RESILIENT LANDSCAPE **VISION** FOR LOWER WALNUT CREEK

Baseline Information & Management Strategies

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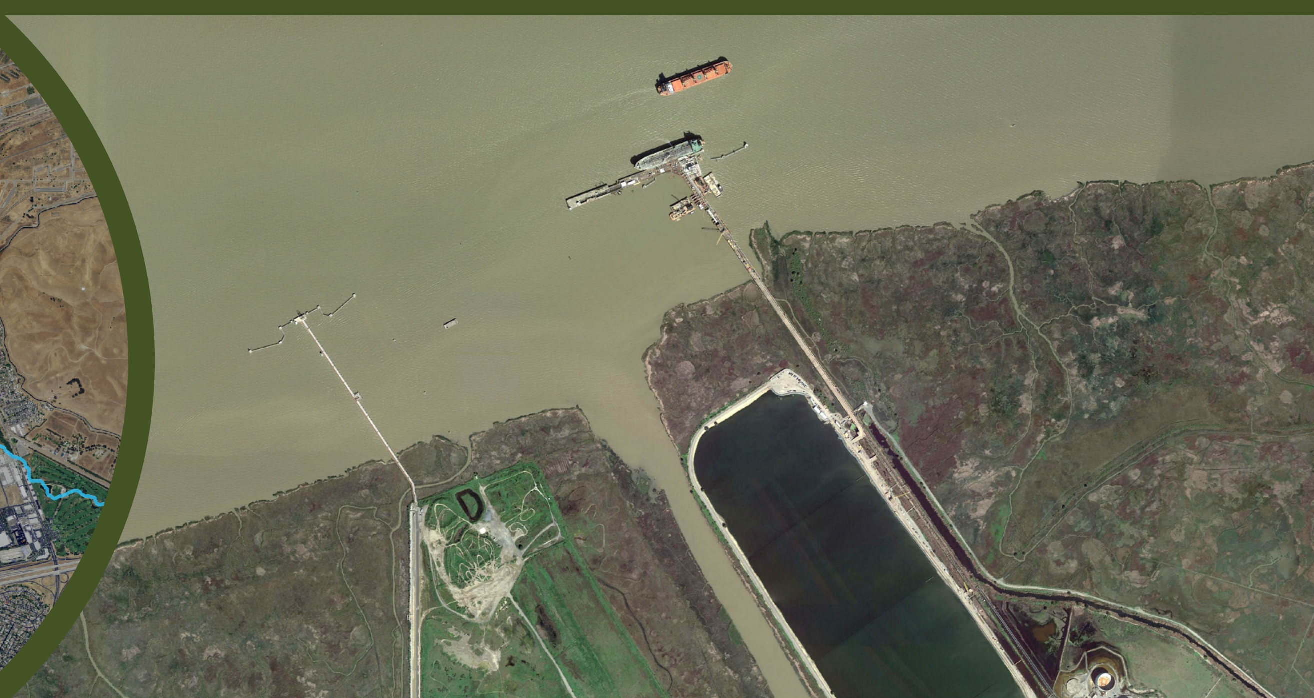

A PRODUCT OF FLOOD CONTROL 2.0

FLOOD CONTROL 2.0

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NOVEMBER 2016

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Version 1.0 (November 2016)

REPORT AVAILABILITY

Report is available at floodcontrol.sfei.org

COVER CREDITS

Front cover, left to right: map of historical conditions of lower Walnut Creek, developed for the Flood Control 2.0 project; imagery courtesy of Google Earth.

Back cover, top to bottom: map of possible measure to sustain resilient marshes, developed for the Flood Control 2.0 project; map of modern conditions of lower Walnut Creek, developed for the Flood Control 2.0 project; 1895 lithograph of Diablo Valley shows Walnut Creek through the marsh (courtesy of Dean McLeod and Contra Costa County Historical Society); photograph of Walnut Creek by Carolyn Doehring (SFEI).

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EXECUTIVE SUMMARY

Lower Walnut Creek (Contra Costa County, CA) and its surrounding landscape have undergone considerable land reclamation and development since the mid-nineteenth century. In 1965, the lower 22 miles of Walnut Creek and the lower reaches of major tributaries were converted to flood control channels to protect the surrounding developed land. In the recent past, sediment was periodically removed from the lower Walnut Creek Flood Control Channel to provide flow capacity and necessary flood protection. Due to the wildlife impacts and costs associated with this practice, the Contra Costa County Flood Control and Water Conservation District (District) is now seeking a new channel management approach that works with natural processes and benefits people and wildlife in a cost-effective manner. Flood Control 2.0 project scientists and a Regional Science Advisory Team (RSAT) worked with the District to develop a long-term management Vision for lower Walnut Creek that could result in a multi-benefit landscape that restores lost habitat and is resilient under a changing climate.

Development of the Vision began with technical analyses focused on understanding past and present landscape functioning and the changes to key processes and landscape features over the past 150 to 200 years. The key findings from these analyses include the following:

- **Landscape change** – During the mid-19th century, lower Walnut Creek was surrounded by a continuous expanse of tidal wetlands occupying approximately 5,000 acres. Perennial freshwater marsh, willow thicket, and alkali meadow formed a large non-tidal wetland complex that adjoined the tidal marsh on its southern end. Over the past century and a half, the non-tidal wetland complex has been lost completely and the tidal wetland area has decreased by 40%. The remaining marsh areas are highly fragmented and cut-off from Walnut Creek by engineered levees. The loss of tidal wetland area has resulted in a substantial decrease in tidal prism and contributed to current in-channel sediment accumulation issues. Around the mouth of Walnut Creek, sediment accumulation has caused the position of the shoreline to expand into the Bay by up to half a mile.
- **Sediment accumulation** – Since 1965, approximately 1.4M cubic yards of sediment have been removed from lower Walnut Creek, with approximately 70% coming from the tidal zone downstream of head of tide (i.e., the inland extent of tidal inundation at mean higher high water). Repeat channel cross-section surveys indicate that the channel quickly fills in with sediment following dredging events (due in large part to decreased tidal prism and associated channel scour capacity) and that the channel bed elevation is currently at or near “quasi-equilibrium.” A

channel sediment budget for 1965-2007 indicates that approximately 80% of the watershed-derived sediment made it through lower Walnut Creek and out to the Bay, while the remaining 20% was likely deposited directly following channel construction and subsequent dredging events.

In November 2015, Flood Control 2.0 scientists, in partnership with the District, held a workshop to present the findings from the technical analyses and develop multi-benefit management concepts that form a long-term Vision for lower Walnut Creek. The workshop participants included the RSAT and other local organizations involved in flood risk management, baylands management, permitting, and water quality. Based on the information presented at the workshop and an extensive knowledge of regional habitat needs, the RSAT recommended the following suite of management strategies and associated actions (or measures) throughout lower Walnut Creek:

- **Strategy 1 – Sustaining resilient marshes by improving natural delivery of freshwater and sediment**

  Measure 1 - Set back levees

  Measure 2 - Reconnect creeks to floodplains

  Measure 3 - Create zones for distributary corridors

  Measure 4 - Modify transportation and pipeline infrastructure

- **Strategy 2 – Sustaining resilient marshes using dredged sediment**

  Measure 5 - Maintain marsh elevations with dredged sediment

  Measure 6 - Protect marsh edge with dredged sediment

- **Strategy 3 – Sustaining resilient marshes using treated wastewater**

  Measure 7 - Support freshwater wetlands with wastewater discharges

  Measure 8 - Support seepage slopes with diffuse wastewater discharges

- **Strategy 4 – Improving ecological connectivity across marshes and along creeks**

  Measure 9 - Enhance wildlife corridors

  Measure 10 - Protect and restore transition zones

The next steps for implementing these measures include conducting feasibility analyses, collaboration with local landowners, garnering regulatory agency support, and securing the necessary funds. The pace of sea-level rise combined with the overall lead time needed to implement the management measures suggest that planning should begin in the near future so that implementation can occur before sea level has risen so high that it's too late.

Pacheco Marsh. (photograph courtesy of Stephen Joseph Photography, stephenjosephphoto.com)

INTRODUCTION

Flood control channels in the Bay Area are the subject of increasing concerns about aging infrastructure, regulatory restrictions, ongoing maintenance issues, and the challenge of increasing water levels with sea-level rise. In addition, there is a growing need to use sediment trapped in the channels as a resource to build and maintain tidal marsh elevations. Here, we present a possible future vision for lower Walnut Creek and adjacent baylands that includes several components that would restore and support natural processes, and in turn, benefit aspects of flood risk management and ecosystem functioning. The Lower Walnut Creek Vision is an element of an EPA-funded project called Flood Control 2.0, which is aimed at integrating wildlife habitat improvement and flood risk management along the San Francisco Bay shoreline for the 21st century and beyond.

Over the past two centuries, lower Walnut Creek and its surrounding landscape have undergone considerable land reclamation and development, which has led to significant channel modifications and a dramatic loss of wildlife habitat. With ongoing sedimentation of the channel and accelerating sea-level rise, channel conveyance for flood flows is a rising concern. In the past, the channel was dredged to increase flow capacity; however, the Contra Costa County Flood Control and Water Conservation District (District) is currently re-evaluating its management practices, especially given dredging impacts to wildlife and future challenges with climate change. Through its current Lower Walnut Creek Restoration Project (LWC Restoration Project), the District is seeking to build and manage a sustainable channel that provides critical flood protection in a way that is more compatible with the plants and wildlife that call the Creek home. Flood Control 2.0 team members and project partners worked with the District to explore a range of landscape-scale opportunities for integrating ecological benefits with flood risk management on lower Walnut Creek considering likely impacts of climate change.

Pacheco Marsh.
(photograph courtesy of Stephen Joseph Photography, stephenjosephphoto.com)

The process for developing the Vision had three main elements. First, the San Francisco Estuary Institute (SFEI) built a baseline understanding of the historical and contemporary geomorphic and ecological conditions, and assessed the likely impact of future drivers (particularly sea-level rise). Second, these findings were presented at a workshop held in November 2015 by the Flood Control 2.0 project team with the District and a Regional Science Advisory Team (RSAT) made up of regional experts. The goal of the workshop was to explore potential integration of improved ecosystem health and flood risk management on lower Walnut Creek to envision a landscape with increased resilience of ecosystem services and ecological functions to climate change. The visioning workshop considered Walnut Creek and the adjacent floodplains from Concord Avenue downstream to Suisun Bay, including land beyond the District's jurisdiction (hence forth referred to as the "study area"). Third, the ideas presented at the workshop and developed in follow-up discussions with the RSAT were synthesized into four over-arching strategies: 1) Sustaining Resilient Marshes by Improving Natural Delivery of Freshwater and Sediment; 2) Sustaining Resilient Marshes Using Dredged Sediment; 3) Sustaining Resilient Marshes Using Treated Wastewater; and 4) Improving Ecological Connectivity Across Marshes and Along Creeks.

The Lower Walnut Creek Vision is intended to help the District, partner agencies, landowners, and other stakeholders explore approaches for multi-benefit landscape management in the coming decades. Lower Walnut Creek has the potential to be redesigned as a better-functioning estuary-delta system that is more resilient to future climate change impacts (e.g., a sea-level rise, salinity shifts) while providing the desired level of flood risk management and improved habitat conditions. Ideally, the Vision will continue to be refined through subsequent analyses and coordinated with visions for landscape management in the watersheds that drain to lower Walnut Creek. This Vision can also be used to help guide channel-bayland redesign efforts around the Bay in similar landscapes.

FLOOD CONTROL 2.0

Over the past 200 years, many of the creeks that drain to San Francisco Bay have been modified for flood risk management. Channel modifications include the building of concrete trapezoidal channels, construction of levees along channels, and complete realignment. In many instances, these flood risk management actions have had considerable impacts on geomorphic channel processes and ecological functioning and the way that sediment and water pass from the watershed to the Bay. Historically, creeks frequently transported watershed-derived sediment to the baylands. Now, leveed channels (with reduced tidal prism) trap sediment at the Bay interface. This has resulted in excess channel deposition, frequent channel dredging, and subsequent adverse impacts to resident plants and animals. Local agencies that operate and maintain flood control channels are coming under increasing pressure from resource agencies to manage or redesign flood infrastructure to provide beneficial uses beyond flood conveyance, including habitat for rare, threatened, or endangered species. In addition, sediment trapped in flood control channels is now being seen as a valuable commodity for baylands restoration.

Recognizing the environmental impacts associated with current flood risk management activities, the high cost of maintaining aging infrastructure, the challenges associated with maintaining flood conveyance in the face of a rising sea level, and the high value of dredged sediment, flood control managers and regulatory agencies are calling for a new overall approach for channel management.

Flood Control 2.0 is an innovative regional project that seeks to integrate habitat improvement and flood risk management at the Bay interface. The project focuses on helping flood control agencies and their partners create landscape designs that promote improved sediment transport through flood control channels, improved flood conveyance, and the restoration and creation of resilient bayland habitats. In addition, the project focuses on beneficial re-use options for dredged sediment from highly constrained flood control channels with limited restoration opportunities. Through a series of coordinated technical, economic, and regulatory analyses, Flood Control 2.0 addresses some of the major elements associated with multi-benefit channel design and management at the Bay interface and will provide critical information that can be used to develop long-term solutions that benefit people and habitats.

Findings from this report and other creek studies (e.g., San Francisquito Creek, Novato Creek) will be synthesized into an online "toolbox." The toolbox will include channel classifications and relevant management concepts (e.g., creek-bayland connections, beach nourishment), a "marketplace" for baylands restoration practitioners to find available dredged sediment (Sedi-Match), a regulatory guidance document with case studies for the regulatory issues associated with flood control project elements (e.g., impacts to existing wetlands, sediment re-use), and a benefit-cost analysis. The toolbox will be completed and available to the public in 2016. In combination with other regional plans (e.g., Baylands Ecosystem Habitat Goals Science Update), this project will provide information to flood control managers and the restoration community for planning sustainable, long-term, multi-benefit redesign projects given landscape, regulatory, and economic challenges.

Additional project information: floodcontrol.sfei.org

PROJECT LEADS

- SAN FRANCISCO ESTUARY PARTNERSHIP (SFEP)
- SAN FRANCISCO ESTUARY INSTITUTE (SFEI)
- SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION (BCDC)
- SAN FRANCISCO BAY JOINT VENTURE (SFBJV)

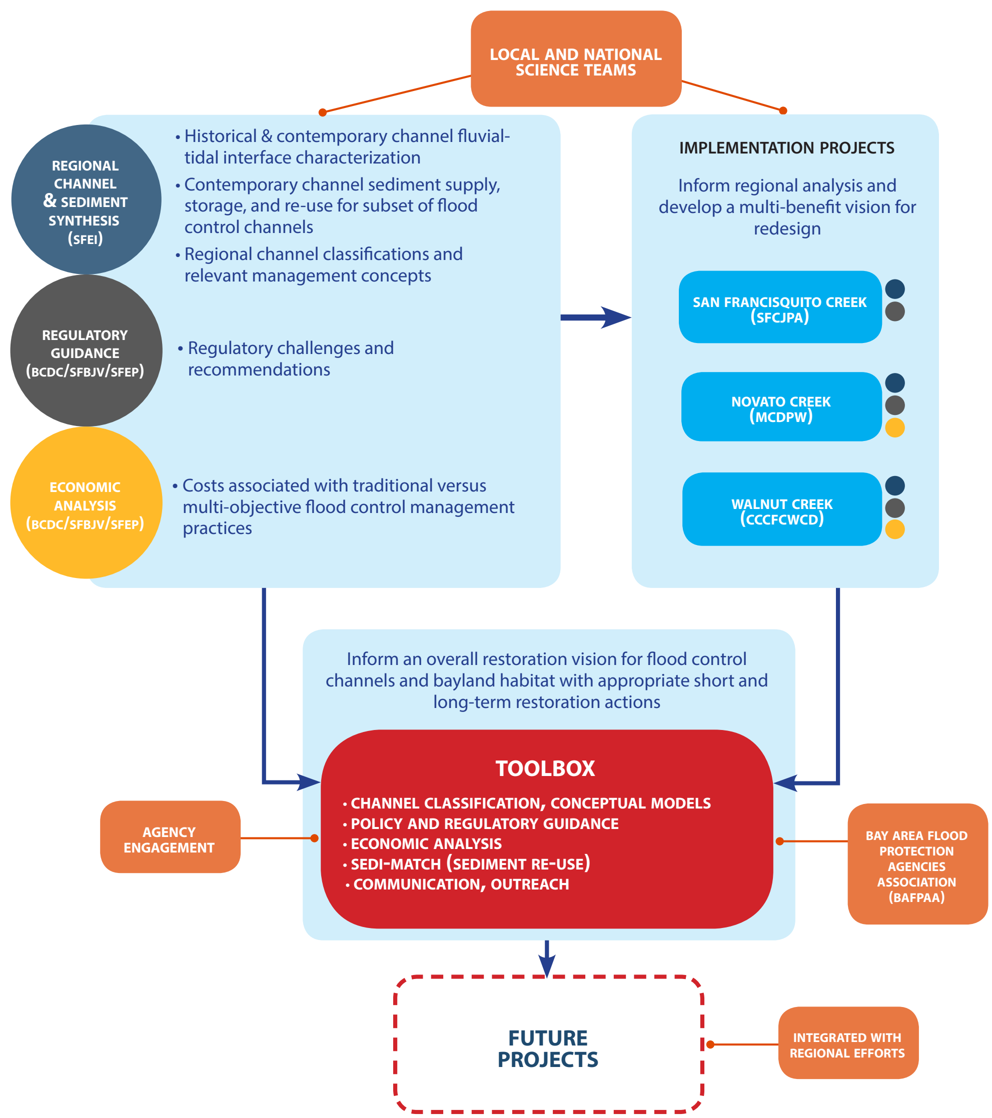
PROJECT PARTNERS

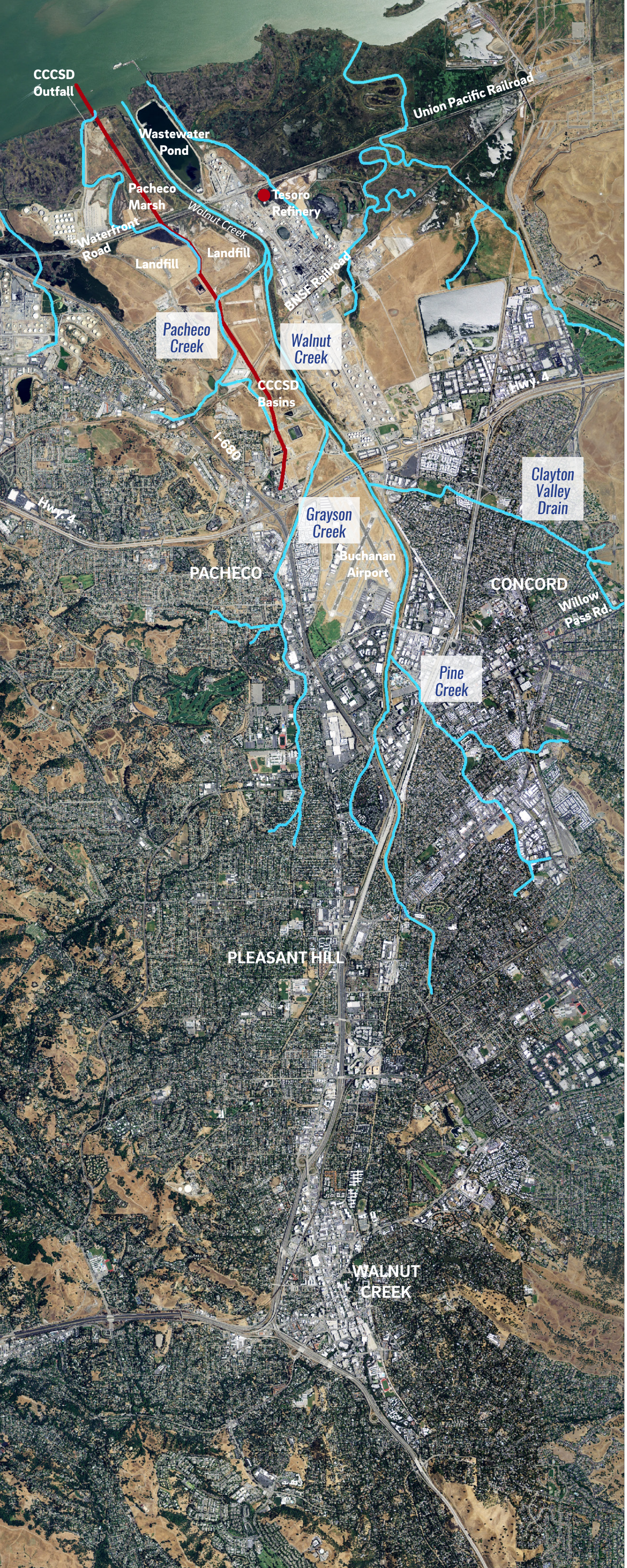
- CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT (CCCFCWCD)
- MARIN COUNTY DEPARTMENT OF PUBLIC WORKS (MCDPW)
- SAN FRANCISQUITO CREEK JOINT POWERS AUTHORITY (SFCJPA)

