MCINNIS MARSH RESTORATION PROJECT:
FEASIBILITY STUDY AND ALTERNATIVES ANALYSIS
MCINNIS MARSH, MARIN COUNTY, CA

Photo by Craig Solin

Prepared for Marin County Parks

By
Kamman Hydrology & Engineering, Inc

In Association with

Avocet Research Associates
M. Carbiener, Fisheries Biologist
Elise Holland, Planner
Peter Baye, PhD., Wetland Ecologist

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PREPARED FOR:

Marin County Parks

and

The California Coastal Conservancy

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1 Purpose, Partners, and Scope

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

This McInnis Marsh Restoration Feasibility Study (FS) was prepared on behalf of Marin County Parks by Kamman Hydrology & Engineering, Inc. (KHE), in collaboration with Jules Evens (Avocet Research Associates), M. Carbiener, Fisheries Biologist, Elise Holland, Planner, and P. Baye, (Ph.D., Coastal Ecologist/Botanist). This FS identifies the range of viable actions for ecological enhancement at McInnis Marsh. As a first step, the study evaluates opportunities and constraints for restoring biological and geomorphic functions and processes in the marsh. This information, and site characterization serve as the basis for identification of a suite of feasible restoration alternatives. Parks can implement the restoration actions associated with the alternatives in a phased approach, as funding is available, or as needed in order to integrate actions with needs for infrastructure modifications and regional bay land management.

1.1 Purpose

The McInnis Marsh Restoration Project addresses issues related to accelerated sea level rise and other impacts from climate change, including overtopping and breaching of levees, impacts to existing park facilities and infrastructure, maintaining public access to the bay lands, and restoring habitat. The project includes the restoration of bayland, tidal, freshwater and upland habitat in the Gallinas Baylands (Figure 1-1), for resident and migratory birds, fish and other wildlife. The special status species of interest present in the marsh include the following federally listed endangered species: “California” Ridgway’s Rail, and “California” Black Rail, Salt Marsh Harvest Mouse (referred to collectively as the “focal species” in this report), and steelhead. The goals of the project 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 while protecting existing park facilities from impacts associated with climate change. This project, and its associated ecological goals, will benefit regionally significant breeding populations of endangered and threatened species that are present in the adjacent Gallinas Creek bayland.

The McInnis Marsh Restoration Project offers the opportunity to expand ecologically significant contiguous marsh adjacent to the project site. With a breach to Miller Creek, the project would also increase freshwater and coarse (alluvial) sediment supply to the Gallinas baylands, and potentially create access to an upland migration corridor via Miller Creek. The opportunity for restored marsh connectivity to transitional upland and riparian ecotones in the Miller Creek corridor, and the associated freshwater and sediment supply, would increase the ecological value and diversity of both Miller Creek and the Gallinas Creek marsh complex and support natural geomorphic adaption to sea level rise and large storm events over the long term.

In 2014, the project team undertook an Analysis of Site Conditions. The information gathered and documented in the associated report (Attachment A) describes current physical, biological and land use conditions on the project site as well as in the surrounding baylands. The Analysis of Site Conditions report provides the basis for this restoration feasibility study and alternatives analysis.

1.2 Lead Agency and Project Partners

The Marin County Parks (Parks) is the lead agency for the McInnis Marsh Restoration Project with support from the California State Coastal Conservancy (SCC), 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 B) to collaborate in the study, funding, and implementation of restoration actions at McInnis Marsh, Lower Las Gallinas Creek, and Lower Miller Creek. Parks is the lead agency with funding support provided by the SCC.

1.3 Project Location and Setting

The McInnis Marsh Restoration Project will be implemented across land owned by Parks and by the LGVSD. Tidal wetland portion of the restoration is focused on McInnis Marsh, a 180-acre area of diked historic wetlands located at the confluence of the North and South forks of Gallinas Creek within McInnis Park. The restoration project includes work in McInnis Marsh, as well as in adjacent reaches of both Gallinas and Miller Creeks, which lay to the south and north respectively. 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 1-2).

Extensive mature subtidal wetlands adjoin the southern and eastern boundary of McInnis Marsh and support several of the special status species that provide the rationale for and focus of this restoration effort. Once restored, McInnis Marsh will link historic, protected, and newly restored marshes on the southwest shore of the San Pablo Bay.

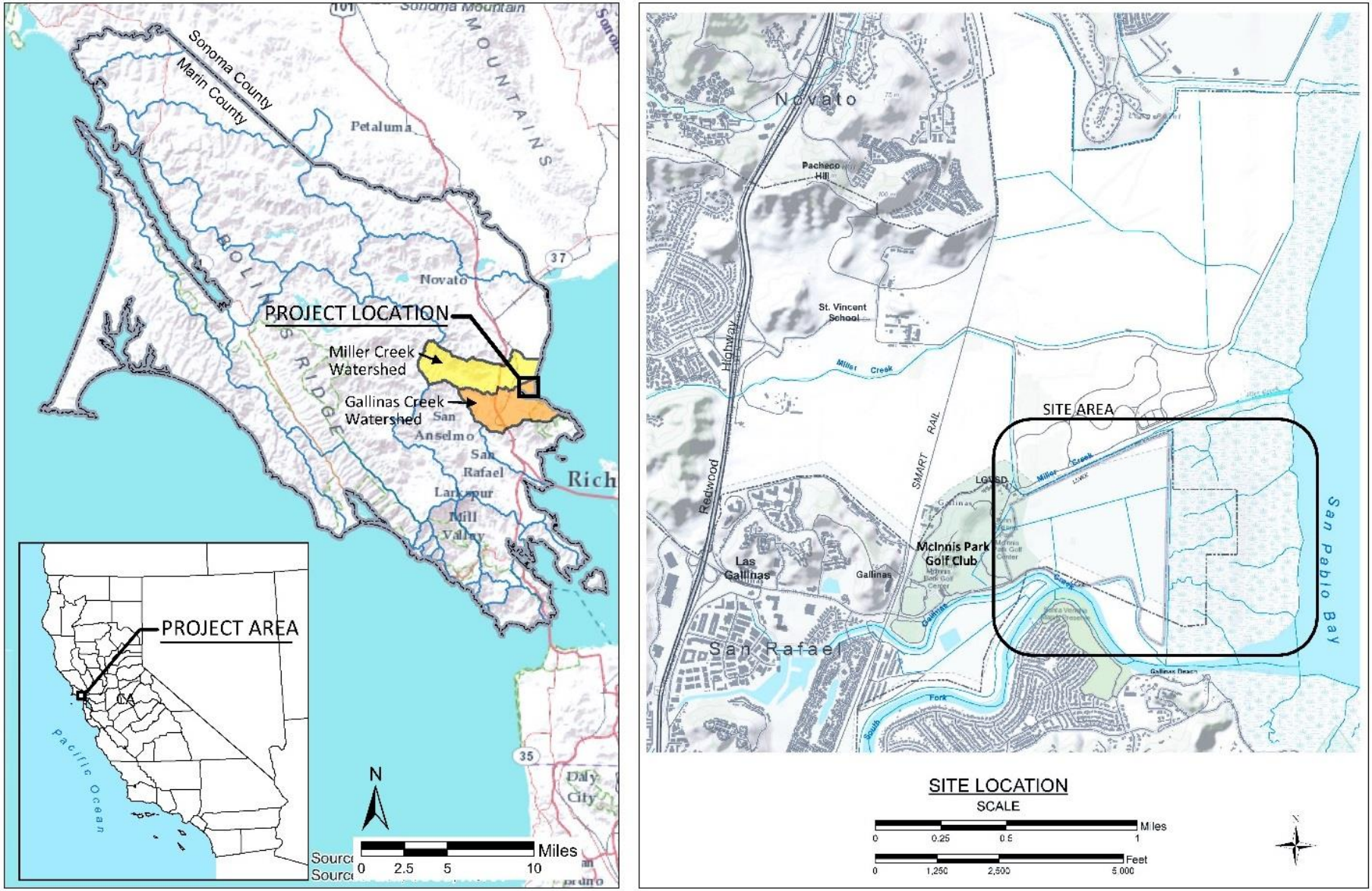
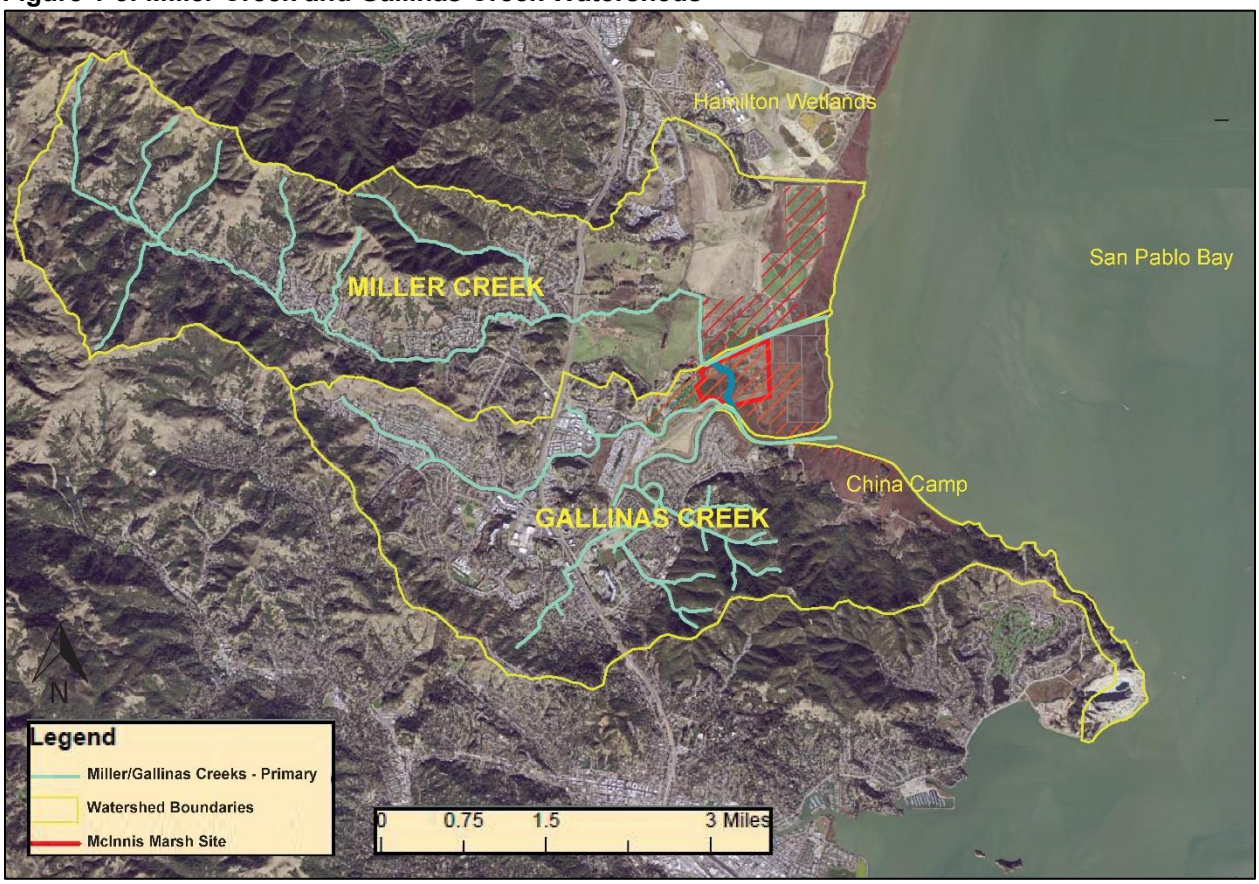


Figure 1-2: McInnis Marsh Site Location Map

Figure 1-3: Miller Creek and Gallinas Creek Watersheds



McInnis Marsh lies within the historic confluence of Miller and Las Gallinas Creeks (

). 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: Gallinas Bayland Tidal Wetland Drainages Circa. 1914 (courtesy of Marin County, 2010)

