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Memorandum

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To Abigail Fateman and John Kopchik - East Contra Costa County Habitat Conservancy

From Jessica Olson, M.L.A., Mark Lindley, P.E. and Jeffrey Haltiner, PhD, P.E.

Subject Knightsen Habitat Restoration Feasibility Study

The East Contra Costa County Habitat Conservancy and its partners are considering acquisition of a 645 acre parcel in Knightsen, CA (project site). Historically, the project site supported alkali wetlands and grasslands, stabilized interior dune, oak savanna, and tidal marsh habitats. This memo describes the methods and results of a restoration feasibility study of the project site for potential to enhance or restore habitats that historically were found on site and to provide storm water quality treatment. The memo first describes historical and present day site conditions, the key components of the target restoration habitats, and storm water quality treatment facilities. Next, the memo discusses opportunities and constraints of restoring target habitats and providing storm water quality treatment. Lastly, we discuss potential next steps, including recommended future studies necessary to develop and implement a restoration plan if the site is acquired.

Site Conditions

We conducted a site visit on December 10th 2012 and reviewed existing GIS data, ESA-PWA's previous storm water study, and analyzed soil conditions to characterize the site conditions.

The 640 acre Knightsen property land cover type currently consists primarily of agricultural fields and limited areas of seasonal wetlands (Figure 2). The site boundaries include several features including roads, canals and neighboring properties (Figure 1). Delta Road bisects a northern parcel from the southern parcel. Eagle Lane defines the southern boundary, along with No Name Slough, which enters the south-eastern portion of project site. Two unnamed irrigation ditches extend north to south bisecting agricultural fields and marking western boundary of the southern portion of project site. South of Delta Road, the western boundary is bordered by Byron Highway and neighboring business and residential properties, while north of Delta road the site is bordered by two residential properties. Several easements for power lines, transmission lines, and irrigation ditches bisect the property (Appendix A).

Soils on site consist of both sand, loam and clay, including Marcuse clay, piper fine sandy loam, Sacramento clay (a sodic or "alkaline" soil type), and Delhi sand (Figure 3). The presence of clay, sand and sodic soils are indicative of historical habitats on the site including tidal marsh, interior sand dunes, alkali seasonal wetlands, and oak savanna (Figure 4). We collected soil samples from areas with clay and/or sand soils throughout the site to test whether the soil pH indicates alkaline soils that would support some of the specific target restoration habitat (see description of seasonal alkali wetland below). Using the Leaf Luster Rapitest pH test kit, we tested the soil pH from 6 soils characterized as clay or clay loam and 4 characterized as sand or sandy clay loam. All of the samples taken in clay soils have a soil pH of approximately 7.5 and indicate alkaline soils. Samples characterized as sand or sandy clay loam (taken from remnant dunes) had pH of 7.0. In addition to testing the soil pH, we sent two samples to a soils lab for further testing. Results indicate that the clay soils on site are slightly saline but not sodic or sodic-saline (Appendix B). See *Seasonal Alkali Wetland Complex* section below for more information.

The site elevation ranges from 1-20 feet NAVD also indicates that the site historically supported a wide spectrum of habitats from tidal wetlands (elevations approx. 6 feet to 3 feet NAVD) to seasonal wetland and upland habitats (elevations greater than 6 ft NAVD) (Figure 3 and 5). Existing ground water elevation is approximately 6.5-7.5 NAVD 88 (PWA 2002). Storm water generally flows from north to south-east (PWA 2012) making the site a potential capture area for stormwater flow from the town of Knightsen.

Existing vegetation along ditches and sloughs is dominated by an herbaceous understory with an occasional tree or shrub in the overstory. Native species observed on site include: sedges (*Carex* sp.), stinging nettle (*Urtica dioica*), salt grass (*Distichlis spicata*), mugwort (*Artemisia douglasiana*), alkali heath (*Frankenia salina*), Western flat-topped goldenrod *(Euthamia occidentalis)*, creeping wild rye (*Elymus tridicodies*), cattails (*Typha angustifolia),* and bullrush (*Schnoplectus acutus*) and an occasional willow (*Salix* sp.). Non-native species include Bermuda grass (*Cynodon dactylon),* Himalayan blackberry (*Rubus discolor*), and giant reed (*Arundo donax*).

