8,280	8,280	8,290

Table 5. Tidal Habitat Areas by Time Step and by Region With and Without Project (Acres) (Continued)

	Region and Habitat Type	Max Elevation	Without Project			With Project		
			Existing Conditions	Early Long Term	Late Long Term	Near Term	Early Long Term	Late Long Term
Total	**Suisun**							
	Upland		14,150	14,150	14,150	14,160	14,170	14,190
	SLR Accommodation	9 ft NAVD	1,150	1,040	840	1,250	870	790
	High Tidal Brackish Marsh	~EHW	1,560	900	370	1,590	1,030	480
	Mid Tidal Brackish Marsh	~MHHW	4,280	4,230	3,340	4,300	4,420	3,670
	Low Tidal Brackish Marsh	~MHW	3,410	4,130	5,550	5,260	6,080	7,920
	Intertidal Mudflat	MLLW + 1 ft	420	360	310	1,540	1,990	2,080
	Subtidal 1	MLLW	2,770	2,500	1,990	4,050	4,160	8,220
	Subtidal 2	MLLW - 3 ft	8,010	7,450	6,200	8,240	7,160	5,700
	Subtidal 3	MLLW - 6 ft	13,400	14,400	16,410	13,070	15,050	18,020
	Suisun Subtotal		***49,156***	***49,156***	***49,152***	***53,453***	***54,918***	***61,066***
	Delta							
	Upland		39,080	39,080	39,070	38,970	39,590	39,890
	SLR Accommodation	9 ft NAVD	8,830	7,260	2,810	10,830	9,000	5,850
	Ecotone	EHW	2,200	2,080	2,310	2,830	3,220	3,590
	Tidal Freshwater Marsh	MHHW	14,240	15,810	20,140	19,990	25,970	42,340
	Intertidal Mudflat	MLLW + 1 ft	840	440	0	800	240	2
	Subtidal 1	MLLW	4,510	4,120	3,460	5,840	6,660	9,870
	Subtidal 2	MLLW - 3 ft	8,010	7,780	7,480	8,410	8,580	14,650
	Subtidal 3	MLLW - 6 ft	40,270	41,290	42,690	40,770	41,930	49,210
	Delta Subtotal			***117,869***	***117,960***	***128,438***	***135,193***	***165,395***
	Hypothetical footprint not yet restored		NA	NA	NA	44,530	36,320	-
		TOTAL	**167,130**	**167,020**	**167,110**	**226,420**	**226,430**	**226,460**

Table 6. Tidal Habitat Areas within the Project Footprints, by Time Step and by Region (Acres)

Region and Habitat Type		Max Elevation	Existing Conditions	With Project		
				Near Term	Early Long Term	Late Long Term
Suisun Marsh	Upland		40	50	60	80
	SLR Accommodation	9 ft NAVD	120	180	150	90
	High Tidal Brackish Marsh	~EHW	330	420	210	130
	Mid Tidal Brackish Marsh	~MHHW	1,580	1,580	1,630	1,200
	Low Tidal Brackish Marsh	~MHW	340	2,110	2,600	3,840
	Intertidal Mudflat	MLLW + 1 ft	9	1,110	1,640	1,780
	Subtidal 1	MLLW	20	1,200	1,780	6,530
	Subtidal 2	MLLW - 3 ft	8	50	80	660
	Subtidal 3	MLLW - 6 ft	9	9	10	10
		Subtotal	2,450	6,710	8,170	14,310
Suisun Bay	Upland		-	-	-	-
	SLR Accommodation	9 ft NAVD	-	-	-	-
	High Tidal Brackish Marsh	~EHW	-	-	-	-
	Mid Tidal Brackish Marsh	~MHHW	-	-	-	-
	Low Tidal Brackish Marsh	~MHW	-	-	-	-
	Intertidal Mudflat	MLLW + 1 ft	-	-	-	-
	Subtidal 1	MLLW	-	-	-	-
	Subtidal 2	MLLW - 3 ft	-	-	-	-
	Subtidal 3	MLLW - 6 ft	-	-	-	-
		Subtotal	-	-	-	-

Table 6. Tidal Habitat Areas within the Project Footprints, by Time Step and by Region (Acres) (Continued)

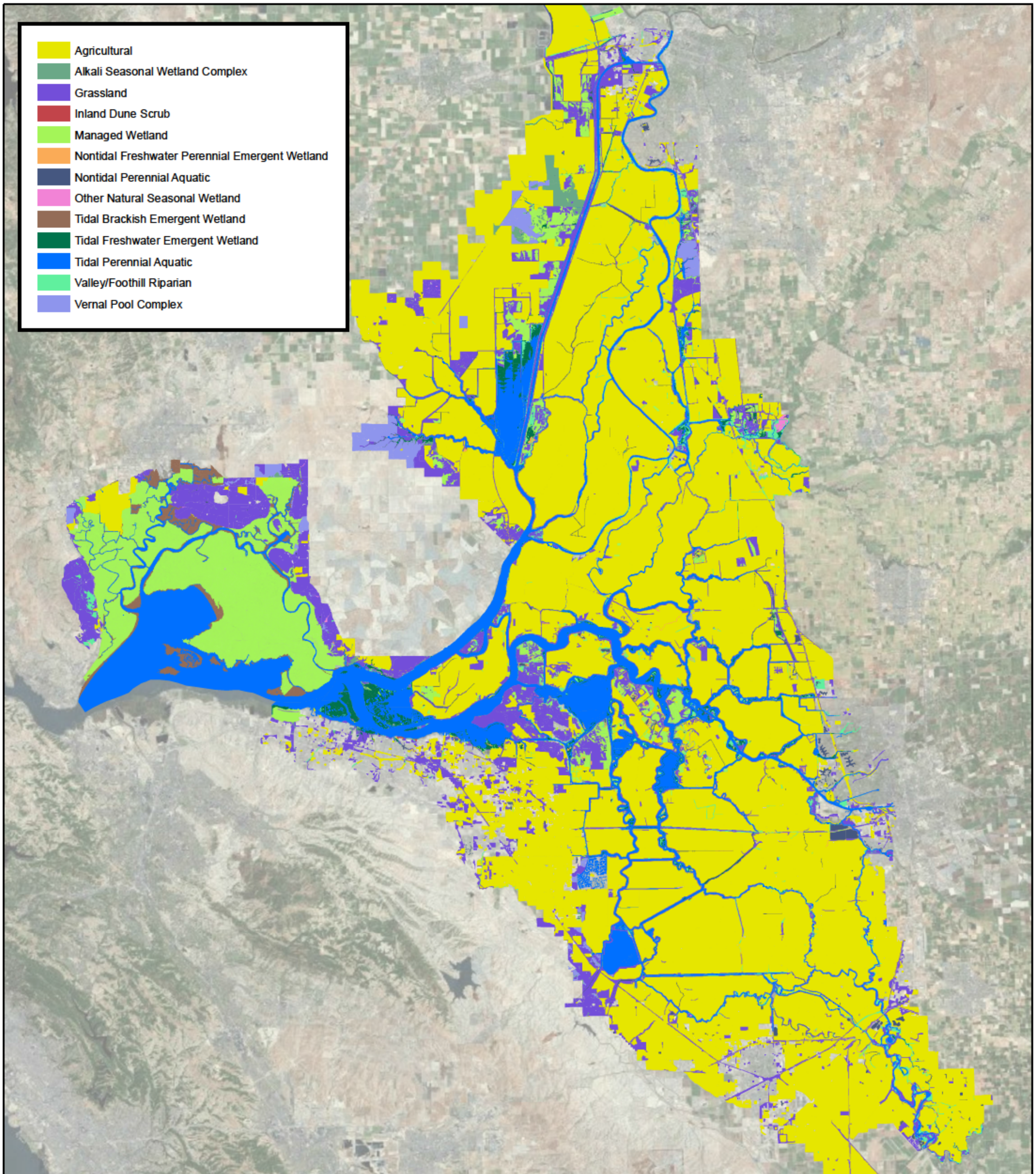
Region and Habitat Type		Max Elevation	Existing Conditions	With Project		
				Near Term	Early Long Term	Late Long Term
Cache Slough	Upland		80	240	420	500
	SLR Accommodation	9 ft NAVD	700	1,880	1,900	830
	Ecotone	EHW	160	980	1,340	1,070
	Tidal Freshwater Marsh	MHHW	300	4,020	7,630	10,590
	Intertidal Mudflat	MLLW + 1 ft	1	160	210	2
	Subtidal 1	MLLW	5	40	1,310	2,720
	Subtidal 2	MLLW - 3 ft	3	9	290	2,220
	Subtidal 3	MLLW - 6 ft	10	20	40	2,340
		Subtotal	1,270	7,350	13,140	20,270
Mokelumne	Upland		7	10	10	350
	SLR Accommodation	9 ft NAVD	1	30	10	40
	Ecotone	EHW	0	30	30	3
	Tidal Freshwater Marsh	MHHW	4	1,240	1,260	1,300
	Subtidal 1	MLLW	1	1,290	1,160	840
	Subtidal 2	MLLW - 3 ft	2	290	420	720
	Subtidal 3	MLLW - 6 ft	1	3	7	20
		Subtotal	20	2,900	2,900	3,270
North Delta	Upland		2	2	3	90
	SLR Accommodation	9 ft NAVD	1	1	0	8
	Ecotone	EHW	0	0	0	6
	Tidal Freshwater Marsh	MHHW	1	1	1	100
	Subtidal 1	MLLW	2	2	2	20
	Subtidal 2	MLLW - 3 ft	1	1	1	20
	Subtidal 3	MLLW - 6 ft	1	1	1	1
		Subtotal	8	8	8	230

Table 6. Tidal Habitat Areas within the Project Footprints, by Time Step and by Region (Acres) (Continued)

Region	Habitat Type	Max Elevation	Existing Conditions	With Project: Near Term	With Project: Early Long Term	With Project: Late Long Term
South Delta	Upland		10	10	10	280
	SLR Accommodation	9 ft NAVD	8	3	7	530
	Ecotone	EHW	3	8	2	950
	Tidal Freshwater Marsh	MHHW	10	10	10	9,880
	Subtidal 1	MLLW	10	10	9	4,070
	Subtidal 2	MLLW - 3 ft	2	3	3	6,060
	Subtidal 3	MLLW - 6 ft	0	0	1	690
		Subtotal	50	50	50	22,450
Western Delta	Upland		380	50	50	50
	SLR Accommodation	9 ft NAVD	20	80	70	8
	Ecotone	EHW	10	40	30	30
	Tidal Freshwater Marsh	MHHW	120	1,370	2,350	2,470
	Subtidal 1	MLLW	2	130	120	10
	Subtidal 2	MLLW - 3 ft	1	170	170	190
	Subtidal 3	MLLW - 6 ft	5	80	80	170
		Subtotal	540	1,910	2,880	2,930
Yolo Bypass	Upland		-	-	-	-
	SLR Accommodation	9 ft NAVD	-	-	-	-
	Ecotone	EHW	-	-	-	-
	Tidal Freshwater Marsh	MHHW	-	-	-	-
	Subtidal 1	MLLW	-	-	-	-
	Subtidal 2	MLLW - 3 ft	-	-	-	-
	Subtidal 3	MLLW - 6 ft	-	-	-	-
		Subtotal	-	-	-	-

Table 6. Tidal Habitat Areas within the Project Footprints, by Time Step and by Region (Acres) (Continued)

