Appendix H – Fish Study Restoration Basis of Design: Lookout Slough Restoration Project, WRA Inc., January 2019.

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FISH STUDY RESTORATION BASIS OF DESIGN

LOOKOUT SLOUGH RESTORATION PROJECT
SOLANO AND YOLO COUNTIES, CALIFORNIA

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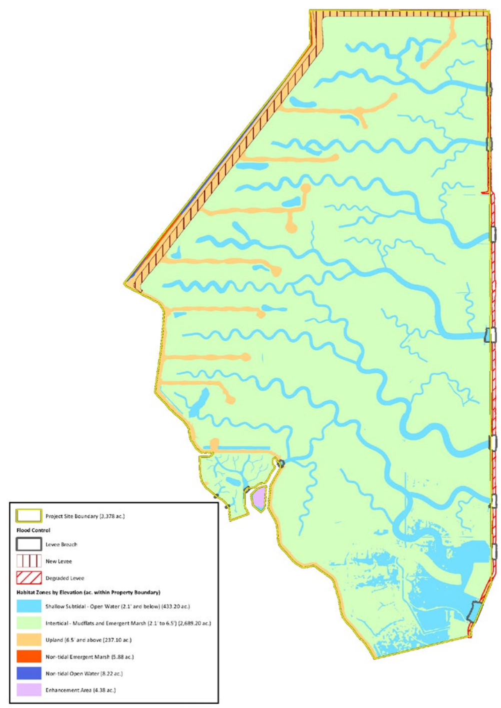

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This fish study technical memorandum provides design guidance and key concepts to inform the restoration of Delta smelt (*Hypomesus transpacificus)* habitat within the Lookout Slough Restoration Project (Project), located in the Cache Slough Complex and lower Yolo Bypass, Solano and Yolo Counties, California. This memorandum provides a synthesis of the current understanding of factors and characteristics beneficial to Delta smelt rearing, food production, and spawning habitat, a framework for how the analysis and habitat selections was performed and the key concepts and design guidelines that were used to inform the restoration design. The memorandum uses a multi-tier approach, similar to a lens that starts at a broad pulled out view and then focusses in on a specific area, as a means to discuss the importance of location, environmental drivers, and local habitat attributes that went into the Delta smelt rearing, food production, and spawning habitat.

Delta smelt is protected under the Federal (ESA; threatened) and California Endangered Species Acts (CESA; endangered). Despite awareness of the vulnerable state of the Delta Smelt, much is still unknown about the factors driving its population dynamics. Critical data and information gaps have been highlighted as a major constraint to current conservation management efforts (IEP 2015). The restoration of the Project area provides a unique opportunity to restore valuable rearing, food production, and spawning habitat to an area known to have Delta smelt occurrences while simultaneously incorporating design parameters that can help improve the current understanding of Delta smelt habitat in the region. Appended to this document is an overview of protected fish species in the region, which includes Delta smelt, and the potential for their different life stages to occur and benefits from the restored Project area (see Attachment A).

SPECIES BACKGROUND

Delta smelt is a member of the Osmeridae family (northern smelts) (Moyle 2002) and is one of six species currently recognized in the genus *Hypomesus* (Bennett 2005). Delta smelt is a California endemic species, found only within the San Francisco and Sacramento-San Joaquin Delta Estuary.

Delta smelt are a pelagic species and the majority of the population lives for only a single year, with a small portion living into the second year. They are fast-growing and short-lived, with the majority of growth occurring in the first seven to nine months of life. Adult Delta smelt are slender bodied fish that generally reach 60 to 70 millimeter (mm) standard length (SL), though a few may reach 120 mm SL (USFWS 2003). While some aspects of this species' life history are known, certain key components of wild fish, such as spawning habitat requirements and locations, are less well known and often inferred by laboratory observations, trawl and sample catch locations of spent females and young larvae, and comparisons with similar species (USFWS 2008).

The US Fish and Wildlife Service (USFWS) proposed to list the Delta smelt as threatened with proposed critical habitat on October 3, 1991 (56 FR 50075). The USFWS listed the Delta smelt as threatened on March 5, 1993 (58 FR 12854), and designated critical habitat for this species on December 19, 1994 (59 FR 65256). Delta smelt was listed as Endangered under the California Endangered Species Act on January 20, 2010. The Delta smelt was one of eight fish species addressed in the Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes (USFWS

1995). A 5-year status review of the Delta smelt was completed on March 31, 2004; that review affirmed the need to retain the Delta smelt as a threatened species.

Outreach and Review to Inform Restoration Design

Information used to inform the restoration design was compiled from a review of peer-reviewed publications, technical reports, outreach, and field visits. Throughout different phases of the design process, outreach was performed with regional academic, restoration practitioners, and the regulatory agencies. Furthermore, baseline biological surveys and site visits to the Project area, coupled with field experiences from the region, also factored into the restoration design guidance. As part of the design process, WRA has been in contact with the following experts during the development of the Project to better understand the factors important to Delta smelt spawning, rearing, and food production habitat design preferences:

- *Dr. Peter Moyle*, University of California, Davis (UC Davis), Distinguished Professor, Emeritus
- *Dr. John Durand*, UC Davis, Postdoctoral Fellow
- *Dr. Jim Hobbs*, UC Davis, Research Scientist
- *Dr. Ted Sommer,* Department of Water Resources, Lead Scientist
- *Dr. Jacob Katz,* CalTrout, Senior Scientist
- *Heather Swinney,* US Fish and Wildlife Service (USFWS) Fisheries Agency Strategy Team (FAST)
- *Dr. Evan Carson*, USFWS, Population Geneticist
- *Dr. Tien-Chieh Hung*, UC Davis Fish Conservation and Culture Lab (FCCL), Director
- *Luke Ellison*, UC Davis FCCL, Manager
- *Dr. Yi-jiun Tsai (Jean)*, UC Davis FCCL, Postdoctoral Scholar

Based on the current understanding of the habitat needs of Delta smelt, several key concepts and guiding parameters were identified to inform the restoration design of the Project area. Key concepts, such as the importance of low salinity, turbidity, and water temperature as they relate to the species needs, were also shared with the design team. These concepts may not be specifically changed by the Project area, but do act upon the restored habitat and factor into the functionality of the Project area. Guiding parameters that can be physically designed and/or influenced during restoration, such as channel size, depth, velocities, and food web supporting habitat (i.e. tidal wetlands) are discussed in the. This information was intended to guide the design team as iterations of the restoration were developed to achieve the overall goals of the Project of supporting Delta smelt spawning, rearing, and food production habitat.

Conceptual Model to Support Delta Smelt Habitat at Lookout Slough

The framework used when evaluating the suitability of the Project area, and the guiding concepts to support Delta smelt spawning, rearing, and food production habitat, was modeled off of the tiered components of the general life cycle model presented in Interagency Ecological Program (IEP) Management, Analysis, and Synthesis Team (MAST) 2015 report. The five-tiered components incorporate the evaluation of geographic location (Tier 1), environmental drivers (Tier 2), habitat attributes (Tier 3), anticipated Delta smelt responses (Tier 4), and transition between the life stage seasons within the Delta smelt conceptual model (Tier 5). The benefit of adapting this tiered approach is to allow a multi-level view of the Project to take place. The Project design team factored in the geographic location (Tier 1), environmental drivers in the region (Tier 2) and the local habitat attributes (Tier 3) when evaluating and then designing the restoration.

The different tiers serve as a lens that helps focus on different levels of the Project as it relates to Delta smelt rearing, food production, and spawning habitat. At the most pulled out view, or high level, is the Tier 1 focus on selecting a suitable site location in the species geographic range. Tier 2 is a more focused look at some of the environmental drivers, or select abiotic factors that influence rearing, food production, and spawning habitat in the selected Project area. Finally Tier 3 drills down into the local habitat attributes of the Project area. It is anticipated that using this multi-level approach will result in the selection and restoration of a target area that would directly benefit Delta smelt at different life stages (which fall under Tiers 4 and 5). The focus of the following sections are to discuss the suitability and design guidance for Tiers 1-3 at the Project area as they relate to rearing, food production, and spawning habitat for Delta smelt.

Tier 1 – Geographic Location

Tier 1 focuses on geographic location relevant to the selection of Delta smelt spawning, rearing, and food production requirements. Lookout Slough is located within the Cache Slough Complex and adjacent to Liberty Island at the terminus of the Yolo Bypass and within an area known as the “North Delta Habitat Arc”. The North Delta Habitat Arc concept has been championed as a core area with the best potential to benefit native fishes through an interconnected series of mostly tidal habitats, see Figure 1 (Durand et al., n.d.).

For spawning habitat, location is an important factor for Delta smelt as spawning locations are dependent upon fresh water flow conditions and can vary in locality yearly. While most spawning occurs within the upper Delta and the Sacramento River above Rio Vista, spawning has occurred within the Montezuma Slough near Suisun Marsh and during years with high rainfall may occur as far west as the Napa River "estuary" (Moyle 2002). Spawning locations are inferred by the locations of captured gravid females, spent females and larvae in trawl samples. Sandy shoals, such as those found in the Sacramento Deepwater Shipping Channel, and sandy beaches, like those along Sacramento River levees outside Sandy Beach and San Andreas Shoal, are believed to be used for spawning. Additionally, subtidal benches or channel banks may be used.

The Cache Slough – Liberty Island Complex features prominently in the Delta smelt recovery strategy, as it makes up a significant portion of the North Delta and one of the few remaining places Delta smelt have been found. A portion of the Delta smelt population is believed to remain in the Cache Slough Complex year-round (IEP 2015). The Cache Slough Complex a priority restoration area for Delta smelt food web, rearing, and spawning habitat projects due to the regional importance this area is believed to have for recovery of the species (DWR 2015). The region includes important channels where Delta smelt have been found including Cache Slough, Hass Slough, Shag Slough, all of which surround and border the Project area. Lookout Slough is therefore located within a core recovery area for the species and meets the Tier 1 focus for relevant selection of potential Delta smelt spawning locations. Furthermore, the geographic location of the Lookout Slough places the Project in an important location for Delta smelt rearing and food production habitat.

Figure 1. North Delta Habitat Arc[1]; the red star indicates the Project area location.

Tier 2 – Environmental Drivers

Tier 2 focuses on environmental drivers (i.e. abiotic factors related to water) that would be relevant to Delta smelt spawning, rearing, and food production. The regional hydrologic connections (part of the geographic location, discussed in Tier 1) have an important impact on environmental drivers relevant to this evaluation, which include salinity, turbidity, and water temperature. These environmental drivers impact the quality, quantity, and seasonality of habitat for Delta smelt; and were used to better understand the type of habitat features and design that would be possible for

[1] Source: https://www.researchgate.net/figure/The-Delta-showing-the-location-of-the-North-Delta-Habitat-Arc-green-in-which-most_fig1_327763148

the Project. Important environmental drivers and key concepts for Delta smelt that informed the development of the restoration design are discussed in the sections below.

