Restoration Feasibility Study: Site Report
McInnis Marsh, Marin County, California

PREPARED FOR:

Marin County Parks

and

The California Coastal Conservancy

BY:

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1 Purpose and Scope

Figure 1-1: McInnis Marsh Restoration Site, Gallinas Baylands (Google Earth, 2015)

The McInnis Marsh Restoration Feasibility Study (FS) was conducted on behalf of Marin County Parks by Kamman Hydrology & Engineering, Inc. (KHE). The purpose of the project is to restore bayland, tidal, freshwater and upland habitat for resident and migratory birds, fish and other wildlife, particularly federally listed endangered species including “California” Ridgeway’s Rail, and “California” Black Rail, steelhead, and salt marsh harvest mouse in the Gallinas Baylands (Figure 1-1). Project goals are to maximize the ecological values now and in the future within the parcel, and to the extent possible, increase the natural geomorphic capacity of the corridor to adapt to sea level rise. This ecological resource directed goal is warranted because the adjacent Gallinas Creek bayland currently supports regionally significant breeding populations of endangered and threatened species. The restoration at McInnis Marsh offers an opportunity to maintain this habitat in the future via expansion of contiguous marsh habitat, an increase in freshwater and coarse sediment supply to the baylands, and potential access to an upland migration corridor via Miller Creek.

This Analysis of Site Conditions report supports the restoration feasibility study, and describes current physical, biological and land use conditions on site and in the surrounding baylands, and the site specific opportunities and constraints associated with tidal wetland restoration. This study was undertaken in collaboration with Jules Evens (Avocet Research Associates), (Fran Demgen Aquatic Biology), M. Carbiener, Fisheries Biologist, Elise Holland, Planner and P. Baye, (Ph.D., Coastal Ecologist/Botanist).

1.1 Lead Agency and Project Partners

The McInnis Marsh restoration effort is led by Marin County Parks (Parks), with the support of the California Coastal Conservancy (CCC), Marin County Flood Control and Water Conservation District (MCFCWCD), and the Las Gallinas Valley Sanitary District (LGVSD). The local project partners signed a Memorandum of Agreement (MOA) in September 2012 (Attachment A) to collaborate in study, funding and implementation of restoration of Lower Miller

Creek, Lower Las Gallinas Creek and McInnis Marsh. Parks is currently directing this Site Assessment and Restoration Feasibility Study with funding support provided by the California Coastal Conservancy.

1.2 Site Location and Setting

The McInnis Marsh/Lower Miller Creek Restoration Project envisioned will be implemented across land owned by Marin County Parks (Parks) and Las Galinas Valley Sanitary District (LGVSD). Tidal wetland restoration focuses on McInnis Marsh, a 180-acre area of diked historic wetlands located within Marin County's McInnis Park, on the west shore of San Pablo Bay, in Marin County. The restoration project includes McInnis Marsh, and adjacent reaches of Miller and Gallinas Creeks. North of McInnis Marsh and LGVSD lands are the newly restored Hamilton Wetlands; to the south are the historic marshes at China Camp State Park (Figure 1-3). Extensive mature tidal wetlands adjoin the eastern boundary of McGinnis Marsh and support several of the special status species that provide the rationale and focus of this restoration effort.

Figure 1-2, Location Map

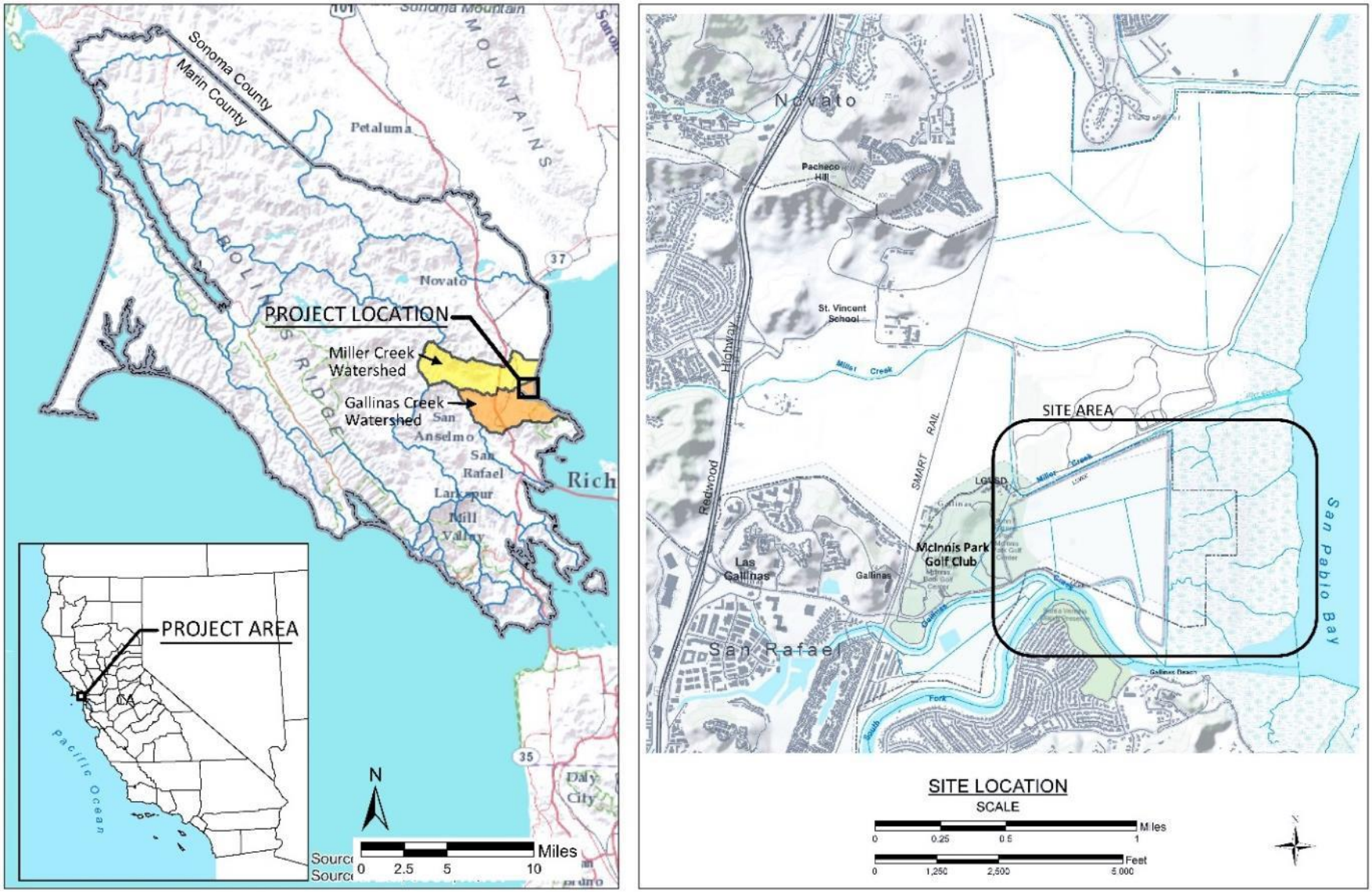
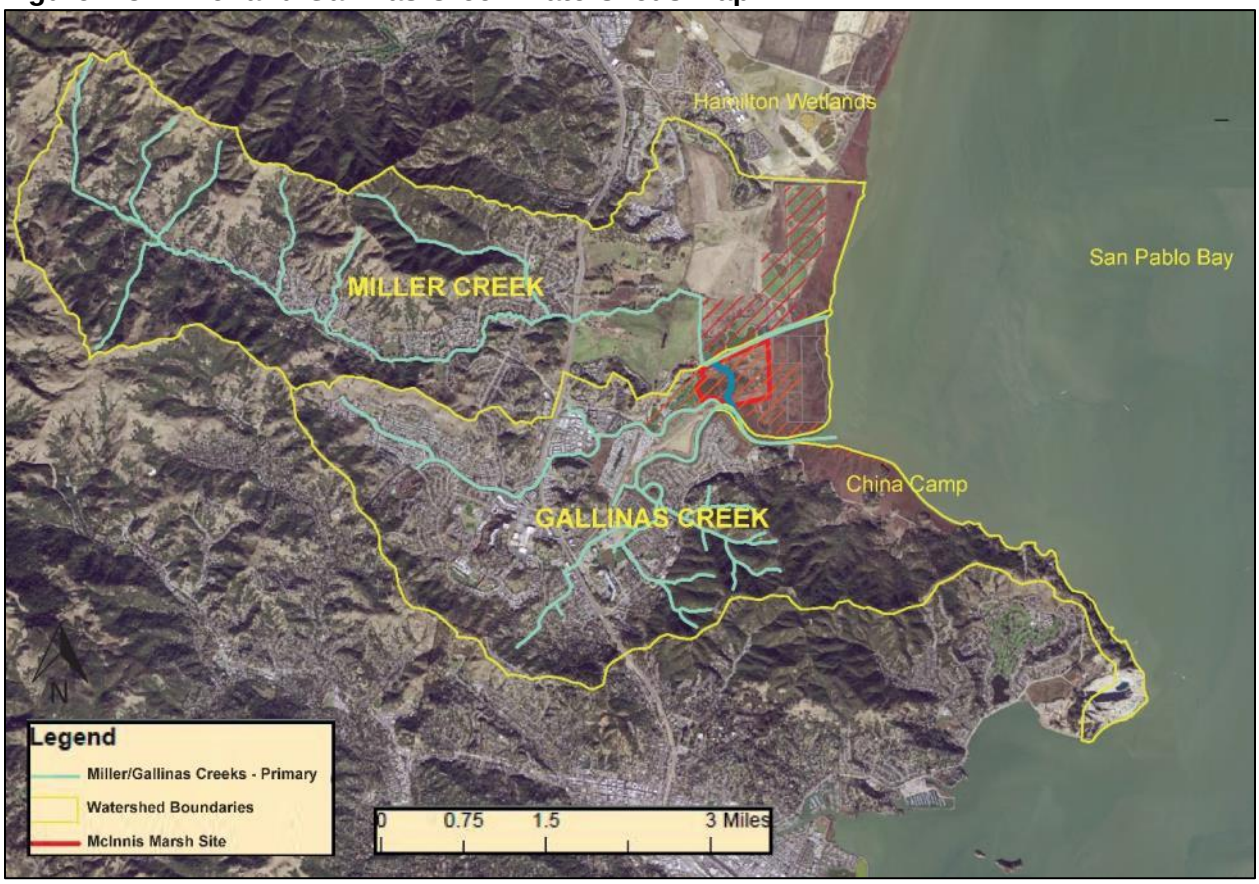
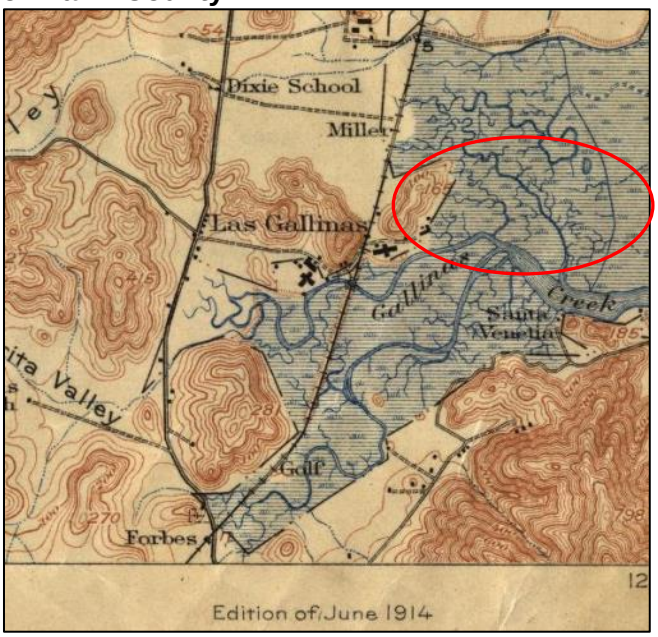


Figure 1-3: Miller and Gallinas Creek Watersheds Map



McInnis Marsh lies within the historic confluence of Las Gallinas and Miller Creeks (Figure 1-3). During periods of flood and high tide, these creeks once flowed unimpeded through a network of tidal wetlands, converging in the Gallinas Baylands. Historically, Miller Creek was a distributary channel/delta network that delivered water and sediment over a broad swath of transitional bay margin. When Miller Creek flooded this bayland complex, water flowed south to Gallinas Creek Figure 1-4). This connectivity was progressively lost in the early 1900's when levees were constructed confining Miller Creek to a narrow (150 ft wide) channel flowing south and then east to San Pablo Bay. The contemporary and historical Gallinas Baylands are illustrated in Figure 1-5 and Figure 1-6, respectively.

Figure 1-4: Gallinas Bayland Tidal Wetland Drainages Circa. 1914 (courtesy of Marin County



1.3 Restoration Project Vision

The vision for the McInnis Marsh restoration project is to restore tidal exchange to the 180 acre McInnis Marsh parcel, expanding contiguous high marsh habitat in the eastern marsh, increasing tidal prism to Gallinas Creek and reducing the need for downstream dredging. If feasible, the project would also reconnect Miller Creek to the Gallinas Baylands increasing connectivity between the baylands, the adjacent upland riparian corridor, and its alluvial sediment. Hydraulic connections will be made via levee breach, channel construction and levee removal. Restoring connectivity between tidal baylands, adjacent upslope lands and alluvial sediments provide opportunity for natural adaption (upslope movement) of wetland ecotones in response to rising tides and increasing storm magnitude and frequency.

Figure 1-5: Gallinas Baylands Circa. 2010 (SFEI, 2012)

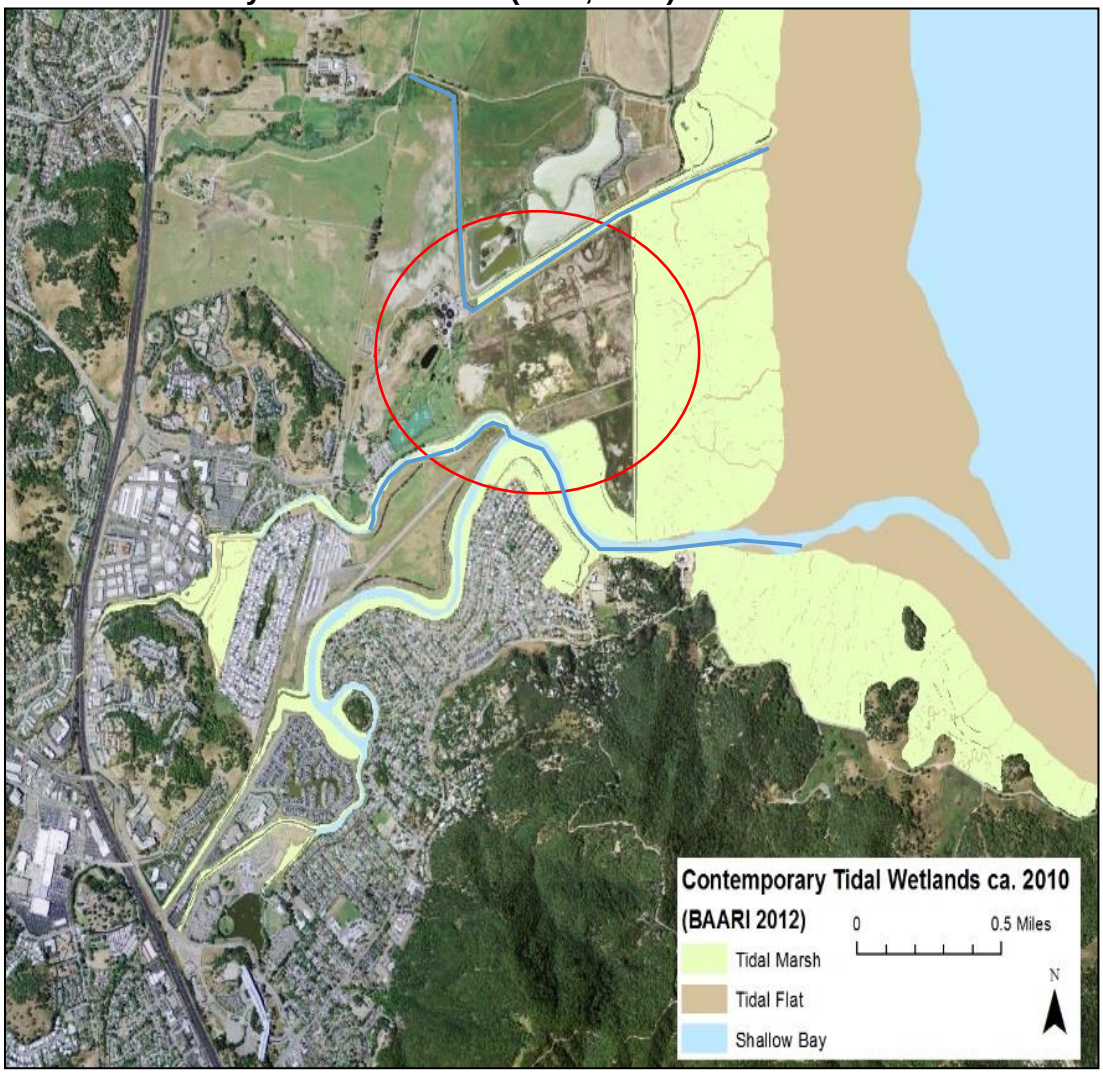
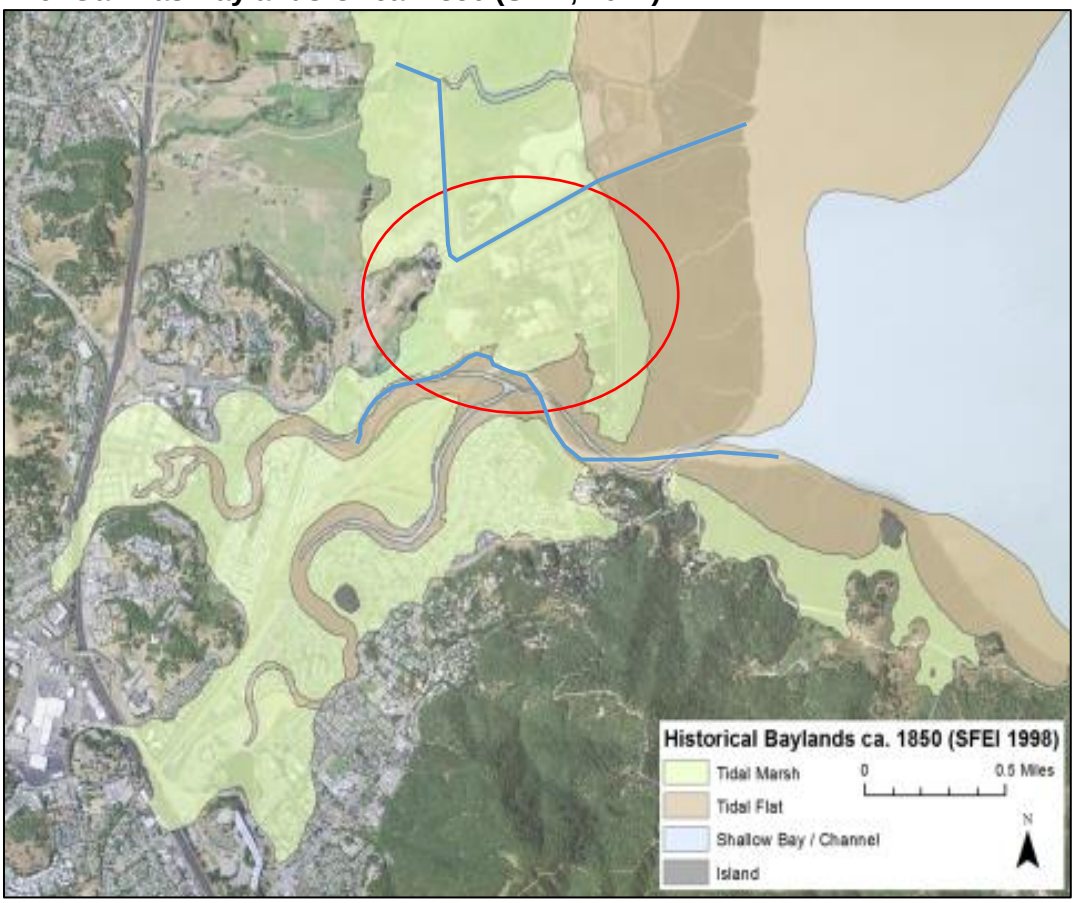


Figure 1-6: Gallinas Baylands Circa. 1850 (SFEI, 2012)



In additional to sustaining critical habitat for endangered wetland wildlife, the restoration project integrates bayland infrastructure modifications to levees, trails, storm water and treated waste water outfalls. If a South Fork Gallinas Creek dredge project is implemented in the near future, opportunity also exist to place sediment at McInnis Marsh. As conceived, this project facilitates bayland management that seeks to improve both ecological functions and community infrastructure; in addition, the restored site will be more responsive to sea-level rise and extreme climate events.

To support these efforts, this site analysis report addresses existing physical and biological conditions in the project area, infrastructure and land use constraints, and anticipated future conditions which can be expected due to climate change (sea level rise and increasing storm magnitude and frequency). Schile et al. (2014) examined the contributions of vegetation, sediment and upland habitat to marsh accretion rates and resiliency (the capacity to adapt to sea level rise). The McInnis marsh restoration project would support multiple factors which are attributed to resiliency including increasing the supply of sediment (which increases marsh accretion rates) and fresh water (which increases vegetation persistence) and availability of adjacent upland habitat for wetland ecotone translation.

2 Existing Conditions: Physical and Hydrologic

Figure 2-1: McInnis Marsh from South Levee to Western Boundary and McInnis Golf Course

The KHE team completed an assessment of existing site to document the physical (topographic, geomorphic, hydrologic, biologic and infrastructure) conditions in the project area. The assessment establishes a baseline from which environmental responses to proposed restoration actions can be evaluated. In addition, it defines the assumptions for future conditions and the anticipated impacts associated with sea level rise. The assessment approach included:

- Review and synthesis of existing information;
- Field reconnaissance and delineation of the site topography, hydrology and drainage;
- Field monitoring of physical characteristics (tidal exchange, storm water detention and routing);
- Field monitoring of biological (vegetation and wildlife) communities and characteristics;
- Fisheries habitat evaluation;
- Evaluation of facilities infrastructure and operations; and
- Evaluation of future conditions with sea level rise.

2.1 Jurisdictional Setting

2.1.1 Land Ownership

The lands within the project area, known as McInnis Marsh, are part of McInnis Park, which is owned and managed by Marin County Parks (Parks) (See Table 2-1: Parcels that Constitute the

Project Site, and Figure 2-2 and Figure 2-3). While McInnis Marsh is part of McInnis Park, it is an undeveloped area within the park boundary, and recreational facilities/activities are limited to levee top trail use. McInnis Marsh also provides an opportunity to observe wildlife and bird (i.e., shorebird, duck, migratory, etc.) habitat. McInnis Golf Course and Driving Range is to the east of the project area. Las Gallinas Creek and the San Rafael Airport lie to the south of the project area, and Miller Creek and the Las Gallinas Valley Sanitary District (LGVSD) are to the north. The lands within the project area are within the City of San Rafael, and are zoned Parks and Open Space by the City [FN: Chapter 14.10 – PARKS/OPEN SPACE DISTRICT (P/OS)]. These lands can be used for very specific purposes as stipulated in Section: 14.10.010 of the Specific Purposes of the parks/open space district, presented below.

- To provide appropriately located land throughout the city for public purposes;
- To provide opportunity for recreational uses in public parks;
- To promote an integrated pattern of open space areas within the city to serve as visual greenbelts and community separators and to protect environmental resources;
- To protect the public health and safety by limiting lands subject to flooding, slides or other hazards to open space use;
- To preserve baylands, waterways and wetlands as open space;
- To retain open space land in a natural open state;
- To discourage public utility facilities in open space areas to minimize harm to the area's visual quality;
- To allow low-intensity, passive recreational uses within open space areas and provide opportunity in appropriate locations for more intensive uses of open space which are consistent with the preservation of open space natural values and have minimal impacts on the environment.

2.1.2 Access and Utility Easements

Numerous access and utility easements encumber the land within the project area, which were established as early as 1912, and up until 1972. The majority of the easements were granted by Marin County in the 1950's and 1960's, and primarily to the LGVSD and to Pacific Gas and Electric Company (PG&E), for the purposes of establishing facilities for public utility purposes. Known access and utility easements are summarized in Table 2-1, and illustrated in Figure 2-2.

Table 2-1: Public Utility Easements

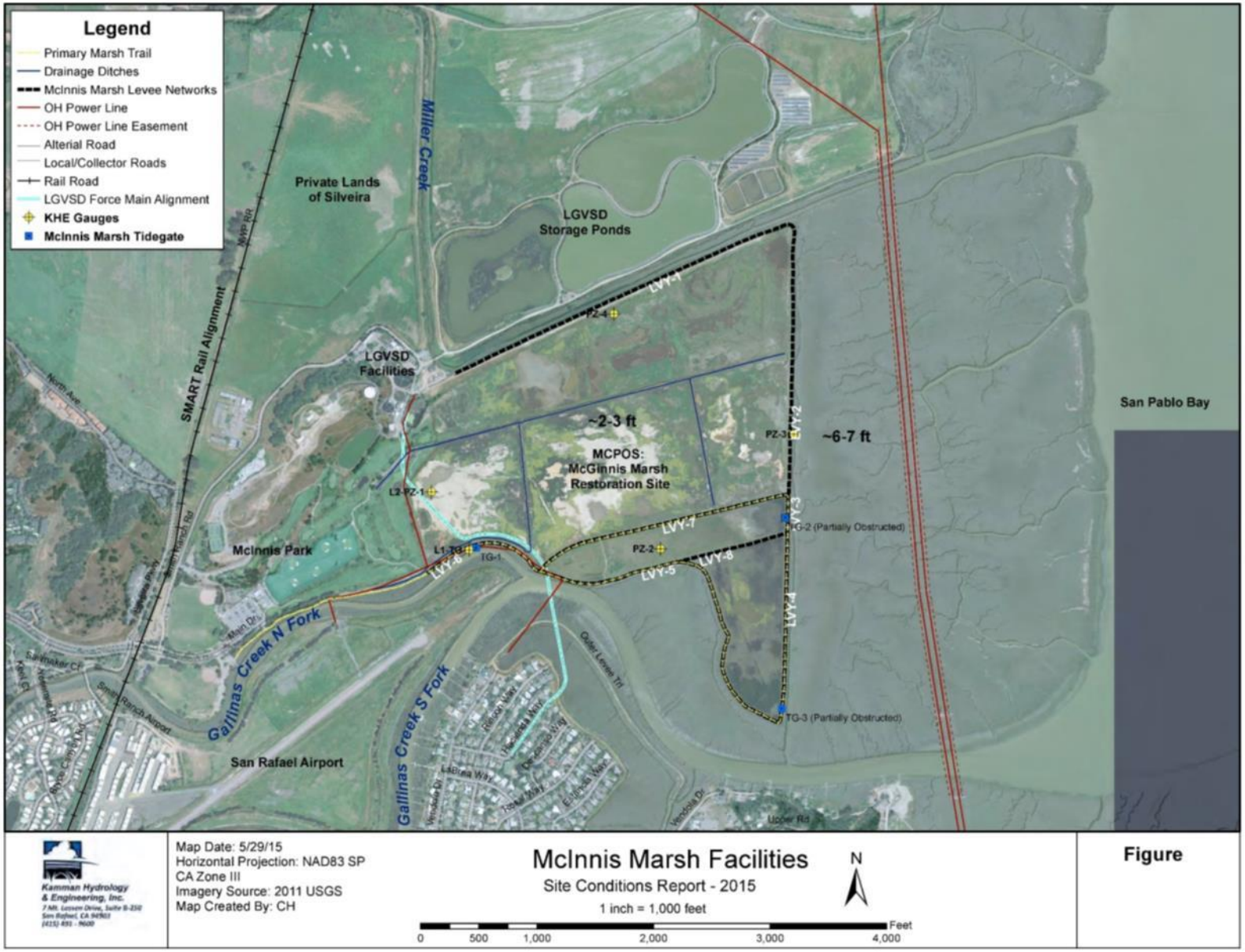
Easement Grantee	General Purpose	Relevant Parcel
Pacific Gas and Electric Company	Pole Line Right of Way	1, 2, 3, 4, 5
Pacific Gas and Electric Company	Single Line of Poles, Guy, and Anchors	1
Pacific Gas and Electric Company	Single Line of Poles	2
Pacific Gas and Electric Company	Single Line of Poles and Towers	3
Pacific Gas and Electric Company	Single Line of Poles	4
Pacific Gas and Electric Company	Gas Pipe Line	2
Pacific Gas and Electric Company	Pole Line Right of Way	2

Easement Grantee	General Purpose	Relevant Parcel
Pacific Gas and Electric Company	Pole Line Right of Way	1, 4, 5, 6
Pacific Gas and Electric Company	Tower Line Right of Way	2
Pacific Gas and Electric Company	Towers, Wires, Cables, Right to Ingress/Egress	2
Las Gallinas Valley Sanitary District	Sewer Pipeline	1
Las Gallinas Valley Sanitary District	Roadway and Utility Purposes	3, 4
Las Gallinas Valley Sanitary District	Roadway and Utility Purposes	5, 6
Las Gallinas Valley Sanitary District	Sanitary Sewer Main	3
County of Marin	Right to Place Fill from Dredging Operations	Parcel 5
County of Marin	Floating Roadway Easement	Parcels 3, 4
County of Marin	Roadway and Utility Easement	Parcel 3, 4

2.1.3 Facilities and Infrastructure

There are limited facilities and infrastructure within the project area. Parks maintains two gated culverts that drain McInnis Marsh to Gallinas Creek. See Section 2.5.2 for the description of site and perimeter drainage facilities. PG&E owns and maintains towers/power lines which cross the site. A second run of lines traverse Gallinas Marsh bayward of the site. Most significant to project restoration is a LGVSD force main which extends south from the LGVSD treatment plant, and traverses the western side of McInnis Marsh before crossing Gallinas Creek to the neighborhood of Santa Venetia (Figure 2-2).

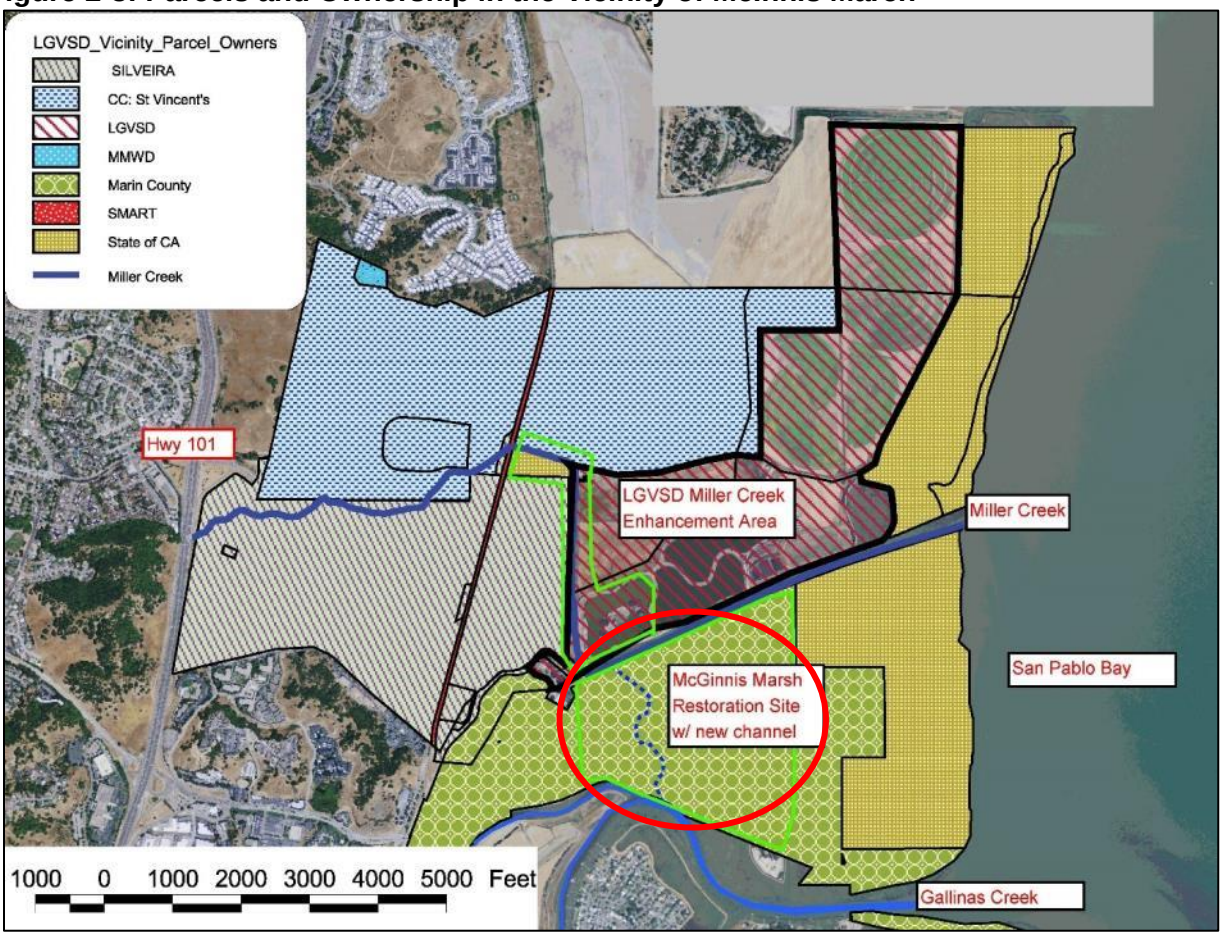
Figure 2-2: Project Site – Existing Facilities and Infrastructure



2.2 Land Use and Planning

2.2.1 Ownership of McInnis Marsh and Adjacent Parcels

Figure 2-3: Parcels and Ownership in the Vicinity of McInnis March



The McInnis Marsh parcel is owned by Marin County Parks, and occupies the eastern portion of McInnis Park, located in unincorporated Marin County at the eastern terminus of Smith Ranch Road. Along the western edge of McInnis Marsh, is the McInnis Park Golf Course. Miller Creek and the lands of Las Gallinas Valley Sanitary District (LGVSD) adjoin the northern parcel boundary. State of California owned baylands are present to the east of marsh front levees at both McInnis Marsh and LGVSD. The South fork of Gallinas Creek traverses the marsh front along the parcels Southern boundary. Adjacent parcels include the SMART tracks (west), San Rafael Airport (the adjacent peninsula), and the community of Santa Venetia (South).

2.2.2 Vegetation Management

Marin County Parks engages in minimal vegetation management within the project site. Typically, on a biannual basis, Parks staff use a side-mount riding mower to cut grass and weeds along the top of the levees, to allow for improved public access. This work was typically done in the late winter and again in the early summer. Recently, within the past year or two, Parks has ceased to undertake this work during bird nesting season, and instead has used a weed whip, on the north side of the trail, to the end of the tree line; and mow approximately 3’

along the south and west side of the trail, so as not to impact actively nesting birds and associated habitat, particularly that of the California Ridgeway's Rail (formerly "Clapper Rail").