	Region and Habitat Type	Max Elevation	Existing Conditions	With Project: Near Term	With Project: Early Long Term	With Project: Late Long Term
Total	**Suisun**					
	Upland		40	50	60	80
	SLR Accommodation	9 ft NAVD	120	180	150	90
	High Tidal Brackish Marsh	~EHW	330	420	210	130
	Mid Tidal Brackish Marsh	~MHHW	1,580	1,580	1,630	1,200
	Low Tidal Brackish Marsh	~MHW	340	2,110	2,600	3,840
	Intertidal Mudflat	MLLW + 1 ft	9	1,110	1,640	1,780
	Subtidal 1	MLLW	20	1,200	1,780	6,530
	Subtidal 2	MLLW - 3 ft	8	50	80	660
	Subtidal 3	MLLW - 6 ft	9	9	10	10
		Subtotal	2460	6710	8160	14320
	Delta					
	Upland		480	320	500	1,260
	SLR Accommodation	9 ft NAVD	730	2,000	1,990	1,420
	Ecotone	EHW	180	1,070	1,400	2,060
	Tidal Freshwater Marsh	MHHW	440	6,630	11,260	24,330
	Intertidal Mudflat	MLLW + 1 ft	1	160	210	2
	Subtidal 1	MLLW	20	1,470	2,610	7,660
	Subtidal 2	MLLW - 3 ft	9	470	880	9,210
	Subtidal 3	MLLW - 6 ft	20	100	120	3,210
		Subtotal	1880	12220	18970	49150
		TOTAL	**4,320**	**18,930**	**27,140**	**63,460**



Source: BDCP Habitat Mapping

N

0 25,000 50,000 100,000 Feet

figure 1

BDCP

BDCP Vegetation Mapping

ESA PWA Ref# - 1996.06

ESA PWA

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Source: RMA Associates

N

0 25,000 50,000 100,000 Feet

figure 2

BDCP

BDCP Geographic Regions Map

ESA PWA Ref# - 1996.06

ESA PWA

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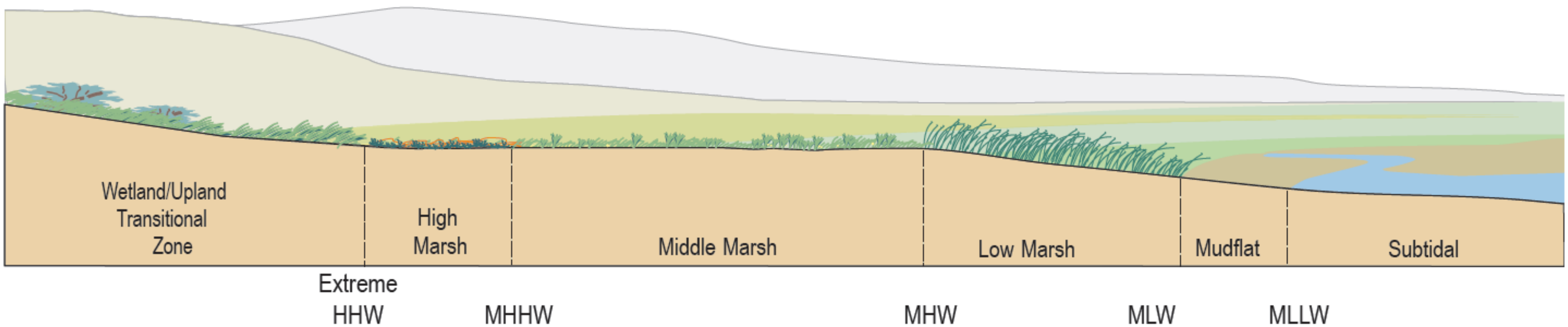
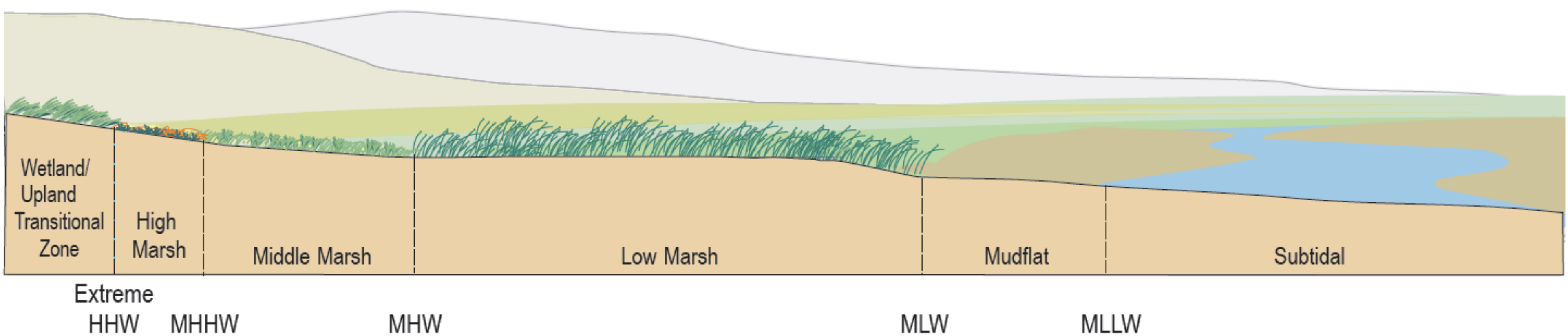
EXISTING



FUTURE WITH SEA LEVEL RISE



SOURCE: ESA-PWA 2012

ESA PWA

BDCP 1996

Figure 3

Schematic of Suisun Marsh Habitats by Tide Levels and Transgression of Habitats with Sea Level Rise

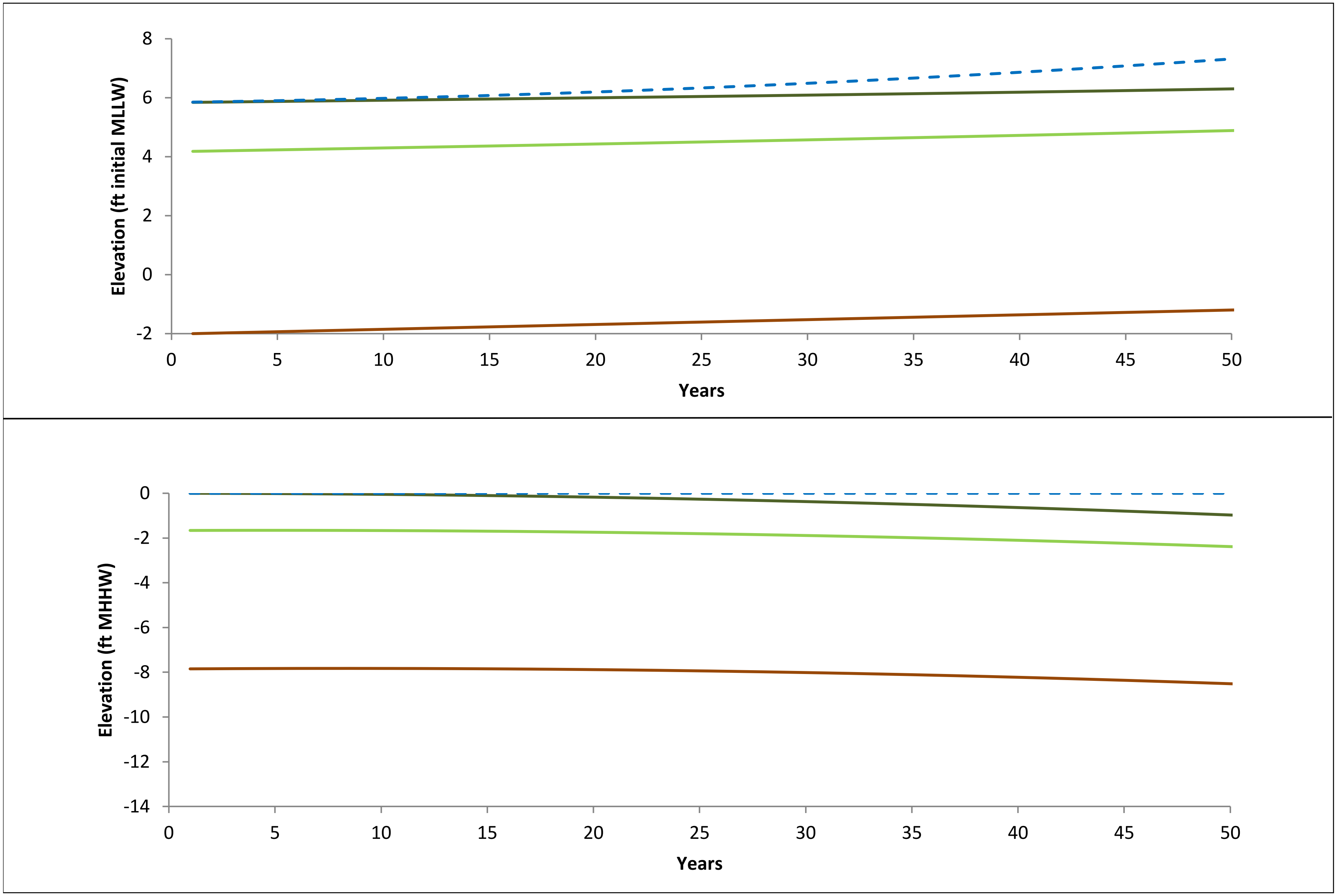


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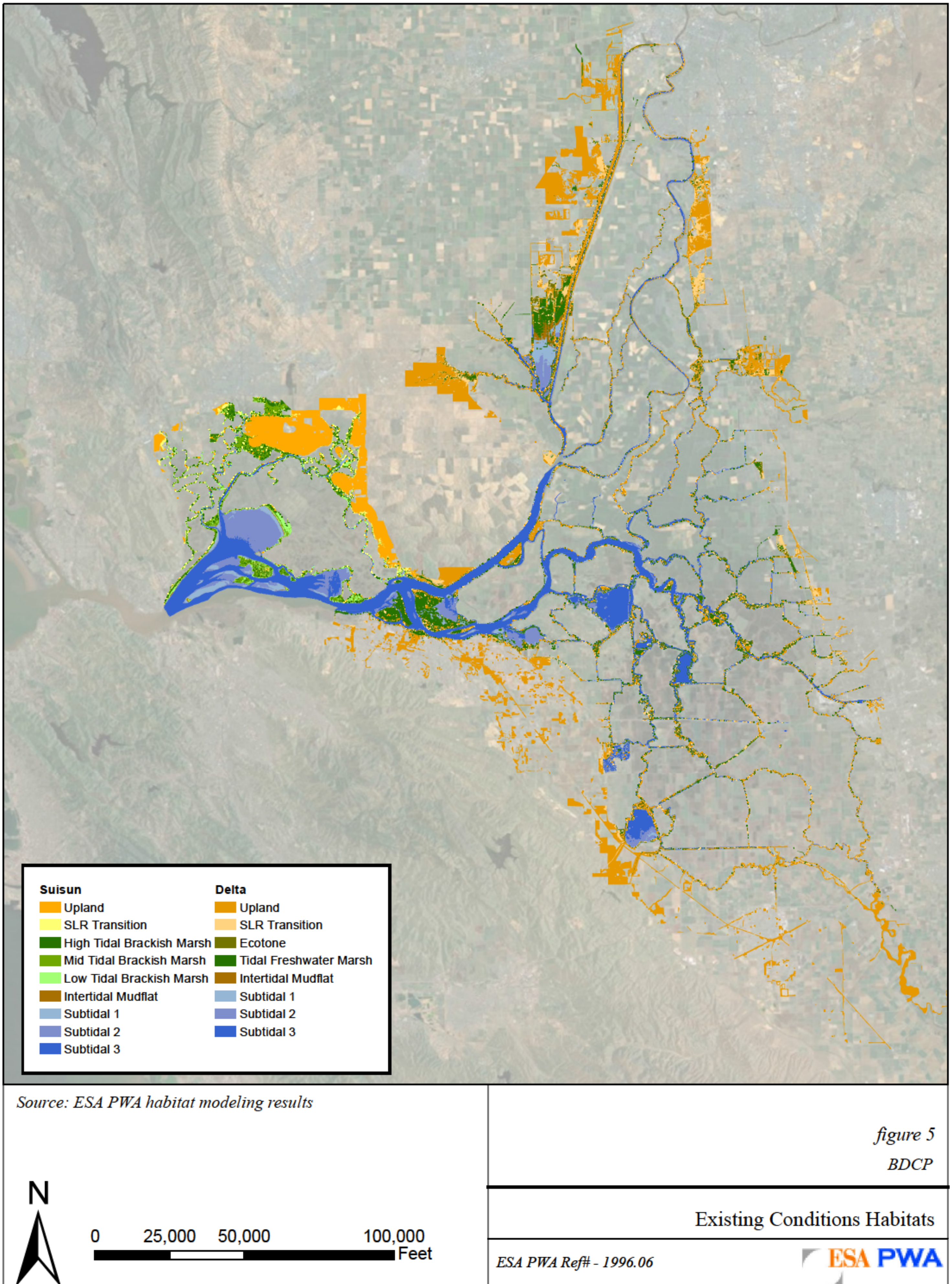
Figure 4
MARSH98 Sedimentation Curves for Suisun Marsh and Bay