Salinity

Key concept: Delta smelt are most abundant in low salinity zones.

Delta smelt distribution typically tracks with salinity distribution within the Delta Estuary, and salinity is considered a key environmental parameter for habitat suitability. The species is generally found in low salinity zones; ranging from 0 to 7 ppt (Moyle *et al* 2016). The species has been found to tolerate salinity in the field up to 19 ppt, and has been shown to survive sea water conditions for short periods of time in the laboratory (IEP 2015, Komoroske *et al* 2014).

The low salinity mixing zone corresponds to the point in the Estuary where the average daily salinity at the bottom of the water is two ppt. This location is referred to as “X2,” which is the distance from this low salinity zone (about 0.6 to 3.0 ppt) to the Golden Gate Bridge, measured in kilometers (USFWS 2008). This distance changes over the course of the year based on freshwater inflow through the Delta (USFWS 2008). Periods when the X2 gradient is located within western Suisun Bay have been found to have a positive effect on Delta smelt abundance (Moyle *et al* 2016).

Adults migrate to freshwater environments of the upper Delta, where they seek out sloughs and shallow edge areas. Spawning occurs in freshwater with larvae subsequently being washed downstream to low salinity mixing zones where they rear; however, some may reside year-round in the Cache Slough Complex (Sommer *et al* 2011).

Turbidity

Key concept: Turbidity is an important habitat feature for Delta smelt.

Delta smelt distribution is strongly associated with turbid water from spring through fall (Moyle et al 2016). Catch rates and entrainment rates have been found to be higher at higher turbidity levels (IEP 2015). For Delta smelt, turbidity is believed to be important for increasing foraging efficiency and decreasing the predation threat (IEP 2015). For spawning, this reduced threat would apply to adults and eggs.

In laboratory experiments, Delta smelt feeding was highest at 12 Nephelometric Turbidity Units (NTUs) and was stable in the turbidity range of 12 – 120 NTU (Hasenbein *et al* 2013). Laboratory results have also found that larval Delta smelt vertical position within the water column shifts upward (i.e. higher/shallower) when turbidity increases, which is believed to put them in more food rich surface waters (IEP 2015). Within the Delta, turbidity is generally between 20-40 NTUs, and can increase to 250-500 NTUs during higher river flows (DWR 2013). Turbidity at or above 250 NTUs is believed to impair feeding (IEP 2015).

Water Temperature

Key concept: Delta smelt typically occupy water temperatures at 10 to 22 degrees Celsius (°C).

Water temperature plays an important role in determining Delta smelt distribution and habitat suitability. The species is typically observed in water temperatures ranging from 10 to 22°C (Moyle *et al* 2016). Delta smelt are sensitive to warm temperatures, as the upper thermal tolerance of the species is at 25°C (IEP 2015). In laboratory conditions, juvenile Delta smelt have been found to have slightly elevated upper thermal tolerance (up to 29°C); however, are rarely found in the field in locations that reach 25°C (Komoroske *et al* 2014, IEP 2015). Thermal related stress is believed to begin in fish exposed to water 20 to 21°C; which while not fatal, could result in the species allocating energy to stress response and away from growth or reproductive output (Moyle *et al* 2016).

Most spawning is believed to take place within 7 to 15°C, though temperatures as high as 22°C may be suitable for reproduction (USFWS 2003). Important components of Delta smelt reproduction, including the spawning season window and fecundity[2] (egg production in females) have been linked to water temperature (IEP 2015). Spawning can occur January through June, with peak spawning activity occurring in April and May (IEP 2015, Moyle 2002). Female Delta smelt in laboratory experiments, and as indicated by recent research on wild fish, demonstrated the ability to produce multiple clutches when spawning conditions were favorable (Moyle *et al* 2016 and Damon *et al* 2016).

Tier 3 – Local Habitat Attributes

Tier 3 focuses on local habitat attributes that impact Delta smelt responses. This level incorporates the location in Tier 1 and the key concepts discussed in Tier 2, with habitat attributes that would apply to the Project area, to focus and refine the restoration design. Local habitat attributes considered important for Delta smelt spawning, rearing, and food production include depth, channel size, spawning habitat and substrate, water velocity, and food web support (i.e. tidal marsh habitat and water residence time). These local habitat factors can be designed for and influenced by the restoration design and construction of the restoration Project.

While the following sections discuss the applicability of local habitat attributes for Delta smelt, it is important for a restoration design to consider potential adverse or unintended consequences with the design such as promoting or supporting invasive species or non-native predators in the restored area. Currently there is no accepted or workable approach in the region that would exclude harmful invasive and predatory species while still allowing Delta smelt open access. Submerged aquatic vegetation (SAV) can alter the habitat dynamics of a site, changing open water areas that could be used by Delta smelt to areas where invasive predators and competitors like bass, sunfish (collectively Centrarchidae) and Mississippi silverside (*Menidia audens*) seek out and thrive (Moyle 2002, IEP 2015, Ta *et al* 2017). Deep, slow-to-stagnant in-channel pools or vast open water tracts like Liberty Island can also benefit predatory species (as reported in Sommer and Meija 2013). While complete control and exclusion of harmful invasive species and non-native predators is not feasible, it is believed that maintaining high levels of hydrologic

[2] Delta smelt fecundity is also linked to the length of the individual, with smaller females producing fewer and smaller egg clutches (Damon *et al* 2016).

connectivity and habitat heterogeneity should be targeted to promote native fish species (Moyle *et al* 2010). These considerations, along with the habitat attributes described below, were incorporated into the restoration design concept.

Depth

Key concept: Shallow subtidal water habitats important to Delta smelt.

While considered a pelagic species, Delta smelt will utilize much of the water column and have been caught in shoals and shallow water (Sommer and Meija 2013). USFWS considers shallow subtidal habitat in the range of Mean High Water down to 3 meters below Mean Lower Low Water (9.8 feet) to be a core part of designated Critical Habitat (USFWS 2004). Shallow open water habitat is one of the few structural habitat components that this otherwise pelagic species has been linked to (USFWS 2008).

The species location throughout the water column can vary throughout the day, and can be driven by tidal conditions, turbidity, life stage, river stage, light, and food availability (IEP 2015). For spawning, Delta smelt rely on shallow and subtidal habitat for spawning (less than three meters), and are not believed to substantially use intertidal areas (Sommer and Meija 2013).

Channel Size

Key concept: Delta smelt can use channels of variable sizes; from widths of 15 meters (49.2 feet) to 280 meters (306.2 feet).

Channel width is not believed to be a constraint for the species. Delta smelt have been captured in a wide range of channel widths; including the Cache Slough (up to 280 meters [306.2 feet]) down to Spring Branch Slough in Suisun Marsh (15 meters wide [49.2 feet]) (Sommer and Meija 2013). Channel size has not been shown to be a significant spawning parameter in Delta smelt populations (Sommer and Meija 2013).

Spawning Habitat and Substrate

Key concept: Delta smelt are believed to lay adhesive eggs on shallow sandy or pebble sized gravel substrates on subtidal beach or slough habitats.

Substrate is an important physical habitat component required by Delta smelt for spawning. While spawning has not been observed in the wild, what is known about Delta smelt spawning and related habitat is inferred from the location of captured post hatch larvae, laboratory culture, and similar species like surf smelt (*Hypomesus pretiosus*) (Sommer and Meija 2013). Suitable spawning habitat is comprised of open, unvegetated, shallow subtidal (less than 3 meters) waters with sand or pebble-sized substrate found within freshwater sloughs, beaches or shoals (USFWS 2008, Moyle 2002, EIP 2015).

See Table 1 below for size ranges that are considered potentially suitable based on particle classification and discussions with members of the FCCL. For reference, silt and clay substrates are <0.06 mm, fine to very coarse sands are in the 0.06 to 2 mm range, and very fine to very coarse gravel are in the 2 to 64 mm range (Gordon *et al* 1992). Of note, while substrates are considered important for spawning, SAV is not thought to be used for spawning by Delta smelt. Because of this, the expansion invasive aquatic plants, like Brazilian waterweed (*Egeria densa*), has likely reduced the availability of suitable spawning site within the Delta (Moyle *et al* 2016).

Table 1. Substrate Size Ranges

Quality/Suitability	***Substrate Size Range (mm)***
Effective in lab	0.25 – 0.5
Potentially suitable	0.06 – 2
May be suitable	2.1 – 4
Poor/unsuitable	<0.06 or >4.1

Water Velocity

Key concept: Delta smelt are not strong swimmers but water movement is thought to be important for smelt eggs.

Delta smelt juveniles and adults are not strong swimmers and have a hard time sustaining themselves in elevated water velocities and are therefore subject to involuntary transport in river flows and tidal exchange (IEP 2015). Delta smelt are believed to move up or down in the water column under different tidal conditions (referred to as ‘tidal surfing’) as a way to reduce energetic cost (IEP 2015).

Delta smelt can swim at a discontinuous “stroke-glide” at less than 10 centimeters per second (cm/s) and sustained swimming occurs above 15 cm/s; however, fish normally will not swim above these velocities (Moyle *et al* 2016). As reported in Sommer and Meija (2013), adult Delta smelt have a critical swimming ability (top speed) near 28 cm/s, and can swim for long periods at rates of up to 2 body lengths per second, which is comparable or slightly below similar-sized fish. Larval Delta smelt have comparatively little swimming ability and are transported to downstream low salinity mixing areas once they hatch out (IEP 2015).

Water velocity is believed to be an important factor for the selection of spawning habitat. Delta smelt are broadcast spawners with demersal, or bottom-sinking, fertilized eggs that adhere to pebble or sand substrate to keep them from washing away and to allow them to "tumble incubate" with wave movement (USFWS 2008). Based on discussions with members of the FCCL and USFWS, water velocities that were utilized for spawning in a laboratory setting included 8.8 - 15.8 cm/sec (0.29 - 0.52 feet per second). While those water velocities have not been confirmed to be used by Delta smelt in the wild, the laboratory observations help inform potential velocity targets that may be sought by the species in the field.

Food Web Support

Key concept: For Delta smelt rearing and food production, vegetated tidal marsh systems that export primary and secondary productivity into open water areas are important.

Key concept: Increased water residence time in tidal freshwater marsh systems supported by dendritic channel networks can support food web dynamics for the species.

Delta smelt feed on small crustacean, called zooplankton, which fill part of the base levels of the food web. Food production for Delta smelt is largely driven by bottom-up dynamics, where nutrient availability and favorable abiotic conditions combine to stimulate phytoplankton and subsequent zooplankton development. In addition to food production, the type of zooplankton available (i.e. food quality) is important for Delta smelt. The primary zooplankton consumed by the species include calanoids (*Eurytemora affinis*, *Pseudodiaptomus forbesi*, *Acartiella sinensis*, *Sinocalanus doerri*), copepods, cladocerans, and even mysid shrimp (*Neomysis mercedis*) by the larger adults (Moyle *et al* 2016, IEP 2015). Turbidity, previously discussed in Tier 2, has been shown to increase foraging efficiency while decreasing predation threat (as cited in IEP 2015).