2.2.3 Facility Maintenance

Marin County Parks engages in minimal facility maintenance within the project site. Occasionally, visitor and utility vehicle use, erosion, riling, and pockmarks adversely impact the condition of the trail network that sits atop the levee system. This can lead to safety hazards for visitors. As a result, Park's staff use hand tools and minimally invasive techniques to repair and address safety hazards and to make the surface of the levee more uniform. Parks does not grade the tops of the levees. Similarly, Parks will inspect the two tide gates and culverts during the winter season and perform any repairs as needed. PG&E and LGVSD have not undertaken any maintenance of facilities within the project site.

2.2.4 Public Access and Recreation

Marin County Parks allows visitor access to the project site via a network of trails that sit atop the levees that traverse McInnis Marsh (See Figure 2-2). While Marin County Parks does not collect visitor use census or survey data, anecdotal information indicates that McInnis Marsh sees extensive public use of its trail network throughout the year. The trails can be accessed at the canoe launch, located at the western entrance to the golf course parking lot. The trail begins at the canoe launch and follows the levee along the north side of Las Gallinas Creek (eastward). The trail forks at approximately the ½ mile mark, and continues in both northeasterly and southeasterly directions towards San Pablo Bay, creating a loop. The entire length of the trail is approximately 2 ½ miles. The trails can also be accessed by crossing the LGVSD property, and entering McInnis Marsh at the north end of the project site. The trails around the ponds on LGVSD property are popular with birdwatchers.

Visitors to McInnis Marsh, and trail users, include pedestrians, and pedestrians with dogs on leash. Bicycling and horseback riding on the trails is not allowed. Visitors to the McInnis Marsh also engage in other passive forms of recreation, including bird watching, wildlife viewing, and photography.

2.3 Historical Conditions

The land within the project area was acquired by Marin County in 1972 and designated as parks and open space. For some period of time, the land was used for cattle grazing, but not under any formal lease agreement. The Marin County Flood Control District did at various times dispose of dredge spoils from Las Gallinas Creek, at the project site. Confirmation of these reports is pending.

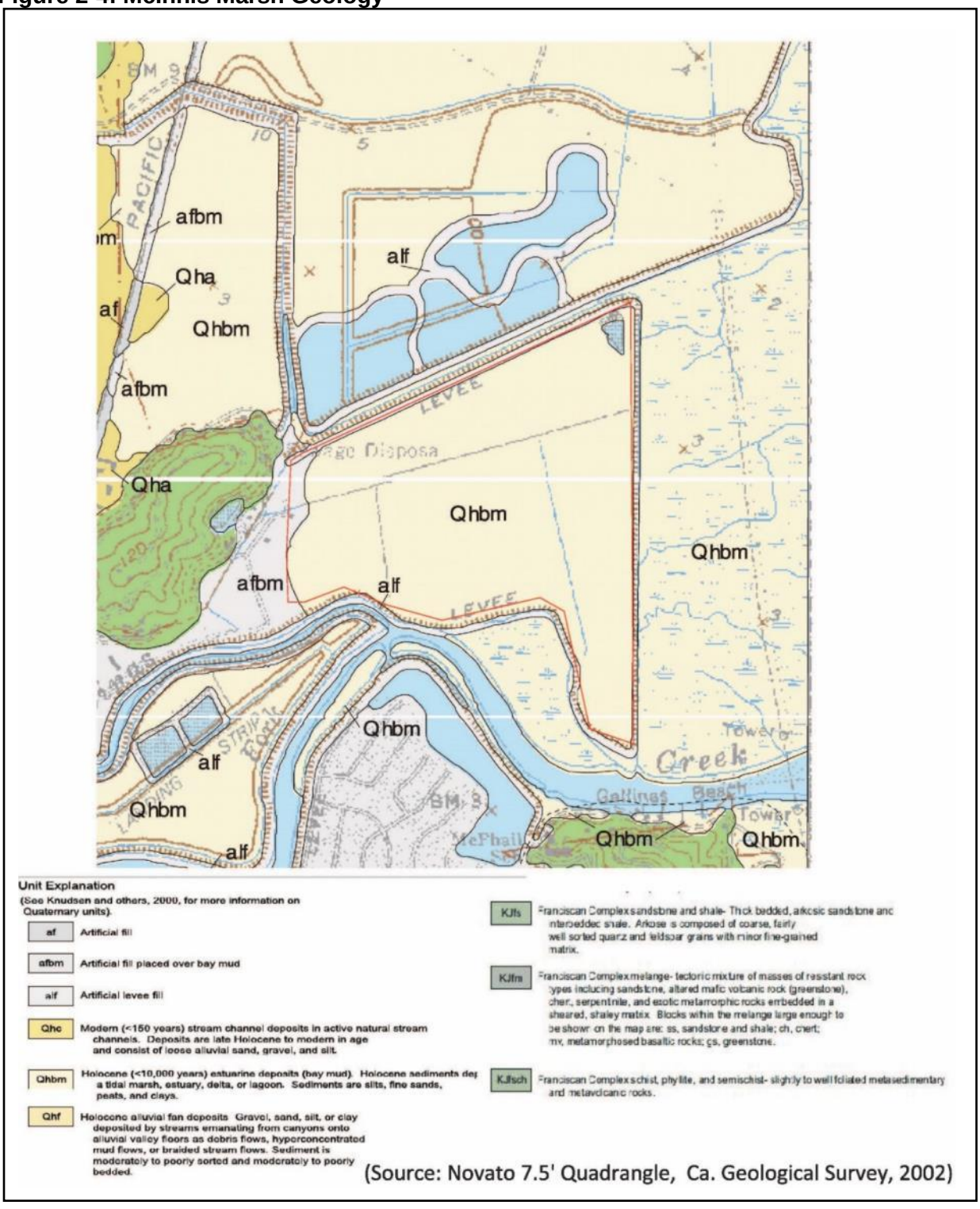
2.4 Geology and Soils

The McInnis Marsh site is located within the Coast Range Geomorphic Province of California. The regional bedrock geology consists of complexly folded, faulted, sheared, and altered sedimentary, igneous, and metamorphic rock of the Jurassic-Cretaceous age (65-190 million years ago) Franciscan Complex. Bedrock is buried except where exposed in local ridges and knolls located west of McInnis Marsh. The site is located within the seismically active San Francisco Bay Region and will therefore experience the effects of future earthquakes. The closest active fault to the site is the Hayward Fault, located about 11 kilometers east of the project site.

For the last 15,000 years the sea level has continually risen (due to melting of glaciers from the Wisconsin glaciation) and flooded the lower topography. For the last 8,000 years silt and clay particles carried in suspension in tidal and floodwater have been deposited in the San Francisco Bay to form the highly compressible "bay mud." This process continues today. The bay mud is soft and subject to slow settlements under new loads (MPEG, 2013).

Regional geologic maps (California Geologic Survey, 2002) indicate the McInnis Marsh site geology is composed of estuarine deposits (bay mud). Map symbol Qhbm on the regional geologic map is presented in Figure 2-4. These native bay muds are described as Holocene sediments deposited in a tidal marsh, estuary, delta or lagoon. Bay mud typically consists of unconsolidated, low-density, highly compressible, impermeable marine silty clay. Lenses of peat and sand are commonly encountered within bay mud deposits. Levees around the parcel perimeter and the adjacent golf course are mapped as artificial fill on bay mud (Figure 2-4, map symbol afbm). Artificial fill typically consists of mixtures of soil, rock, debris, and bay mud. The Soil Survey of Marin County (USDA SCS, 1985) concurs, and classifies the soil covering the project area east of the SMART tracks as Reyes clay. This soil unit is described as very deep, somewhat poorly drained on reclaimed tidelands. The Survey reports that native vegetation on the clay consists mainly of water-tolerant plants – effective rooting depth is limited by a seasonally high water table.

Figure 2-4: McInnis Marsh Geology



2.5 Topography, Drainages and Ground Control[1]

2.5.1 Topography

Topographic relief within the project area is low, with elevations that range from -6.0 ft. (NAVD88) [approximately 3 ft. below mean sea level] in the Lower Gallinas Creek Channel to approximately 15 ft. along the western upland project boundary. Typical grades within the central McInnis marsh parcel are 2.0 ft. (NAVD88). Levee crest elevations range from 8-10 ft. In the southern quarter of the site and the outboard marsh, the pickleweed high marsh plain is at 6 ft., and the fringing chord grass marsh ranges from 4-6 ft. The subtidal channel thalweg in Gallinas Creek ranges from -6 ft. at the outboard limit of survey to -3 ft. immediately adjacent to the restoration site. Detailed existing site topography was derived from publically available Golden Gate LiDAR data acquired during the summer of 2010 for the counties and parks of the Marin and San Francisco Peninsulas. This data set was used to develop a site digital elevation model (DEM) (

)[2].

2.5.2 Tibutary Drainages and Annual Rainfall

Introduction of tidal exchange into McInnis Marsh, and the associated realignment of the flood protection levees will alter surface water drainage patterns to and through the restored marsh. These tributaries, and direct precipitation are the primary source of freshwater to the parcel. Using the site DEM, KHE delineated tributary drainages to McInnis March to evaluate the impact of restoration on drainage from adjacent parcels, and to support development of an integrated storm water management plan for adjacent park facilities. Figure 2-9 maps the tributary drainages and outflow points to McInnis Marsh. Three drainages were identified encompassing a total tributary area of 49.3 acres. Land use in these drainages includes both the McInnis Park golf course and reclaimed water facilities. Storm water is conveyed from these adjacent areas to McInnis Marsh via surface ditches, and discharges to Gallinas Creek via a tide gate (L1-TG on Figure 2-9).

Civic Center rainfall records (KHE, 2004) indicate a median annual rainfall total near McInnis Marsh of 32 inches per year. Both direct precipitation and runoff from surrounding drainages contribute to the ponding of freshwater within the parcel during winter months. Based on McInnis Marsh and tributary areas (180 ac and 50 ac respectively), an estimated 613 ac-ft of freshwater pass though McInnis Marsh in a typical year. Freshwater ponds seasonally across the subsided bayland parcel, which dry-down in summer months leaving salt pannes and dry vegetated marshplain outside of the drainage ditches. Figure 2-5 and Figure 2-6 illustrate wet and dry season conditions across McInnis Marsh, respectively. Downstream of D3, freshwater ponds throughout the year provide summer freshwater habitat. These shallow ponds (pannes) provide seasonally important habitat for wildlife, especially migrant and locally breeding

[1] All site grades, ground survey and LiDAR data are provided in US survey feet relative to a NAVD88 vertical datum.

[2] The Golden Gate LiDAR Project is a cooperative project sponsored by the US Geological Survey (USGS) and San Francisco State University (SFSU) that has resulted in the collection and processing of high resolution 2-meter nominal pulse spacing or better LiDAR and meets objectives of the American Recovery and Reinvestment Act (ARRA) (Source: http://lidar.cr.usgs.gov/).

shorebirds, therefore protection or replacement of this ecotone should be incorporated in the restoration plan.

Figure 2-5: Wet Season Conditions at the inner subsided marsh salt panne near PZ-1

Figure 2-6: Dry Season Conditions at the inner subsided marsh salt panne near PZ-1

Figure 2-7: McInnis Marsh Topography

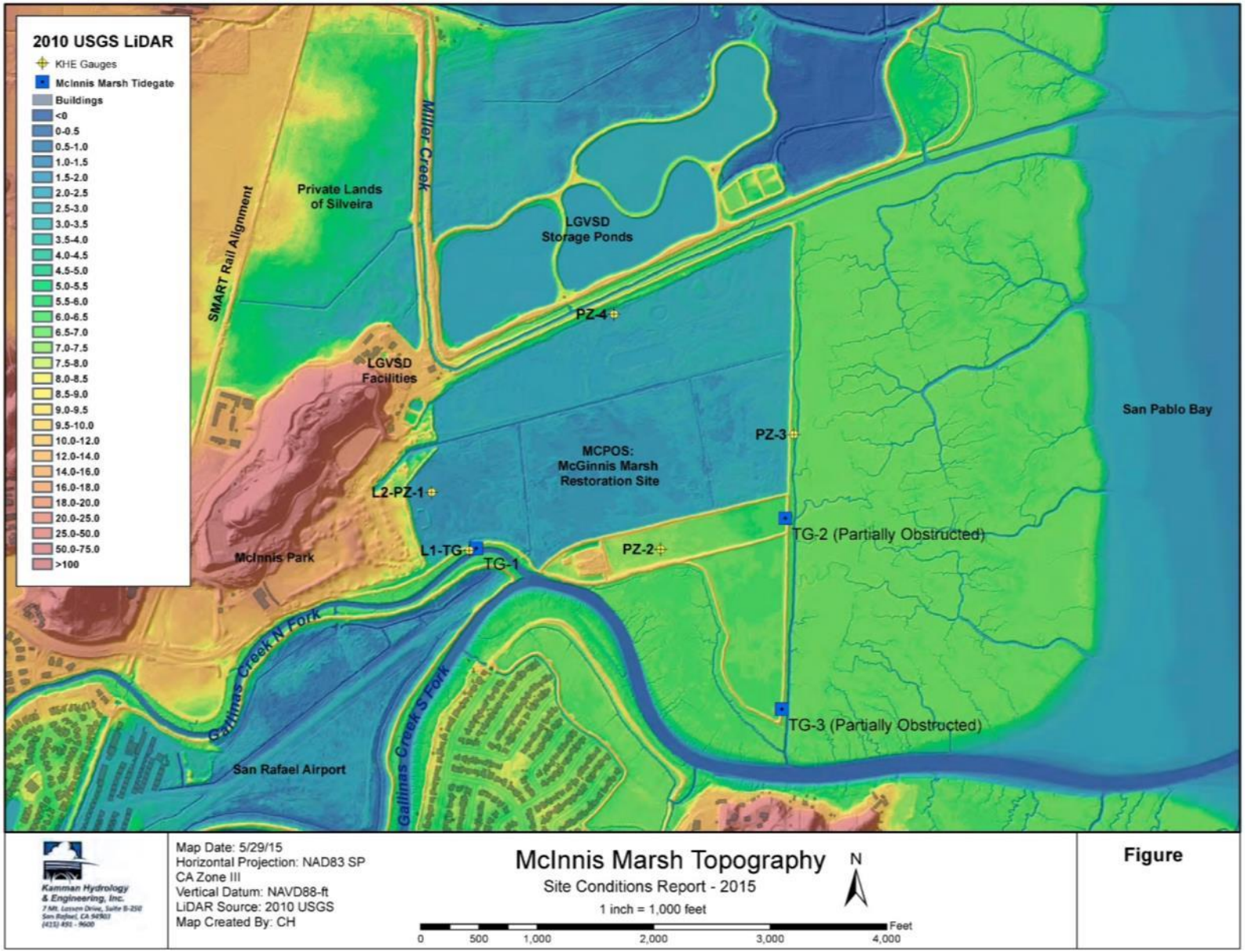
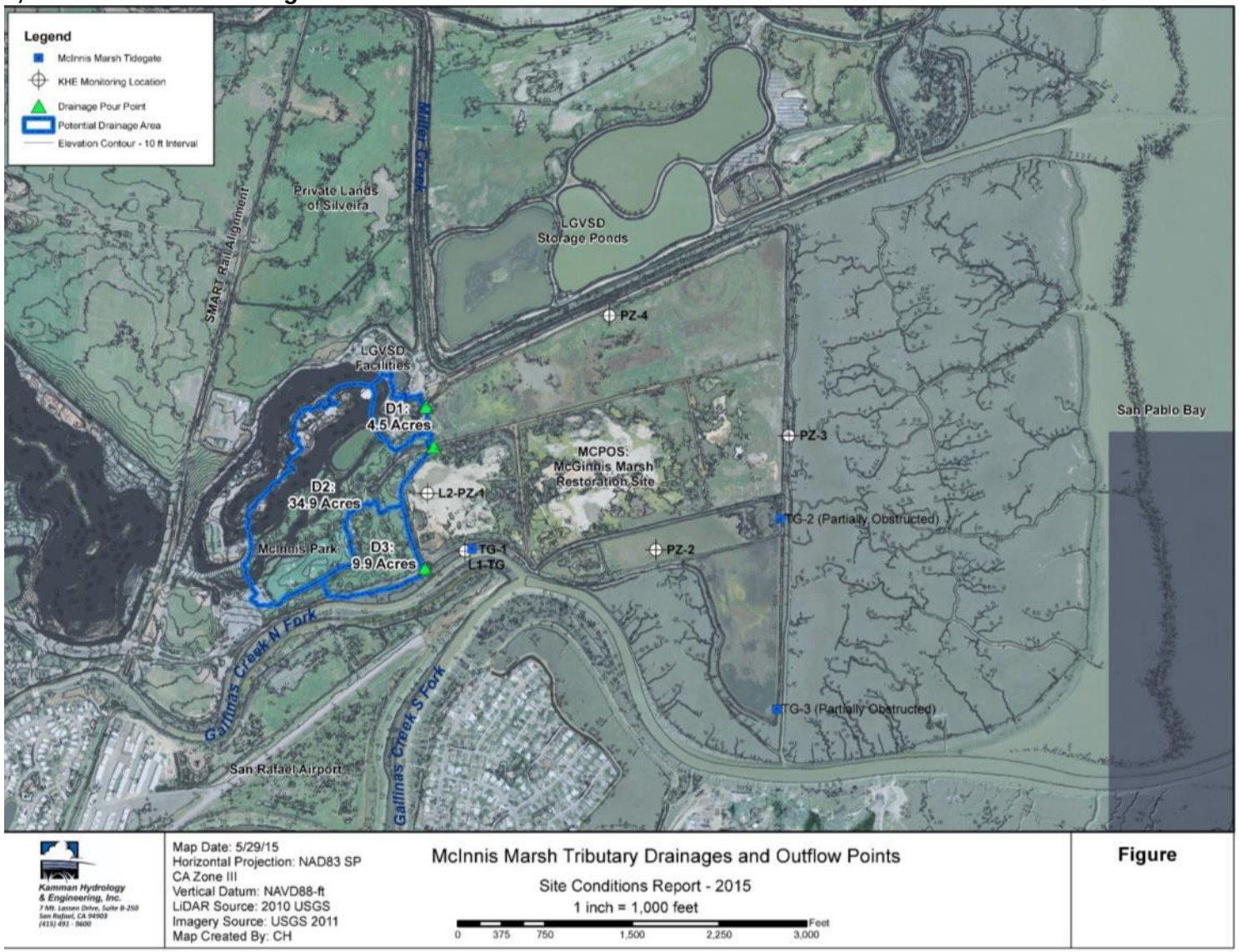


Figure 2-8, McInnis Marsh Drainage



2.5.3 Ground Control and Surveys

All project ground surveys utilized a NAVD88 vertical datum, and local ground controls located on the adjacent LGVSD Reclamation Bridge and installed by surveyors L.A. Stevens & Associates (May 2013) (Table 2-2).

Table 2-2: Ground Control utilized for project ground surveys, (KHE, 2013)

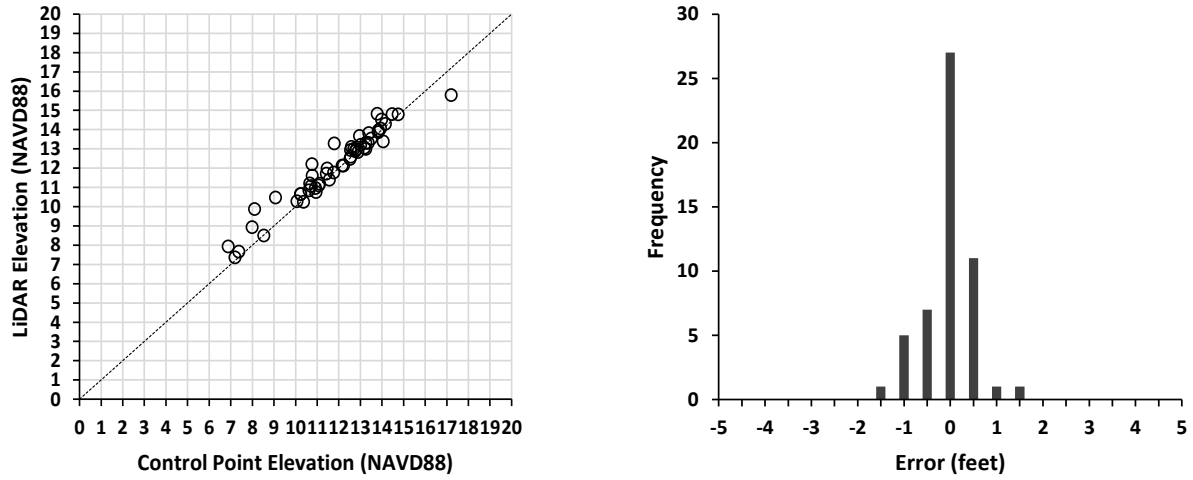
Northing (ft.)	Easting (ft.)	Elevation (NAVD88-ft)
2,202,138.801	5,980,594.334	14.171
2,202,235.474	5,980,357.295	12.185
2,202,129.298	5,980,599.890	14.127
Northings and Eastings reference the Nad83 California State Plane Zone 3 Horizontal Projection		

Topographic surveys of Miller Creek levee and channel were conducted in 2013 for LGVSD by L.A. Stevens and Associates, Inc. (LAS) and Terra Firma Surveys. KHE conducted point surveys within McInnis Marsh (2014) to determine the elevation of installed monitoring instruments, and to verify the LiDAR based DEM depicting project topography.

To compare DEM elevations relative to local ground control, KHE plotted point data from previous topographic surveys and KHE instrument surveys against point values from the DEM (

). In general, LiDAR and ground survey elevations were in agreement, and largely within the reported 0.65 ft. (10 cm) error range for the data. LiDAR data was observed to have a slight bias toward an overestimate ground surface elevations (RMS error of 0.598 feet), which we assumed due to vegetation. Ground surveys are recommended to support final design. No adjustment of the DEM is recommended for this terrain analysis.

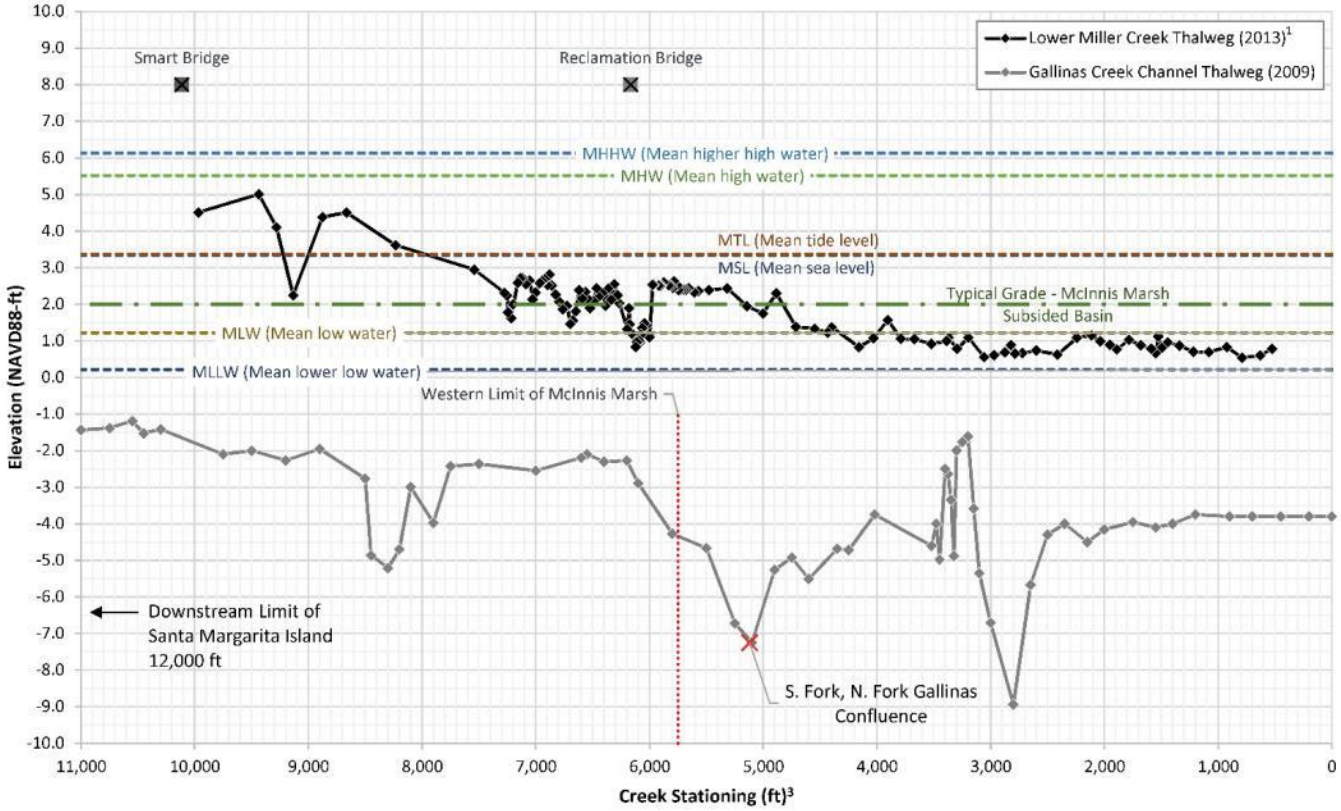
Figure 2-10: Relationship between LAS and TF CP elevations and LiDAR-derived elevations



2.5.4 Gallinas and Miller Creek Channel Surveys

LiDAR data does not provide ground elevation returns below a water surface. Channel geometry data for Miller Creek was gathered by LGVSD through land and boat surveys in 2013. These surveys identified the Miller Creek thalweg at 0.50 to 2.0 ft. downstream of Reclamation Bridge (Station 6,000 ft.). Upstream of Reclamation Bridge, the channel thalweg slopes up through intertidal elevations as the channel form transitions from tidal bayland slough to a leveed fluvially dominated creek. 2009 channel geometry data for Gallinas Creek identifies the South Fork Gallinas Creek thalweg at -5 ft. and -3 ft. at the confluence with the North Fork (station 5,750 ft.) and at a comparable upland limit respectively (Marin County, 2015, Figure 2-11). For the purposes of this study, we assume the Gallinas Creek South Fork channel thalweg is comparable. Thalweg profiles of Gallinas and Miller Creek are plotted together in Figure 2-11.

Figure 2-11: Longitudinal Profiles along Miller Creek and Gallinas Creek channel thalweg



[1]Miller Creek thalweg elevations are a combination of channel surveys conducted by L.A. Stevens & Associates, Inc. (stations 526 ft through 548 ft) and Terra Firma Surveys, Inc. (Stations 5,570 through 9,969) from LGVSD Channel Surveys, (KHE, 2013).
[2]Gallinas Creek Thalweg elevations are based on surveys conducted in 2009 by Gahagan-Bryant Associates (GBA), (DPW, 2009).
[3]Miller Creek/Gallinas Creek start of stationing (0+00) is located at creek mouths where creeks enter San Pablo Bay.

Figure 2-12: Miller and Gallinas Creek Profile Stationing

2.5.5 Topographic Transects

KHE analyzed site topography by examining elevations on fourteen transects located along levee tops and traversing the Marsh basins (Figure 2-12). Figure 2-12 presents elevation profiles extracted along primarily east-west transects (Transects A-H). Figure 2-12 shows the Miller Creek thalweg and adjacent levee tops (Transects A-C). The Lower Miller Creek channel is very flat, with thalweg elevations currently ranging from 2 ft. upstream of Reclamation Bridge to 1 ft. 4,600 feet downstream at the beginning of the un-diked marsh. Profiles AA and CC occupy Miller Creek levee tops, and indicate that Miller Creek's northern levee is higher than

then southern levee bordering McInnis Marsh. As such, removal of the south levee along Miller Creek would not increase flood risks to LGVSD facilities.

Profiles DD and EE (Figure 2-13) depicts grades within the subsided McInnis Marsh basin. Interior drainage ditches are at a typical grade of 1 foot, and 1-2 feet below the 2 ft. elevation of the bottom of the basin. The interior (western) edge of the marsh adjoins uplands at approximately 12 ft. The outboard levee reaches a maximum grade of only 9 ft.[3]. The outer marsh grade is at 6-7 ft. Transects FF, GG and HH (Figure 2-13) traverse levee and pickleweed high marsh plain (6 ft.) within the 2 southern McInnis Marsh basins. These transects also cross the Gallinas Creek channel, and the adjacent more deeply subsided airport parcel. Transect FF follows on leg of the primary recreational trail loop along an internal levee with crest elevations of ~11 ft. Site grades lying south of transect FF support high marsh and at 6 to 7 ft. are notably higher than the subsided northern marsh basin (elev. 1-2 ft.).

Figure 2-15 presents elevation data extracted along primarily north-south transects in Figure 2-13. Transect I-I presents elevations along the upland boundary located on the west edge of the project area. Between stations 700 and 1,100 this transect crosses tributary drainages with invert elevations currently at 1 – 3 ft. Modifications to these drainages will be required to accommodate construction of a new perimeter levee along this alignment. Transects J,K,L (Figure 2-15b) traverse the subsided basin moving progressively from west to east. These transects indicate gentle undulation in essentially flat terrain, with no discernable slope. Grades within the subsided basin range from 2 to 3 ft., and drainage channels are cut to grades of 0 -1 ft. As discussed in Section 3, this low gradient undulating topography supports a mosaic of pond, panne and marsh habitat. Between stations 200 and 3000, transects K and L traverse the McInnis levees and cross in the outboard Gallinas Baylands marsh (6 ft.) and a forth order marsh channel (2 ft.). Figure 2-15c plots eastern transects (L, M & N). Transect L which traverse McInnis Marsh, the eastern perimeter levee, and the outboard undisturbed marsh is plotted on both Figures 2-14b and 2-14c. Comparing transects L and N between stations 300 and 2500 presents an excellent picture of the subsided McInnis Marsh basin, and the 4 ft. of departure between existing grades and the mature marsh plain. Transect M plots the intervening levee profile. Transect N traverses both the Miller Creek channel (stations 100 to 350) and the Gallinas Creek channel (stations 5,000 to 5,200). Thalweg elevation within the channels were determined using ground and boat survey as 1 ft and -4 ft., respectively. (Figure 2-15c).

[3] The offset in levee crest alignments illustrated is due to a difference in the starting point of the stationing.

Figure 2-13: McInnis Marsh topographic profile alignments map

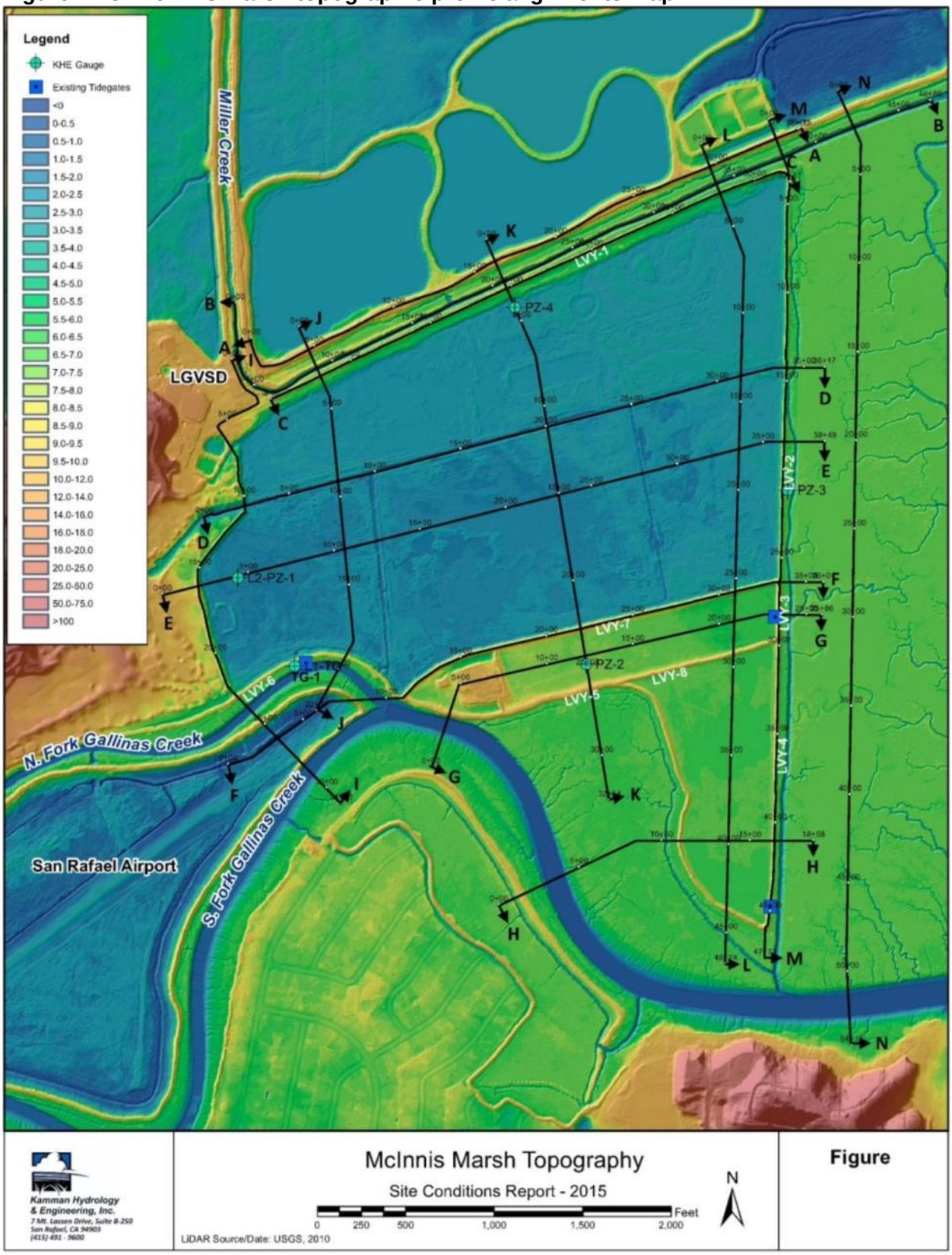


Figure 2-14, Profile Plots for McInnis Marsh and Levee Alignments

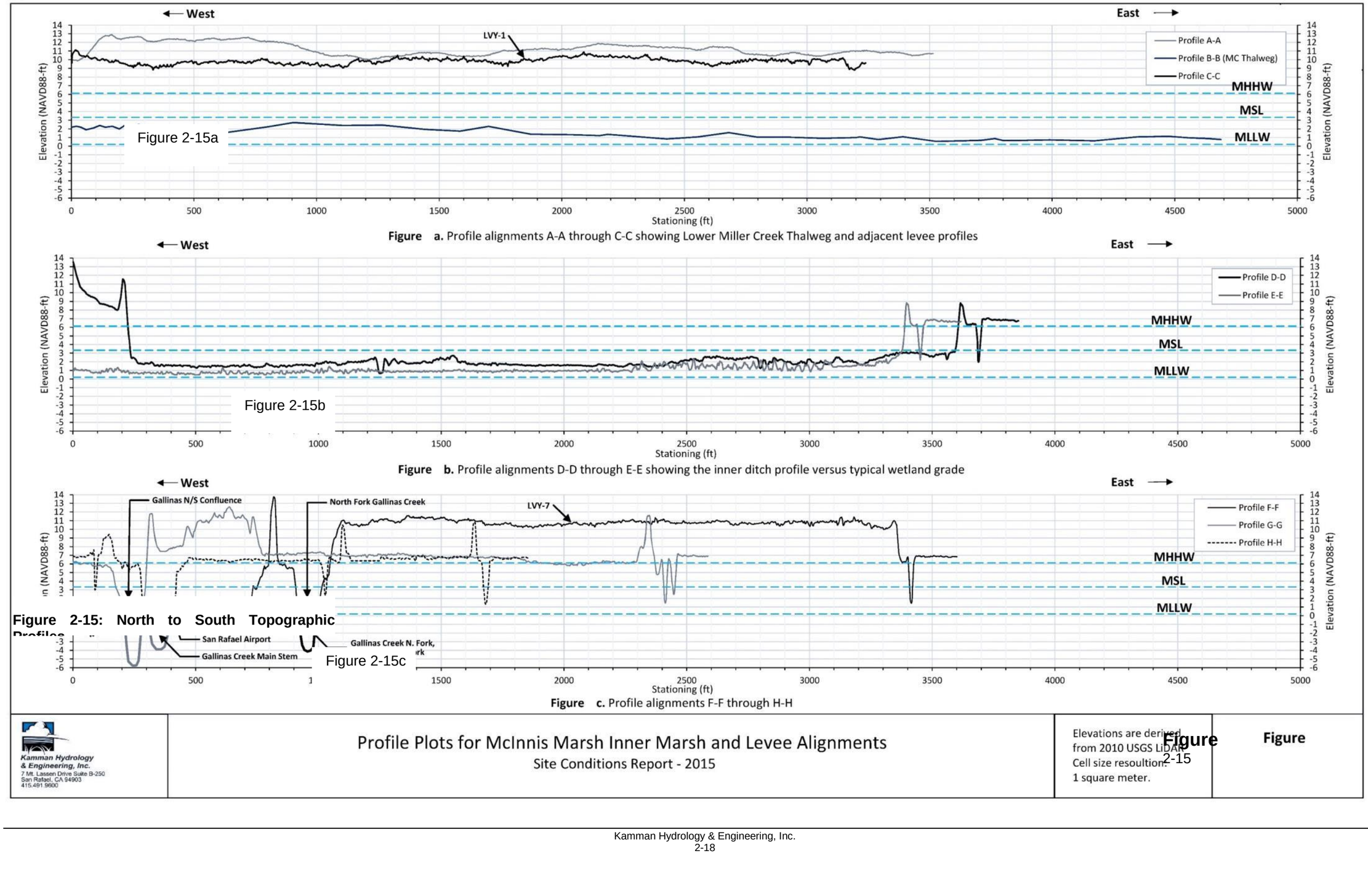


Figure a. Profile alignments A-A through C-C showing Lower Miller Creek Thalweg and adjacent levee profiles