Notes: MARSH98 Sedimentation Analysis for SLR Scenario = NRC-III; suspended sediment concentration =50 mg/L. Organic accretion rate=2.0 mm/yr for the 4.18 and 5.84 ft MLLW curves. No organic accretion for the -2 ft MLLW curve. MHHW=5.84 ft MLLW (Year 0) . z0 = initial elevation.

z0 = 5.84
z0 = 4.18
z0 = -2
MHHW



Source: ESA PWA habitat modeling results

figure 5

BDCP

Existing Conditions Habitats

ESA PWA Ref# - 1996.06

ESA PWA

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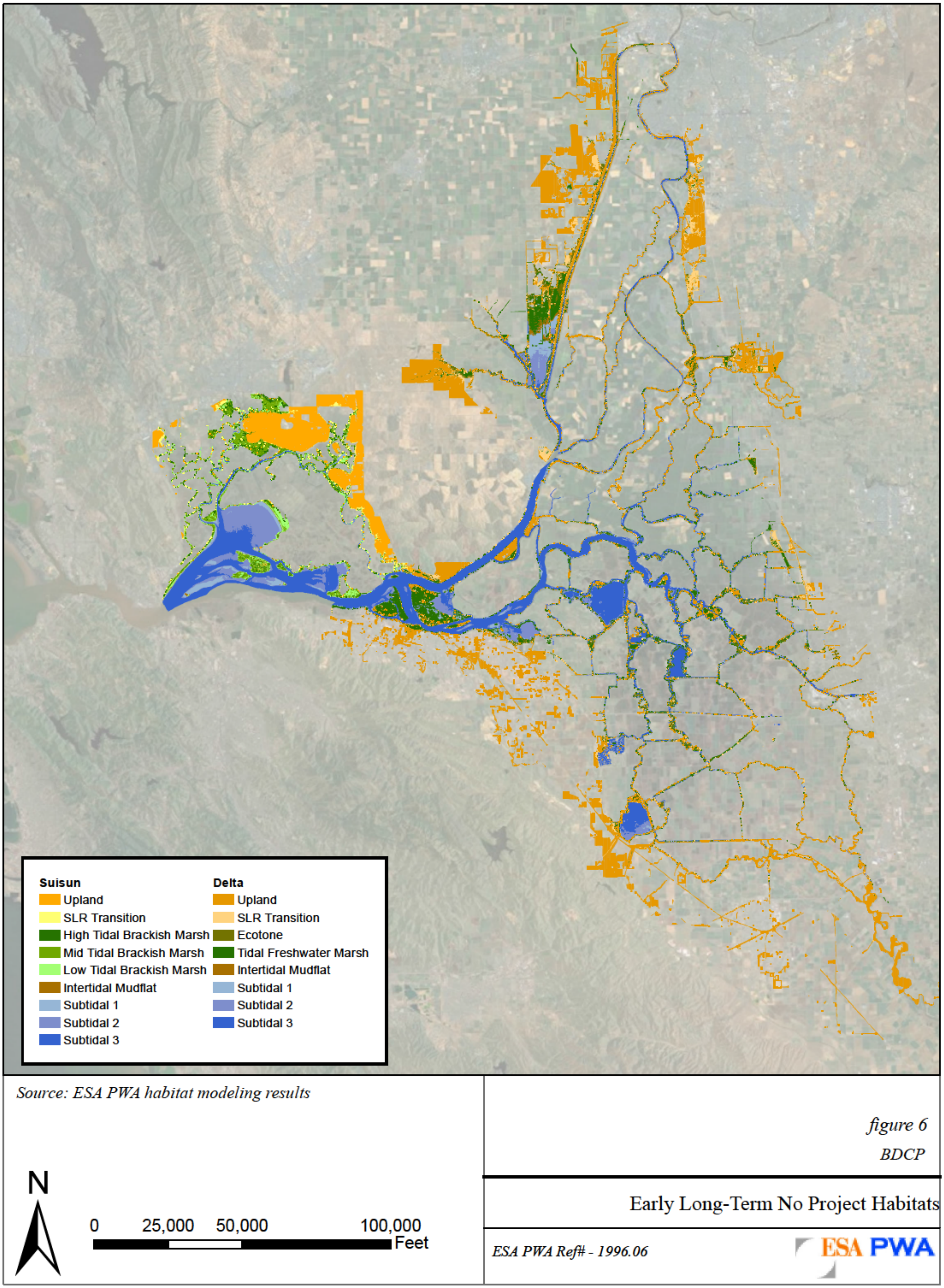

Source: ESA PWA habitat modeling results

figure 6

BDCP

Early Long-Term No Project Habitats

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ESA PWA

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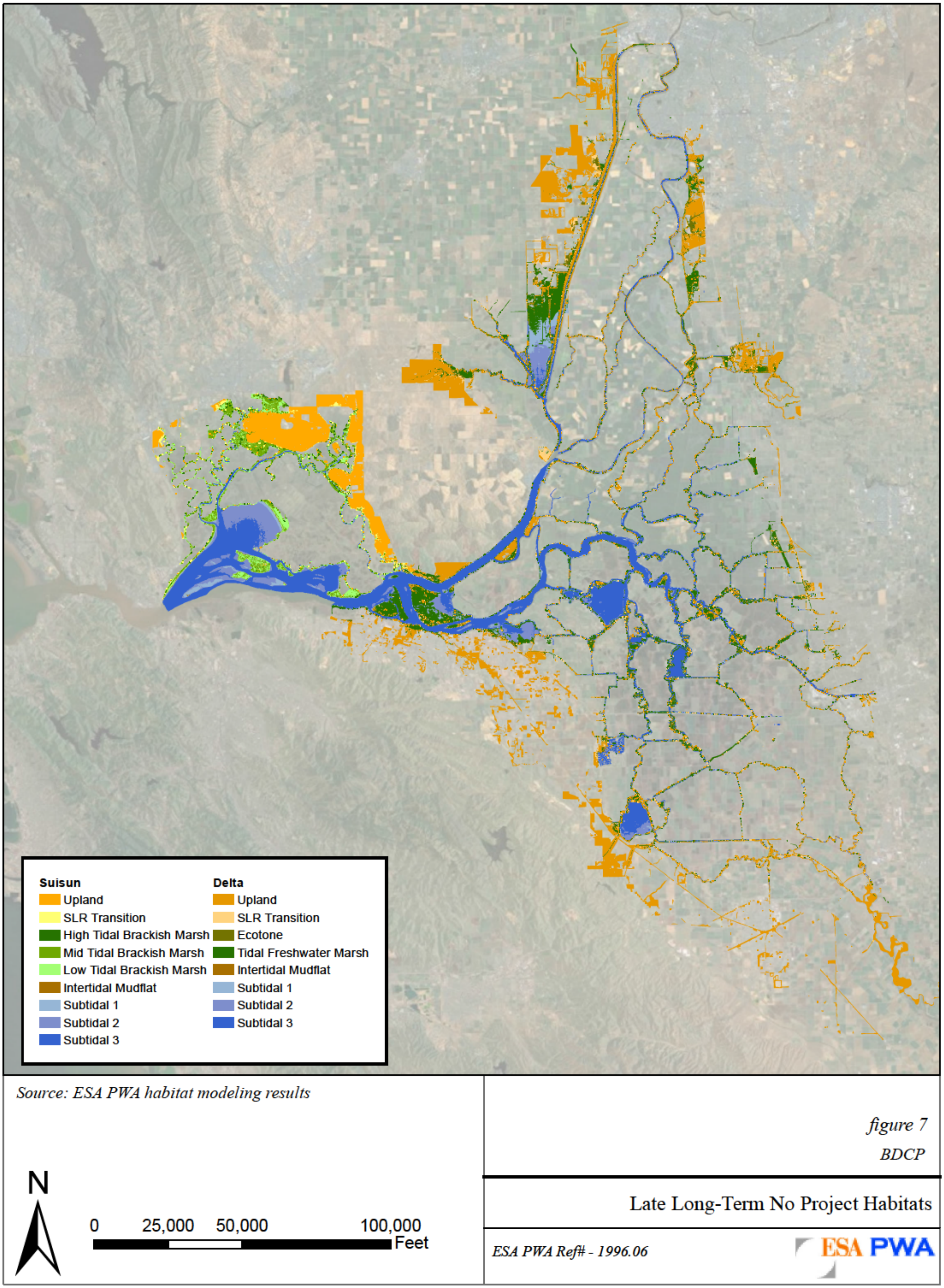

