Memorandum

Project #4207-01

To: Michelle Orr, ESA

From: Ron Duke
October 25, 2018

Subject: Lower Walnut Creek Restoration Project, Salt Marsh Harvest Mouse Technical Memorandum

Background

Purpose

The Contra Costa County Flood Control and Water Conservation District is proposing the Lower Walnut Creek Restoration Project (LWC project) to: (1) restore and enhance tidal wetlands along the southern shore of Suisun Bay; and (2) provide sustainable flood protection that extends upstream from Suisun Bay along Walnut Creek and its tributary Pacheco Creek (ESA 2017). The purposes of this technical memorandum are to update the existing science on salt marsh harvest mouse (Reithrodontomys raviventris halicoetes) (SMHM) habitat use and to apply the current science to predict the project’s impacts and benefits to the SMHM.

Distribution

The SMHM is found only in saline and brackish wetlands of the San Francisco Bay and its tributaries. The southern subspecies (R. r. raviventris) is primarily restricted to the area along both sides of San Francisco Bay, from San Mateo County and Alameda County south to Santa Clara County. The historical range of the species included tidal marshes within the San Francisco and San Pablo Bays, east to the Collinsville-Antioch area. Agriculture and urbanization has claimed much of the former historical tidal marshes, resulting in a 79% reduction in the amount of tidal marshes in these areas (Goals Project 1999). At present, the northern subspecies (R. r. halicoetes) occurs along Suisun and San Pablo Bays north of Point Pinole in Contra Costa County, and in Point Pedro in Marin County. The southern subspecies is found in marshes in Corte Madera, Richmond, and South Bay (primarily south of the San Mateo–Hayward Bridge on State Route 92).
Habitat and Biology

The SMHM has evolved to a life in tidal marshes and the associated upland transitional zones of San Francisco Bay. This species has adapted well to the managed marshes surrounding the bay, especially in the diked marshes of Suisun Bay. Specifically, it has evolved to depend mainly on dense pickleweed \((\text{Salicornia} \text{ spp.})\) as its primary cover and food source but also uses other vegetation (e.g., salgrass \((\text{Distichlis} \text{ spicata})\), bulrush \((\text{Schoenoplectus} \text{ spp.})\) and \((\text{Bolboschoenus} \text{ spp.})\)) typically found in the salt and brackish marshes of this region. In natural systems, SMHM can be found in the middle tidal marsh and upland transitional zones, as well as in managed marshes. Upland refugia during high tide events and vegetation structure (i.e., room to climb above the tides or managed flooding) are essential habitat components for the SMHM.

Although its primary habitat (especially in the South Bay) was thought to consist of pickleweed-dominated areas in the upper regions of tidal marshes, the SMHM is also found in diked and muted tidal marshes comprised mainly of pickleweed. More recently, this species has been found in dense vegetation within brackish marshes in the South Bay, specifically tri-corner bulrush \((\text{Schoenoplectus americanus})\) marshes that are mature and have a thick, well-developed layer of thatch (H. T. Harvey & Associates 2006, 2010). As discussed below, recent work on the northern subspecies \((\text{R. r. halocoetes})\) shows substantially less or no preference for pickleweed-dominated areas.

Threats

Historically, the marshes in San Francisco Bay were a complex mosaic of vegetation zones, generally consisting of low marsh adjacent to mudflats dominated by cordgrass \((\text{Spartina} \text{ foliosa})\), high marsh plains dominated by pickleweed, and broad transitions of peripheral halophytes (i.e., salt-tolerant plants that cannot endure as much tidal inundation) into upland habitats, with narrower transitional zones on natural levees along larger channels within the marshes. Most of the tidal marshes around San Francisco Bay, and especially in the South Bay, were eliminated; the remaining marshes have lost the upper portion of their pickleweed zones as well as the higher zone of peripheral halophytes (Shellhammer 1982, Shellhammer and Duke 2004). Most of the tidal marshes in the South Bay are small, isolated swaths along the backshores of levees or other hardened structures that promote predation, inhibit further high marsh development, and are threatened by sea level rise (Shellhammer 1989). Similarly, most of the tidal marshes do not contain higher order tidal channels and therefore lack a configuration of natural levees supporting shrubs (e.g., gum plant \((\text{Grindelia} \text{ spp.})\) and other peripheral halophytes) that could provide escape cover for SMHM. Shellhammer and Duke (2004) note that most of the marshes of the South Bay are de facto corridors; they are likely not wide enough to support viable populations but are broad enough to function as dispersal corridors.