Figure b. Profile alignments D-D through E-E showing the inner ditch profile versus typical wetland grade

Figure c. Profile alignments F-F through H-H

Figure 2-15: North to South Topographic Profiles

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Profile Plots for McInnis Marsh Inner Marsh and Levee Alignments
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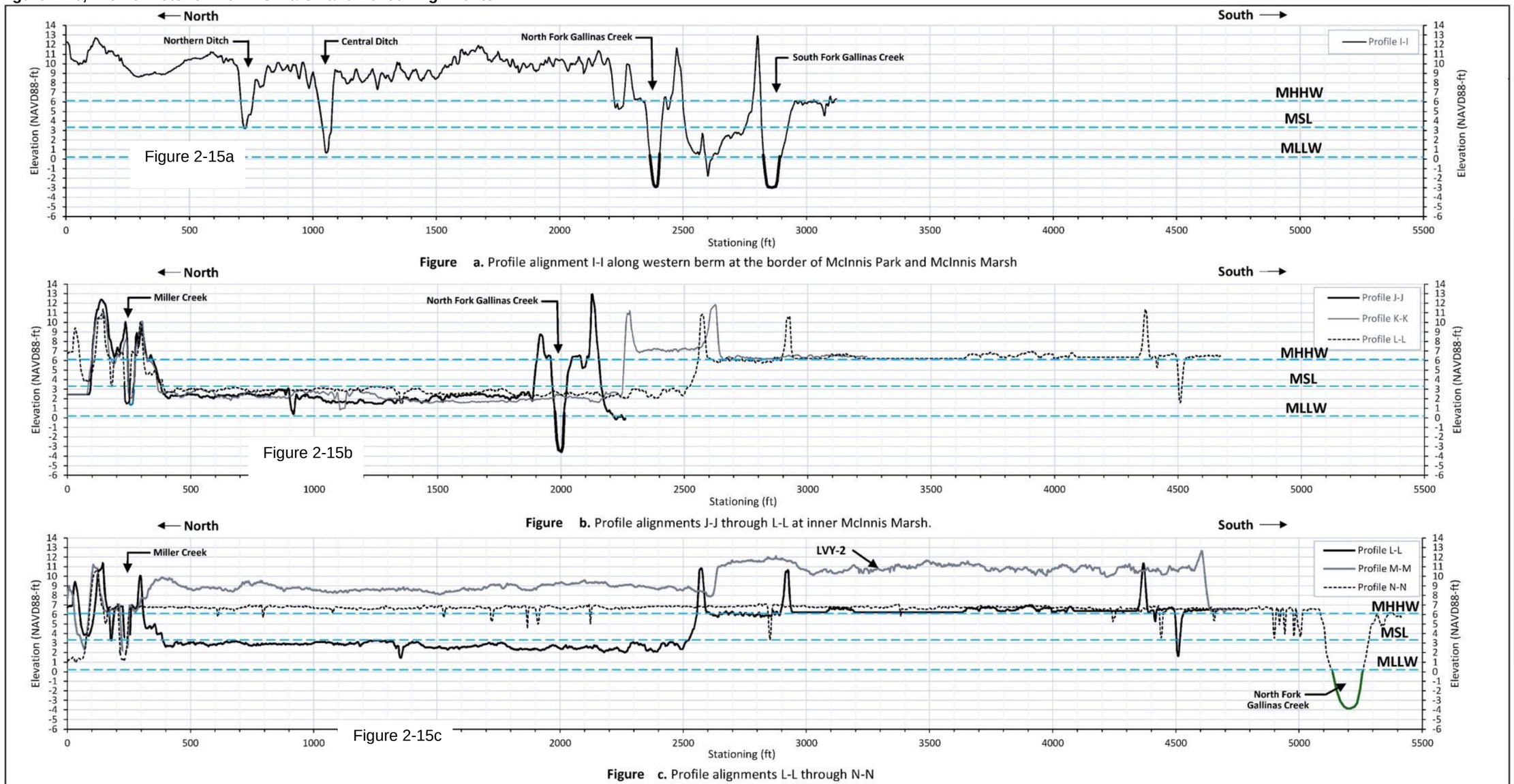
Elevations are derived from 2010 USGS LiDAR. Cell size resoultion: 1 square meter.

Figure 2-15

Figure

Figure 2-16, Profile Plots for McInnis Marsh and Levee Alignments



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Profile Plots for McInnis Marsh Inner Marsh and Levee Alignments
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Elevations are derived from 2010 USGS LiDAR. Cell size resoultion 1 square meter.

Figure 2-15

Figure

2.6 Tidal Datums and Sea Level Rise

The tidal influence on wetland hydrology and potential impacts associated with sea level rise are evaluated based on current and projected tidal datums near McInnis Marsh. The closest reported tidal datums for the project site are for the mouth of Gallinas Creek (NOAA Station #9415052) located along the south shore of the Gallinas Baylands, approximately 1000-feet south of Miller Creek. The tidal datums presented in Table 2-3 were derived from the National Geodetic Survey (NOAA NGS) for the 1983-2001 tidal epoch.

Table 2-3: Gallinas Creek mouth (NOAA Station #9415052) Tidal Datums

Datum	Elevation NAVD88
Maximum Observed. HW (MHHW + 2.5')	8.6
MHHW (Mean higher high water)	6.13
MHW (Mean high water)	5.52
MSL (Mean sea level)	3.34
MTL (Mean tide level)	3.37
NGVD29	2.68
MLW (Mean low water)	1.22
MLLW (Mean lower low water)	0.21
NAVD88	0.00

Table 2-3 depicts potential inundation areas for the project site at selected tidal datums if the site were opened to full tidal exchange. This figure illustrates that, if restored to tidal exchange, the subsided McInnis Marsh basin would be subject to tidal influence at water levels above MLW (1.2 ft.). The southern region would begin to be inundated at water levels greater than MHHW (6.1 ft.). Areas anticipated to be subject to daily tidal inundation during monthly spring tide are depicted to extend 2 ft. above MHHW.

Because of the low lying grades in the project area, sea level rise (SLR) can be expected to impact both Parks facilities and restoration, and should be considered in levee and trail management and restoration planning. Scientists agree that global sea levels are now rising faster than at any time in the past 2,000 years, with rates that vary depending on local oceanic, near shore and tectonic processes. Fortunately, the recent convergence of engineering and land use guidance documents prepared by the National Research Council for the West Coast (NRC, 2012), the US Army Corps of Engineers (USACE, 2011), and the State of California (SCC, 2013) provide consistent estimates of SLR at McInnis Marsh. Table 2.4 presents the expected range of sea level rise based on the California Coastal Commission's sea level rise policy guidance document (SCC, 2013) for a range of years within the project's planning horizon. For this study, the upper limit of the range of these values is applied to generate the recommended SLR correction.

Table 2-4: Predicted Sea Level Rise at McInnis Marsh

Date	Years	SLR (feet)
2000	0	0.0
2020	20	0.5
2050	50	1.3
2100	100	2.8

A recent USACE hydraulics study of Gallinas Creek (USACE 2013) estimated return periods for existing and future water surface elevations under the combined influence for storm flow in the creek and coastal (high tide) risk. Table 2-5 summarizes these estimates for Gallinas Creek under existing conditions, and assuming historic and accelerated rates of SLR. USACE planning guidance recommends evaluation and planning for both the high and low values of the predicted range of SLR impacted values. Thus for restoration design an facilities planning for a 50-yr. design storm, McInnis marsh and the associated levees should be expected to see maximum water levels in Gallinas Creek of 9 ft. (Year 0 condition), with elevations rising 0.5 - 2.0 ft. over the next 50 years to a maximum water level of (9.8 - 11.1 ft.). These estimates predict a current (Year 0) 2-yr. high tide of 7.9 ft., increasing to 8.7-10.9 ft. (Year 50). These estimates and the local COE generated estimates (Table 2-5) represent predicted changes in tidal conditions over the 50 year planning horizon of the project, and frame the 0.5 to 2 ft. range of values considered in this study.

Table 2-5: Gallinas Creek Predicted Storm Water Level Maxima (USACE, 2013)

Annual Probability (Percent)	Return Period (years)	Year 0 Condition (feet, NAVD88)	Historic SLR (feet NGVD 29)	Year 50 Condition Low: NRC 1	Year 50 Condition High - NRC 3
50	2	7.9	8.4	8.7	10.0
20	5	8.3	8.8	9.1	10.4
10	10	8.5	9.0	9.3	10.6
4	25	8.8	9.3	9.6	10.9
2	50	9.0	9.5	9.8	11.1
1	100	9.1	9.6	9.9	11.2
0.4	250.0	9.3	9.8	10.1	11.4
0.2	500.0	9.5	10.0	10.3	11.6

Within the planning horizon of the project, one can also anticipate individual storm events which produce storm surge, and El Nino driven seasonal rises in coastal water levels on the order of an additional 1-3 feet or more. Figure 2-17 illustrates and example of such an event generated by a barometric low (absent rainfall) which produced NOAA observed water levels of 0.5 to 1.2 feet above predicted water levels at the nearby Richmond station. Comparable 8+ foot water level maxima were observed at McInnis marsh during 2014 hydrologic monitoring. Extreme high tides currently impact conditions within McInnis Park, where surface ponding can be observed

during dry season high tides west of the marsh on ball fields and within the golf course (Figure 2.17 and Figure 2.18).

Figure 2-17: Predicted and measured tide levels recorded the Richmond NOAA Station 9414963

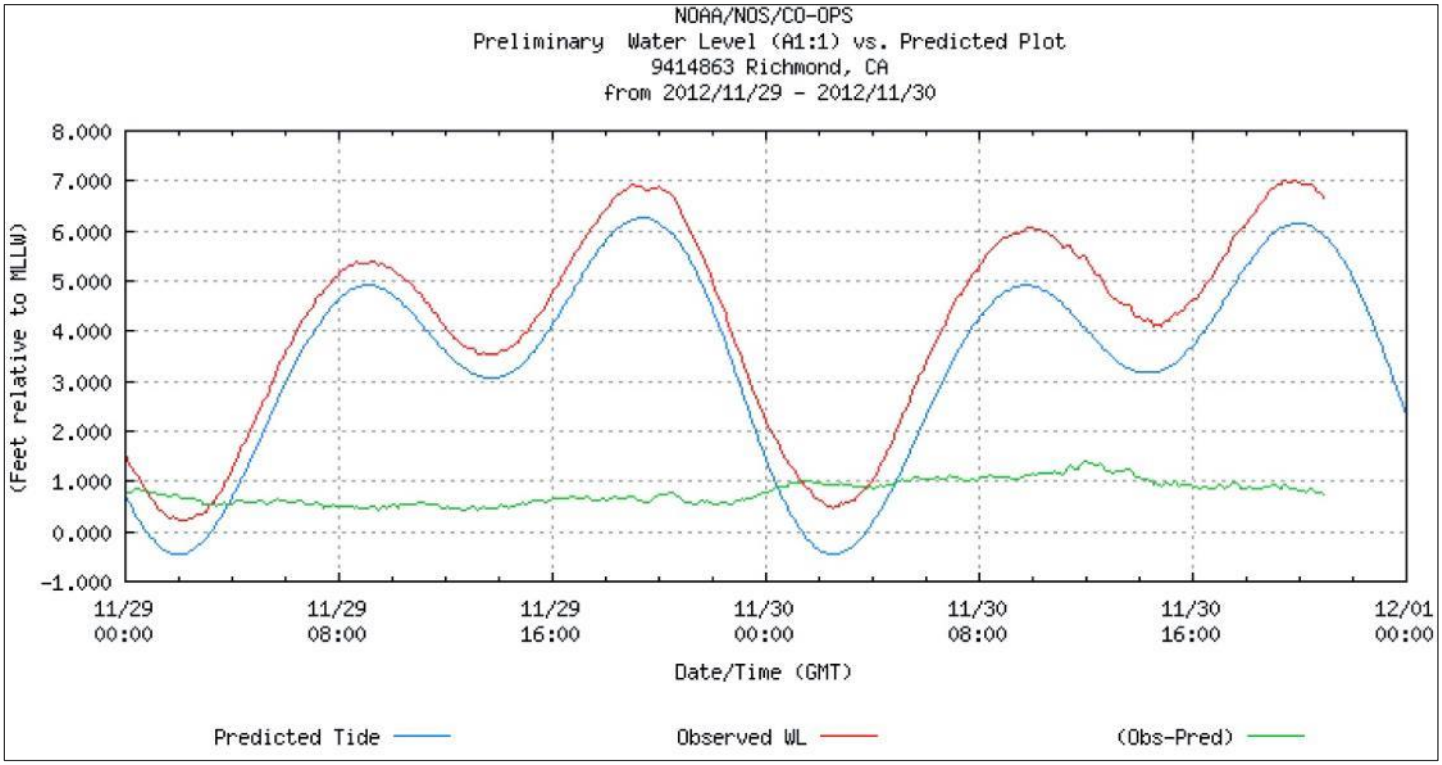


Figure 2-18: Potential Inundation Areas

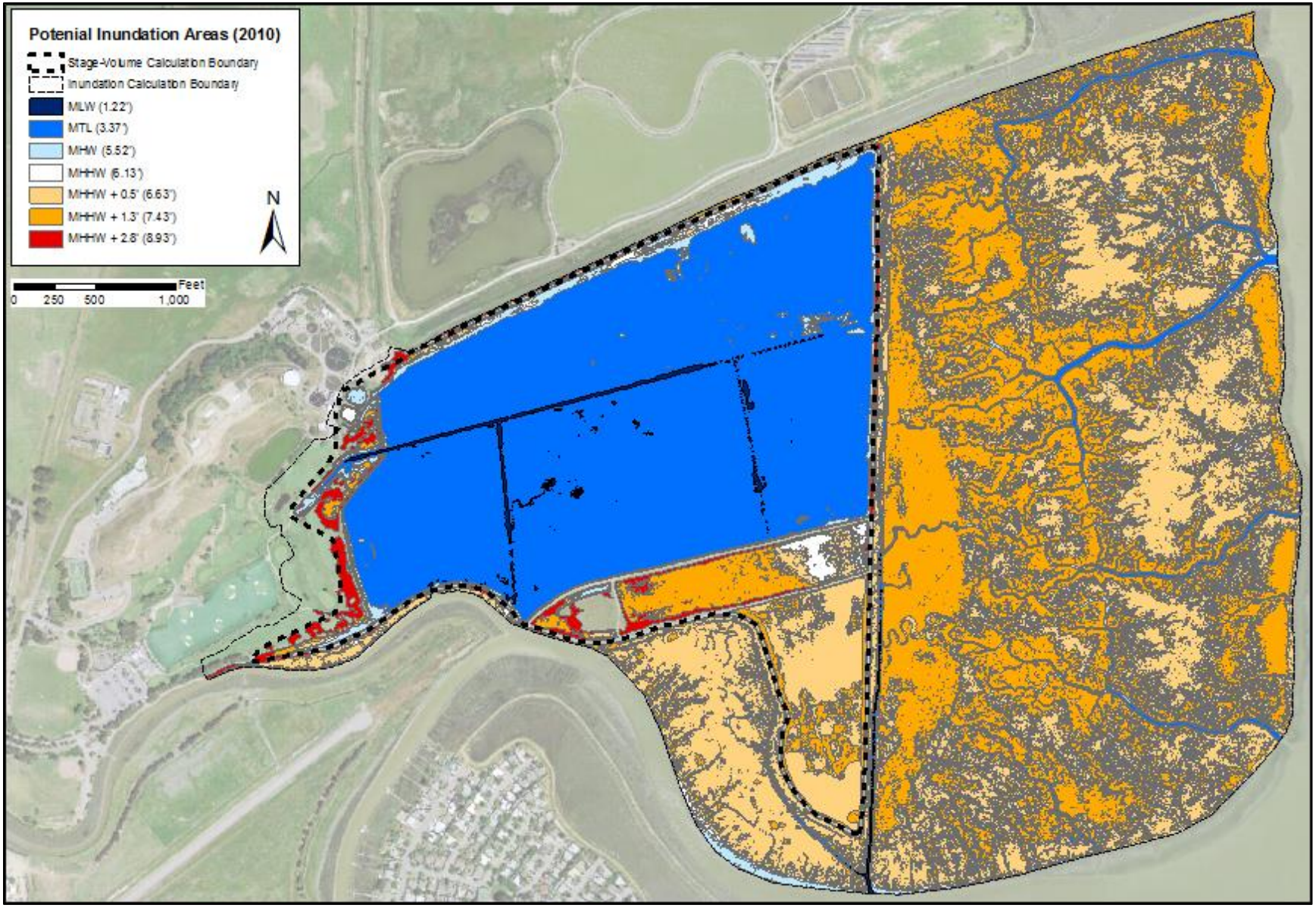


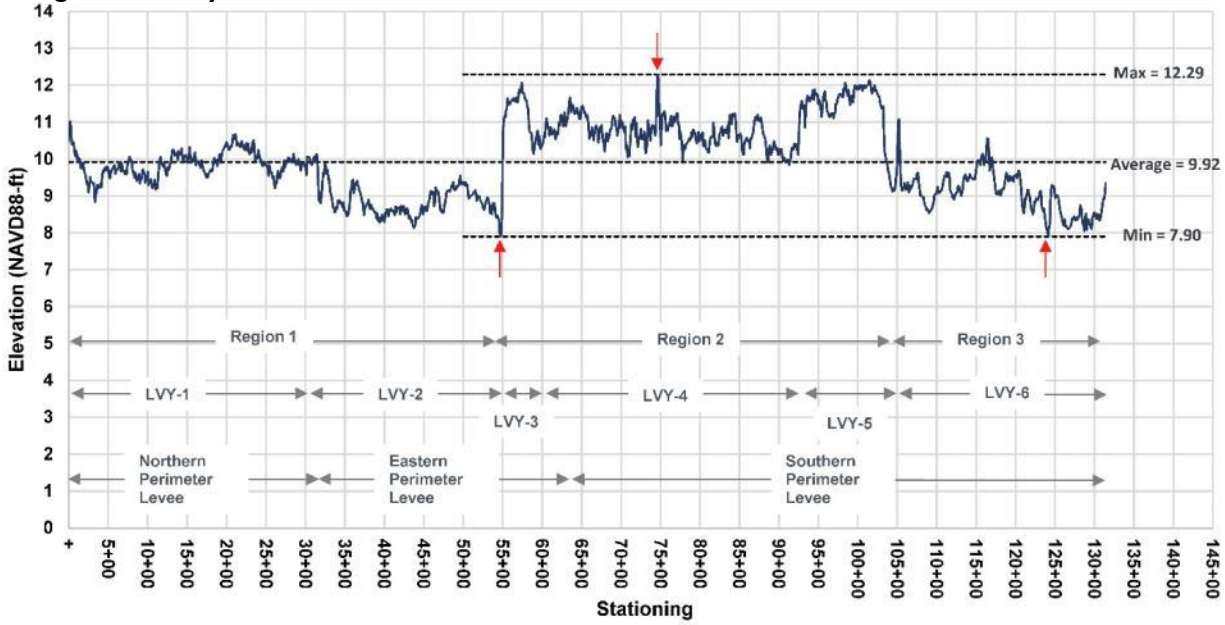
Figure 2-19: Surface Ponding at McInnis Soccer Field

Figure 2-20: Surface Ponding at McInnis Golf Course
Levee Crest Elevations

To evaluate inundation and overtopping risks for the existing perimeter levee and trail system, KHE extracted levee top elevations from the project DEM. Stationing along the alignment was oriented clockwise along the levee perimeter extending from a northern point near LGVSD's Reclamation Bridge to the southern levee near the McInnis Golf Club parking lot . The alignment length was approximately 2.5 miles. Levee crest elevations along this transect range from 7.9 to 12.3 ft. KHE identified relative low points along the levee (less than the predicted 9 ft. (50-yr. return period storm water level maxima for existing conditions) at two locations: adjacent to the outboard marsh between stations 30+00 and 55+00, and along the primary trail adjacent to the

McInnis Park Golf Course between stations 105+00 and 135+00 (Figure 2-21). A comparison between levee crest elevations and the range and the predicted 2-yr. storm peak water levels in Gallinas Creek (Table 2-6) suggests that overtopping of the outboard levee eminent and the frequency of overtopping will increase at these low points throughout the 50 year period of sea level rise.

Figure 2-21: McInnis Marsh Perimeter Levee Profile (Sampled from 2010 USGS LiDAR along Levee CL)



The elevation profile of the levee tops along the outer perimeter of McInnis Marsh were categorized into three (3) regions. These regions were selected based on elevation trends of the levee profile. Region 1 (Stations 0+00 – 55+00) and Region 3 (Stations 105+00 – 131+00) levee top elevations averaged at approximately 9-ft. (NAVD88-ft.). The Region 2 profile was, on average, 1.5 feet higher than the Region 1 and 3 profiles, displaying an average elevation of 10.97. Levee crest elevation statistics for each region are summarized in Table 2-6.

Figure 2-22, McInnis Marsh Perimeter Levee

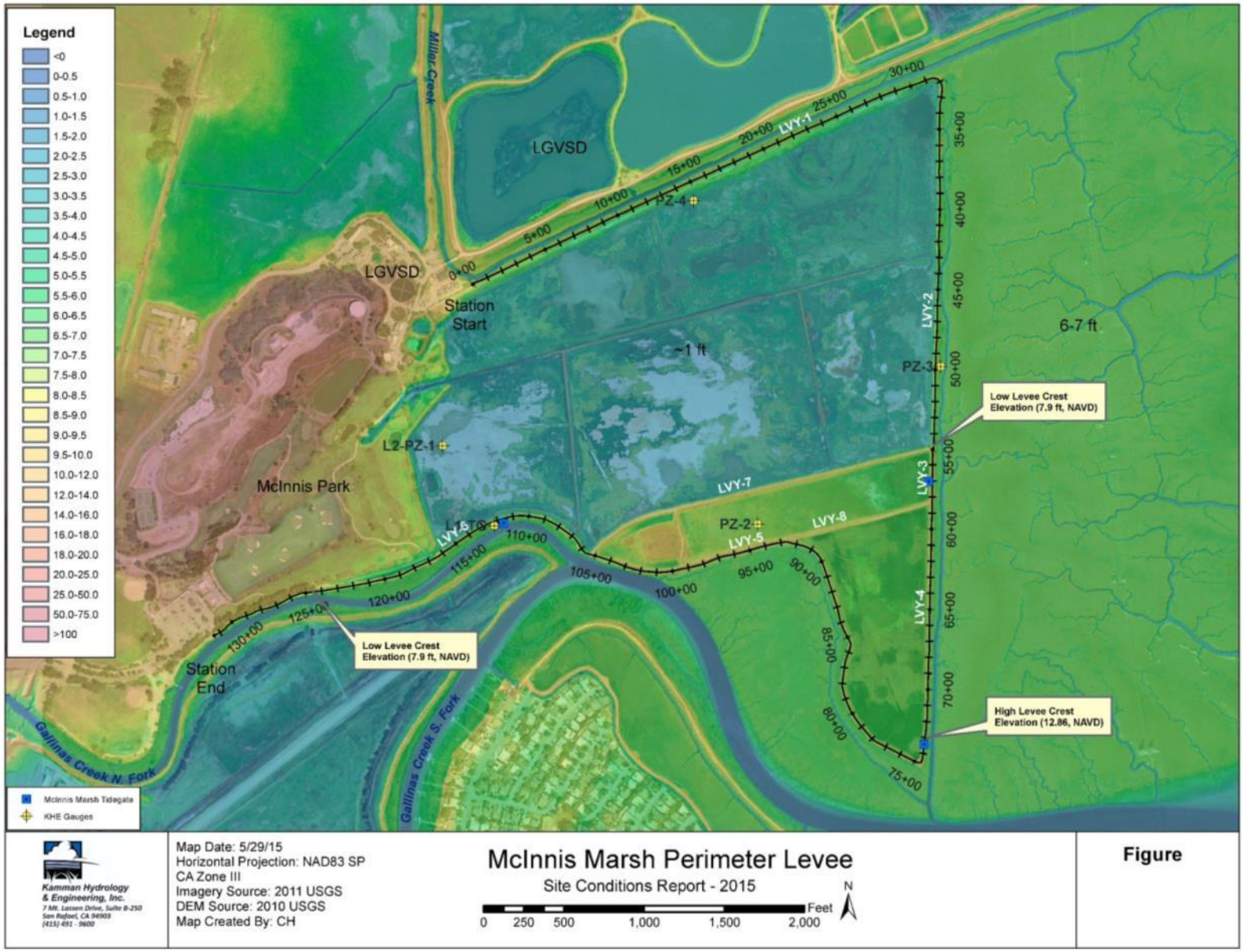


Table 2-6: Statistics of perimeter levee crest elevations by region

Profile Region	Description	Elevation (NAVD88-ft)	Station (ft)
Region 1	Max =	11.02	20
	Average =	9.43	-
	Min =	7.91	5,470
Region 2	Max =	12.29	7,460
	Average =	10.97	-
	Min =	9.85	9,130
Region 3	Max =	11.08	10,520
	Average =	9.08	-
	Min =	7.90	12,410

2.7 Existing Levee Fill Volumes and Upland Areas

To support the assessment of benefits and impacts of levee removal or realignment, KHE calculated the volume of levee above adjacent marsh grades in McInnis Marsh. After dividing the perimeter levee system into eight (8) segments (Table 2-7), KHE defined a surrounding area and a cut line from the typical grade of the outboard marsh to the typical interior grade. The volume of material estimated each levee segment and the associated upland area are presented in Table 2-7:. Based on field studies (Section 3), the transition to upland was observed to occur at elevation 7.5 ft., 1.5 ft. above the local MHHW elevation of 6.0 ft.[4]. The total estimated volume of levee fill available to be removed is 58,850 CY.

KHE estimated the area of upland associated with each levee segment. A total of 8.9 acres of upland could be converted to wetland if all perimeter and interior levees were removed. Removal of levees would leave an estimated 3.7 acres of upland within the project boundary. These levee fill volumes and uplands areas will be used to support alternative development and wetland impact analysis.

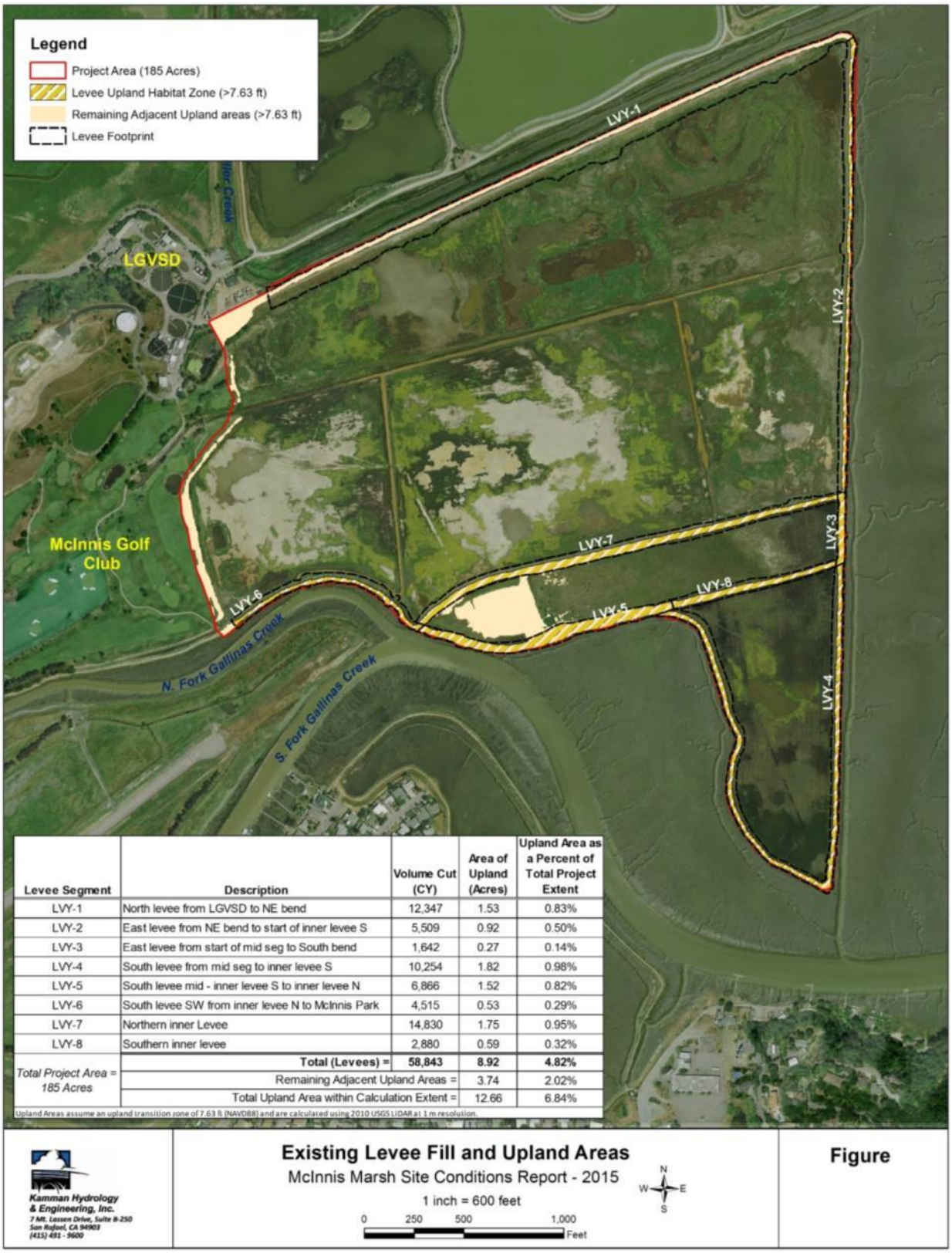
Table 2-7: Levee Cut Volume and Upland Area Estimates

Name	Description	Volume Cut (CY)	Area of Upland (Acres)
LVY-1	North levee from LGVSD to NE bend	12,347	1.53
LVY-2	East levee from NE bend to start of inner levee S	5,509	0.92
LVY-3	East levee from start of mid seg to South bend	1,642	0.27

[4] Determination of upland transition was based on field observations of wetland plant communities and ground survey.

LVY-4	South levee from mid seg to inner levee S	10,254	1.82
LVY-5	South levee mid - inner levee S to inner levee N	6,866	1.52
LVY-6	South levee SW from inner levee N to McInnis Park	4,515	0.53
LVY-7	Northern inner Levee	14,830	1.75
LVY-8	Southern inner levee	2,880	0.59
Area inside calculation boundary = 185 Acres	**Total (Levees) =**	**58,843**	**8.92**
	Remaining Adjacent Upland Areas =		3.74
	Total Upland Area within Calculation Extent =		12.66

Figure 2-23: Existing Levee Fill and Upland Areas within and including McInnis Marsh Perimeter Levee Networks.



Levee Segment	Description	Volume Cut (CY)	Area of Upland (Acres)	Upland Area as a Percent of Total Project Extent
LVY-1	North levee from LGVSD to NE bend	12,347	1.53	0.83%
LVY-2	East levee from NE bend to start of inner levee S	5,509	0.92	0.50%
LVY-3	East levee from start of mid seg to South bend	1,642	0.27	0.14%
LVY-4	South levee from mid seg to inner levee S	10,254	1.82	0.98%
LVY-5	South levee mid - inner levee S to inner levee N	6,866	1.52	0.82%
LVY-6	South levee SW from inner levee N to McInnis Park	4,515	0.53	0.29%
LVY-7	Northern inner Levee	14,830	1.75	0.95%
LVY-8	Southern inner levee	2,880	0.59	0.32%
Total Project Area = 185 Acres	**Total (Levees) =**	**58,843**	**8.92**	**4.82%**
	Remaining Adjacent Upland Areas =		3.74	2.02%
	Total Upland Area within Calculation Extent =		12.66	6.84%

Upland Areas assume an upland transition zone of 7.63 ft (NAVD88) and are calculated using 2010 USGS LIDAR at 1 m resolution.

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Existing Levee Fill and Upland Areas
McInnis Marsh Site Conditions Report - 2015
1 inch = 600 feet
0 250 500 1,000 Feet
N W E S

Figure

2.8 Stage Area, Stage Volume and Tidal Prism Relationship

The expected characteristics and distribution of tidal wetlands restored at McInnis Marsh is determined largely by the tidal range and the relationship between tidal stage (elevation), marsh area, and tidal prism (the volume of water exchanged over a representative flood/ebb tidal cycle). At McInnis Marsh, wetland vegetation can be expected to colonize within the tidal range between the Mean Lower Low Water (MLLW) and Mean Higher High Water (MHHW) elevations[5].

[5] These elevation are known as Tidal Datums, and represent statistical measures of average high, median and low water elevations over a tidal cycle.

Table 2-8 summarizes the elevations associated with generally expected wetland habitats and BCDC Jurisdictional zones relative to local project datums.[6]

- Above MHHW: Upland Transition Vegetation (Grindelia)
- Between MHHW and Mean Tide Level (MTL): High marsh (Pickleweed)
- Between MTL and MLLW: Low marsh (Cordgrass) and is typically found
- Bellow MLLW: Mudflat and Subtidal Habitats (Eel Grass)

[6] A detailed discussion of observed and anticipated wetland plant communities is presented in Section 3.