Source: ESA PWA habitat modeling results

figure 7

BDCP

Late Long-Term No Project Habitats

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ESA PWA

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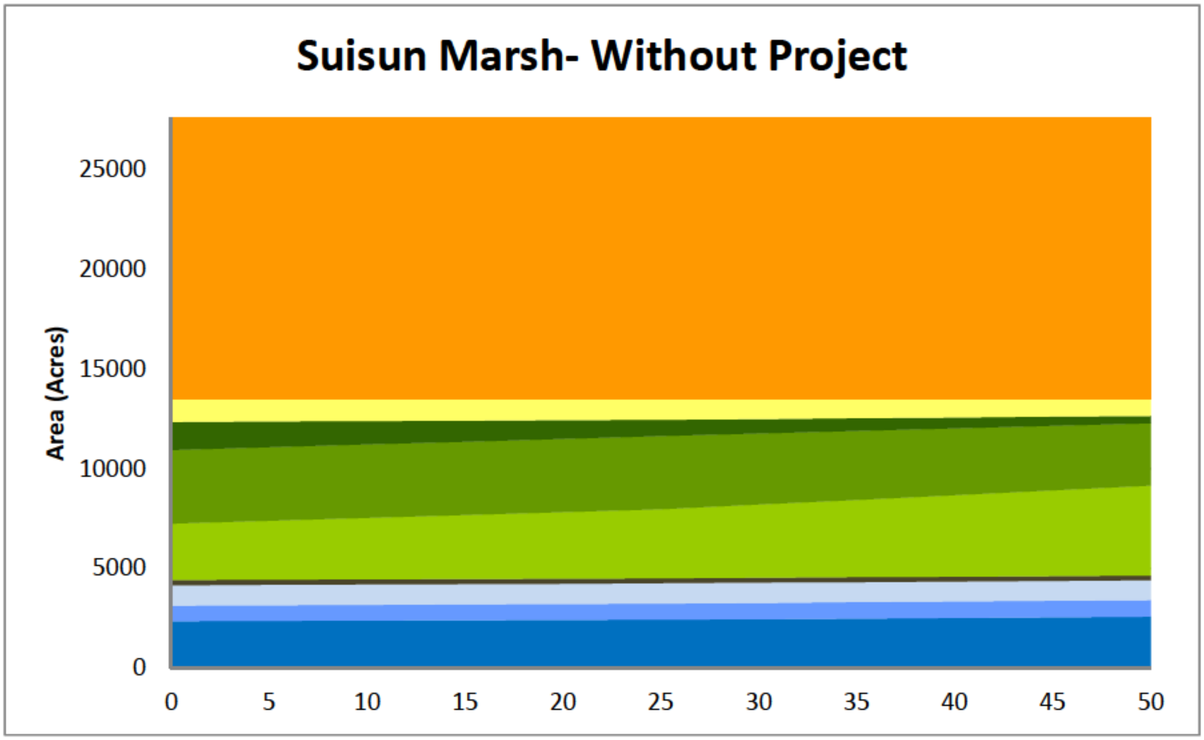
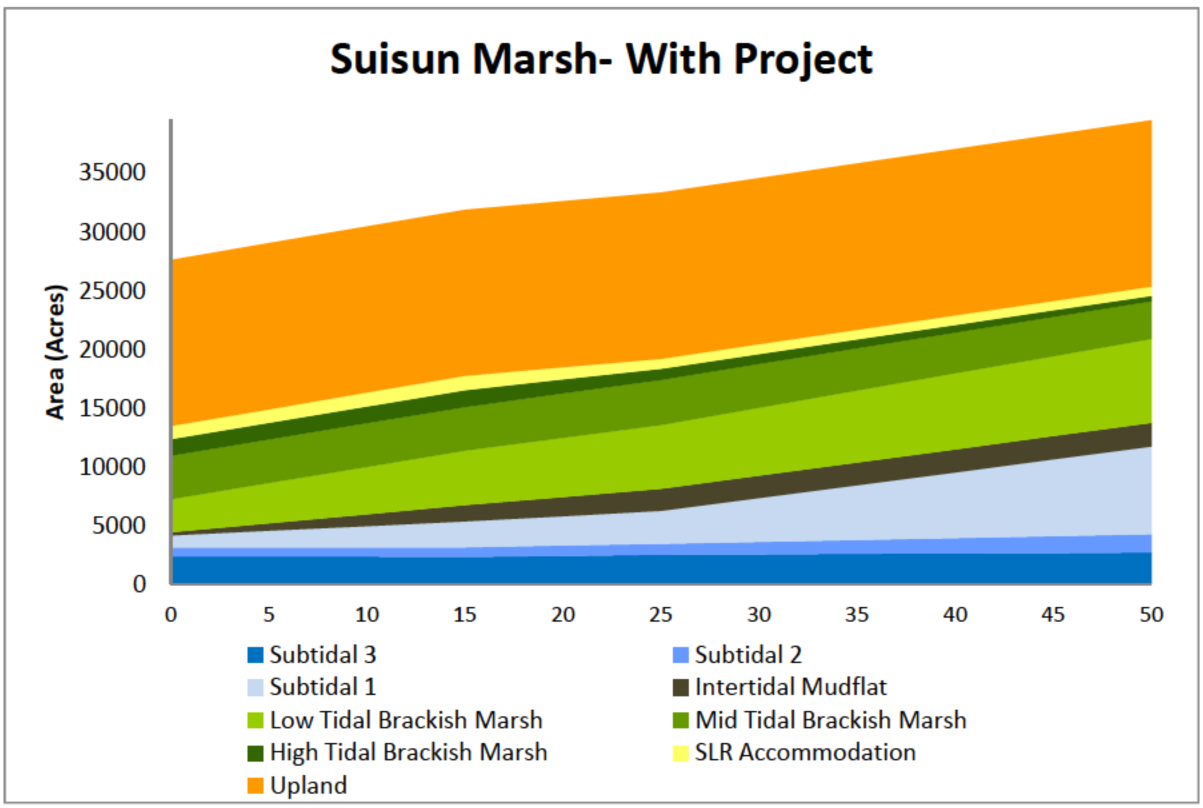




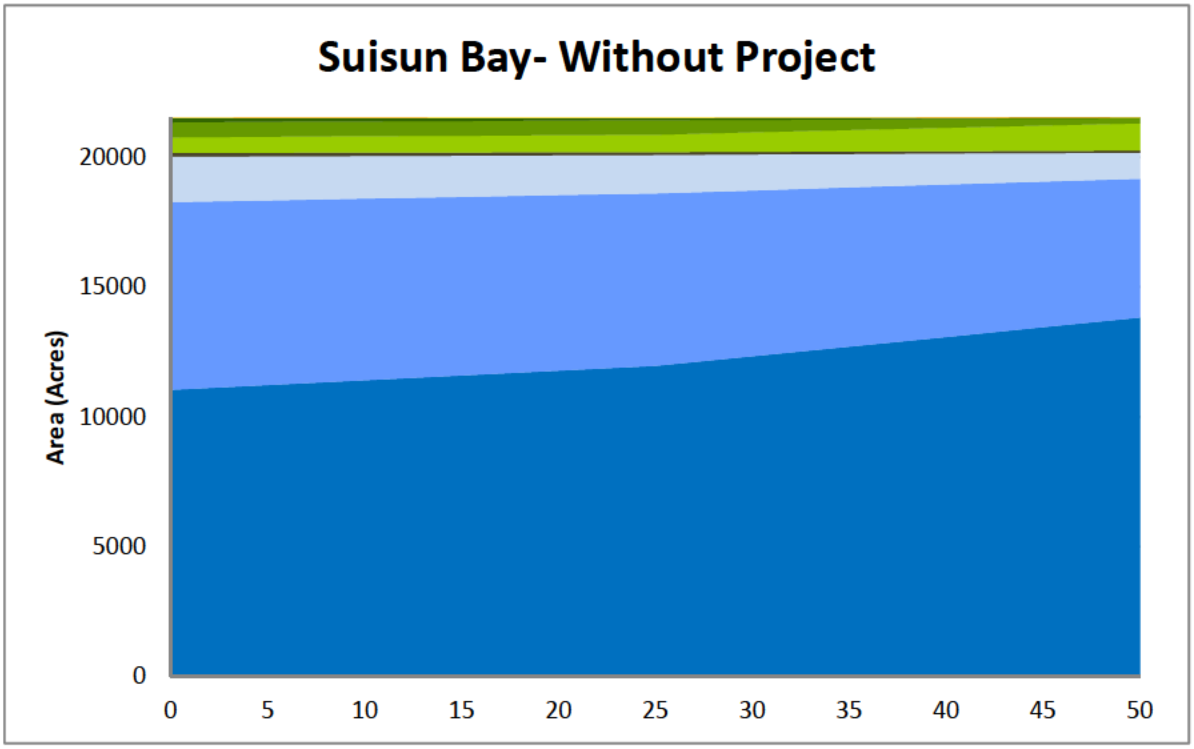
Source: ESA PWA habitat evolution modeling 2012

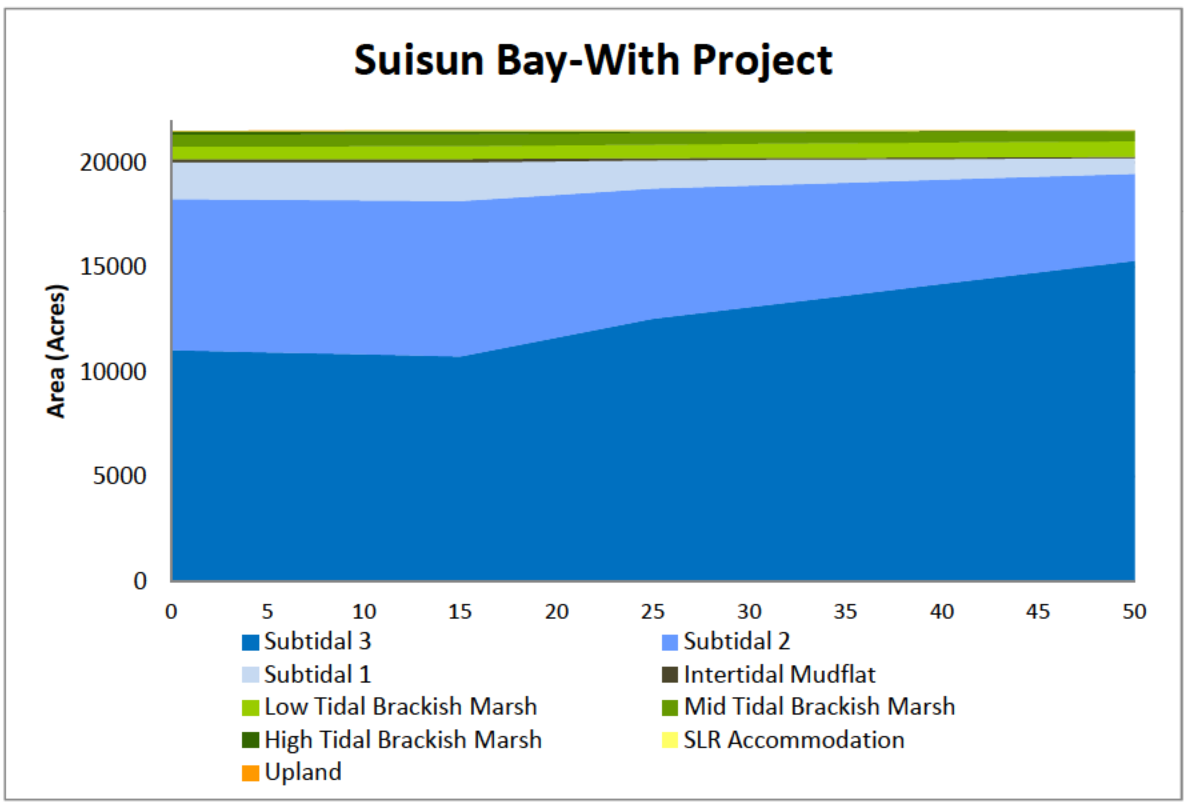
figure **8**

BDCP

Suisun Marsh Habitat Evolution

ESA PWA Ref#: 1996.06





Source: ESA PWA habitat evolution modeling 2012.