A database of all SMHM studies was compiled by H. Shellhammer at H. T. Harvey & Associates (Shellhammer and Duke 2004). Trapping records from permits issued by the U.S. Fish and Wildlife Service and California Department of Fish and Game (now California Department of Fish and Wildlife [CDFW]) were reviewed and compiled. The database, which includes 198 trapping projects (estimated 95% of all such projects and studies) representing 134,204 trap nights (TN) completed through 2003, shows that 37% of all trapping projects (i.e., 73 of 198 projects, or 49,481 of 134,204 TN) captured no SMHM. The average capture efficiency (C.E., or total
effort in TN divided by the number of mice captured) of all trapping projects was 0.013. In terms of unit effort, it took an average of 79 TN to capture one harvest mouse. For projects in which at least one SMHM was captured, approximately 64% (153 of 198) had a C.E. equal to or less than 0.019; it took 77 TN to capture a single SMHM. There were few projects where numerous harvest mice were captured (i.e., only 8 projects had a C.E. of 0.06 or more).

Despite the species’ apparently low populations, the SMHM is known to rapidly colonize restored areas. Multiple trapping reports in the database indicated that this species quickly moves into areas of appropriate habitat from nearby inhabited areas. Restored habitats at the Concord Naval Weapons Station were recolonized within 2 years (H. T. Harvey & Associates 1996). More extensive work in the Suisun Marsh over the last 10 years has shown that the diked and tidal marshes of the Suisun Bay support a robust SMHM population; this research is described below.

**Current Science on SMHM Habitat Use**

**Distribution of the SMHM in the Vicinity of the Lower Walnut Creek Restoration Site**

The tidal and non-tidal marshes of Suisun Bay have been known to support SMHM for more than a century (Dixon 1908). Trapping efforts in the tidal marshes in the vicinity have historically been infrequent, and generally related to evaluation of impacts and potential damage to these marshes. Figure 1 depicts the distribution of most of the trapping efforts that were conducted in the area, as compiled from public records (Shellhammer and Duke 2004, Shellhammer 2005). An extensive trapping effort was undertaken after the 1988 Shell Oil Spill as part of an extensive study of the spill’s effects implemented under the Shell Oil Spill Assessment and Recovery Monitoring Environmental Effects Program (Shell Oil program) (H. T. Harvey & Associates 1989a). Those trapping efforts detected SMHM in the Peyton Slough Marsh to the west of the LWC project area. The SMHM was detected in numerous locations, including along trap lines in areas abutting the northwest quadrant of the North Reach of the LWC project area, and near the remnant channel where the culverts will be improved to expand tidal connection to the western quadrants (Figure 2). The Shell Oil program trapping also detected SMHM in the Point Edith Ecological Reserve immediately east of the LWC project (Figure 3), as well as in the Hastings Slough Marsh slightly farther to the east (Figure 1). Additionally, SMHM was found in several other locations along the edges and islands of the Suisun Bay. The vegetation in these brackish tidal marshes consists of a mixture of bulrushes, pickleweed, and other marsh plants. The Shell Oil program trapping also detected SMHM along the fringes of what was previously known as McNabney or Shell Marsh and is now referred to as the Waterbird Regional Reserve (Figure 1). This marsh was the most substantially affected by the 1988 oil spill and subsequent clean-up efforts; however, Lower Walnut Creek was also heavily oiled by the spill. Although there have been no recent studies in the vicinity, the brackish marshes to the east and west of the North Reach of the LWC project have long supported robust SMHM populations. Fisler’s landmark work on the species (Fisler 1965) included collecting numerous specimens from an area referred to as Martinez Marsh, which was 2 miles west of Martinez and coincides with the current location of Peyton Slough Marsh.
Figure 1. Salt Marsh Harvest Mouse Trapping Records