Table 2-8: Habitat Zones by elevation and tidal datum compared to BCDC jurisdictional zone.

BCDC Jurisdictional Zone	Wetland Habitat Zone	Elevation NAVD88-ft	Tidal Datum
Submerged Lands	Mudflat/ Open water	0.00	-
		0.21	MLLW
Tidelands	Lower Intertidal Marsh	1.00	-
		1.22	MLW
		2.00	-
		2.68	NGVD29
		3.00	-
		3.34	MSL
		3.37	MTL
Marshlands	Upper Intertidal Marsh	4.00	-
		5.00	-
		5.52	MHW
		6.00	-
		6.13	MHHW
	Upland Transition Zone	7.00	-
		7.63	-
		8.00	-
	Upland	8.34	-
		9.00	-
		10.00	-

To inform restoration design, KHE evaluated the relationship between tidal stage, area and volume at McInnis Marsh.

Figure 2-24, Figure 1-1, and Table 2-10 present estimates of marsh area and volume calculated over the sites 0 – 9 ft. topographic range (0-9 ft.) and at tidal datums. In Figure 2-24, each point value indicates the acres of the parcel area which would be subject to tidal inundation (flooding) if the tide were at that elevation. Table 2-10 illustrates the change in inundation area associated with tidal datums for the site. The figures show that none of the site is currently below MLLW. The majority of the basin is at elevations between MLW (1.2 ft.) and MTL (3.4 ft.). 133 acres of the Parcel are currently below MTL and would be low marsh. High marsh can be anticipated over 10 acres which are available between MTL (133 ac) and MHHW (143 ac). **This analysis indicates that the subsided site lays at a low intertidal elevation which could support up to 145 ac of intertidal marsh, 93% of which would be low marsh.** Given an estimated 193 ac

of marsh area for the entire South Fork of Gallinas Creek (MCDPW, 2015), the marsh area represents a significant increase in the total Gallinas Bayland marsh area. Figure

presents the cumulative volume of storage within the parcel boundary. **The Potential Tidal Prism (PTP) of the subsided site (total volume between MHHW and MLLW) is estimated as 526.3 ac-ft.**

Figure 2-24: Stage-Area Curve – Plotted numbers indicate surface area

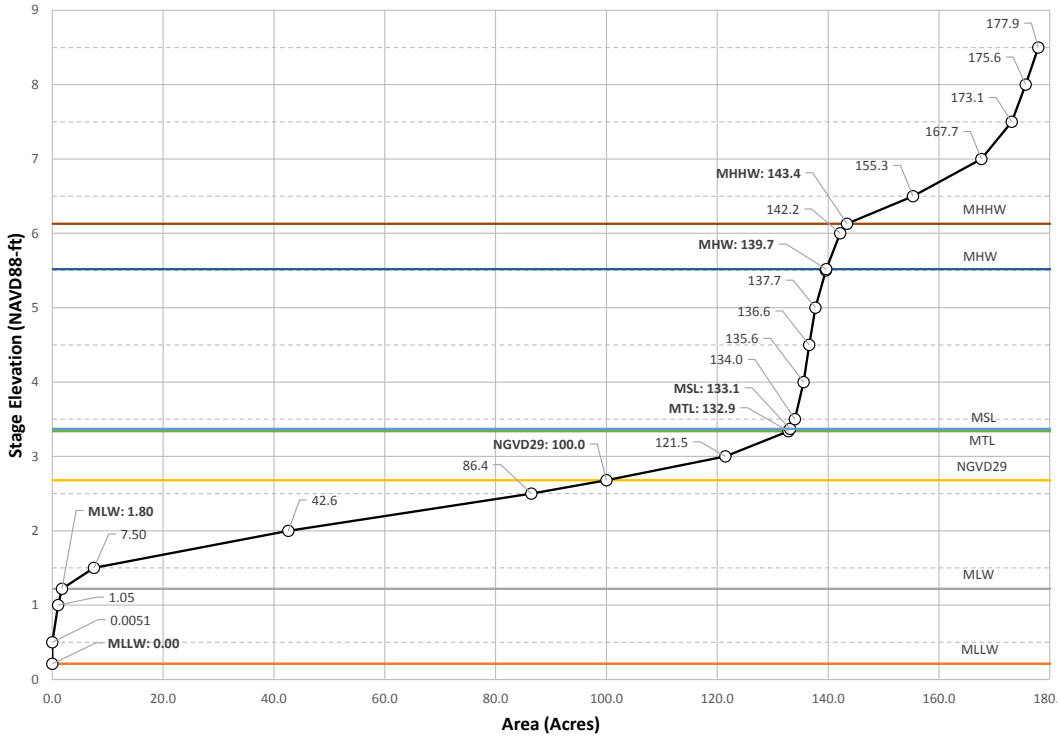
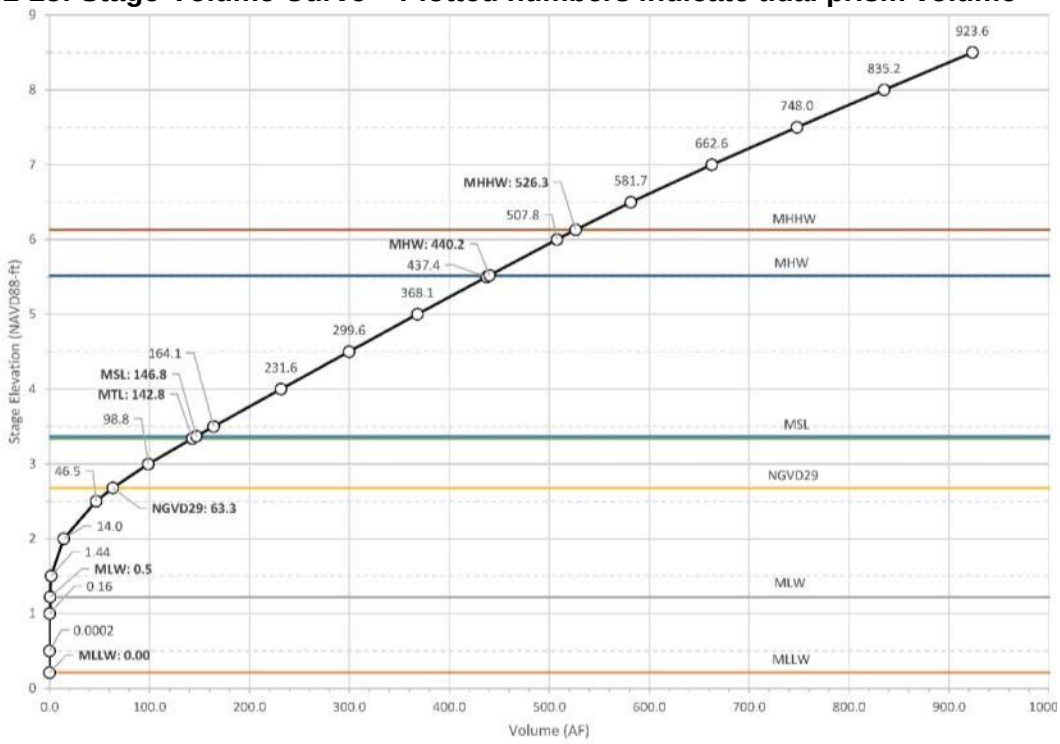


Figure 2-25: Stage-Volume Curve – Plotted numbers indicate tidal prism volume



These estimates of anticipated tidal prism and inundated marsh area will guide in restoration design to predict the size (width and depth) of the channels needed to support a healthy marsh. Figure 2-24 and Figure 2-25 present hydraulic geometry relationships for San Francisco

Bay marshes which describe the observed relationship between marsh area, potential tidal prism (PTP) and equilibrium (mature marsh) channel size (PWA and Faber, 2004). These San Francisco Bay hydraulic geometry relationships and estimates of McInnis Marsh MHHW marsh area and PTP (143 ac and 537 ac-ft. respectively), are used to predict the geometry of equilibrium channels expected at McInnis Marsh and the associated increase in channel geometry in Lower Gallinas Creek bayward of the restoration site.

The predicted post breach and equilibrium tidal prism associated with the estimated marsh area of 143 ac is approximately 530 and 90 ac-ft., respectively (Table 2-9). If we conservatively assume that 75% of the 440 ac-ft. of tidal prism is available for natural sedimentation, **the subsided basin can be expect to store 330 ac-ft. (or 575,000 cy) of sediment as it evolves from an open water basin to a mature marsh.** Table 2-9 also presents hydraulic geometry based estimates of existing and equilibrium channel depths and widths within McInnis Marsh, and in the Lower Gallinas Creek Channel. These values serve as the basis for design and downstream channel impact assessment.

Table 2-9: McInnis Marsh and Gallinas Creek Hydraulic Geometry

	Post-Breach Tidal Prism (Acre-feet)	Equilibrium Tidal Prism (Acre-feet)	Post-Breach Channel Thalweg (feet, NAVD88)	Equilibrium Channel Thalweg (feet, NAVD88)	Post-Breach Channel Width (feet, NAVD88)	Equilibrium Channel Width (feet, NAVD88)
McInnis Marsh	530	90	-7.9	-4.1	230.1	101.7
Lower Gallinas Creek Confluence (Current)	256	256	-6.2	-6.2	164.6	164.6
Gallinas Creek Confluence (with McInnis Marsh Restoration)	786	346	-8.9	-6.8	275.9	189.1

Figure 2-26: Correlation of the potential diurnal tidal prism as a function of marsh area for mature San Francisco Bay marshes (Source: PWA and Faber, 2004).

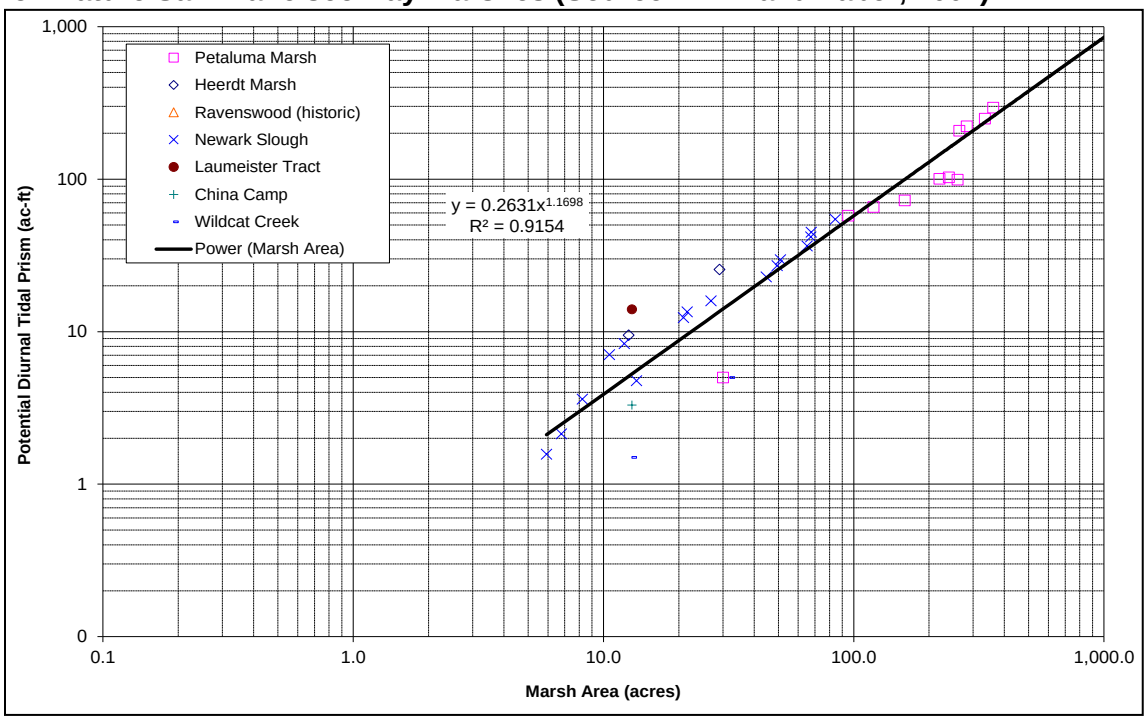


Figure 2-27: Correlation of the maximum Channel depth below MHHW as a function of tidal prism for mature San Francisco Bay marshes (Source: PWA and Faber, 2004).

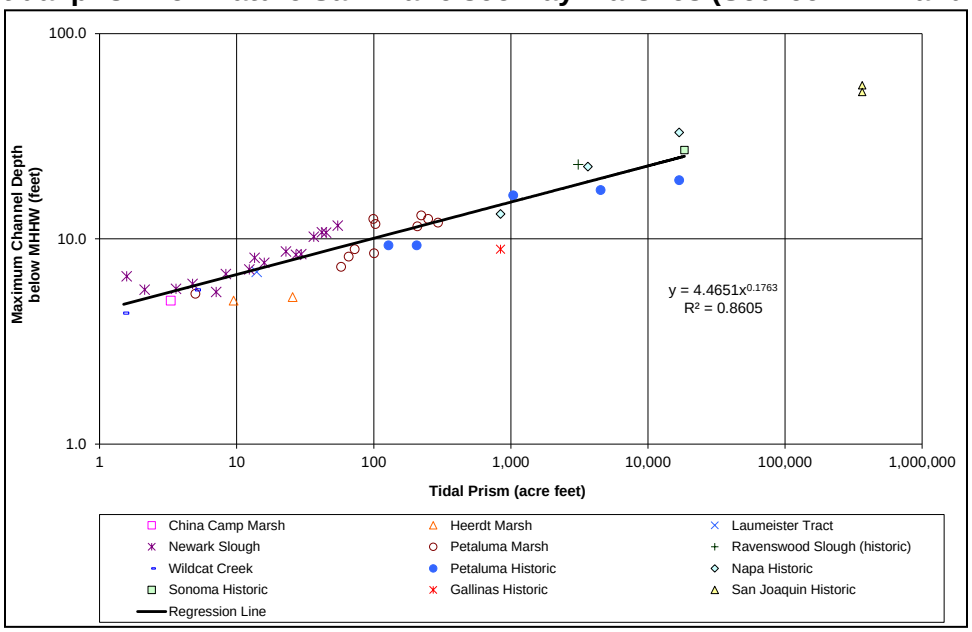


Figure 2-28: Correlation of the maximum channel top width and depth as a function of tidal prism for mature San Francisco Bay marshes (Source: PWA and Faber, 2004).

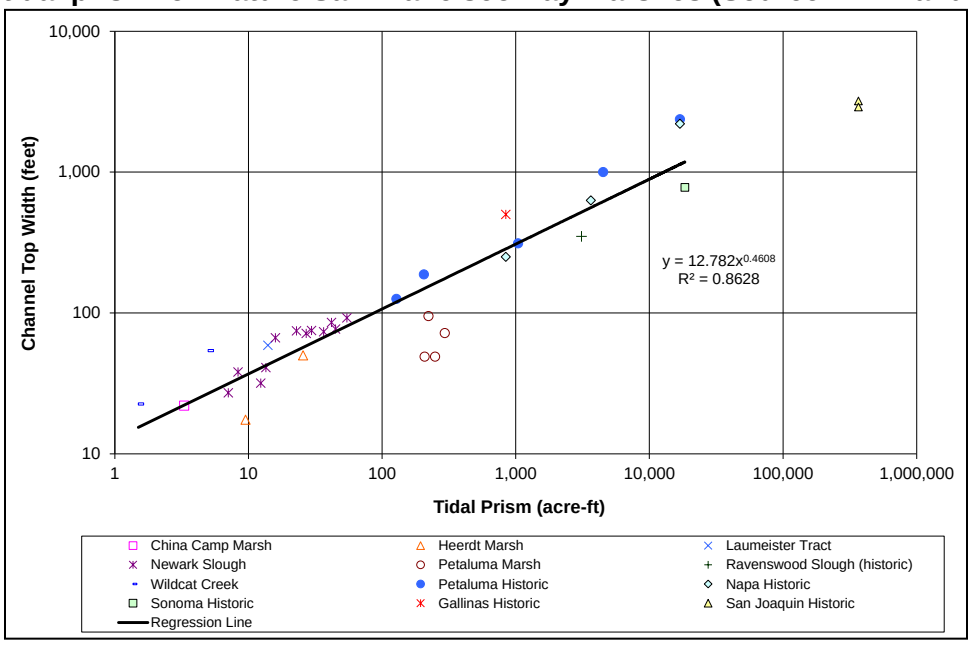


Table 2-10: State-Area, Stage-Volume results for McInnis Marsh

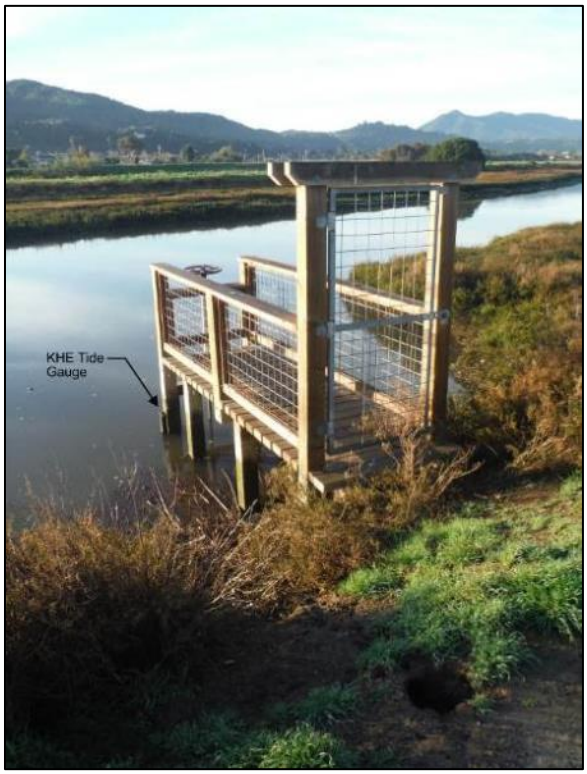
Stage Elevation (NAVD88-ft)	Description	Cumulative Inundation Volume (AF)	Cumulative Inundation Volume (CY)	Cumulative Inundation Area (Acres)	Incremental Inundation Volume (AF)	Incremental Inundation Volume (CY)	Incremental Inundation Area (Acres)
0.21	MLLW	0.0	0	0.0	0	0	0
0.50	-	0.0	0	0.0	0.0	0	0.0
1.00	-	0.2	260	1.0	0.2	260	1.0
1.22	MLW	0.5	730	1.8	0.3	470	0.7
1.50	-	1.4	2,330	7.5	1.0	1,600	5.8
2.00	-	14.0	22,650	42.6	12.6	20,330	35.1
2.50	-	46.5	75,060	86.4	32.5	52,410	43.8
2.68	NGVD29	63.3	102,130	100.0	16.8	27,070	13.6
3.00	-	98.8	159,440	121.5	35.5	57,310	21.5
3.34	MSL	142.8	230,320	132.9	43.9	70,870	11.4
3.37	MTL	146.8	236,760	133.1	4.0	6,440	0.3
3.50	-	164.1	264,780	134.0	17.4	28,020	0.9
4.00	-	231.6	373,580	135.6	67.4	108,800	1.6
4.50	-	299.6	483,350	136.6	68.0	109,780	1.0
5.00	-	368.1	593,930	137.7	68.5	110,580	1.1
5.50	-	437.4	705,730	139.6	69.3	111,800	1.9
5.52	MHW	440.2	710,240	139.7	2.8	4,510	0.1
6.00	-	507.8	819,220	142.2	67.5	108,980	2.5
6.13	MHHW	526.3	849,160	143.4	18.6	29,940	1.2
6.50	-	581.7	938,430	155.3	55.3	89,270	11.9
7.00	-	662.6	1,068,940	167.7	80.9	130,510	12.3

Stage Elevation (NAVD88-ft)	Description	Cumulative Inundation Volume (AF)	Cumulative Inundation Volume (CY)	Cumulative Inundation Area (Acres)	Incremental Inundation Volume (AF)	Incremental Inundation Volume (CY)	Incremental Inundation Area (Acres)
7.50	-	748.0	1,206,710	173.1	85.4	137,770	5.5
8.00	-	835.2	1,347,410	175.6	87.2	140,700	2.5
8.50	-	923.6	1,490,040	177.9	88.4	142,630	2.3

2.9 Hydrologic Monitoring

Hydrologic conditions were characterized at McInnis Marsh via observations and measurements of both surface water and groundwater levels between the time period of June 2014 and March 2015. KHE installed four (4) shallow groundwater piezometers (PZ-1 through PZ-4), three instruments inboard of perimeter levees and one outboard of the Eastern levee in the adjacent undiked marsh (Figure 2 2). A stilling well was also installed at the Park's tide gate (TG-1). Continuous water level measurements were collected on a 15 minute sampling interval to characterize tidal water fluctuations along the North Fork of Gallinas Creek. Continuous water level monitoring was performed both in Gallinas Cr and in the interior of McInnis Marsh at PZ-1 for an approximately 8 month period (6/19/14 – 2/17/15). The Gallinas Creek water level instrument was installed on the southwest pier of the tide gate (TG-1) on the North Fork of Gallinas Creek. (Figure 2-29) The PZ-1 logger was installed inside the well casing in the largest tidal pond/panne in the subsided basin (see Figure 2-5 and Figure 2-6 for photos of PZ-1).

Figure 2-29: Photo of McInnis Marsh Tide Gate (TG-1) and KHE tidal monitoring stilling well (2/11/15).



2.9.1 Hydrologic Monitoring Results

The 2014-2015 KHE groundwater and tidal monitoring at McInnis Marsh Restoration site captures simultaneous measurements under various wet/dry season conditions. This information provides a measurement of the changing water level gradients during dry periods and heavy rain events. Continuous water level monitoring results for PZ-1 and TG-1 are presented in Figure 2-32 for a full period of record (POR). An additional plot (Figure 2-33) provides continuous logger data for PZ-1 and TG-1 during mid-December, 2014 storms to show the effect of groundwater and surface water conditions during a large precipitation event and high flows out of Gallinas Creek's North Fork. Point readings of water surface elevations (WSE) and depth to water (DTW) readings for all piezometers (PZ-1 through PZ-4) are presented in Figure 2-34 and Figure 2-35, respectively. All water level readings were converted to elevations in NAVD88-ft from the surveys conducted by KHE staff.

2.9.1.1 Gallinas Creek Tidegate Monitoring at TG-1

Monitoring took place at TG-1 under a variety of tidal and storm events during the monitoring period. Concurrent measurements recorded at the Richmond NOAA Gauge indicate a 1-hr lag at the TG-1 WL recorder compared to tidal events recorded at the Richmond gauge. Peak high tides were recorded at TG-1 on 12/3/14 at 9:06 AM at 8.16 ft., NAVD88, 0.16 ft. higher than the 8.0 ft. high tide recorded at the Richmond Gauge. KHE suspects levee overtopping during this tidal event at the minimum levee crest elevation at 7.91 ft. along the Eastern perimeter levee (Station 5,500). Low tides recordings at the TG-1 monitoring gauge were not captured due to the water level recorder being above the water surface during low tide events.

Figure 2-30: Low Tide at TG-1. Photo Taken 5/19/15, 10:20 AM

Figure 2-31: High Tide at TG-1. Photo Taken 12/22/14, 12:11 PM.

2.9.1.2 PZ-1 Monitoring

Continuous water level recording at PZ-1 indicated short-term response to storms, followed by a gradual groundwater recession. Seasonal groundwater rises within the basin due to wet season recharge. Up to 2 ft. of wet season ponding was observed at PZ-1 between early December and mid to late March due to direct precipitation and runoff. Dry season recession was observed from winter groundwater conditions towards spring conditions (Figure 2-32). No tidal influence was observed for groundwater levels at PZ-1.

Figure 2-33 shows the change in water level in McInnis Marsh as a result of direct precipitation and storm runoff from adjacent drainage through McInnis Marsh to Gallinas Creek during the December 11th, 2014 storm event. During the December 2014 storm, 4.67 inches of total daily rain were recorded at the Big Rock Station (Station NBRC1, Big Rock, San Rafael, CA). Figure 2-33 also shows that storm impacts increase low tidal water levels on Gallinas creek during high flow events.

Water quality monitoring was outside the scope of this study, however, KHE took point salinity readings during various site visits to assess general fresh/salt water conditions and compare salinity in the inner marsh to Gallinas baylands salinity. Salinity measurements were recorded in

piezometer and well casings with a YSI 556 MPS Multi Probe. High salinity levels were recorded at PZ-1 ranging from 41-42 PPT (Table 2-11). Hypersaline concentrations (> 32-35 ppt) occur due to evaporation. Concurrently, instantaneous measurements of salinity levels in Gallinas creek were recorded as 30 PPT during a flood tide and 23 during a tidal ebb indicating brackish conditions in Gallinas Creek. Water quality and water level monitoring in Gallinas Creek is now being collected by the San Francisco National Estuarine Research Reserve, which maintains an instrument near Bucks Landing (see SWMP at http://www.sfbaynerr.org).

Table 2-11: Salinity readings (Parts per thousand, PPT) measured during KHE site visits at the five monitoring locations

Monitoring Location	7/21/2014	9/11/2014	4/6/2015
PZ-1	42.34	41.27	41.97
PZ-2	21.61	-	16.06
PZ-3	19.36	-	30.30
PZ-4	32.71	30.81	30.81
TG-1	30.50	-	22.78

2.9.1.3 Groundwater Levels – Point Readings

Point observations indicate similar groundwater conditions at PZ-1, PZ-2 and PZ-4, on the interior subsided marsh region (Figure 2-34 and Figure 2-35). Dry summer water level conditions for the subsided interior marsh show water levels ranging from -4 feet to -2 feet (NAVD88). Observed wet winter conditions that resulted from storms in mid-December 2014 caused groundwater levels on the subsided interior marsh to increase from the dry late summer levels by 5-6 ft. at the ground surface at PZ-2 and PZ-4 to approximately +3.0 ft., NAVD88. As discussed above, long-term seasonal ponding occurs at PZ-1. Here, average grades are approximately 5-ft lower (1.5-3.0 ft., NAVD88) than the adjacent undiked marsh (6-7 ft., NAVD88). Post precipitation events in the subsided interior marsh result in a smooth groundwater recession toward dry summer month water levels at (-4ft - -2ft, NAVD88). Groundwater levels in the outboard marsh at PZ-3 did not change much during the monitoring period (Figure 2-32 and Figure 2-33), with groundwater levels remaining at or near the marsh plain surface.

Figure 2-32: Water level monitoring results for PZ-1 and the outer tide gate at McInnis Marsh compared with NOAA tide data from station RCMC1 – Richmond CA.

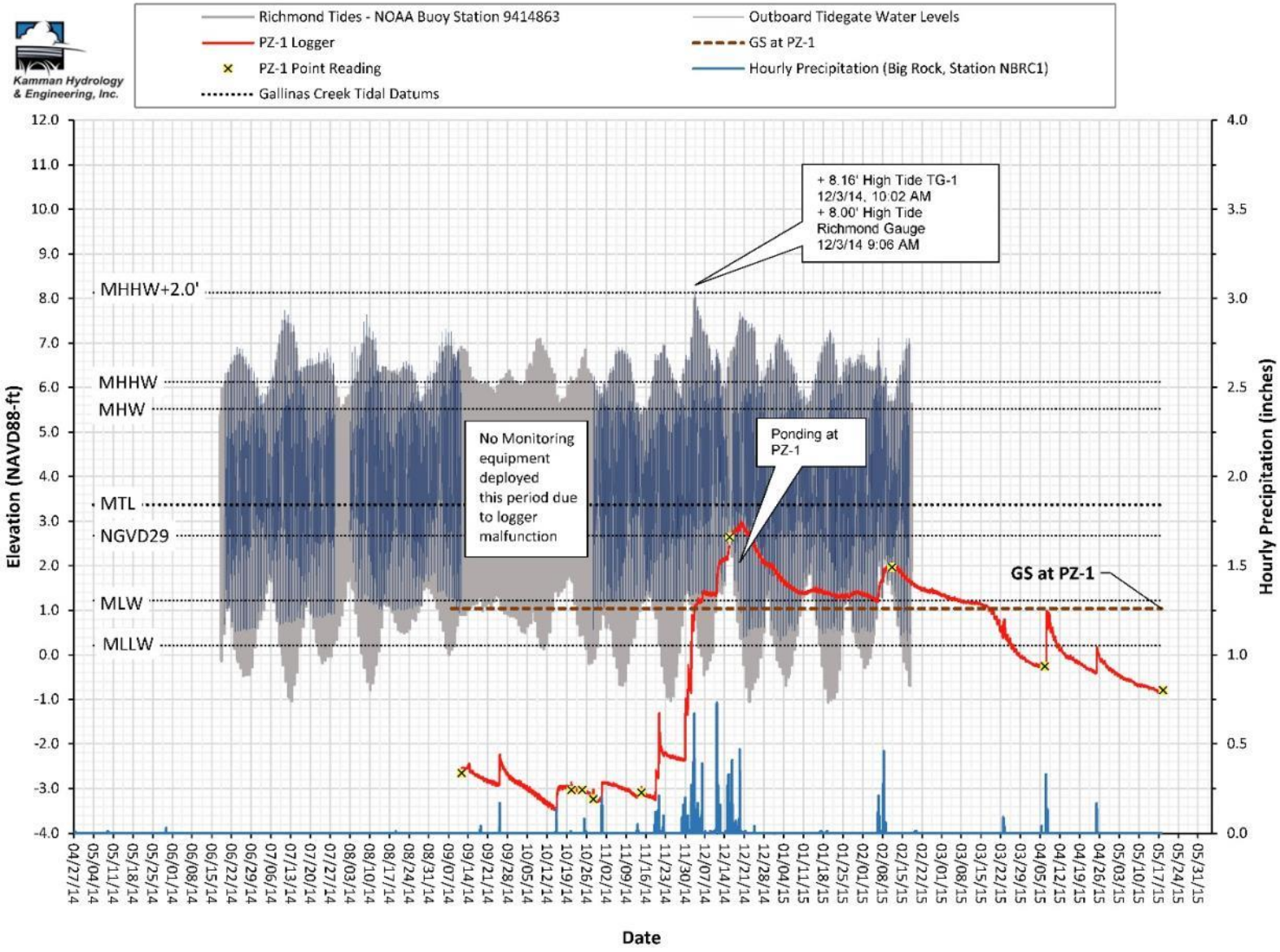


Figure 2-33: Water level monitoring results during December 2014 storm and high tide events.

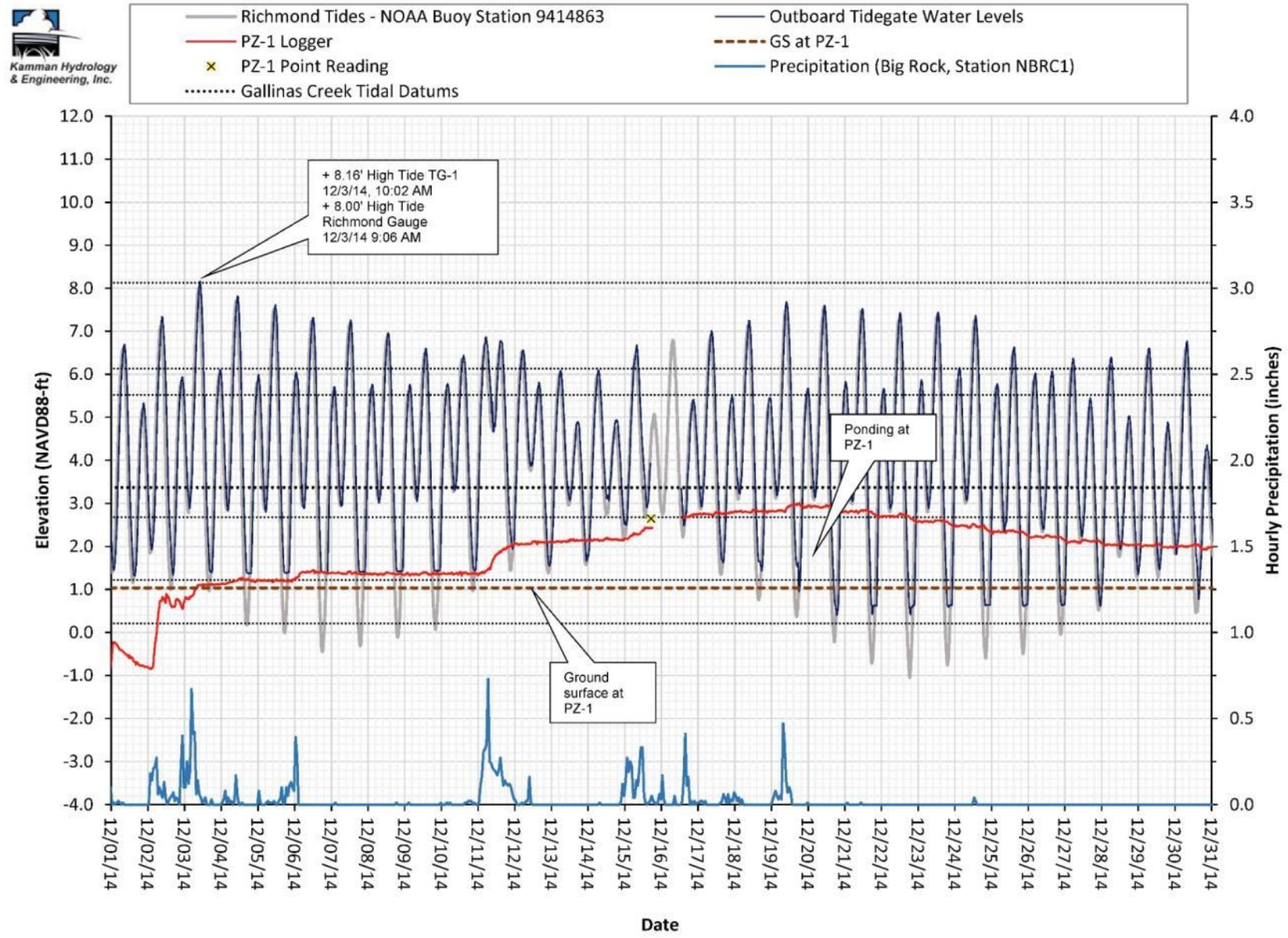


Figure 2-34: Groundwater Elevation (NAVD88) at KHE Gauges

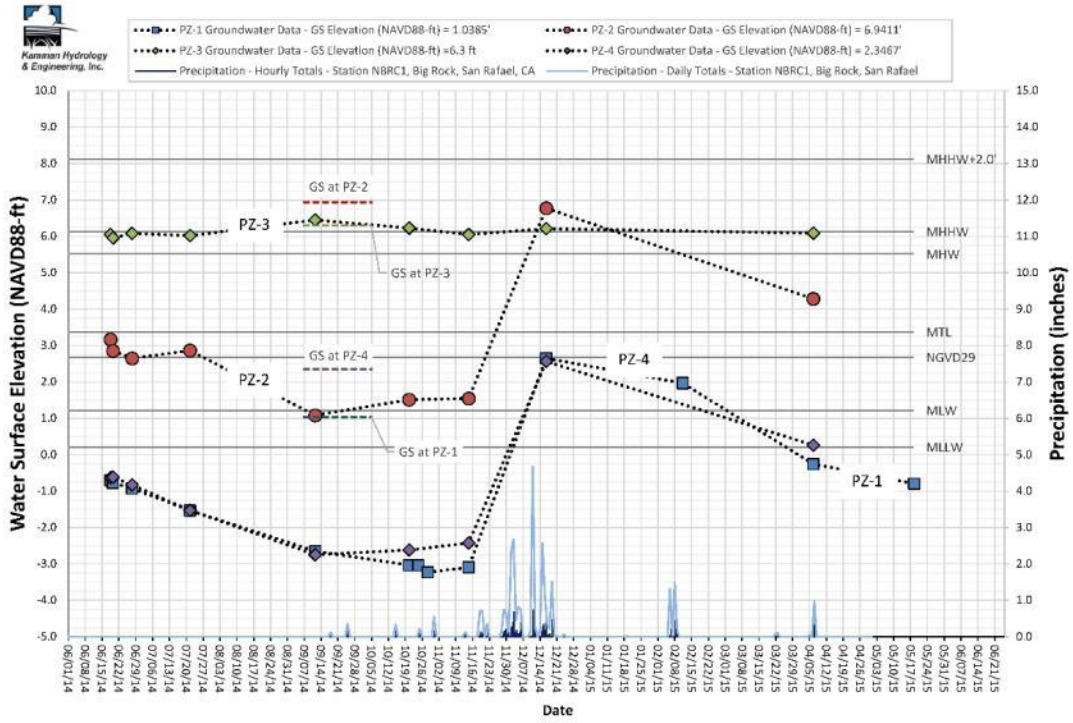
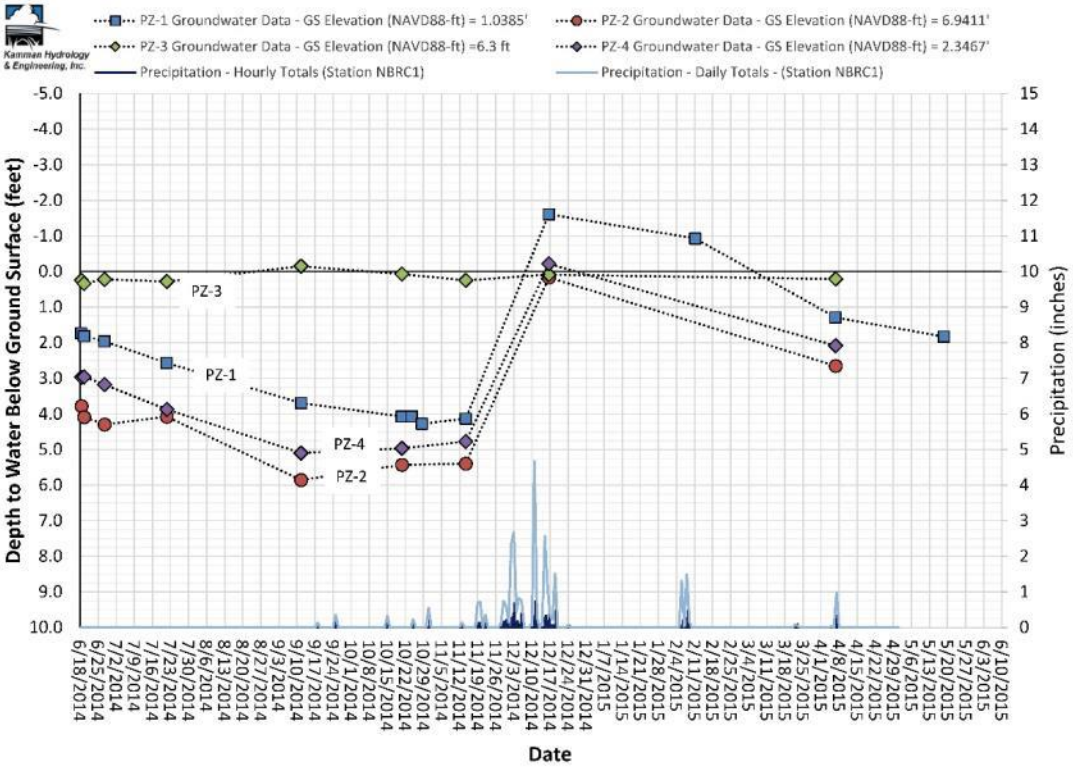


Figure 2-35: Depth to water readings for KHE Gauges



2.10 Miller Creek Hydrology and Hydraulics

Miller Creek tidal datums are the same as those presented for Gallinas Creek in Table 2-3. Figure 2-36 depicts existing inundation areas at selected tidal datums along Lower Miller Creek. Tide waters are restricted to the channel area between the adjacent levees; and MHHW water currently extends up to the SMART Bridge.