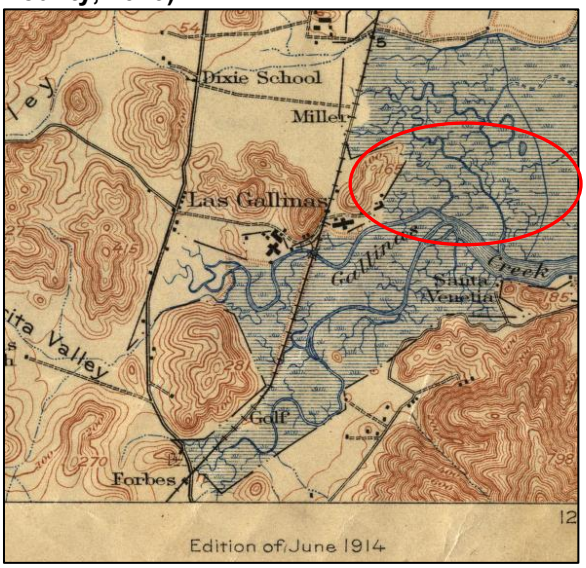
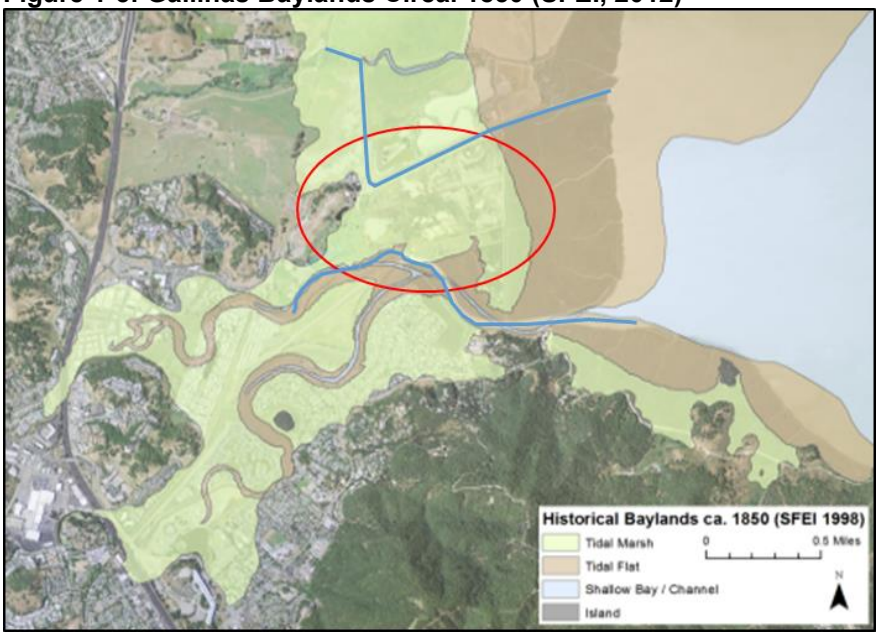
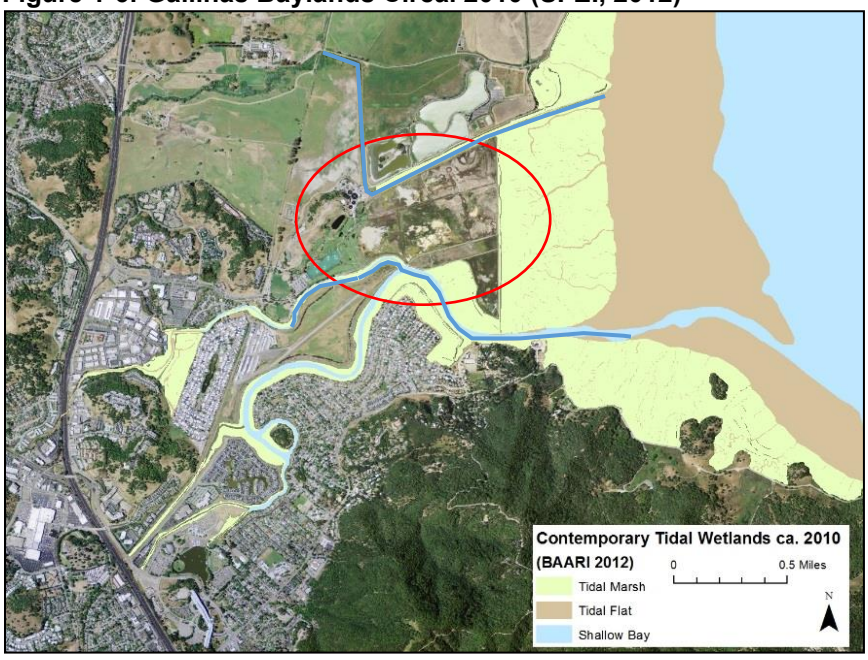


Figure 1-5: Gallinas Baylands Circa. 1850 (SFEI, 2012)



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 and Figure 1-6 respectively.

Figure 1-6: Gallinas Baylands Circa. 2010 (SFEI, 2012)



1.4 Restoration Project Scope and Benefits

The McInnis Marsh Restoration Project would restore tidal exchange to the 180-acre McInnis Marsh, expand contiguous high marsh habitat in the eastern marsh, increase tidal prism to Gallinas Creek, and potentially reduce the need for downstream dredging. The study focuses on

the feasibility of reconnecting Miller Creek to the Gallinas Baylands. This would restore a needed ecological corridor between the Gallinas Marsh complex a natural alluvial creek and riparian corridor[1]. The project includes connections via levee breach, channel construction and levee removal. Restoring connectivity between subtidal and intertidal 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. These actions also improve foraging and passage opportunities for Splittail and Steelhead. In the absence of these actions, rising tides will result in the progressive loss of intertidal wetland habitat, and the resident population of focal species.

In addition to expanding and sustaining critical habitat for wetland focal species and fish, the project integrates needed bayland infrastructure needed to address sea level rise in low-lying areas. Project improvements to community infrastructure include managed retreat and upgrade of coastal flood protection levees and trails, raising storm drains and treated wastewater outfalls, and incorporating reclaimed water reuse. The integration of coastal infrastructure and habitat would maintain and restore ecological connectivity across the upland riparian/tidal wetland transition zone, and maximize the capacity for wetland/riparian community response and adaption to climate change (sea-level rise and extreme climate events). If MCFCWCD implements a Gallinas Creek dredge project the opportunity also exists for the beneficial reuse of dredged sediment at McInnis Marsh.

1.5 Summary of Considerations

This FS includes both an assessment of opportunities and constraints, and identification and analysis of a suite of restoration alternatives. The feasibility study relies upon the evaluation of physical and biological conditions on the project site, the characterization of future habitat conditions on the project site, and the incorporation of the impacts of rising sea levels and increasing storm magnitude, on the project site (KHE, 2015). This work improves facilities and resource managers understanding of important considerations that influence the selection, design and implementation of restoration actions. These considerations are summarized below:

- McInnis Marsh sits within the Gallinas Bayland marsh complex, which supports a large number of breeding populations of focal (special status) species. Large-scale loss of high marsh habitat (>90%) is expected in Gallinas Baylands by 2100 due to sea level rise.
- The McInnis Marsh is hydraulically and physically isolated from the outboard marsh. Existing ecotones have an estimated 80% cover of non-native and invasive weeds, which reduce the ecological value and use of existing habitat.
- The greatest opportunity associated with this restoration project is the expansion and augmentation of existing habitat for two federally endangered species (California Ridgway's Rail and Salt Marsh Harvest Mouse), and one state threatened species (California Black Rail). Restoration actions that support focal species will also benefit other resident and migratory marsh denizens. More specifically, restoration actions that increase tidal influence and freshwater and sediment input to McInnis Marsh, will

[1] Upland reaches of Gallinas Creek are concrete lined channel that provides minimal ecological benefit for natural communities. Recently, the construction of SMART has further reduced the quality of the limited transitional and upland ecotones available.

increase habitat heterogeneity within the project site, and increase connectivity with proximate habitats, that may currently support these focal species.

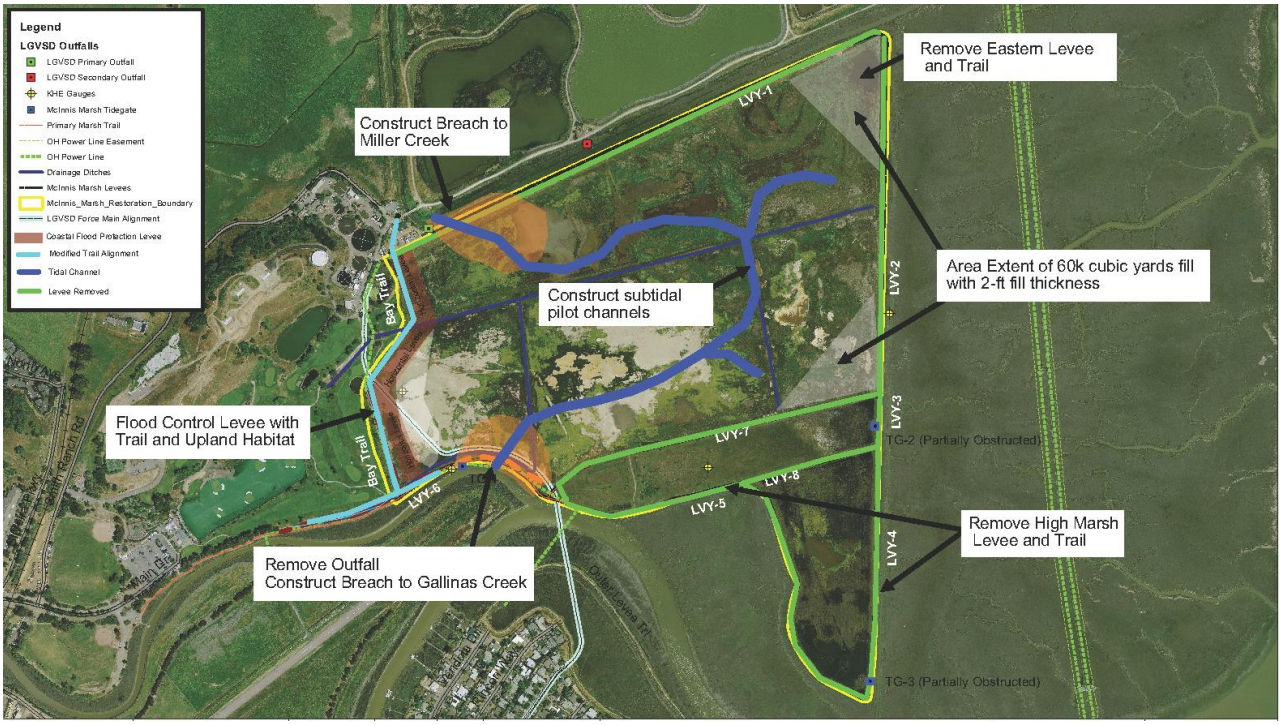
- The most significant constraint associated with this restoration project is the location of LGVSD facilities, which include two outfalls on Miller Creek, and a force main. The wet season outfalls are located on Miller Creek east of the LGVSD plant. The force main runs south from the LGVSD plant, traverses the western side of McInnis Marsh and continues south under Gallinas Creek to the community of Santa Venetia. Relocation and/or protection of these facilities would be required.
- The adjacent Miller Creek corridor hosts a comparable suite of focal species, as well as a resident population of steelhead. This highly altered drainage spans the upland transition zones. Restoring the connection between Miller Creek and McInnis Marsh would provide a viable, though narrow, corridor for upslope ecotone migration, in response to sea level rise. In addition, the added freshwater and sediment inflows to McInnis Marsh and the Gallinas Bayland would enhance ecological diversity and provide an additional source of alluvial sediment, which would increase marsh plain sedimentation rates, and in turn the capacity for natural adaption to sea level rise.
- The location of McInnis Marsh provides an ideal site to increase ecological connectivity between the functional tidal wetlands of the Gallinas Creek Marsh Complex, the San Pablo Bay shoreline and Lower Miller Creek.
- Within the 180 acre marsh complex, the 120-acre subsided parcel is four feet below the adjacent marsh plain. If open to tidal exchange, the basin would be inundated much of the time and function as a large open water bayland. Relocation of the perimeter levees provides a sufficient volume of material to implement the project without additional fill.
- The addition of fill material from the adjacent channel maintenance project is desirable to enhance and expand intertidal and upland transitional marsh habitats. Restoration design would benefit from the addition of as much as 200,000 cubic yards of additional fill.
- The opportunity for restored connectivity to transitional upland and riparian ecotones in the Miller Creek corridor, and the associated freshwater and sediment supply, increases the potential ecological value now and supports natural geomorphic adaption to sea level rise and large storm events over time.
- The five restoration alternatives described and evaluated in this FS represent actions that would improve habitat values for focal and resident wetland species. The first four alternatives (A-D) are an incremental suite of actions that increasingly restore habitats and physical processes to support wetland function and connectivity between Gallinas Baylands, McInnis Marsh, and Miller Creek. These actions could be undertaken together or in phases, and would improve existing habitat values, as well as ecotone resilience to climate change. Alternative E provides an alternative scenario to Alternative D, but connects McInnis Marsh only to Miller Creek. The five alternatives are summarized as follows:
    - Alternative A: Restoration via Modified Management. ($90,000) This Alternative modifies tide gate operations and uses vegetation management to increase habitat values in the subsided marsh and on the levees. No earthwork is undertaken.
    - Alternative B: High Marsh Levee Setback ($850,000), This Alternative excavates levees adjacent to existing high marsh. The excavated material would be reused on site to construct a new coastal flood protection levee for McInnis Park and adjoining lands. The new levee would necessitate upgrades to LGVSD force main and McInnis Park drainage facilities. Parks would build a new trail on this levee to allow for continued access to the bay and would designate it as a segment of the San Francisco Bay Trail.

- Alternative C: Tidal Wetland Restoration, with Breach to Gallinas Creek ($1,360,000) This alternative incorporates Alternative A and B actions and restores tidal exchange in McInnis Marsh by constructing a breach to the South Fork of Gallinas Creek. Excavation of the breach and subtidal interior channels, and removal of the eastern levee would reconnect McInnis Marsh to the surrounding Gallinas Baylands. This alternative allows for the reuse of excavated material to construct a horizontal levee bench along the eastern side of the new setback levee and placed within the basin to enhance wetland habitat.
- Alternative D: Tidal Wetland Restoration, with Breaches to Gallinas Creek and Miller Creek ($1,600,000) This Alternative incorporates Alternative A, B, and C actions and constructs a breach between Miller Creek and McInnis Marsh. LGVSD would raise or relocate its outfall as part of breach. The breach would add freshwater and coarse (creek) sediment to the restored marsh, increasing its ecological values and its capacity to aggrade (fill with sediment) and naturally adapt to sea level rise. The restored connection between Gallinas Creek and Miller Creek reopens an upland migration corridor that would provide valuable refuge and room for wetland ecotones to move upland. The connection of Miller Creek to the subtidal channel of Gallinas Creek also improves fish passage for steelhead resident in Miller Creek.
- Alternative E: Tidal Wetland Restoration, with Breaches to Miller Creek ($1,700,000) This Alternative restores tidal exchange to McInnis Marsh without connection to Gallinas Creek. The alternative includes removal of perimeter levees, as in Alternative D, but does not include a breach to Gallinas Creek. Instead, Parks would construct a second, more eastern breach on Lower Miller Creek to maximize conveyance through McInnis Marsh. This Alternative enhances tidal marsh without a connection between Miller and Gallinas Creeks. This alternative would provide the highest benefit for focal species, but does not provide enhancement to as broad a suite of native wetland species.