Salt Marsh Harvest Mouse Trapping Records
- Captures (Date / Captures)
- No Captures

Captures (Date / Captures):
- 1988 / 5
- 1997 / 0
- 1997 / 8
- 2001 / 0
- 1989 / 9
- 1995 / 0
- 1980 / 0
- 1990 / 1
- 1990 / 0
- 1994 / 8
- 1990 / 1
- 1997 / 0
- 2001 / 0
- 1997 / 7
- 1988 / 5
- 1988 / 5
- 1988 / 22
- 1988 / 22
- 1988 / 22
- 1971 / 12
- 1979 / 19
- 1988 / 37
- 1980 / 6
- 1007 / 0
- 1009 / 0
- 1007 / 22
- 1009 / 22
- 1009 / 22

Background: Digital Glode Aerial (8/28/17)
Figure 2. Peyton Slough Marsh Trapping

Legend
- SMHM Capture Sites
- Transect Lines

Background: Digital Glode Aerial [8/28/17]
Figure 3. Point Edith Marsh Trapping

Legend
- SMHM Capture Sites
- Transect Lines

Background: Digital Globe Aerial (8/28/17)
The area between the North and Middle Reaches of the LWC project area has been trapped occasionally with mixed results. The drainage ditches to the south of Waterfront Road were trapped as part of an investigation related to an oil spill from the Kinder Morgan Energy Partners pipeline on Dec. 12, 2000 (H. T. Harvey & Associates 2001) (Figure 1). No SMHM were discovered, although some harvest mice that were trapped had intermediate traits and were therefore not assigned to species; Dr. Howard Shellhammer determined that none of these individuals were SMHM. The seasonal wetland between Waterfront Road and the Acme Landfill was trapped in the late 1980s and a few SMHM were present (H. T. Harvey & Associates 1989b) (Figure 1). West of the Tosco oil refinery, SMHM were also found in the marshes along Waterfront Road (H. T. Harvey & Associates 1997a) (Figure 1). Farther east, SMHM are known from the brackish marshes of the Concord Naval Weapons Station, including those near Middle Point (H. T. Harvey & Associates 1992, 1997b).

Extensive SMHM trapping has been undertaken recently in the Suisun Marsh across Suisun Bay from the project site. That trapping, conducted by CDFW and researchers from the University of California, Davis, has revealed a robust population of SMHM in both tidal and managed brackish marshes (Smith et al. 2017, 2018). Diked managed marshes in the Suisun Marsh provide high-quality habitat, with densities of SMHM that are comparable to the tidal marshes, and habitat use is similar between the diked and tidal marshes. Within these Suisun Marsh areas, there are tall pickleweed areas intermixed with bulrushes, fat hen (*Atriplex prostrata*), Baltic rush (*Juncus balticus* ssp. *ater*), and alkali heath (*Frankenia salina*) (Goals Project 1999, as cited in Smith et al. 2018).

**Distribution and Habitat Use of SMHM in the Suisun Bay Marsh**

As described above, there have been extensive trapping efforts in the tidal marshes and managed wetlands of Suisun Marsh in recent years. Smith et al. (2014) conducted extensive trapping and radio-telemetry work, which focused on the movements of SMHM during high tide events and compared the species’ movements in tidal versus non-tidal wetlands of the Suisun Marsh. Individual SMHM tended to stay within their home ranges, and mostly moved vertically within the vegetation in response to high tides and/or managed flooding of diked marshes.

Moreover, there seems to be little preference for pickleweed-dominated habitats within SMHM populations occupying the Suisun Marsh. This observation is based on both habitat occupation (i.e., little or no preference for pickleweed over more brackish marsh species), and on dietary preferences. Food preference tests conducted by Smith showed that SMHM ate a wide variety of plants and seeds, rarely showing preference, but consumed what was available (Smith 2014, 2017). Thus the brackish marshes of the Suisun Bay, including the vast diked marshes, provide extensive high quality habitat for the SMHM. Smith reported annual average densities of 31.5 to 35 individuals per hectare in managed and tidal marshes, respectively, which indicated a population of approximately 750,000 individuals in the Suisun Marsh (Smith 2017).