REGIONAL SCIENCE ADVISORY TEAM

- PETER BAYE (ECOLOGICAL CONSULTANT)
- LETITIA GRENIER (SFEI)
- JEFF HALTINER (HYDROLOGY CONSULTANT)
- JEREMY LOWE (SFEI)

FLOOD CONTROL 2.0 PROJECT STRUCTURE





Lower Walnut Creek study area. (Imagery courtesy of NAIP 2014)

RECENT MANAGEMENT
OF WALNUT CREEK

Walnut Creek in central Contra Costa County flows through the cities of Walnut Creek, Pleasant Hill, and Concord before entering Suisun Bay. Over the past 150 years, the watershed has undergone many changes. Historically, Walnut Creek would spread out onto a large freshwater marsh before draining to a tidal marsh. During the late 1800s and early 1900s, the watershed experienced several damaging floods with high sediment loads, leading to levee building and channel realignment in the creek's lower reaches. In the 1960s, the United States Army Corps of Engineers (USACE) built the Walnut Creek project, which included the lower 22-mile reach of mainstem Walnut Creek and the lower reaches of major tributaries. In the tidal portion of the project, the channels were widened and flood control levees were constructed. USACE anticipated minimal long-term channel maintenance but the channel filled with sediment soon after construction. Less than a decade after it was built, USACE dredged over 800,000 cubic yards of newly deposited sediment from the mouth to the BNSF Railroad bridge before transferring channel maintenance to the District. Sedimentation of Walnut Creek has continued, reducing the channel's capacity to convey floodwaters.

For the last 40 years, the District has maintained the Walnut Creek project in accordance with USACE standards with the exception of dredging the tidal portion of the project. Dredging to meet USACE requirements would have negative impacts on aquatic and wetland habitat and therefore be extremely difficult to permit and costly to mitigate. The District determined that dredging was not sustainable and worked with USACE from 2004 to 2012 to find a sustainable solution; however, the effort stalled due to lack of federal funding. In 2014, Congress approved the District's request for a selective deauthorization from USACE project authority that returned oversight of 2.5 miles of lower Walnut Creek and 1.5 miles of lower Pacheco Creek to the District.

The District is currently undergoing an extensive community-based planning process to develop restoration alternatives within the District's existing jurisdiction (called the Lower Walnut Creek Restoration Project). The Restoration Project seeks to transform the channel into a sustainable system that provides wildlife habitat and flood protection benefits, and has reasonable maintenance costs (CCCFCWCD 2014). This effort has roots in the District's "50 Year Plan," which is a vision for converting classic engineered flood control channels back to natural channels that provide the same level of flood protection throughout Contra Costa County by mid-century (CCCFCWCD 2009). This effort also includes close coordination with the restoration plan being developed by the District and the John Muir Land Trust for Pacheco Marsh (122 acres) adjacent to the Restoration Project at the mouth of Walnut Creek.

This history has created an array of challenges and opportunities associated with channel management:

CHALLENGES

- Transportation and transmission infrastructure (e.g., Union Pacific and BNSF railroads, Waterfront Road, pipelines) within the floodplain
- The need to maintain access to infrastructure (e.g., Central Contra Costa Sanitary District [CCCSD] outfall) for maintenance and repairs
- Landfills and contaminated sites
- Limited lands that are under District ownership; many adjacent lands are privately owned
- High maintenance costs and regulatory restrictions for continued dredging
- Limited areas for habitat migration with sea-level rise, because much of the floodplain is developed or is naturally at higher elevations
- Risk of tidal marsh loss (likely changing to mudflat or subtidal habitat) with sea-level rise
- Potential that watershed sediment supply may not be able to support baylands under rising sea levels

OPPORTUNITIES

- Improve level of flood risk protection through setback of levees, floodplain expansion, and re-connection to fluvial channels
- Increase tidal prism to maintain flood conveyance and promote sedimentation on the marsh plain
- Re-use sediment to enhance resilience of tidal habitats and habitat value of estuarine-terrestrial transition zones
- Minimize or avoid environmental disturbances and costs associated with maintenance channel dredging
- Utilize treated wastewater for enhancing salinity gradients across marsh habitats
- Restore and enhance habitat for wildlife (e.g., Ridgway's Rail, salt marsh harvest mouse), including tidal marshes, fluvial floodplains, transition zones, and riparian areas
- Increase public access for recreation and wildlife viewing

THE PROCESS
FOR DEVELOPING A LONG-TERM VISION FOR LOWER WALNUT CREEK

Step 1
Pre-Workshop

UNDERSTANDING LANDSCAPE FUNCTIONING

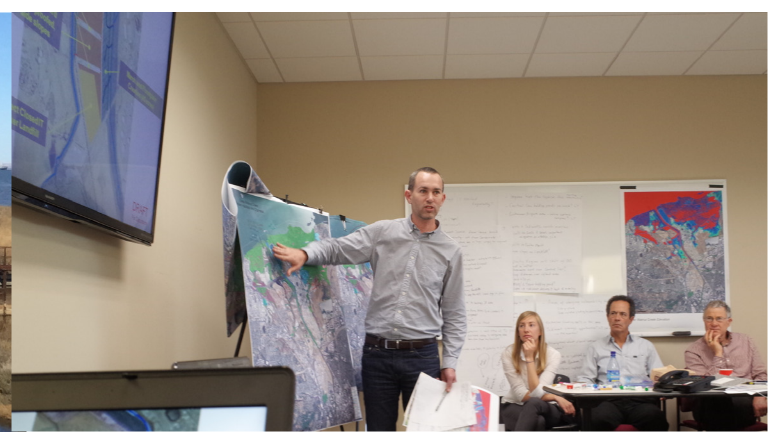
Developing management approaches that lead to a resilient landscape requires understanding the processes that create and maintain landforms and associated habitat types. The first step in developing this understanding included synthesizing archival data to reconstruct the pre-development (mid-19th century) landscape of lower Walnut Creek and adjacent baylands. The historical conditions were then compared to contemporary conditions to highlight changes in physical processes and habitat extent and configuration. SFEI also drew on existing data to complete a contemporary geomorphic analysis of lower Walnut Creek focusing on the magnitude of watershed sediment yield and the major drivers for the current excess sedimentation issues.

Step 2
At Workshop

WORKSHOP

In November 2015, Flood Control 2.0 project leads, in partnership with the District, held a workshop to discuss ideas for improving flood management and habitat conditions within lower Walnut Creek. A Regional Science Advisory Team (RSAT) consisting of regional experts with backgrounds in flood risk management, tidal marsh ecology, and coastal geomorphology were recruited to review the current challenges facing the District and identify potential strategies to address these challenges. Local organizations involved with flood risk management, baylands management, permitting, and water quality were also present at the workshop. The workshop was facilitated by Andy Gunther of the Bay Area Ecosystems Climate Change Consortium (BAECCC).

During the workshop, SFEI presented an analysis of historical and contemporary channel morphology and alignment, sediment dynamics, and habitat extent and configuration in the study area. The District and Environmental Science Associates (ESA; engineering consultants



working on the lower Walnut Creek Restoration Project) presented the history of flood management in lower Walnut Creek, existing infrastructure, and the District's current efforts for enhancing flood management and habitat benefits through near-term restoration projects. During the workshop field trip, participants visited Pacheco Marsh and the lower reaches of Walnut Creek and Pacheco Creek. Based on the information presented, the RSAT provided their expert advice on a range of multi-benefit opportunities for landscape change.

Step 3
Post-Workshop

DEVELOPING THE VISION

The ideas developed at the workshop were synthesized into four overarching strategies aimed at improving long-term resilience of the lower Walnut Creek landscape to support ecosystem services and wildlife habitat under changing future conditions. Each strategy contains several detailed measures (i.e., management actions) that focus on both physical and ecological enhancements to the study area. Together, the measures make up a long-term landscape "Vision."

We used SFEI's recently released Landscape Resilience Framework (Beller et al. 2015) to help guide Vision development. Within this framework, landscape resilience is defined as "the ability of a landscape to sustain desired ecological functions, robust native biodiversity, and critical landscape processes over time, under changing conditions, and despite multiple stressors and uncertainties." The framework provides a robust guide for incorporating the fundamental drivers of ecological resilience into the design of ecosystems and environmental management at the landscape scale. Additional information about the Landscape Resilience Framework can be found at resilientsv.sfei.org.

Walnut Creek Vision Workshop. (photographs by SFEI, 2015)

Step 1
Pre-Workshop

HISTORICAL ECOLOGY
OF LOWER WALNUT CREEK

OVERVIEW

Designing a resilient landscape requires reestablishing the processes that allow ecosystems to thrive, recover, and adapt under changing conditions while providing benefits like flood protection and erosion control. One of the most useful ways to identify those processes and learn how they can be reestablished is to study how a given landscape looked and functioned prior to its extensive modification: its historical ecology.

The use of historical data to study past ecosystem characteristics is a powerful tool not only for reconstructing the past landscape, but also for revealing patterns and processes still operating today and for helping us to envision future landscape potential. Reconstructing the historical ecology of lower Walnut Creek can shed light on a range of important questions: What was the distribution and extent of wetland habitat types? What wildlife species relied on these habitats? How did water and sediment move across the landscape? How has the landscape been modified over the past 150 years? What physical processes or remnant features are still intact that might provide opportunities for restoring ecological functions and enhancing landscape resilience?

To address these and other questions, we collected and synthesized a range of historical sources to reconstruct how the lower Walnut Creek landscape looked and functioned in the recent past. The study area for the historical reconstruction (page 16) encompasses the full historical extent of the tidal wetlands area (i.e., the "baylands") around lower Walnut Creek, adjacent non-tidal wetlands, and downstream portions of the major stream channels that flowed into the baylands; it extends along the shoreline from Bulls Head Point (at the southern landing of the Benicia Bridge) east to Seal Bluff Landing (near Port Chicago).

Data Collection and Compilation

We drew on a wide variety of archival datasets dating back to the late 18th century, including maps, photographs, drawings, and textual documents. Key sources included Spanish explorer diaries, U.S. Coast [and Geodetic] Survey maps, General Land Office Survey plats and field notes, newspaper articles, USGS topographic quadrangles, USDA soil surveys, and aerial photographs. Data were collected from online databases and local, regional, state, and federal archives (see table below).

Source Institution	Location
The Bancroft Library, UC Berkeley	Berkeley
Bureau of Land Management (remotely)	Sacramento
California State Archives	Sacramento
California Historical Society	San Francisco
California State Railroad Museum	Sacramento
Contra Costa County Historical Society	Martinez
Earth Sciences and Map Library, UC Berkeley	Berkeley
Society of California Pioneers	San Francisco
Water Resources Collections and Archives, UC Riverside	Riverside

Source institutions visited or contacted.

Selected data sources were compiled in a Geographic Information Systems (GIS) database. We georeferenced approximately 40 maps and over 100 spatially explicit excerpts from textual documents. A photomosaic of orthorectified 1939 aerial imagery (USDA 1939), covering all of Contra Costa County, was published by SFEI in 2011 (Salomon 2011); orthorectification of the existing photomosaic was refined in some portions of the study area to improve local accuracy. We also orthorectified two aerial photographs from 1928-9 (Russell 1928-9).

Synthesis and Mapping

Historical sources differ widely in terms of accuracy, level of detail, spatial extent, and purpose. While no single source provides a complete picture of the historical landscape, the comparison and synthesis of multiple independent sources allows for a much more accurate reconstruction. Data sources assembled for this study were synthesized to develop a series of GIS layers representing average ecological conditions circa 1850, prior to major Euro-American modifications (page 16). Features were classified as one of the following habitat types:

Tidal Marsh — vegetated portions of the baylands

Marsh Pond/Panne — open water or unvegetated areas on the marsh plain

Subtidal Channel — portions of tidal channels that do not completely drain at low tide

Channel Flat and Bay Flat — portions of tidal channels and the bay that dewater during low tide. Small tidal sloughs were mapped as line features

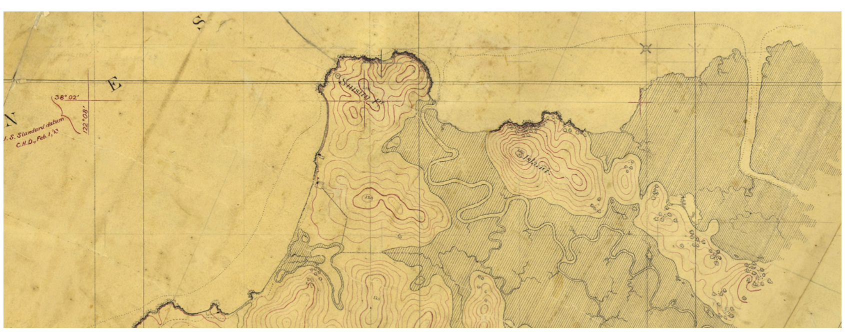
Perennial Freshwater Wetland / Willow Thicket — non-tidal wetlands dominated by emergent vegetation and willows

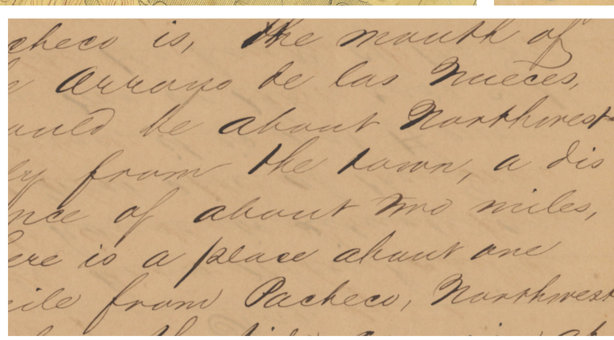
Alkali Meadow — seasonal wetlands characterized by moderately alkaline soils, seasonal flooding, and a salt-tolerant plant community

Stream Channels/Distributaries — non-tidal stream channels. Streams were mapped as line features, and streams that spread into multiple distributary channels are shown with a forked crow's foot symbol

Feature boundaries were mapped from the most spatially accurate sources representative of pre-modification conditions. Wherever possible, the classification and extent of each feature was verified using secondary sources. Each feature was attributed in GIS with both supporting sources and certainty levels representing our confidence in feature classification, shape/size, and location.

For the landscape change analysis (pages 18-19), modern habitat type mapping (page 17) was compiled from the Bay Area Aquatic Resource Inventory baylands and wetlands layers (SFEI-ASC 2015), a Contra Costa County stream layer (Contra Costa County 2008), and the San Francisco Bay Shore Inventory dataset (SFEI 2016).





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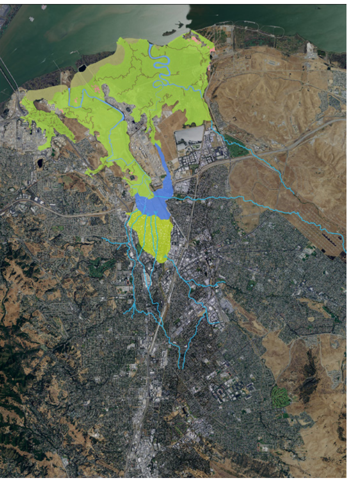
Maps, photographs, and textual documents comprised the principal data types collected. (left to right, top to bottom: Rodgers 1856, courtesy of NOAA; Hesse 1861, courtesy of The Bancroft Library, UC Berkeley; BANC MSS Land Case Files 87 ND, courtesy of The Bancroft Library, UC Berkeley; Russell 1928-9, courtesy of Earth Sciences & Map Library, UC Berkeley)

Step 1
Pre-Workshop

HISTORICAL ECOLOGY
OF LOWER WALNUT CREEK

THE LOWER WALNUT CREEK LANDSCAPE, CIRCA 1850



During the mid-19th century, the lower Walnut Creek watershed was dominated by extensive wetlands, meandering creeks, and grassy plains. The following section describes key features of the historical landscape.