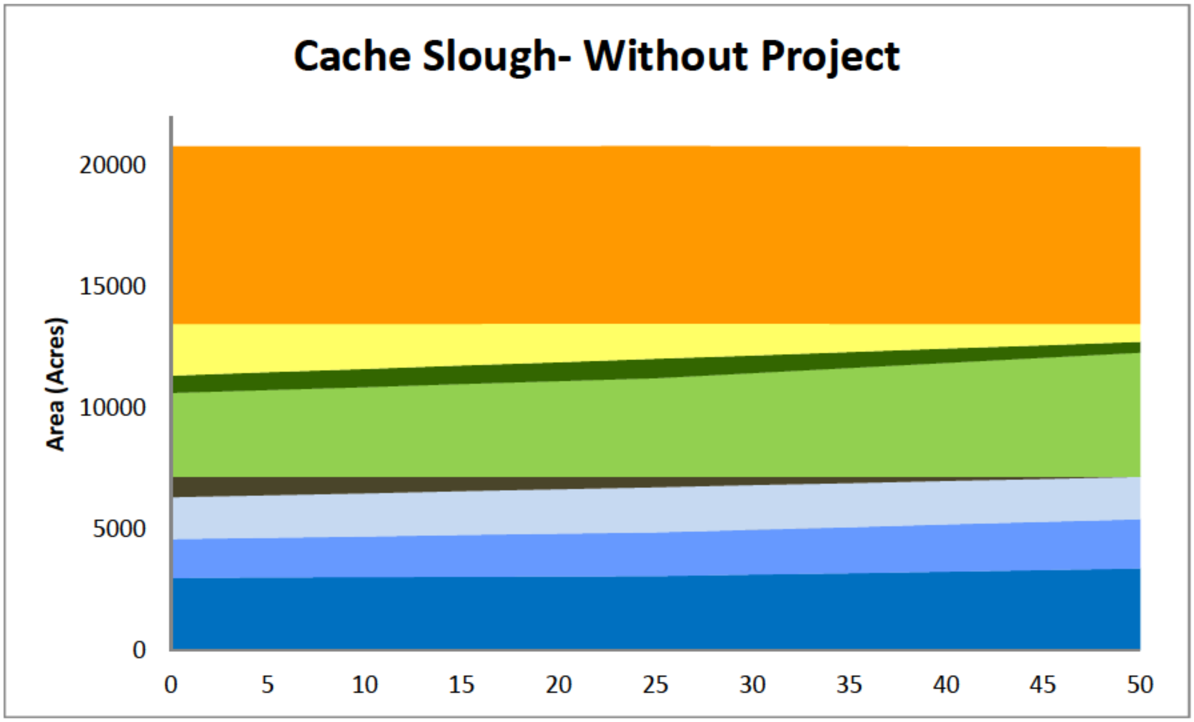
Notes:
Upland habitats and SLR accommodation exists, but in limited acres (3 acres and between 7-20 acres respectively) and are not evident on figure.

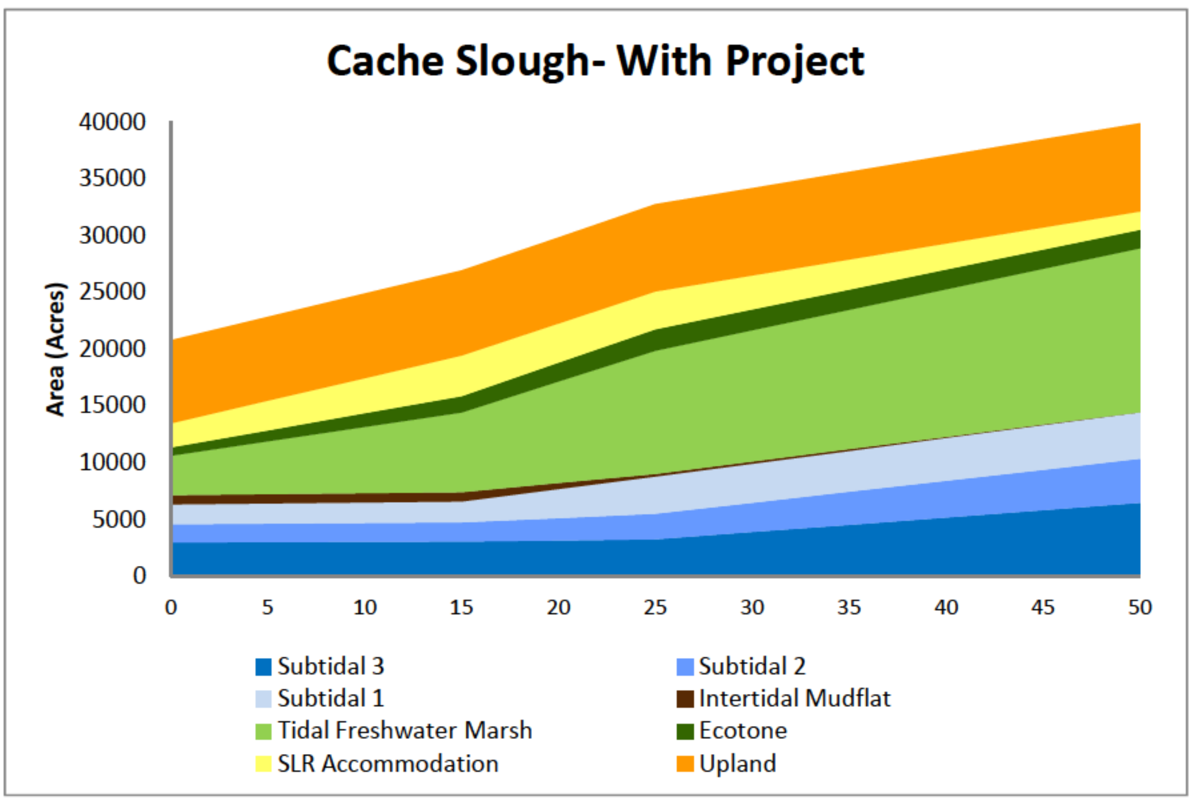
figure **9**

BDCP

Suisun Bay Habitat Evolution

ESA PWA Ref#: 1996.06





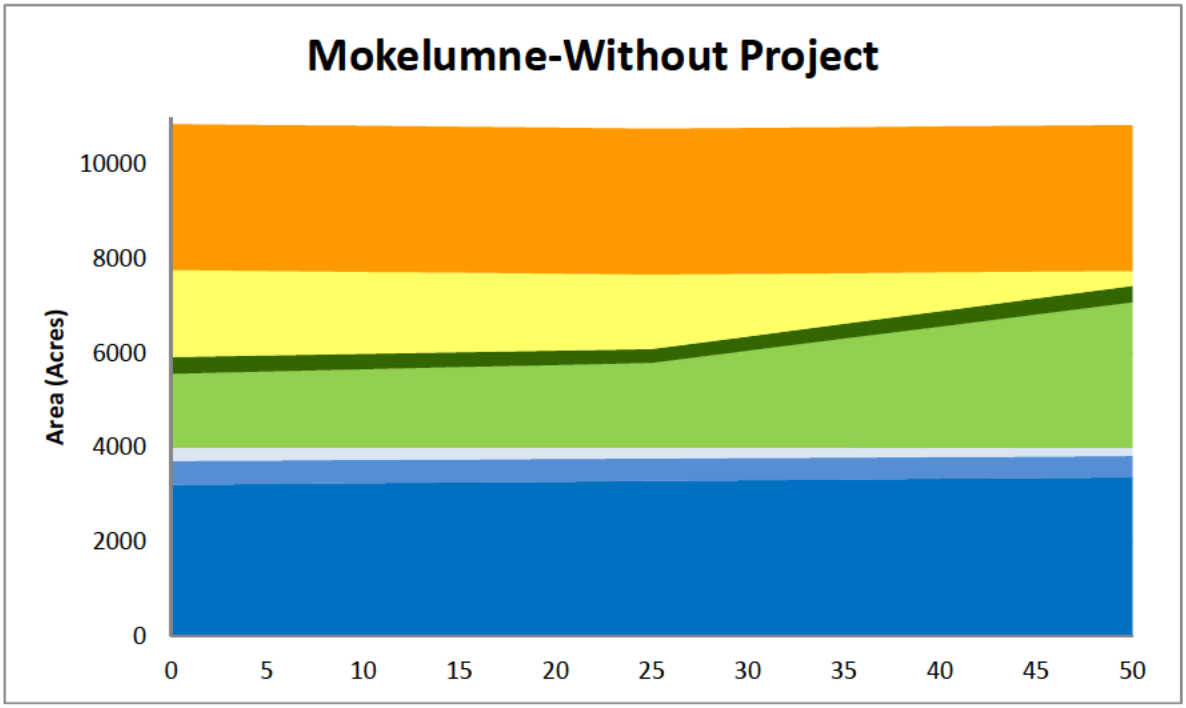
Source: ESA PWA habitat evolution modeling 2012