1.6 Recommendations

Based on the analysis of site conditions, opportunities and constraints, and alternatives, the KHE team recommends Alternative D for implementation at McInnis Marsh. Alternative D maximizes ecological values in McInnis Marsh, removes and reuses upland fill for habitat enhancement, and integrates needed improvements in infrastructure to protect existing parks facilities, maintain public access to the bay, maintain LGVSD services, provide coastal flood protection, and incorporate drainage. This alternative restores a valuable estuarine transition zone that would benefit the broadest possible palette of subtidal, intertidal, transitional, and riparian species. The connection to Miller Creek restores the capacity for natural geomorphic processes to support habitat development and response to climate change. This alluvial sediment supply is critical to marsh formation at McInnis, and will increase the persistence of the Gallinas Bayland marshes as sea levels rise.

Figure 1-7: Recommended Alternative D: Tidal Wetland Restoration with Breach to Gallinas Creek and Miller Creek



2 Opportunities and Constraints Analysis

The following summary of restoration opportunities and constraints is based on information gathered in site analysis (Attachment A), and on preliminary restoration concepts described in Section 3 of this report. This report categories the opportunities and constraints into three categories: ecological, infrastructural, and recreational. Overall, there are many opportunities for ecological enhancement at McInnis Marsh. None of the constraints, including protection of existing habitat, adjacent property, and public utilities and infrastructure, renders the project infeasible. In addition, the project partners can implement associated action that support needed improvements to community infrastructure (i.e., levees, storm water and wastewater facilities). Figure 2-2 resents a base map of the project area illustrating site features.[2]

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

[2] The analysis and description of alternatives presented utilizes a CA State Plane III projection and NAVD88 vertical datum.

2.1 Opportunities

2.1.1 *Ecological Opportunities*

- Restore tidal exchange and enhance ecological values at McInnis Marsh, a 180 acre-historic southern San Pablo Bay tidal wetland. McInnis Marsh restoration will expand contiguous available habitat for more than a dozen special status species known to occur in adjacent salt marshes, including federally endangered Ridgway Rail, Black Rail, and Salt Marsh Harvest Mouse. Restoration will include: 1) expansion of existing marsh plain habitat; 2) reintroduction of tidal exchange to historically tidal wetland, that is now a diked and subsided seasonal wetland; and 3) reconnection of Miller Creek to Gallinas Creek.
- Restore ecological connectivity from subtidal San Pablo baylands, across the estuarine transition zone to an alluvial creek channel; thereby, enhancing fish passage and upslope migratory corridors for both the local steelhead population and native wetland plant and animal communities.
- Enhance wetland, upland and riparian ecotone connectivity from San Pablo Baylands, across estuarine and seasonally fresh water transition zones to upland riparian corridor[3]. The availability of contiguous upslope habitat will enhance plant and animal community resilience to climate extremes, predation pressure, and the opportunity for upslope migration in response habitat loss associated with both episodic storm events and sea level rise. This broad transition zone provides habitat and buffers the erosion and disturbance impacts of extreme storm events.
- Restore a corridor for the movement of coarse alluvial sediment (sand and gravel) from Miller Creek to McInnis Marsh by removing dividing levees. An alluvial sediment supply will support estuarine wetland regeneration, and is especially important for high marsh formation in the subsided portion of McInnis Marsh. Sediment deposition rates across the riparian bayland transition zone will increase with rising tides, and the aggrading sediment will support natural marsh plain aggradation and adaption to sea level rise. The alluvial sediments also may help to sustain the Gallinas Creek Marsh Complex[4].
- Expand contiguous wetland marsh plain habitat for breeding populations of Rails. There are two smaller un-subsided basins within McInnis Marsh that are currently at high marsh grades, but do not support rails. By removing dividing levees and construction of small tidal channels, Parks will likely improve habitat quality and permit the rapid expansion of adjacent high density nesting habitat.
- Optimize subtidal habitat within the subsided basin for Sacramento Splittail, as well as juvenile nursery/ rearing habitat for a variety of species, including steelhead. Splittail spawn in shallow water (less than 2 meters deep) over flooded vegetation habitat

[3] Ecological connectivity is best established by restoring continuous environmental gradients (transition zones or ecotones) between subtidal baylands, intertidal mudflats, and marshes, through the estuarine transition zones to riparian, creek channel, and upland habitats.

[4] Stream sediments are critical to supporting existing San Francisco Bay wetlands because the projected acceleration of sea level rise is likely to exceed the capacity for vertical growth in most San Francisco Bay salt marshes. To survive, bay marshes will need to store sediments, aggrade, and keep pace with seal level rise. Marshes with a terrestrial/alluvial sediment supply are most likely to be sustained by natural landscape adaption processes.

(CDWR 2013). Thus, the project could create spawning and rearing habitat for splittail, steelhead, and other fishes in the subsided portion of McInnis Marsh. In intertidal areas, grades constructed or developed through natural sediment aggradation processes will increase habitat value for wading birds.

- Construction of a channel connecting McInnis Marsh and Miller Creek would expand steelhead migration corridors between the Gallinas Creek Marsh Complex and Miller Creek. By reestablishing a corridor from the North Fork of Gallinas Creek to Miller Creek, the project would improve sediment transport in lower Miller Creek and reduce ongoing channel aggradation. High sediment loads currently results in the formation of channel spanning bars. Under dry/low flow conditions, these elevated bed forms create isolated pools with poor water quality. In addition, the channel realignment will connect Miller Creek to subtidal channels within Gallinas Creek, reducing the length of intertidal mudflat and channel between Miller Creek and San Pablo Bay.
- The restoration will include improved efforts to manage invasive weeds to support the restored native plant communities and wildlife habitat. Improved transition zone and upland vegetation management will improve aesthetic values for visitors, and habitat values for resident and migratory species.

2.1.2 *Infrastructural Opportunities*

- Plan and implement managed retreat (landward relocation) of bayward levees removing unneeded infrastructure, improving critical habitat for endangered species and reducing levee and trail maintenance obligations. Establishing a more western "set back" levee alignment (See Alternative C, Figure 4-3) will reduce the growing maintenance needs and safety concerns of the existing levee trail[5]. In addition, installation of wider, gently sloping ("horizontal") levee behind wide restored marshes may reduce wave run-up despite sea level rise, and thereby reduce the need to raise levee crest elevations as sea level rises. Managed retreat of levees would reduce long-term levee and trail maintenance obligations, and reduces the risk of levee failure and reconstruction.
- Reuse excavated levee material in a setback levee alignment incorporating a multi-use trail. To the extent possible, expand the upland transition zone along the levee to provide high tide refuge along the marsh perimeter. Managed retreat (and removal of outboard levees) creates a source of material for construction of new coastal flood protection levees for McInnis Park and adjacent landowners.
- Creating wide low gradient vegetated levee slopes will increase shoreline stability and buffer storm wave energy that would otherwise pose high risk of erosion or overtopping. Ecologically, the wider levee slope expands the diverse and species-rich wetland/upland transition zone and provides high tide refuge along the marsh perimeter.
- Integrate wastewater effluent reuse/discharge in the creek corridor plan and horizontal levee design to support freshwater transitional and upland ecotones along the western edge of the wetland. Integrate McInnis Park drainage in the horizontal levee design to maintain storm water conveyance for adjacent and upslope parcels.

[5] At its current elevation, this trail is will require increasing repair due to flooding.

- Increase the North Fork Gallinas Creek tidal prism bayward of the McInnis Marsh confluence to sustain a navigable channel thalweg in Lower Gallinas Creek, and thereby reduce maintenance dredging obligations.
- If available, incorporate up to 100,000 CY cubic yards of South Fork Gallinas Creek dredge material in the restoration design. Dredge material placed within the subsided basin will raise site grades and speed establishment and spread of marsh and subtidal vegetation. Local dredge material disposal will reduce dredging costs.

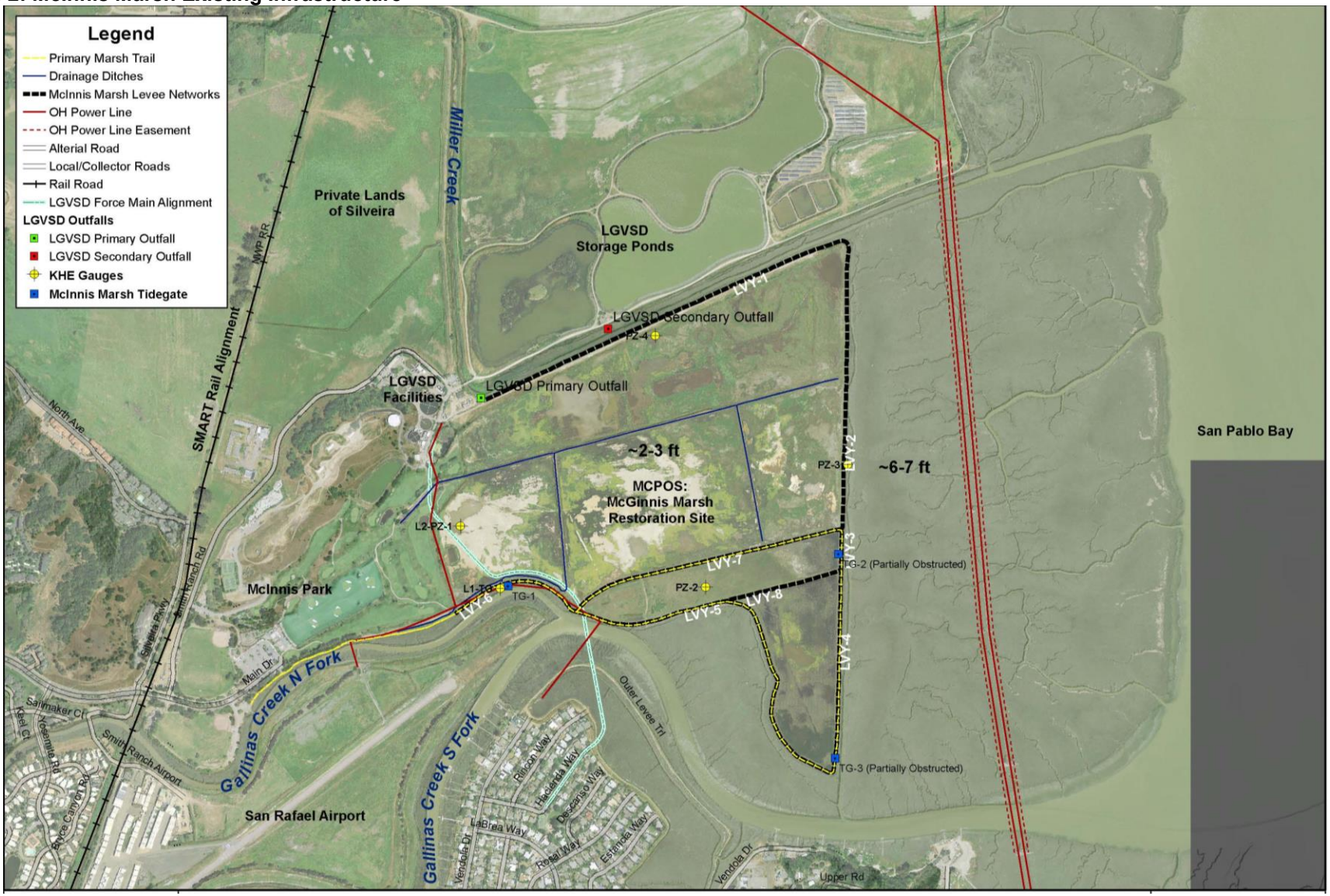
2.1.3 *Recreational Opportunities*

- Trail Use. Install a multiuse trail that will: improve the public access trail connection between McInnis Marsh and LVGSD wetland trails; serve as an extension of the Bay Trail; and reduce recreational disturbance to special status species. Provide interpretive opportunities (scenic and wildlife viewing points, interpretive displays) along the new trail alignment, which will traverse San Francisco Bay ecotones from historic bayland to riparian corridor[6]. The change in trail alignment and managed retreat of the outboard levee trail supports the recovery of endangered species on Parks' property.
- Managed Retreat of Levee Trails. Loss of public access along the levee trails is a likely impact from sea level rise and other effects associated with climate change. The project provides Parks with an opportunity to incorporate continued public access to the bay as part of the project.
- Visitor Experience. Enhance the visitor experience by providing interpretive opportunities along the new trail alignment. This visitor use access will allow for wildlife viewing and other forms of passive recreation. In addition, Parks has an opportunity to provide public interpretation and education. The new trail will span a continuum of habitat types, from subtidal marsh to riparian creek, with exceptional opportunities for waterfowl and wildlife viewing. During the 10-20 year transitional period following tidal restoration, the subsided basin site will primarily support sheltered, productive shallow open subtidal water and lower intertidal mudflat habitat. Fish and benthic invertebrate productivity would likely attract conspicuous numbers of shorebirds, diving ducks, wading birds, and dabbling ducks. Watchable wildlife within the basin would likely be spectacular before tidal marsh dominates the tide-breached baylands[7].
- Interpretive and Educational Signage. Signs and observation points will be defined that will build public awareness and understanding of the phases of the project, the goals of the project, the intended outcomes, and how the public can become involved in stewardship efforts. Interpretive displays would be able to narrate the rapid evolution of the wetland habitats in the transformed baylands landscape as it responds to short-term restoration actions and long-term climate changes. Education and experience would likely lead to increased public engagement and support of the project. Restoration design should include signage that interprets the restoration process, the range of habitats, and the ecological response to climate change over time.