Tidal Marsh

Low-lying areas along lower Walnut Creek supported a large tidal marsh extending from Suisun Bay south to present-day Highway 4 (Rodgers 1856, Rodgers and Chase 1866). The marsh is described as a "tule marsh" in some accounts (e.g., Ransom 1851, Coffee 1857), and as a "salt marsh" in others (e.g., Taylor 1864a); early surveyors also noted the presence of "samphire," or pickleweed (e.g., Lewis 1870). The vegetation of the Walnut Creek baylands likely had similarities to the Napa River tidal marshes, with extensive tule stands along brackish channels and halophytes such as pickleweed and salt grass in areas with poorer drainage (Collins and Foin 1992, Grossinger 2012). Pannes were distributed throughout the marsh plain (Rodgers 1856, Hesse 1861, Rodgers and Chase 1866). Between Bulls Head Point and Point Edith, a wide intertidal mudflat separated the marsh plain from the deeper waters of Suisun Bay. In total, the baylands (including tidal marsh, pannes, and channels) between Bulls Head Point and Seal Bluff Landing occupied approximately 5,000 acres. To the west and east the baylands were bordered by steep hillslopes, while at the southern end of the marsh a low gradient area supported a broad freshwater-brackish transition zone (USGS [1893-4]1897, USGS 1896[1901]).

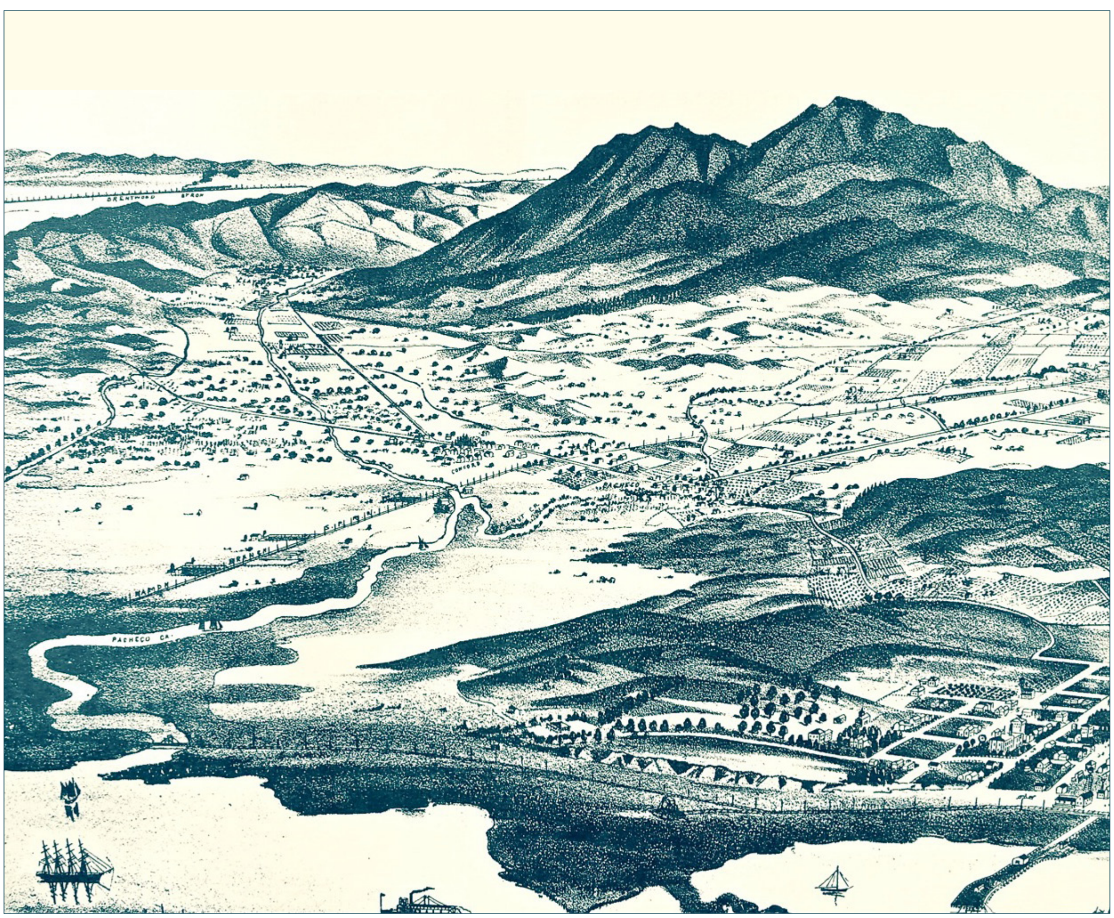
Non-tidal Wetlands

A non-tidal wetland complex, sustained by high groundwater levels, adjoined the tidal marsh on the southern end. Totaling aproximately 800 acres, these wetlands formed an ecologically complex and highly productive area which provided habitat for plant and animal species of current conservation interest such as California Tiger Salamander (CNDDB 2012). Historical evidence suggests that wetland types within this area included freshwater marsh, willow thicket, and brackish/alkali marsh and meadow. As a result of the area's flat topography, boundaries between wetland habitat types were gradual and thus challenging to define precisely. Immediately adjacent to the baylands, a perennial freshwater wetland complex was found in the area around present-day Buchanan Field Airport (Williamson 1850, USGS [1893-4]1897, USGS [1896]1901). An arm of the wetland extending downstream along the eastern side of the present-day Tesoro Refinery functioned as an overflow channel for Walnut Creek during floods. Early accounts describe a willow swamp or thicket, referred to as "Monte del Diablo" ("thicket of the devil"), within this wetland complex, though its size is not specified (Smith & Elliott [1879]1979, Viader and Cook 1960). Further south, the wetland complex graded into an alkali meadow, characterized by moderately alkaline soils, seasonal flooding, and a salt-tolerant plant community (Carpenter and Cosby 1933, 1939).

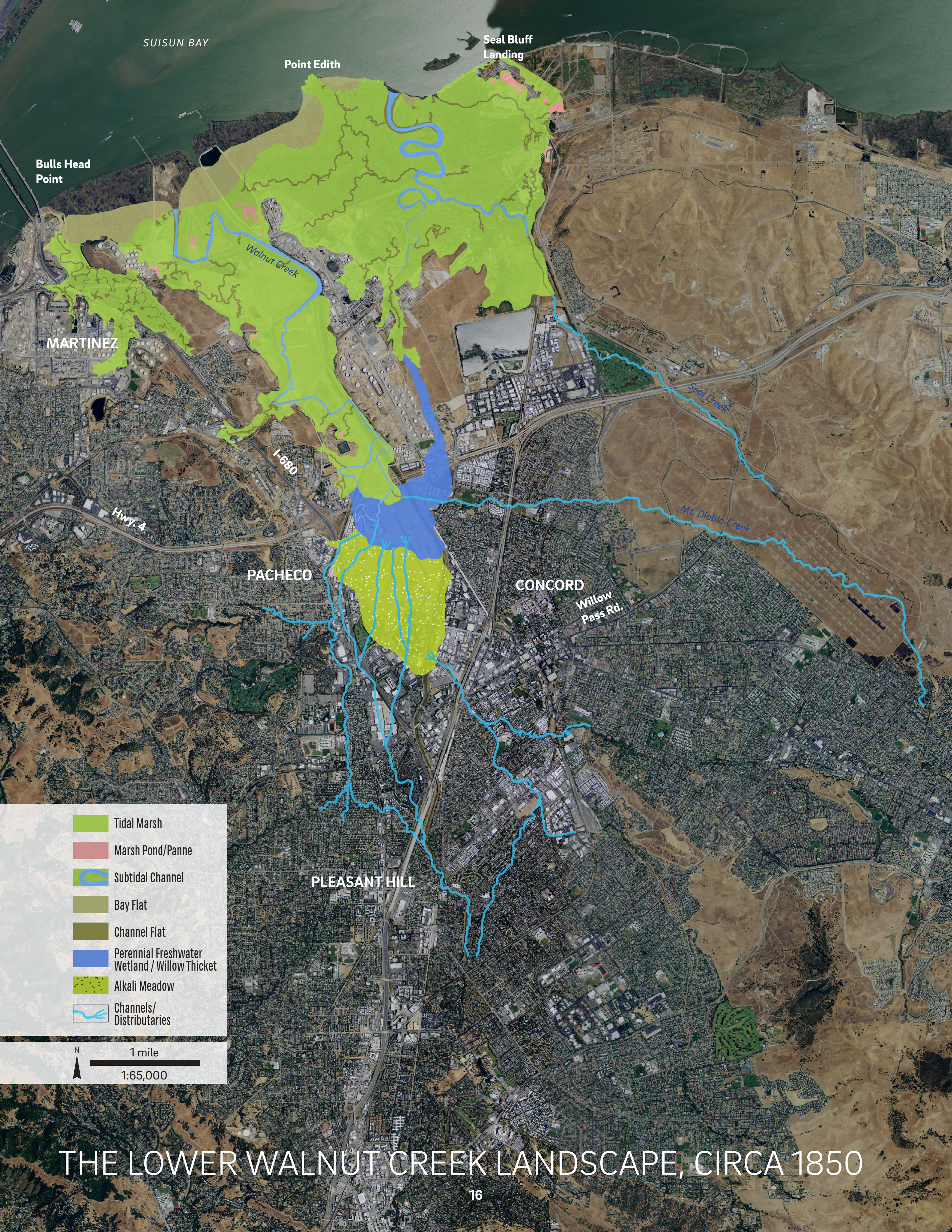
Stream Channels

Upstream of the baylands and the non-tidal wetland complex, Walnut Creek flowed along the western side of the valley (Coffee 1857, Allardt 1861, USDA 1939). A mixed riparian forest (not shown in the mapping) composed of willows, ashes, oaks, cottonwoods, alders, walnuts, and laurels lined the creek (Small 1855, Taylor 1864b, Crespí and Bolton 1927, Viader and Cook 1960). Several secondary channels branched off on the eastern side, reconnecting with the mainstem downstream or terminating in the wetland complex (Williamson 1850, McMahon and Minto 1885, USGS [1893-4]1897). Early observers noted that sections of Walnut Creek had little or no flow during the dry season: camped along the creek with the Anza Expedition in April 1776, for example, Pedro Font wrote, "[It] would be not a bad place for a settlement... if only the stream were a year-round one. But evidently it is not, as we found it having no flow and with only small pools" (Font and Brown 2011). Walnut Creek followed a meandering course through the tidal marsh to its mouth at Suisun Bay, and tides regularly overflowed the channel banks onto the marsh plain (Carpenter and Cosby 1933, 1939). In the mid-19th century, the creek was navigable as far inland as the town of Pacheco, which for a short time was an important shipping point for grain and other products (e.g., *Daily Alta California* 1860).

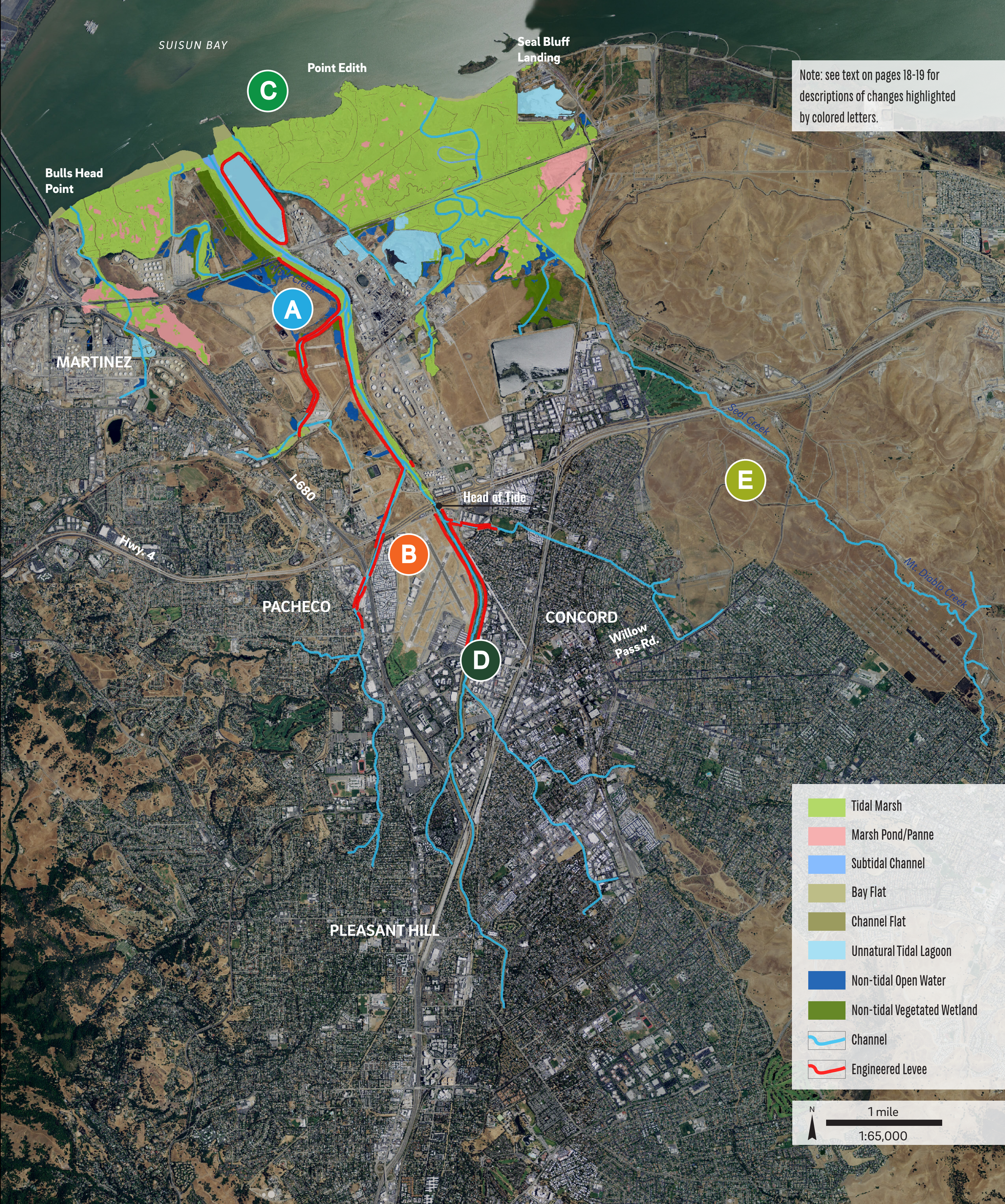
Numerous other streams, including Seal Creek, Mt. Diablo Creek, Galindo Creek, Pine Creek, Grayson Creek, and Hidden Valley Creek, drained into the baylands. Mt. Diablo Creek, which today drains into Seal Creek and Hastings Slough, historically flowed west through present-day Concord to connect with Walnut Creek on the southern end of the baylands (Britton & Rey 1871, Whitney 1873, McMahon and Minto 1885).



This 1895 lithograph of Diablo Valley shows "Pacheco Cr." (an early name for lower Walnut Creek) meandering through the marsh on its course to Suisun Bay. Several ships are visible navigating up the creek towards the town of Pacheco. Mt. Diablo rises in the background. (courtesy of Dean McLeod and Contra Costa County Historical Society)



THE LOWER WALNUT CREEK LANDSCAPE, CIRCA 1850



THE LOWER WALNUT CREEK LANDSCAPE, CIRCA 2010

Step 1
Pre-Workshop

LANDSCAPE CHANGE
OF LOWER WALNUT CREEK

THE LOWER WALNUT CREEK LANDSCAPE, CIRCA 2010

Note: colored letters in the text correspond to annotations on the circa 2010 map (preceding page).

The lower Walnut Creek landscape has changed dramatically over the past 150 years. Grazing and logging, which were dominant land uses in the watershed during the early to mid-1800s, likely contributed to increased rates of erosion and sediment delivery. Major roads and railroad lines were constructed through the baylands in the late 19th and early 20th centuries, reducing habitat connectivity and constricting both fluvial and tidal flows. Industrial development, urbanization, and stream channelization has greatly reduced wetland extent and altered hydrology in the lower watershed.

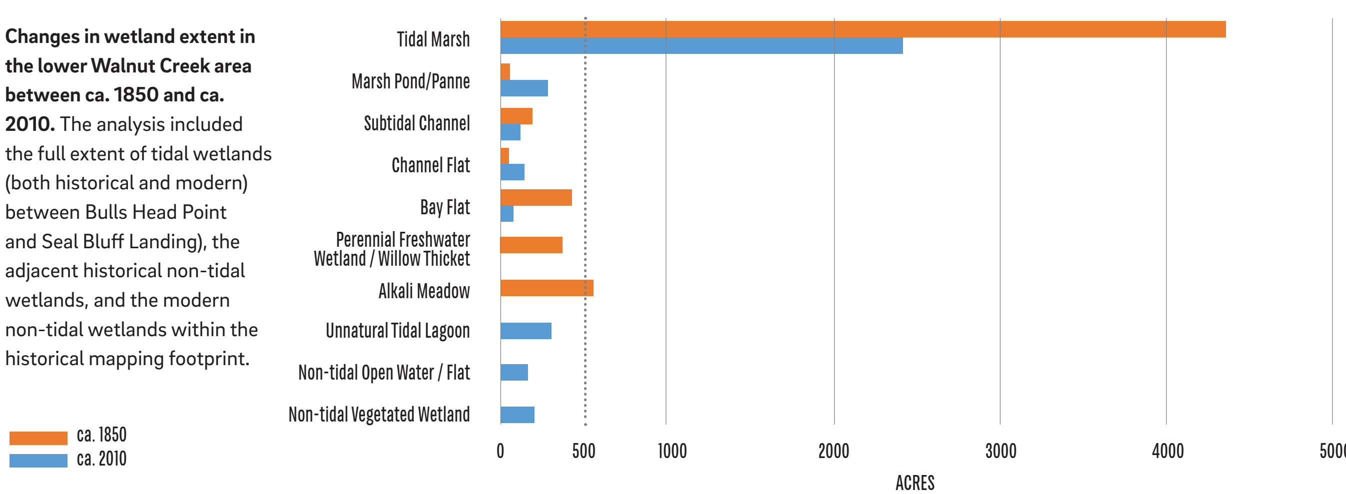
Loss of Tidal Wetlands

Industrial and urban development during the late 19th and 20th centuries reduced tidal wetland extent by approximately 40% between Bulls Head Point and Seal Bluff Landing. Immediately adjacent to lower Walnut Creek (excluding the Bay Flat and Unnatural Tidal Lagoon features and the wetlands west of Pacheco Marsh), approximately 85% of historical tidal wetland area has been lost, and remaining marsh areas are confined to a narrow corridor along the channel A. Both lateral and longitudinal connectivity in the remaining tidal wetland areas has been greatly reduced by industrial facilities, roads, and other infrastructure. In addition to the overall impact on habitat extent and quality, the loss of tidal wetlands also represents a substantial reduction in tidal prism volume, which has resulted in a decrease in channel scour capacity and contributed to sediment accumulation within the tidal portion of Walnut Creek (pages 20-23).