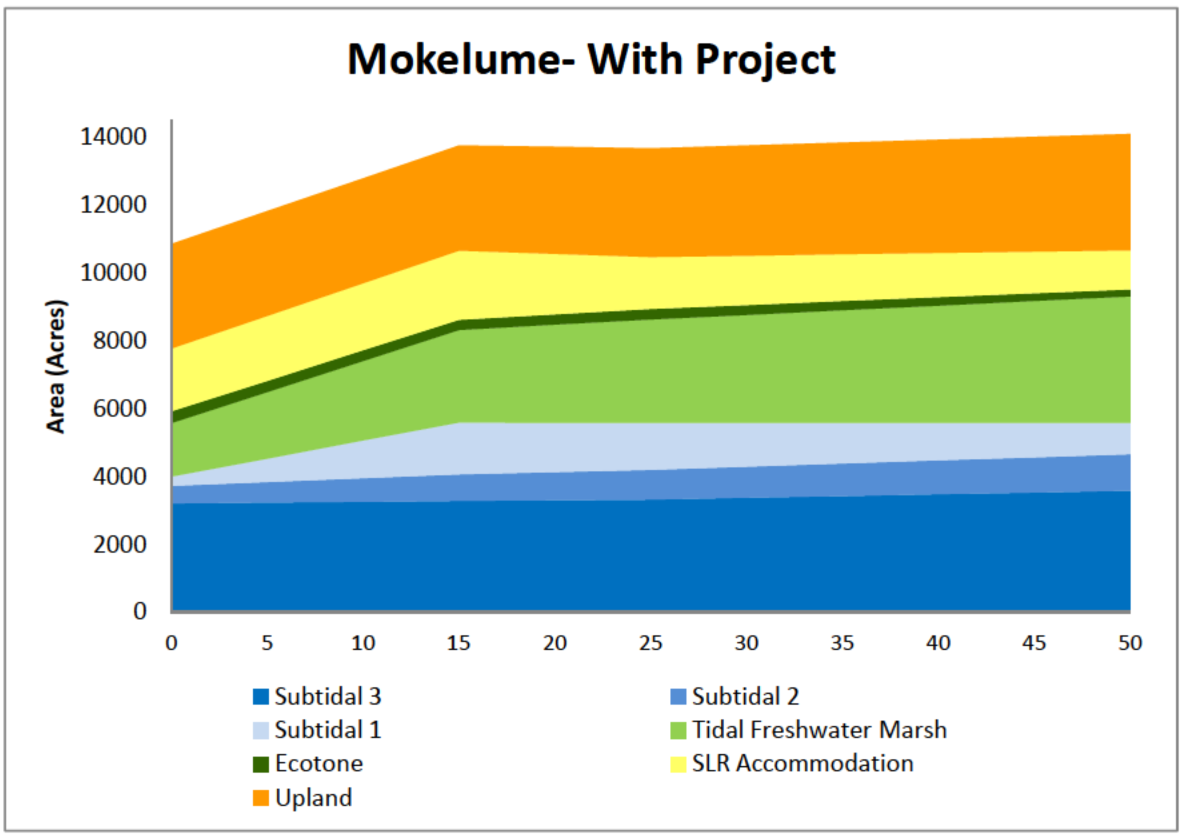
figure **10**

BDCP

Cache Slough Habitat Evolution

ESA PWA Ref#: 1996.06





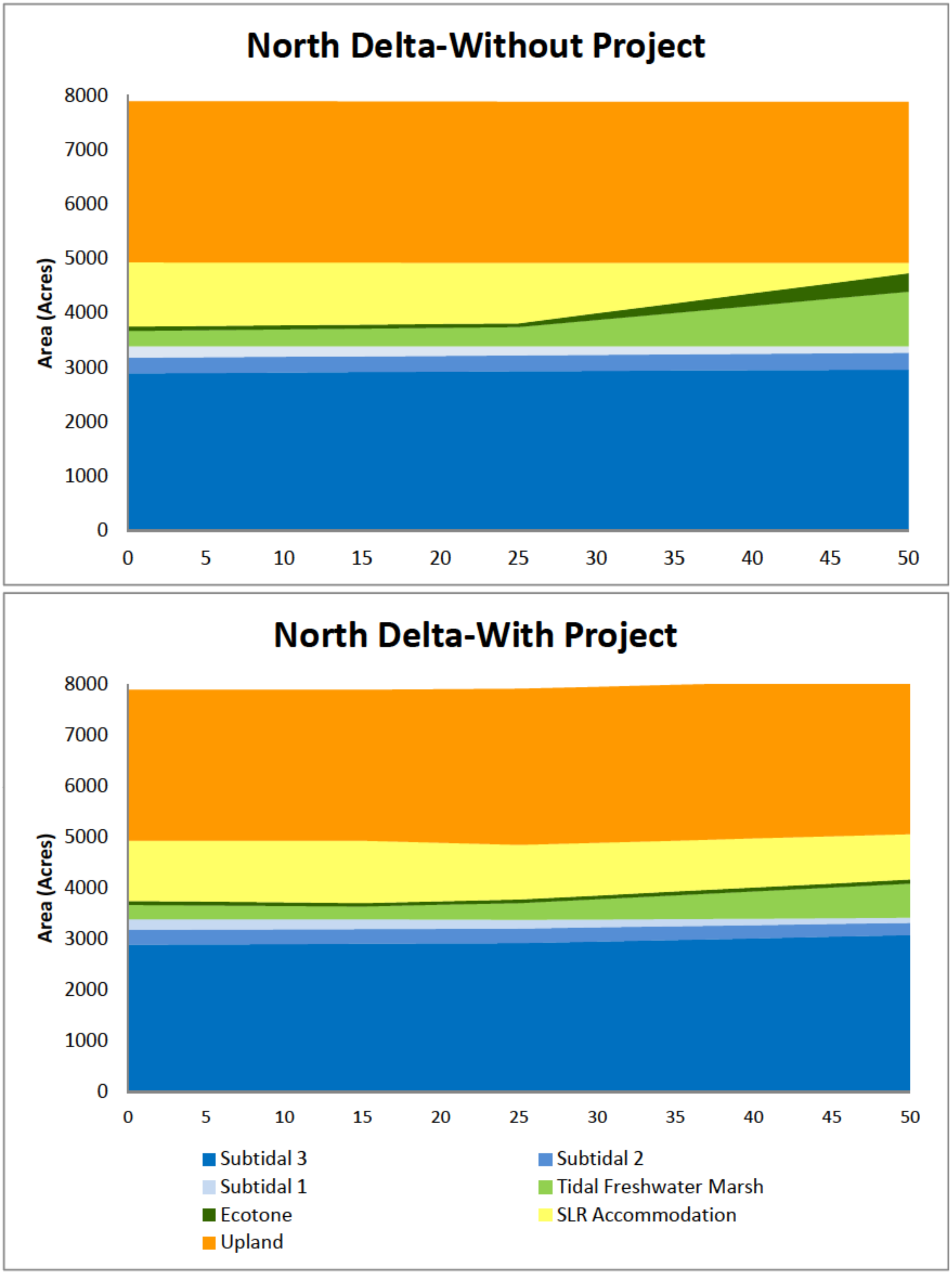
Source: ESA PWA habitat evolution modeling 2012

figure **11**

BDCP

Mokelumne Habitat Evolution

ESA PWA Ref#: 1996.06



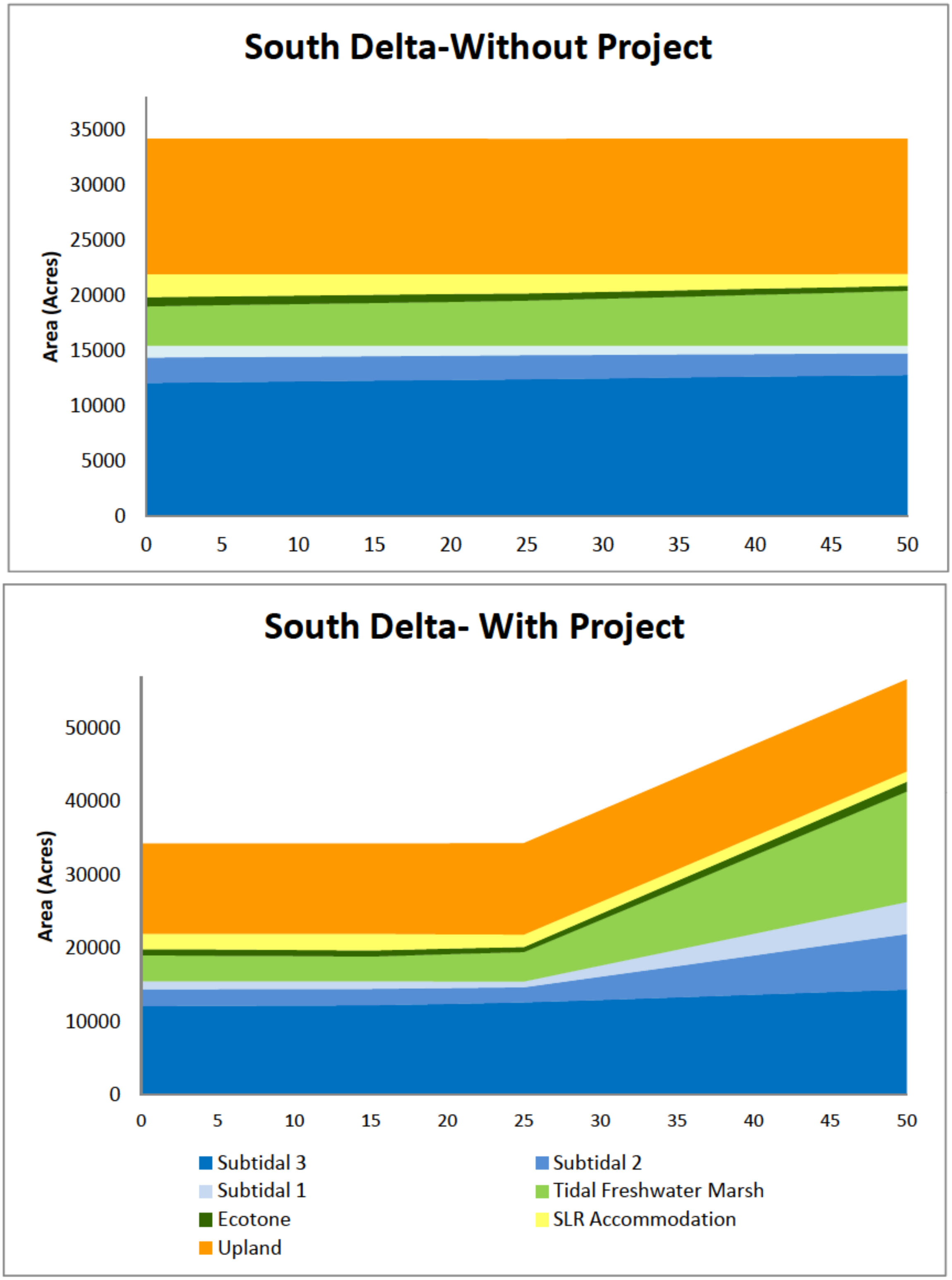
Source: ESA PWA habitat evolution modeling 2012