Vegetation on the northern parcels includes several plant species indicative of sand dunes and alkali seasonal wetlands. Previous surveys indicate the presence of plant species characteristic of sand dunes including California croton (*Croton californicus*) (Abigail Fateman pers. comm. December 2012). Seasonal wetland species observed on the December 2012 field visit include: alkali heath (*Frankenia salina*), alkali weed (*Cressa truxillensis*), rushes (*Juncus* sp.), sedge (*Carex* sp.), alkali mallow (*Malvella leprosa*). Lastly, a large heritage oak tree is present on the southern parcel, indicative of historical oak savanna habitat type (Figure 4). Follow up surveys, at multiple times of year to capture flowering times, are recommended to characterize all existing vegetation.

Target Restoration Habitats

The Conservancy and its partners are interested in restoring or creating the following habitat types on site (1) seasonal alkali wetlands (2) stabilized interior dune (3) oak savanna (4) freshwater tidal marsh. We describe the key components of each habitat type and discuss the opportunities and constraints of restoring these features at the project site. Opportunities and constraints that apply to all habitats are discussed below. While the term "restoration" may imply complete reversion to previous state, actually converting a site back to a certain point in history is usually unrealistic because present day conditions reflect altered conditions in disturbance regimes, species invasions, hydrologic regime, climate change, surrounding land use changes and adjacent site land use constraints (Hobbs et al. 2009). However, recreation of the major habitat types, to provide the same functions as were provided historically is often feasible within site constraints. We consider the historical conditions as context and discuss how the site may function following restoration.

Primary sources of reference information include:

- East Contra Costa County Historical Ecology Study (Stanford et al. 2011)
- Sacramento- San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process (Whipple et. al 2012)
- Manual of California Vegetation (Sawyer et al. 2009)
- Tidal Wetland Vegetation in the San Francisco Bay-Delta Estuary (Vasey et. al 2012)

Alkali Seasonal Wetland Complex

Historically, alkali seasonal wetlands occurred on the project site (Figure 4) and the presence of seasonal alkali vegetation adjacent to current farmed areas indicates the potential to support this habitat following restoration. Alkali seasonal wetlands are characterized by hummocky, varied micro topography which supports a mosaic of salt-influenced habitats including small brackish ponds/pools, alkali flats, alkali sink-scrub and seasonally inundated alkali meadow (Stanford et al. 2011). Alkali seasonal wetlands are seasonally inundated from a couple of inches (meadow features) to one foot or more (pond/pool features) (Stanford et al. 2011). Alkaline habitats are characterized by having sodic soils. There are several characteristics of sodic soils including (Brandy and Weil 2002):

- Alkaline pH (greater than 8.5 pH)
- The “sod” in sodic refers to sodium (Na), which is prevalent on the cation exchange complex (CEC). But Na is not the only reason for alkalinity. Bicarbonate and borates can also cause the high pH, so sodic soils can have Ca, K and/or Mg as well. Sodium Adsorption Ratio (SAR) of sodic soils is typically greater than 13-15.
- There are two classes of sodic soils, sodic and saline-sodic. The later has an Electrical Conductivity (EC) > 4, or greater than 2 mmhos/cm.
- Sodic soils typically have high clay content.

Soil testing indicates clay soils are not sodic or saline-sodic but have some characteristics of saline soils (Appendix B). Soils have a slightly alkaline pH (7.3-7.4 pH) and high percent cation saturation of magnesium (Mg) (35-41%) and moderate percentage cation saturation of potassium (K) (3.2-3.6%), and moderate to high percent cation saturation of sodium (Na) (4.6-8.2%), and low percent cation saturation of calcium (47-56%). Soils are slightly saline with high to moderate concentrations of soluble salts (1.6-2.1 mmhos/cm). The sodium adsorption ratio, however, is significantly lower than characteristic of sodic soils (3.8-4.9) (Appendix B). Results can vary seasonally as rainfall and seasonal flooding can decrease sodium concentrations. Further, soils may become more saline following restoration of seasonal wetlands. In particular, as water evaporates and leaves behind salts, soils may become increasingly saline.