Loss of Non-Tidal Wetlands

The freshwater marsh, willow thicket, and seasonal alkali meadow historically found immediately south of the baylands have been eliminated by urban development B. Buchanan Field Airport and other developed areas occupy much of the historical footprint of this wetland

Changes in wetland extent in the lower Walnut Creek area between ca. 1850 and ca. 2010. The analysis included the full extent of tidal wetlands (both historical and modern) between Bulls Head Point and Seal Bluff Landing), the adjacent historical non-tidal wetlands, and the modern non-tidal wetlands within the historical mapping footprint.



complex. Though numerous small, non-tidal wetlands exist within the historical baylands area, these fragmented features do not provide the same degree of flood attenuation, sediment storage, groundwater recharge, or wildlife habitat formerly provided by the large wetland complex.

Shoreline Expansion

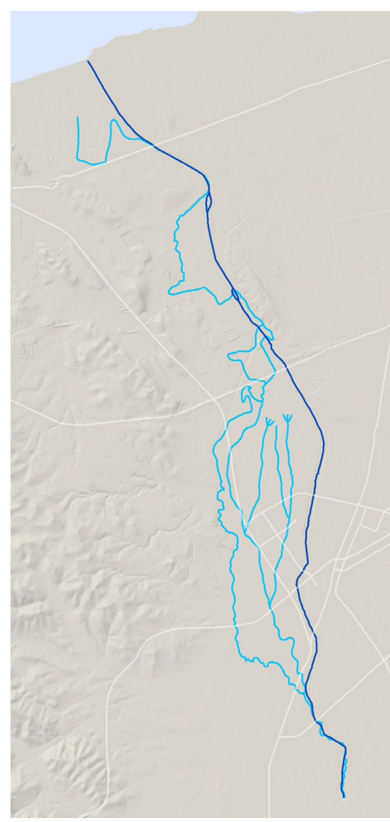
The shoreline between Bulls Head Point and Point Edith has prograded (i.e., expanded bayward) by up to half a mile over the past 150 years C (Rodgers 1856, Rodgers and Chase 1866, Davidson 1886b). This process was already underway by the 1880s, as evidenced by an 1886 Coast Survey descriptive report: “On the flats between Bull’s Head Pt. and Pacheco Creek… No grass is shown in the sheet of the former [1866] survey. Now it extends nearly half a mile off shore” (Davidson 1886a). The report attributes most of the expansion to “washings brought down by Pacheco [Walnut] Creek,” though it is likely that debris from hydraulic mining also contributed to the sediment accumulation, as has been documented in other locations around the bay (Gilbert 1917, Atwater et al. 1979). Shoreline position to the east of Point Edith has been much more stable, with little to no change over the past 150 years.

Changes in Channel Alignment and Floodplain Connectivity

Stream channels upstream of the baylands have experienced major modifications over the past century and a half, resulting in an overall decrease in floodplain connectivity and channel sinuosity. Channel alterations had begun by the late 19th century, when local farmers and landowners constructed diversions and levees to direct floodwaters towards the bay. Along lower Walnut Creek, a series of early 20th century modifications culminated with the construction of a trapezoidal flood control channel by the Army Corps during the 1960s. As a result, the mainstem channel is today shifted up to a mile further east, and is separated from its floodplain by engineered levees D. The secondary channels which historically distributed flows throughout the non-tidal wetland complex have been eliminated (see figure at right).

Another significant hydrologic change was the re-alignment of Mt. Diablo Creek, which historically connected with Walnut Creek at the southern end of the tidal marsh. In the late 19th century, local landowners diverted the creek and connected it to Seal Creek on the eastern side of the valley E, thereby removing a large source of both freshwater flow and sediment to lower Walnut Creek and the surrounding wetlands.

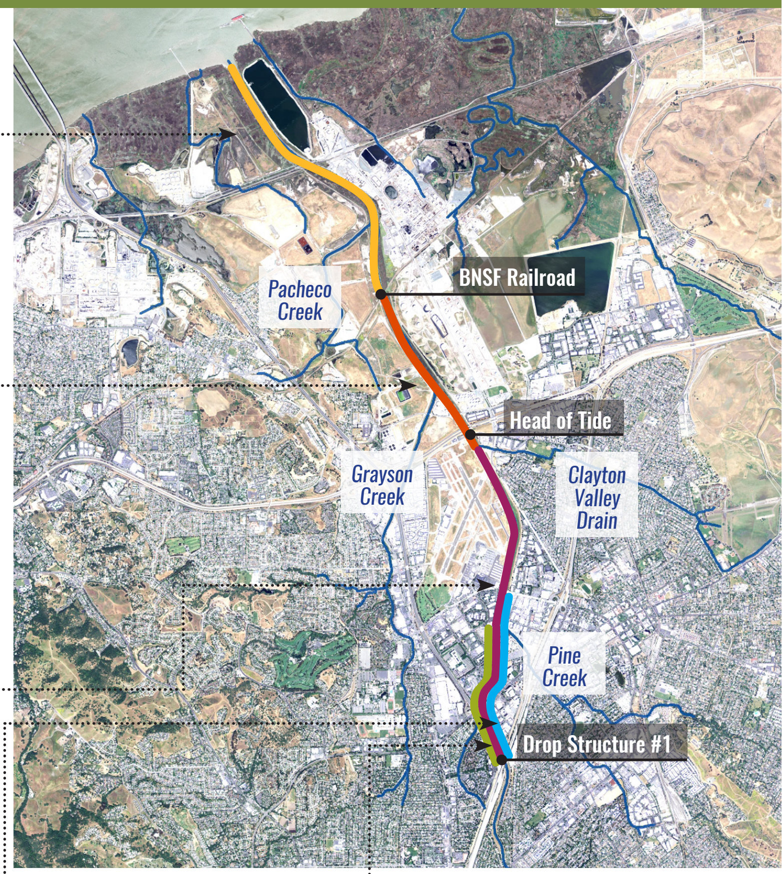
Changes in alignment of lower Walnut Creek, ca. 1850 (light blue) to ca. 2010 (dark blue).



Step 1
Pre-Workshop

SEDIMENT ACCUMULATION
IN LOWER WALNUT CREEK

The lower Walnut Creek Flood Control Channel has a well-documented history of sediment accumulation followed by sediment removal to maintain flood conveyance capacity. Since its completion in 1965, approximately 1.4M cubic yards (CY) of sediment have been removed between the channel mouth and a channel grade control structure 6.5 miles upstream (Drop Structure #1) during five major removal efforts.



1973 • 850,000 CY

The USACE suction dredged most of the sediment that accumulated in the tidal reach between the mouth and the BNSF railroad bridge following channel construction. The USGS determined that the sediment deposited between the Pacheco Creek confluence and the BNSF railroad bridge was predominantly sand, indicating it likely came from the surrounding watersheds. By 2004, over 800,000 CY of sediment was redeposited in this reach.

2007 • 192,000 CY

Tidal Zone • 144,000 CY | Fluvial Zone • 48,000 CY

To address USACE's concerns about decreased flood conveyance, the District desilted (i.e., excavated) the mostly tidal reach between the BNSF railroad bridge and the Clayton Valley Drain confluence. The sediment removed from both the fluvial and tidal zones was coarse-grained bar deposits (i.e., watershed-derived fluvial sediment), which represented most of the sediment that had accumulated in this reach since channel construction.

1986 & 1989 • 276,000 CY

The District conducted targeted desilting in the reach between the Clayton Valley Drain confluence and Drop Structure #1. Sediment deposited on the floodplain benches adjacent to the low flow channel was removed using off-channel excavators to minimize in-channel habitat impacts, with removal occurring from one side of the channel during each year. This approach has been used in the subsequent dredging efforts above head of tide.

2006 • 25,500 CY

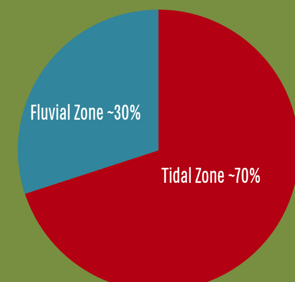
The District conducted targeted desilting in the reach between Concord Ave. and Drop Structure #1. The effort focused on the channel areas where the deep sediment deposits had accumulated since in the 1993-1995 desilting events.

1993 & 1995 • 76,000 CY

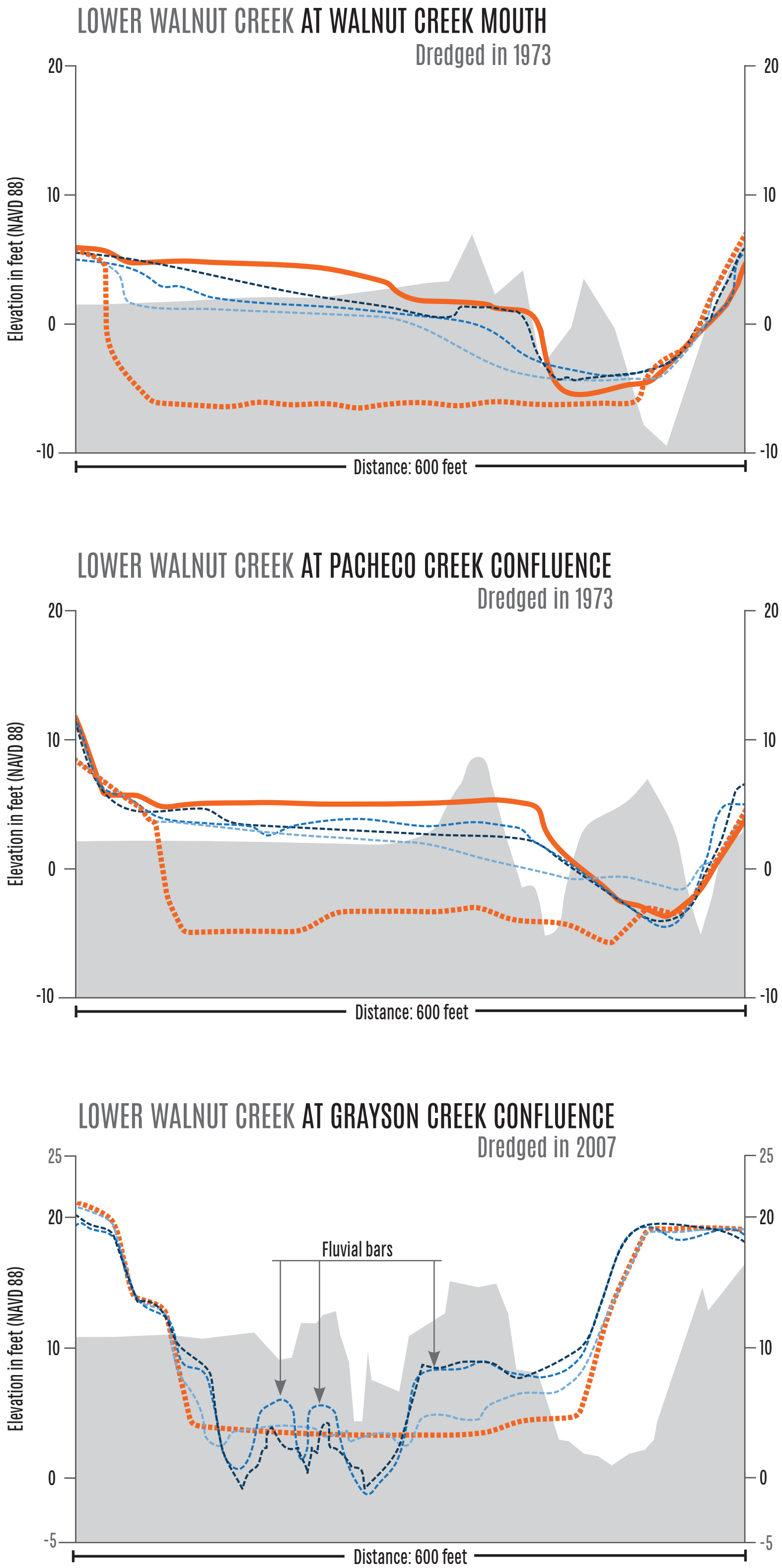
The District conducted targeted dredging in the reach between the Pine Creek confluence and Drop Structure #1. Similar to the 1986-1989 dredging events, sediment was removed from one floodplain bench during each year.

Sources: Porterfield 1972, CCCFCD 2007, Detjens 2009, MBH 2012, RDG 2013

Since its construction, the vast majority of the sediment removal in the lower Walnut Creek Flood Control Channel between the mouth and Drop Structure #1 was from the tidal zone (i.e., downstream of head of tide at the Highway 4 bridge crossing). Best available data suggest that more than one-third of the tidal zone sediment removed in 1973 (~341,000 CY) and all of the tidal zone sediment removed in 2007 (~144,000 CY) came from the surrounding watersheds via fluvial transport.



TOTAL SEDIMENT REMOVAL



Repeat channel cross-section surveys in lower Walnut Creek.

2015*
2005
1995
1972
1965 (after channel construction)
1962 (before channel construction)

*2015 cross section not available for Grayson Creek confluence

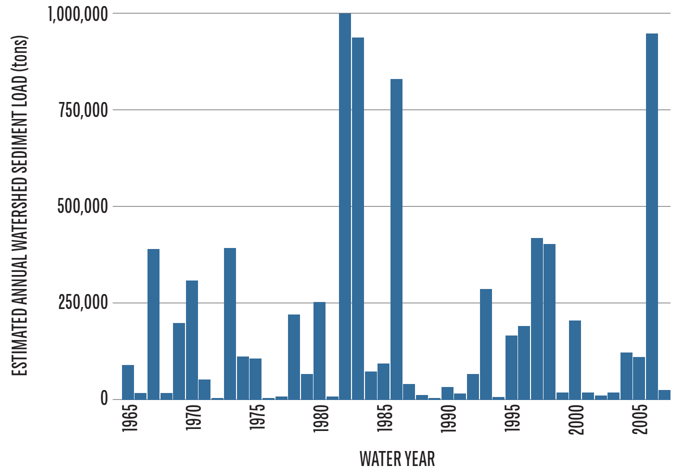
Channel cross sections over the past 50 years clearly illustrate channel in-filling dynamics and help elucidate the dominant factors driving sediment deposition. In just seven years following channel construction, sediment accumulation in the lower portion of the tidal reach brought channel bed elevations close to pre-construction values. This sediment appears to be a combination of fluvial sediment deposited during major storm events (e.g., January 1967 flood) and tidal sediment deposited due to relatively low tidal prism (55% reduction in tidal prism from historical conditions) and associated low channel scour capacity during normal tides. In the two decades following the 1973 dredging event, channel bed elevations in the lower portion of the tidal reach approached near 1972 elevations, suggesting a return to a quasi-equilibrium state driven by tidal prism. Channel slope reduction associated with channel in-filling likely caused the deposition of fluvial bars at the upstream end of the tidal reach during large storm events (e.g., January 1982 flood). Channel bed elevations in the tidal zone remained relatively static from 1995 to 2005 and show a modest increase from 2005 to 2015 in the lower tidal zone (likely driven in large part by sediment deposited during the large December 2005 flood). Overall, the lower Walnut Creek tidal zone appears to be at or near a state of quasi-equilibrium, with sediment accumulation being balanced by transport processes that maintain relatively stable channel elevations.

Sources: USACE 1964, USACE 1965, USACE 1972, Towill 1995, Towill 2005, MBH 2012, ESA 2015 (all courtesy of E. Divita, ESA)

SEDIMENT ACCUMULATION

IN LOWER WALNUT CREEK (continued)

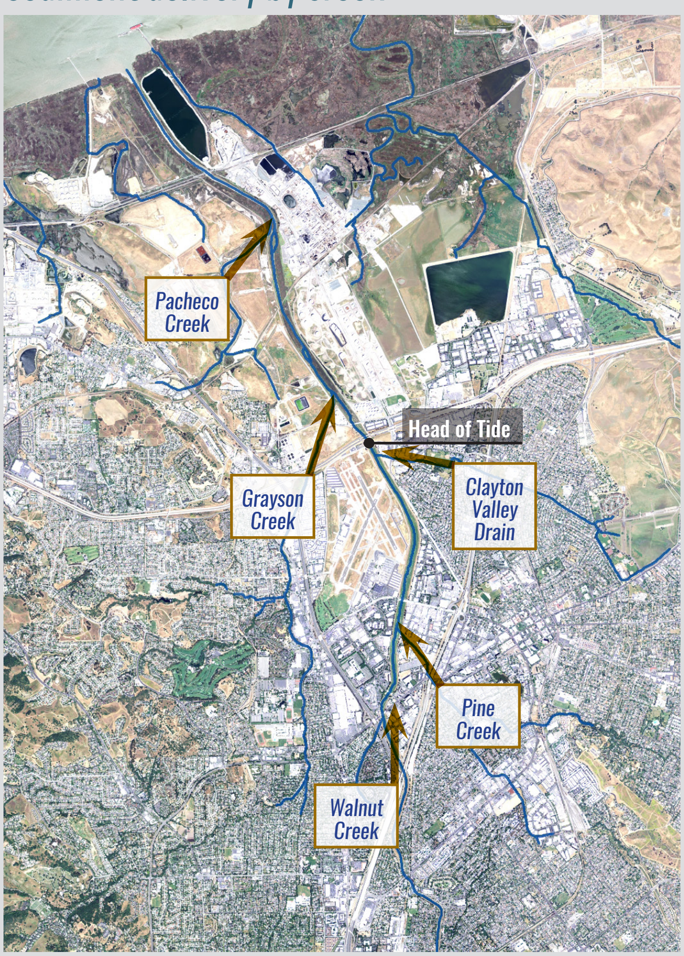
Watershed-derived sediment is delivered to the lower Walnut Creek Flood Control Channel from three primary sources: Walnut Creek upstream of the Pine Creek confluence, Pine Creek, and Grayson Creek. A recent analysis of long-term watershed sediment delivery to lower Walnut Creek at the head of tide gives a total sediment load of 8.4M tons (or 6.6M CY) over the 43-year period between channel construction and the most recent dredging event, with almost half of the sediment delivered in just 4 years (1982, 1983, 1986, 2006). The total load translates to a sediment delivery rate during this time period of approximately 195,000 tons/year, or almost 1,350 tons/mi^2/year, which is one of the highest average annual sediment delivery rates in the region. The primary drivers for the high watershed sediment yield include a history of watershed land clearing, moderately erosive bedrock geology, and relatively rapid uplift rates in the eastern portion of the watershed around Mt. Diablo.

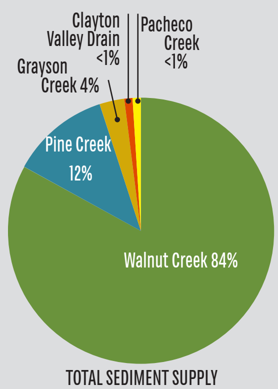


Walnut Creek watershed total sediment load (1965-2007).