figure **12**

BDCP

North Delta Habitat Evolution

ESA PWA Ref#: 1996.06



Source: ESA PWA habitat evolution modeling 2012

figure **13**

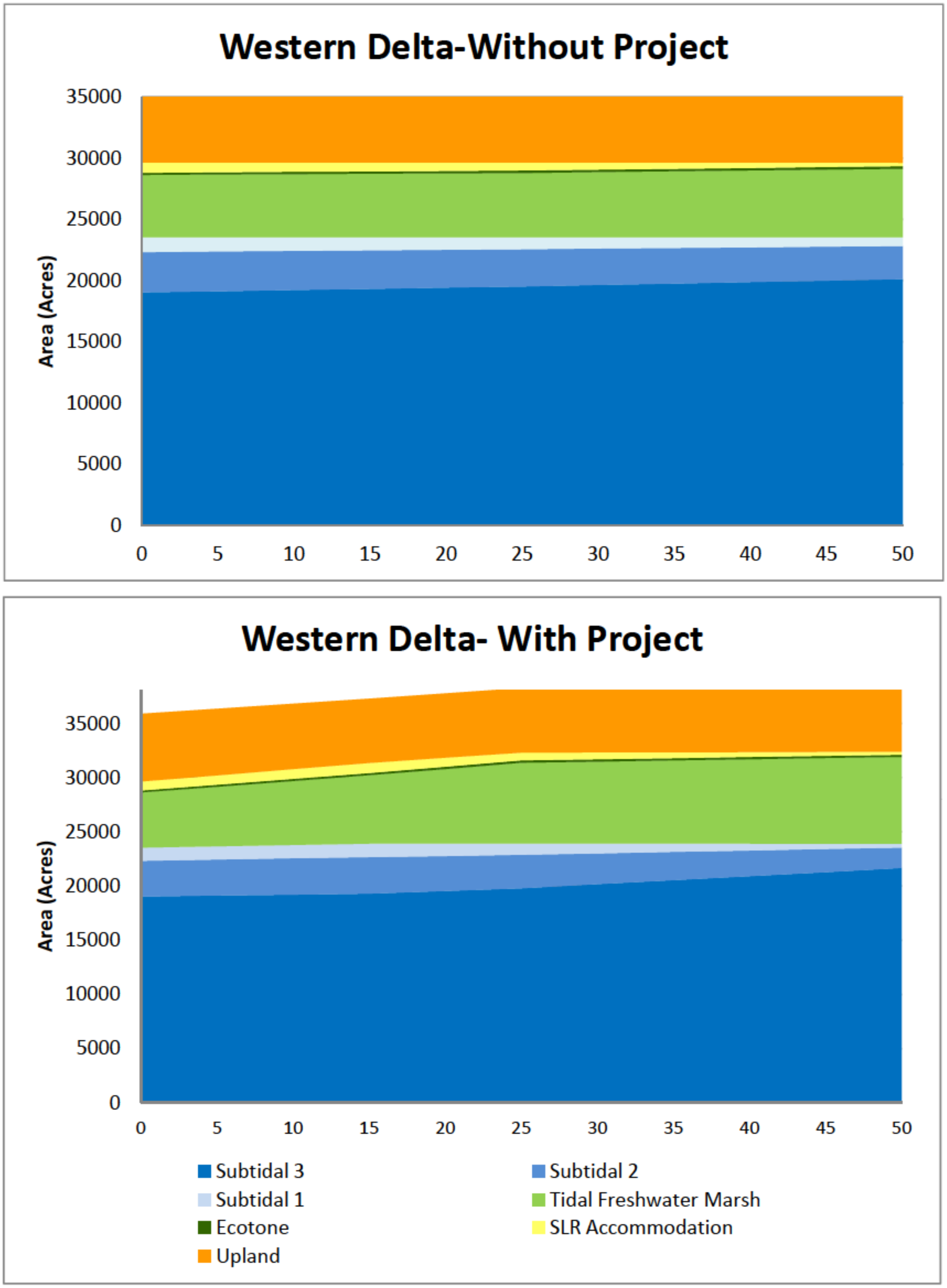
BDCP

South Delta Habitat Evolution

ESA PWA Ref#: 1996.06

ESA PWA

P HabitatAreas - correction 18Jun12_figuresJJO_adjusted2/ New South Delta



Source: ESA PWA habitat evolution modeling 2012

figure **14**

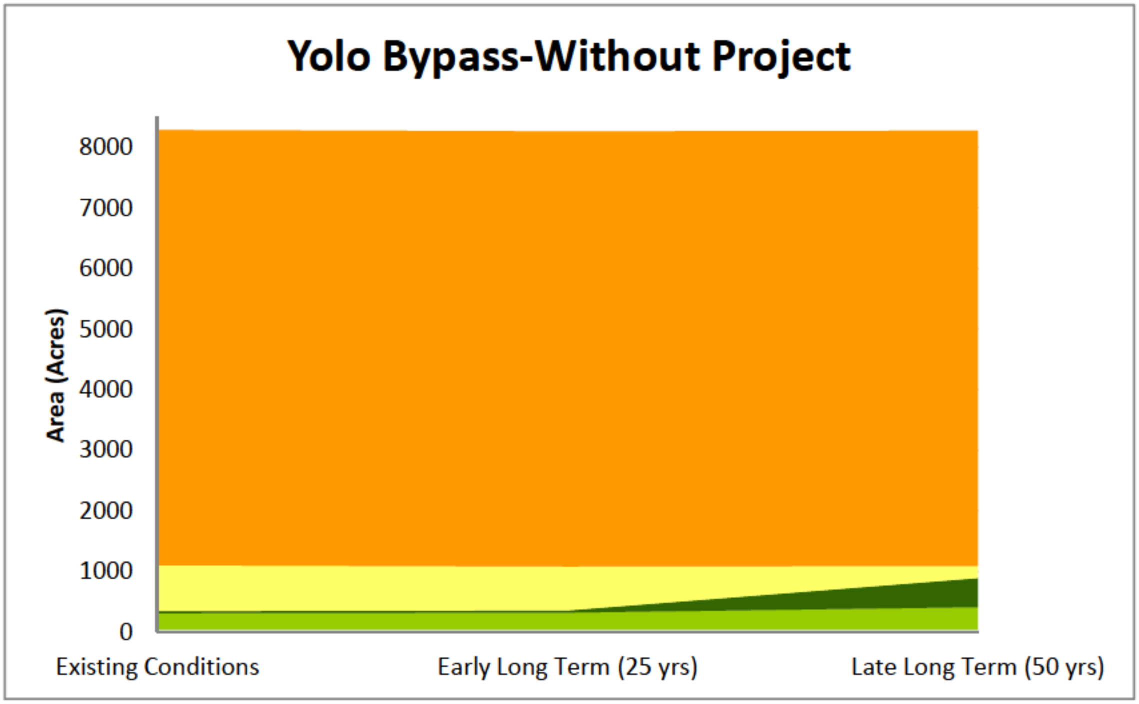
BDCP

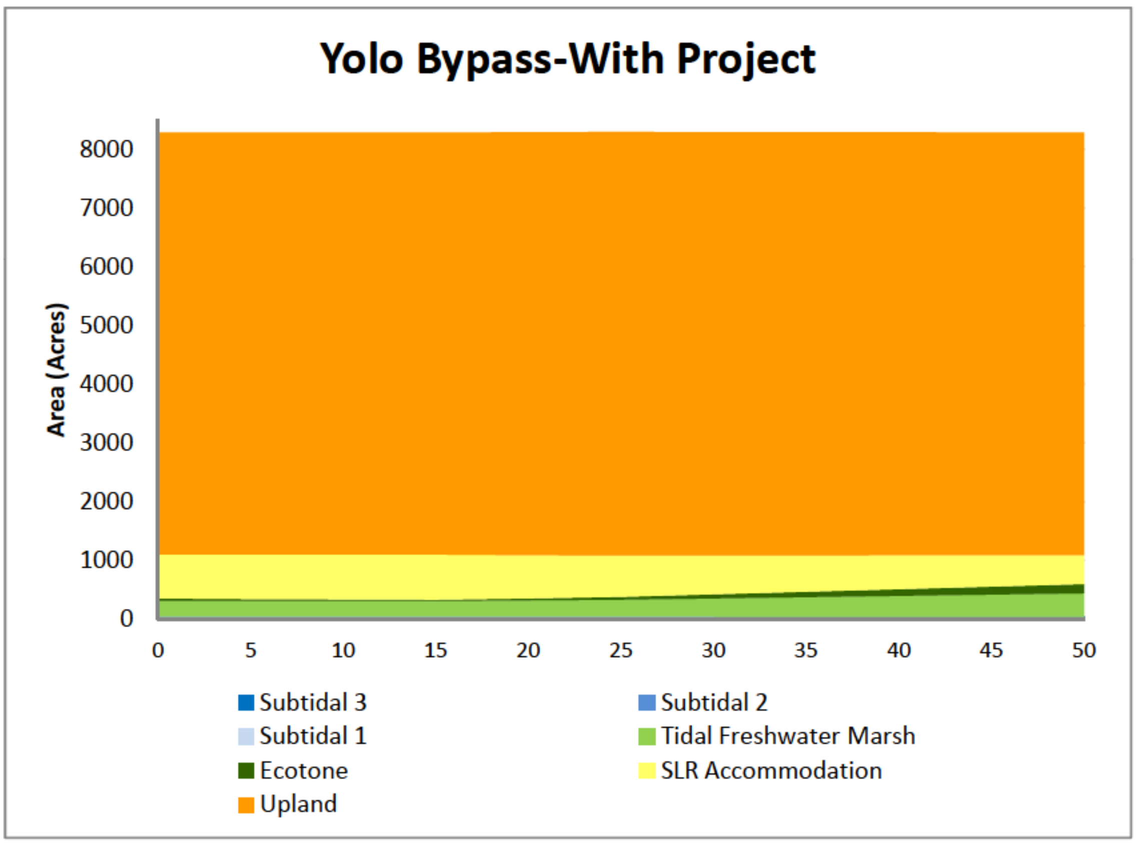
Western Delta Habitat Evolution

ESA PWA Ref#: 1996.06

ESA PWA

P HabitatAreas - correction 18Jun12_figuresJJO_adjusted2/ New Western Delta





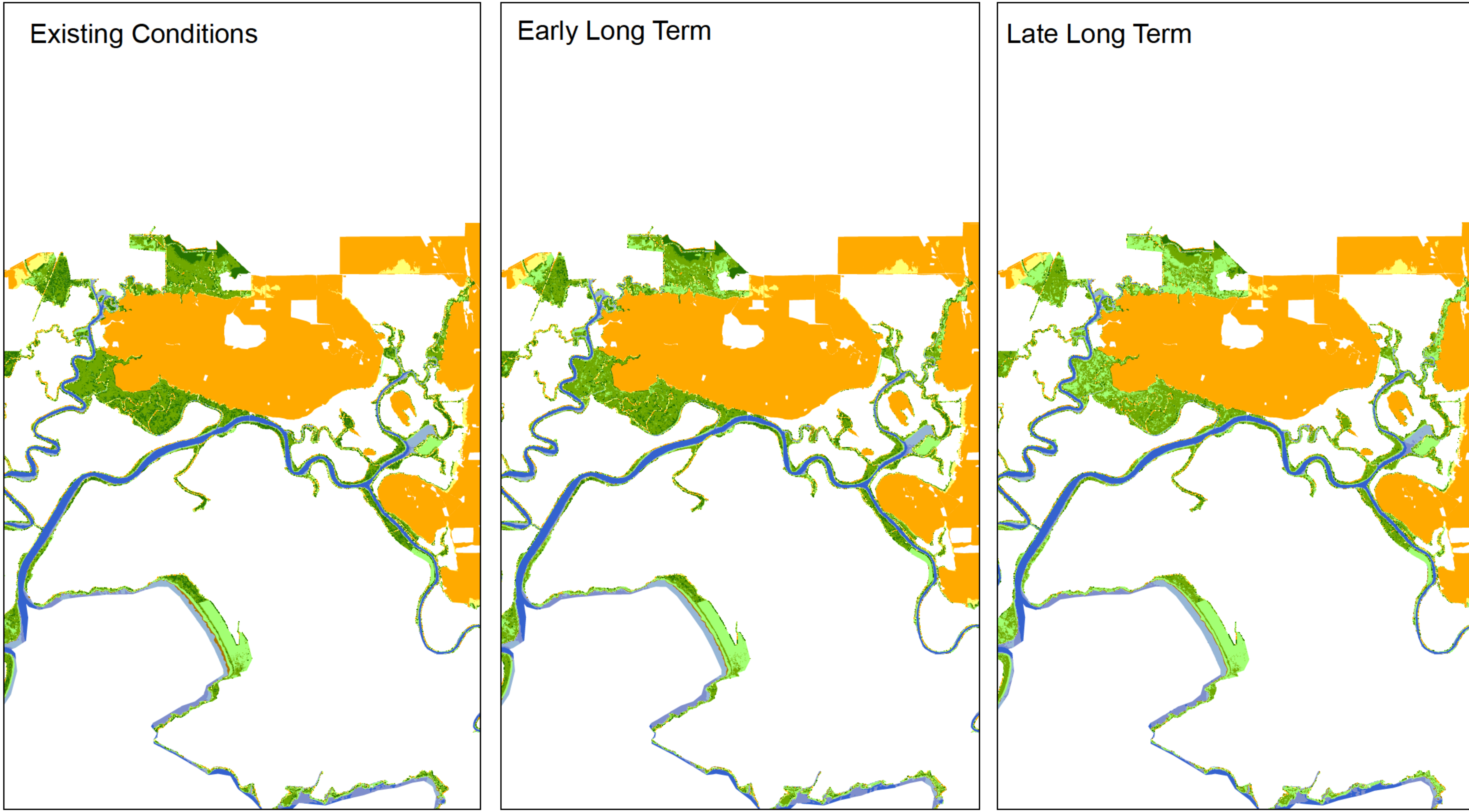
Source: ESA PWA habitat evolution modeling 2012

figure **15**

BDCP

Yolo Bypass Habitat Evolution

ESA PWA Ref#: 1996.06



Source From ESA PWA habitat evolution modeling

N

0 7,000 14,000 28,000 Feet

- Upland
- SLR Transition
- High Tidal Brackish Marsh
- Mid Tidal Brackish Marsh
- Low Tidal Brackish Marsh
- Intertidal Mudflat
- Subtidal 1
- Subtidal 2
- Subtidal 3