Food web support and improving primary and secondary productivity in the Delta has been identified as critical part of the effort to recover Delta smelt. Vegetated marsh and floodplain habitat support primary productivity, but these habitats have been significantly decreased by the establishment of levees throughout the Delta system. Historically, there were over 3,000 km of marsh and floodplain habitat connected to water; however, this number is now estimated to have been reduced to only 31 km (Cloern *et al* 2016). Connecting channels to emergent marshes, where water can have an extended residence time to generate more primary productivity, forms an important base for food production. This linkage can connect the pelagic and detrital pathways, further supporting food web productivity. The contribution of emergent and aquatic vegetation, and biological detritus that occur within tidal wetlands, can all contribute to food web support (Durand 2015).

In addition to reconnecting tidal habitat, food web enhancements flows have been used in the Yolo Bypass to stimulate plankton blooms within the Delta (CNRA 2016a). Using seasonal pulse flows, targeted applications of water are transported through wetland and tidal slough complexes and have been shown to create beneficial downstream phytoplankton blooms (CNRA 2016b). Increasing the water residence time in tidal channels, so that water exchanges more along the spring-neap tidal cycle, can provide benefits to phytoplankton development. The Cache Slough Complex has been found to have high primary and secondary productivity when low flow conditions result in greater water residence times (Young *et al* 2015). Increased water residence[3] time in tidal wetlands and dendritic channel networks, directional water flow through tidal systems, and targeted use of managed wetlands are believed to promote phytoplankton blooms which support zooplankton development and improved food web conditions for Delta smelt (CNRA 2016b, Brown *et al* 2016).

[3] More detailed discussion on the exposure time and particle tracking model analysis and approach for the Project are provided in the 2019 *Basis of Design Report – Tidal Hydrology and Hydraulic Analysis* prepared for EIP by Environmental Science Associates for the Lookout Slough Restoration Project.

ANTICIPATED PROJECT BENEFITS FOR DELTA SMELT

Habitat within Lookout Slough is currently inaccessible to Delta smelt, with the exception of the narrow strip of habitat on the outboard side of the US Army Corps of Engineers (Corps) flood control levee. Additional habitat is temporarily available during elevated winter flows which can result in Cache Slough flooding the very southern portion of the Project area (i.e. the Vogel property). However, once waters recede, the low lying levees that serve to keep water out of the Vogel property then act to trap water and fish inside the island, in a temporary 65 acre lake. The remaining 3,000 acres plus of the Project area are blocked by Corps levees. While there is a small network of screw gate culverts along the levees, these provide only a small amount of managed water movement into or out of the Project area. The levee protected irrigated agricultural land that comprises the Project area is emblematic of a legacy of habitat loss that has occurred throughout the geographic range of Delta smelt. Only a small fraction of the historic tidal wetlands, sloughs, and floodplain habitat of the Delta remain, and the loss of these key nursery and breeding grounds that support food web productivity, rearing, and spawning habitat have significantly affected the population stability of Delta smelt.

The proposed Lookout Slough Restoration Project will reconnect historic habitat and creating new high quality spawning, rearing, and food production habitat in an important location for Delta smelt. Following restoration, the Project area will have a direct hydrologic connection to Shag Slough and Cache Slough (i.e. Tier 1), which has habitat conditions that support Delta smelt. These conditions include salinity, turbidity, and water temperatures that are known to support all life stages of Delta smelt (i.e. Tier 2). The proposed restoration has incorporated the current understanding of the habitat requirements of Delta smelt to design favorable depth, channel size, spawning habitat and substrate, water velocity, and food web support (i.e. tidal marsh habitat and water residence time) for the species (i.e. Tier 3).

The restoration is designed to provide full tidal inundation into a freshwater tidal marsh system with constructed networks of dendritic channels[4]. Levee breach locations, size, and channel geometry is geared to facilitate tidal conditions reaching the full extent of the restored area. The existing Corps flood control levee with be breached in nine locations along Shag Slough, with breaches ranging in size from 269 to 576 feet at the base, with the remaining levee degraded to the elevation of the 0.1% Annual Exceedance Probability (equivalent to the 10-year flood event). Along Cache Slough, one approximately 100-foot levee breach will occur in a Corps flood control levees. Additionally, three levee breaches of Vogel Island in the non-Corps levees will occur. An estimated 22 miles of dendritic channels ranging in size from 50 to 200 ft in width, with channel invert elevations between -1.0 and 1.0ft NAVD88, and maximum side slope of 3:1 will be constructed. Site and regional hydrology has been incorporated into the overall design of Lookout Slough and the modeled restoration design is anticipated to provide suitable velocities to support rearing and spawning habitat, and will have water residence time and direct connections to tidal wetlands, to facilitate food production for Delta smelt[3]. A conceptual figure of the restoration design and cross sections of the breach and channel at the nine Shag Slough and one Cache

[4] More detailed discussion of the modeling analysis and approached used for the hydrology and hydraulic design of the Project are provided in the 2019 *Basis of Design Report – Tidal Hydrology and Hydraulic Analysis* prepared for EIP by Environmental Science Associates for the Lookout Slough Restoration Project.

Slough location are included in Attachment B. Fundamental benefits for Delta smelt are anticipated to include:

- **Newly created and enhanced existing rearing habitat.** The restoration of over 3,000 acres of habitat will provide important nursery habitat for juvenile fish. Subtidal dendritic channels bordered by tidal wetlands will provide foraging habitat for Delta smelt, as open water areas will be in close proximity to food producing tidal wetlands. Heterogeneous habitat, with seasonally deeper elevations occurring in the southern portion of the Project area and shallower subtidal and intertidal channels occurring in the northern portion, is anticipated to provide a range of rearing opportunities under different tidal and flow conditions. The restoration design includes a breach of the levee surrounding the Vogel property, which currently acts to trap fish after high flows recede and impounded water forms a temporary lake. Restored tidal channel connection in this portion of the Project will correct a potential stranding area for native fish. The planned restoration will also increase Delta Smelt critical habitat by reconnecting thousands of acres of diked land to the adjacent channels.

- **Added food web support.** Improved access to primary productivity and zooplankton, particularly during the summer and fall months, have been identified as a necessity to recovering Delta smelt (IEP 2015). Marsh and floodplain habitat support primary productivity, but these habitats have been significantly decreased by the establishment of levees throughout the Delta system. Reconnecting and establishing over 3,000 acres of heterogeneous subtidal, intertidal, wetland, and floodplain habitats will result in varied water residence times and increased nutrient availability. Particle tracking and exposure time assessment modeling conducted for the Project indicate exposure times ranging from 1 to 25 days plus and an export of particles from the Project area following restoration activities (ESA 2019 and see figures in Appendix B). The proposed restoration Project is anticipated to provide food web support to Delta smelt within the Cache Slough Complex, and serve as an exporter of nutrients and basal trophic level support during seasonal pulse flows and more extreme tidal periods. Because a portion of the population is believed to remain in the Cache Slough Complex year-round (IEP 2015), restoration of the Project area is anticipated to benefit all life stages of Delta smelt.

- **Improved and new created spawning habitat.** The Cache Slough Complex contains suitable spawning habitat for Delta smelt and the detection of larval smelt indicates the area is a core portion of the species remaining spawning grounds (Sommer and Meija 2013, Young *et al* 2015, Morris and Damon 2016, CDFW 2017). The creation of subtidal channels tidally connected to the Cache Slough Complex, and incorporating favorable depth, channel structures, water velocities and substrates, is anticipated to provide potentially suitable spawning habitat for Delta smelt. While specific spawning habitat requirements are not certain, the restoration design incorporates the current understanding of suitable spawning habitat for the species. An approach with heterogeneous subtidal habitat, with seasonally deeper elevations occurring in the southeastern portion of the Project area and shallower subtidal and intertidal channels occurring in the northwestern portion, is anticipated to provide a range of spawning sites under different tidal and flows conditions.

- **High Flow Refugia.** The planned restoration will open up thousands of acres of land near the terminus of the Yolo Bypass to flood waters and high flow refugia for Delta smelt. Multiple breach locations, dendritic channel networks, and established tidal marsh plain within the proposed restoration Project will benefit Delta smelt that seek reduced velocities during seasonal flood events. Under elevated winter flows, much of the Project area will submerge, providing increased foraging habitat for Delta smelt. These large tidal marsh and adjacent floodplain areas provide important “on and off ramps” that allow fish to move out of channelized flood conveyance areas and reduce the potential for them to be swept downstream and out of productive rearing habitat.

The habitat benefits of restoring the Project area for Delta smelt are anticipated to be numerous and dynamic. Seasonal changes and annual variability in flows will change the amount and duration various portions of the Project area are accessible and alter the roles these habitats can play. Restoring and reconnecting heterogeneous habitats within the Cache Slough Complex will provide Delta smelt with a better chance of completing their life cycles and aids in the recovery of the species.

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ATTACHMENT A

LOOKOUT SLOUGH RESTORATION PROJECT

Protected Fish Species Potential to Occur

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FISH HABITAT RESTORATION PROGRAM TARGET SPECIES

This section will discuss the potential for target protected fish species identified in the Department of Water Resources Biological Opinion from the US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) and the California Department of Fish and Wildlife Service (CDFW) Incidental Take Permit to occur within the Cache Slough Project Property in Solano County, California (Project area). "Target protected fish species" covered under these respective documents include Delta smelt (*Hypomesus transpacificus*), steelhead (*Oncorhynchus mykiss)*, winter and spring-run Chinook salmon (*O. tshawytscha)*, green sturgeon (*Acipenser medirostris*), and longfin smelt (*Spirinchus thaleichthys*). While the design consideration and benefits of the planned restoration Project for Delta smelt are discussed at length in the main document; the Project will also benefit a number of target protected fish species at their different life stages. The following table discusses key components of each species life history and provides an evaluation of the potential for each to occur within the Project area following restoration. Life history components discussed include adult and juvenile rearing, migration, and spawning habitat. Where present, federally designated critical habitat is also addressed. Additionally, a brief discussion of the anticipated benefit from the restoration is discussed.