Source: SFEI-ASC 2016

Sediment delivery by creek





Pacheco Creek

Accounts for 3% of the lower Walnut Creek drainage area (4 mi^2) and provides <1% of the total watershed sediment and sand delivered to lower Walnut Creek

Clayton Valley Drain

Accounts for 4% of the lower Walnut Creek drainage area (6 mi^2) and provides <1% of the total watershed sediment and sand delivered to lower Walnut Creek

Grayson Creek

Accounts for 12% of the lower Walnut Creek drainage area (18 mi^2) and provides approximately 4% of the total watershed sediment and approximately 1% of the sand delivered to lower Walnut Creek

Pine Creek

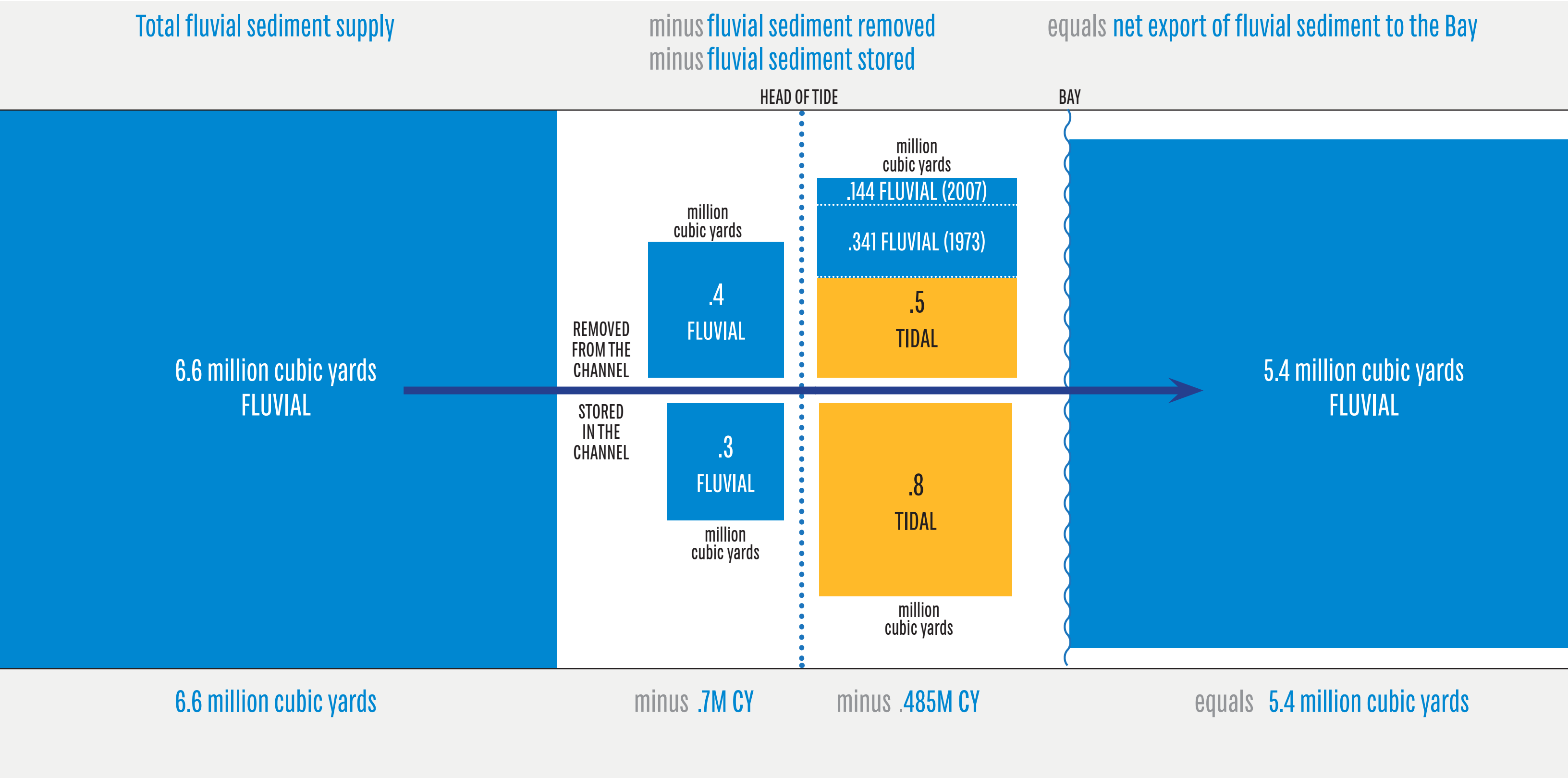
Accounts for 22% of the lower Walnut Creek drainage area (31 mi^2) and provides approximately 12% of the total watershed sediment and approximately 7% of the sand delivered to lower Walnut Creek

Walnut Creek at Concord

Accounts for 59% of the lower Walnut Creek drainage area (86 mi^2) and provides approximately 84% of the total watershed sediment and approximately 90% of the sand delivered to lower Walnut Creek

Sources: Detjens 2009, MBH 2012

Simple accounting of fluvial sediment input to and sediment removal in the lower Walnut Creek Flood Control Channel (i.e., a channel sediment budget) provides an estimate of the amount of fluvial sediment that makes it through the flood control channel, which can be used with the cross-section elevation data to clarify the current sediment storage and channel in-filling dynamics.



Walnut Creek sediment budget, 1965-2007.

Assuming the sediment stored in the tidal zone following the 1973 dredge event is primarily tidally-derived (as indicated by sediment core data), the lower Walnut Creek sediment budget for 1965 to 2007 suggests that, at a maximum, approximately 80% of the watershed sediment delivered to the channel made it out to the Bay. The 20% that deposited was composed primarily of fine gravel, sand, and silt filling in the channel following channel construction and each subsequent desilting event. However, repeat channel cross-sections indicate that the tidal zone is currently at or near a state of quasi-equilibrium, suggesting there could be less fluvial sediment deposition in the future if the channel is not dredged as it was in the past.

Sources: Porterfield 1972, Detjens 2009, HT-E 2009, MBH 2012, SFEI-ASC 2016

Step 1
Pre-Workshop

CHANGING FUTURE CONDITIONS

The lower Walnut Creek landscape will evolve as climate continues to change. A changing climate is expected to cause a continued rise in sea level, inland migration of head of tide and freshwater-brackish water mixing zone, more intense storms, altered watershed and tidal sediment supply, warmer air temperatures, and altered freshwater inputs. These changes will increasingly impact both human and wildlife communities if no landscape adaptation actions are taken. Here, we consider a subset of features and processes that will be impacted by climate change and their possible effects on the physical and ecological conditions of lower Walnut Creek and the surrounding baylands.

Overall Climate Change Impacts

Sea-level Rise

Over the past century, mean tide elevation in San Francisco Bay increased by over 220 mm (8.7 in) (Flick et al. 1999). Acknowledging uncertainties, future projections for the Bay suggest that mean tide elevation will rise by approximately 12 to 61 cm (4.5 to 24 in) by 2050 and approximately 42 to 166 cm (16.5 to 65 in) by 2100 (NRC 2012). These projections include a sharp increase in the rate of sea-level rise around mid-century, although such an inflection point could occur sooner depending on factors such as deep ocean warming rates and the destabilization of the Greenland and Antarctic ice sheets (DeConto and Pollard 2016).

Salinity Shifts

The relatively low salinity of the tidal inflow from Suisun Bay results in brackish marshes along the lowest reaches of Walnut Creek. As sea level rises and tidal inundation extends further inland, the salinity of Suisun Bay and lower Walnut Creek is expected to increase. A change in salinity could affect tidal marsh plant community composition and habitat quality and suitability for brackish and freshwater species. Potential future changes to freshwater flow due to water demand and re-use could also drive plant communities and local salinity gradients along lower Walnut Creek.

Waterfront Road during king tide, December 2015. (photograph courtesy of Mike Carlson, CCCFCWCD)

Flood Events

Climate change could affect the frequency and intensity of storm events leading to flooding and coastal erosion. Over the past several decades, the frequency of extreme precipitation events in the region increased by approximately 30-45% (Madsen and Figdor 2007). In the future, increases in fluvial flooding will likely track extreme precipitation events (which are projected to increase in frequency [Flint and Flint 2012]) and will be exacerbated when peak flood discharge coincides with high Bay water levels (Dettinger et al. 2011). More large storm events could also impact the shoreline through direct flooding from storm surge and erosion of the shoreline with higher wind waves.

Sediment Supply

The supply of tidal and watershed sediment delivered to lower Walnut Creek will likely change in the coming decades. The tidal sediment supply in San Francisco Bay has been on the decline since the turn of the century, due in large part to the depletion of an erodible sediment pool in the Bay that was a result of 19th century hydraulic mining in the Sierra Nevada (Schoellhamer 2011). On the other hand, increased large storm frequency in the future could result in an overall increase in watershed sediment yield and an associated increased supply of sediment to the adjacent marshes over the long term.

Potential Responses to Climate Change

Channel Changes

As sea level rises and the frequency of large storms increases, the lower Walnut Creek channel will likely undergo considerable changes. The head of tide will likely migrate upstream, causing decreased channel capacity during floods when tides are high and a potential increase in the amount and inland extent of tidal sediment deposition. More frequent large floods coming out of the watershed would cause increased channel bank erosion and put levees and floodplain infrastructure at risk. In addition, more large storms could cause increased watershed sediment delivery to lower Walnut Creek , which could increase in-channel sediment deposition and reduce channel capacity upstream of head of tide, adding to flood concerns.

Baylands Evolution

With anticipated accelerated sea-level rise in the coming decades, reduced suspended sediment supply from the Bay, and increased salinity, tidal marshes adjacent to lower Walnut Creek could evolve in a number of ways. Increased salinity in Suisun Bay caused by sea-level rise could cause a shift from brackish marsh to salt marsh vegetation around the creek mouth. High marsh currently flooded during spring tides could downshift to low marsh depending on sediment supply (Goals Project 2015). Lower elevation marshes that are currently flooded regularly by tides could convert to mudflats depending on accretion rates and wave energy. In addition, marsh shoreline erosion may also be of concern in the future with higher storm surge and higher sea levels contributing to higher wind waves. Therefore, it is important to create areas for landward migration of tidal habitats, develop approaches to enhance vertical marsh accretion, and consider if outboard natural protection measures (such as beaches along marsh scarps) are appropriate.

Wildlife Impacts

Climate change could have profound impacts on a variety of wildlife communities along lower Walnut Creek. The conversion of brackish marsh to mudflat caused by sea-level rise could drastically decrease the current amount of habitat available for Ridgway's Rail, Black Rail, and salt marsh harvest mouse. A shift from brackish to salt marsh vegetation (and an associated decrease in vegetation height and structural complexity) could decrease existing marsh bird habitat, such as cover and breeding habitat for Marsh Wrens and Common Yellowthroats. Increased salinity in the tidal portion of the creek and an inland movement of the freshwater-brackish water mixing zone could also alter resident fish communities. Also, increased tidal flooding frequency near the mouth could affect survival and reproduction of tidal marsh mammals and birds.

Photo sources. (top to bottom) Pacheco Marsh, photograph by Amy Richey, SFEI; Pacheco Marsh, photograph by Amy Richey, SFEI; Marsh Wren, photograph courtesy of Greg Schechter, Creative Commons; salt marsh harvest mouse, photograph courtesy of USGS.

Step 2
At Workshop

VISION GUIDANCE

VISION FOR IMPROVING LANDSCAPE FUNCTIONALITY AND RESILIENCE

Pacheco Marsh. (photograph courtesy of Stephen Joseph Photography, stephenjosephphoto.com)

The development of a long-term Vision for lower Walnut Creek and the surrounding landscape focused on restoring lost habitat and promoting long-term ecological resilience in a changing climate within the context of flood risk management.

This section describes four overarching management strategies that reflect the ideas put forth by the RSAT during the one-day workshop in November 2015 and are consistent with the District's restoration and flood risk management goals. Each strategy has several actions (or measures) that could be implemented to provide multiple benefits over the short- and long-term. The strategies and measures focus on physical and ecological enhancements that could result in additional co-benefits, such as recreational opportunities. Further analysis will need to be conducted to determine feasibility, specifications, and integration with other plans in the study area. Additionally, the cooperation of willing landowners will be critical to move from the list of strategies provided here to functioning on-the-ground projects.

The Vision strategies draw from recommendations in the *Baylands Ecosystem Habitat Goals Science Update* (Goals Project 2015). Using input from over 100 scientists, the Goals Project identified science-based actions to support ecosystem functions and services given climate change drivers within the different subregions and segments of San Francisco Bay.

The Goals Project identifies the following actions as essential for maintaining existing and restored baylands in the face of climate change:

1. **Restore estuary-watershed connections that nourish the baylands with sediment and freshwater.**
    - Realign some stream courses where necessary and feasible to restore natural sediment-delivery processes.
    - Identify ways to increase the availability of watershed sediment to tidal marshes and mudflats.
    - Use suitable sediment from various sources (excavated or dredged) for baylands restoration and management.
    - Identify and implement opportunities for taking advantage of treated wastewater and stormwater to create salinity gradients and maximize peat accumulation in the baylands, while protecting water quality and minimizing nutrient loads.
2. **Design complexity and connectivity into the baylands landscape at various spatial scales.**
3. **Restore and protect complete tidal marsh systems.**
4. **Restore the baylands to full tidal action before 2030.**
5. **Plan for the baylands to migrate.**

Within the Suisun Subregion/North Contra Costa shoreline segment, where lower Walnut Creek is located, the Goals Project recommends the following:

- **Restore large areas of tidal marsh in diked and muted tidal marsh areas.**
- **Where tidal marsh cannot be restored, improve water management to enhance diked wetlands through realigning levees and drainage ditches and connecting historical sloughs.**
- **Enhance and restore the natural transition zone, focusing on tidal marsh transitions, incorporating protective buffers wherever possible, particularly around the base of alluvial fans to provide sediment to the terrestrial side of marshes.**
- **Restore riparian vegetation, particularly willow groves (or sausals) where appropriate, along small and large streams.**
- **Restore historical pans where salt-making plants are no longer active.**
- **Realign railways to allow for migration of the baylands with sea-level rise.**

Union Pacific Railroad Bridge over lower Walnut Creek. (photograph by Carolyn Doehring, SFEI)

LOWER WALNUT CREEK VISION STRATEGIES

STRATEGY 1: Sustaining Resilient Marshes by Improving Natural Delivery of Freshwater and Sediment.

Historically, freshwater and sediment nourished baylands habitats and allowed them to keep pace with sea-level rise. However, watershed-estuary connections that deliver freshwater and sediment have been greatly reduced throughout lower Walnut Creek due to channel levees and other infrastructure. Within the study area, there are several opportunities to re-establish delivery of watershed sediment and freshwater to tidal marshes and mudflats, as well as to restored non-tidal freshwater wetlands (or freshwater marshes) further upstream.

- *Set Back Levees*
- *Reconnect Creeks to Floodplains*
- *Create Zones for Distributary Corridors*
- *Modify Transportation and Pipeline Infrastructure*

STRATEGY 2: Sustaining Resilient Marshes Using Dredged Sediment.

In the future, the need for sediment to drive rapid marsh accretion will increase as sea level rise accelerates. Dredged sediment from the lower Walnut Creek channel and other local sources could be utilized in a variety of ways, including maintaining marsh elevations as sea level rises and protecting the shoreline from erosion.

- *Maintain Marsh Elevations with Dredged Sediment*
- *Protect Marsh Edge with Dredged Sediment*

STRATEGY 3: Sustaining Resilient Marshes Using Treated Wastewater.

The freshwater input to Walnut Creek marshes has been significantly altered by the construction of levees, drainage ditches, and stormwater channels. Treated wastewater could be used to enhance wetland types that have been reduced or eliminated in the study area. In particular, using treated wastewater to create seasonal freshwater wetlands and brackish wetland seepage slopes could help increase peat accumulation and provide habitat for native wildlife.

- *Support Freshwater Wetlands with Wastewater Discharges*
- *Support Seepage Slopes with Diffuse Wastewater Discharges*

STRATEGY 4: Improving Ecological Connectivity Across Marshes and Along Creeks.

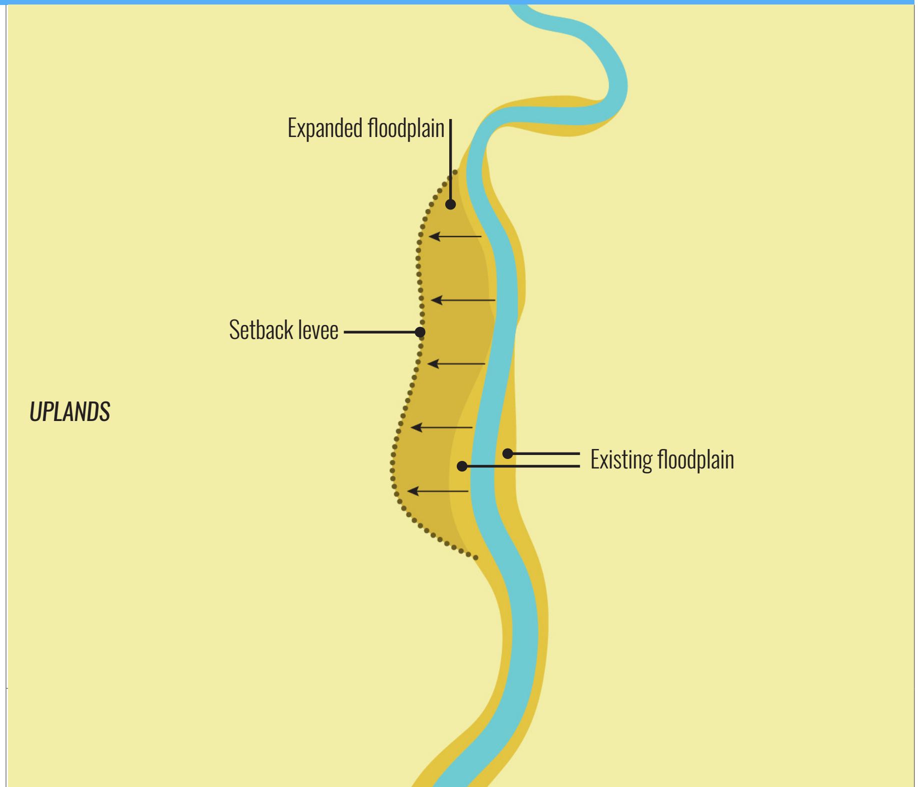
With altered land use and urbanization, many wildlife corridors along the creek channel, tidal marsh, and adjacent hills have been reduced or fragmented. Such connectivity will be increasingly important as climate change impacts wildlife resources (e.g., via salinity shifts). Protecting and expanding transition zones for marsh migration also assists in the long-term persistence of baylands wildlife.