Earlier work at the Concord Naval Weapons Station (H. T. Harvey & Associates 1992) had also demonstrated that the SMHM was widespread in brackish marshes and showed some preference for pickleweed-dominated habitats; however, they were widespread in areas with relatively high cover values for salt grass, invasive perennial
pepperweed (*Lepidium latifolium*), and Baltic rush. The 1992 study also noted that other habitat components, including vegetative cover and structure, were important to SMHM.

The subsequent, extensive work of Smith et al. (2017) was far more definitive, combining radio-telemetry with food studies and involving approximately 10,000 hours of effort. This radio-telemetry work also allowed for the detection of numerous SMHM nests in a variety of settings, including those constructed up in vegetation, on the ground, and in cracks in dry mud or soil. There was little preference for vegetation type detected in the choice of nesting locations (Smith 2017). There were areas that seemed to be avoided by SMHM. These areas contained sparse pickleweed and other low vegetation and/or consisted primarily of bare ground or scalds.

Additionally, by using radio-telemetry, it became clear that bare areas, including levees, were crossed consistently and regularly as were areas of open water (e.g., sloughs) thus really did not present barriers for SMHM movement. While the width and constitution of the barriers were not necessarily compared, it is clear that SMHM move more readily throughout the marsh environments than previously thought.

### Proposed Project's Effects on the SMHM

#### Potential SMHM Use of Existing Habitats within the Project Area

The existing diked habitats within the South Reach of the LWC project are comparatively poor for the SMHM. While mapped as wetlands, the area is a mixture of sparse, low pickleweed, grasses, and barren, seasonally-ponded areas. The lack of vegetative cover for most of the diked habitats in the South Reach limits their SMHM habitat value. The adjoining tidal marsh along Walnut Creek and Pacheco Creek in the South Reach is a mixture of freshwater and brackish marsh plant species, which possibly could support small numbers of SMHM, especially those that may move into the area from more suitable habitat downstream.

The Middle Reach is similar to the South Reach; in the diked areas there is a mixture of sparse, low pickleweed, grasses, and barren, seasonally-ponded areas. Diked sections along Pacheco Creek are similar to those of the South Reach. Diked sections along Lower Walnut Creek, while still marginal habitat, show some improvement in habitat quality toward the north end of the Middle Reach. Patches of pickleweed are larger and denser, and the overall vegetative cover is higher and more continuous, which are factors that improve the SMHM habitat quality. The habitat quality of the adjoining tidal marshes along Pacheco Creek and Lower Walnut Creek similarly improves in the downstream direction; the marsh conditions transition from predominantly freshwater to more brackish. These brackish areas have a higher likelihood of supporting SMHM. Near the north end of the Middle Reach, the habitat improves somewhat in the adjacent Acme Landfill seasonal wetland where SMHM were trapped in the late 1980s. However, anecdotally the habitat in that area may have declined due to repeated flooding and lack of drainage.

Portions of the North Reach provide much better habitat for the SMHM. Specifically, there are currently deep, dense stands of pickleweed within the southeast and southwest quadrants of the North Reach. Although these
areas are somewhat isolated from each other by the current access road and are subject to flooding during heavy rainfall years, they provide some of the best potential habitat for SMHM on the LWC project site. Other areas within the northeast quadrant also provide suitable habitat, including patches of pickleweed, grasses, and other species providing relatively dense cover. The areas of the northwest quadrant proposed for restoration have no habitat value for the SMHM, except perhaps for occasional dispersal or grassland foraging. Lower Walnut Creek on the east side of the North Reach provides suitable brackish marsh habitat for the species; it is similar to the tidal marshes to the east and west of the site but may be slightly less brackish due to freshwater discharges from the Walnut Creek watershed. The brackish tidal marshes along Lower Walnut Creek, especially in the Middle and North Reaches of the project area, likely support good populations of SMHM on the basis of the species being reported in similar brackish marshes on both sides of Suisun Bay.