Despite the lack of sodic soils, vegetation typical of alkaline wetlands already occurs on site, indicating the soils are suitable to support alkali vegetation. Expected vegetation within alkali seasonal wetlands includes salt grass (*Distichlis spicata*), alkali heath (*Frankenia salina*), alkali weed (*Cressa truxillensis*), pickleweed (*Salicornia* sp.), rushes (*Juncus* sp.), sedge (*Carex* sp.), alkali mallow (*Malvella leprosa*), and saltbush (*Atriplex* sp.) (Stanford et al. 2011). Several of these species were present within the northern parcels of the property between the dune communities and adjacent to sloughs and ditches on the southern parcels.

The presence of alkali vegetation currently on site indicates that portions of the site have suitable soils and hydrology to support seasonal alkali wetland features. Restoring and managing tidal flows to the site may further assist in seasonal wetland development as extreme high tides may inundate seasonal wetlands and allow for a more dynamic hydrologic system. This tidal to seasonal wetland transition zone is likely to shift landward as sea level rises, known as estuarine transgression. Maintaining hydrological connection between seasonal wetlands and tidal wetlands is an important aspect in making it possible for estuarine transgression to occur.

Stabilized Interior Dune

Historical interior dune features in this area were created as a result of windblown processes during the Pleistocene (Stanford et. al. 2011). Two historical dune features are present in the northern portion of the property and are characterized by sandy soils (Figure 3 and 4). Historically, the sand dune features on the project site were probably sparsely vegetated but little historical reference data exists to characterize the vegetation (Stanford et. al. 2011). Based on sources available, stabilized interior due vegetation includes silver bush lupine (*Lupinus albifrons*), California croton (*Croton californicus*), slender buckwheat (*Erogonum gracil),* and valley lessingia *(Lessingia gladulifera)* (Stanford et. al. 2011). California croton has been observed on site (Abigail Fateman pers. comm. December 2012). In addition, non-native invasive grass species have extensively colonized the dune.

The existing site topography, presence of sandy soil, and presence of target vegetation indicates a good opportunity to restore or enhance the existing dune features. The existing native vegetation on both the dune and seasonal wetland habitats in the northern parcels indicates that the entire northern parcel could require a less intensive approach to restoration. A vegetation enhancement project could be implemented, to expand existing native vegetation patches and reduce weed patches. Since existing desirable native vegetation is in a patchy mosaic, site grading would be difficult without impacting desirable vegetation. Alternatively, extensive manipulation of the site may be preferable if complete elimination of invasive species is required. We observed extensive grading on an adjacent parcel with comparable sandy soils (to create ponding). Where the excavated sand had been placed in large mounds, it appears to remain mostly unvegetated. While invasive grasses appear to be absent after using this approach, desirable species would be impacted by site grading as well. Vegetation surveys at appropriate times of year to characterize all vegetation present would help in deciding whether extensive site manipulation is necessary or a less intensive approach is appropriate.

Oak Savanna

Oak savanna habitat features are characterized by widely spaced blue oak (*Quercus douglasii*) or valley oak (*Quercus lobata)* trees (between 10-30% canopy cover), and an herbaceous understory (Sawyer et. al 2009). While the elevations are suitable to support oak savanna, the poorly drained clay soils that dominate the site may be unsuitable to support blue oaks. Blue oak woodlands are typically found on shallow, low fertility, and moderately to excessively drained soils (Sawyer et. al 2009). However, there is potential to support valley oak woodland, as they can tolerate seasonally saturated soils and alluvial or residual soils (Sawyer et. al 2009). Further, the presence of what appears to be a large heritage valley oak, perhaps remnant from when the south western parcels were oak savanna indicates the potential to restore oak savanna.