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Life stages of Fish Habitat Restoration Program Target Species and Critical Habitat for Cache Slough Complex within the Vicinity of the Project area

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Delta smelt *Hypomesus transpacificus*	FT, SE	Endemic to the Sacramento Delta, where it is distributed from the Suisun Bay upstream through the Delta in Contra Costa, Sacramento, San Joaquin, Solano and Yolo counties. The delta smelt is a pelagic and euryhaline species.	**ADULT (REARING/MIGRATION)**	**High Potential.** The Cache Slough Complex is known to support Delta smelt adult rearing habitat and serves as a portion of the Delta the species seasonally migrates through (DWR 2015, Bennett 2005, USFWS 1996). A small portion of the Delta smelt population is believed to inhabit the Cache Slough Complex year round (IEP 2015). Data from CDFW trawls confirms that adult smelt have been consistently detected in this area (CDFW 2017). Tidally reconnected habitat in the Project area would create and increase adult rearing and migratory habitat for this species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** The Cache Slough Complex is known to support Delta smelt juvenile rearing habitat and serves as a portion of the Delta the species seasonally migrates through (DWR 2015, Bennett 2005, USFWS 1996). A small portion of the Delta smelt population is believed to inhabit the Cache Slough Complex year round (IEP 2015). Data from CDFW trawls confirms that juvenile and larval smelt have been consistently detected in this area (CDFW 2017). Tidally reconnected habitat in the Project area would create and increase juvenile rearing and migratory habitat for this species.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Delta smelt cont.			**SPAWNING**	**High Potential.** Suitable spawning habitat is comprised of open, unvegetated, shallow subtidal (less than three meters) waters with sand or pebble sized substrate found within freshwater sloughs (USFWS 2008, Moyle 2002). The Cache Slough Complex contains suitable spawning habitat for the species and the detection of larval smelt indicate the species uses these areas as a core portion of their remaining spawning grounds (Sommer and Meija 2013, Young et al 2015, Morris and Damon 2016, CDFW 2017). Tidally reconnected habitat in the Project area would create potential spawning habitat for this species.
			CRITICAL HABITAT	**Present.** The entire Project area is included with the geographic extent of designated critical habitat for the species; however, all but the outboard side of the Corps levees are inaccessible and not currently part of critical habitat. Tidally reconnected habitat in the Project area would increase the amount of accessible critical habitat for the species.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
steelhead - Central Valley Distinct Population Segment *Oncorhynchus mykiss*	FT, NMFS	Anadromous, spending most of life cycle in the ocean. Occurs in the Sacramento and San Joaquin Rivers and their tributaries, excluding San Francisco and San Pablo bays and their tributaries. Adults migrate upstream to spawn in cool, clear, well-oxygenated streams. Juveniles remain in fresh water for 2 or more years before migrating downstream to the ocean. Resident form of the species, called rainbow trout, are protected in anadromous streams and waterways below impassable fish barriers.	**ADULT (REARING/MIGRATION)**	**Moderate Potential.** The Sacramento River serves as a major migratory corridor. The close proximity of the Cache Slough Complex to the Sacramento River and Yolo Bypass make it likely that migrating adults may periodically utilize the areas adjacent to the Project area. Tidally reconnected habitat in the Project area may create and increase opportunistic rearing habitat for adult steelhead; however, it would not serve as a migratory corridor for the species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** Juvenile steelhead can spend several years rearing in freshwater before migrating to the ocean. Sloughs, marshes, and off-channel habitats like those found throughout the Cache Slough Complex provide important rearing habitat and cover during migration (NMFS 2016). Juvenile steelhead have been regularly encountered by CDFW within the area (DWR 2015). Tidally reconnected habitat in the Project area would create and increase rearing habitat for juvenile steelhead.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide suitable stream habitat for spawning. Tidally reconnected habitat in the Project area would not provide spawning habitat for steelhead.
			CRITICAL HAITAT	**Present.** The southern portion of the Project area, along Cache Slough, falls within designated critical habitat for the species. Tidally reconnected habitat in the Project area would increase the amount of accessible critical habitat for the species.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Chinook salmon, Central Valley spring-run Evolutionary Significant Unit (ESU) *Oncorhynchus tshawytscha*	FT, ST, NMFS	Anadromous, spending most of life cycle in the ocean. Federal listing includes populations spawning in the Sacramento River and its tributaries. Adults migrate upstream typically February though June to spawn in cool, clear, well-oxygenated spring fed streams. Juveniles remain in fresh water for one or more years before migrating downstream to the ocean.	**ADULT (REARING/MIGRATION)**	**Unlikely.** The Sacramento River serves as the primary migratory corridor for this species. The close proximity of the Project area to the Yolo Bypass makes it possible for the species to migrate past the Project area; however, the Cache Slough Complex does not provide a migratory route for the species. Furthermore, adults do not feed after entering freshwater so rearing habitat is not required. Tidally reconnected habitat in the Project area would not provide adult rearing or migratory habitat for this species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** Juvenile spring-run Chinook salmon typically emigrate January through April. Migration generally occurs at night within the deeper portions of rivers; however, day time rearing habitat is often in shallow vegetative covered locations where food and shelter are more abundant. Sloughs, marshes, and off-channel habitats like those found throughout the Cache Slough Complex provide important rearing habitat and cover during outmigration (NMFS 2016). Spring Kodiak trawl data from CDFW operations south of Liberty Island, as well as fish rescue operations in the Yolo Bypass have confirmed the presence of the species throughout the local area (CDFW 2017, Acierto et al 2014). Tidally reconnected habitat in the Project area would create and increase rearing habitat for juvenile spring-run Chinook salmon.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide suitable spring fed stream habitat for spawning. Tidally reconnected habitat in the Project area would not provide spawning habitat for the species.
			CRITICAL HABITAT	**Present.** The southern portion of the Project area, along Cache Slough, falls within designated critical habitat for the species. Tidally reconnected the Project habitat would increase the amount of accessible critical habitat for the species.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Chinook salmon, Sacramento River winter-run ESU *Oncorhynchus tshawytscha*	FE, SE, NMFS	Occurs in the Sacramento River below Keswick Dam. Spawns in the Sacramento River but not in tributary streams. Requires clean, cold water over gravel beds with water temperatures between 6 and 14 degrees C for spawning. Adults migrate upstream to spawn in cool, clear, well-oxygenated streams. Juveniles typically migrate to the ocean soon after emergence from the gravel.	**ADULT (REARING/MIGRATION)**	**Unlikely.** The Sacramento River serves as the primary migratory corridor for this species. The close proximity of the Project area to the Yolo Bypass makes it possible for the species to migrate past the Project area; however, the Cache Slough Complex does not provide a migratory route for the species. Furthermore, adults do not feed after entering freshwater so rearing habitat is not required. Tidally reconnected habitat in the Project area would not provide adult rearing or migratory habitat for this species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** Juveniles typically emigrate September – January. The Project area provides suitable rearing habitat for emigrating juveniles and may be used seasonally by the species. Spring Kodiak trawl data from CDFW operations south of Liberty Island, as well as fish rescue operations in the Yolo Bypass have confirmed the presence of the species throughout the local area (CDFW 2017, Acierto et al 2014). Tidally reconnected habitat in the Project area would create and increase rearing habitat for juvenile spring-run Chinook salmon.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide suitable stream habitat for spawning. Tidally reconnected habitat in the Project area would not provide spawning habitat for the species.
			CRITICAL HABITAT	**Not Present.** The Project area does not fall within designated critical habitat for the species.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Chinook salmon, Central Valley fall/late fall-run ESU *Oncorhynchus tshawytscha*	SSC, NMFS	Spawning populations in the Sacramento and San Joaquin Rivers and their tributaries. Adults migrate upstream to spawn in cool, clear, well-oxygenated streams. Juveniles may remain in fresh water for 1 or more years before migrating downstream to the ocean	**ADULT (REARING/MIGRATION)**	**Unlikely.** The Sacramento River serves as the major migratory corridor for this species. The close proximity of the Project area to the Yolo Bypass makes it possible for the species to migrate past the Project area; however, the Cache Slough Complex does not provide a migratory route for the species. Furthermore, adults do not feed after entering freshwater so rearing habitat is not required. Tidally reconnected habitat in the Project area would not provide adult rearing or migratory habitat for these species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** Juvenile fall-run Chinook salmon typically emigrate March – April, and late fall-run juveniles generally emigrate April - October. Sloughs, marshes, and off-channel habitats like those found throughout the Cache Slough Complex provide important rearing habitat and cover during outmigration (NMFS 2016). Spring Kodiak trawl data from CDFW, as well as fish rescue operations in the Yolo Bypass have confirmed the presence of the species near the Project area (CDFW 2017, Acierto et al 2014). Tidally reconnected habitat in the Project area would create and increase rearing habitat for these species.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide suitable spawning habitat. Tidally reconnected habitat in the Project area would not provide spawning habitat for the species.
			CRITICAL HABITAT	**Not designated for these species.**

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
green sturgeon, southern Distinct Population Segment (DPS) *Acipenser medirostris*	FT, SSC NMFS	Spawn in the Sacramento River and the Feather River. Spawn at temperatures between 8-14 degrees C. Preferred spawning substrate is large cobble, but can range from clean sand to bedrock. Spawn in deep pools or "holes" in large, turbulent, freshwater river mainstems. Adults live in oceanic waters, bays, and estuaries when not spawning. Species is known to forage in estuaries and bays.	**ADULT (REARING/MIGRATION)**	**Moderate Potential.** Adult green sturgeon occur within the Sacramento River and Yolo Bypass. The Project area is located adjacent to core habitat for the species, and Cache Slough Complex provides suitable adult foraging habitat. Adult sturgeon may forage and migrate past the Project area during elevated flows when the Yolo Bypass is inundated. Tidally reconnected habitat in the Project area would create and increase potential rearing habitat for adult green sturgeon.
			JUVENILE (REARING/MIGRATION)	**Moderate Potential.** Juvenile sturgeon distribution during their freshwater rearing period is not well known; however, the Cache Slough Complex provides suitable rearing habitat for this life stage. Tidally reconnected habitat in the Project area would create and increase potential rearing habitat for juvenile green sturgeon.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide deep-water mainstem riverine areas typically used by the species for spawning. Tidally reconnected habitat in the Project area would not provide spawning habitat for green sturgeon.
			CRITICAL HABITAT	**Not Present.** The Project area is located immediately adjacent to designated critical habitat for the species. Shag Slough is the western boundary of critical habitat in the vicinity of the Project area.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
longfin smelt *Spirinchus thaleichthys*	ST, FC	Euryhaline, nektonic and anadromous. Found in open waters of estuaries, mostly in middle or bottom of water column. Prefer salinities of 15 to 30 ppt, but can be found in completely freshwater to almost pure seawater. Adults move into freshwater streams in the winter to spawn. Juveniles and larvae rear for a period of time in low salinity zones.	**ADULT (REARING/MIGRATION)**	**High Potential.** The Cache Slough Complex is known to seasonally support adult longfin smelt as they migrate to spawning habitat (La Luz and Baxter 2015, CDFW 2017). During these periods, it's likely that opportunistic rearing takes place. Tidally reconnected habitat in the Project area would create and increase adult rearing and migratory habitat for this species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** The Cache Slough Complex is known to seasonally support juvenile longfin smelt as they rear in freshwater before migrating to more marine conditions (La Luz and Baxter 2015, CDFW 2017, Morris and Damon 2016). Data from CDFW trawls confirms that juvenile and larval smelt have been consistently detected in this area (CDFW 2017). Tidally reconnected habitat in the Project area would create and increase juvenile rearing and migratory habitat for this species.
			SPAWNING	**High Potential.** The Cache Slough Complex contains suitable spawning habitat for the species and the detection of larval smelt indicate the species uses these areas as an important portion of their spawning grounds (Young et al 2015, Morris and Damon 2016, CDFW 2017). Tidally reconnected habitat in the Project area would create potential spawning habitat for this species.
			CRITICAL HABITAT	**Not designated for the species.**