[6] Interpretive opportunities include observation of: 1) the landscape response to short-term restoration actions; 2) progressive evolution to estuarine salt marsh; and 3) upslope habitat migration in response to sea level rise.

[7] Increased fish populations are also likely to increase recreational fishing opportunities in the Gallinas Baylands.

Figure 2-2: McInnis Marsh Existing Infrastructure



2.2 Constraints

2.2.1 *Ecological Constraints*

The project site currently functions as a seasonal wetland. Proposed actions would convert seasonal wetland to tidal wetland and generally improve ecological values within the parcel. Primary ecological constraints lay in minimizing impacts and disturbance to existing wetlands and the changes in habitat as the site evolves from subsided open water bayland to mature marsh. None of the constraints described below preclude project implementation.

- The subsided portion of the site has existing grades of 1-2 ft. NAVD88, which are 2-4 ft. below low and high marsh plain habitat elevations for special status species. Following restoration of tidal flows, the site will support shallow open water habitat, and form estuarine mudflat and salt marsh with the deposition of sediment from San Pablo Bay and Miller Creek. During this 10-20 year transitional period, when the subsided basin supports primarily open water habitat, there will be an interim loss of wetlands. This temporary, decade or more, reduction in overall vegetated wetland habitat, currently provided by non-tidal seasonal (summer-dry) wetlands, would be offset by both rapid and slow ecological succession to new tidal aquatic and wetland habitats with year-round versus winter-spring high productivity8. Over decades, tidal marsh (primarily cordgrass) will re-establish vegetated wetlands over portions of the site's emerging mudflats. The extent of vegetated tidal wetlands will depend on the rate of regional sea level rise, and local (creek and wetland) sediment deposition rates.
- The intertidal site will function much like the adjacent tidal creek and marsh channels. However, sediment depositional could obstruct drainage under low flow conditions. If necessary, local grading may be required to clear channels to maintain drainage and for vector control.
- Levee removal, channel excavation and other heavy earthworks will create a short-term disturbance within the McInnis Marsh interior. Parks will implement the project to minimize impacts to sensitive species by use of buffers and avoidance of critical use seasons.
- Parks will minimize impacts to the outboard marsh by using appropriate buffers and scheduled work to avoid disturbance during sensitive use periods.
- Existing ponds store storm and irrigation water at the south western corner of McInnis Marsh. The freshwater habitat is highly desirable to many resident and migratory coastal marsh birds. Restoration actions should protect or maintain a freshwater marsh ecotone.

2.2.2 *Infrastructural Constraints*

The most significant infrastructural constraints are associated with existing LGVSD's facilities including their primary plant outfall, which is located on Miller Creek just downstream of the Reclamation Bridge, and the LGVSD force main, which traverses the site, crossing the alignment of the setback levee and the breach to Gallinas Creek.

[8] In the short-term (1-2 years), estuarine fish and benthic invertebrate productivity would likely increase significantly and attract conspicuous numbers of shorebirds, diving ducks, wading birds, and dabbling ducks. Wildlife viewing opportunities are expected to increase from seasonal (wet season only) to year-round.

- **Wastewater discharges:** The LGVSD force main traverses the western end of McInnis Marsh, and runs parallel to the southern levee before continuing South across the North and South Forks of Gallinas Creek to the community of Santa Venetia. Restoration actions should minimize impacts to the force main. Unfortunately, the current force main alignment is likely to intersect with the setback levee alignment, the McInnis Marsh levee breach to Gallinas Creek, and portions of the restored subsided basin. Construction of a new overlying levee would be problematic, because consolidation and settle of the surrounding bay mud would compromise the integrity of the line. Therefore, a new LGVSD force main will be required in locations intersecting the setback levee. At a typical grade of -6 ft. (NAVD88), the force main crosses below the Gallinas Creek bed, and has not constrained prior dredging of Gallinas Creek. Therefore, Parks can undertake levee removal, channel excavation, and wetland restoration without affecting the force main (*Pers. Comm.* M. Williams, LGVSD). The restoration design will maintain adequate cover along force main alignment.

  The outfall for LGVSD's waste water treatment facilities currently discharges to Miller Creek approximately 150 feet bayward for Reclamation Bridge and just upstream of the anticipated connection between Miller Creek and McInnis Marsh. The outfall is currently at an elevation of -1 foot (NAVD88), and is at risk of burial by aggrading creek sediments. Bed elevations in Miller Creek and in McInnis Marsh are currently at one foot, and will likely increase over time in response to aggrading sediments and sea level rise. Raising and/or relocating the outfall will be necessary to accommodate both aggradation due to rising tides and the anticipated increase in coarse sediment that will be conveyed past the outfall after reconnecting Miller Creek to McInnis Marsh. Members of the public have expressed a preference for maintaining the Miller Creek outfall downstream of the Miller-Gallinas confluence, and have objected to discharge of treated effluent to Gallinas Baylands (pers. comm. M. Williams, LGVSD). *Restoration design should ensure the discharge of treated effluent does not adversely affect McInnis Marsh or Gallinas Bayland wetlands or water quality.*

- **Storm water and irrigation water discharges.** Drainage ditches from the adjacent McInnis Park and golf course convey storm water and excess irrigation water to the marsh. Restoration actions should incorporate modifications to maintain this or a comparable level of drainage for upslope parcels. To the extent that sediments move through McInnis Marsh as internal grades rise, the alluvial sediments may aggrade at the North Fork Gallinas Creek confluence. Restoration actions should incorporate measures to maintain tidal exchange and flood conveyance in upstream reaches of the North Fork Gallinas Creek. Hydraulic analysis should also be undertaken to confirm that the proposed addition of Miller Creek discharges to the Gallinas Baylands do not increase flood risks in the adjacent Santa Venetia, Captain's Cove and Contempo Marin communities.

2.2.3 *Regulatory and Land Use Policy Constraints*

There are several land use and regulatory constraints on the restoration of McInnis Marsh. None of the constraints, identified and summarized below, would prohibit restoration, but rather only minimally influence development of design alternatives.

Memorandum of Agreement. Implementation of any restoration alternative will require the full participation of the three public agencies: Parks, LGVSD, and MCFCD. Currently, the three agencies are party to a Memorandum of Agreement (signed Sept. 18, 2012) that sets parameters for how the agencies will work together to prepare this feasibility study. In order to

move forward with design, environmental review, permitting, funding, and implementation, the Agencies will need to revise the Memorandum of Agreement.

County Service Area No. 6 (CSA 6). In implementing the project, Parks will need to coordinate with the MCFCWCD on its Lower Gallinas Creek dredging, as funded by CSA-6. The Attachment C includes Marin County Board of Supervisors resolution creating CSA-6 and a map of its boundaries. The boundaries of CSA-6 include a portion of the North Fork of Gallinas Creek upstream of the confluence, and McInnis Marsh near the LGVSD force main crossing. The project will increase tidal prism to the lower bayland, supporting channel maintenance and reducing dredging needs. In addition, McInnis Marsh restoration provides an opportunity for local reuse of dredge material, thereby reducing project costs if CSA 6 were to implement a concurrent dredging project in lower Gallinas Creek.

Property Ownership. The project area consists of parcels solely owned by the County of Marin. The LGVSD owns adjacent parcels to the north and the State of California, County of Marin, and Marin County Open Space District owns parcels to the east. There are no constraints associated with private property owners, or site access.

Adjacent Land Uses

The privately owned and operated San Rafael Airport is to the south of the project area. The Airport is in historic tidal baylands that are a relatively high use corridor for migratory birds, waterfowl, and shorebirds that move between the Marin County Civic Center lagoon to the south, and the LGVSD ponds to the north. Creation of deep water and intertidal habitats in the project area will likely attract an increased number of migratory waterfowl and shorebirds. As such, there may be some increased risk to migratory birds in the corridor (e.g., bird strike), as well as some increased risk to aviation safety.

The McInnis Park Golf Course is to the west of the project area. While both the golf course and the driving range are within the boundary of McInnis Park, a private entity operates these facilities under lease agreement with Parks. This entity performs all maintenance of the lands and facilities within the Golf Course and Driving Range. Currently, the golf course drains to McInnis Marsh. As such, coordination between the lessee and the collaborating agencies, will be necessary in order to manage changes in drainage from the golf course to McInnis Marsh.

Pacific Gas & Electric Company. The Pacific Gas & Electric Company (PG&E) facilities (i.e., poles, lines, wires) could limit excavation and movement of soils, relocation of levees, and creation of habitat in a small part of the project area. Relocation of any of PG&E's facilities in order to implement restoration actions is highly unlikely.

San Francisco Bay Trail. The alignment of the San Francisco Bay Trail follows the levees in McInnis Marsh. The removal of these levees will affect this segment of the Bay Trail. However, the new horizontal levee will include a new trail alignment, which will replace the affected segment of the Bay Trail.

San Francisco Water Trail. The San Francisco Water Trail identifies a landing site on Gallinas Creek at McInnis Park, several hundred feet west of the marsh. However, there are no landing sites adjacent to the marsh.

2.2.4 *Recreational Use Constraints*

Currently, visitor access to and use of the lands within McInnis Marsh is via a trail network that extends along existing levees. The trail network provides access for pedestrians, and pedestrians with dogs on leash, and bicyclists. Other activities popular with users include bird watching, wildlife viewing, and photography. The removal of the levees will result in elimination

of the existing trail. However, these trails are likely to be lost to sea level rise in the near future, and the project will protect this use by providing an alternative route not threatened by sea level rise.

Visitor Access. The removal of the existing levee system as part of the project will also eliminate the existing trails. The loss of this access will occur as the bay elevations continue to rise. Additionally, storm surges and other flood hazards will increase hazards related to continued public use of the levee trails. One of the purposes of the project is to protect public access to the bay by building a new trail on the horizontal levee and improve connections to trails on the LGVSD property.

3 No Action: Project Rationale

Ridgway' Rail

Black Rail

Salt Marsh Harvest Mouse

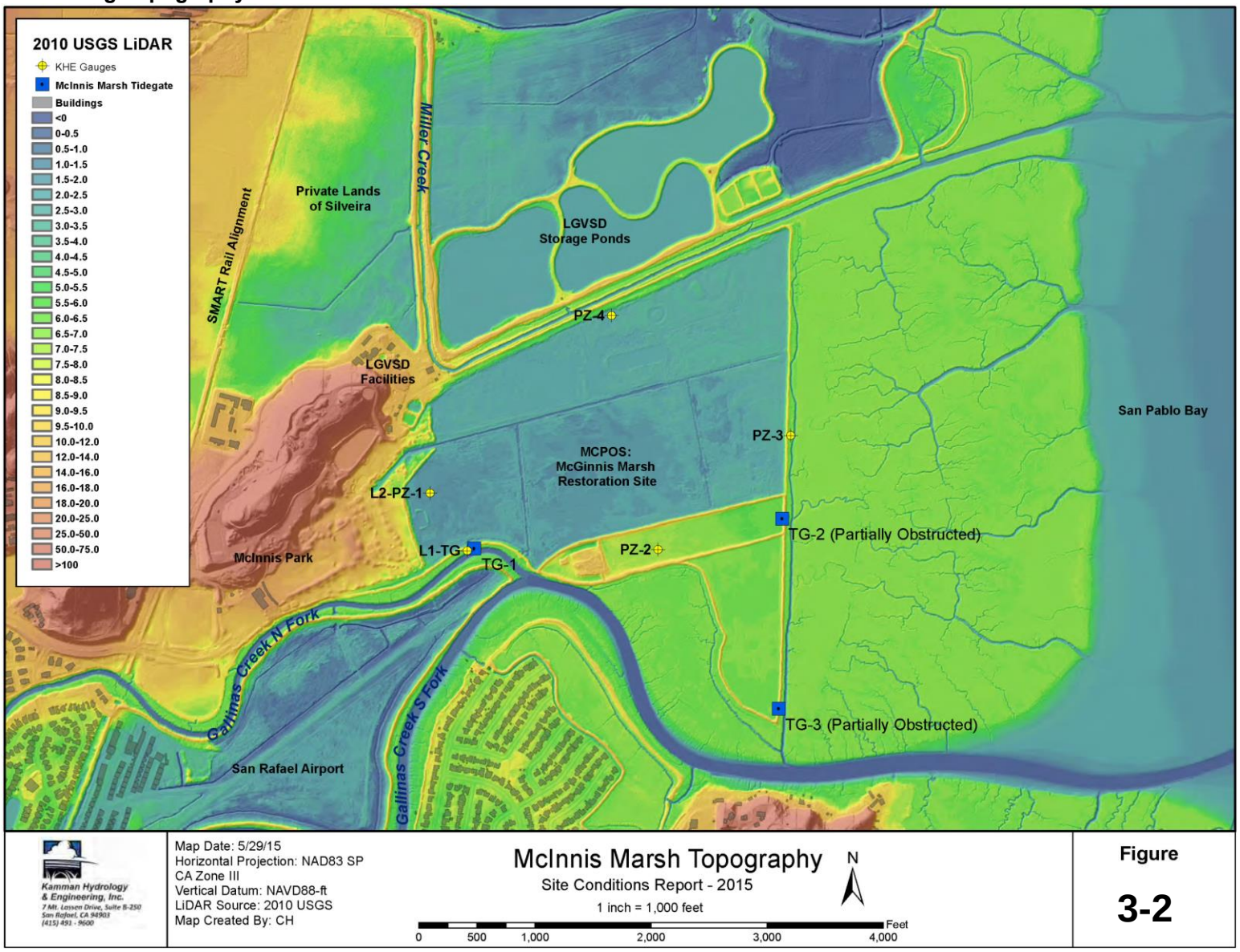
Figure 3-1: Focal Species for Gallinas Bayland Restoration

3.1 Existing Biological Conditions

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 (Figure 1-4, 1-5). It is part of the Gallinas Creek Marsh Complex, which supports a diverse population of wetland species, including 30 state and federally listed special status species. Table 3-1 summarizes special status species known or expected to occur in the area. A levee system built in the early 1900s isolates the site from surrounding hydrological influences and fragments the wetland habitat mosaic that existed previously. Restoration of McInnis Marsh is a valuable opportunity to improve and expand wetland habitat deemed critical for species survival (USFWS, 2009).