To better characterize channel grades within the leveed banks, KHE mapped inundation areas at each tidal datum assuming the levees adjacent to Miller Creek did not restrict tidal exchange across the regional landscape topography (

Figure 2-37). This map indicates that in the absence of the levees, tidal influence would extend across LGVSD, St. Vincent, Silveira and SMART parcels. Flood hydraulics analysis (Section 2.10) indicates that at high tides, Lower Miller Creek overtops both right and left banks downstream of the SMART bride during greater than 2-yr storm events. While it is outside this scope of study, given the high current likelihood of overbank flooding, and the increasing flooding risk anticipated with SLR, bayland storm water and natural resources management should be integrated across these adjacent and potentially tidally influence parcels.

Figure 2-38 presents the longitudinal profile of lower Miller Creek from the outboard limit of marsh vegetation on San Pablo Bay to the SMART Bridge. Tidal datums on the figure illustrate the transitional nature of the reach hydrology which is dominated by tidal exchange upstream of the Silveira Pump station, and both fluvially (creek) dominated and tidally influenced upstream of the SMART bridge.

Figure 2-36: Miller Creek Existing Conditions Inundation Areas

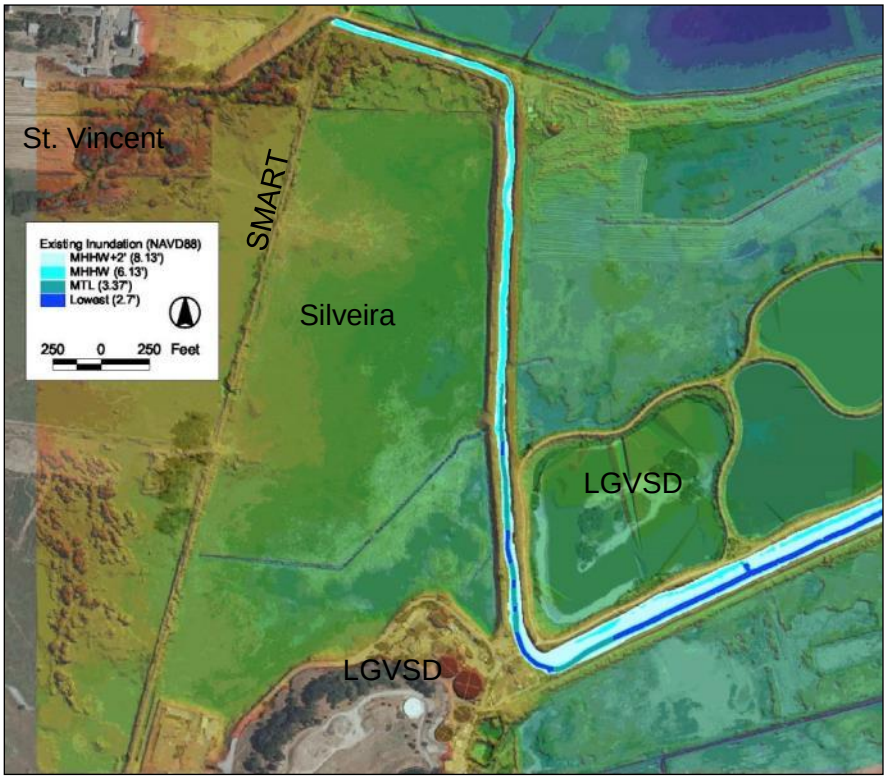
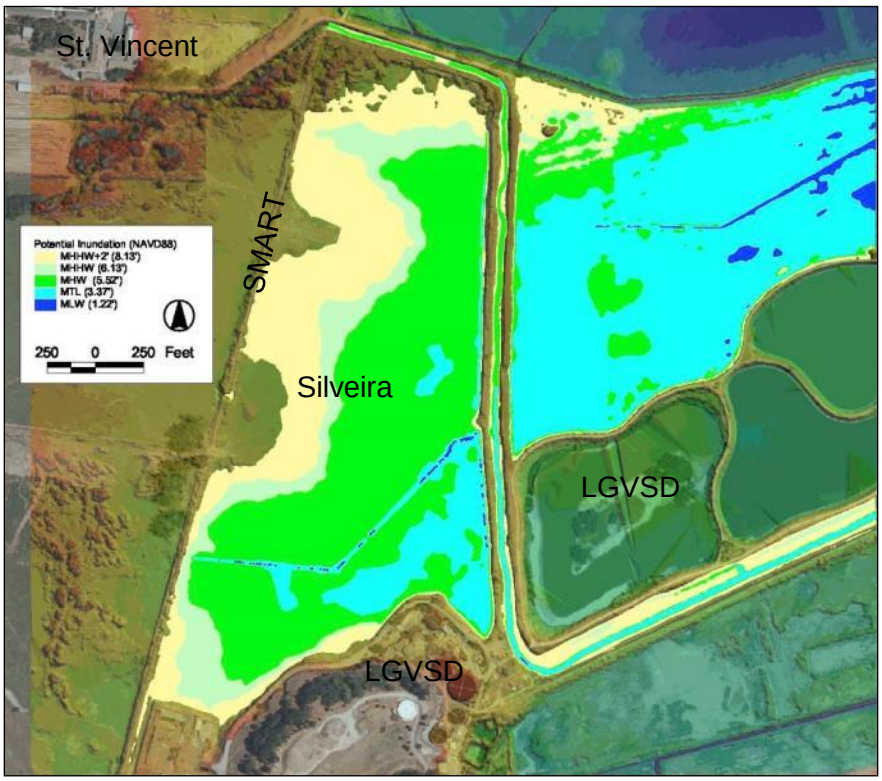


Figure 2-37: Miller Creek Potential Inundation areas



2.10.1 Water Level Monitoring in Miller Creek

Continuous water level monitoring was performed at two locations along lower Miller Creek for an approximate seven-month period. The upstream-most gauge was placed in a small pool within the channel at the 90-degree creek bend (Figure 2-38). A second downstream gauge was placed within the Miller Creek channel near the LGVSD outfall, 65 feet downstream of Reclamation Bridge. The period of record for the upstream and downstream gauges was June 21, 2013 through February 5, 2014 and July 7, 2013 through February 5, 2014, respectively.

Figure 2-38: Longitudinal Profile of the Project Reach

Water Level monitoring consisted of Solinst-brand Levelogger water-level recorders (combined pressure transducer and data loggers) placed inside 2-inch diameter PVC stilling wells and secured to metal posts driven into the channel beds. Staff plates secured to the outside of the stilling wells were used by KHE staff to make visual water level readings during site visits. The elevations of staff plates relative to known benchmarks were defined by L.A. Stephens & Associates, Inc. in topographic surveys conducted to support the project April, 2013[7]. Water level recorders collected measurements every 15 minutes. KHE staff correlated the instrument record to staff plate elevation observations. Water level readings were compensated for barometric pressure and converted to elevations (feet NAVD88) to generate a continuous water level record over the monitoring period.

2.10.1.1 Monitoring Results

The 2013-2014 KHE tidal monitoring for Lower Miller Creek captures simultaneous measurements of water surface elevations at both gages. This information is valuable because it provides a measurement of the changing water level gradients in the reach. Recorded water levels for the two monitoring locations are plotted in Figure 2-39 and Figure 2-40. Results provide uninterrupted tidal signature for both gauges. Maximum observed tidal range at the

[7] The elevation of the upstream gauge near the bend was tied to benchmarks with LAS Point ID numbers 40, 69 and 95 established by L.A. Stevens & Associates, Inc. of Novato, California in April of 2013. The lower gauge near Reclamation Bridge was tied to LAS Point ID numbers 1 and 7 of this same survey.

upper and lower gauges during the July 22nd, 2013 spring tide were 1.6 feet and 4.8 feet, respectively. The upper gauge was installed in a small pool where tidal water does not recede during low tide, enabling the gauge to remain submersed for the entire period of record. During the monitoring period, the channel is intertidal, and was intermittently dry during the summer low flow monitoring period.

Figure 2-39: Water level monitoring results for Upper and Lower Miller Creek Gauges compared with NOAA tide data from station RCMC1 – Richmond CA. (Period of Record: June 21st, 2013 through February 5th, 2014).

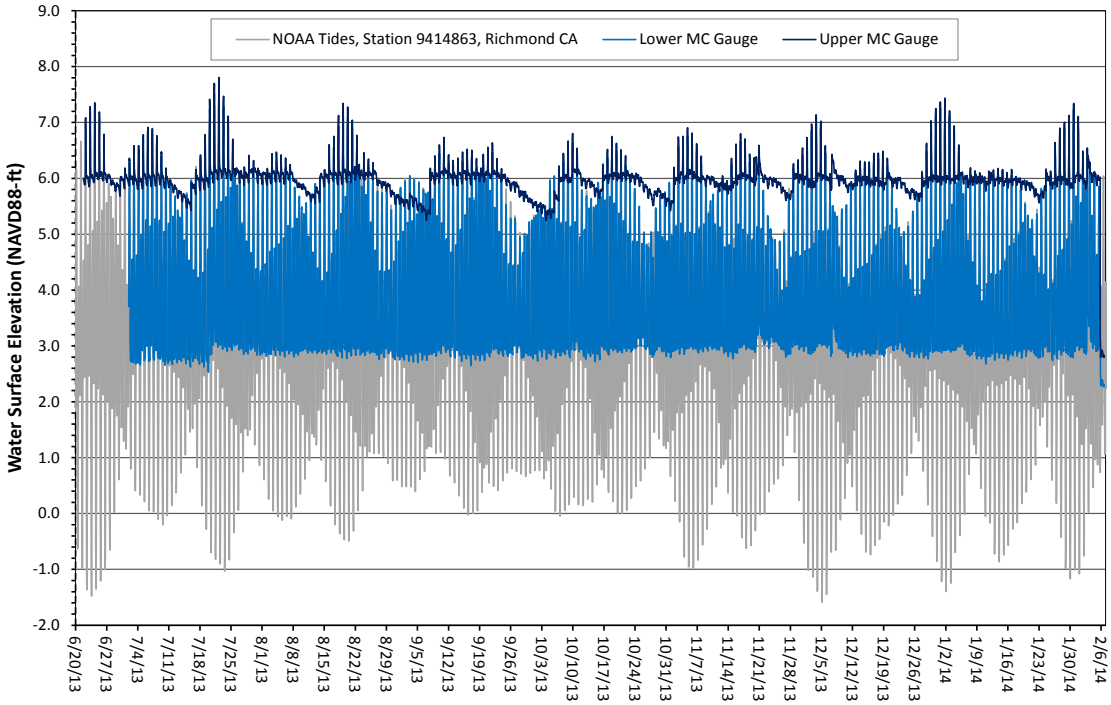
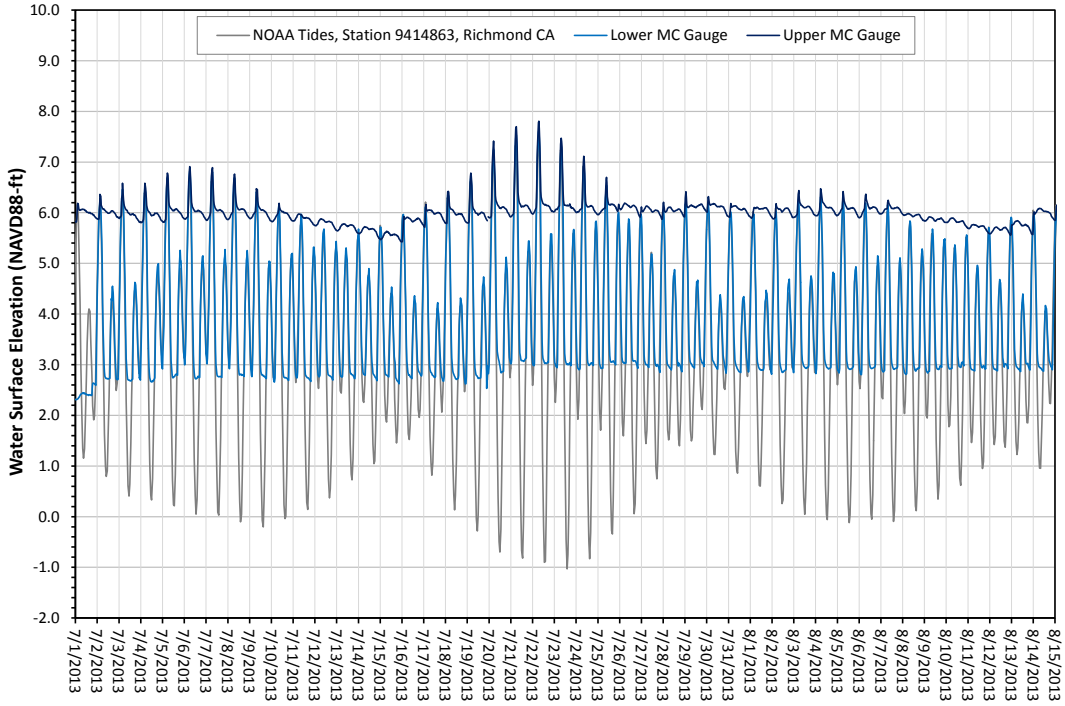


Figure 2-40: Water level monitoring results (expanded) compared to NOAA tide data from station RCMC1 – Richmond CA (time period within period of record: July 1, 2013 through August 15th, 2013).



The lower limit of the water level range for both the upstream and downstream Miller Creek gauges are dependent on local bed elevations. In comparison to NOAA recorded bay tides at Richmond, low tide levels at both Creek gauges were truncated as a result of the rising bed elevation in the Miller Creek channel (see creek profile on Figure 2-38). As noted above, the upstream gauge is installed in a scour pool at the 90-degree bend and there are alternating gravel bars downstream, which truncate the lower tidal range (Figure 2-38). At water levels less than 5.8 feet (NAVD88), the intertidal channel drains leaving residual water in pools. The declining water level below the elevation of 5.8-feet observed in the more upstream pool during low tide periods may be due to longer period changes in groundwater flow gradients which effect rate of subsurface seepage draining the pool. Evaporation losses may also attribute to this decline. Bed elevation at the Lower gauge was approximately 2.3 feet (NAVD88) which was verified by topographic surveys. Truncation at the lower gauge occurred at tides less than 2.9 feet (NAVD88) due to slightly higher bed elevations in downstream bars on Miller Creek.

Records for both the NOAA Richmond and Las Gallinas Creek tide gauges[8,9] were utilized to compare tidal elevations in NAVD88-ft and tidal phase between each other and the two Miller Creek gauges (see Figure 2-40). The Las Gallinas Creek Gauge only provided water depth measurements but was utilized to compare tidal phase shift between the San Pablo Bay tide and the two KHE Miller Creek gauges. The two Miller Creek gauges appeared to be in sync with

[8] Richmond Tide Gauge: Station RCMC1 – 9414863 – Richmond, CA. Owned and Maintained by NOAA's National Ocean Service Water Level Observation Network. Gauge is located near the western span of the Richmond San Rafael Bridge.

[9] Las Gallinas Creek Gauge: Station GGGC1. Owned and Maintained by the National Estuarine Research Reserve System. NEERS Water Quality Station. Gauge located approximately 1,500 feet upstream of the mouth of Las Gallinas Creek.

one another, however a time lag of approximately 1.5-hours was observed between the Las Gallinas and the Miller Creek gauges. The phase shift between the Miller Creek gauges and the Richmond tide gauge was nearly 2-hours. Tidal elevations at the Richmond and Miller Creek gauges are in close agreement.

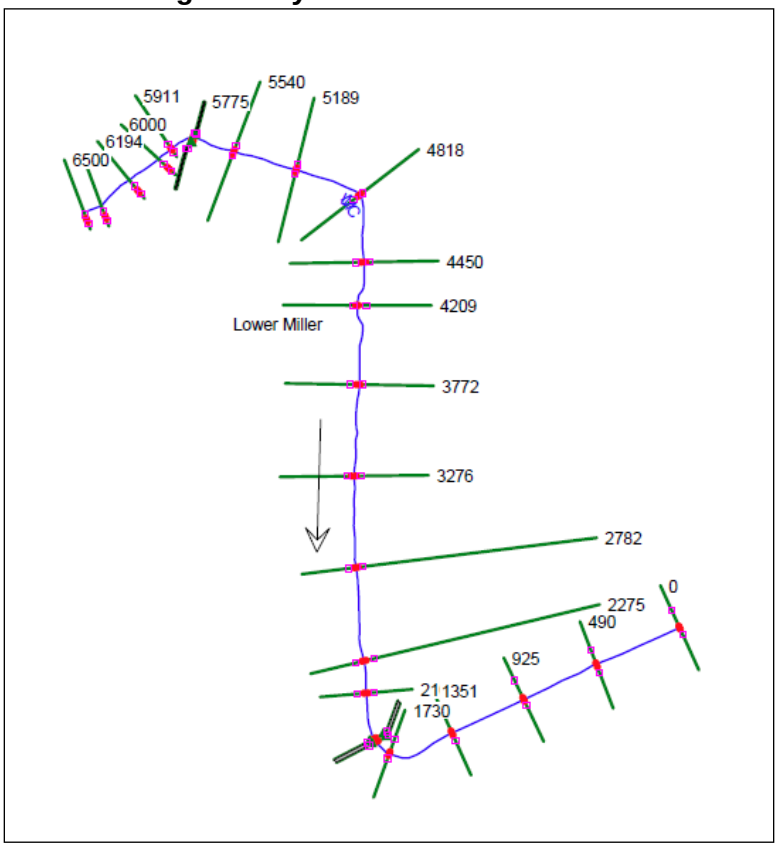
2.10.2 Hydraulic Analysis

2.10.2.1 Numerical Model Development

In order to evaluate existing flood conditions within the study reach, KHE, Inc. developed a numerical hydraulic model. The lower Miller Creek model was built using the U.S. Army Corps of Engineers HEC-RAS one-dimensional steady flow model code. The model domain begins a few hundred feet upstream of the SMART Bridge crossing Miller Creek. The channel turns southeast at the bridge for nearly 1,000 feet, and then turns southward to the Reclamation Bridge, and finally turns northeast towards the outlet at San Pablo Bay (Figure 2-41).

The existing channel conditions are represented in the model using 24 cross-sectional profiles derived from the terrain model of existing conditions. Model cross-sections were extended along left and right banks to identify locations of levee over-topping into the adjacent off-channel areas. The model geometry (stationing, alignment and cross-sections) is provided in Figure 2-41.

Figure 2-41: HEC-RAS model geometry



2.10.2.2 Creek Design Flows

Creek flows ranging from the 2- through 100-year peak 24-hour duration storms were simulated using the hydraulic model. The 10-, 50-, and 100-year recurrence interval peak storm flows on Lower Miller Creek are from FEMA at the location of the Southern Pacific Railroad (now SMART) (FEMA, 2009). A logarithmic trend line was fitted to this data to extrapolate the 2- and 5-year recurrence interval peak flow values (Figure 2-42). Additionally, a "low-flow" value of 1-cfs was analyzed to characterize the range of tidal influence under base flow conditions. The flow recorded during the January 20, 2010 storm event was also analyzed; this storm delivered a peak flow estimated to have an approximately 7-year recurrence interval. Miller Creek peak flow, and current estimates of peak flows in the North Fork of Gallinas Creek (Noble, 2012) are provided in Table 2-12.

Figure 2-42: Miller Creek design storm vs. flow correlation

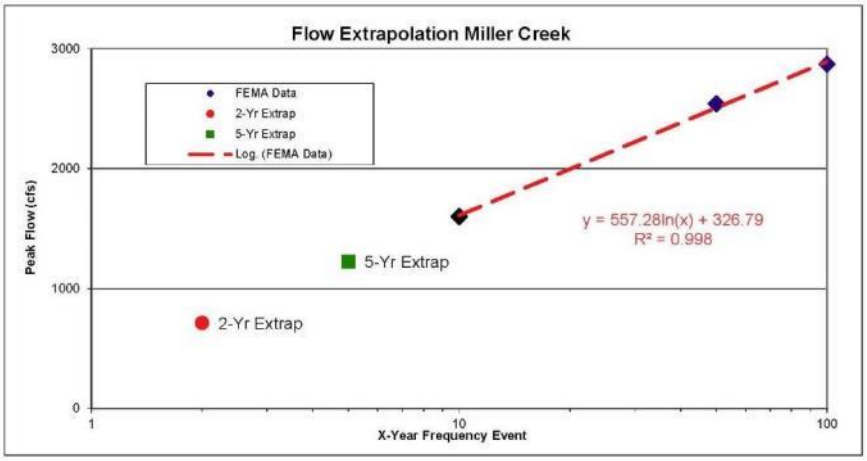


Table 2-12: Peak Flood Flows.

	Low Flow	2-Yr (cfs)	5-Yr (cfs)	01/20/2010 (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
Miller Creek (@ LGVSD)	1	713	1,224	1,383	1,600	2,540	2,870
So. Fork Gallinas Cr. (upstream of Confluence)	n/a	340	679		920	1,401	1,596
So. Fork Gallinas Cr. (downstream of Confluence)	n/a	693	1,369	n/a	1,843	2,778	3,159

2.10.2.3 Water Surface Elevations

KHE (2013) provides a complete description of Miller Creek modeling and simulation results. Analysis was conducted for a range of peak and low inflows and downstream tidal water surface elevations. Pertinent conclusions are summarized as follows:

- Under low flow conditions, the effect of the downstream tidal boundary water surface elevation is most pronounced, with MHHW influencing water surface elevations upstream of the SMART Bridge and the representative high water surface (MHHW + 2.5-ft) influencing water surface elevations even further upstream.
- As flood flow increases in magnitude, the tidal influence becomes progressively less pronounced as the flows become larger (larger storms).
- Downstream of the SMART Bridge and the 90-degree bend, the 2-year flow event remains within channel levees along the long-straight north-south stretch, as well as remaining well below the soffit of the Reclamation Bridge.
- The 5-year flow event overtops the right levee just downstream of the SMART Bridge under any tidal condition, and again overtops the right levee downstream of the Reclamation Bridge under any tidal condition.
- The 10-year flow event overtop both the left and right levees downstream of the SMART Bridge, as well as overtopping the right levee downstream of the Reclamation Bridge under any tidal condition. Greater magnitude flows overtop these same levee locations for longer periods of time and at greater depths, in addition to other locations.
- At the Smart Bridge, all simulated design flows except the low flow condition result in a predicted water surfaces which intersect the soffit of the SMART Bridge resulting in no freeboard beneath the existing SMART Bridge deck. Simulation results indicate that peak flows in excess of 2,540-cfs (50-Yr recurrence interval) over-top the SMART Bridge under any tidal boundary condition.
- Midway down the north-south Miller Creek channel reach at 50-yr and 100-yr design flows overtopping the left levee at 50-yr flows, and overtopping of both levees is predicted during the 100-year flood. This occurs during both MLLW and MHHW tidal conditions.
- Because floodwaters overtop the upstream levees, in no case does this bridge experience overtopping, nor do water levels reach the bridge soffit elevation. In addition to decreased flow rates reaching the Reclamation Bridge due to upstream overbank flooding, the bridge offers a slight constriction within the channel, which mildly increases the velocity beneath the bridge, thereby decreasing the water surface through the constriction.

2.10.2.4 Flow Velocities

Model simulation results indicate that in general, a 2-year flow generates channel velocities between 4 to 5 feet per second, a 5-year flow generates channel velocities between 5.5 to 7 feet per second, and a 10-year flow generates channel velocities between 6 to 8 feet per second. The 50 and 100-year flows generate velocities between 11 to 13.5 feet per second. Overall, velocities increased when passing beneath the SMART and the Reclamation Bridges.

2.11 Miller Creek Sediment Characteristics, Yield and Transport

As with Section 2.10, this report section was modified from KHE's 2013 site assessment of Lower Miller Creek, conducted on behalf of the LGVSD to support District facilities operation and maintenance, and ongoing stewardship of Miller Creek the natural resources (KHE, 2013).

2.11.1 Sediment Characteristics and Yield

2.11.1.1 Sediment Characteristics

Based on visual reconnaissance and sediment sampling, KHE delineated a clear surficial transition between a coarse gravel-dominated substrate and soft, fine-grained mud substrate as observed on the summer bed surface (Figure 2-43). District staff indicate that they have observed coarse gravel material extending down to Reclamation Bridge, which is obscured by a thin cover of fine-grained sediment during low flow periods.

Two pebble counts were completed (locations PC-1 and PC-2 on Figure 2-43) on well-developed gravel bars within the main channel pursuant to the methods of Wolman (1954). The grain-size distribution from these pebble counts (Figure 2-44) reveal that grain-size is relatively consistent through the upper project reach and consists predominantly of coarse grained gravel. The source of gravel in the project reach is from erosion and fluvial sediment delivery from the upper watershed.

The fine-grained deposits in the lower project reach consist of very soft mud consisting predominantly of flocculated clay. The limits of the fine sediment appear to correlate with the maximum footprint of the channel inundation area associated with the Mean Tide Level (MTL) datum (compare Figure 2-36 to Figure 2-43). The likely dominant source of the fine sediment is from San Pablo Bay via tidal exchange through Lower Miller Creek.

2.11.1.2 Sediment Yield

No sediment supply field monitoring was completed as part of the Lower Miller Creek study. In order to estimate sediment yields to the project site, a literature and data search was conducted regarding sediment yield estimates for local vicinity watersheds displaying topographic, geologic and hydrologic conditions similar to the Miller Creek watershed. A plot of reported annual unit area sediment yield rates (tons of sediment per square mile per year) from the literature search are provided in Figure 2-45 and include data for: Miller Creek (Balance, 2011); Corte Madera Creek (Stetson Engineers, 2000); Redwood Creek (Stillwater, 2004); Lone Tree Creek in West Marin (Lehre, 1982); Bolinas Lagoon (Tetra Tech, 2001 and Ritter, 1970); Lagunitas Creek (Stillwater, 2010 and Cover, 2012); Petaluma River tributaries (Southern Sonoma County RCD, 1998); Sonoma Creek tributaries (NRCS AmeriCorps, 1996); and the Napa River (Porterfield, 1980). For comparison, unit area sediment yields from the Upper Eel River are also plotted (Porterfield and Dunham, 1964) – the Eel River watershed represents one of the highest sediment yields in the US.

As indicated above, one study (Balance, 2011) contained sediment yield data for the upper Miller Creek watershed. This study was completed as part of the proposed Skywalker Properties development at Grady Ranch in the headwaters of Miller Creek. The 2011 investigation reports that portions of the upper Miller Creek reach have undergone 11 feet of incision over the past 17 years. Balance also stated that sediment transport rates were high relative to San Geronimo Creek, particularly bedload transport. Balance also reported that rates were elevated relative to those in other Marin County streams of similar size and geomorphic location[10]. The elevated rates may be associated with ongoing channel incision. Rates may also be episodically elevated

[10] Plots of sediment yields from Marin County watersheds presented in Figure 21 do not indicate that Upper Miller Creek sediment yield in 2010 was notably elevated in comparison to other Marin watersheds.

due to the effects of the Dec. 31, 2005 storm, one of the largest during recorded history in this watershed.

Figure 2-43: Miller Creek General sediment characteristics.