*** Key to status codes:**

FE	Federal Endangered	SE	State Endangered
FT	Federal Threatened	ST	State Threatened
FC	Federal Candidate	SSC	CDFW Species of Special Concern
NMFS	Species under the Jurisdiction of NMFS		

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ATTACHMENT B

LOOKOUT SLOUGH RESTORATION PROJECT

Restoration Conceptual Design and Breach Cross Sections

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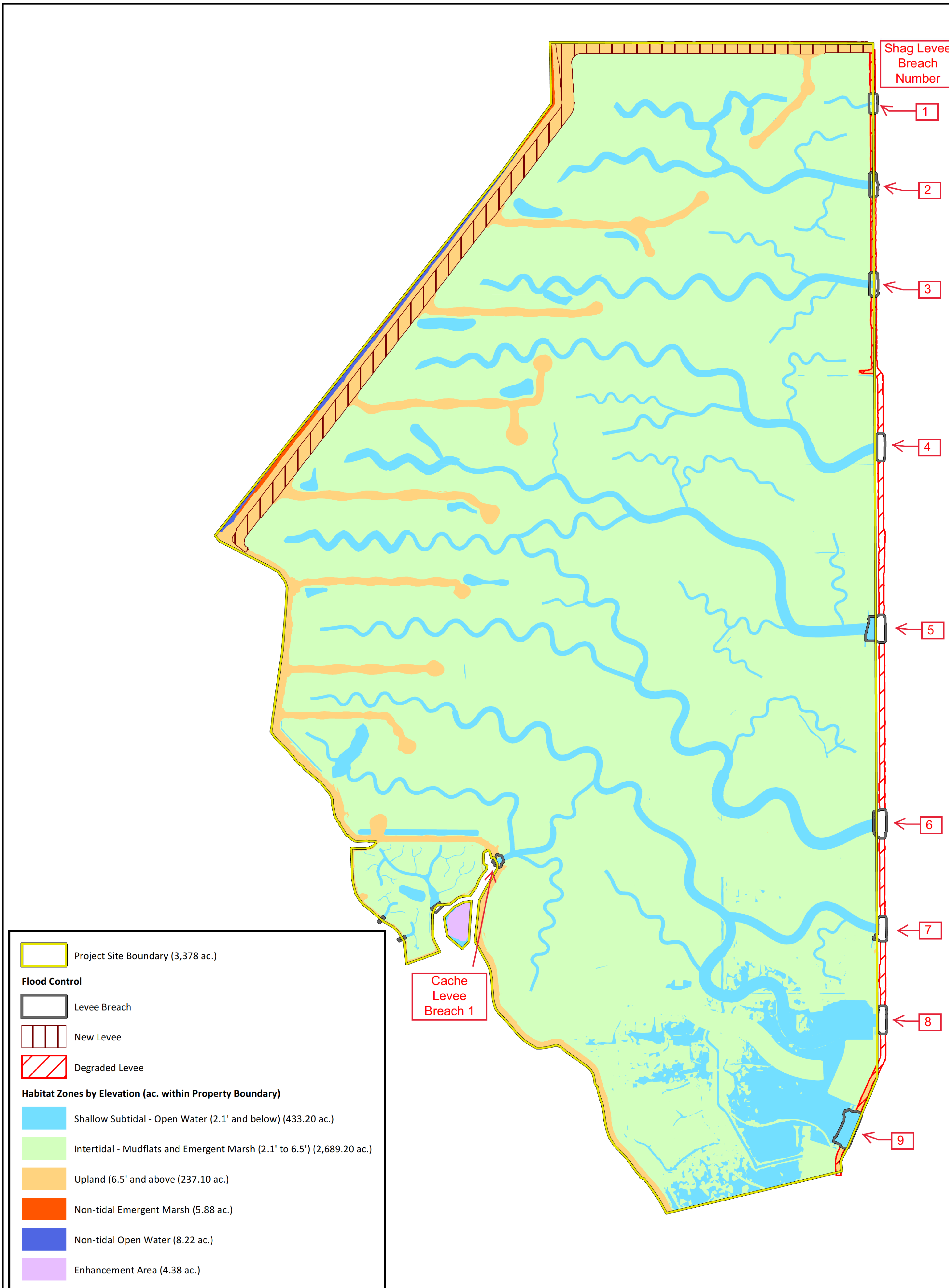

Conceptual Design Draft

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Lookout Slough Restoration Project

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 1/7/2019
Map Prepared By: pkobylarz
Base Source: Wood Rogers
Base Date: 10/24/17
Data Source(s): WRA

wra ENVIRONMENTAL CONSULTANTS

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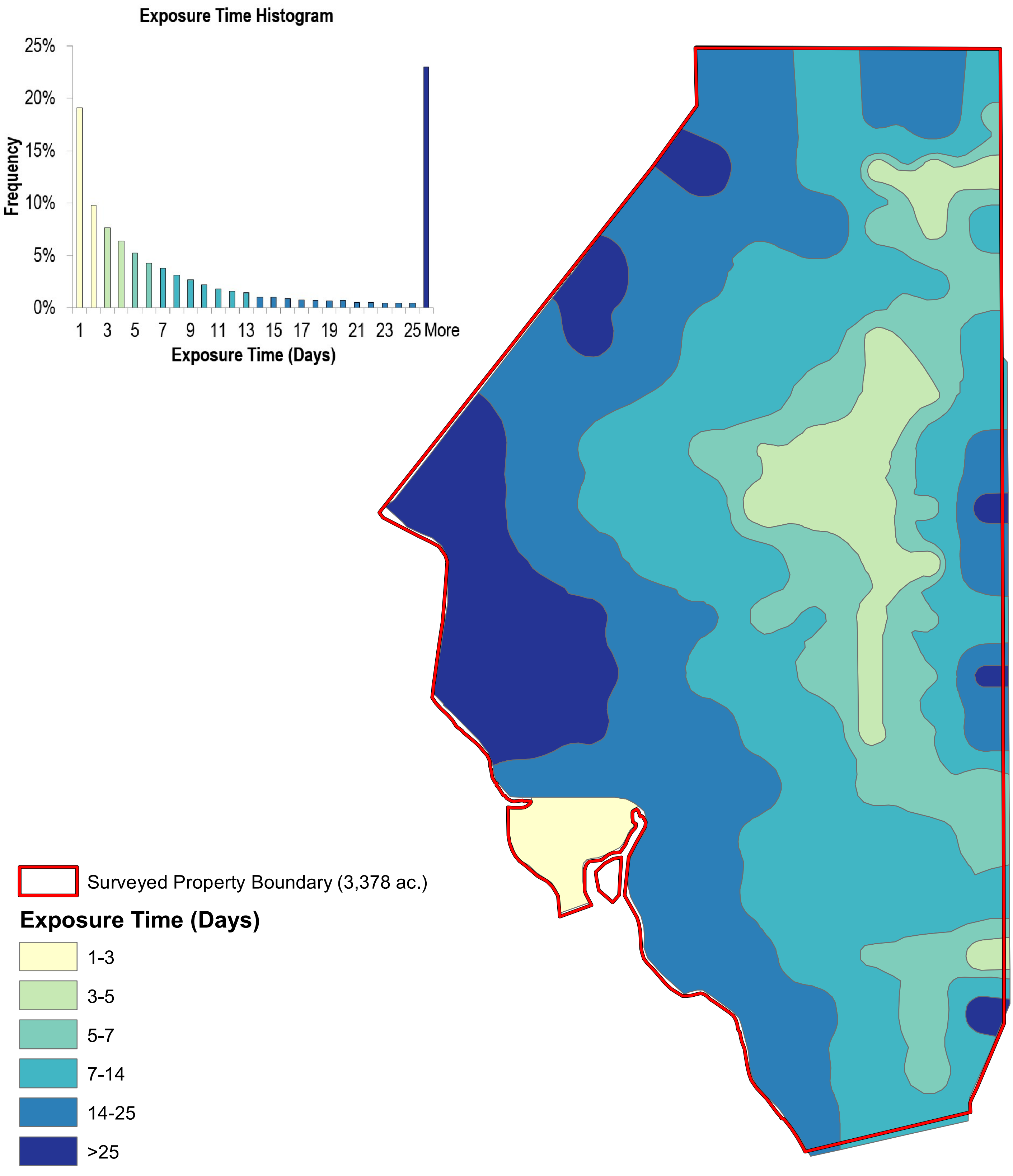

Figure from ESA 2019:
Particle Exposure (i.e. Residence) Time Assessment Following Restoration

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Lookout Slough Restoration Project

Ecosystem Investment Partners

Prepared by:
ESA

Map Prepared Date: 12/31/2018
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
DWR, USGS, Wood Rodgers