The underlying restoration assumption is that restoring connectivity with adjacent Gallinas Creek Marsh Complex and increased freshwater and sediment input from Lower Miller Creek will increase habitat heterogeneity and, in turn, increase biodiversity. The reintroduction of fluvial (creek) inputs of water and sediment increase ecological diversity and marsh accretion rates, slowing and potentially abating habitat loss due to sea level rise. In addition, opening the corridor between bayland and upland provides opportunity for ecotone shifting and wildlife movement along a contiguous unobstructed bayland to upland corridor.

Figure 3-2 Existing Topography



Currently, the site is subject to limited tidal influence, and is isolated from the fluvial influence of Miller Creek. Drainage from the parcel is from a single manmade channel connected to the adjacent tidal marsh through a culvert with an operable tide gate. Attachment A includes a detailed site assessment and characterization of existing physical and biological conditions. Information from those studies serves as the basis for conceptual design and evaluation of proposed alternatives.

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

Source[9]	Occurrence[10]	Common Name	Latin Name	Federal ESA Status	State ESA Status	CDFW Status[11]
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*			
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*	Endangered	Endangered	FP

[9] 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

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

[11] 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[9]	Occurrence[10]	Common Name	Latin Name	Federal ESA Status	State ESA Status	CDFW Status[11]
			raviventris			
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				-

3.2 No Action Elements

Under the No Action Alternative, there would no modifications to existing conditions or operations are proposed. In this Alternative, Parks would continue current trail and infrastructure maintenance. However, because of rising tides and increasing storm magnitudes, ongoing operations over a 50-year project life will require both increasing maintenance and improvement to existing facilities (levees, trails, and tide gates) as described below.

A. Perimeter Levees[12]: 8,800 linear feet of perimeter levee surrounds the subsided parcel. Ongoing levee maintenance and improvements will be required to maintain the current level of flood protection. Table 3-1 summarizes USACE predicted existing and future water surface elevations in Gallinas Creek considering both storm flow and costal (tidal) flood risk (USACE, 2013). Under current conditions much of the levee currently provides approximately 50-year flood protection with crest elevations currently at 9 ft. or greater. Two locations where levee crest elevations drop to between 8 and 9 feet (at McInnis Golf Course (station 125+00) and at the southeast corner of the site (station 55+00) (See Figure 3-2 and Attachment A, Figure 2-20) should be raised to 9 ft. to provide 50-yr. flood protection and preclude near term overtopping. USACE estimates indicate that existing levee crest elevations will need to be raised to 10-11 feet to provide a comparable level of flood protection in the future.

Table 3-2: Gallinas Creek predicted storm water surface elevations maximums.

Annual Probability (%)	Return Period (Years)	Current Conditions Storm Water Surface Elevations Max (feet, NAVD88)	Year 50 Conditions Storm Water Surface Elevations Max - Low (NRC1) (feet, NAVD88)	Year 50 Conditions Storm Water Surface Max - High(NRC3) (feet, NAVD88)
50	2	7.89	8.69	9.99
20	5	8.29	9.09	10.39
10	10	8.49	9.29	10.59
4	25	8.79	9.59	10.89

[12] Note: Parks currently maintains the levee tops and trails, and the McInnis Marsh tide gate. Marin County Flood Control maintains the levee structurally.

Annual Probability (%)	Return Period (Years)	Current Conditions Storm Water Surface Elevations Max (feet, NAVD88)	Year 50 Conditions Storm Water Surface Elevations Max - Low (NRC1) (feet, NAVD88)	Year 50 Conditions Storm Water Surface Max - High(NRC3) (feet, NAVD88)
2	50	8.99	9.79	11.09
1	100	9.09	9.89	11.19

B. Tide Gates: The ongoing operations and maintenance of the tide gate will not require any modifications. Long-term management will require levee improvements to prevent overtopping of the tide gate, and a pump to provide drainage for storm and bay water against rising bay tides.

C. Trails: Because of accelerated sea-level rise, Parks will have to modify its trail operations and maintenance practices. The trails sit atop levees that are at a typical crest elevation of 9-feet. In the absence of actions to raise the levees, trails will be subject to increasing risk of overtopping. Table 3-1 indicates that the predicted frequency of storm water levels exceeding the levee crest elevation shift from a 1% probability (100-year return period) to a 20-50% probability (a 5 to < 2-year return period) between current and 50 year conditions. As flood events occur with increasing frequency, Parks can expect more closures and additional maintenance requirements of the trails. Additionally, potential increases in storm surge and storm frequency raise the potential for levee breaches.

3.2.1 *Habitat Response to No Action and Sea Level Rise*

Change in Wetland Communities

In the absence of habitat enhancement actions at McInnis marsh, there could be a significant impact to sensitive wetland habitat. In Gallinas Creek baylands studies indicate that 1.3 feet of sea level rise within the fifty-year planning horizon, will bring an increasing risk of levee overtopping and a rise in saline groundwater. Wetland conditions, plants, and animals will evolve with increases in salinity, and the depth and duration of ponding. If Parks operates the tide gate to maintain a limited degree of tidal influence, the rate of change will be slower within the subsided McInnis Marsh parcel than is predicted for the surrounding wetlands. The un-subsided parcels, which have the highest topography in the basin, will continue to support high marsh vegetation. In the surrounding "outboard" marsh, sea level rise will generally result in a comparable increase in habitat grades. Rising tides and increasing storm magnitudes will progressively inundate the surrounding wetlands and will result in regional loss of high marsh habitat between now and 2100.

Figure 3-3 illustrates the projected areal extent of tidal inundation associated with current tidal datums and projected mean higher high water elevations in 20, 50 and 100 years (0.5, 1.3 and 2.8 feet, respectively[13]. The total area shaded at, or below, each elevation mark indicates the

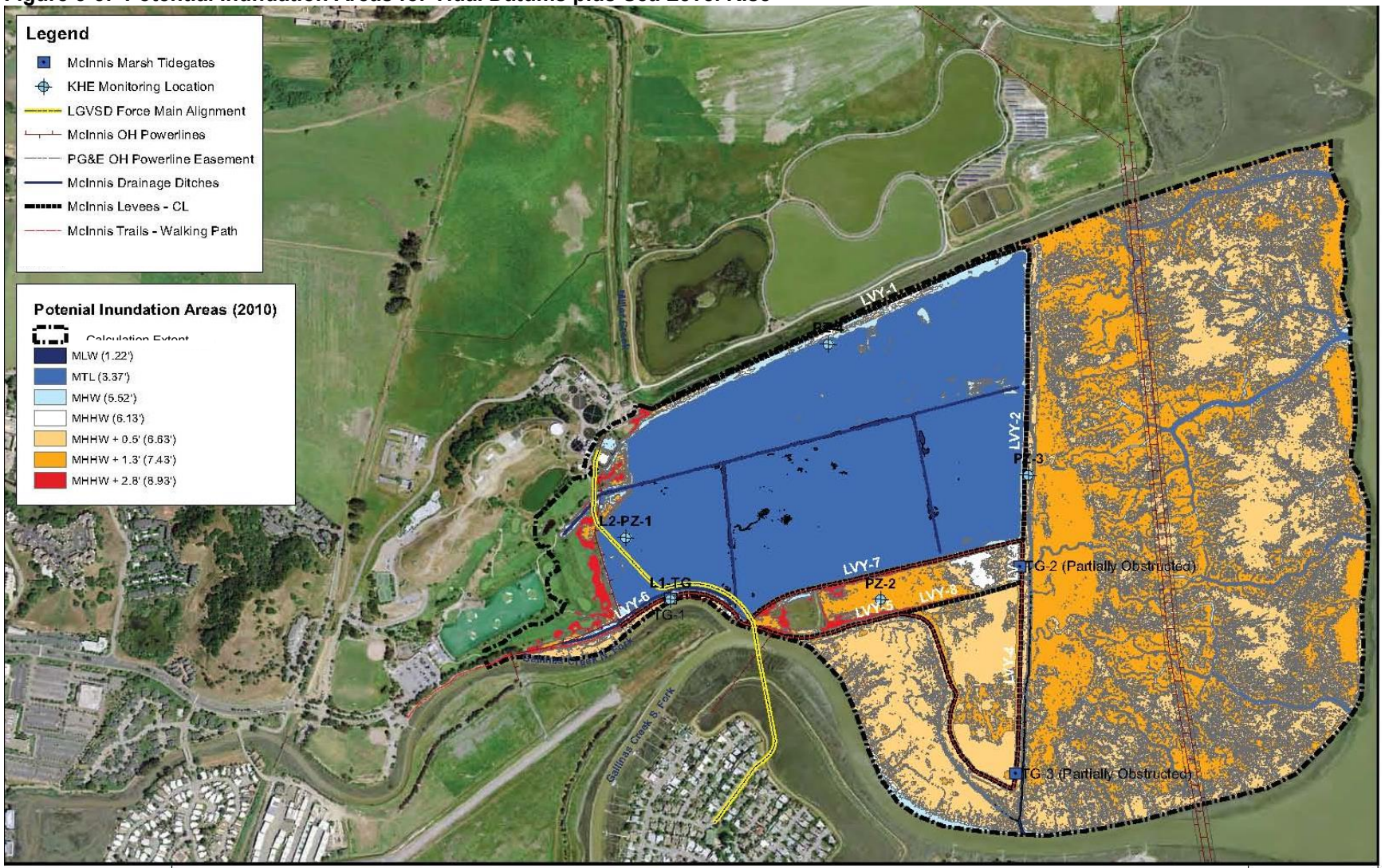
[13] Projected rates of marshplain sedimentation will not keep pace with rising tides.

percent of the marsh that the tides will inundated at MHHW over time. The waning areal extent of each band is indicative of the expected loss in high marsh habitat over time.

Increasing tidal inundation would transform the existing high marshplain into low marsh/mudflat habitat. High marsh ecotones will transition from broad flat marsh plain onto the narrow banks of bounding levees. The habitat shift across the leveed terrain will result in a progressive loss of high marsh habitat and already scarce transitional and upland habitat. The capacity for marsh plain response to sea level rise is limited by the available supply of sediment from San Francisco Bay. Historically, sediment supply has been low in this sheltered corner of San Pablo Bay[14]. The steeply sloped levees around the marsh perimeter offer minimal room for upslope marsh migration. As a result, we anticipate area wide loss of wetland habitat critical to support focal species. Table 3-2 summarizes the predicted changes in available habitat within McInnis Marsh, the surrounding Gallinas Baylands and the Miller Creek corridor.

[14] Sediment mobilized from the recently breached Hamilton Wetlands may increase local sediment supply. However, the projected rates of marshplain sedimentation are not anticipated to keep pace with rising tides (Calloway, 2012)

Figure 3-3: Potential Inundation Areas for Tidal Datums plus Sea Level Rise



Kamman Hydrology & Engineering, Inc.
7 Mt. Lassen Drive, Suite B-250
San Rafael, CA 94903
(415) 491 - 9600

Potential Inundation Areas with Sealevel Rise

McInnis Marsh Restoration Project

1 inch = 1,000 feet

0 250 500 1,000 1,500 2,000 Feet

N W E S

Imagery Source/Date: USGS/2011
LGVSD force main alignment was digitized from plan sheets provided by LGVSD dated October, 1984 by Nute Engineering.
Vertical Datum: NAVD88-ft
Tidal Datums based on Gallinas Creek NOAA Gauge 9415052

Figure 3-3

Table 3-3: Predicted changes in McInnis Marsh habitat with sea level rise.

Potential Habitat Zones – McInnis Marsh Restoration Site[15]

Habitat Zone	2010 Conditions (Acres)	2020 Conditions (Acres)	2050 Conditions (Acres)	2100 Conditions (Acres)
Mudflat/Open Water	0.00	0.44	8.22	121.87
Lower Intertidal Marsh	130.92	134.92	128.94	24.99
Upper Intertidal Marsh	14.89	23.35	35.43	33.34
Upland Transition Zone	30.10	21.48	8.98	7.86
Upland	12.15	9.78	6.49	2.11

Potential Habitat Areas – Miller Creek Corridor[16]

Habitat Zone	2010 Conditions (Acres)	2020 Conditions (Acres)	2050 Conditions (Acres)	2100 Conditions (Acres)
Mudflat/Open Water	0.00	0.00	0.05	4.10
Lower Intertidal Marsh	4.59	5.22	6.07	4.93
Upper Intertidal Marsh	4.28	7.5	14.87	15.55
Upland Transition Zone	13.78	11.86	4.27	6.26
Upland	8.19	7.02	5.58	2.31

Potential Habitat Areas – Outer Marsh[17]

Habitat Zone	2010 Conditions (Acres)	2020 Conditions (Acres)	2050 Conditions (Acres)	2100 Conditions (Acres)
Mudflat/Open Water	0.47	1.24	4.77	12.45
Lower Intertidal Marsh	15.34	19.98	27.16	307.91
Upper Intertidal Marsh	304.08	303.08	292.45	4.02
Upland Transition Zone	4.49	0.08	0.00	0.00
Upland	0.00	0.00	0.00	0.00

In McInnis Marsh, the dominant habitat shift predicted is from low marsh to mudflat and open water, and there is a 30%-50% loss of upland and transitional habitat. In the Miller Creek corridor, habitat zones move longitudinally along the rising grades in the creek channel. Available high marsh expands in the creek corridor, though available transitional and upland habitat wane on the levee banks at rates comparable those predicted at McInnis. The most dramatic shift in available wetland ecotones occurs across the broad intertidal marsh plains of the Gallinas Creek Marsh Complex, which serve as the primary habitat for regional focal species. Across the marsh plain, increasing inundation will push plant community's upslope, and over time, available high pickleweed marsh is likely to be replaced by cordgrass marsh and mudflat. Table 3-3 indicates that the ecotone shift from high marsh to low marsh is evident by

[15] McInnis Marsh Wetland Restoration site is defined as the area within the perimeter levee networks at McInnis Park and to the eastern boundary of the McInnis Park Golf Center.