**Projected Habitats and Habitat Values Post-restoration**

Within the South Reach, the newly created tidal marsh will have vegetation similar to that of the outboard tidal marshes along Lower Walnut Creek (i.e., transitioning from freshwater to brackish marsh). Lowering and breaching the outboard levee, creating a set-back levee, and preserving and enhancing the existing seasonal wetlands at the south end of the reach will create habitats more likely to support SMHM. In particular, the upper edges of the marsh, which will be at somewhat higher elevations from grading onto the new levee side slopes, should provide a border of brackish/salt marsh vegetation that will provide more continuous potential habitat for SMHM. The created marshes should provide dense vegetative cover (where it is currently sparse) and sufficient structure to support use by the SMHM. Although freshwater portions of the habitat may not be used as extensively as more brackish areas, there will be an overall enhancement of the habitat.

Conditions for the SMHM in the Middle Reach will also improve, albeit less so for the more freshwater areas upstream along Pacheco Creek compared to the downstream areas along Lower Walnut Creek. As with the South Reach, marshes in the Middle Reach will be a combination of tidal brackish-freshwater dominated habitats, with fringes of pickleweed and brackish marsh plant species at higher elevations. Similar to the South Reach, there will be an overall enhancement of habitat, with dense tidal marshes replacing sparsely-vegetated, non-tidal marshes.

The tidal marsh to upland ecotones (transitional zones) in the North Reach and the value of these transitions to SMHM is somewhat more complex, but will provide the best overall improvements of the habitats for the mouse. While the southern portions of the North Reach currently provide good habitat within the large patches of diked pickleweed marsh, these areas are currently subject to uncontrolled flooding during high-rainfall years. Opening these areas to the tides will introduce brackish flows comprised of freshwater outfall from Lower Walnut Creek and incoming bay waters. However, the elevation range in the southeast quadrant is high enough relative to the tidal elevations of the site (i.e., roughly the mean high water elevation and above) so that much of the existing pickleweed marsh is expected to be maintained and will be mixed with brackish marsh habitat similar to that within existing tidal marshes. These conditions will provide quality habitat for the SMHM, especially when combined with the planned expansion of the transitional zones. The southeastern quadrant is even more likely to remain dominated by pickleweed, as the muted tidal regime should help the pickleweed flourish, and lowering
the levees on the west side of the site should provide additional tidal flooding and better drainage. The new tidal marsh habitats created in the northwest quadrant will create quality SMHM habitat where there is currently none.

**Projected SMHM Use of Restored Habitats**

The proposed restoration will increase the habitat value of the site for the SMHM, as well as expanding the overall acreage of suitable and high-quality habitat. The existing relatively low-quality habitat within the diked wetlands of the South and Middle Reaches will be converted to tidal brackish marshes of the type known to support SMHM. Some habitats within the South Reach will likely be more freshwater due to the incoming flows from Lower Walnut and Pacheco Creeks; however, these areas will likely mix with the brackish conditions in the existing tidal marshes adjoining the restoration site.

The restoration at the Pacheco Marsh sites is expected to expand brackish tidal marshes along the two creeks, but given the tidal elevations of existing pickleweed habitats in the diked areas, the brackish marshes will likely continue to intersperse with the pickleweed-dominated areas that are found in the tidal marshes to the east and west of the Pacheco Marsh. The muted tidal areas on the west side of the site (fed by the remnant Walnut Creek) will likely support a mixture of habitats somewhat more saline and will also be suitable for the mouse. Moreover, lowering levees along the site and excavating for new marsh habitat in the northwest quadrant will expand the total acreage of suitable marsh for SMHM and create additional connectivity with the SMHM-occupied marshes to the east and west.

**Reziliency of the Project to Sea-level Rise**

The planned creation and enhancement of transitional zone habitats that adjoin the tidal marshes throughout most of the restoration zones will provide high-tide refugia for the SMHM during extreme tides and/or high flows, and room for the marshes to migrate upslope with sea-level rise. Although SMHM can move up in vegetation in response to flooding and/or tidal events, these transitional zones are still considered important for the mouse, especially in extreme events (Shellhammer 1989). Additionally, they are recommended in the *Recovery Plan for Tidal Marshes* (U.S. Fish and Wildlife Service 2013) and the updated *Baylands Wetlands Ecosystem Goals* (Goals Project 2015).

**References**