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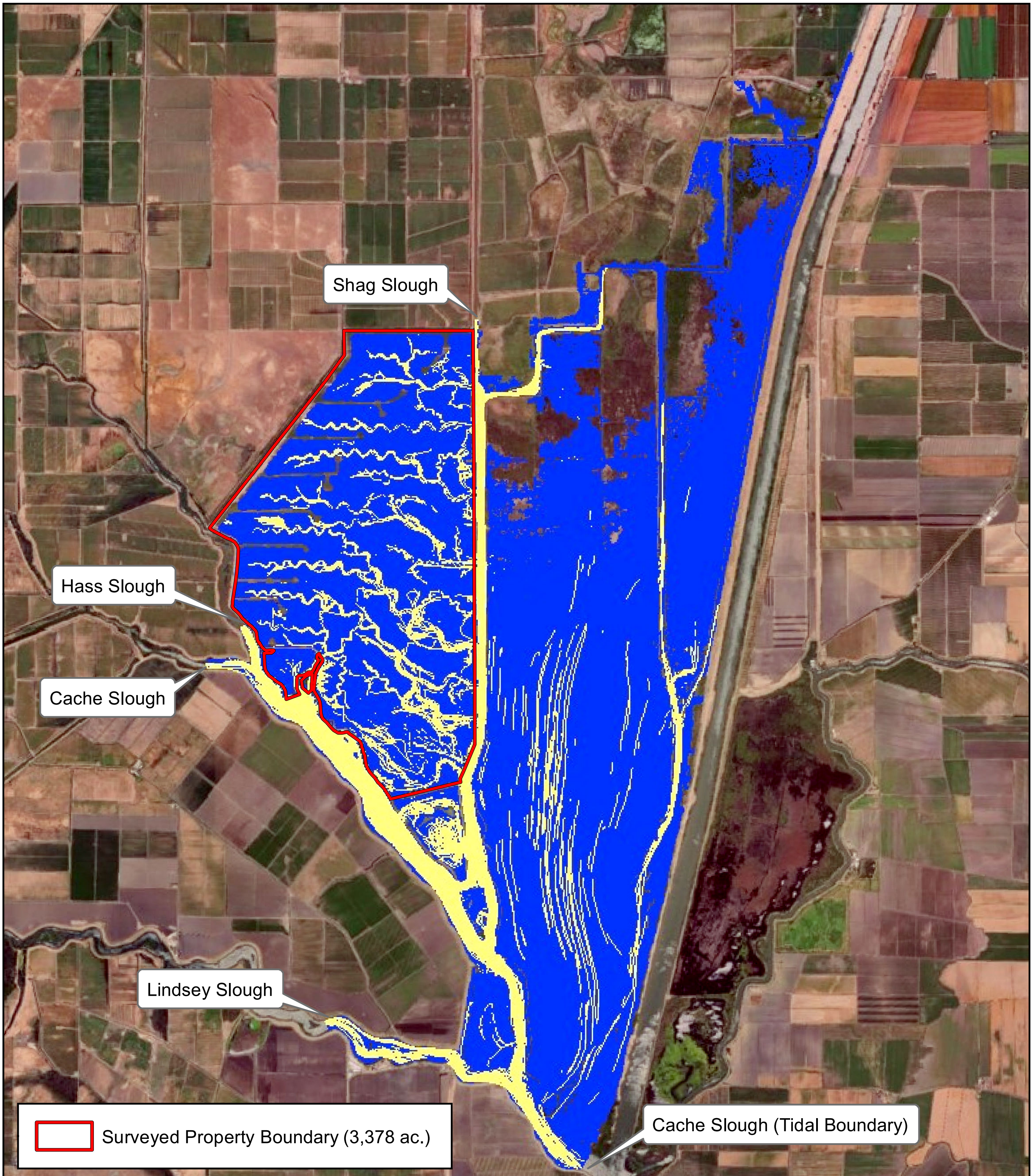

Figure from ESA 2019:
Particle Pathways - General Export Pattern Pathways

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Lookout Slough Restoration Project

Ecosystem Investment Partners

Prepared by:
ESA

Map Prepared Date: 12/31/2018
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
DWR, USGS, Wood Rodgers

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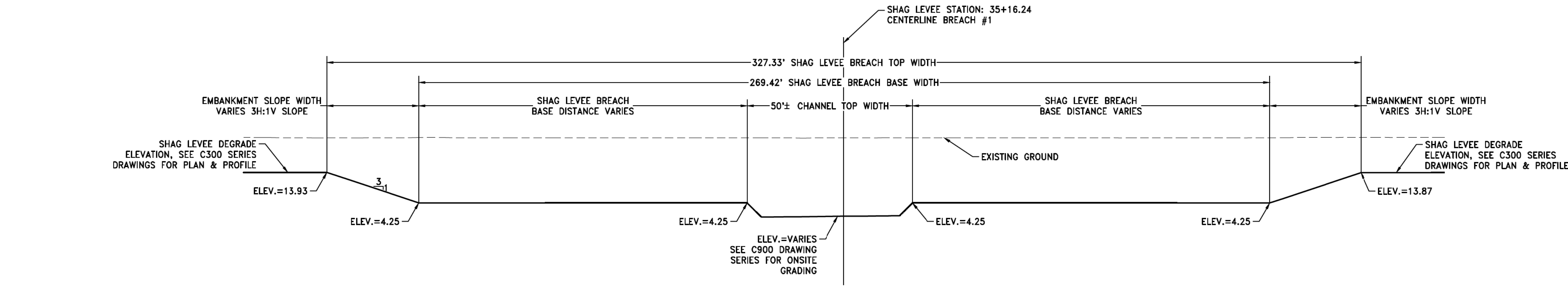

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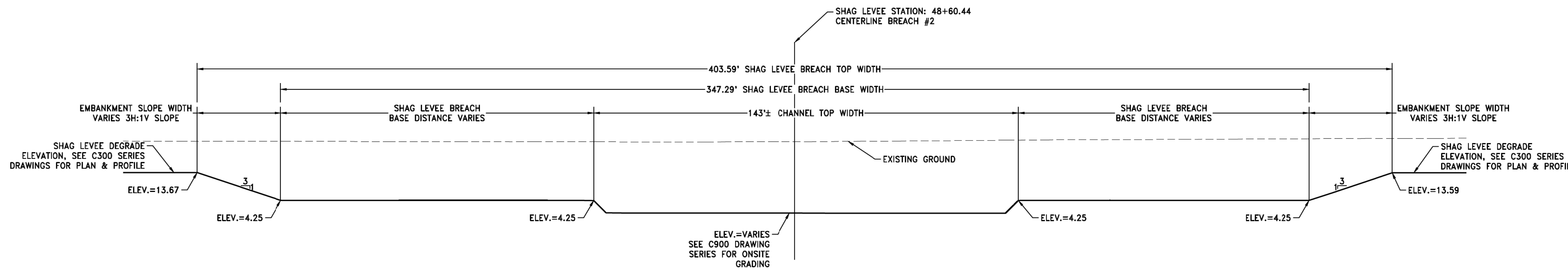

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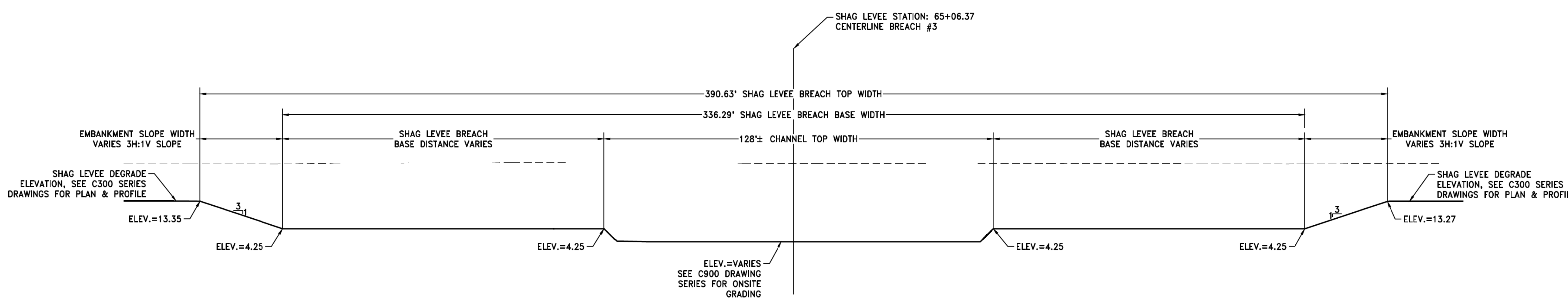

SHAG LEVEE BREACH #3 SECTION STATION 65+06.37 (3/–)
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REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: JESSE J. PATCHETT, P.E., CFM
DRAWN BY: JARED GORE, P.E.
CHECKED BY: PETE TOBIA, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 12/21/2018

PRELIMINARY (REGISTERED PROFESSIONAL ENGINEER, JONATHAN L..., CIVIL, STATE OF CALIFORNIA)

WOOD RODGERS
DEVELOPING • INNOVATIVE • DESIGN • SOLUTIONS
3301 C STREET, BLDG. 100-B, SACRAMENTO, CA 95816
PHONE: (916) 341-7760 FAX: (916) 341-7767

SUBMITTED APPROVED

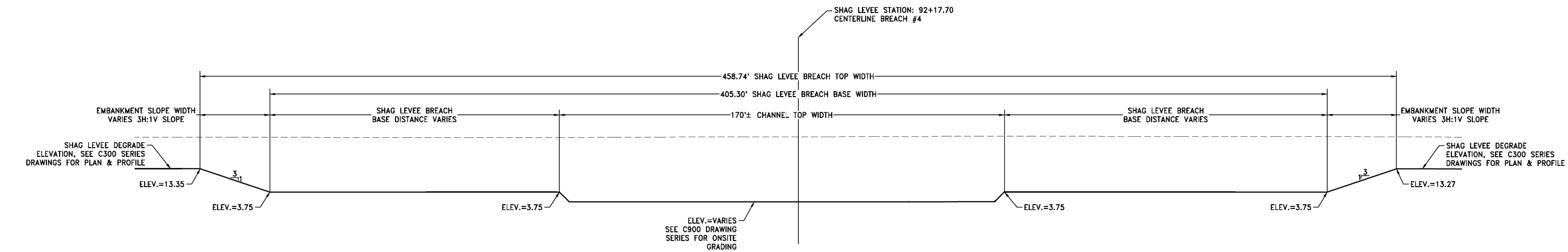
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS
LOOKOUT SLOUGH RESTORATION PROJECT
LEVEE BREACH DETAILS 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

DRAWING NO. G301 SHEET 38

J:\3000-s\3487_Ecosystem_Invest_Partners\3487003 Lookout Slough Preliminary Design\Civil\Dwg\Levee Plans\SHEETS\LEVEE BREACH DETAILS 1.dwg 12/20/2018 2:33 PM Jared Gore



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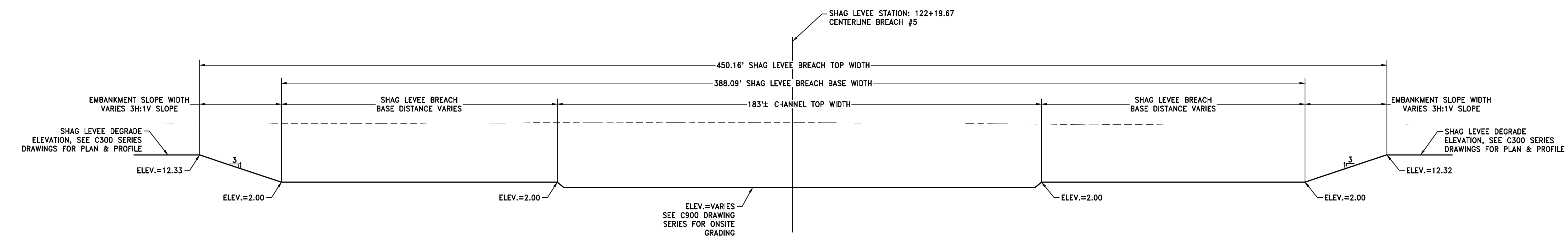
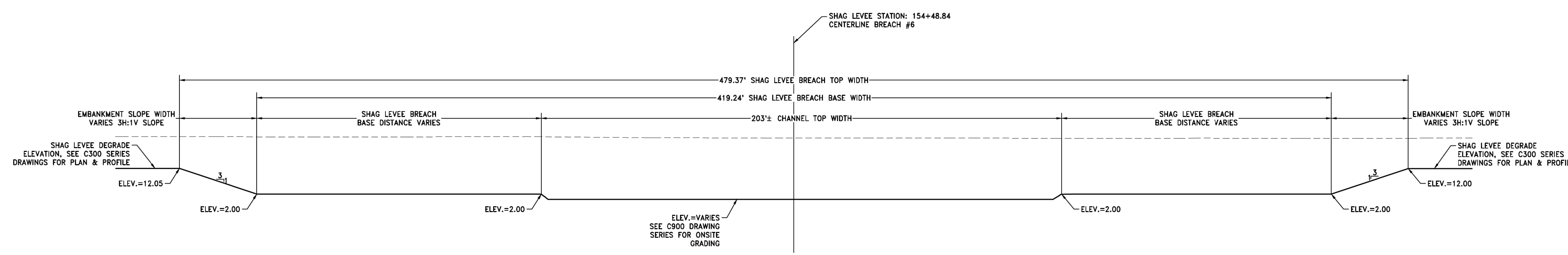