[16] Miller Creek Corridor is defined as the region between the center line of the levees from The SMART bridge crossing to the Miller Creek mouth at San Pablo Bay.

[17] Outer marsh region is defined as the area on the bay side of the McInnis Marsh perimeter levees and outside of the Miller Creek corridor.

2050, by 2100 over 95% of currently available high marsh will support low marsh communities. Similarly dire is the overall loss of available transitional and upland ecotones[18].

Changes in Special Status and Wetland Wildlife Usage

General Note: This report evaluates the "No Action Alternative" and the proposed restoration alternatives in terms of value to special status species, with a particular focus on the habitat requirements of the federally endangered Salt Marsh Harvest Mouse and California Ridgway's Rail, and the state-threatened California Black Rail. The habitat affinities of these three species serve as an "umbrella" for other tidal marsh dependent species, and are referred to as "the focal species" in this document.

In light of the anticipated changes in habitat distribution, we foresee large-scale loss of high marsh plant and animal communities, including the focal species currently present in the Gallinas Creek Marsh Complex. Available habitats will limit remaining populations. The ability of tidal-marsh dependent species to "move upgradient" is extremely limited, if possible at all. Salt Marsh Harvest Mouse can survive in adjacent upland if there is sufficient tidal marsh available, but the rails only use upland as refugia habitat, to survive short-term flooding/disturbance/displacement. Sea level rise will eliminate critical survival habitat for these species unless there is room for aggradation of the marsh plain concurrent with loss of lower elevation habitat.

The available land for upgradient expansion of high marsh ecotones from the historic baylands into adjacent transitional and upland ecotones is also very limited. The Gallinas Creek watershed offers limited available upland. The recent construction of the Sonoma Marin Area Rail Transit (SMART) bisects and displaces transitional upland along the bay margin. Upslope of the SMART ROW, adjoining land uses are generally residential and light commercial/industrial. The Miller Creek corridor, though narrowly constrained between levees, offers a relatively gently sloping transitional corridor, within which high and low marsh plain habitat distributions shift without significant loss. This indicates that expansion of the Miller Creek corridor will be critical to sustaining available high marsh habitat for the large population of special status species resident in the Gallinas Baylands.[19]

[18] Existing site conditions and design grades associated with habitat ecotones are presented and discussed in Attachment A, Section 2.9)

[19] The LGVSD is planning to expand marsh plain and floodplain habitat within the Miller Creek corridor as mitigation for impacts associated with the removal of aggrading sediment, which increasingly threaten to block District outfalls. Acquisition or easement on privately owned property adjacent and upgradient of the creek would be required for further expansion of available habitat.

4 McInnis Marsh Restoration Alternatives

The design team developed a suite of five restoration alternatives (Alternatives A-E) for McInnis Marsh. This study bases the alternatives on the findings of the physical and ecological site assessment (Attachment A) and the opportunities and constraints analysis (Section 2). The "No Action" Alternative described in Section 3 presents future conditions in McInnis Marsh and the surrounding Gallinas Creek Marsh Complex if Parks does not implement the restoration project. The restoration of both site conditions and geomorphic processes will support the natural recovery and persistence of historical wetlands, the expansion of endangered species habitat. Sea level rise adaptive modifications to community infrastructure (levee and channel) will reduce ongoing maintenance costs and storm damage, and protect public access to the bay. Alternatives B to E represent cumulatively increasing efforts to restore natural (physical and biological) processing at McInnis Marsh by removing levees and increasing connectivity between Gallinas Creek and Miller Creek.

By enhancing ecological connectivity across the ecotones transitioning from subtidal to riparian habitat, the McInnis Marsh project provides a viable and valuable upslope migration corridor for a large population of at-risk special status species. To support evaluation and selection of a preferred alternative, the project team describes the anticipated changes in special status and wetland wildlife usage. The study broadly addresses wetland ecotones, with focus on the habitat requirements of focal species. The habitat affinities of these three species serve as an "umbrella" for other tidal marsh dependent species.

4.1 Alternative A: Restoration via Modified Management

If support for the project is not available, and construction actions cannot be implemented, hydrological modifications can be undertaken that will improve ecological values in the subsided parcel. In alternative A (Figure 4-1, attached), wetland habit would be enhanced by modifying outfall operations, management of freshwater sources, and maintenance of bay levees.

4.1.1 *Alternative A: Modified Management Elements*

1. Operate outfalls to increase interior ecological values:
    a. Determine habitat objectives to support recovery plans and stakeholder consensus.
    b. If needed, replace culvert to support increased tidal exchange
    c. Modify outfall operations[20] to provide tidal exchange and/or increase depth and duration of ponding to expand/support available marsh habitat.
2. Modify trail alignments/use to:
    a. Reduce impacts on special status species through use restrictions (e.g. high tide closures);
    b. Restore native transitional and upland plant communities to increase upland values along interior and perimeter levees ;
    c. Integrate the Bay Trail and increase connectivity with LGVSD wetland trails
    d. Improve public education regarding high value habitat; expand learning/outreach/stewardship opportunities;

[20] Current outfall operations limit tidal exchange to drainage within a network of excavated channels.

e. Protect public from hazardous trail conditions due to large storm events and/or accelerated sea level rise.

4.1.2 *Alternative A: Modifications to Facilities and Maintenance Needs*

This alternative maintains the existing levees and infrastructure and is similar to the No Action Alternative.

4.1.3 *Habitat Response to Restoration and Sea Level Rise*

Alternative A will enhance wetland habitat values in the subsided parcel. Parks can modify tide gate operations over time to support interior wetland ecotones. These actions would support those species with less narrow niches. Due to the absence of marsh channels and wetland complexity, these actions will not provide significant benefits for focal species. This alternative does not include any modifications to the outboard marsh.

Change in Wetland Communities

In McInnis Marsh, one to two feet of sea level rise within the fifty-year planning horizon will bring an increased risk of levee overtopping, as well as a rise in saline groundwater. Both wetland conditions and plant and animal communities will evolve with the increases in salinity, and the depth and duration of ponding. If Parks operates the tide gate to maintain a limited degree of tidal influence, the rate of change will be slower within the subsided McInnis Marsh parcel than is predicted for the surrounding wetlands. The un-subsided parcels have the highest topography in the basin, and currently have the potential to support high marsh vegetation.

In the surrounding "outboard" marsh, one to two feet of sea level rise will generally result in a comparable increase in habitat grades. Projected rates of marsh plain sedimentation are not likely to keep pace with rising tides. Increasing tidal inundation will transform the existing high marsh plain into low marsh/mudflat habitat. High marsh ecotones will transition from broad flat marsh plain onto the narrow banks of bounding levees. The habitat shift across the leveed terrain will result in a progressive loss of high marsh habitat and already scarce transitional and upland habitat. The capacity for marsh plain response to sea level rise is limited by San Francisco Bay sediment supply, which is historically low in this sheltered corner of San Pablo Bay[21]. The steep levees east of the existing offer minimal room for upslope marsh migration. As a result, we anticipate area wide loss of wetland habitat critical to support special status species.

In Alternative A, the subsided McInnis marsh parcel provides freshwater habitat will be increasingly valuable for coastal wildlife. The number and diversity of species using the site would likely increase depending on hydrology and salinity. Parks can modify the tide gate operations to support target habitats, as defined by its resource managers. *Habitat enhancements inside the subsided McInnis Marsh basin will not increase high marsh habitat values, and therefore will not benefit focal species.* Increasing San Pablo Bay water levels will increase salinities in adjacent tidal areas and groundwater, making brackish marsh habitat increasingly scarce. To the extent that interior habitat can be designed at proper elevations

[21] Sediment mobilized from the recently breached Hamilton Wetlands may increase local sediment supply.

(MHW and above) and receive tidal influence, some habitat benefits could be fostered. Although it is not a benefit for focal species, an increase in freshwater ponding and muted-tidal exchange would increase the habitat value and use of the site for other avian species of interest, including wading birds and birds with less narrow niches (e.g. Song Sparrow, Yellowthroat).

In the surrounding wetlands, the transition of marsh plain from high marsh to low marsh and upland to high marsh will result in a progressive loss of available high marsh habitat utilized by numerous special status intertidal wetland species in Gallinas Baylands. Habitat is lost because the area of transitional upland habitat potentially inundated and converted to high marsh is much less, than the area of the existing high marsh plain flooded by the rising tide. In addition, the available upland transition zone is developed and recently disturbed due to SMART construction, and provides minimal carrying capacity for wetland ecotones. The proposed actions that reduce upland disturbance via high tide use modification and cultivation of native upland plant communities would increase the availability of waning high tide refugia and upland (levee) habitat for tidal marsh dependent species.

4.2 Alternative B: High Marsh Levee Removal

The Gallinas Creek Marsh Complex surrounding McInnis Marsh support one of the largest breeding populations of endangered California Ridgeway's Rail in San Francisco Bay. Population numbers are likely limited by the area of available marsh habitat (J. Evans, Pers. Comm. 2014). Alternative B (Figure 4-2, attached) includes the removal of levees (and trails) surrounded by high marsh. The levee removal will connect 35 acres of existing marsh plain habitat to 320 acres of adjacent sub- and inter-tidal San Pablo Bay marsh. These two interior basins currently do not support Ridgway's or black rails. These basins are at grade with the adjacent high marsh, the rail habitat would be available immediately after construction. The Parks will use the excavated fill to construct the setback levee, which will support the potential Bay Trail alignment and connect trails to the LGVSD facilities. Parks will reuse surplus material on site to increase the width of the levee face and replace transitional upland habitat, or to modify interior wetland grades to enhance the diversity of estuarine intertidal habitat.

4.2.1 *Alternative B: Recommended Actions*

1. Implement Alternative A actions
2. Remove High Marsh levee
    a. Do not disturb adjacent outboard marsh
    b. Cut pilot channels to two feet below grade to connect the remnant marsh to the outboard marsh
    c. Remove compacted levee/wetland fill above high marsh grades (@ 7 ft.)
    d. Haul levee material to the sites western boundary for reuse as setback levee fill
    e. Monitor wildlife occupation prior to and during construction, and 1-3 years after restoration work is complete.
3. Construct a set-back levee along the western boundary of the site
    a. Reuse material from excavation of the upland perimeter levee
    b. Install an outfall and pump to convey upslope drainage past the levee
    c. Protect or realign existing LGVSD force main
    d. integrate recycled water reuse in the setback levee design and to support freshwater ecotones on the horizontal levee and irrigate upland and transitional wetland vegetation
    e. Excess fill material can be used to
        i. Increase perimeter grades to restore and sustain upland transition zone

   ii. Modify internal drainage to retain freshwater, maintain or replace freshwater habitat
   iii. Construct dredge placement cells (if receiving Gallinas Creek dredge sediments)
4. Modify trail alignments to support removal of high marsh levees
   a. Remove trails with levees
   b. Construct new Bay Trail segment as part of the setback levee design
   c. Provide observation stations and updated interpretive signs that encourage citizen science and local stewardship

4.2.2 *Alternative B: Modifications to Facilities and Maintenance Needs*

This alternative would maintain existing levees and infrastructure surrounding the subsided parcel as described in Alternative A. Parks would modify facilities and maintenance needs associated with Alternative B actions, as described below.

A. Perimeter Levee Excavation and Material Reuse: Alternative B removes 5,500 linear feet of levee adjacent to high marsh, removing 20,000 cubic yards of wetland fill. Maintenance on remaining levees would be similar to the requirements described in Alternative A.

   This alternative includes a new 1,500, linear-foot setback levee using the excavated upland fill (Figure 4.2, attached). Preliminary earthwork estimates indicated a minimum of 15,500 cubic yards of compacted fill would be required to construct a 12-foot high setback levee along the proposed alignment. (Figures 4-3, attached PDF). Attachment D describes the preliminary estimates of earthwork volumes for proposed levee excavations and a feasible range of setback levee configurations. All of the alternatives would use a surplus material for trail or habitat enhancements. The project will require upslope drainage from the adjacent golf course to maintain storm water conveyance through the levee. An existing LGVSD force main crosses the proposed levee alignment; therefore, the project would require protection or realignment of the force main as part of facilities design.

B. Tide gates: Tide gate modifications for this alternative are as described in Alternative A.

C. Trails: Alternatives B removes 5,500 LF (@ 1.0 mile) of actively used bayland trail at McInnis Marsh. The trail could be is replaced with a 10,600 LF (@ 2 mile) trail surrounding the subsided basin perimeter. As rising tides increase maintenance and user risks along this bay-front trail, Parks will redirect shoreline access to the western setback levee alignment, and connection to 3.5 miles of newly connected LVGSD bay-front trails and wildlife ponds.