- *Enhance Wildlife Corridors*
- *Protect and Restore Transition Zones*

STRATEGY 1: Sustaining Resilient Marshes by Improving Natural Delivery of Freshwater and Sediment

MEASURE 1: Set Back Levees

Expand the area and width of floodplain by setting back levees.

DESCRIPTION	Levees along Walnut Creek could be moved inland to allow for an expanded channel width along the creek corridor. Historically, Walnut Creek was able to migrate back and forth and flood across the floodplain in fluvial reaches and within the tidal marsh, supporting diverse ecosystem functions. Historical mapping suggests that Walnut Creek and Mt. Diablo Creek had meander corridors that were about 0.5 to 0.75 miles wide.	CONCEPT	
LOCATION	This measure could be implemented along the western bank of lower Walnut Creek between BNSF Railroad and the confluence of Pacheco Creek. Floodplain expansion could also be assessed along Walnut Creek between Concord Ave. and Highway 4, the location of historical freshwater wetlands and distributary channels. Additional levees could be set back in the future as opportunities arise.	KEY BENEFITS	**Increases tidal prism,** causing channel scour and increasing flood conveyance capacity at low tide (i.e., when the channel is not filled with tidal water), decreasing excess sediment deposition, and decreasing the need for sediment removal **Increases flood water detention capacity,** potentially decreasing flood elevations **Re-establishes freshwater and fine sediment delivery to the adjacent marsh plain,** creating salinity gradients and restoring brackish and freshwater wetland vegetation that provides habitat for native wildlife communities **Re-establishes the exchange of energy, materials, and wildlife** between the channel and adjacent marsh plain

On levee, looking downstream at lower Walnut Creek. (photograph by Sean Baumgarten, SFEI)

STRATEGY 1: Sustaining Resilient Marshes by Improving Natural Delivery of Freshwater and Sediment

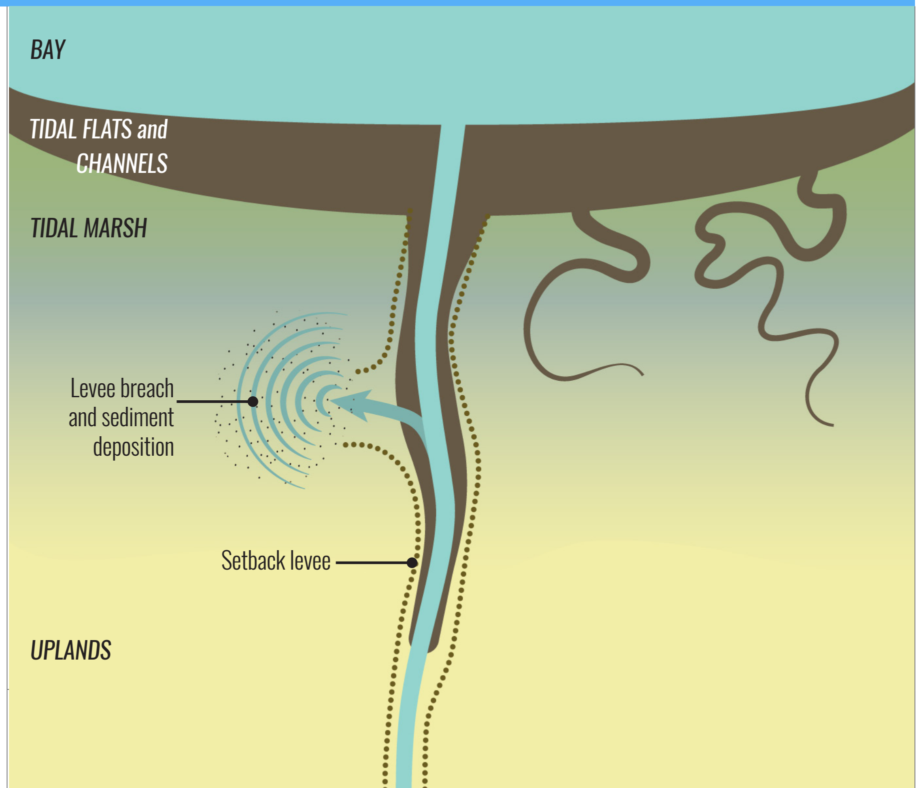
MEASURE 2: Reconnect Creeks to Floodplains

Increase the amount of water and sediment from the creek reaching the marsh.

DESCRIPTION

Levees along Walnut Creek interrupt the hydrologic connections to fluvial and tidal floodplains that existed historically. Targeted levee breaching could allow a portion of creek flows to once again spread out over these areas and supply sediment needed to maintain the marsh plain elevation and build localized depositional fans. Vegetation management could help with the establishment of native species that would be resilient to continued flood disturbances over the long term.

CONCEPT



LOCATION

This measure could be implemented at strategic locations on Walnut Creek from Union Pacific Railroad crossing to Suisun Bay (e.g., from Walnut Creek to Pacheco Marsh) or along the eastern bank of Pacheco Creek before its confluence with Walnut Creek. Locations would need to be chosen that would not increase flood risk.

KEY BENEFITS

Increases marsh plain area and associated tidal prism, causing channel scour and increasing flood conveyance capacity at low tide, decreasing excess sediment deposition, and decreasing the need for sediment removal

Increases flood water detention capacity, potentially decreasing flood elevations

Re-establishes freshwater and fine and coarse sediment delivery to the adjacent marsh plain, creating salinity gradients, depositional fans, and restoring brackish and freshwater wetland vegetation that provides habitat for native wildlife communities

Re-establishes the exchange of energy, materials, and wildlife between the channel and adjacent marsh plain

On levee, looking upstream at lower Walnut Creek (left) and historical floodplain adjacent to the Acme landfill (right). (photograph by Carolyn Doehring, SFEI)

STRATEGY 1: Sustaining Resilient Marshes by Improving Natural Delivery of Freshwater and Sediment

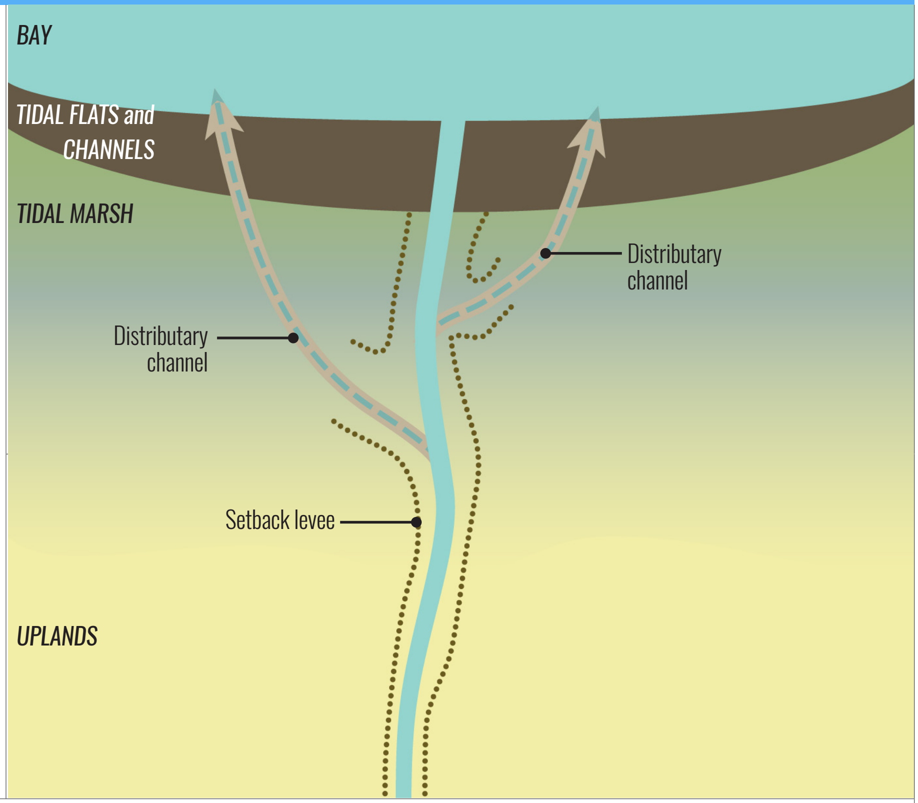
MEASURE 3: Create Zones for Distributary Channels

Create high flow distributary channels to reduce flood risk during higher flows.

DESCRIPTION

Distributary channels connecting Walnut Creek to Suisun Bay could be re-established in the landscape. They could mimic the historical channels that carried freshwater and sediment out to marsh plain, mudflat, and Suisun Bay during large flood flows. Tidal scour would help keep channel from infilling between floods.

CONCEPT



LOCATION

Distributary channel corridors for Walnut Creek could be considered at two locations: 1) Walnut Creek (near Highway 4) to Point Edith Marsh through Hastings Slough (re-establishing historical freshwater wetland connection to Point Edith Marsh); and 2) from Walnut Creek (near Waterfront Road) to Pacheco Marsh. Locations would need to be chosen that would not increase flood risk.

KEY BENEFITS

Increases flow pathways to the Bay, which increases flood conveyance capacity at low tide, decreases excess sediment deposition, and decreases the need for sediment removal

Re-establishes freshwater and fine and coarse sediment delivery to downstream baylands, providing both the freshwater and sediment that the tidal-terrestrial transition zone and the adjacent tidal marsh plain need to keep pace with sea-level rise

Increases the exchange of energy, materials, and wildlife between the channel and adjacent Bay

Historical path of lower Walnut Creek near Waterfront Road. (photograph by Sean Baumbargten SFEI)

STRATEGY 1: Sustaining Resilient Marshes by Improving Natural Delivery of Freshwater and Sediment

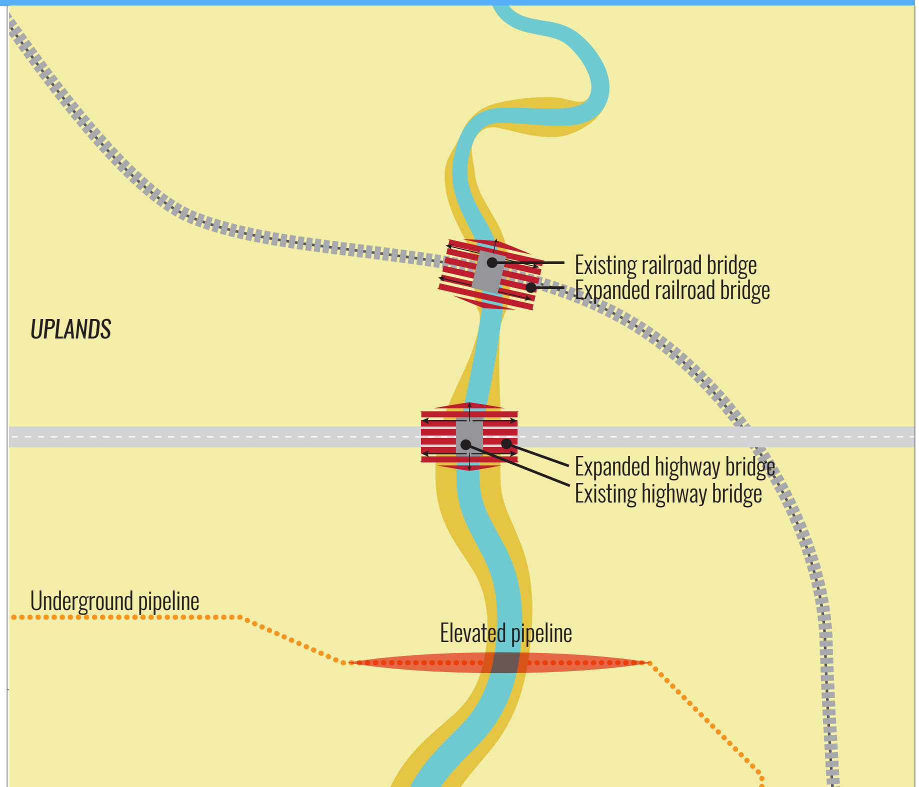
MEASURE 4: Modify Transportation and Pipeline Infrastructure

Decrease vulnerability of roads, rail line, and pipeline to flooding.

DESCRIPTION

Transportation and transmission infrastructure within the study area could be retrofitted (e.g., elevated or modified) to accommodate higher water levels with sea-level rise. Roads, rail beds, and pipelines could be elevated and supporting infrastructure could be modified to increase flow conveyance. Currently, Waterfront Road floods during king tides (i.e., the highest high tides). Over time, the frequency of flooding will increase, affecting business operations. Modifications should be done in a way that is compatible with natural processes and supports habitat creation and maintenance over the long term.

CONCEPT



LOCATION

Transportation infrastructure within the study area includes Waterfront Road, Union Pacific Railroad, and BNSF Railroad. Pipelines run parallel to Waterfront Road and cross lower Walnut Creek just north of the Waterfront Road bridge.

KEY BENEFITS

Decreases flooding vulnerability, which decreases long-term infrastructure maintenance costs

Improves fine sediment delivery to the adjacent marsh plain and downstream baylands, which increases the supply of sediment that the tidal marsh plain and adjacent mudflats in Suisun Bay need to keep pace with sea-level rise

Improves the migration corridor that many aquatic and terrestrial wildlife species use to move between estuarine and upland habitats

Union Pacific Railroad bridge during king tide, December 2015. (photograph courtesy of Mike Carlson, CCCFCWCD)

STRATEGY 2: Sustaining Resilient Marshes Using Dredged Sediment

MEASURE 5: Maintain Marsh Elevations with Dredged Sediment

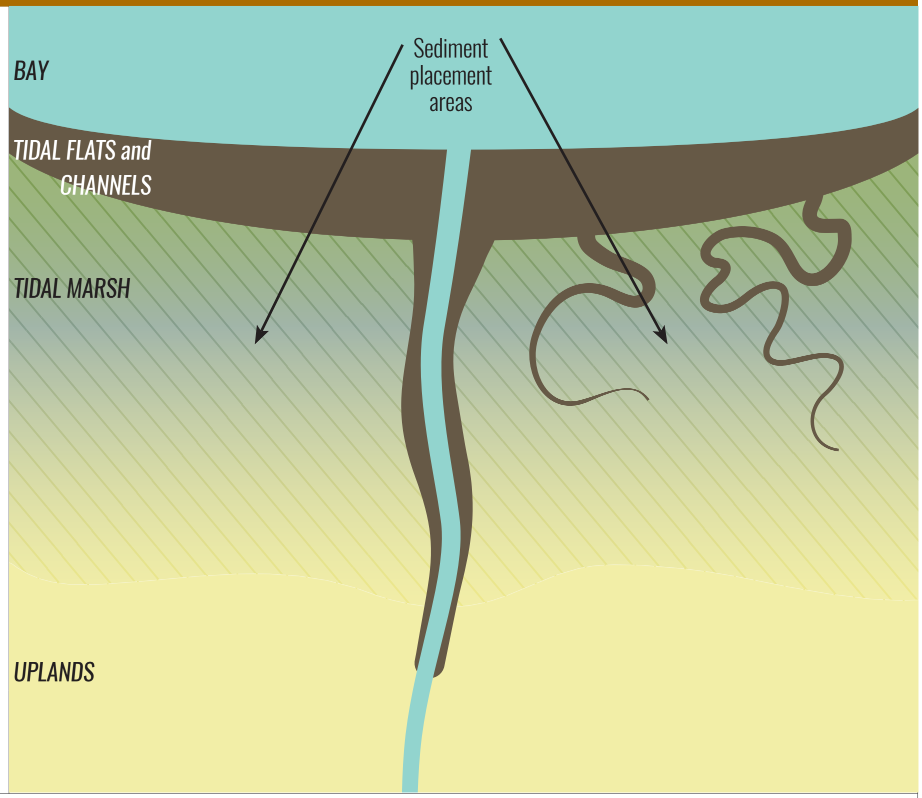
Increase vertical accretion rates of marshes.

DESCRIPTION

Historically, natural marsh plain accretion adjacent to Walnut Creek occurred through the accumulation of organic matter and trapping of fluvial and tidal inorganic sediment. However, the building of channel levees along Walnut and Pacheco creeks has disconnected local marshes from watershed sediment sources. As sea level rises, it is likely that existing and restored marshes along lower Walnut Creek and its tributaries will require artificial sediment augmentation to maintain intertidal elevations. Dredged sediment from the flood control channels, as well as the historical dredged sediment stored on Pacheco Marsh, could be placed as a thin layer on the marshes or placed at the landward edge of marshes to create estuarine-terrestrial transition zones. This approach would likely require building of semi-permanent infrastructure to deliver the sediment (e.g., slurry pipes).

Some areas of Pacheco Marsh are already well above mean higher high water (MHHW) due to historical filling of the marsh with dredged sediment. While these areas are not currently high quality tidal marsh habitat, the RSAT did not recommend grading down this area to reach current intertidal elevations. It may be useful to grade these areas to lower intertidal elevations to ensure there is marsh habitat in the second half of the century when sea-level rise may be threatening current marshes. The RSAT suggested a design for Pacheco Marsh that includes connected marsh patches, a high marsh core-to-edge ratio, and maintaining the area's "elevation capital," or its relatively high elevation that will allow it to provide migration space for tidal marsh in the future.

CONCEPT



LOCATION

Sediment could be placed along transition zones and on marsh plains of Pacheco and Point Edith marshes and any restored marsh areas.