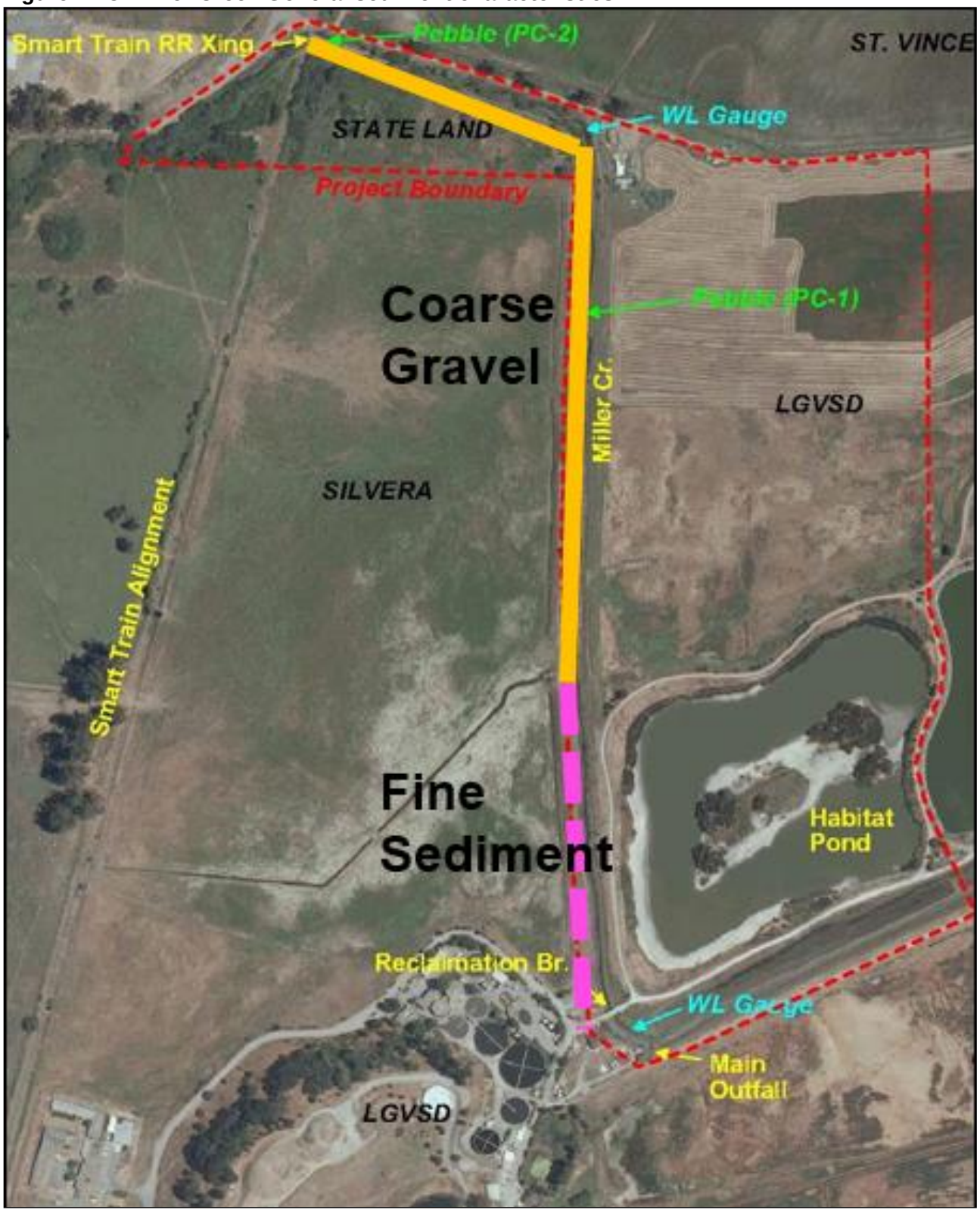
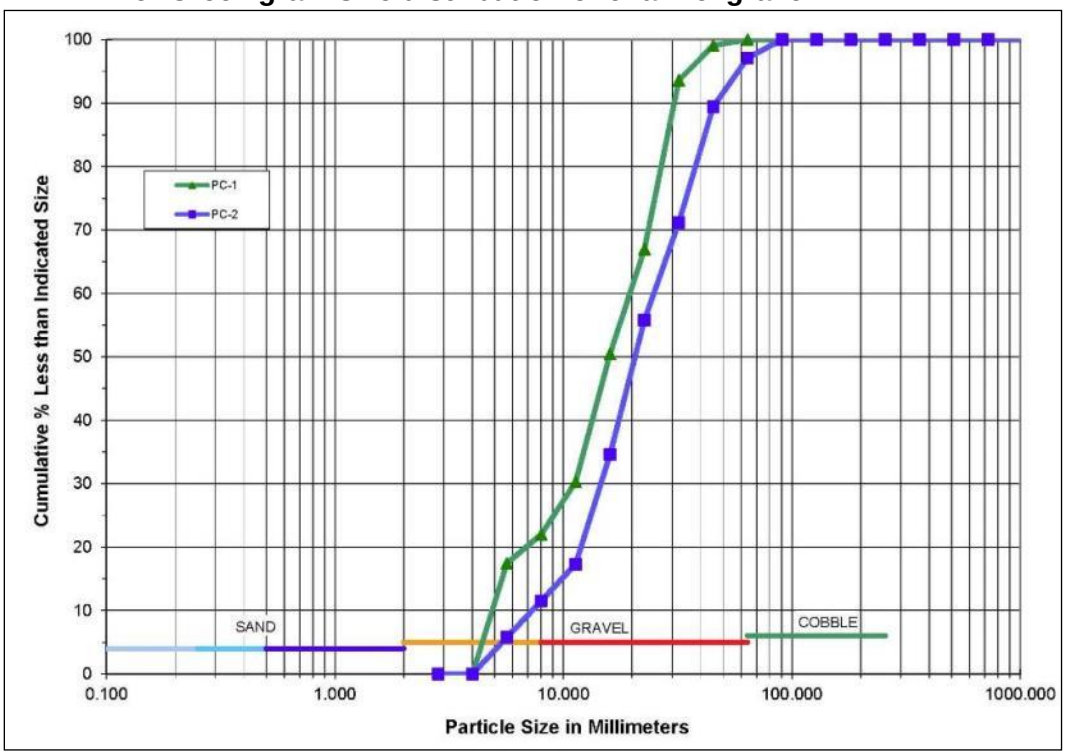


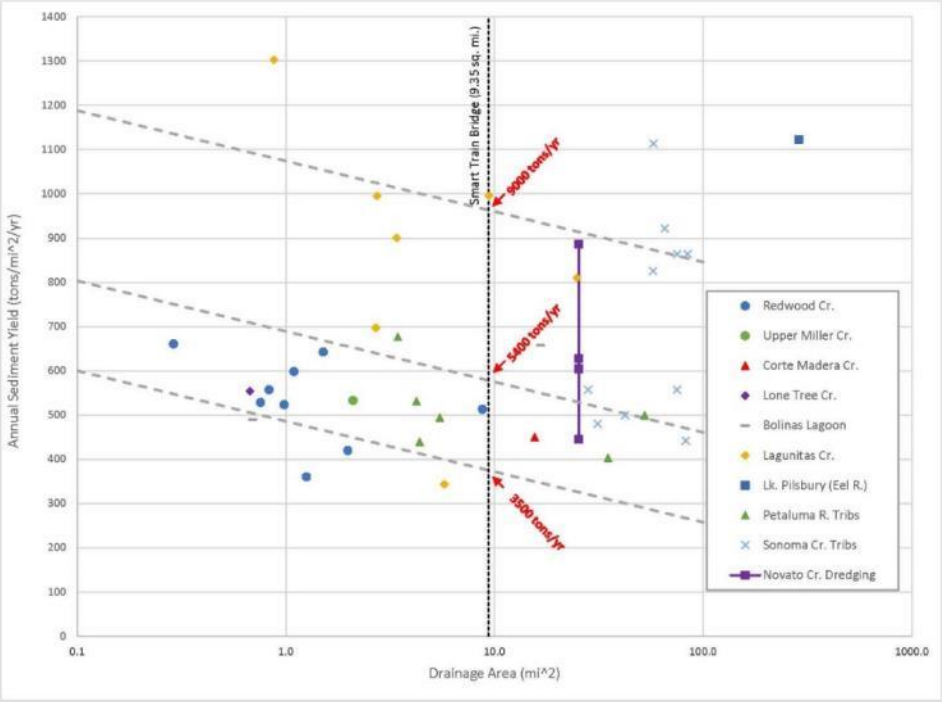
Figure 2-44: Miller Creek grain size distribution of channel gravel.



The County of Marin has been dredging lower Novato Creek every four-years since 1990. Analysis of excavation volumes removed during this period were used to estimate annual sediment yields from the watershed. The Novato Creek data indicate that annual yields have ranged widely, from near 900- to 450-tons/sq. mi/yr. KHE evaluated these results for correlation trends with relative wet and dry cycles. No correlation that linked high sediment yields to wet periods was observed.

It is clear from the plot of reported data that sediment yields in regional watersheds display considerable variability. In order to bracket the range of sediment yields to the upstream end of the project site (SMART Bridge crossing), dashed lines of visual best fit are plotted on Figure 20 depicting the low, mid, and upper range of reported annual sediment yields. It's worth noting that these boundary lines reflect an inverse relationship between sediment yield and watershed drainage area, where unit sediment yields decrease with increasing drainage area (Langbein and Schumm, 1958). Based on this analysis, annual sediment yields to the project reach are estimated to range from 3500- to 9000-tons/year, with an average of around 5400-tons/year. These yields reflect contributions from the entire upstream watershed and the variability in rates likely reflects changes in upstream storage and erosion.

Figure 2-45: Annual sediment yield from local area watersheds.



The estimated sediment yields presented above reflect the total volume and grain-size distribution (fine through coarse-grained) of material delivered to the upstream end of the site. The grain-size distribution of material deposited in the upper reaches of the site consists of fine- and coarse-grained gravel, suggesting that much of the fine-grained material is transported through the upper reach. Using Novato Creek as an analog, sediment grain-size data and descriptions of material dredged from the Novato Creek sediment management area (MPEG, 2005 and Collins, 1998) were evaluated to estimate the percentage of material coarser than fine gravel found in the entire sediment yield estimate presented above (hereafter referred to as "Coarse Material"). Based on this analysis, we estimate that about 10-percent of the entire sediment yield is Coarse Material[11]. For purposes of this study, we assume a similar size-distribution in the sediment delivered to the Lower Miller Creek Project site. Thus, we estimate that the annual volume of Coarse Material sediment that potentially accumulates in the upper reach of the study area ranges from 350- to 900-tons/year, which equates to between 250- to 650-cubic yards per year (CY/yr.) assuming 1.4-tons per CY.

2.11.2 Sediment Transport Capacity

This section presents sediment transport threshold estimates that initiate and maintain the movement of sediment found in Lower Miller Creek. The information presented includes theoretical critical velocities and shear stresses that represent mobility thresholds for non-cohesive and cohesive sediment transport. These values can be compared to modeled flow

[11] Based on professional experience in monitoring sediment transport rates on numerous Bay Area creeks and review of Bay Area sediment rating curves, suspended sediment transport rates are routinely an order of magnitude larger than bedload transport rates. This general finding is consistent with the 10% estimate of total sediment yield representing the bedload size fraction in Novato and Miller Creeks.

velocities for selected design flows to evaluate the associated grain-size class available for transported.

Standard approaches for characterizing erosion potential can be placed in one of two categories: maximum permissible velocity, and critical shear stress. The former approach is advantageous in that velocity is a parameter that can be measured or modeled. Shear stress cannot be directly measured – it must be computed from other flow parameters. As flow over the bed and banks of a stream increases, a condition referred to as the threshold state is reached when the forces tending to move materials on the channel boundary are in balance with those resisting motion. The forces acting on a soil particle lying on the bed of a flowing stream include hydrodynamic lift, hydrodynamic drag, submerged weight, and a resisting force. The permissible velocity is defined as the maximum velocity of the channel that will not cause erosion of the channel boundary. It is often called the critical velocity because it refers to the condition for the initiation of particle motion. Critical shear stress can be defined by equating the applied forces to the resisting forces. Like critical velocity, particle motion is initiated when applied shear forces exceed the resisting forces.

Critical shear stress of bed material is obviously controlled by the physical properties of the material, thus a distinction between non-cohesive and cohesive material is warranted as both are abundant in Lower Miller Creek corridor. Cohesive sediments are composed primarily of clay-sized material, which have strong inter-particle forces due to their surface ionic charges. As particle size decreases, its surface area per unit volume increases, and the inter-particle forces, not the gravitational force, dominate the behavior of sediment. There is no clear boundary between cohesive sediment and non-cohesive sediment. In general, finer grain size material are more cohesive. For purposes of this study, sediment sizes smaller than 2 microns (um), the size of clay particles, are considered cohesive sediment. Sediment of size greater than 60 um is coarse non-cohesive sediment. Silt (2- to -60 um) is considered to be between cohesive and non-cohesive sediment. The cohesive properties of silt are primarily due to the existence of clay. Thus for purposes of this analysis, silt and clay are both considered to be cohesive sediment. Table 2-13 presents published ranges of critical velocity and shear stresses that initiate particle motion for non-cohesive and cohesive sediments.

In order to identify and characterize sediment transport through the existing study reach, comparison of hydraulic model results to critical velocity values (Table 2-13) can be used to illustrate grain size transport capacity and associated conditions leading to sediment erosion and deposition. Simulated 2-year velocities in Lower Miller Creek range from 4- to 5-feet per second. These 2-year flood velocities likely mobilize and transport up to sand and fine gravels, leading to channel sediment transport and possibly erosion in the channel of material up to this grain-size. During low flow periods when the velocity dips to 1.0- foot per second, little if any sediment is mobilized and conditions favor sediment deposition. Under high flow regimes, where velocity reaches 13.5-feet per second, a wide range of non-cohesive particle sizes are potentially mobilized, ranging from silt to fine cobble. At the downstream end of the reach, high tides during a 2-year flood flow event likely back water up into the channel, reducing flow velocity, which promotes deposition at the downstream end of the reach even though many particle sizes had been put into movement immediately upstream.

Table 2-13: Critical shear stress and critical velocity values for non-cohesive and cohesive sediment types within the Novato Creek (Sources: critical shear stress values from Berenbrock and Tranmer (2008); critical velocity values from Vanoni (1977); Novato Creek clay data from Noble et al. (2005); and San Francisco Bay mud data from Partheniades (1965). Note: 1 N/m^2 = 0.02089 lbs/ft^2

Particle classification (name)	Particle diameters (mm)	Critical shear stress (N/m^2)	Critical velocity (ft/s)
Coarse cobble	128 – 256	112 – 223	
Fine cobble	64 – 128	53.8 – 112	9.5 - 10.0
Very coarse gravel	32 – 64	25.9 – 53.8	8.0 - 9.5
Coarse gravel	16 – 32	12.2 – 25.9	5.5 - 8.0
Medium gravel	8 – 16	5.7 – 12.2	3.8 - 5.5
Fine gravel	4 – 8	2.7 – 5.7	2.5 - 3.8
Very fine gravel	2 – 4	1.3 – 2.7	1.7 - 2.5
Very coarse sand	1 – 2	0.47 – 1.3	1.2 - 1.7
Coarse sand	0.5 – 1	0.27 – 0.47	0.9 - 1.2
Medium sand	0.25 – 0.5	0.194 – 0.27	0.8 - 0.9
Fine sand	0.125 – 0.25	0.145 – 0.194	0.8 - 0.9
Very fine sand	0.0625 – 0.125	0.110 – 0.145	0.9 - 1.3
Coarse silt	0.0310 – 0.0625	0.0826 – 0.110	1.6 - 1.3
Medium silt	0.0156 – 0.0310	0.0630 – 0.0826	2.2 - 1.6
Fine silt	0.0078 – 0.0156	0.0378 – 0.0630	3.2 - 2.2
Novato Creek cohesive clay	0.0052 - 0.0271	0.6	2.0
Novato Creek flocculated clay	0.0075 - 0.013	0.13	n/a
SF Bay Mud (cohesive)	n/a	0.011 - 0.93	n/a
SF Bay Mud (flocculated)	n/a	0.15 - 0.44	n/a

The channel constriction beneath the SMART Bridge creates an increase in channel velocity at the higher flow rates, and erosive conditions. At lower, 2-year flows, the reach may be scour dominant or depositional at the same location resulting in episodic cycles of bar formation and transport. At the low summer non-flood flows velocities the reach is only depositional. The localized velocity increase at the SMART railroad bridge mobilizes sediment, which creates the local scour hole beneath the bridge. Levee overtopping downstream and the associated drop in velocity causes sediment deposition of coarse-grained material downstream of the SMART Bridge during high flow events as observed in the field. The coarser sediment, previously excavated as a source of local fill, now aggrades in the downstream reaches of Miller Creek.

Figure 2-46: Sediment Front in Miller Creek (2014): Looking Upstream from the Silveira pump station.

2.11.3 Bedload Transport Analysis

Using available field measurement information and commonly accepted bed load transport equations, KHE completed a series of sediment transport calculations along the Upper-, Middle- and Lower Creek Reaches to identify changes and/or trends in channel bed load transport capacity. Acknowledging that bed load transport rates can vary by several orders of magnitude, the objective of this exercise was to generate reasonable estimates based on available data at selected intervals through the Creek Reach and compare those estimates to hydraulic modeling results and observations of existing sediment sizes and geomorphic conditions.

Two bed load transport rate equations were used to develop bed load rating curves (discharge or flow rate vs. bed load transport rate) at each of the pebble count locations. The equations used included the surface-based bed load equation of Parker (1990) and surface-based relation of Wilcock and Crowe (2003)[12]. Data necessary to support these computations included: a)

[12] The reader is directed to Parker (1990) and Wilcock-Crowe (2003) for a full presentation and discussion of the derivation and application of these bed load transport equations.

surveyed channel cross-sections; b) reach-average slope of bed elevations; c) estimated discharge rates over the range of expected values bracketing the 2- and 100-year peak flows at each location; and d) the grain-size distribution derived from pebble counts of bed sediment. For all computations, a Manning's bed roughness coefficient (n) of 0.035 was used based on field observations and professional judgment. The variables of mean flow velocity and hydraulic radius were derived using HEC-RAS cross-section and flow estimates at selected water depth intervals.

Results of the transport model indicate that the 2-yr flow nearly fills the entire bank-full channel area and flows in excess of the 5-year event begin to overtop banks – results consistent with those of hydraulic modeling. The sediment transport analysis indicates that no significant transport of the coarse material measured at each pebble count location is expected to occur at the lower (2- to 10-year) design flows. These results also suggest that it takes a storm magnitude at or above the 10-year peak flow to mobilize coarse bed material. Taken in concert with the results of hydraulic modeling and grain-size analysis, study findings indicate that at these higher flows, fine grained material (smaller than fine gravel) is transported through the system leaving the coarser (larger than fine gravel) material in the reach. These results reflect pebble counts from KHE selected sample locations (gravel bars) containing the largest grain-size material. Characterization of the average grain-size distribution upstream of the project reach is recommended to improve sediment transport capacity estimates as part of final project design.

3 Existing Conditions: Biological Resources

KHE, Avocet Research Associates and Demgen Aquatic Biology completed an assessment of existing site conditions to document the biological conditions in the project area. Information presented in the assessment is based on both project monitoring conducted between 2013 and 2015, and prior observations both on site and in the San Pablo Bay area. The information presented establishes a baseline from which the environmental response to proposed restoration actions will be evaluated. In addition, we evaluate future conditions and the anticipated impacts associated with sea level rise. The assessment approach included:

- Review and synthesis of existing information (All)
  Field reconnaissance and preliminary restoration approach development (All)
- Field observation and mapping of vegetation communities and characteristics (KHE/Demgen Aquatic Biology (KHE/DAB))
- Field monitoring and assessment of wildlife communities and characteristics (Avocet Research and Associates (ARA))
- Fisheries habitat evaluation (M. Carbiener, Fisheries Biologist (MCB)
- Evaluation of future conditions with sea level rise (KHE/ARA/BP)

McInnis Marsh is part of the Gallinas Bayland wetland complex which supports a diverse population of wetland species, including 30 state and/or federally listed special status (Threatened or Endangered) species. Table 3-1 summarizes special status species known or expected to occur in the Gallinas Baylands. Enhancement of ecological values at McInnis Marsh is anticipated to improve habitat for these species, and in turn their likelihood of persistence. As land owners and stewards of McInnis Marsh, Marin County Parks is committed to maintaining and protecting these lands and in turn the rare plants animals they support. Restoration of McInnis Marsh is a valuable opportunity to improve and expand wetland habitat deemed critical for species survival (USFWS, 2009).

Table 3-1: special status species known or expected to occur in the Gallinas Baylands

Source[13]	Occurrence[14]	Common Name	Latin Name	Federal ESA Status	State ESA Status	CDFW Status[15]
CNDDB	N	Ubick's gnaphosid spider	*Talanites ubicki*	None	None	-
CNDDB	N	Marin blind harvestman	*Calicina diminua*	None	None	-
CNDDB	P	California brackishwater snail	*Tryonia imitator*	None	None	-
CNDDB	N	Marin hesperian	*Vespericola marinensis*	None	None	-
CNDDB	P	Opler's Longhorn Moth	*Adela oplerello*	None	None	-
CNNDB	N	Tidewater Goby	*Eucyclogobius newberryi*	Endangered	None	SSC
CNDDB	N	Longfin Smelt	*Spirinchus tholeichthys*	Candidate	Threatened	SSC
CNDDB	Y	Foothill yellow-legged frog	*Rana boylii*	None	None	SSC
CNDDB	N	California red-legged frog	*Rana draytonii*	Threatened	None	SSC
CNDDB	P	Western pond turtle	*Emys (=Actinemys) marmorata*	None	None	SSC
CNDDB	Y	White-tailed Kite	*Elanus leucurus*	None	None	FP
NBB	P	American Bittern	*Botaurus lentiginosus*			

[13] 1) CNDDB: California Natural Diversity Database; 2) NBB: North Bay Birds listserve; 3) IUCN: International Union for Conservation of Nature; 4) Pers. Obs.: Personal Observation

[14] 1) N: Not Likely to Occur; 2) P: Potentially Occurring; 3) Y: Yes, Known to Occur

[15] 1) CBSSC-1, 2, and 3: California Bird Species of Special Concern Priority 1, 2 and 3; 2) SCC: Species of Special Concern; 3) FP: Federally Protected

Source[13]	Occurrence[14]	Common Name	Latin Name	Federal ESA Status	State ESA Status	CDFW Status[15]
NBB	P	Least Bittern	*Ixobrychus exilis*			CBSSC-2
CNDDB	Y	Great Blue Heron	Ardea herodias	None	None	-
CNDDB	P	California Black Rail	*Laterallus jamaicensis coturniculus*	None	Threatened	FP
CNDDB	P	California Ridgway's Rail	Rallus obsoletus obsoletus	Endangered	Endangered	FP
CNDDB	N	Western Snowy Plover	*Charadrius alexandrinus nivosus*	Threatened	None	SSC
NBB	Y	Northern Harrier	*Circus cyaneus*	None	None	CBSSC-3
NBB	Y	Long-eared Owl	*Asia otus*	None	None	CBSSC-3
CNDDB	N	Short-eared Owl	*Asia flammeus*	None	None	CBSSC-3
CNDDB	P	Burrowing Owl	*Athene cunicularia*	None	None	CBSSC-2
CNDDB	N	Northern Spotted Owl	*Strix occidentalis caurina*	Threatened	Candidate Threatened	SSC
NBB	Y	Vaux's Swift	*Chaeturo vauxi*	None	None	CBSSC-2
NBB	Y	Yellow Warbler	*Setophaga petechia*	None	None	CBSSC-2
CNDDB	Y	Saltmarsh Common Yellowthroat	*Geothypis trichas sinuosa*	None	None	SCC
NBS	P	Yellow-breasted Chat	*Icteria Virens*	None	None	CBSSC-3
Pers. Obs.	Y	“Bryant’s” Savannah Sparrow	*Passeculus sandwichensis alaudinus*	None	None	CBSSC-3
CNDDB	Y	“San Pablo” Song Sparrow	*Melospiza melodia samuelis*	None	None	CBSSC-3
NBB	P	Tricolor Blackbird	*Agelaius tricolor*	None	None	CBSSC-1
CNDDB	P	Salt-marsh harvest mouse	*Reithrodontomys raviventris*	Endangered	Endangered	FP
CNDDB	N	Pallid Bat	*Antozous pallidus*	None	None	SCC
CNDDB	N	Townsend’s Big Ear Bat	*Corynorhinus townsendii*	None	Candidate Threatened	SSC
IUCN	Y	River Otter	*Lontra Canadensis*	None	None	-
Pers. Obs.	Y	Coyote	*Canis Latrans*	None	None	-
CNNDB	Y	Coastal Brackish Marsh				-
CNNDB	Y	Northern Coastal Salt Marsh				-

3.1 McInnis Marsh Wetland Vegetation and Communities

3.1.1 Introduction

A vegetation survey was conducted in the McInnis Marsh Restoration Project Site to 1) identify existing, dominant vegetation species and communities, including non-native invasive plants; 2) determine the potential for rare plants; and 3) to understand the physical factors influencing current vegetation and potential for change within the project site. The survey also characterized conditions in the adjacent un-diked tidal marshlands to the south and east of the site. The project site is comprised predominantly of subsided diked baylands consisting of seasonal brackish marsh, emergent brackish to freshwater marsh, and upland habitats. The vegetation survey identified marsh plant communities on the project site, such as perennial pickleweed (*Salicornia pacifica*), alkali bulrush (*Bolboschoenus maritimus*), and cattail (*Typha latifolia*) that occupy historical tidal channel depressions or swales. Invasive weedy species such as perennial pepperweed (*Lepidium latifolium*), prickly lettuce (*Lactuca serriola*), and yellow starthistle (*Centaurea solstitialis*) have colonized the higher ground adjacent to swales and along levee tops. Other upland plant communities include coyote brush (*Baccharis pilularis*), annual grasslands, and ruderal vegetation.

Factors such as elevation, seasonal ponding of rainwater, groundwater, tidal exchange, drainage efficacy, and soil salinities affect the type of wetland vegetation currently present and its ecological functioning. Disturbance at the project site from levee construction and draining, disposal of dredged materials, and levee maintenance has resulted in significant invasion by non-native plant species, reducing native species diversity. These factors contribute to the unstable nature of plant community composition in the diked wetlands of the site.

The McInnis Marsh Project Site is a former tidal marsh which has been isolated for many years from tidal action. In a process known as subsidence, soil oxidation of marsh peats and drying and shrinking of clays has led to consolidation and a 3-4 ft. reduction in surface elevation in many areas. Currently, much of the project site is below mean sea level and adjacent intertidal marsh elevations (See Section 2.4.5). Both differential subsidence of the relict marsh plain and excavated drainage channels have created topographic variability visible as depressions and sinuous swales visible in the current topography and modern aerial photography of the project site.

Due to the influence of periodic tidal inundation, much of the project site exhibits periods of saline and hypersaline conditions. Winter rains reduce salinities in surface waters and the upper levels of the soil through percolation and dilution. Summer evaporation brings the trapped salts to the surface, inhibiting vegetation growth. The balance between rainfall and evaporative losses is also affected by yearly weather variability, which leads to inter-annual differences in soil and water salinity. The result is a mosaic of vegetation on the project site exhibiting three levels of salt tolerance: relatively salt-sensitive weedy, annual species, patches of halophytic pickleweed, and expanses of alkali flat with either hyper-salinity tolerant alkali Russian thistle (Salsola soda) or no vegetation at all. The plant community compositions are not discrete, but merge continuously and vary significantly over time.

3.1.2 Methods

3.1.2.1 Field Surveys

On July 15 and July 17, 2014, KHE associated biology consultant Patrick Furtado conducted a biological assessment and mapping of existing vegetation on the project site, including adjacent tidal salt marsh and a section of Miller Creek on the site's northern border. Although no focused rare plant surveys were conducted as part of this analysis, the potential for the site to support special-status plant species was assessed. The reconnaissance-level survey of the site included both the walking of all levee top trails and traversing of all wetland, salt pan, and upland areas. The delineations of plant communities were accomplished, whenever feasible, by walking the vegetation perimeters using a handheld GPS device. Other methods of delineation included assessing vegetation boundaries from levee tops and from the Geographical Information System (GIS) analysis described below. Table 3-2 lists all plant species observed during the field surveys.

3.1.2.2 Literature Review and Geographical Information System Analysis

Available reports of biological resources on and in the vicinity of the project site were reviewed to identify existing types, amounts, and distribution of habitats and vegetation (see References below). Special-status species databases were also utilized to identify plant species potentially occurring on the project site (see Special-status Plant Species below). GIS data on the project site and vicinity were obtained from various sources including the United States Geological Survey, Marin County, and the San Francisco Estuary Institute. Before visiting the site, a

preliminary GIS vegetation classification and preliminary evaluation was conducted via analysis of vegetation spectral signatures from high-resolution satellite imagery of McInnis Marsh.

3.1.3 Wetland Vegetation Mapping

KHE mapped and calculated areas associated with identified dominant vegetation species and communities identified in and adjacent to the McInnis Marsh restoration site (July of 2014). Area calculations for habitat zones for each delineated habitat type and the percentage of the total marsh area are presented in Table 3-3. The mapping extent includes the McInnis Marsh wetlands inboard of the perimeter levees, upland communities on the perimeter levees and the upland transitional zone adjacent to McInnis Marsh Golf Course (see Figure 3-1). A description of the wetland communities found on site is provided in Section 3.1.4. Based on mapping and field observation:

Wetland Communities:

- Pickleweed and alkali Russian Thistle are the dominant habitat types within the wetland communities at 32% and 29% of the total project area, respectively.
- Prickly Lettuce occupy 18% of the wetland communities.

Upland Communities:

- Ruderal/Grassland dominate the upland communities over Coyotebrush at 9% and 3% of the total project area, respectively.

Table 3-2: McInnis Marsh Plant Species, Marin County, California

Scientific Name	Common Name	USACE Rating	Cal-IPC Rating
Family: Aizoaceae			
Sesuvium verrucosum	western sea purslane	FACW	
Carpobrotus edulis	iceplant	FACU	High
Family: Apiaceae			
Foeniculum vulgare	fennel		High
Family: Arecaceae			
Phoenix canariensis	Canary Island date palm		Limited
Family: Asteraceae			
Baccharis pilularis	coyote brush		
Centaurea solstitialis	yellow starthistle		High
Cirsium vulgare	bull thistle	FACU	Moderate
Cotula coronopifolia	brass buttons	OBL	Limited
Grindelia stricta	yellow-flowered gumplant	FACW	
Helminthotheca echioides	bristly ox-tongue	FACU	Limited

Scientific Name	Common Name	USACE Rating	Cal-IPC Rating
Iva axillaris	poverty weed	FAC	
Jaumea carnosa	marsh jaumea	OBL	
Lactuca serriola	prickly lettuce	FACU	
Pseudognaphalium stramineum	cottonbatting plant	FAC	
Sonchus asper	spiny sowthistle	FAC	
Family: Brassicaceae			
Lepidium latifolium	perennial pepperweed	FAC	High
Raphanus sativus	wild radish		Limited
Family: Chenopodiaceae			
Atriplex prostrata	fat-hen	FACW	
Salicornia pacifica	Pacific pickleweed	OBL	
Salsola soda	alkali Russian thistle	FACW	Moderate
Family: Convolvulaceae			
Convolvulus arvensis	field bindweed		
Cuscuta salina	saltmarsh dodder		
Family: Cyperaceae			
Bolboschoenus maritimus	alkali bulrush	OBL	
Family: Fabaceae			
Acacia dealbata	silver wattle		Moderate
Acacia melanoxylon	blackwood acacia		Limited
Lotus corniculatus	bird's foot trefoil	FAC	
Family: Frankeniaceae			
Frankenia salina	alkali heath	FACW	
Family: Plumbaginaceae			
Limonium californicum	western marsh rosemary	FACW	
Family: Poaceae			
Avena spp.	wild oats		Moderate
Bromus diandrus	ripgut brome		Moderate
Cortaderia jubata	pampas grass	FACU	High
Distichlis spicata	salt grass	FAC	

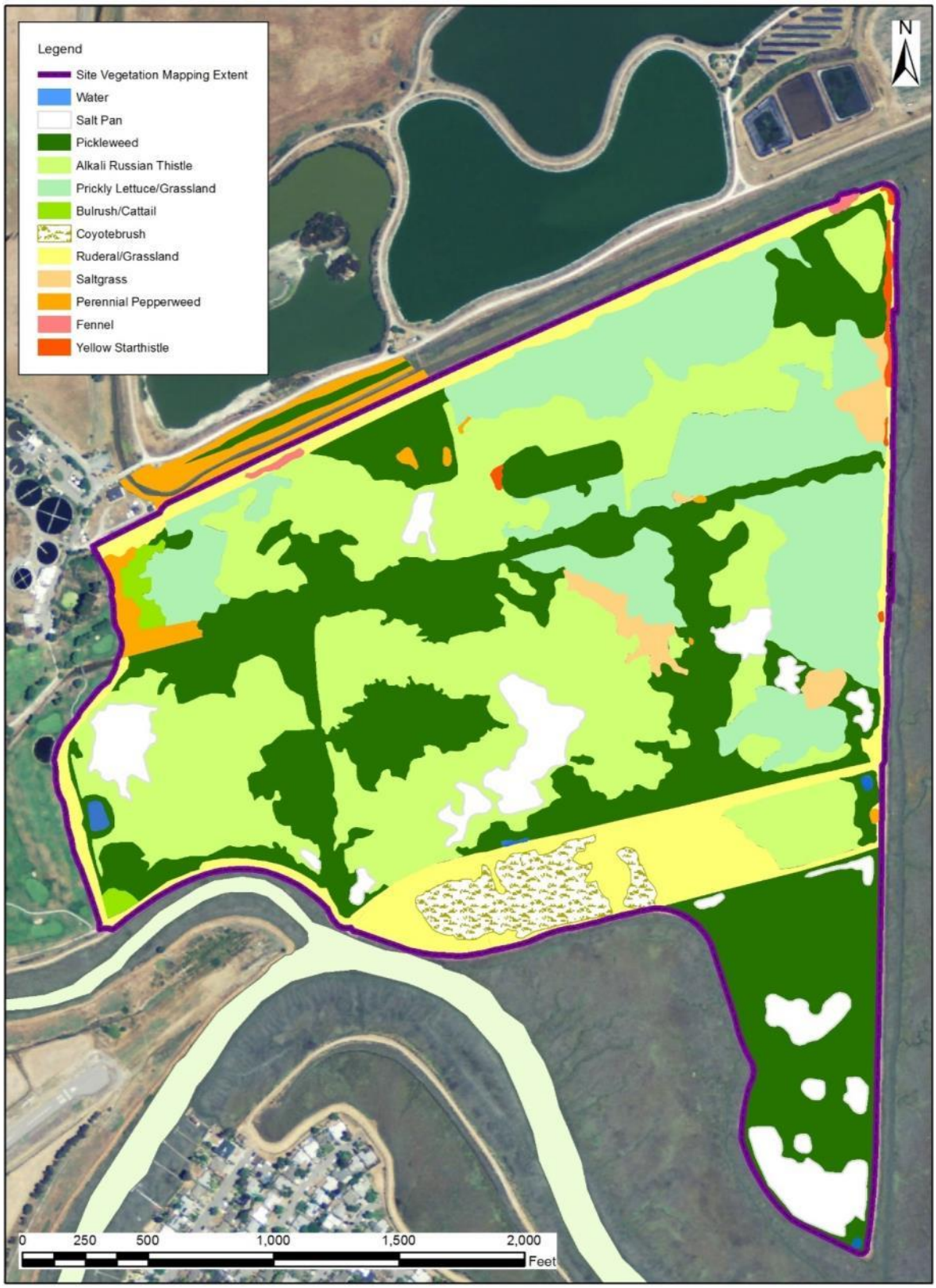
Scientific Name	Common Name	USACE Rating	Cal-IPC Rating
Festuca perennis	Italian rye grass	FAC	Moderate
Hordeum marinum	seaside barley	FAC	Moderate
Phalaris aquatic	Harding grass	FACU	Moderate
Polypogon monspeliensis	rabbitsfoot grass	FACW	Limited
Spartina foliosa	Pacific cordgrass	OBL	
Family: Polygonaceae			
Polygonum aviculare	prostrate knotweed	FACW	
Rumex crispus	curly dock	FAC	Limited
Family: Rosaceae			
Rubus armeniacus	Himalayan blackberry	FACU	High
Family: Typhaceae			
Typha latifolia	broadleaf cattail	OBL	

Table 3-3: Habitat area calculation for McInnis Marsh vegetation mapping (Furtado, 2014)

Habitat Type	Habitat Area (Acres)**	Habitat Area as a Percentage of McInnis Marsh Area
Salt Pan	10.2	5.5%
Pickleweed	59.7	32.4%
Alkali Russian Thistle	53.2	28.9%
Prickly Lettuce/ Grassland	32.8	17.8%
Bulrush/Cattail	0.96	0.5%
Coyotebrush	4.70	2.6%
Ruderal/Grassland	17.2	9.3%
Saltgrass	2.70	1.4%
Perennial Pepperwood*	1.70	0.9%
Fennel*	0.30	0.2%
Yellow Starthistle*	0.57	0.3%
Water	0.32	0.2%

*Invasive Species
** McInnis Marsh Area (acres) = 184.4 ac

Figure 3-1: McInnis Marsh restoration site vegetation and plant communities (Furtado, 2014).



3.1.4 Wetland Communities

3.1.4.1 Brackish Marsh

The predominant wetland type on the McInnis Marsh Project Site is non-tidal brackish marsh. Most of the low elevation areas enclosed within the site's levees meet this characterization. On the project site, brackish marshes have developed from a mixture of occasional tidal saltwater inputs and seasonal freshwater inputs from winter rains. Brackish marsh vegetation at the site is generally a dynamic continuum between the salt marsh vegetation of San Pablo Bay and freshwater tidal marsh vegetation of nearby creeks and rivers[16]. Plant community composition varies with seasonal and annual tidal inundation and rainfall amounts and, as a result, is never fully stable. Dominant plant species include perennial pickleweed, salt grass, and fat-hen (*Atriplex prostrata*). These species co-exist with non-native species with lower tolerances for salinity, such as rabbitsfoot grass (*Polypogon monspeliensis*) and Italian rye grass (*Festuca perennis*). Other brackish marsh species on the project site associated with pickleweed include brass buttons (*Cotula coronopifolia*) and poverty weed (*Iva axillaris*). Much rarer is the orangish, leafless annual shoot-parasite of pickleweed, saltmarsh dodder (*Cuscuta salina*) (Figure 3-2).

Over large areas of the project site (Figure 3-1), the wetland obligate perennial pickleweed is co-dominant with the wetland facultative alkali Russian thistle. Monotypic stands of these two species gradually merge into each other with one or the other often becoming dominant. In the southernmost peninsular section of the project site, frequent inundation by tidal action maintains a pure stand of tall, dense pickleweed. Alkali Russian thistle is not adapted to the regular tidal flooding and is excluded here.

Figure 3-2: Perennial pickleweed (*Salicornia pacifica*) and the tangled, orange parasitic nets of salt marsh dodder (*Cuscuta salina*)

[16] The differentiation between brackish and salt marsh plant communities is difficult as there is no specific salinity threshold where one type changes to another.