Sea level rise poses a potential constraint to restoring oak savanna, assuming the restored oak savanna areas would be hydrologically connected to estuarine habitats. Specifically, as estuarine habitats shift upslope as sea level rises, the future range of potential suitable oak savanna habitats would be narrowed. Concentrating the oak savanna restoration effort to the highest elevation areas and anticipating future transgression areas could alleviate this constraint.

Freshwater Tidal Marsh

Historically freshwater tidal marsh occurred on site (Figure 3). Key components of freshwater tidal wetlands include a complexity of channels and low to high marsh vegetation, and hydric soils. Elevations necessary to support a variety of low to high marsh vegetation are approximately 2-6 feet NAVD (Table 1) and occur on site. Soils are typically high in clay content, which is also found throughout the site (Figure 3). Expected vegetation within these features is characterized below.

Table 1. Local Tidal Datum's at Dutch Slough

	Feet NGVD	Feet NAVD
Mean Higher High Water (MHHW)	3.15	5.97
Mean High Water (MHW)	2.7	5.48
Mean Tide Level (MTL)	1.47	4.29
Mean Low Water (MLW)	0.23	3.11
Mean Lower Low Water (MLLW)	-0.29	2.58

Based on local reference site at nearby Sand mound Slough (Vasey et. al 2012) a diversity of vegetation may have potential to be supported on site. Low marsh to mid marsh areas have potential to support emergent vegetation such as California bulrush (*Scirpus californicus*) and cattail (*Typha* spp.), tule (*Scirpus acutus*) (Vasey et al. 2012).

Mid to high marsh vegetation may include silverweed (*Potentilla anserine)*, Western flat-topped goldenrod *(Euthamia occidentalis)*, seaside arrow grass *(Triglochin maritima)*, willow herb *(Epilobium cilatum)*, marsh fleabane *(Pluchea odorata)*, spikerush *(Eleocharis macrostachya)*, water smartweed *(Persicaria punctata)*, California loosestrife *(Lythrum californicum)*, bur marigold *(Bidens laevis)*, panicle bulrush *(Scirpus microcarpus)*, slough sedge (*Carex obnupta)* and Baltic rush (*Juncus balticus*). In small patches, woody species including dogwood *(Cornus sericeus)*, arroyo willow *(Salix lasiolepis)*, and cottonwood *(Populus fremontii)* have potential to establish on site (Vasey et. al 2012). Future studies that characterize vegetation at Sand mound slough in relation to tidal datums would be helpful to develop refine revegetation plans at the project site.

The Knightsen property has high potential to establish tidal freshwater wetlands on site without extensive site grading. With a low gradient slopes and elevations that can support tidal marsh to upland habitats there is also potential for tidal wetlands to transgress landward as sea level rises. Since many existing wetland to upland transition zones are disconnected because of roads, development or other infrastructure, locations than can accommodate estuarine transgression are increasingly important to restore (The Goals Project 1999). Overall, this site is extremely well-suited for restoring tidal marsh.

Water Quality Treatment

Previous studies (PWA 2002) identified the 645 acre Knightsen property as an excellent site to treat stormwater using treatment wetlands and biofilter swales. Treatment wetlands detain water and are sized based on an expected storm water volume whereas biofilter swales allow stormwater to slowly flow through vegetation while infiltrating and are sized on a flow rate/velocity.

Because standing water has been observed on parcels immediately south of Delta Road (PWA 2002), this area may be particularly well-suited to host treatment wetlands or biofilter swales. The areas to the north may have limited potential as well assuming this does not conflict with dune restoration and seasonal wetland enhancement.

If the location of the water quality treatment site is within tidal elevation ranges (as is the case with the area immediately south of Delta Road) biofilter swales and treatment wetland features will need to be hydrologically disconnected from tidal wetlands in order for the these feature to function properly, filter pollutants and to prevent the area from converting to tidal marsh. Treated storm water could be pumped out or discharged from the storm water treatment features, but tidal exchange would need to be prevented.