KEY BENEFITS

Supports future marsh plain elevation under a rising sea level and potential decreased Bay sediment supply, which helps ensure the marsh survives and continues to provide habitat for native wildlife communities and other ecosystem services (e.g., water quality regulation, wave attenuation, and coastal flood protection) into the future

Tidal channel through Pacheco Marsh (left) and dredged sediment pile on Pacheco Marsh (right). (photographs by Sean Baumgarten and Amy Richey, SFEI)

STRATEGY 2 Sustaining Resilient Marshes Using Dredged Sediment

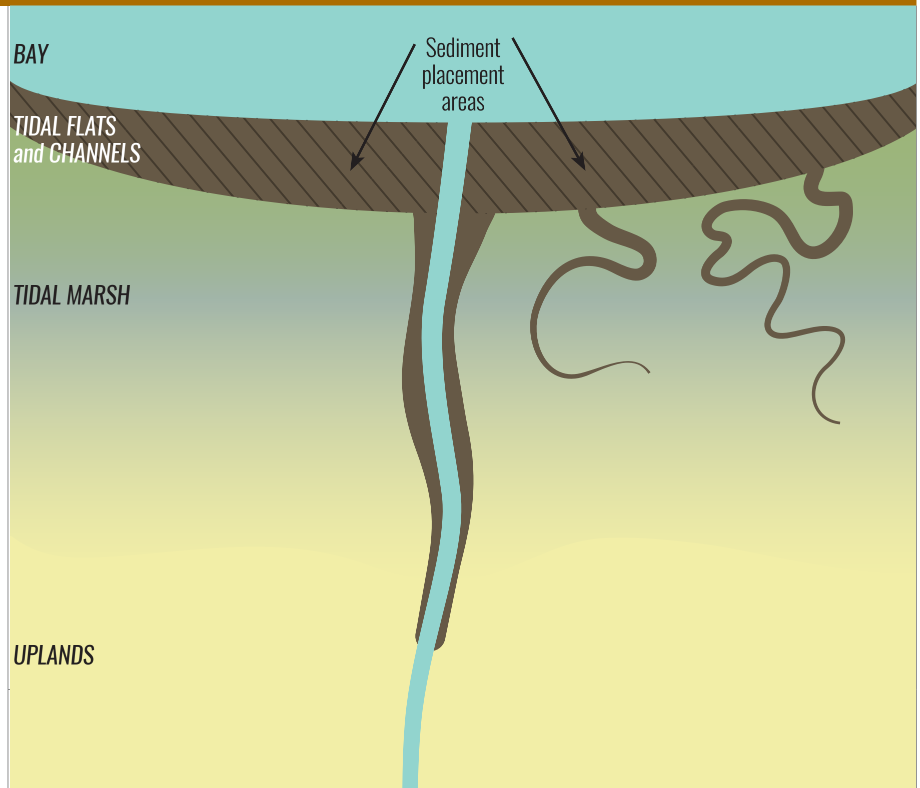
MEASURE 6: Protect Marsh Edge with Dredged Sediment

Reduce marsh edge erosion to help maintain marsh extent.

DESCRIPTION

Outboard coarse-grained beach features could be created using sediment from the existing sand piles on Pacheco Marsh and coarser material (sand and gravel) that is trapped within the lower Walnut Creek channel. The sediment could be placed along the current marsh shoreline to form beach faces (i.e., beaches below marsh scarp crest) and on adjacent mudflats to allow wave action to build a coarse-gained beach berm above the marsh scarp over time.

CONCEPT



LOCATION

This measure is recommended along the bayward edge of Pacheco Marsh.

KEY BENEFITS

Decreases future marsh shoreline erosion under conditions of increased large storms and high wave power, which helps ensure the marsh survives and continues to provide habitat for native wildlife communities and other ecosystem services (e.g., water quality regulation, wave attenuation, and coastal flood protection) into the future

STRATEGY 3: Sustaining Resilient Marshes Using Treated Wastewater

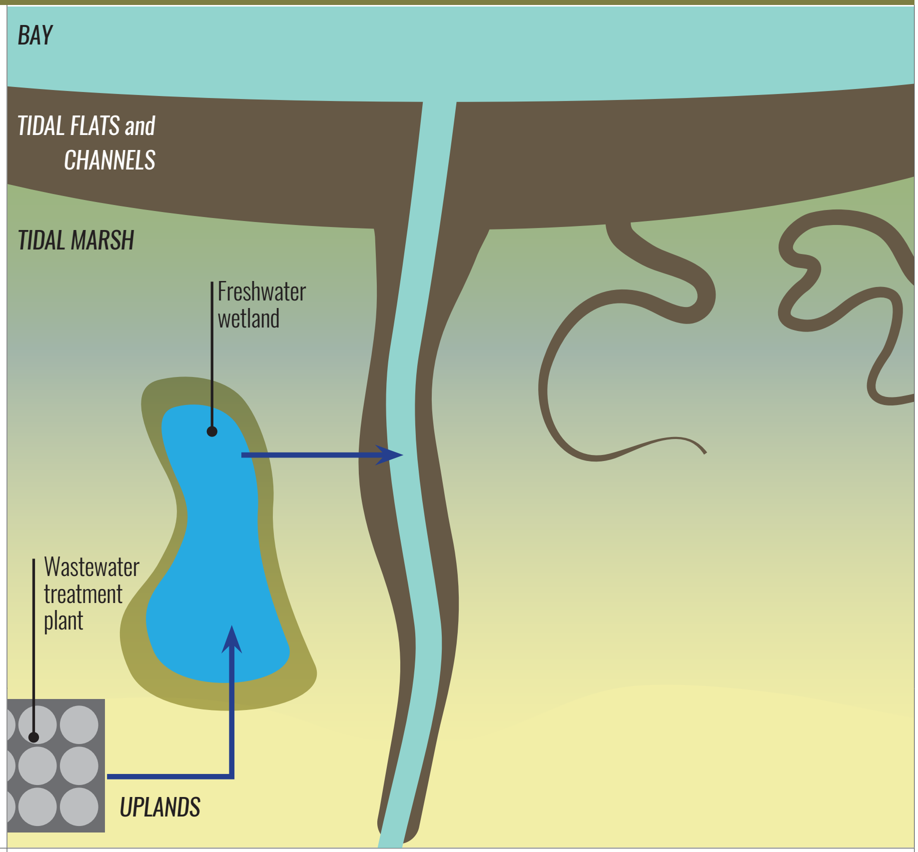
MEASURE 7: Support Freshwater Wetlands with Wastewater Discharges

Increase area of freshwater wetlands within study area.

DESCRIPTION

Treated wastewater could be used to support freshwater surface treatment wetlands (STWs) in the Central Contra Costa County Sanitary District (CCCSD) wastewater equalization basins. The basins are located on the historical Walnut Creek floodplain and are currently used for wet-weather storage and to provide a buffer during routine maintenance. The basins contain ruderal grasslands but lower topographic areas seemingly could support seasonal wetlands due to the presence of poorly drained soils. While storage capacity in the equalization basins will need to be maintained in the future, the basins could potentially be modified to become STWs (emergent freshwater marshes mixed with open water) and used to "polish" treated wastewater before it is discharged to Walnut Creek. This idea presupposes that there are no contaminants that would be harmful to resident wildlife and that wastewater has a low ammonia concentration (i.e., concentration that would not be problematic for mosquito control or vegetation management).

CONCEPT



LOCATION

This measure could be implemented within one or more of CCCSD's detention basins with possible discharge to brackish wetland areas along lower Walnut Creek.

KEY BENEFITS

Increases freshwater wetland vegetation and open water features that provide habitat for waterfowl and other wildlife species and potentially increase opportunities for the public to view wildlife

Improves the water quality of the wastewater discharge through nutrient removal and biomass retention, thereby benefiting water quality in lower Walnut Creek and potentially helping CCCSD meet current and foreseeable water quality discharge regulations

On levee separating CCCSD detention basin from lower Walnut Creek. (photograph by Carolyn Doehring SFEI)

STRATEGY 3: Sustaining Resilient Marshes Using Treated Wastewater

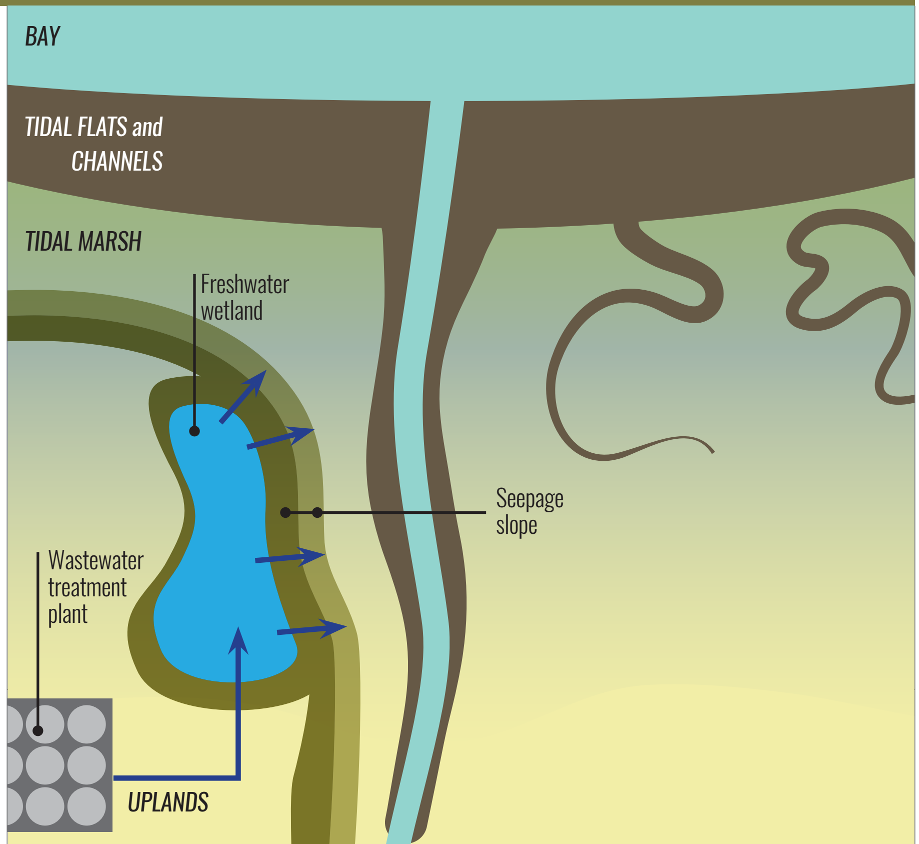
MEASURE 8: Support Seepage Slopes with Diffuse Wastewater Discharges

Emulate historical hydrologic transitions between lowlands and baylands, restoring their habitat diversity and ecological functions.

DESCRIPTION

Treated wastewater from CCCSD could be redistributed as diffuse discharges (overland flows or shallow subsurface flows) towards low-gradient habitats bordering tidal marshes, referred to here as seepage slopes. This could mimic shallow groundwater discharges that historically flowed from lowlands onto marshes. Treated wastewater could be applied during the growing season to existing low-lying areas or as a part of a horizontal levee where a seepage slope is built on the outboard side of a constructed flood risk management levee (e.g., measure 7). The seepage slopes would be built with permeable soils, enabling them to maintain the relatively high soil moisture content needed to support marsh vegetation. Within existing low lying areas, freshwater discharges could convert ruderal grassland to a mix of native wet meadow, freshwater marsh, and riparian scrub. Discharges from the seepage slopes could also support a broad fresh-brackish marsh gradient at the landward edge of marshes, adding habitat diversity and increasing the rate of peat accumulation.

CONCEPT



LOCATION

Treated wastewater from CCCSD could be used along the terrestrial edge of existing and future tidal marshes (e.g., perimeter of existing landfills). Horizontal levees with seepage slopes would be most appropriate where there is an existing steep-sided levee and lack of migration space.

KEY BENEFITS

Supports freshwater and brackish marsh vegetation that provides habitat for a variety of native wildlife (e.g., salt marsh harvest mouse) and high organic matter accretion rates that could help the marsh keep pace with sea-level rise

Improves the water quality of the wastewater discharge through nutrient removal and carbon sequestering, thereby benefiting water quality in lower Walnut Creek and potentially helping CCCSD meet current and foreseeable water quality discharge regulations

Black Rail. (photograph courtesy of Julio Mulero, Creative Commons)

STRATEGY 4: Improving Ecological Connectivity Across Marshes and Along Creeks

MEASURE 9: Enhance Wildlife Corridors

Allow wildlife to move within and between habitats.

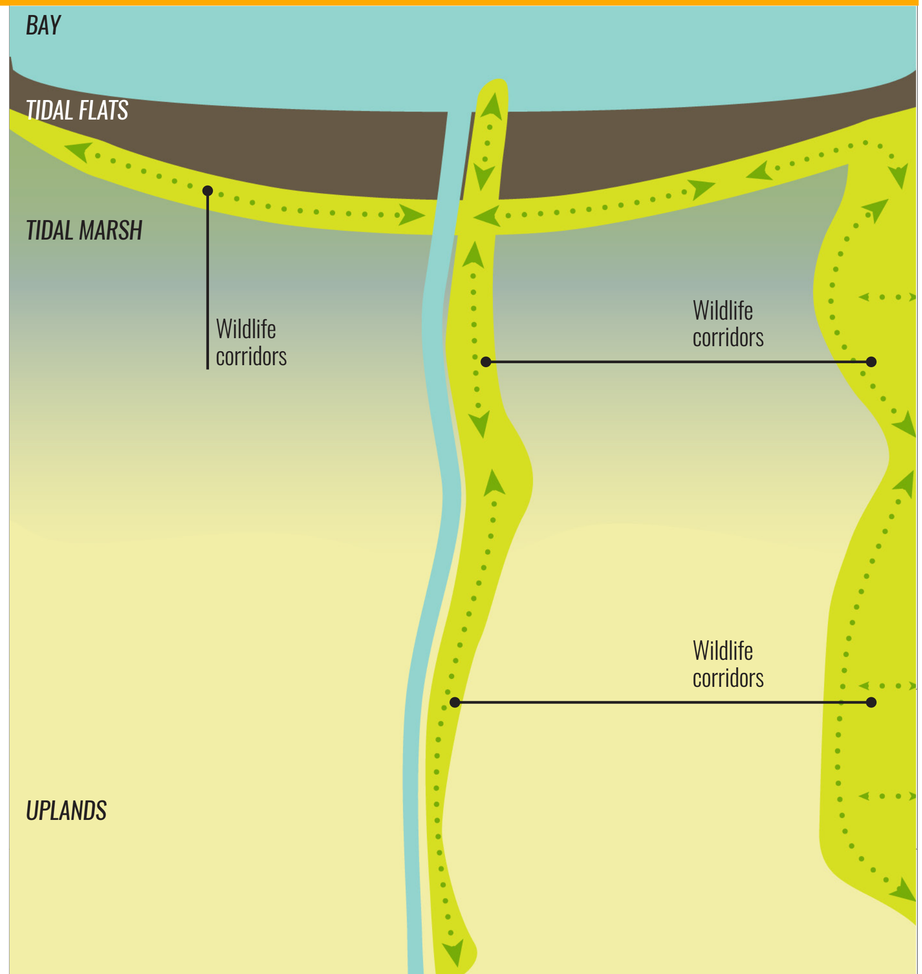
DESCRIPTION

Habitat connectivity is important for movement of wildlife at different time scales, including for daily resource needs, to access appropriate habitat as conditions change, and for dispersal. Habitat connectivity within the baylands and between the baylands and the watershed could be improved through wildlife corridors. Three types of corridors are recommended: 1) "baylands corridor", across the marshes parallel to the Bay shore, 2) "estuarine-terrestrial transition zone corridor", along the landward edge of tidal marsh and including the adjacent transition zone, and 3) "riparian corridor" along Walnut Creek from the tidal marshes through the urbanized area and into the open space in the surrounding hills. With sea-level rise, the tidal marshes will be squeezed against steep levees unless broad transition zones are created to facilitate marsh migration, wildlife refuge during high water events, and wildlife movement. Therefore, partnerships should be developed with adjacent landowners to plan and create such transition zone corridors.

LOCATION

A "baylands corridor" could be established to link tidal marsh habitats along the shore from Point Edith Marsh to Peyton Hill Marsh. A broad "transition zone corridor" could be established that runs along the landward side of Pacheco and Point Edith marshes and incorporates adjacent terrestrial and wetland habitats. A "riparian corridor" could be established along Walnut and Pacheco creeks. While continuous, wide corridors may not be feasible, creating corridors that are as continuous as possible and wide in particular areas should be the focus.

CONCEPT



KEY BENEFITS

Improves connectivity along the bayland corridor that enables native mammal species (e.g., salt marsh harvest mouse) to access resources from multiple marsh areas

Improves connectivity along the transition zone corridor that enables native wildlife species (e.g., Ridgway's Rail) to access feeding and refuge habitats during high tide

Improves connectivity along the riparian corridor that enables far-ranging mammals (e.g., medium-sized carnivores) to access resources from the hills down to the baylands

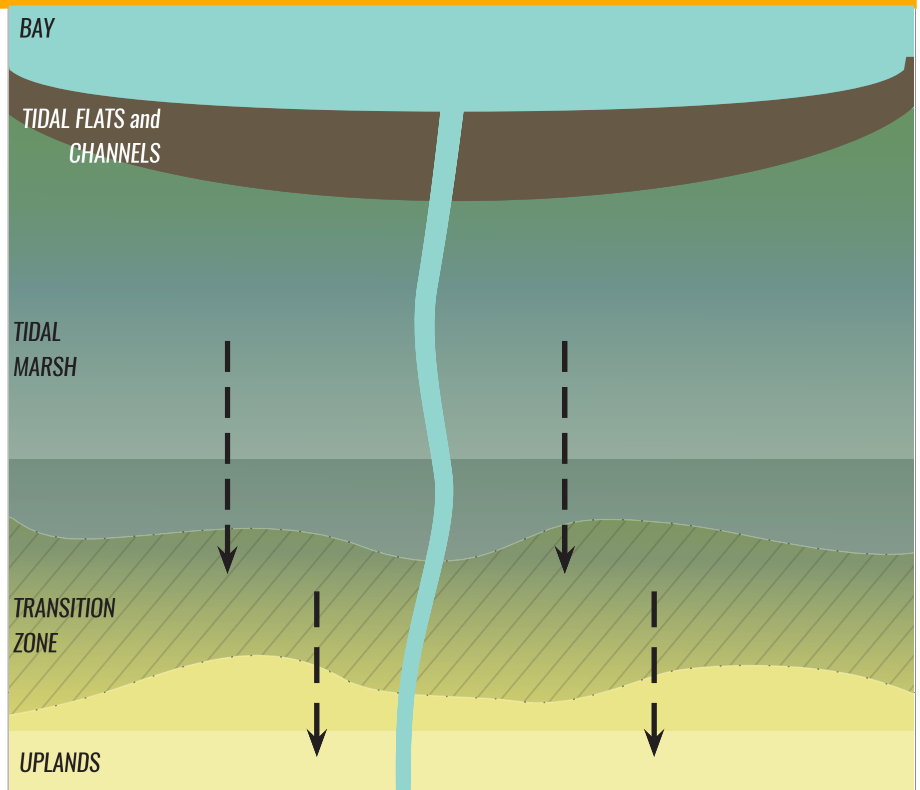
Ridgway's Rail (left). (photograph courtesy of Emile Chen, Creative Commons)