4.2.3 *Habitat Response to Restoration and Sea Level Rise*

Alternative B will enhance wetland habitat values in 35 acres of high marsh, which is adjacent to but separated from the outboard marsh. Rails currently, do not occupy this area. Removal of the levees and construction of pilot channels will restore hydrologic and ecotone connectivity to existing marsh plain. The project does not include any modifications to the intact high marsh east (bay side) of the levee

Change in Wetland Communities

In Alternative B, the changes to wetland communities would be similar to those described in Alternative A, with the addition of changes in the 35 acres of high marsh reconnected to the bayland. Grades in the southern parcel are comparable to the outboard marsh and rising tides will progressively inundate, as described in Alternative A. In the more northern parcel, elevations range from one foot below the outboard marsh elevation to grades as high as 12 feet over approximately 1.75 acres in the northern quarter of the parcel. With rising tides, wetland communities will shift upslope across the site, sustaining remnants of high marsh and transitional ecotones at elevations above the current marsh plain.

Changes in Special Status and Wetland Wildlife Usage[22]

In Alternative B, the special status and wildlife changes will be similar to Alternative A, with modification in the 35-acre reconnected marsh. Implementation of Alternative B would increase nesting habitat and high tide refugia for the local California Ridgeway's rail population, as well as for saltmarsh harvest mouse and California black rail. Because this alternative includes the Alternative A modifications, it would also serve those species discussed above. The added capacity for adaptation/resilience, and response to sea level rise, though less than two acres, would enhance long-term potential for survivorship and recovery of the focal species.

4.3 Alternative C: Tidal Wetland Restoration With Breach to Gallinas Creek

In Alternative C (Figure 4-3, attached), the project description adds an open channel breach between Gallinas Creek and the 120-acre subsided basin at McInnis Marsh restoring the site to intertidal bayland. This alternative removes a mile of perimeter levees to the east and south of the subsided basin, and replaces the existing culvert with a broad breach channel from Gallinas Creek into McInnis Marsh. The project will include a material reuse plan that would prioritize placement of excavated material, including: (1) expanding of transitional wetland habitat through the construction of a horizontal levee; (2) raising interior grades to increase habitat diversity; and (3) constructing interior cells for receipt of dredged material from South Fork Gallinas Creek. Recommended actions include the excavation of interior pilot channels to provide a subtidal connection between the McInnis Marsh and Gallinas Creek. Parks would re-use material from channel excavation to increase the bed elevation and variation within the subsided parcel to increase the rate of plant colonization and habitat complexity. If the projects can be coordinated, the Flood Control District could also place Gallinas Creek dredge material in cells within the subsided basin. If anticipated, the placement of dredge material for habitat benefit should be incorporated in restoration design. Restoration actions need also incorporate measures to protect the existing LGVSD force main, which crosses the parcel and the breach alignment.

[22] See General Note in Alternative A.

4.3.1 *Alternative C: Recommended Actions*

1. Implement Alternative B Actions
2. Excavate Gallinas Creek Breach and Interior channels
    a. Excavate 5,000 linear feet of internal channels in a 30- by 3-foot geometry to provide subtidal habitat connectivity within the restored basin
    b. Remove the existing outfall and adjacent levee to construct a breach between restored marsh and the North Fork of Gallinas Creek
    c. Excavate wide (700-foot) breach in levee and adjacent marsh, while protecting an existing LGVSD force main along the breach alignment[23]
    d. Redistribute 19,700 cubic yards of excavated soils within the parcel, raising grades two feet for rapid vegetation colonization over 4.1 acres of marsh
3. Modify trail alignments:
    a. Incorporate public access to the bay by constructing a trail along the new levee connecting McInnis Park to LGVSD trails. A spur trail could also be created on the levee between McInnis Marsh and Miller Creek.
    b. Construct elevated observation station with interpretive resources
4. Implement managed retreat measures by removing remaining Southern and Eastern bay front levees
    a. Avoid disturbance to the adjacent outboard marsh
    b. Remove upland levee to support tidal exchange and marsh expansion
    c. Reuse upland fill to support habitat enhancement and marsh development for focal special status species; incorporate construction of isolated upland refuges, expand horizontal levee transition zones, and raise internal grades
    d. Reuse upland fill or weedy surface soils to construct Gallinas Creek dredge disposal cells to support beneficial reuse of locally dredged sediment

4.3.2 *Alternative C: Modifications to Infrastructure and Facilities*

Alternative C adds removal of the culvert and perimeter levees along the southern and eastern perimeter of the subsided parcel, and construction of a broad breach and interior channels within the restored intertidal wetland. This alternative expands reuse of excavated material within the parcel to increase grades in the subsided basin and expand the horizontal levee bench on the eastern levee slope. Modifications to infrastructure and facilities associated with Alternative C actions are described below.

A. Perimeter Levee Excavation and Material Reuse: Alternative C removes and additional 5,600 linear feet (@ 1.1 mi) of levee adjacent to high marsh, removing 24,900 cubic yards of wetland fill and all associated maintenance actions and costs. This brings the total volume of wetland fill excavated in Alternative C to 44,000 cubic yards, and restores 3.2 acres of upland to tidal wetland.

[23] The force main is at or below elevation -6 ft. in the baylands, which is below the existing channel bed in both north and south forks of Gallinas Creek. Creek dredging and levee maintenance operations have occurred in the past without adverse impact to the line. Preliminary design should identify measure to protect or realign the Force Main as needed during construction. Restoration actions include excavation of a wide breach intended to minimize the localized scour risk to the line.

Parks would reuse excavated material to expand the horizontal levee and raise grades in the wetland interior to support rapid vegetation colonization. Horizontal levee expansion would use a low 10-20:1 slope across the upland transition and upper intertidal elevations (4-8 feet NAVD88). Fill volumes required for likely horizontal levee geometries a range from 20,000 to 28,000 cubic yards Figures 4-5 presents typical levee cross sections that use a 20:1 slope. Attachment D presents preliminary horizontal levee design scenarios.

Excavated levee fill enhances ecological values if placed in the interior of the subsided basin. A one to three-foot increase in interior grades would raise the basin bottom (currently at 2 feet NAVD88) to intertidal elevations of three to five feet These higher grades would support more rapid vegetation colonization after breach.[24] The available fill volume provides approximately 11 acres of fill at a two-foot depth, and promotes cover over approximately nine percent of the subsided basin[25].

CSA 6 MCFCWCD is concurrently developing a dredge project along the South Fork of Gallinas Creek, and plans to reuse the dredged material to increase elevations within Gallinas Marsh, potentially placing between 60,000 - 100,000 cubic yards of material within the restoration site. This beneficial reuse of dredge sediments would accelerate wetland colonization and raise grades to increase resiliency for sea level rise. Assuming a three-foot fill depth, this fill volume would raise site grades over 12 to 20 acres. This would place fill over up to 12-17% of the basin. The material used to construct temporary dredge disposal cell levees could come from within the basin channel alignment or from upland fill excavated from perimeter levees.

B. Tide gates: In Alternative C, a broad levee breach will replace the tide gate. Replacing the tide gate, a detention basin and pump will be required to discharge storm water from the below grade drainage network to adjacent tidal baylands.

C. Trails: Alternatives C removes another 5,600 LF (@ 1.1 mi) of bayland trail at McInnis Marsh. The trail would be is replaced with a 5,100 LF (0.9 mi) trail along the setback levee alignment and the levee top between Miller and Gallinas Creek. As rising tides increase maintenance and user risks along this bay-front trail, Parks will redirect shoreline access, as in Alternative B, to the western setback levee alignment, and 3.5 miles of LVGSD trails and wildlife ponds.

4.3.3 *Habitat Response to Restoration and Sea Level Rise*

Restoration actions in Alternative C significantly enhance marsh habitat over Alternatives A and B by opening 120 acres of diked wetlands to tidal action. Existing grades within the basin are low and would result in open water and mudflat habitat over much of the basin if unmodified. The project does not require additional fill material to raise base elevations. Over time, bay sourced sediment will fill the site, raising grades to inter-tidal and ultimately high marsh elevations. The vertical aggradation rates average three to five millimeters per year in the San

[24] Existing grades are in the low intertidal range and would support mudflat and open water immediately following breach.

[25] The horizontal levee will require approximately 28,000 cubic yards of material, leaving 16,000 cubic yards of upland material available for interior grading. The project also includes the redistribution of an additional 20,000 cubic yards of material from channel excavation.

Pablo Bay region (Calloway et. al., 2012). Relying only on bay-sourced sediment would require over 100 years of natural sedimentation to restore marsh elevations within the restoration area. Fortunately, subsided basins aggrade more rapidly, with initial rates as much as ten to twenty times higher than marsh plain aggradations rates (Revell, D., et. al. 2011, Callaway, 2012). This suggests that at existing marsh grades, it would take ten to twenty years of open water sedimentation before vegetation colonizes the interior basin. However, sea level rise, which historically was at 2.0 millimeters per year, is expected to accelerate over the planning horizon of the project. These data suggest that initial open water sedimentation rates may be adequate to keep up with sea level rise, but are not adequate to keep rising tides from drowning both the restored and the historic outboard marsh. As a result, the restored marsh, if dependent solely on bay sourced sediment, is likely to function primarily as shallow open water subtidal habitat.

Change in Wetland Communities

Alternative C adds 120 acres of intertidal bayland habitat at McInnis Marsh. With reuse of excavated material, five to ten acres of interior wetland would be expected to rapidly (within five years) support marsh vegetation. However, as described above, the subsided tidal basin will not aggrade at rates that will keep pace with rising tides. The plan allows for the establishment of wetland ecotones along the horizontal levee at current marsh and future (currently transitional upland) elevations. The distribution and duration of available habitat will be dependent on the elevations on the site perimeter. In the interior basin, vegetated habitat will likely be limited to those areas filled to grades that support rapid colonization.

Overall, the added tidal exchange along the Gallinas Creek channel will influence the wetland community response in the outboard marsh. Post breach, downstream channel depth could increase by as much as two to three feet in response to the added 450-530 acre-feet of tidal prism. Over time, as the subsided marsh progressively fills, the channel would recover resulting in a 0.5 ft. increase in channel depth. Post breach, an increase in sediment deposition would be expected upstream of the breach, due to changes in flow patterns. The large geometry of the breach will mitigate any associated short-term conveyance loss by expanding available flow area at the confluence and providing room for channels to migrate laterally to maintain capacity. In the long term, rising tides will increase channel geometry both upstream and downstream of the breach.

Changes in Special Status and Wetland Wildlife Usage[26]

This alternative incorporates the two preceding actions and, therefore, achieves the same benefits for focal species described for Alternative B. In Alternative C, the added focal species usage changes associated with sediment reuse and restoration of tidal exchange in the 120 acres subsided basin. The increase in tidal action would eliminate some existing tidal marsh habitat (at the point of the breach), but would offset that loss with relocation of high marsh ecotones to both perimeter (horizontal levee) and interior (sediment reuse) areas. There would be a conversion of habitat in the marsh interior due to the tidal inundation of the existing seasonal ponds and salt panne. The open water habitat does not support focal species, but would serve local and migratory shorebirds and waterfowl and improve fish habitat. The expansion of high marsh habitat within the site would benefit all three focal species. Expanded

[26] See General Note in Alternative A.

transition zone ("refugia") habitat would serve the needs of the focal species during periods of inundation, and increase habitat viability for passerines ("land birds"), particularly the San Pablo Song Sparrow and the San Francisco Common Yellowthroat.

The creation of open water habitat at McInnis Marsh connected to the subtidal channel network of the Gallinas Creek Marsh Complex would provide habitat for spawning and rearing Sacramento splittail, and potentially other species, including green sturgeon and other small fishes. Interior grading and sediment reuse to create varying depths connected by deeper channels enhances access and refuge for both large and small fish. Splittail spawn in shallow water (less than two meters deep) over flooded vegetation habitat (CDWR 2013). Based on experience on nearby sites, this species could occupy the new tidal basin shortly after breaching. 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). Under Alternative C, the site would provide open water habitat for many years. As the vegetation grows within the restoration area, spawning habitat for splittail will improve. The basin may also provide habitat and food for a variety of invertebrates, which will provide rearing fish and avian populations with an abundant food source. Opportunities for eel grass restoration should also be evaluated both within the parcel and in the adjacent subtidal channels. If rising tide prevents mature marsh from developing, the project would still sustain fish and expand available habitat for both Sacramento Splittail and anadromous Steelhead.

4.4 Alternative D: Tidal Wetland Restoration with Breaches to Gallinas Creek and Miller Creek

Alternative D (Figure 4-4, attached) implements actions of Alternatives B and C; and would add removal of the levees between McInnis Marsh and Miller Creek. This alternative connects Miller Creek to McInnis Marsh, and maintains a high marsh division between the restored marsh and Gallinas Creek. Connecting Miller Creek to the restored marsh provides an alluvial sediment source to the site, and provides for conditions that favor all focal species. However, the absence of a connection to the subtidal channels of Gallinas Baylands reduces potential habitat values for fish. As in Alternative C, rising tides and increased conveyance of creek sediment would require modifications to the elevation and location of LGVSD wet season outfall(s). Raising the outfall is consistent with LGVSD's current climate change response planning. Integration of the requisite LGVSD facilities improvements and implementation in coordination with restoration actions would minimize the disturbance associated with work proposed in the corridor.

4.4.1 *Alternative D: Recommended Actions:*

1. Implement Alternative B and C Actions (without the breach to Gallinas Creek)
2. Modify trail alignments:
    a. Trail access provided along the horizontal levee trail with connection to LGVSD walking paths
    b. The spur trail on the levee between Miller Creek and McInnis Marsh would be eliminated with levee removal
3. Remove Northern Miller Creek levee
    a. Do not disturb outboard marsh
    b. Remove 1.53 acres of compacted levee/wetland fill above high marsh grades (6 ft.) feet to support tidal exchange and marsh expansion
    c. Redistribute the 12,400 cubic yards of excavated fill along the parcel perimeter to expand upland transitional wetland habitat, or to enhance intertidal habitat by raising internal grades 2 feet over 3.8 acres

4. Construct Miller Creek Breach
    a. Raise or relocate (to the east), LGVSD's primary outfall;
    b. Excavate a 150 feet long, 100 foot-wide at grade channel from Miller Creek to McInnis Marsh. Retain conveyance along the existing Miller Creek alignment to San Pablo Bay.
    c. Reuse 3,000 cubic yards of breach cut material to expand horizontal levee transition zone or raise internal site grades.