3.1.4.2 Emergent Brackish to Freshwater Marsh

Emergent marsh is a shallow-water wetland with seasonably variable water levels found in several locations throughout the project site (Figure 3-1). The plant species that can grow under continuous inundation are characterized by spongy (aerenchyma) tissue that allows oxygen transport to roots. The dominant emergent wetland plant species on the project site are alkali bulrush (*Bolboschoenus maritimus*) and broadleaf cattail (*Typha latifolia*) (see map unit "Bulrush/Cattail," Figure 3-1). Alkali bulrush, in association with pickleweed, grows in swales under periodic tidal flooding adjacent to Miller Creek. In a wet depression in the northwest corner of the project site, alkali bulrush is found growing with halophytes alkali Russian thistle, poverty weed (*Iva axillaris*), and fat-hen (*Atriplex prostrata*). It is also found in association with broadleaf cattail in a freshwater pond in the southwest corner of the site, adjacent to the golf course. It is outcompeted here by cattail (Figure 3-3).

3.1.4.3 Saltpans and Hypersaline Vegetation

Figure 3-3: Salt pan with alkali Russian thistle (*Salsola soda*)

Topographic depressions and seasonal fluctuations between winter flooding and summer evaporation lead to hypersaline saltpans devoid of vegetation, or where only the most salt-tolerant species can persist (Figure 3-3). Salt pans on the project site are generally encircled by monotypic stands of the invasive halophyte alkali Russian thistle with occasional patches of halophytic western sea purlane (Sesuvium verrucosum), a recent invader native to the Great Basin (Figure 3-1). In aerial imagery from April 2011, alkali Russian thistle is much less extensive than currently mapped (Figure 3-1). Large alkali pans, devoid of vegetation then, are now nearly wholly covered with the halophyte, demonstrating the dynamic nature of vegetation at the project site. Salt pan ponds with submerged wigeongrass (Ruppia maritima) may be present under wetter conditions but were not observed during July 2014 surveys.

3.1.4.4 Tidal Marsh

An intact tidal salt marsh vegetation community borders the project site on the south and east (Figure 3-1). From the project site's easternmost levee, the marsh plain extends east for a half

mile to the bay and is covered by the succulent, branching stems of perennial pickleweed. Also known as Pacific swampfire or Pacific pickleweed, the wetland obligate dominates the salt marsh flats of San Pablo Bay. The pickleweed marsh plain is cut by man-made drainage ditches as well as naturally formed, more sinuous tidal channels. The low marsh fringing the tidal channels is dominated by Pacific cordgrass (Spartina foliosa). Cordgrass can tolerate relatively long periods of inundation and occupies the lower intertidal elevations within the channels. Natural deposition has raised the marsh plain adjacent to the tidal channels. These depositional features support linear strands of yellow-flowered gumplant (Grindelia stricta) which can be conspicuously seen winding across the pickleweed plain (Figure 3-4).

Closer to the marsh's landward edge and alongside the project site's levees, a man-made ditch drains the marshlands. The slightly-elevated and better drained soils here support a transitional marsh-to-upland habitat of perennial, halophytic high marsh forbs including gumplant, western marsh rosemary (Limonium californicum), salt grass (Distichlis spicata), alkali heath (Frankenia salina), and marsh jaumea (Jaumea carnosa). This transitional vegetation provides important high-tide refugia from predators for the special-status salt marsh species California clapper rail and salt marsh harvest mouse.

Figure 3-4: Tidal salt marsh looking southeast from levee towards China Camp State Park. Alkali heath (Frankenia salina) is in foreground and borders the perennial pickleweed (Salicornia pacifica) marsh plain. The tidal creek channel is lined with Pacific cordgrass

3.1.5 Upland Communities

3.1.5.1 Ruderal/Grassland Vegetation

A narrow band of degraded salt marsh–upland transitional habitat is found on perimeter levees. Due to subsidence and the need to maintain levee crest elevations through periodic additions of dredged mud, the project site's levees and diked wetlands are under a continual cycle of disturbance. This disturbance cycle has favored ruderal vegetation communities on levee tops and slopes, including many invasive, non-native species such as wild oats (*Avena* spp.), wild radish (*Raphanus sativus*), prostrate knotweed (*Polygonum aviculare*), fennel (*Foeniculum vulgare*), curly dock (*Rumex crispus*), yellow starthistle, bristly ox-tongue (*Helminthotheca*

echioides), and spiny sowthistle (*Sonchus asper*) (Figure 3-5). The network of dikes provides corridors for a weedy flora to disperse throughout tidal and diked marshes. It also provides an elevated platform for easy dispersal into adjacent wetlands. Perennial pepperweed, in particular, is found on many levee tops throughout the project site, facilitating its invasion of brackish marshes.

Relatively salt-sensitive invasives are found on more slightly elevated locations within the wetlands. One widespread seasonally wet grassland community (Figure 3-1) consists of prickly lettuce, seaside barley (*Hordeum marinum*), and Italian rye grass (*Festuca perennis*), with intermittent monotypic patches of salt grass (*Distichlis spicata*), brass buttons (*Cotula coronopifolia*), and rabbitsfoot grass (*Polypogon monspeliensis*).

Figure 3-5: Ruderal vegetation in heavily disturbed area adjacent to water treatment plant: perennial pepperweed (*Lepidium latifolium*), yellow starthistle (*Centaurea solstitialis*), fennel (*Foeniculum vulgare*), and non-native annual grasses.

3.1.5.2 Coyote Brush

In a southern section of the project site, coyote brush (*Baccharis pilularis*) has been rapidly colonizing an upland area (Figure 3-1). Dikes and upland transitional areas that are infrequently maintained can often become dominated by dense stands of coyote brush, a pioneer species that invades and increases in the absence of fire, grazing, or clearing. Aerial imagery from 2011 show that coyote brush in this area has increased its extent by as much as ten-fold in just a little over three years. Associated with coyote brush is a mixture of weedy annual grassland species including ripgut brome (*Bromus diandrus*), bull thistle (*Cirsium vulgare*), wild oats, spiny sowthistle, bristly ox-tongue, and prickly lettuce (Figure 3-6).

Figure 3-6: Coyote brush (*Baccharis pilularis*) rapidly colonizing an upland area of dredged materials in a southern section of the project site.

3.1.6 Invasive Plant Species

3.1.6.1 General Description

Non-native invasive plants have a competitive advantage over natives because they are no longer controlled by their natural predators and can quickly spread out of control. They often grow in dense monocultures, altering the composition and structure of native plant communities by excluding or preventing the reestablishment of native plant species. Many invasives also significantly affect ecosystem processes such as hydrology, fire regimes, and soil chemistry.

The California Invasive Plant Council (Cal-IPC) maintains the California Invasive Plant Inventory, which categorizes non-native invasive plants that threaten the state's wildlands. The Inventory categorizes plants as High, Moderate, or Limited based on the level of each species' negative ecological impact. Six invasive plant species ranked High by Cal-IPC are found on the McInnis Marsh Project Site: perennial pepperweed, yellow starthistle, fennel (*Foeniculum vulgare*), iceplant (*Carpobrotus edulis*), pampas grass (*Cortaderia jubata*), and Himalayan blackberry (*Rubus armeniacus*). These species are notable because they have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes contribute to high rates of dispersal and establishment[17].

The following sections provide further detail on three of the most highly invasive and established species on the project site.

[17] The prevention of colonization by invasive plant species is usually a highly significant constraint encountered in salt marsh restoration design. In their *Design Guidelines For Tidal Wetland Restoration In San Francisco Bay*, The Bay Institute and Coastal Conservancy recommend that "[E]xisting invasive vegetation should be removed from a restoration site prior to dike breaching."

3.1.6.2 Perennial Pepperweed

Perennial pepperweed is found in patches of different sizes throughout the project site (Figure 3-7), growing within the wetlands and along levee banks. It is most prevalent in the northwest corner of the site adjacent to the water treatment plant and on both banks of Miller Creek bordering the project site (Figure 3-1).

Perennial pepperweed (*Lepidium latifolium*) is a highly invasive perennial herb (family *Brassicaceae*) found in moist or seasonally wet sites throughout California. It is adapted to conditions of moderate salinity, but is not an obligate halophyte. Deep-seated rootstocks make this weed difficult to control.

Surveys of perennial pepperweed in San Pablo Bay have found it present at most tidal restoration sites in the bay. It is a non-native plant of greatest concern in the estuary due to its ability to form near monocultures and exclude the native vegetation required by tidal marsh-dependent species. Active restoration areas are at an even greater risk of invasion than adjacent intact wetlands as perennial pepperweed recruitment is accelerated by disturbance.

Figure 3-7: Perennial pepperweed (*Lepidium latifolium*) growing in a large monoculture near the water treatment plant.

3.1.6.3 Yellow Starthistle

Though not as abundant as perennial pepperweed on the project site, yellow starthistle (*Centaurea solstitialis*) is also a highly invasive non-native plant (family Asteraceae) of concern due to its ability to propagate rapidly by seed. During the 2014 monitoring, it was found growing on higher ground within the project wetlands. It is more prevalent in disturbed areas near the water treatment plant and alongside levee trails (Figure 3-1). This invasive annual is typically 2 to 3 feet tall, and a large plant can produce nearly 75,000 seeds. Flower heads are yellow and armed with thorns up to 3/4 inch long.

3.1.6.4 Fennel

Another highly invasive non-native plant found growing on levee tops throughout the project site (Figure 3-1) is fennel (*Foeniculum vulgare*). Fennel (family *Apiaceae*) is a tall, erect perennial herb that often colonizes disturbed moist soil adjacent to fresh or brackish water. It reproduces from both root crown and seed.

3.1.6.5 Special-Status Plant Species

Database searches for possible special-status plant species on the McInnis Marsh Project Site included:

- California Native Plant Society's Online Inventory of Rare and Endangered Plants (8th Edition)
- California Department of Fish and Wildlife's California Natural Diversity Database
- Sacramento U.S. Fish and Wildlife Office's Online List of Threatened and Endangered Species

Database searches for known occurrences of special-status species focused on the Novato and Petaluma Point 7.5 minute USGS quadrangles. Table 2 lists 16 special-status vascular plant species that were evaluated for their potential to occur on the project site. Four species potentially have habitat within the project site: johnny-nip (*Castilleja ambigua* ssp. *ambigua*), northern ("Point Reyes") salt marsh bird's-beak (*Chloropyron maritimum* ssp. *palustre*), white seaside tarplant (*Hemizonia congesta* ssp. *congesta*), and Marin knotweed (*Polygonum marinense*). None of these four species were observed during surveys of the project site conducted on July 15 and July 17, 2014. This is not unexpected, as these species are generally found only in undisturbed and ecologically intact habitat, which is not present on the project site. A population of northern salt marsh bird's-beak does occur to the south of the project site at Buck's Landing at the mouth of Gallinas Creek.

3.2 Miller Creek Corridor Ecology and Plant Communities

This report section is a summary of information presented in LGVSD's Lower Miller Creek Flood and Channel Maintenance study (KHE, 2014).

3.2.1 Miller Creek Corridor Ecology

The adjacent reach of Miller Creek extends for approximately one mile from San Pablo Bay mudflat to the SMART Bridget. Ecotones within the reach transition from a fully tidal slough with adjacent salt marsh in reaches parallel to McInnis Marsh, to a creek dominated alluvial channel flanked by a wooded riparian corridor upstream of the SMART Bridge. The information presented here-in is based on field data collected during field visits on March 26, 2013, and September 16-17, 2013.

The project area reach was characterized in seven representative locations based on physical similarities and differences. Six stations were located in the channel, and one in the fallow agricultural area east of channel. Ecological characteristics (channel dimensions, creek salinity/temperature and dominant vegetation) for the observation stations are summarized in Table 3-4. Field observations are indicative of a moment in time at each station in this intertidal reach. For example, water depth is dependent on twice daily tides at the first three stations, however, likely only spring tides reach the upstream-most station.

Table 3-4: Summary of ecological monitoring results.

Station	Dimensions	Near Surface salinity	Water temp	Dominant vegetation
47+50	Marsh plain 61 ft Open channel 25 ft 2 ft deep @ edge	29 ppt	Not measured (Incoming)	SAVI, LELA, ATTR, GRST
47+50+X	Marsh plain 70 ft	30 ppt	22^{o}C	SAVI, LELA, SCRO, PHAQ, GRST
63+00 to 70+00	Marsh plain <10 ft 1.5 ft deep	30 ppt	23 ^{o}C outgoing	SAVI, SCRO, SPX
87+00	Not applicable (NA)	No surface water	NA	AVFA, HOMA, LOPE, CEPU
90+00	Channel 21 ft wide Pool 4= 3.4 ft deep	36 ppt	25^{o}C	First willow on bank SAVI, DISP toe of slope
95+00	Channel wetted width 24 ft 0.8 ft deep	39 ppt	23 ^{o}C	SASP, LELA, CAPY, BAPI
CSX5540	4 ft wetted width 13.5 ft gravel bar 5.5 ft wetted width	42 ppt	Not measured	Tree = ALRH, FRLA Understory = DIFU,RUUR, POMO, CYER

The vegetation communities along lower Miller Creek are distinguished from one another by elevation/position in the channel cross section and distance on the longitudinal channel profile from the tidal source - San Pablo Bay. Aquatic plants occupy the lowest elevation position in the channel at each section. For example, saline tolerant, high marsh species pickleweed (Salicornia virginica) and salt grass (Distichlis spicata) grow in the downstream three-quarters of the longitudinal profile. Ruderal, non-native grasses (many invasive) and forbs occupy the constructed levee crest at the highest elevation position. Below the dry crest, native willow and alder trees grow closer to the channel's edge.

The physical and chemical properties associated with tidal action are the primary factors determining the biotic community inhabitants. The Bay is saltiest in fall prior to the onset of winter rains and 2012-2013 was a drought year. Both factors contribute to the site data collected representing the saline end of annual temporal variability. Dissolved salt concentrations in the water also exhibit spatial variation, increasing along the length of the reach from 29 parts per thousand (ppt) at the downstream end to 42 ppt at the upstream-most station. Hypersaline concentrations (> 32-35 ppt) occur in upstream isolated pools due to evaporation. Salts in the channel, replenished by tidal and evaporative processes, restrict vegetation recruitment to saline tolerant species in the channel and at the toe of the bank upstream to Station ECSX4500.

3.2.1.1 Miller Creek Vegetation

During site visits, seventy five species of plants were identified. Plants observed within the project area are listed in Appendix B. Plants are listed alphabetically and categorized based on several variables, including: native, non-native and invasive; growth form; and Army Corps

Indicator status. No particularly rare plants were observed, likely due to heavy disturbance of the surrounding area from cattle.

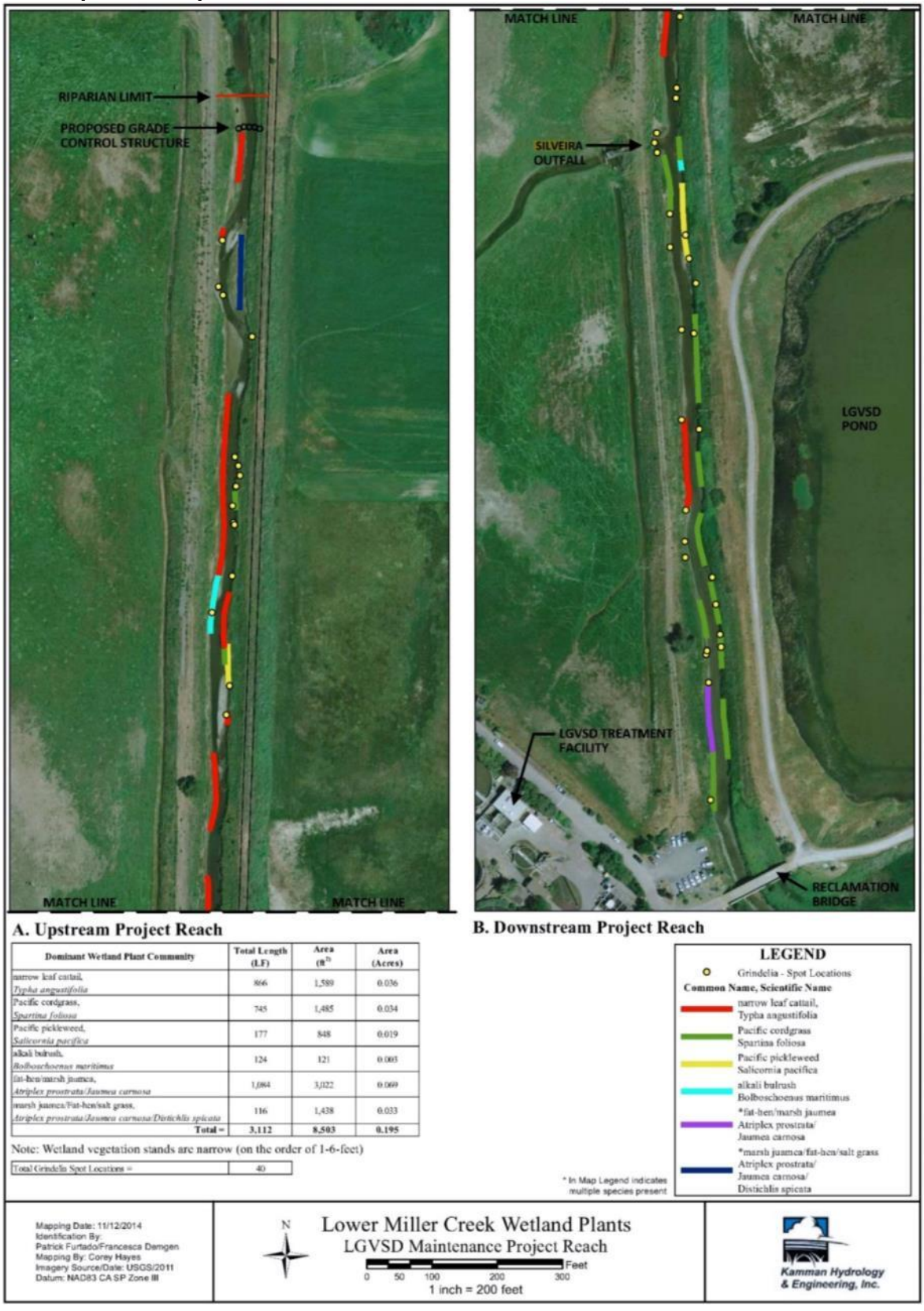
3.2.1.2 Miller Creek Special Status Plant Species

Based on review of available sensitive species lists from local area studies (CDFW's California Natural Diversity Database (CNDDB), 2014; Marin County Department of Public Works, 2014; and LSA, 2001), sensitive species that potentially reside at the site are listed in Table 3-5. It's important to note that the high salinity and hypersaline pools develop in the channel between periods of extreme tidal flooding. The elevated salinity concentrations likely preclude breeding and rearing of California red-legged frog (CRLF) and California tiger salamander. Surveys completed in 2001 for CRLF in Miller Creek and the adjacent St. Vincent's property did not encounter any CRLF (LSA, 2001).

3.2.1.3 Miller Creek Jurisdictional Wetlands

No wetland delineation was completed as part of this project. However, based on site reconnaissance and ecosystem characterization, it is likely that all of the site falling below and elevation of 7-feet could likely be designated as wetland. This leaves the upper portion of levees as the main non-wetland (upland) areas.

Figure 3-8: Lower Miller Creek Wetland Plant Identification – LGVSD Maintenance Project Reach (KHE, 2013)



Dominant Wetland Plant Community	Total Length (LF)	Area (ft²)	Area (Acres)
narrow leaf cattail, *Typha angustifolia*	866	1,589	0.036
Pacific cordgrass, *Spartina foliosa*	745	1,485	0.034
Pacific pickleweed, *Salicornia pacifica*	177	848	0.019
alkali bulrush, *Bolboschoenus maritimus*	124	121	0.003
fat-hen/marsh jaumea, *Atriplex prostrata/Jaumea carnosa*	1,084	3,022	0.069
marsh jaumea/Fat-hen/salt grass, *Atriplex prostrata/Jaumea carnosa/Distichlis spicata*	116	1,438	0.033
Total =	**3,112**	**8,503**	**0.195**

Note: Wetland vegetation stands are narrow (on the order of 1-6-feet)

Total Grindelia Spot Locations =	40

Table 3-5: Sensitive species potentially residing in Lower Miller Creek

Latin name	Common Name	Federal Status	State Status
Rana boylii	foothill yellow-legged frog	None	None
Rana draytonii	California red-legged frog		
Emys marmorata	western pond turtle		
Ardea herodias	great blue heron		
Asio flammeus	short-eared owl		
Athene cunicularia	burrowing owl		
Charadrius alexandrinus nivosus	western snowy plover	Threatened	
Circus cyaneus	northern harrier		
Elanus leucurus	white-tailed kite		
Eremophila alpestris actia	California horned lark		
Falco columbarius	merlin		
Geothlypis trichas sinuosa	saltmarsh common yellowthroat		
Laterallus jamaicensis coturniculus	California black rail		Threatened
Melospiza melodia maxillaris	Suisun song sparrow		
Melospiza melodia pusillula	Alameda song sparrow		
Melospiza melodia samuelis	San Pablo song sparrow		
Rallus longirostris levipes	light-footed clapper rail	Endangered	Endangered
Rallus longirostris obsoletus	California clapper rail	Endangered	Endangered
Strix occidentalis caurina	northern spotted owl	Threatened	Candidate Threatened
Nycticorax	Black-crowned night-heron		
Egretta thula	snowy egret		
Ardea alba	great egret		
Oncorhynchus mykiss irideus	steelhead - central California coast DPS	Threatened	
Oncorhynchus tshawytscha	chinook salmon - Central Valley spring-run ESU	Threatened	Threatened
Oncorhynchus tshawytscha	chinook salmon - Central Valley fall / late fall-run ESU		

Latin name	Common Name	Federal Status	State Status
Pogonichthys macrolepidotus	Sacramento splittail		
Spirinchus thaleichthys	longfin smelt	Candidate	Threatened
Hesperoleucus symmetricus	California Roach		
Gasterosteus aculeatus	threepine stickleback		
Leptocottus armatus	staghorn sculpin		
Cottus asper	prickly sculpin		
Cottus gulosus	riffle sculpin		
Cyprinus carpio	common carp		
Castostomus occidentalis	Sacramento sucker	extinct	
Calicina diminua	Marin blind harvestman		
Talanites ubicki	Ubick's gnaphosid spider		
Adela oplerella	Opler's longhorn moth		
Danaus plexippus	monarch butterfly		
Antrozous pallidus	pallid bat		
Corynorhinus townsendii	Townsend's big-eared bat		Candidate Threatened
Reithrodontomys raviventris	salt-marsh harvest mouse	Endangered	Endangered
Sorex ornatus sinuosus	Suisun shrew		
Tryonia imitator	mimic tryonia (CA brackish water snail)		
Vespericola marinensis	Marin hesperian		
Amsinckia lunaris	bent-flowered fiddleneck		
Arabis blepharophylla	coast rockcress		
Arctostaphylos montana ssp. montana	Mt. Tamalpais manzanita		
Calochortus umbellatus	Oakland star-tulip		
Castilleja ambigua var. ambigua	johnny-nip		
Chloropyron maritimum ssp. palustre	Point Reyes salty bird's-beak		
Eleocharis parvula	small spikerush		
Eriogonum luteolum var. caninum	Tiburon buckwheat		
Hemizonia congesta ssp. congesta	white seaside tarplant		
Hesperolinon	Marin western flax	Threatened	Threatened

Latin name	Common Name	Federal Status	State Status
congestum			
Leptosiphon acicularis	bristly leptosiphon		
Polygonum marinense	Marin knotweed		
Ranunculus lobbii	Lobb's aquatic buttercup		
Streptanthus glandulosus ssp. pulchellus	Mount Tamalpais bristly jewelflower		

3.3 McInnis Marsh Wildlife

RIDGWAY'·RAIL¶ BLACK·RAIL¶

3.3.1 Wildllife Setting

McInnis Marsh is a diked historic tidal wetland situated at the confluence of Gallinas and Miller creeks, on the western shore of San Pablo Bay in central Marin County. Historically, Gallinas and Miller creeks flowed into San Pablo Bay through a network of tidal channels that included McInnis Marsh (Figure 1-4). The levee system that was built in the early 1900s served to isolate the site from surrounding hydrological influences and fragment the wetland habitat mosaic that existed previously. Currently, the site is subject to limited tidal influence, and is isolated from the fluvial influence of Miller Creek. Drainage from the parcel is reduced to a single manmade channel connected to the adjacent tidal marsh through a culvert with an operable tide gate. (See Section 2.10). The underlying restoration assumption is that restoring connectivity with adjacent Gallinas Baylands tidal wetlands and increased freshwater and sediment input from adjacent uplands and Lower Miller Creek will increase habitat heterogeneity and, in turn, increase biodiversity.

Section 3.2 describes the vegetation communities at McInnis Marsh that are dominated by three species: native perennial pickleweed (*Sarcocornia pacific*), and two invasive non-native weeds— alkali Russian thistle (*Salsola soda*) and prickly lettuce (*Lactuca serriola*). These comprise approximately 80 percent of the community, with other associations accounting for the remaining 20 percent. Other invasive plant species on site that are classified as having a “high”

impact to native ecosystems by the California Invasive Plant Council[18] include yellow star thistle (*Centaurea solstitialis*), fennel (*Foeniculum vulgare*), and perennial pepperweed (*Lapidium latifolum*). (The latter is particularly invasive in tidal wetlands and poses a threat to adjacent habitats.) There is a small bulrush/cattail marsh along the western edge of the site, indicative of freshwater influence, probably from irrigation runoff from the adjacent McInnis Park Golf Center. This patch of habitat provides appropriate habitat for several native bird species.

The location of McInnis Marsh provides an ideal site to increase ecological connectivity between the functional tidal wetlands of Gallinas Creek and the San Pablo Bay shoreline and Lower Miller Creek.

3.3.2 Wildlife Assesment Methods

An assessment of currently occurring sensitive wildlife species was determined by a review of relevant databases and available literature, and informed by several decades of previous field work in the Gallinas Creek tidal marshlands (J. Evens, unpubl. data). Attachment B- identifies the sources consulted to develop a list of occurring, or potentially occurring, special status wildlife species.

3.3.3 Wildlife Assessment Findings

The greatest opportunity this restoration provides for threatened and endangered wildlife is the expansion and augmentation of existing habitat values for two federally endangered species (California Ridgway's Rail & Salt Marsh Harvest-Mouse) and one state threatened species (California Black Rail). Restoration actions that will increase tidal influence and freshwater and sediment input into McInnis Marsh will increase the habitat heterogeneity of the wetland complex within the site and increase connectivity with proximate habitats that already support the aforementioned special status species.

The species and species groups described below were selected to represent potential impacts and benefits to wildlife by restoration actions which restore tidal exchange and increase connectivity to adjacent salt marsh and creek corridors. Species groups include: two federally endangered species (one mammal, one bird); seven birds, one classified as "State Threatened" and six classified by California Department of Fish and Wildlife as "Bird Species of Special Concern;" three avian species guilds; and two keystone mammals.

3.3.4 Federally Endangered and Threatened Species

Northern Salt Marsh Harvest Mouse (***Reithrodontomys raviventris halicoetes*****)** [**SMHM**]

Endemic to the tidal marshes of San Francisco Bay (SFB), the western limit of this federally endangered species is the marshes bordering the mouth of Gallinas Creek on the upper Marin Peninsula (USFWS 1984). Because a preponderance of the native habitat has been destroyed, altered, or fragmented (Shellhammer et al. 1982, USFWS 1984), the extensive marsh complex that stretches from China Camp northward to the Petaluma River is arguably the most critical habitat available to the population. SMHM are critically dependent on dense cover in salt

[18] http://www.cal-ipc.org

marshes and their preferred habitat is pickleweed (*Sarcocornia pacifica*). SMHM are seldom associated with cordgrass or alkali bulrush. In addition to preferential use of the pickleweed zone, this species require a bordering zone of halophytes, slightly higher in elevation, to escape the highest tides. SMHM may spend a considerable portion of their lives at this higher elevation. SMHM also move into the adjoining grasslands during the highest winter tides.

Presence

Presence of SMHM at McInnis Marsh is unknown, but suspected given the quality and proximity of adjacent habitats.

Opportunities for habitat enhancement

An increase in habitat connectivity between the Gallinas Creek marsh complex and McInnis Marsh would benefit this and other tidal marsh dependent species. Likewise, an increase in vegetative cover by native tidal marsh plants (especially pickleweed), improved quality of upland refugial habitat, and a decrease in the extent of invasive non-native plants within the site would improve habitat values for SMHM both on site and in adjacent occupied habitat.

"California" Ridgway's (=Clapper) Rail (*Rallus obsoletus obsoletus*) [CRR]

The distribution of this federally endangered species is confined to the tidal marshes of San Francisco Bay. The Gallinas Creek complex holds the largest known population of CRRs in San Pablo Bay and perhaps throughout its range (Albertson and Evens 2000, Liu 2009, McBroom 2014). Occupied CRR territories border McInnis Marsh along its north, east and south boundaries with especially high densities in the broad outboard marsh complex to the east (Collins *et al.* 1994, Liu *et al*. 2009, McBroom 2014). To the north, CRR occurs in the downstream portion of Miller Creek adjacent to the Las Gallinas Sanitary District (LGSD) lands (Evens and Collins 1992, NBB, etc.). Foraging habitat is available along the Lower Miller Creek channel that traverses LGVSD property and links Miller Creek's riparian corridor to the broad outboard tidal marshes of Southern San Pablo Bay. To the east and south, CRR is a year-round resident nesting and raising young in the fully tidal outboard marshes as well as along the banks of Gallinas Creek.

Opportunities for habitat enhancement

Same as listed under SMHM (above). Additionally, any increase in tidal channelization and tidal complexity that occurred as a result of increased hydrological connectivity would benefit the CRR. Tidal channel complexity is a critical component of viable CCR habitat.

3.3.5 Species of California Concern

"California" Black Rail (*Laterallus jamaicensis coturniculus*) [CBR]

The preponderance of the population of this state-threatened species is confined to San Francisco bay (Evens *et al*. 1991, Trulio and Evens 2000). Black Rails are resident in the

Gallinas Creek marsh complex, breeding in the pickleweed zone of the high marsh plain. As with the SMHM (see above), a critical component of CBR's habitat requirements is upland refugia adjacent to the high marsh zone (Evens et al. 1991, Trulio and Evens 2000). Territorial CBRs are resident annually in the tidal marsh habitat immediately outboard of the levees surrounding the McInnis diked wetlands (NBB, J. Evens, pers. obs.).

Opportunities for habitat enhancement

Same as listed under SMHM (above)

American Bittern (*Botaurus lentiginosus*)

American bittern populations have been declining since the 1960's primarily as a result of habitat loss and wetland degradation. The bittern was listed by the U.S. Fish and Wildlife Service (USFWS) as a Nongame Species of Management Concern in 1987 and was included on the National Audubon Society's Blue List in 1976 (Tate 1986 as cited in Gibbs *et al.* 1992).

This secretive marsh bird is rare resident in Marin Co., but has been recorded from the cattail marsh in the LGSD treatment ponds in recent years (NBB 2014, 2015), immediately to the north of McInnis wetlands. Although occurrence at the LGVSD ponds is apparently sporadic, there is some evidence that the species nested in recent years (NBB 2014). In comparison to the sympatric Least Bittern (*Ixobrychus exilis*) (see below), the American Bittern appears to use a wider variety of wetland cover-types, less densely vegetated sites, and shallower water depths (Lowther *et al*. 2009).

Opportunities for habitat enhancement

An increase in the extent of emergent monocots (e.g. cattails) along the western edge of McInnis Wetlands in concert with restoration of the Lower Miller Creek watershed (KHE 2014) would increase the attractiveness of the general area to the American Bittern as well as other brackish/freshwater marsh associated species (e.g. Marsh Wren, Song Sparrow, Red-winged Blackbird).

Least Bittern (*Ixobrychus exilis*)

Considered a Nongame Bird of Management Concern by the U.S. Fish and Wildlife Service in 1982 and 1987 (Poole *et al*. 2009) and a California Species of Special Concern (Shuford and Gardali 2008), the Least Bittern is an extremely rare species in Marin Co., but did nest successfully at the LGVSD ponds in 2014 (NBB 2014). This smallest member of the heron family is closely associated with cattails (*Typha* spp.) and other emergent monocots in freshwater and brackish wetlands. The recent successful nesting along Lower Miller Creek (2014) suggests that McIinnis marsh could provide suitable habitat, especially with an increase in emergent monocots (cattails.bulrushes).

Opportunities for habitat enhancement

Same as listed under American Bittern (above).

Northern Harrier (*Circus cyaneus*)

This grassland and marshland diurnal bird of prey is currently considered a Bird Species of Special Concern (breeding), priority 3, by the California Department of Fish and Wildlife (Shuford and Gardali 2008). Historic declines in the population are attributed to the loss of wetlands that began in the 19th century and accelerated in the early 20th century when these habitats were modified by diking and draining for agricultural cultivation (Dahl 1990). Harriers have been recorded regularly foraging over McInnis wetlands during the course of field work for this assessment and are known to nest in the outboard tidal marshes from Gallinas Creek, in the upland riparian corridor of Miller Creek, and northward to Novato Creek (Shuford 1993, J. Evens, pers. obs., Kamman pers. obs.). With its preference for treeless plains with minimal human disturbance, the extensive marshlands fringing the western shoreline of San Pablo Bay provide valuable habitat for this ground-nesting raptor.

Opportunities for habitat enhancement

Although present currently, there is an opportunity to increase the value of the habitat for harriers on the site. An increase in native vegetative cover on the marsh plain would enhance foraging and nesting opportunities. Reduced human presence during the breeding season (March-August) would further enhance the viability of post-restoration habitat.

3.3.5.1 Short-eared Owl (Asio flammeus)

Currently considered a Bird Species of Special Concern (breeding), priority 3, by the California Department of Fish and Wildlife (Shuford and Gardali 2008), this grassland/marshland, ground-nesting owl occurs sporadically in the area. Recent sightings have been concentrated in the "spray fields" north of the LGVSD treatment ponds, and birds have been seen on occasion foraging over the Gallinas Creek marshes as well as McInnis Marsh (NBB, J. Evens, pers. obs.).

Opportunities for habitat enhancement

The occurrence of Short-eared owls would likely increase with an increase in native vegetative cover and a reduction in human traffic through the area.

"San Francisco" Common Yellowthroat (*Geothlypis trichas sinuosa*)

This locally endemic wetland-associated warbler is classified as a Bird Species of Special Concern (year round), priority 3, by the California Department of Fish and Wildlife (Gardali and Evens 2008). The range is restricted to the greater San Francisco Bay area where it is associated with riparian wetlands and brackish and saline marshes.

Observations at McInnis Marsh are centered around the habitat patch of cattail/bulrush along the western boundary of the site. It's habitat affinities are similar to, but more restricted than, the

Song Sparrow (*q.v*) and overlap more closely with the Marsh Wren. It is likely that numbers increase in the non-breeding season with smaller numbers remaining to nest in the spring and summer.

Opportunities for habitat enhancement

An increase in the extent of brackish marsh with a dense cover of emergent monocots (cattail and bulrushes) will increase the viability of the habitat for this species.