The size of the wetland treatment facility will be determined based on the contributing watershed area. These may range from the immediate adjacent subwatersheds that flow into the site or eventually, all stormwater from the central and southwestern regions of Knightsen (PWA 2002). The ultimate site design can be flexible in this, perhaps initially treating runoff from a smaller area, then expanding as various stormwater conveyance improvements are made in the more developed parts of Knightsen. Potential locations and water quality treatment volumes (in acre feet) from individual subwatershed or for regions were identified in the earlier PWA study (Table 2). Watersheds 4 and 9 are immediately adjacent to the project site, which would require treatment of 12.3 and 8.5 acre-feet respectively. The site could also be used to treat 28 and 54 acre feet of storm water from central and southwest Knightsen (Figure 6). Based on an approximate treatment depth of 1- to 2-ft, approximately 40-80 acres of the site could be used for the treatment wetland. This area would have a seasonally-varying habitat function, ranging from season- freshwater marsh to shallow freshwater pond. It would likely include extensive fresh and brackish marsh vegetation in the perennially wet areas, transitioning to alkali marsh vegetation in the drying areas.

Table 2. Potential Stormwater Treatment Requirements (From PWA 2002)

Watershed (WS)	Watershed Area (Acres)	Water Quality Volume (Acre-ft)
WS 3	321	5.8
WS 4 (Adjacent to Project Site)	684	12.3
WS 5	1,537	27.7
WS 6	1,146	20.6
WS 7	189	3.4
WS 8	235	4.2
WS 9 (Adjacent to Project Site)	473	8.5
Region		
Central Knightsen (WS 4,7,8,9)	1,581	28.4
Southwest Knightsen (WS 3,5,6)	3,004	54

Summary of Opportunities and Constraints

Overall, the existing site topography, soils, and existing vegetation indicate the site is well suited to accommodate the full range of historical habitats from tidal marsh to upland habitats. The site topography has been not greatly altered from natural elevations, sites soils have been only slightly modified and the potential hydrological parameters are available. With a low gradient slopes and elevations suitable to support tidal marsh to upland habitats, minimal site grading would be required. The site is suitable not only for the target habitats in the short term, but also over the long term. With a low gradient slopes and no barriers to estuarine transgression, there is potential for tidal wetlands to transgress landward as sea level rises. Since many existing tidal wetland to upland transition zones within the San Francisco Bay and Delta are disconnected because of roads, development or other infrastructure, locations than can accommodate estuarine transgression are increasingly important to restore (The Goals Project 1999).

The existing native vegetation and varied micro topography on dune and seasonal wetland habitats in the northern parcels indicate that the entire northern parcel would require a vegetation enhancement project, to expand existing native vegetation patches and reduce weed patches. Since the northern parcels are largely a patchy mosaic of desirable native vegetation, site grading would be difficult without impacting desirable vegetation. However, it may also be preferable to regrade the site, eliminate the exotic species seed source, and replant with native vegetation. Additional plant surveys at appropriate times of year and information about the site history will help determine the preferred approach.

Potential constraints to neighbor properties may include a high ground water table and increased flood risk and seepage with restoration. This constraint could be managed by (1) limiting the site location where fill tidal circulation is allowed (2) allowing dampened or managed tidal circulation in certain areas (3) providing engineered levees around the site (4) providing drainage ditches/maintaining pumping facilitation to manage ground water elevation at property boundaries (5) an adaptive monitoring/management program to identify and manage the site if problems are identified.

Existing power lines and transmission lines on the project site also represent a restoration constraint. While transmission line towers are anchored into 7-foot tall cement footings, power line towers are anchored in with smaller concrete footings, at elevations closer to site grade. Coordination would be required with the utility owners to insure that the functions of these facilities are not compromised. Powerlines and transmission lines may interfere with bird navigation and could result in bird collisions with power or transmission lines (Bevanger 1998). Birds associated with water tend to be especially susceptible to being victims of collisions with a transmission lines (Bevanger 1998). Locating water features that attract waterfowl adjacent to existing powerlines may increase the likelihood of this occurring.