4.4.2 *Alternative D: Modifications to Infrastructure and Facilities*

Alternative D adds removal of the northern perimeter levee between McInnis Marsh and Miller Creek, and excavation of a channel cut between Miller Creek and the subsided marsh. Modifications to infrastructure and facilities associated with Alternative D actions are as follows:

A. Perimeter Levee Excavation and Material Reuse: Alternative D removes and addition 3,200 linear feet (@ 0.6 mi) of levee between McInnis Marsh and Miller Creek, removing 12,400 cubic yards of wetland fill. This brings the total volume of wetland fill excavated in Alternative D to 52,400 CY, and restores and additional 1.5 acres of upland to tidal wetland.

   As in Alternative C, the project would reuse excavated material within the parcel to expand the horizontal levee bench on the eastern levee slope or increase site grades to elevations that would support low and high marsh vegetation in the subsided basin.

   The available fill volume provides approximately 16 acres of fill at a two-foot depth, which would promote cover over approximately 13.5 percent of the subsided basin[27].

   The South Fork Gallinas Creek dredge project would add an additional 60,000-100,000 cubic yards of dredge material, which would also accelerate wetland colonization. Assuming a three-foot fill depth, this volume of fill could raise site grades over 12- 20 acres (up to 10-17%) of the basin.

B. Tide gates: Parks will remove the tide gate, as in Alternative C, and does not propose any new infrastructure in Alternative D.

C. Trails: As in Alternatives B and C, Alternative D includes a new trail alignment on the newly constructed western levee, which includes connections to trails on the LGVSD property. This alternative removes the 3,200 linear foot (@ 0.6 mile) spur trail along the northern site boundary. The proposed new trail alignment would include 5,100 linear (0.9 mile) on the western setback levee and a new connections to the 3.5 miles of LVGSD bay-front trails and wildlife ponds.

D. Levee Breach: Alternative D proposes construction of a breach channel between Miller Creek and McInnis Marsh. The Miller Creek breech will require routine inspection seasonally and following large storm events. Within the breach, scour is not expected to be a concern because the available cross section is significantly larger than the adjoining channel. However, if local scour develops adjacent to the breach, Parks may be required to install and maintain erosion protection measures.

4.4.3 *Alternative D: Habitat Response to Restoration and Sea Level Rise*

Alternative D adds to the previous enhancement alternatives by incorporating a breach to Lower Miller Creek. The breach restores the historic bayland connection of the drainages, bringing freshwater and sediment from the ten-square-mile Miller Creek watershed, and opening a corridor between bayland and an upland riparian corridor. As in Alternative C, the creation of open water habitat will occur after breaching. In Alternative D, the addition of Miller Creek's alluvial sediments would accelerate the rate of marsh sedimentation and ecotone development. In the long term, the connection to course sediment supply from Miller Creek would increase the capacity for the site to keep pace with sea level rise.

The McInnis Marsh site assessment (Attachment A) evaluates lower Miller Creek sediment characteristics, and estimates that annual sediment loading rates to McInnis Marsh range from 3,500 to 9,000 tons/year. The annual average is estimated to be 5,400 tons per year. The site assessment report concludes that an estimated 10% of the total sediment load to be course sediment. At these loading rates, 2,500 – 9000, cubic yards (1.5 to 4 acre-feet) per year[28] of sediment would aggrade on the site. If sediments aggrade over 80% of the site, this range of loading rate equates to 4.9 – 12.7 millimeters per year of sedimentation. These rates exceed historical and current sea level rise rates, but the 7.6 millimeters per year average falls short of accelerating sea level rise rates of as high as 13 millimeters per year (NRCS, 2012). While there is a large degree of uncertainty in both sediment yield the sea level rise estimates, analysis indicates that a breach between Miller Creek and Gallinas Bayland would allow natural geomorphic processes to raise internal grades 1.5 to 2.8 feet[29] over the 50 year life of the project. The proposed addition of dredge material and levee fill to the site would reduce the anticipated timeline for marsh ecotone formation (over the more elevated portions of the site) to a 5 - 20 year horizon.

Restoring the corridor between the Gallinas Creek Marsh Complex and Miller Creek would promote development of a complex mosaic of estuarine habitats that include salt marsh, brackish marsh, creek, and riparian ecotones. This contiguous transition zone is valuable because it provides the opportunity for both wildlife and habitat to adapt to climate change by moving within the corridor during storm events, and for habitat translation along the corridor to occur over time, as sea level rises. This results in an increase in wetland community resilience because it allows for both short-term response to extreme events, and long-term upslope ecotone migration. Unlike non-tidal reaches of Gallinas Creek, Miller Creek's riparian corridor, though narrowed, is largely intact. Miller Creek supports a persistent steelhead population (See Attachment A, Section 3.5). The quality of the steelhead habitat in Lower Miller Creek is increasingly limited due to reduction of riparian habitat, unfavorable stream flow regimes created by the levees, ongoing upstream channel incision which produce high sediment deposition rates in lower Miller Creek (which currently fill and disconnect pools), and grazing disturbance. During low-flow conditions, the degradation of water quality occurs as perched disconnected pools suffer elevated summer water temperatures and salinity.

[28] Assuming 1.4 tons per CY.

[29] This includes aggradation of an estimated 0.7 ft. of bay sourced sediment aggradation.

Change in Wetland Communities

Alternative D includes the addition of freshwater and sediment from Miller Creek, to increase the complexity and resilience of generate 120 acres of intertidal bayland habitat at McInnis Marsh. With reuse of excavated material on site, 10-15 acres of interior wetland should rapidly (0-5 years) support marsh vegetation. Over time, the subsided basin would fill with creek and bay sediments, and aggrade to form an estuarine marsh complex with a high degree of ecological diversity. Sediment will likely aggrade in lobes forming a mosaic of brackish and salt marsh vegetation that would evolve in response to storm history, substrate, and tidal and seasonal variation in salinity structure. As in Alternative C, the horizontal levee would support wetland ecotones at existing and future marsh (currently transitional upland) elevations. The distribution and lifespan of available transitional and upland habitat will be dependent on the elevations on the site perimeter. Within adjacent channels in the Gallinas Creek Marsh Complex, increased freshwater inflows will bring an increase in ecological diversity in the baylands, and extend the duration of brackish conditions in the marsh. The contribution bed and suspended sediment from Miller Creek will accelerate outboard marsh plain aggradation, increasing sea level rise resilience in the existing high value Gallinas Creek marshes. The coarse bed material may also improve substrate conditions for eel grass and other subtidal vegetation.

Overall, the wetland community response would initially be comparable to Alternative C, though the added freshwater inflows will increase the extent and duration of brackish water conditions. As the marsh fills and forms wetland and channels, coarser alluvial sediment will reach Gallinas Creek during large storm events. The addition of alluvial sediment will increase local rates of channels and marsh plain aggradation, providing added resiliency in the face of sea level rise. Reclaimed water reuse via irrigation or lateral discharge would be ideal to supplement upland and transition zone plantings on the levee bench and along the Bay Trail.

Changes in Special Status and Wetland Wildlife Usage[30]

This alternative incorporates the habitat modifications described Alternatives B and C, and expands upon them to include connectivity with a freshwater and course sediment from Miller Creek. The enhanced habitat variability—greater range of salinity values, freshwater pulses and ponding, seasonal hydraulic exchange, and range in elevation— would provide habitat elements to improve existing conditions for the focal species and most if not all other species discussed in the site report (See Attachment A, Section 3.) **From a wildlife perspective, the goal of increasing the range of tidal/brackish/freshwater/upland habitats inherent in Alternative D is the most desirable outcome of all alternatives.**

In terms of fish species, the brackish marsh complex will enhance habitat for spawning and rearing splittail and other species, including steelhead. The breach to Miller Creek will improve steelhead passage between the baylands and the riparian corridor, shortening the length of intertidal mudflat and channel crossing by approximately one mile, and increasing bed load transport in the Lower Miller Creek corridor when tides are favorable. The increase in sediment transport may improve fish passage during waning and low flows by reducing the formation of above grade bars that disconnect the channel and perch warm hyper-saline water near the head of tide (approximately the SMART crossing on Miller Creek).

[30] See General Note in Alternative A.

4.5 Alternative E: Tidal Wetland Restoration with Breaches to Miller Creek

Alternative E (Figure 4.5, attached) is a variation on Alternative D that implements actions of Alternatives D replacing the breach to Gallinas Creek with a second downstream breach to Miller Creek. Under this alternative, McInnis Marsh would return to intertidal bayland. In addition to actions previously described, Alternative D would construct a second at grade breach from Miller Creek to McInnis Marsh. The western breach would redirect Lower Miller Creek into McInnis Marsh expanding estuarine conditions and providing an alluvial sediment source to McInnis Marsh. The eastern breach would provide a self-sustaining bayland outfall hydraulically distant from the alluvial sediment supply. Connection to Gallinas Creek would be available across high marsh, allowing hydraulic exchange only at spring tides and flood stages. Additional material from levee removal and channel excavation would be used on site to support expansion of the perimeter levee or to raise interior wetland grades. Alternative E actions would integrate modifications to elevation and location of LGVSD effluent outfalls as described in Alternative D.

4.5.1 *Alternative E: Recommended Actions*

1. Implement Actions in Alternative B and Alternative C
2. Modify trail alignments as in Alternative C
    a. Create new access to the bay along the setback levee and LGVSD Trails
    b. Manage retreat of existing levee trails
3. Relocate/raise LGVSD outfall
    a. Evaluate expansion of current secondary outfall bayward of western breach
    b. Evaluate opportunity to discharge via laterals along the horizontal setback levee
4. Construct two at-grade breaches between Miller Creek and McInnis Marsh
    a. Minimize disturbance of the outboard marsh.
    b. Excavate a western breach as described in Alternative D
    c. Excavate a comparably sized east breach to promote low-flow tidal deposition and sediment conveyance during peak flows and favorable tides
    d. Reuse 6,000 cubic yards of breach cut material to expand or raise grades on the horizontal levee or raise internal site grades

4.5.2 *Alternative E: Modifications to Infrastructure and Facilities*

Alternative E is comparable to Alternative D in terms of the overall changes to infrastructure and facilities.

4.5.3 *Alternative E: Habitat Response to Restoration and Sea Level Rise*

Alternative E enhancement actions result in comparable extent and likely distribution of wetland habitat and connectivity. Miller Creek does not support a subtidal channel to San Pablo Bay, and therefore, cannot sustain subtidal channels within the McInnis Marsh parcel. Sea level rise response would be comparable to Alternative D within McInnis Marsh. However, without a tidal channel connection between McInnis Marsh and Gallinas Creek, Miller Creek alluvial sediment would not be available to the southern Gallinas Creek Marsh Complex. During large storm events, high flows would overtop the bayland marsh plain increasing suspended sediment transport from Miller Creek to the Gallinas Creek marsh plain.

Change in Wetland Communities

The change in wetland communities in Alternative E is comparable to those expected in Alternative D. In the absence of subtidal channels, the marsh may support a greater percentage of high marsh communities.

Changes in Special Status and Wetland Wildlife Usage[31]

Alternative E should provide the greatest enhancement of habitat values for the three focal species and for other tidal marsh dependent species (e.g. Song Sparrow), but does not include some of the Alternative D habitat components that would benefit a broader suite of species. Fish usage would be more limited than in Alternative D due to the absence of subtidal habitat. Foraging and fish passage for lower Miller Creek would be improved both post breach and throughout marsh development.

[31] See General Note in Alternative A.

5 Alternatives Cost Estimates

Table 5-1 provides a preliminary cost estimate for construction of proposed conceptual restoration alternatives. The level of detail and order of magnitude of costs used to develop these estimates is consistent with the conceptual nature of proposed alternatives. The cost estimates provide a realistic magnitude of construction costs, and accurate representation of the incremental costs changes between alternatives. Table 5-1 summarizes the total construction costs of each conceptual alternative. Preliminary line item cost estimates for the study alternatives are presented in Attachment E.

Table 5-1: Preliminary Construction Cost Estimate

Item	Total Cost
Alternative A	$1,230,000
Alternative B	$1,860,000
Alternative C	$3,500,000
Alternative D	$4,570,000
Alternative E	$4,680,000

PLEASE NOTE: Costs for modification/improvements/protection to LGVSD facilities are not included in the cost estimates.

6 References

The majority of the references cited in this document presented in Sections 7-10 of the site conditions report (Attachment A). References listed below are those cited in this analysis of alternatives feasibility.

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Attachments

Attachment A: KHE Existing Site Conditions Report

Attachment B: McInnis Restoration Partners MOU

Attachment C: CSA 6 Boundaries

Attachment D: Levee Earthwork Volume Estimates

Attachment E: Preliminary Cost Estimate

Attachment A: KHE Existing Conditions Site Report

Attachment B: McInnis Restoration Partners MOU

Attachment C: CSA 6 Boundaries

Attachment D: Levee Earthwork Volume Estimates

Attachment E: Preliminary Cost Estimates

Notes:

1. Unit costs do not reflect material and equipment fuel and other time sensitive conditions, since the timeline for implementation is currently unknown.
2. Costs do not includes those required to modify or protect the LGVSD force main which traverses the new horizontal levee alignment and the Gallinas Creek breach.