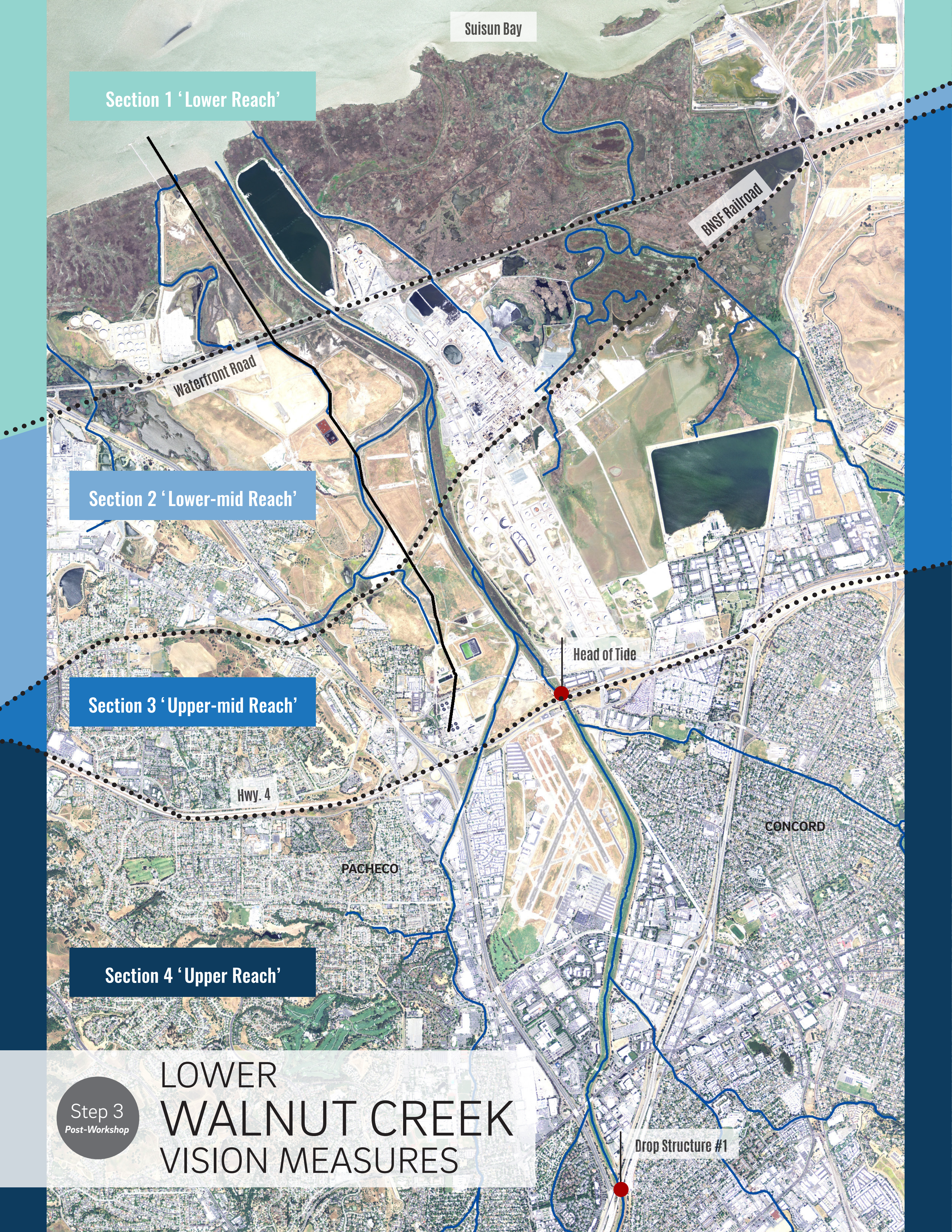
Transition from marsh plain to upland hills (right). (photograph by Sean Baumgarten, SFEI)

STRATEGY 4: Improving Ecological Connectivity Across Marshes and Along Creeks

MEASURE 10: Protect and Restore Transition Zones

Create higher areas for marshes to move into as sea level rises.

DESCRIPTION	Estuarine-terrestrial transition zones within the study area should be identified and restored or protected. These zones typically exist at an elevation between MHHW and extreme high water (EHW) and provide critical habitat for wildlife and a variety of ecosystem services (e.g., coastal flood buffering). As sea level rises, these zones can become "squeezed" against upland infrastructure and shrink in size, thereby decreasing their functionality and preventing them from migrating inland.	CONCEPT	
LOCATION	This measure could be implemented at broad, low-slope transition zone areas along that landward edge of all tidal marshes, the banks of Pacheco Creek, and the perimeter of existing landfills.	KEY BENEFITS	**Provides marsh migration space as sea level rises,** ensuring the existence of marsh in the future **Provides buffering from coastal flooding,** which protects adjacent upland infrastructure **Supports freshwater and brackish marsh vegetation** that provides foraging and refuge habitat for a variety of native wildlife (e.g., salt marsh harvest mouse)



Step 3
Post-Workshop

LOWER
WALNUT CREEK
VISION MEASURES

Section 1 ‘Lower Reach’ (Suisun Bay to Waterfront Road)

Within the lowest reach of Walnut Creek and adjacent baylands, there are many opportunities to optimize existing habitats and support their persistence and evolution with future sea-level rise. Recommended measures include re-use of dredged sediment to protect the bay edge, connecting marshes along Suisun Bay for wildlife corridors, and modifying infrastructure (e.g., levees and roads) to support conveyance of flows and sediment from Walnut Creek to adjacent habitats. Sediment from the existing sand pile to the west of the creek mouth could be re-used to support transition zones between Pacheco Marsh and adjacent upland hills.

Measure 2: *Reconnect Creeks to Floodplains*

Measure 4: *Modify Transportation and Transmission Infrastructure*

Measure 5: *Maintain Marsh Elevations with Dredged Sediment*

Measure 6: *Protect Marsh Edge with Dredged Sediment*

Measure 9: *Enhance Wildlife Corridors*

Section 2 ‘Lower-mid Reach’ (Waterfront Rd. to BNSF Railroad)

This segment of lower Walnut Creek floodplain could be expanded along the western bank to support flood risk management, additional habitat, and wildlife corridors. A distributary channel from Walnut Creek to Pacheco Marsh could be considered for reducing the vulnerability of road and railroad infrastructure to flooding. Additionally, railroad infrastructure could be modified to facilitate higher flows with sea-level rise and storm surges. Marsh migration zones could also be protected and restored within this area so existing marsh habitats are not entirely squeezed with future sea-level rise.

Measure 1: *Set Back Levees*

Measure 2: *Reconnect Creeks to Floodplains*

Measure 3: *Create Zones for Distributary Channels*

Measure 4: *Modify Transportation and Transmission Infrastructure*

Measure 9: *Enhance Wildlife Corridors*

Measure 10: *Protect and Restore Transition Zones*

Section 3 ‘Upper-mid Reach’ (BNSF Railroad to Highway 4)

This segment of lower Walnut Creek provides opportunities to re-use treated wastewater from CCCSD to support brackish marshes, seepage slopes (gently sloping wide levee with riparian and wetland vegetation), and freshwater wetlands. Wildlife corridors could also be enhanced along the mainstem of Walnut Creek.

Measure 7: *Support Freshwater Wetlands with Wastewater Discharges*

Measure 8: *Support Seepage Slopes with Diffuse Wastewater Discharges*

Measure 9: *Enhance Wildlife Corridors*

Section 4 ‘Upper Reach’ (Highway 4 to Drop Structure 1)

The upper reach has an opportunity to re-establish the historical hydrologic connection from Walnut Creek to Point Edith Marsh, which could improve flow conveyance and support sediment accretion of Point Edith Marsh. Walnut Creek’s floodplain could be re-connected to support brackish and freshwater wetlands. Riparian creek corridors could also be enhanced along Walnut Creek within this area.

Measure 2: *Reconnect Creeks to Floodplains*

Measure 3: *Create Zones for Distributary Channels*

Measure 9: *Enhance Wildlife Corridors*

CONSTRAINTS

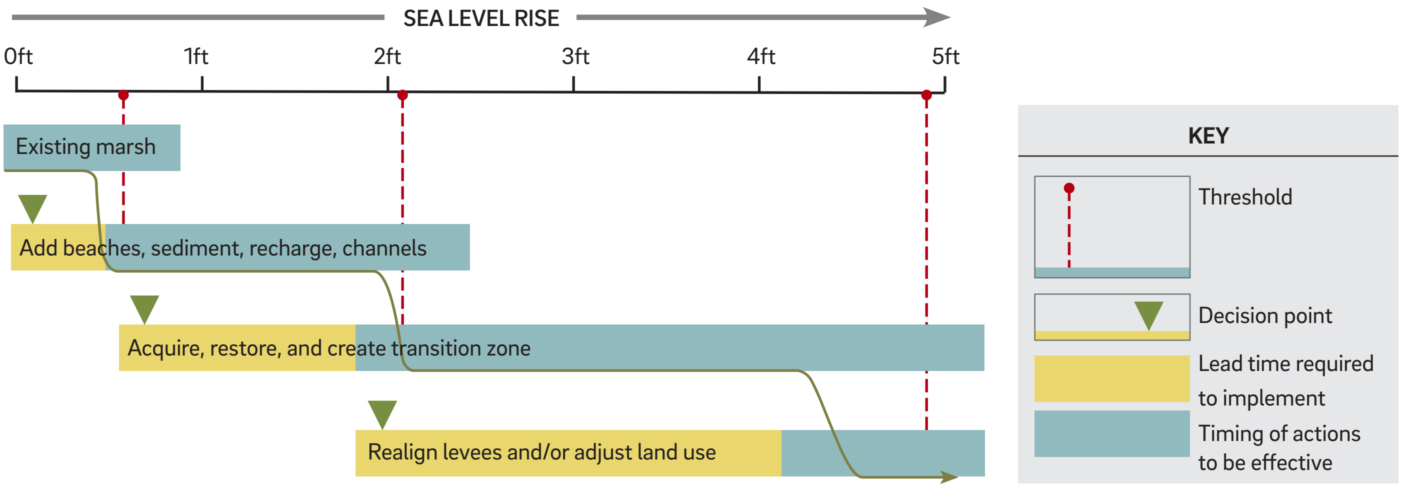
This report explores multi-benefit opportunities for improving ecological functions in the context of flood risk management in lower Walnut Creek. Implementing any of the suggested measures would require feasibility analysis, planning, collaboration and consensus from landowners, regulatory agency support, and financial support.

The types of constraints that would need to be addressed include:

- **Property access.** The majority of the strategies presented are on private property or property owned by the local sanitary district. Restoring areas on the floodplain would require coordination with willing landowners.
- **Integration with other plans.** Measures would need to be assessed given other land-use plans. For example, modifying CCCSD's detention basins to facilitate freshwater wetlands would need to be assessed given CCCSD's Master Plan, which is currently under modification. CCCSD's future infrastructure risk, basin capacity needs, other recycled water uses, among others elements, would need to be evaluated. Additionally, topographic gradients recommended for Pacheco Marsh should be assessed within larger restoration objectives and future designs for the marsh.
- **Permitting.** The regulatory issues associated with discharging treated wastewater to seepage slopes or placing re-used sediment onto existing tidal marsh plains would need to be resolved before implementation. Other permitting issues could be resolved by early consultation with relevant regulatory agencies long before submitting a permit application and receiving feedback from managers who have had to obtain permits for similar project designs.
- **Existing infrastructure.** Implementation of several measures would require modification, relocation, or removal of existing infrastructure and restoration of relevant habitats. For example, to facilitate wildlife corridors, Tesoro's treatment pond would need to be modified as it currently divides Pacheco and Point Edith Marshes and impedes the connectivity of a baylands corridor along Suisun Bay. In other areas, creek floodplains could be expanded to support riparian vegetation (e.g., immediately west of Walnut Creek), although establishment of creek corridors are currently limited by channel leveeing for flood risk management. Feasibility of infrastructure modifications will range based on type, age, and ownership of infrastructure affected. Opportunities to upgrade or redesign infrastructure may occur during the normal schedule of maintenance and renewal when infrastructure reaches the end of its expected lifespan.
- **Flood risk management benefits.** It will be important to complete site-specific modeling to assess dynamic controls on water surface elevations within the study area. Channels and associated floodplains at the fluvial-tidal interface need storage capacity for both tidal water (both daily tides and storm surges) and varying watershed flood flows.
- **Sediment availability and re-use.** It is important to consider the long-term availability of future sediment sources to ensure marsh sustainability given accelerated sea-level rise. For example, the episodic nature of watershed sediment delivery could be a major constraint for using this sediment to build and maintain habitats (i.e., the amount of sediment required in the short term could exceed the sediment delivered). There are also a variety of engineering and design constraints associated with both thin-layer sediment placement (e.g., mechanically spreading sediment over a marsh plain) and targeted sediment placement (i.e., mechanically placing sediment to build a beach) that need to be considered.

TIMING OF IMPLEMENTATION

Many of the measures presented in the Vision could be completed in the near-term and provide benefits upon implementation. Although specific dates for implementing the recommended strategies are not known, it is important to consider sea-level rise rates in project timing. Due to the time required for planning, permitting, and construction, measures would need to be implemented before they are needed. Ideally, many of the measures (e.g., creek connection to marshes) could be implemented before sea-level rise accelerates to maximize vertical accretion of marshes. Sea levels are projected to begin rising much more rapidly slightly after mid-century (NRC 2012) and some newer studies suggest the acceleration may happen even sooner. Sea level along the California Coast is projected to rise by 12 to 61 cm (about 4.5 to 24 in) by 2050 and 42 to 166 cm (about 16.5 to 65 in) by 2100 (NRC 2012).



Conceptual phasing of measures triggered by sea-level rise, rather than a chronological timeline (adapted from Goals Project 2015).

Pacheco Marsh. (photograph courtesy of Stephen Joseph Photography, stephenjosephphoto.com)

MOVING FORWARD

The Vision is intended to provide the District and adjacent landowners a launching point for discussing an integrated approach for supporting natural processes, and in turn, benefiting flood risk management and ecosystem functioning within and adjacent to lower Walnut Creek. This Vision complements existing restoration and management plans in the area by providing a larger framework (time and scale) for integrating multi-benefit uses beyond individual parcels and projects. While this redesigned, multi-benefit landscape would require several large, coordinated infrastructure and restoration projects, it has the potential for diverse, synergistic benefits, including improving habitat conditions while providing more near-term flood protection, reduced sediment management costs, and increased local water treatment and re-use.

The transition from idealized Vision concepts shown here to actionable projects will be complex, requiring detailed technical analyses and extensive collaboration among stakeholders. This would need to be viewed as a multi-decade process where Vision components are implemented in phases based on factors such as available financial resources, site constraints, and project interdependence (i.e., some projects need to be implemented before others). This process should ultimately be coordinated with the development of new management plans for the watersheds that drain to lower Walnut Creek.

Next steps:

Assess the benefit-cost relationships

As part of Flood Control 2.0, the Vision concepts will be assessed from a benefit-cost perspective looking at the trade-offs between existing management (e.g., continued dredging) compared to possible altered management incorporating Vision components. The benefit-cost analysis will be completed by the end of Fall 2016 and can be used to help identify projects to prioritize in the near-term.

Integrate with the Lower Walnut Creek Restoration Project

As part of the LWC Restoration Project, the District is currently developing restoration alternatives aimed at decreasing peak storm water surface elevation and restoring habitat. The alternatives mainly focus on floodplain expansion within the District's current jurisdiction and developmeant of restoration measures for Pacheco Marsh. The alternatives contain multi-benefit elements that can be viewed as short-term Vision actions. We will continue to coordinate with the District and develop ideas for expanding short-term restoration actions into long-term Vision concepts.

Continue Vision analysis and planning

Subsequent efforts will ideally include periodic refinements and adaptations of the Vision as more knowledge is gained and there is more coordination with local landowners. More in-depth analyses of the ecological benefits and flood risk management impacts associated with the Vision will be needed to identify priorities and synergies that exist between necessary infrastructure improvements and ecosystem restoration, and to define short-term and longer-term actions.

ACKNOWLEDGEMENTS

We wish to thank many individuals who contributed to the development and reporting of this project. We would first like to thank the Regional Science Advisory Team whose ideas formed the backbone of the Vision and whose critical review greatly improved this report. The panel included Peter Baye (Ecological Consultant), Letitia Grenier (SFEI), Jeff Haltiner (Hydrology Consultant), and Jeremy Lowe (SFEI). Andy Gunther (BAECCC) moderated the Vision workshop and deserves many thanks for his services. We would also like to thank Mike Carlson, Paul Detjens, and Mitch Avalon (CCCFCWCD) for their enthusiasm for this work, their support in putting on the workshop, and their review of this report. We also received helpful feedback on this report from Dyan Whyte (SFRWQCB) and Luisa Valiela (USEPA). Michelle Orr and Eddie Divita (ESA) graciously provided the lower Walnut Creek channel elevation data used in our analysis and helped develop the Vision. Erin Beller, Sarah Pearce, Amy Richey, and Emily Clark (SFEI) provided research assistance and helped compile information for this report. Tyler McIntosh, an intern from the Bill Lane Center for the American West at Stanford University, assisted with historical ecology data collection and synthesis. We are grateful to the staff and volunteers at all of the archives visited during the course of our historical ecology research. Dean McLeod provided many helpful leads and graciously shared materials from his personal collection. This project was possible through funding provided by the EPA Region IX's San Francisco Bay Water Quality Improvement Fund as part of the Flood Control 2.0 project. Additional funding for the historical ecology work was provided by the Contra Costa County Flood Control & Water Conservation District.

Walnut Creek. Photograph by SFEI.

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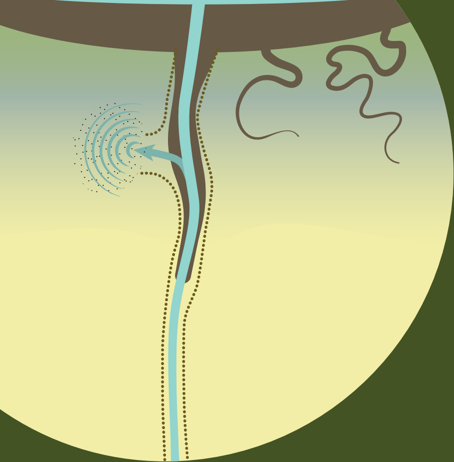

As we rethink land management along the San Francisco Bay shoreline in the face of climate change, we know well-functioning resilient tidal landscapes can protect development and sustain native ecosystems. Here, we present a possible future vision for lower Walnut Creek and adjacent baylands that includes several components that would restore and support natural processes, and, in turn, benefit aspects of flood risk management and ecosystem functioning. The Resilient Landscape Vision for lower Walnut Creek is an element of an EPA-funded project called Flood Control 2.0, which is aimed at advancing new approaches for flood risk management and habitat enhancement along the San Francisco Bay shoreline for the 21st century and beyond.

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