An additional constraint to the restoration of target habitats may be invasive species. The invasive weed perennial pepperweed (*Lepidium latifolium*) was observed on site, and additional field studies may reveal additional invasive species. The history of actions taken on a site (site history) can define the species composition found on site and whether or not it is dominated by natives or non-native species. Site history refers to species colonization (what species are first to colonize), dispersal (some species are dispersal limited), and disturbance. Site history plays a significant role in shaping the restoration trajectory, and whether or not restoration is successful (Suding and Hobbs 2009). In restoration, we can help limit the constraint posed by invasive species through active revegetation, attempting to establish the desirable species first and introduce source material for desirable dispersal limited species. Maintenance is often required until a native cover is fully established.

Use of a portion of the site as a treatment wetland and/or biofilter swales would affect the type of habitat that can be created in these areas. For example, tidal action will not be able to be restored in treatment wetland areas. However, the benefit of reducing pollution entering the delta likely outweighs the impact of reducing the acreage of freshwater tidal wetland. Further, biofilter swales can be considered desirable seasonal wetland habitat, as they provide habitat for many birds and wildlife.

If one of the goals of the project is to restore habitat for the giant garter snake (*Thamnophis gigas*), there may be constraint to restoring full tidal action. In order to accommodate GGS the restored wetlands would have to be designed (e.g., through grading) to facilitate extended hydroperiods in shallow basins that experience only small, gradual (i.e., slower than tidal flooding/draining) changes in inundation. Design features may include notched or lowered levees that prevent full draining during low tides, intertidal dendritic channels with variable bottom elevations, and other features that retain water such as potholes, ponds/pannes, and shallow isolated backwaters (Eric Hansen pers. comm. August 2012).

Depending on project goals and evaluation of site opportunities and constraints, there are several potential configurations of the target habitat on the project site. One potential configuration could be to limit tidal wetlands to the southern parcels and maximize the seasonal alkali wetland acreage (Figure 7, Table 3). Tidal marsh and oak woodland acreages would be reduced if a portion of the site is designated for biofiltration in locations depicted in Figure 6.

Table 3. Potential Acreage per Habitat Type

Habitat Type	Potential Acres
Freshwater Tidal Marsh	320
(Alkali) Season Wetland Complex	140
Stabilized Interior Dune	22
Oak Savanna	157
Total	**639**

Notes: As described previously, using a portion of the site for storm water treatment (Figure 6, Table 2) would replace a maximum of 40-80 acres of the above freshwater tidal marsh and the oak savanna with a somewhat wetter and fresher seasonal marsh/pond complex.

In summary, the site appears to provide an excellent opportunity for the restoration of the four target habitat types with moderate constraints requiring design and management to control.

Next Steps

This memo provides a preliminary assessment of the restoration potential of the site. If the site is acquired for restoration we suggest the following next steps to refine descriptions of the site conditions and develop a conceptual restoration plan for the site. These include:

1. Collect existing and historical data to characterize existing site physical biological and land use conditions including (but not limited to):

- Conducting complete vegetation surveys at appropriate times of year, in order to identify species during all possible flowering times, within the existing ditches, sloughs and the northern parcels to characterize existing vegetation.

- Conduct additional soil testing in summer months to test sites soils for sodic (alkali) properties including: pH, electrical conductivity, sodium absorption ratio, and exchangeable sodium percentage.

2. Refine site specific, quantitative restoration goals/objectives for each habitat type.

3. Based on data collected in above, refine the opportunities and constraints for restoration

4. Identify site options and alternatives for restoration

5. Develop a permitting and stakeholder involvement process

6. Select a preferred alternative

7. Conduct additional studies at reference sites assist in development of conceptual plan including (but not limited to):

- Conduct reference site vegetation and elevation surveys at Sand mound slough in order to develop elevation-vegetation relationships necessary to refine a revegetation list.

- Identify and characterize vegetation at a suitable dune reference plant community in order to assist in development of revegetation list.

8. Develop Conceptual Plan & Cost estimate

9. Develop detailed plans and specs

10. Develop a construction level funding program

11. Construct the project

12. Implement a post project monitoring and adaptive management program

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