SHAG LEVEE BREACH #5 SECTION STATION 122+19.67 (5/–)

SCALE: 1"=20'



SHAG LEVEE BREACH #6 SECTION STATION 154+48.84 (6/–)

SCALE: 1"=20'

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: JESSE J. PATCHETT, P.E., CFM
DRAWN BY: JARED GORE, P.E.
CHECKED BY: PETE TOBIA, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 12/21/2018

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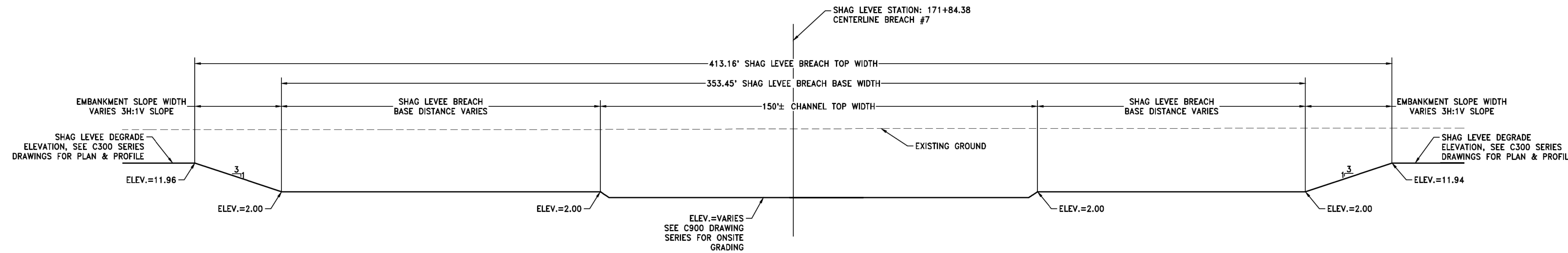
LEVEE BREACH DETAILS 2

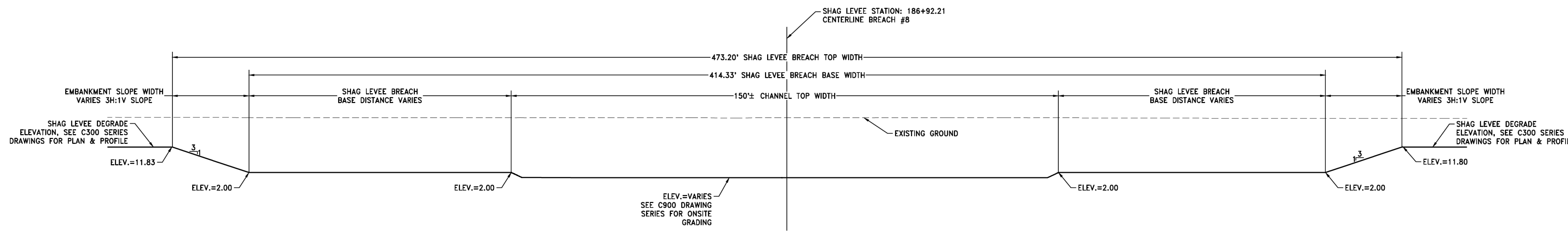
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 — 1"

DRAWING NO. G302 | SHEET 39

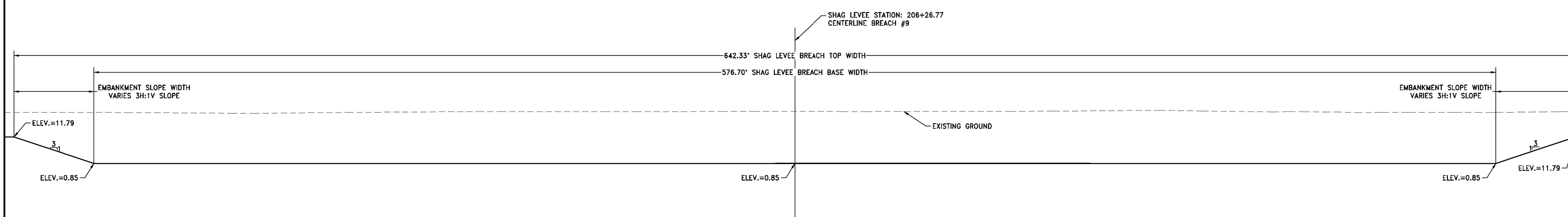
J:\3000-s\3487_Ecosystem_Invest_Partners\3487003 Lookout Slough Preliminary Design\Civil\Dwg\Levee Plans\SHEETS\LEVEE BREACH DETAILS 2.dwg 12/20/2018 2:33 PM Jared Gore



SHAG LEVEE BREACH #7 SECTION STATION 171+84.38 (7/–)
SCALE: 1"=20'



SHAG LEVEE BREACH #8 SECTION STATION 186+92.21 (8/–)
SCALE: 1"=20'



SHAG LEVEE BREACH #9 SECTION STATION 206+26.77 (9/–)
SCALE: 1"=20'

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: JESSE J. PATCHETT, P.E., CFM
DRAWN BY: JARED GORE, P.E.
CHECKED BY: PETE TOBIA, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 12/21/2018

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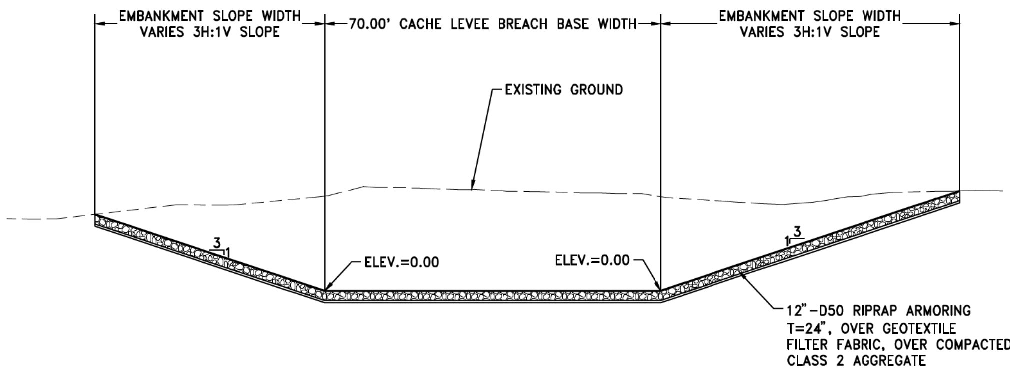
LEVEE BREACH DETAILS 3

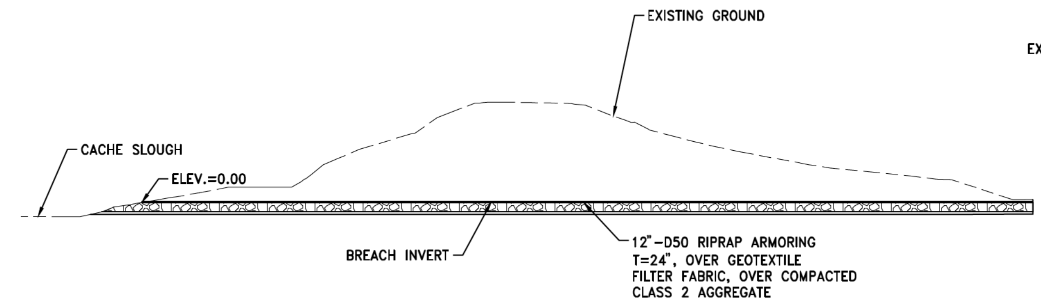
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

DRAWING NO. G303
SHEET 40

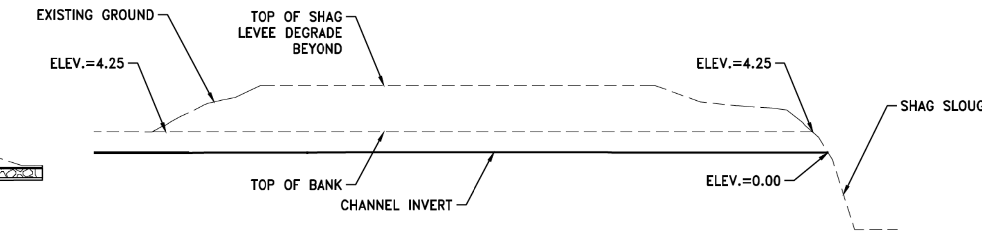
J:\3000-s\3487_Ecosystem_Invest_Partners\3487003 Lookout Slough Preliminary Design\Civil\Dwg\Levee Plans\SHEETS\LEVEE BREACH DETAILS 3.dwg 12/20/2018 2:33 PM Jared Gore



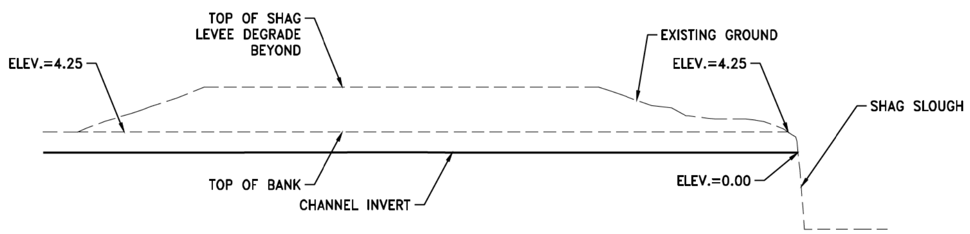
CACHE LEVEE BREACH (10/–)
SCALE: 1"=20'