"San Pablo" Song Sparrow (*Melospiza melodia samuelis*)

Classified as a "Bird Species of Special Concern" (year round), priority 3. This subspecies is endemic to San Francisco Bay, with a distribution restricted to tidal marsh fringing San Pablo Bay. It is associated primarily with high marsh vegetation along slough edges and levees, particularly where gumplant (*Grindelia*) is present (Spautz and Nur *in* Shuford and Gardali 2008). Among the management recommendations for this sparrow is the statement "Restoration projects underway in the Napa-Sonoma marshes and in Marin County are critical" (*Ibid*). This Song Sparrow presently nests within the McInnis wetlands, with an apparent preference for larger clumps of picklweed and the cattail marsh on the western edge of the site. The nesting season of this taxon spans early March to July (Spautz and Nur *in* Shuford and Gardali 2008).

Opportunities for habitat enhancement

With an increase in the extent of native tidal marsh (pickleweed) and brackish marsh vegetation (cattail/bulrush) that would occur with an increase in tidal influence and freshwater inflow, territorial densities are expected to increase the abundance and density of this endemic taxon.

Other Selected Guilds and Species

RAPTORS

Several species of raptors commonly forage on the site in its current (pre-restoration) condition, most commonly

Northern Harrier (see account, above)

White-tailed Kite (*Elanus leucurus*)

Red-tailed Hawk (*Buteo jamaicensis*)

American Kestrel (*Falco sparverius*)

Other species occasionally occur on foraging forays: Cooper's Hawk (*Accipiter cooperii*), Sharp-shinned Hawk (*Accipiter striatus*), Merlin (*Falco columbarius*), Peregrine (*Falco peregrinus*),

Observations of a territorial pair of White-tailed Kites in March of 2015 suggest that they may nest in the eucalyptus grove in the WNW corner of the site.

Opportunities for habitat enhancement

Current conditions provide viable raptor habitat within the site. An increase in tidal influence and/or freshwater inflow is expected to increase the value of the site for prey species and, in turn, foraging raptors.

Avian Waders (various species)

Shorebirds forage on the unvegetated tidal flats along Gallinas Creek and the San Pablo Bay shore in large numbers from July through April.[19] McInnis wetland attracts small numbers of waders when the salt pannes are hydrated. Killdeer (*Charadrius vociferous*), Least Sandpipers (*Calidris minutilla*), and Greater Yellowlegs (*Tringa melanoleuca*) are the most common visitors. Less common are Great Blue Heron (*Ardea herodis*), Great Egret (*Ardea alba*), Snowy Egret (*Egretta thula*), and Black-necked Stilts *(Himantopus mexicanus*).

Opportunities for habitat enhancement

Use of the site by all these species is expected to increase in response to an increase in tidal influence or fresh water inflow. However, immediately post construction an increase in the depth and duration of water ponding may reduce available shallow water habitat.

Historical evidence indicates that salt pannes were important features of tidal marshlands prior to urbanization of the San Francisco estuary (Goals Project 1999, Palaima 2012). These un-vegetated depressions provide foraging opportunities for birds, particularly waders, and add to the habitat heterogeneity within the marsh complex. Because this habitat would not occur at existing grades, restoration alternatives that include design of some proportion of pannes or shallow ponds within the high marsh zone will be required to increase use of the site by shorebirds. Pannes provide habitat “analogous” to managed shallow ponds that are present in diked wetlands (Palaima 2012).

Land birds (various species)

A list of land birds and mammals detected on field visits is provided in Appendix B.1. In its current condition, McInnis Marsh provides habitat that attracts some landbirds in small numbers, most notably: Black Phoebe, Say’s Phoebe, Western Bluebird, Western Meadowlark, Savannah Sparrow, Song Sparrow.

Opportunities for habitat enhancement

Changes in land management which reduce upland disturbance and/or non-native plant communities would improve Land Bird habitat.

[19] http://data.prbo.org/apps/pfss/

3.3.6 Keystone Mammals

River Otter (Lontra canadensis)

Although this aquatic mammal has no special status and is listed as "least concern" by the IUCN Red List, it is a charismatic species considered a sentinel apex predator[20] in aquatic ecosystems and is the focus of considerable interest in Marin County where the population has rebounded in recent decades.[21] Numerous sightings have been reported from the vicinity of lower Miller Creek, the Las Gallinas treatment ponds, and the Gallinas Creek marshlands.[22]

Opportunities for habitat enhancement

Increased hydrological connectivity between proximate watercourses and McInnis Marsh will improve the habitat values for otters and potentially increase predation pressure on fish.

Coyote (*Canis latrans*)

Coyotes are common along the San Pablo Bay shore, including the project area, (J. Evens, pers. obs.) and the restoration will not affect their abundance or distribution appreciably. To the extent that the restorative actions increase connectivity to riparian vegetation upstream (lower Miller Creek), it is likely to have a positive impact on coyotes and, in turn, on ground and shrub nesting birds (Crooks and Soulé 1999). This apex level predator has no legal protection, but is a keystone species when present and causes "mesopredator release" when absent (*Ibid*).

Opportunities for habitat enhancement

Coyotes, which already frequent the Southern San Pablo Bay shoreline levee system from Gallinas Creek north to Novato Creek, will not be impacted greatly by changes in the McInnis Marsh. However, to the degree that increased connectivity between the wetland complexes north of the Gallinas Creek shoreline and the conversion of habitat from non-native vegetation to a more natural environment will enhance the prey base (small mammals), coyotes will benefit.

[20] A predator at the top of a food chain that is not preyed upon by any other animal A predator at the top of a food chain that is not preyed upon by any other animal whose abundance in a given area is believed to indicate certain environmental or ecological conditions or suitable conditions for a group of other species.

[21] http://www.marinij.com/marinnews/ci_24920213/river-otters-making-strong-comeback-marin-and-around

[22] http://www.riverotterecology.org/maps-of-bay-area-sightings.html

3.3.7 Potential Project Related Effects and Avoidance Measures

The actions anticipated for McInnis Marsh Restoration will create short-term disturbances on site and in habitats immediately adjacent. The following avoidance measures are recommended as input to restoration alternative development and implementation:

1) By scheduling the project outside the avian nesting season direct impacts to potentially nesting bird species will be avoided. The "non-nesting" season for the Federally-endangered California Ridgway's Rail is September 1-February 1 (USFWS, pers. comm.), a time period that is also outside the nesting season of the other special status species discussed above. Therefore, if earth-moving and construction activities are completed within this time period, and if machinery is contained within the McInnis Marsh boundaries, disturbance to nesting birds will be avoided.

2) When adjacent tidal marshlands are inundated (above mean higher high water), rails and SMHM may use the site for temporary refuge. Within the September through January construction window, construction activities should avoid extreme high tides or periods of inundation when the tidal marsh plain is flooded.

3) Although the likelihood is slight that either rail species or SMHM is present within the McInnis site, clearance surveys should be completed before construction begins. The most sensitive species are also the most furtive (both rails and SMHM). The purpose of "clearance" would be to flush any of these species off the site into adjacent habitats. This could be accomplished by some method that was disturbing enough to "flush" the animals without physical injury. One method used is "rope dragging" in which a long, weighted rope with two people at either end is dragged across the marsh plain, forcing any creatures in the path of the rope to flee from the disturbance and take refuge in adjacent habitat.

3.4 Lower Miller Creek Wildlife

Avocet Research and Associates (ARA, 2015) prepared a biological assessment of wildlife in the Lower Miller creek reach of interest in support of regional planning and permitting for channel maintenance (removal of aggrading sediment) currently planned for Fall 2015. The following summary of wildlife conditions within the corridor is adapted from the ARA report.

To support planning and implementation of measures in Lower Miler Creek that seek to protect and enhance wildlife in the corridor, ARA identified and evaluated currently occurring sensitive wildlife species in the corridor and the potential benefit of downstream wetland enhancements based on a review of relevant databases, the available literature, two site visits in October 2014, and previous field work in the Gallinas Creek tidal marshlands (J. Evens, unpubl. data).

Miller Creek supports a population of federally listed Steelhead (Oncorhynchus mykiss), however special status fish, like plant species, will be addressed in separate report sections. The adjacent wetlands currently (and potentially) support several other state- and federally listed special status species, most notably the federally endangered Salt Marsh Harvest Mouse (Reithrodontomys raviventris) and "California" Ridgway's Rail (Rallus obsoletus obsoletus) and

the state threatened "California" Black Rail (Laterallus jamaicensis coturniculus). This assessment addresses those and other sensitive wildlife species that may occur in the area and may be affected by the restoration project.

3.4.1 Lower Miller Creek Wildlife Setting

This wildlife biological assessment focuses on the reach of Lower Miller Creek between the SMART RR Bridge and the Reclamation Bridge, approximately 2655 linear feet of creek channel (Figure 3-9). The study area is a highly altered drainage channel with muted tidal flow (See Section 2).

Figure 3-9: Lower Miller Creek Channel, SMART to LGVSD Ponds

Downstream from the eastern extent of the study area at Reclamation Bridge the channel makes an abrupt bend east-northeasterly and flows into San Pablo Bay. For the first 1000-m from the Reclamation Bridge to the broader saltmarsh downstream, the channel is narrow and straight with emergent tidal marsh approximately 20 meters in width along its north bank (Figure 5). This downstream habitat provides an important link between the bayshore tidal marshes and the section of the creek reach on which this report focuses. First- and second-order channels have developed within this linear strip marsh that provide habitat for several tidal dependent, special status species (e.g. California Ridgway's Rail and California Black Rail). Farther downstream, the channel enters an extensive northern tidal salt marsh habitat that extends 3.4 miles (5.5 kms) from the mouth of Gallinas Creek northward to the Hamilton Wetland Restoration Site (Figure 2), the largest extent of contiguous tidal marsh habitat in San Pablo Bay (Dedrick 1993). The value of this marsh complex to several special status, tidal marsh dependent species is well documented (USFWS 1984, Nur et al. 1997, Albertson and Evens 2000, Evens and Nur 2002, USFWS 2004, Liu et al. 2009).

The importance of habitat connectivity and contiguity for conservation is thoroughly documented in the ecological literature (e.g. Goals Project 1999, Hilty *et al*. 2006) and recognized by the regulatory agencies.[23] The McInnis Marsh restoration project provides an opportunity to increase the connectivity of the existing tidal marsh downstream to upstream habitat, to improve the condition of associated tidal marsh habitat on the channel banks, and to increase the availability of foraging habitat for shorebirds.

Figure 3-10: Lower Miller Creek restoration site looking north (upstream). Note the extensive cover of ruderal vegetation on the east (right) bank.

[23] https://www.wildlife.ca.gov/Conservation/Planning/Connectivity

Figure 3-11: Lower Miller Creek restoration site looking north (upstream). Note the extensive cover of ruderal vegetation on the east (right) bank.

Figure 3-12: View of the tidal channel downstream from the Reclamation Bridge looking NE toward San Pablo Bay. The vegetative community of the north bank of the channel is a wide bench supporting a dense community of halophytes dominated by pickleweed (Sarcocornia pacifica).

3.4.2 Miller Creek Wildlife Findings

ARA compiled a list of special status species that occur in the region (Table 3.4aaa). The likelihood of occurrence at or near the project site is provided in Column B (Not likely to occur; Potentially occurring; Known to occur). This table also provides sources of information and the regulatory status of each species. In addition, a list of wildlife species observed on the site during two field visits in October, 2014 is provided in Table 3-5. A list of "Special Animals" (CDFW 2014) not recovered from a search of the CNDDB query, but known to occur in the LGVSD complex is provided in (Table 3-5.)

3.4.2.1 Miller Creek Wildlife Species of Conservation Concern

The species considered here include those listed under the Federal Endangered Species Act and California Department of Fish and Wildlife's list of Special Animals, as well as species recognized as deserving special attention given their rarity, the vulnerability of their populations, or their ecological functions. Many of these species are identical to those found in and surrounding McInnis Marsh.

3.4.2.2 Federally Endangered and Threatened Species

Northern Salt Marsh Harvest Mouse (***Reithrodontomys raviventris halicoetes***).

Endemic to the tidal marshes of SFB, the western limit of this federally endangered species is the marshes bordering the mouth of Gallinas Creek on the upper Marin Peninsula (USFWS 1984). Because a preponderance of the native habitat has been destroyed, altered, or fragmented (Shellhammer et al. 1982, USFWS 1984), the extensive marsh complex that stretches from China Camp northward to the Petaluma River is arguably the most critical habitat available to the population. SMHM are critically dependent on dense cover in salt marshes and their preferred habitat is pickleweed (*Sarcocornia pacifica*). SMHM are seldom associated with cordgrass or alkali bulrush. These mice require an upper zone of peripheral halophytes adjacent to the "pickleweed zone" to escape the highest tides, and may spend a considerable portion of their lives at this higher elevation. SMHM also move into the adjoining grasslands during the highest winter tides.

"California" Ridgway's (=Clapper) Rail (*Rallus obsoletus obsoletus*). [CRR]

The distribution of this federally endangered species is confined to the tidal marshes of San Francisco Bay. The Gallinas Creek complex holds the largest known population of CRRs in San Pablo Bay and perhaps throughout its range (Albertson and Evens 2000, Liu 2009). CRR occurs in the downstream portion of Miller Creek adjacent to the Las Gallinas Sanitary District lands (Evens and Collins 1992, NBB, etc.) year-round and nests within 1 km of the Reclamation Bridge at the southern edge of the restoration site. Foraging habitat is available along the channel that links Miller Creek to the broad outboard tidal marsh from the Reclamation Bridge downstream.

3.4.2.3 Species of California Concern

"California" Black Rail (*Laterallus jamaicensis coturniculus*) [CBR]

The preponderance of the population of this state-threatened species is confined to San Francisco bay (Evens *et al*. 1991). Black Rails are resident in the Gallinas Creek marsh complex, breeding in the pickleweed zone of the high marsh plane. A critical component of their habitat requirements is upland refugia adjacent to the high marsh zone (Evens et al. 1991, Trulio and Evens 2000). Territorial calling birds are present annually in the linear strip of marsh habitat that borders Miller Creek adjacent to Las Gallinas Sanitary Districts holding ponds (NBB, J. Evens, pers. obs.). To the degree that emergent marsh vegetation increases along the banks of the restoration site, it will increase the viability of the habitat for CBR.

American Bittern (*Botaurus lentiginosus*).

American bittern populations have been declining since the 1960's primarily as a result of habitat loss and wetland degradation. The bittern was listed by the U.S. Fish and Wildlife Service (USFWS) as a Nongame Species of Management Concern in 1987 and was included on the National Audubon Society's Blue List in 1976 (Tate 1986 as cited in Gibbs *et al.* 1992).

This secretive marsh bird is rare resident in Marin Co., but has been recorded at the Las Gallinas ponds in recent years (NBB 2014). In comparison to the sympatric Least Bittern (*Ixobrychus exilis*) (see below), the American Bittern appears to use a wider variety of wetland cover-types, less densely vegetated sites, and shallower water depths (Lowther *et al*. 2009). Although occurrence at the Gallinas Ponds is apparently sporadic, there is some evidence that the species nested in recent years (NBB 2014). An increase in emergent monocots (e.g. cattails) along lower Miller Creek would increase the attractiveness of the general area to the American Bittern.

Least Bittern (*Ixobrychus exilis*)

Considered a Nongame Bird of Management Concern by the U.S. Fish and Wildlife Service in 1982 and 1987 (Poole et al. 2009) and a California Species of Special Concern (Shuford and Gardali 2008), the Least Bittern is an extremely rare species in Marin Co., but did nest successfully in the Las Gallinas Sewage Ponds in 2014 (NBB 2014). This smallest member of the heron family is closely associated with cattails (*Typha* spp.) and other emergent monocots in freshwater and brackish wetlands. The recent successful nesting at Las Gallinas (2014) suggests that Millar Creek could provide suitable foraging habitat to the degree that the banks are colonized by cattails and other tall, emergent monocots.

"San Pablo" Song Sparrow (*Melospiza melodia samuelis*)

This taxon, whose distribution is restricted to tidal marsh fringing San Pablo Bay, is associated primarily with high marsh vegetation along slough edges and levees particularly where gumplant (*Grindelia*) is present (Spautz and Nur *in* Shuford and Gardali 2008). Among the management recommendations for this sparrow is the statement "Restoration projects underway in the Napa-Sonoma marshes and in Marin County are critical" (*Ibid*). This Song Sparrow presently nests in the vegetated portions of Lower Miller Creek within the project's footprint (J. Evens, pers. obs.). The nesting season of this taxon spans early March to July (Spautz and Nur *in* Shuford and Gardali 2008). Territorial densities are expected to increase with an increase in tidal marsh vegetative structure.

Avian Waders (various species)

Shorebirds use the unvegetated substrate (tidal flats) of Miller Creek sporadically in its current condition. Killdeer (*Charadrius vociferous*) commonly occur here, and occasionally Black-necked Stilts *(Himantopus mexicanus*), Least Sandpipers (*Calidris minutilla*) and dowitchers (*Limnodromus* spp.), as well as other shorebirds, forage on the exposed flats. Ardeids—Great Blue Heron (*Ardea herodis*), Great Egret (*Ardea alba*), and Snowy Egret (*Egretta thula*)—are relatively common visitors to the project site.

Use of the site by all these species is expected to increase in response to an increase in the connectivity between tidal flats, tidal marshplain, and riparian corridor. Upstream of the Silveira pump station, the aggrading creek bed is more fluvially dominated (sandier substrate, more undulating bed); downstream it is a more tidally dominated system with an increasing proportion of bay mud substrate. Sediment maintenance (channel exaction) in this downstream portion will most likely benefit foraging waders.

Additionally, as the extent of emergent monocots increases along the boundary of the channel, it is should provide increased habitat for prey sought after by waders.

Land Birds (various species)

A list of land birds and mammals detected on the two October field visits is provided in Appendix A of Attachment B-2. Upland planting, including placement of willows (*Salix* spp.) at the most upstream limit of the project is anticipated. (See Initial Study, GECO, 2015.) Additionally, the project will incorporate exclusionary fencing, which will improve nesting and ground cover conditions as well as connectivity with existing riparian vegetation along the upstream reach of Miller Creek. Once established, this riparian community will increase the attractiveness of the creek's banks for nesting and foraging land birds and mammals.

River Otter (*Lontra canadensis*)

Although this aquatic mammal has no special status and is listed as "least concern" by the IUCN Red List, it is a charismatic species considered a sentinel apex predator in aquatic ecosystems and is the focus of considerable interest in Marin County where the population has rebounded in recent decades.[24] Numerous sightings have been reported from the vicinity of Miller Creek, the Las Gallinas treatment ponds, and the Gallinas Creek marshlands.[25] The restoration should improve the habitat values for otters and potentially increase predation pressure on fish.

Coyote (*Canis latrans*)

Coyotes are common along the San Pablo Bay shore, including the project area, (J. Evens, pers. obs.) and the restoration will not limit their abundance or distribution. To the extent that the restoration increases connectivity to riparian vegetation upstream, it is likely to have a positive impact on coyotes and, ultimately, on ground and shrub nesting birds (Crooks and Soulé 1999).

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[24] http://www.marinij.com/marinnews/ci_24920213/river-otters-making-strong-comeback-marin-and-around

[25] http://www.riverotterecology.org/maps-of-bay-area-sightings.html

This apex level predator has no legal protection, but is a keystone species when present and causes “mesopredator release” when absent (*Ibid*).

3.5 McInnis Marsh and Miller Creek Fisheries Habitat Evaluation

3.5.1 Fisheries Setting

The reach of interest in Miller Creek forms the transition between an alluvial/riparian upland corridor and bay tidal slough/marsh habitat. Further upstream, the reach supports riparian/ willow grove habitat. This largely intact riparian corridor extends upstream through agricultural and residential development for over 5 miles upstream to the headwaters of Miller Creek. Creek headwaters are largely undeveloped, and much of the land is dedicated as Open Space Preserve. The BA for NMFS related species prepared to support channel maintenance in Lower Miller Creek (Carbiener, 2014) provides a detailed description of fisheries habitats and restoration values for Lower Miller Creek (Attachment B.3).

Lower Miller Creek within the Project Area is a tidally-influenced engineered earthen-bank flood control channel bordered by levees. Lower Miller Creek is intermittently dry in the summer months. The project reach is tidally influenced and tidal inundation and salinity varies continuously across the reach with tidal amplitude decreasing with increasing bed elevation and distance upstream (KHE, 2015). During summer low flow periods, freshwater flows in the aggraded lower Miller Creek wane to intermittent or subsurface, and the reach is dry during low tides. Sediments aggrading in the upstream half of the reach create an undular bar/pool bed form, and bury emergent vegetation within the channel. In the lower half of the reach, aggrading sediments increase bed elevations but remain covered with bay mud. Substrate within the lower half of the project reach is dominated by bay muds typical of San Pablo Bay marshes. Approximately 1,400 feet upstream of Reclamation Bridge, substrates increase in size and shift toward fluvially- sourced sands and gravels. The channel bottom is generally clear. Instream vegetation within the project area is limited to narrow bands of marsh habitat in the region, with pickleweed (*Salicornia pacifica*) and salt grass (*Distichlis spicata*) where grades are suitable. Ruderal, non-native grasses dominate the upland habitats.

3.5.2 Methods

3.5.2.1 Reconnaissance Survey

A reconnaissance survey was conducted by fisheries biologist Michael Carbiener on August 16, 2014 to observe site conditions. The site visit was conducted between 12:00 pm and 3:00 pm during low tide (2.0 feet). Observations were made of conditions of Miller Creek and Gallinas Creek at the time of the survey, as well as conditions of McInnis Marsh.

3.5.2.2 Literature Review

A variety of sources was reviewed in regards to this fisheries habitat assessment, including various management plans, historical and current ecological reports on Miller Creek and the surrounding areas, barrier assessments, and previous fisheries resource assessments in the region. This information, along with information gleaned during the reconnaissance survey were used to prepare this fisheries habitat evaluation.

3.5.3 Results

3.5.3.1 Habitat within Project Area

Miller Creek within the Project Area is bounded by levees along both banks and subject to tidal influence from San Pablo Bay. During low tides and low flows, the intertidal channel drains across the San Pablo Bay mudflats, and is dry at elevations below mean low water. The downstream portion is a single channel, approximately 25-30 feet wide. Approximately 1,300 feet upstream from San Pablo Bay a small tidal tributary extends to the north and drains a small area of tidal vegetation. Upstream of this tributary Miller Creek is confined within levees. A small side channel runs parallel to the main channel as it flows from the west. The LGVSD treated effluent outfall is located along the right bank just downstream of Reclamation Bridge and Miller Creek's southern-most 90 degree turn. At LGVSD, approximately 5,800 feet upstream from the bay, Miller Creek turns to the north and traverses an intertidal corridor toward, continuing North toward the SMART Bridge. Miller Creek is still tidal at this point, however during low tides, bay waters recede from this portion of the channel, whereas the lower portion remains inundated by tidal bay waters.

Miller Creek within the Project Area currently provides some low quality habitat for target fish species. It provides a suitable migration corridor for adult steelhead (*Oncorhynchus mykiss*) to access upstream spawning habitat and smolts returning to the ocean. It may provide some limited juvenile rearing habitat for steelhead, primarily in the small side channels where they can adjust to changing salinities and avoid larger predators. A lack of riparian cover in the portion of Miller Creek upstream of the Project Area likely reduces the quality of habitat in the project area by potentially increasing water temperatures and allowing for increased algal growth. In addition to the low quality habitat for steelhead described above, some marginal habitat for Sacramento splittail (*Pogonichthys macrolepidotus*) may be also present in the side channels.

Fisheries surveys were not conducted on the portion of Miller Creek upstream of the LGVSD ponds during the course of this project. However, physical and biological surveys indicated that the intertidal reach between Reclamation Bridge and SMART Bridge is currently aggrading with fine to coarse sediments. The relatively high upstream sediment loading increases the bed grades. The associated bars disconnect the channel thalweg and pools during lower tidal regimes reducing habitat connectivity and increasing pool temperatures and salinity. Hypersaline pools were observed during low flow monitoring in 2014 (R. Kamman, pers. com.).

3.5.3.2 Upstream Habitat

Much of the description below of fish habitat upstream of the Project Area is taken from a 2009 stream habitat assessment conducted by the California Department of Fish and Game (now called California Department of Fish and Wildlife) (CDFG, 2011). This assessment covered 7.2 miles of Miller Creek from upstream of LGVSD to the headwaters.

According to the CDFG assessment, the majority of Miller Creek consists of a F4 channel, which is characterized as entrenched, meandering, riffle/pool channels on low gradients with high width/depth ratios and gravel-dominated substrates (Rosgen, 1994). In the lower reaches of this section, cattle ranching activities have likely led to a decrease in the quality of riparian cover and bank stabilization, while increasing the nutrient load and turbidity within Miller Creek. In 2014, a large winter storm resulted in overbank flows which flooded agricultural land and school facilities on the St. Vincent's School parcel located north of the creek. Conditions in the corridor have not been evaluated since the 2014 flood event.

CDFG reports (2009) that upstream of Highway 101, Miller Creek retains the F4 channel-type, however the riparian cover is more extensive and habitat conditions become more appropriate for salmonids. Temperatures are likely cooler in this section than downstream. Just downstream of Lassen Drive, a three foot tall dam may be a barrier to juvenile and adult salmonids. No other known barriers occur within this section of Miller Creek, however several bedrock sills and engineered grade or erosion control structures may reduce connectivity in this ephemeral corridor.

The section of Miller Creek upstream of Mt. Lassen is a B4 channel type. This channel type extends 2,564 feet upstream and is characterized by moderately entrenched riffle dominated channels with low width/depth ratios and gravel dominated substrates. One barrier, a private road crossing with a 7 foot down cut occurs in this section. The uppermost reach of Miller Creek consists of an A3 channel. A3 channels are characterized by steep, narrow, cascading, step-pool streams with high energy and debris transport associated with depositional soils and cobble dominated substrate.

3.5.4 Fish Species within Project Area

3.5.4.1 Current and Historical Assemblage

Miller Creek is known to support several native fish species, including steelhead, threespine stickleback (*Gasterosteus aculeatus*), Sacramento sucker (*Catostomus occidentalis*), and California roach (*Hesperoleucus symmetricus*), as well as staghorn sculpin (*Leptocottus armatus*), riffle sculpin (*Cottus gulosus*), and prickly sculpin (*C. asper*) (Leidy 2007, CDFG 2011, Becker et al. 2007). Additionally, common carp (*Cyprinus carpio*) is known to occur in the lower reaches, likely in the project area. There is no evidence that coho salmon (*Oncorhynchus kisutch*) occurred historically or currently within Miller Creek.

Within the Project Area portion of Miller Creek, it is likely that several bay-oriented fish may utilize the lower-most reaches of Miller Creek. No records were discovered to verify this, but it is likely that species such as striped bass (*Morone saxatilis*), gobies (*Gobiidae sp.*), and inland silverside (*Menidia beryllina*) occur within the Project Area depending on tidal conditions.

3.5.4.2 Potential Species Post-Restoration

Depending on the final configuration of restoration within McInnis Marsh, several other species may utilize Miller Creek and the Project Area. Most importantly, Sacramento splittail could use the restored mash as spawning and rearing habitat. Splittail spawn in flooded vegetation on floodplains. It is likely that this species will utilize the Project Area provided conditions are appropriate.

3.5.4.3 Life Histories of Key Fish Species

This section describes key fish species expected to occur within the Project Area. Fish species that occur in the upper reaches of the watershed but are not expected within the Project Area are not discussed below.

3.5.4.4 Steelhead/ Rainbow trout

Steelhead/ rainbow trout is a salmonid species that may exhibit anadromous or freshwater resident life cycles. Resident individuals are typically referred to as rainbow trout whereas

anadromous individuals are called steelhead. Steelhead migrate from freshwater to the ocean and return to their natal streams to spawn as adults. Resident rainbow trout remain in streams during their entire life. However, this life cycle is variable and often both resident and anadromous forms are found in the same stream. In Miller Creek, the majority of the trout are considered steelhead and will be referred to as such throughout this document.

Steelhead exhibit a variable life history with each stage requiring different habitat preferences. Spawning and rearing habitats are typically limiting factors for this species in local streams. Pool habitats are important as they provide habitat features required during spawning and rearing and are used by all life stages of resident rainbow trout. Riffles and glides are an important habitat type as they are used expensively by young trout. These features occur upstream on Miller Creek in the Marinwood neighborhood between Hwy 101 and Las Gallinas Ave.

Preferred spawning habitat for steelhead is found in pool tail-outs where favorable flow and depth conditions are most often met. Additionally, glides, runs, and riffles may provide some spawning habitat if conditions are appropriate. Ideal spawning substrate has a low percentage of fines resulting in high gravel permeability and oxygen levels for developing eggs and embryos. Steelhead typically prefer spawning gravels in the 0.5 to 4 inch size range (Reiser and Bjornn 1979). Rearing juvenile steelhead and resident rainbow trout require pools with sufficient depth and low temperatures. Cover and sufficient food are also important habitat components.

3.5.4.5 California roach

California roach is a minnow native to western North American and commonly found in intermittent streams throughout central California. The California roach is found in a variety of habitats, but is most commonly found in small, warm, intermittent tributaries to larger streams (Moyle et al. 1989). It is typically found in pool habitats and lower, warmer sections of streams where it is capable of withstanding extreme environmental conditions. The California roach is a bottom feeder, filamentous algae is the primary diet, followed by aquatic invertebrates. California roach spawn in shallow, flowing sections of streams where the substrate is covered with gravel, where they lay adhesive eggs. These eggs hatch in two to three days and the fry remain in gravels until they are large enough to swim (Moyle 2002).

3.5.4.6 Threespine stickleback

The threespine stickleback is a small fish that is commonly found in bay area streams, where it lives in shallow, weedy pools and backwaters or among emergent plants at stream edges over bottoms of gravel, sand, and mud (Moyle 2002). Both anadromous and freshwater resident stickleback occur in bay area streams (Rich 1996); it is likely that Miller Creek supports both forms. Freshwater forms of this species feed primarily on bottom dwelling invertebrates, as well as those living among aquatic plants. Anadromous forms tend to feed more on free swimming crustaceans, although bottom dwelling invertebrates are also consumed. Stickleback generally require cool temperatures and are not usually found in streams with temperatures greater than 24°C. As this species is a visual feeder, it is rarely found in turbid waters. This hardy fish is known to withstand wide variations in salinity. This, coupled with three locking spines that defend against predation, allows the stickleback to thrive in the presence of predatory species despite its small size.

The majority of sticklebacks complete their lifecycle in one year, although individuals may live up to three years. Stickleback spawn in the spring and summer, following an elaborate courtship ritual. Each female lays between 50 and 300 eggs during separate spawns. Eggs typically hatch

in 6 to 8 days (at 18-20°C) and the newly hatched fry typically stay in the nest for a couple of days. As the fry start to emerge from the nest, the male will guard them by collecting wandering fry in his mouth and returning them to the main school. Eventually the fry become too active for the male to protect and he leaves to either re-spawn or join a school of similar sized fish. The fry join other schools of similar sized fish.

3.5.4.7 Sacramento splittail

Sacramento splittail is not currently known from Miller Creek (Leidy 2007, CDFG 2011). However, it is possible that this species may occur in the future if habitat conditions improve as a result of restoration activities.

Sacramento splittail is endemic to the California Central Valley. During most years, they are primarily found in the Delta, Suisun Bay, Suisun Marsh, the lower Napa River, the lower Petaluma River, and other parts of the San Francisco Estuary (Moyle 2002). Splittail are adapted for estuarine habitat that is subject to changing conditions. They can tolerate high salinities and temperatures and low oxygen conditions. These adaptations make them well suited to sloughs and slow moving sections of rivers. Splittail feed primarily on bottom dwelling invertebrates in areas with low to medium currents. This includes opossum shrimp, copepods, amphipods, clams, various crustaceans, and insect larvae. During flooded conditions, they are known to feed on earthworms. Splittail are predated by striped bass and are commonly caught by anglers and used as bait.

Splittail move upstream during winter and spring to spawn on submerged vegetation. Wet years typically have higher spawning success due to increased flood plain inundation. Spawning occurs in spring, as adults release adhesive eggs that stick to submerged vegetation and debris. Eggs hatch within 3-7 days and larval fish remain in shallow weedy areas near the nest for 10-14 days before moving into deeper water. Young –of-the-year and yearling splittail are most commonly found in water less than 2 meters deep. They are able to swim against strong tidal and river currents despite their relatively small size.

3.5.5 Conclusions and Recommendations

In order to improve the Project Area for target fish species, several features should be incorporated into the project design. As Miller Creek is a known steelhead stream, up and downstream migration should be a primary factor in the design. The lower reaches of Miller Creek should be improved to maximize the low flow channel allowing adult steelhead easier passage into the stream to access upstream spawning habitat. A direct connection to the bay, as currently exists, should be maintained in order to provide steelhead access to the stream without confusion. Routing Miller Creek through the proposed restoration area may be appropriate, however the restoration design should maintain the existing Miller Creek connection to the bay. Additionally, a low flow channel within Miller Creek would help downstream migrating steelhead smolts access the bay on their way downstream.

Where appropriate, increased riparian cover should be considered along Miller Creek. While the Project Area is at the extreme downstream end of Miller Creek and it is unlikely to support riparian vegetation, upstream landowners should endeavor to protect and restore riparian cover to sustain cooler water temperatures and food for invertebrate resources. Headwater resources should also be protected to the fullest extent possible to maintain base flows in this ephemeral stream corridor.

The portion of the Project Area within McInnis Marsh that is planned for restoration can be optimized for splittail habitat, as well as juvenile nursery/ rearing habitat for a variety of species, including steelhead. Splittail are known to spawn in shallow water (less than 2 meters deep) over flooded vegetation habitat (CDWR 2013). Through appropriate recontouring of the interior of McInnis Marsh and connection to Miller Creek, spawning and rearing habitat for splittail can be created. This habitat should be designed to flood during spring flows and remain flooded for several weeks during the spring/ early summer. The area should consist of varying depths connected by deeper channels to provide access and refuge for larger fish. If configured correctly, these conditions can provide suitable habitat for spawning and rearing splittail, as well as steelhead and other small fishes. Within a recently restored salt pond in the Napa River, juvenile steelhead and splittail were collected within two years of restoration activities (Demgen et al. 2012).

3.5.6 Expected changes to habitat resulting from no action and planned restoration activities.

If no restoration activities are undertaken within the Project Area, conditions for fish will remain similar to current conditions. Significant fish habitat is not viable within McInnis Marsh. Fish passage currently exists within lower Miller Creek depending on flow conditions. Sedimentation of the lower reach will continue. However, tidal and fluvial actions will help continue to promote sedimentation in the reach and without channel maintenance or reconfiguration, it is possible that fish passage will be impeded. Habitat conditions for other target species, such as Sacramento splittail, will continue to be poor as the flooded vegetation they require for spawning is not present within the Project Area.

If restoration is undertaken within the Project Area, McInnis Marsh will provide habitat for spawning and rearing splittail and other species, including steelhead. Depending on the sediment load and scour rates within the restoration area, this habitat should continue to provide habitat for many years. As the vegetation grows within the restoration area, spawning habitat for splittail will improve. This vegetation will also provide habitat and food for a variety of invertebrates, which will provide rearing fish with an abundant food source. The vegetation will also trap sediment and reduce the depths within the restoration area. Over time, it is likely that this habitat will decrease and the marsh will eventually return to an upland or wetland transition zone. Depending on inundation and water levels within this area, fish usage and habitat may decline over time.

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