Figure 16

BDCP

Suisun Marsh Tidal Habitat Evolution- Detail

ESA PWA Ref # - 1996.06

ESA PWA

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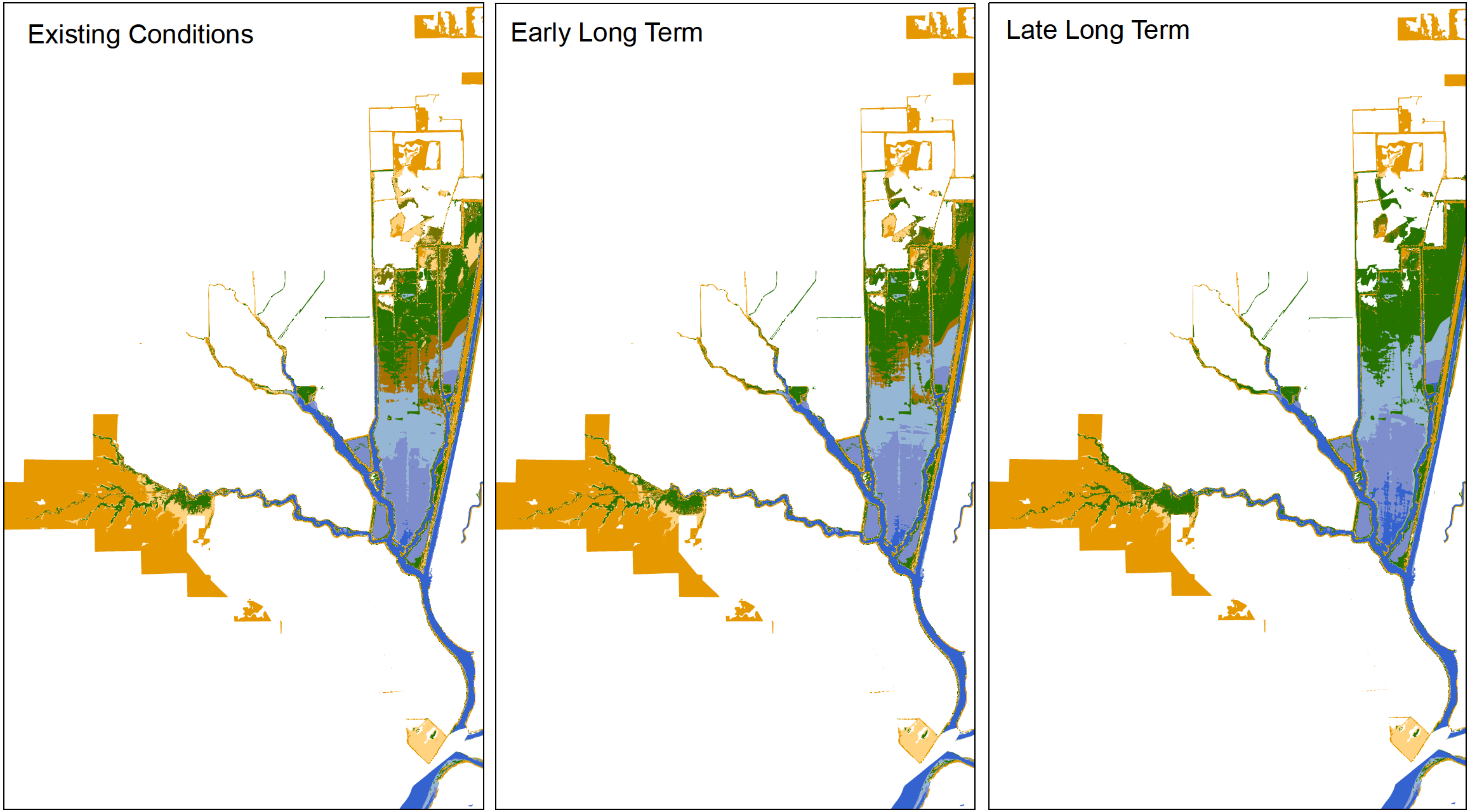

Source From ESA PWA habitat evolution modeling

N

0 7,500 15,000 30,000 Feet

- Upland
- SLR Transition
- Ecotone
- Tidal Freshwater Marsh
- Intertidal Mudflat
- Subtidal 1
- Subtidal 2
- Subtidal 3

Figure 17

BDCP

North Delta Tidal Habitat Evolution- Detail

ESA PWA Ref # - 1996.06

ESA PWA

J:\1996_BDCP_Tidal_Wetlands\Projects\ZoomedNorth.mxd

Attachment A. GIS Metadata

1. SAIC Topography/Bathymetry

This elevation grid was generated in support of BDCP habitat conservation planning processes. It is comprised of multiple elevation data sources that include: - 2 meter DEM derived from DWR's 1 meter LiDAR data (BOR 2008, 2 meter, NAVD88; resampled to 10 meters) - DWR's 1 meter LiDAR data (DWR 2007, 1 meter, NAVD88; resampled to 10 meters) - Liberty Island bathymetry data (DWR 2003, converted to NAVD88 and resampled to 10 meters) - IFSAR/USGS data (URS developed a 10 meter DEM (NAVD88) comprised of IFSAR data and USGS bathymetry to form a continuous terrain surface). The above datasets were merged giving priority to the datasets as they are listed.

2. BDCP Vegetation Mapping Metadata:

In order to perform BDCP Habitat Conservation Planning analysis a vegetation and land use dataset was required for the Legal Delta, Suisun Marsh, and the Yolo Bypass. There was no single dataset available that addressed all three regions. Therefore this dataset was compiled from a collection of vegetation surveys that include: -CDFG 2007 Vegetation and Land use Classification and Map of the Sacramento-San Joaquin River Delta, -CDFG 2006 Suisun Marsh Vegetation Mapping Change Detection, -San Francisco Estuary Institute1998 EcoAtlas, -Yolo County 2008 Natural Heritage Program, - CDFG 2008, additional mapping of the western Delta near Pittsburg, Collinsville, Van Sickle Island. Also note that a small amount of mapping was completed by SAIC staff to assign general vegetation classes to areas that fell between the boundary of the CDFG 2007 vegetation and land use layer and the Legal Delta boundary extents. The various datasets used to compile this general vegetation and land use dataset were developed with different methodologies, minimum mapping units, and source data representing different instances in time. Each dataset has various levels of associated error. Users of this compiled dataset are cautioned against using the information for detailed analysis. The information should be used in the context of habitat conservation planning activities occurring at the regional scale. It is acknowledged that conditions on the ground have continued to change; however, this information represents the most current data available for the planning area of interest. For further information concerning each source dataset please refer to following associated reports: California Department of Fish and Game, 2006. Suisun Marsh Vegetation Mapping Change Detection 2006. Prepared by T. Keeler-Wolf and R. Boul. California Department of Fish and Game, 2007. Vegetation and land use classification and map of the Sacramento-San Joaquin River Delta. Prepared by D. Hickson and T. Keeler-Wolf for the Bay Delta Region, California Department of Fish and Game, February 2007. The Yolo County Natural Heritage Program Regional Vegetation dataset: http://www.yoloconservationplan.org/maps-and-documents.html San Francisco Estuary Institute EcoAtlas version 1.50b4, October 1, 1998 (edited October 2007), http://www.sfei.org

Additional upland areas surrounding Suisun Marsh were mapped by ICF using 2010 NAIP aerial imagery. These areas were mapped at the natural community scale and do not have the higher detail associated with the DFG vegetation survey data.

Attachment B. MARSH98 Accretion Values in Suisun Marsh and Bay

Implementation Period	End Period	Ground Elevation (ft MLLW)	Accretion (ft)
Start	NT	-2	0.23
Start	NT	4.18	0.18
Start	NT	5.84	0.11
Start	ELT	-2	0.39
Start	ELT	4.18	0.32
Start	ELT	5.84	0.2
Start	LLT	-2	0.8
Start	LLT	4.18	0.71
Start	LLT	5.84	0.46
NT	ELT	-2	0.16
NT	ELT	4.18	0.14
NT	ELT	5.84	0.09
NT	LLT	-2	0.57
NT	LLT	4.18	0.53
NT	LLT	5.84	0.35
ELT	LLT	-2	0.41
ELT	LLT	4.18	0.39
ELT	LLT	5.84	0.26

Note: NT = Near-term; ELT = Early long-term; LLT = Late long-term

Attachment C. Depth Analysis

The average depth of each habitat type was estimated to support the BDCP effects analysis. To do this, ground elevations for each category and region were calculated as the average of the top and bottom ends of the elevation range for that habitat category. For example, the habitat category Subtidal 1, which ranges between MLLW and 3 ft below MLLW, has an average ground elevation equal to 1.5 ft below MLLW. For the depth analysis, the tidal datums for each region were spatially-averaged.

Since MTL is the average water level, at a ground elevation of MLLW, the average depth would be MTL minus MLLW. This is an average of the time-varying depths, which range from dry to covered by the full tide range. At a ground elevation of EHW, the average depth is zero since this is the maximum water height. At different elevations, depths were interpolated between those at MLLW and EHW. These values are presented in Table C-1Table .

Table C-1. Inundation Depths by Habitat Type, Late Long-Term With Project Scenaı

	Habitat Type	Ground Elevation			Inundation Depth	
		Maximum (with respect to Tidal Datum)	Maximum (ft NAVD)	Average (ft NAVD)	Average Depth (ft)	Depth at MHHW (ft)
Suisun Marsh	High Tidal Brackish Marsh	EHW	8.42	8.06	0.15	
	Mid Tidal Brackish Marsh	MHHW	7.71	7.41	0.43	0.09
	Low Tidal Brackish Marsh	MHW	7.11	5.72	1.16	1.79
	Intertidal Mudflat	MLLW + 1 ft	4.33	3.83	1.97	3.68
	Subtidal 1	MLLW	3.33	1.83	3.68	5.68
	Subtidal 2	MLLW - 3 ft	0.33	-1.17	6.68	8.68
	Subtidal 3*	MLLW - 6 ft	-2.67	< -2.67	> 8.18	> 10.18
Suisun Bay	High Tidal Brackish Marsh	EHW	8.22	7.86	0.15	
	Mid Tidal Brackish Marsh	MHHW	7.51	7.21	0.43	0.29
	Low Tidal Brackish Marsh	MHW	6.92	5.66	1.09	1.84
	Intertidal Mudflat	MLLW + 1 ft	4.41	3.91	1.84	3.60
	Subtidal 1	MLLW	3.41	1.91	3.55	5.60
	Subtidal 2	MLLW - 3 ft	0.41	-1.09	6.55	8.60
	Subtidal 3*	MLLW - 6 ft	-2.59	< -2.59	> 8.05	> 10.1
Cache Slough	Tidal Freshwater Marsh	MHHW	7.13	6.24	0.60	0.89
	Intertidal Mudflat	MLLW + 1 ft	5.36	4.86	1.17	2.27
	Subtidal 1	MLLW	4.36	2.86	2.87	4.27
	Subtidal 2	MLLW - 3 ft	1.36	-0.14	5.87	7.27
	Subtidal 3*	MLLW - 6 ft	-1.64	< -1.64	> 7.37	> 8.77
Mokelumne	Tidal Freshwater Marsh	MHHW	6.91	5.86	0.59	1.05
	Subtidal 1	MLLW	4.82	3.32	2.46	3.59
	Subtidal 2	MLLW - 3 ft	1.82	0.32	5.46	6.59
	Subtidal 3*	MLLW - 6 ft	-1.18	< -1.18	> 6.96	> 8.09
North Delta	Tidal Freshwater Marsh	MHHW	7.29	6.21	0.62	1.08
	Subtidal 1	MLLW	5.13	3.63	2.51	3.66
	Subtidal 2	MLLW - 3 ft	2.13	0.63	5.51	6.66
	Subtidal 3*	MLLW - 6 ft	-0.87	< -0.87	> 7.01	> 8.16
South Delta	Tidal Freshwater Marsh	MHHW	6.56	5.38	0.69	1.18
	Subtidal 1	MLLW	4.21	2.71	2.65	3.85
	Subtidal 2	MLLW - 3 ft	1.21	-0.29	5.65	6.85
	Subtidal 3*	MLLW - 6 ft	-1.79	< -1.79	> 7.15	> 8.35
Western Delta	Tidal Freshwater Marsh	MHHW	7.06	5.54	0.88	1.52
	Subtidal 1	MLLW	4.02	2.52	2.99	4.54
	Subtidal 2	MLLW - 3 ft	1.02	-0.48	5.99	7.54
	Subtidal 3*	MLLW - 6 ft	-1.98	< -1.98	> 7.49	> 9.04

Table C-1. Inundation Depths by Habitat Type, Late Long-Term With Project Scenario (Continued)

	Habitat Type	Ground Elevation			Inundation Depth	
		Maximum (with respect to Tidal Datum)	Maximum (ft NAVD)	Average (ft NAVD)	Average Depth (ft)	Depth at MHHW (ft)
Yolo Bypass	Tidal Freshwater Marsh	MHHW	7.16	5.87	0.73	1.29
	Subtidal 1	MLLW	4.58	3.08	2.72	4.08
	Subtidal 2	MLLW - 3 ft	1.58	0.08	5.72	7.08
	Subtidal 3*	MLLW - 6 ft	-1.42	< -1.42	> 7.22	> 8.58

* For Subtidal 3 category, value shown for average ground elevation is maximum elevation and values shown for depths are the minimum depths.