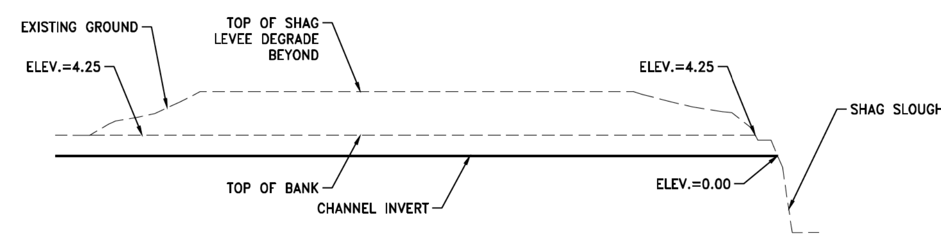
CACHE LEVEE BREACH (11/–)
SCALE: 1"=20'



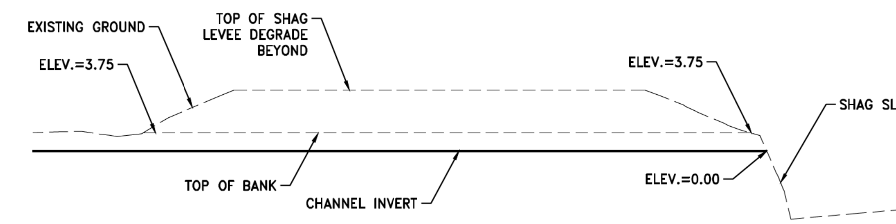
SHAG LEVEE BREACH #1 (12/–)
SCALE: 1"=20'



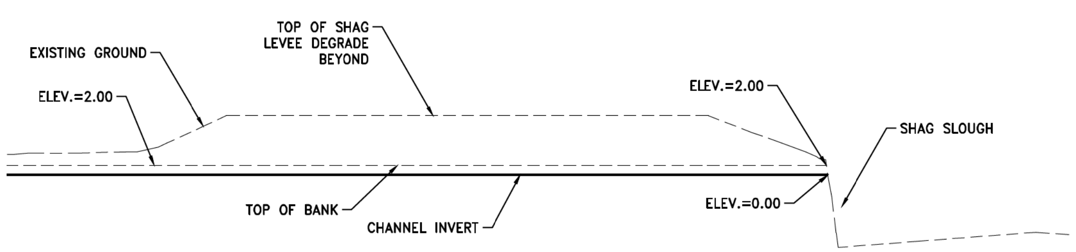
SHAG LEVEE BREACH #2 (13/–)
SCALE: 1"=20'



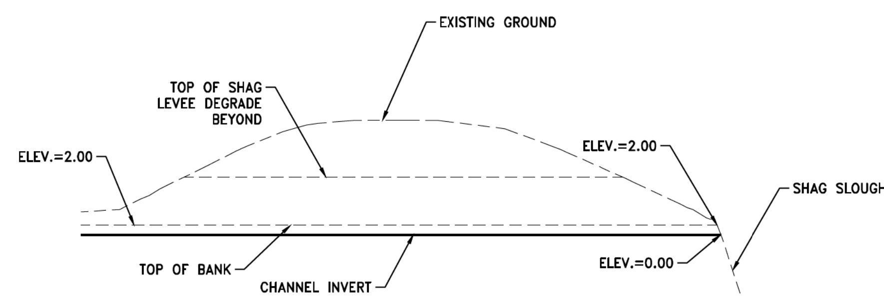
SHAG LEVEE BREACH #3 (14/–)
SCALE: 1"=20'



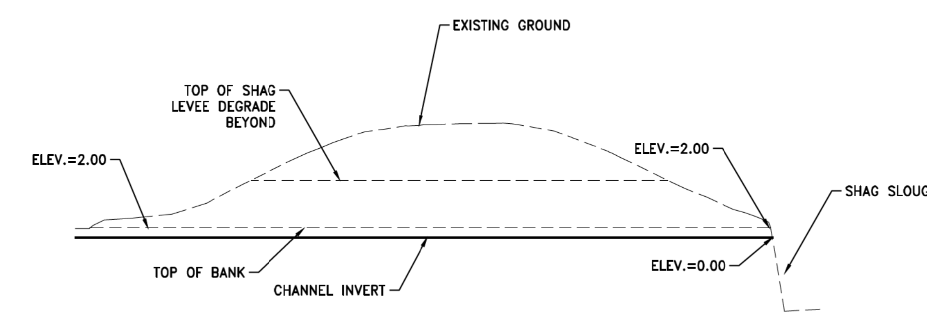
SHAG LEVEE BREACH #4 (15/–)
SCALE: 1"=20'



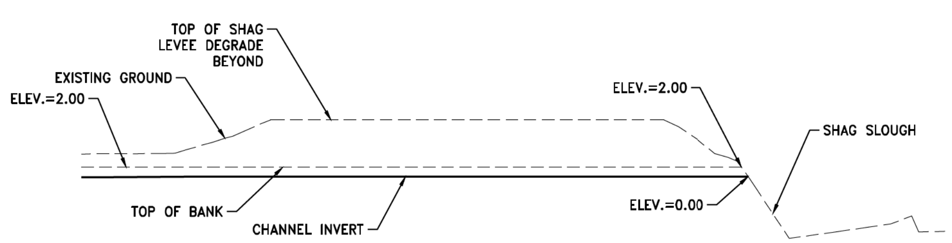
SHAG LEVEE BREACH #5 (16/–)
SCALE: 1"=20'



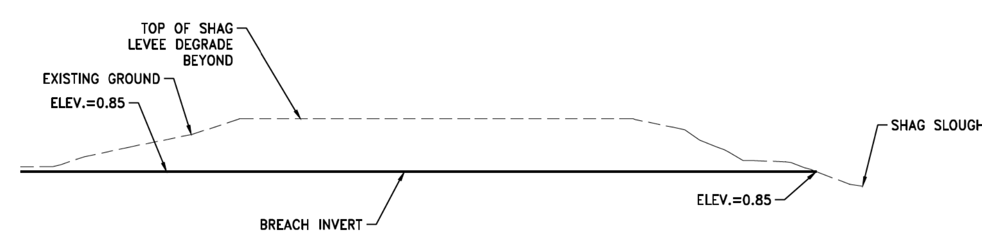
SHAG LEVEE BREACH #6 (17/–)
SCALE: 1"=20'



SHAG LEVEE BREACH #7 (18/–)
SCALE: 1"=20'



SHAG LEVEE BREACH #8 (19/–)
SCALE: 1"=20'



SHAG LEVEE BREACH #9 (20/–)
SCALE: 1"=20'

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: JESSE J. PATCHETT, P.E., CFM
DRAWN BY: JARED GORE, P.E.
CHECKED BY: PETE TOBIA, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 12/21/2018

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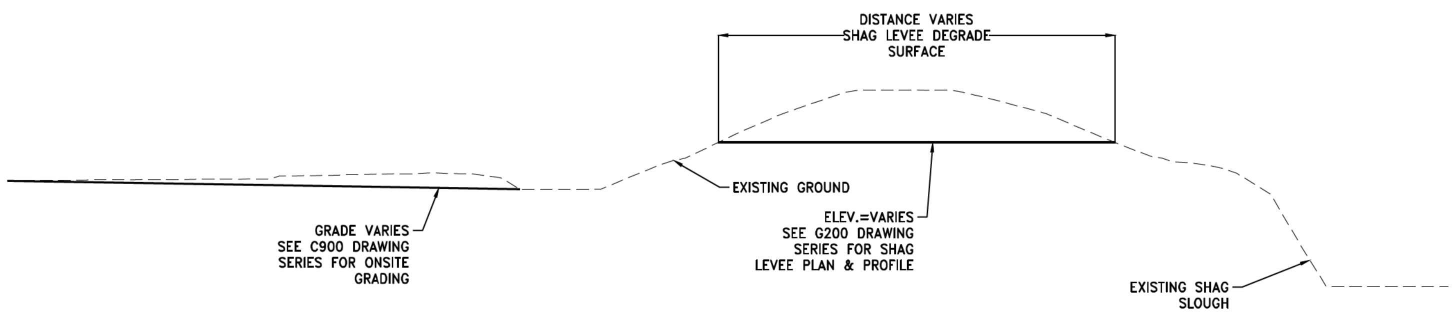
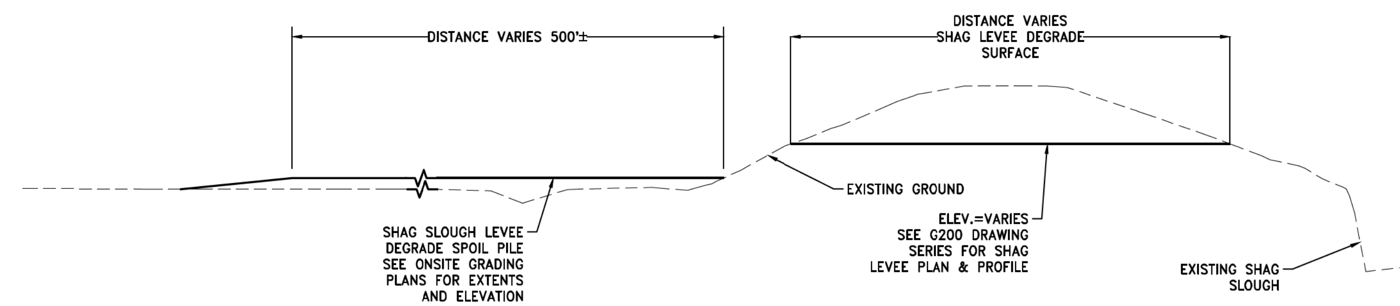
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 — 1"

DRAWING NO. G304
SHEET 41

J:\3000-s\3487_Ecosystem_Invest_Partners\3487003 Lookout Slough Preliminary Design\Civil\Dwg\Levee Plans\SHEETS\LEVEE BREACH DETAILS 4.dwg 12/20/2018 2:34 PM Jared Gore



SHAG LEVEE DEGRADE SECTION (21 / –)
SCALE: 1"=20'
STA. 26+24.82 TO 87+78.93



SHAG LEVEE DEGRADE SECTION (22 / –)
SCALE: 1"=20'
STA. 87+78.93 TO 89+00.42
STA. 95+39.50 TO 118+82.68
STA. 125+55.10 TO 150+99.08
STA. 157+84.65 TO 168+75.47
STA. 175+06.68 TO 183+33.67
STA. 190+51.02 TO 201+90.93
STA. 210+39.29 TO 214+67.03

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: JESSE J. PATCHETT, P.E., CFM
DRAWN BY: JARED GORE, P.E.
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IN CHARGE: JONATHAN KORS, P.E.
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VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

DRAWING NO. G305
SHEET 42

J:\3000-s\3487_Ecosystem_Invest_Partners\3487003 Lookout Slough Preliminary Design\Civil\Dwg\Levee Plans\SHEETS\LEVEE BREACH DETAILS 5.dwg 12/20/2018 2:34 PM Jared Gore

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