Coastal Resilience Assessment of the San Francisco Bay and Outer Coast Watersheds

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Cover Image: Aerial view of Don Edwards National Wildlife Refuge, Fremont, California

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Abstract

The San Francisco Bay and Outer Coast Watersheds Coastal Resilience Assessment focuses on identifying areas of open space where the implementation of fish and wildlife habitat restoration or conservation actions could build human community resilience in the face of increasing storms and flooding impacts. Much of the developed shoreline of the San Francisco Bay Area occurs within or immediately adjacent to historical wetland habitats resulting in high vulnerability to both current and future flooding.

This assessment combines human community assets, threats, stressors, and fish and wildlife habitat spatial data in a unique decision support tool to identify Resilience Hubs (Hubs), which are defined as large area of contiguous land, that could help protect human communities from storm impacts while also providing important habitat to fish and wildlife if appropriate conservation or restoration actions are taken to preserve them in their current state. The Hubs were scored based on a Community Vulnerability Index that represents the location of human assets and their exposure to flooding events combined with Fish and Wildlife Richness Index that represents the number of fish and wildlife habitats in a given area. Local stakeholders and experts were critical to the assessment process by working with the project team to identify priority fish and wildlife species in the watershed and provide data sets and project ideas that have potential to build human community resilience and fish and wildlife habitat within the San Francisco Bay and Outer Coast Watersheds.

As part of the assessment process, 92 resilience-related project ideas were submitted through the stakeholder engagement process, of which three are described in detailed case studies in this report. The case studies illustrate how proposed actions could benefit fish and wildlife habitat and human communities that face coastal resilience challenges such as storm surge during extreme weather events.

The products of the assessment process include this report, the Coastal Resilience Evaluation and Siting Tool (CREST) interactive online map viewer, and a Geographic Information System-based decision support tool pre-loaded with assessment datasets. These products provide opportunities for a variety of users, such as land use, emergency management, fish and wildlife, and green infrastructure planners to explore vulnerability and resilience opportunities in the watershed. The products can also be used to guide funding and resources into project development within high scoring Resilience Hubs, which represent areas where human communities are exposed to the greatest flooding threats and where there is sufficient habitat to support fish and wildlife. The decision support tool also allows users to manipulate the community vulnerability and fish and wildlife datasets to identify areas of value based on their own objectives.

Executive Summary

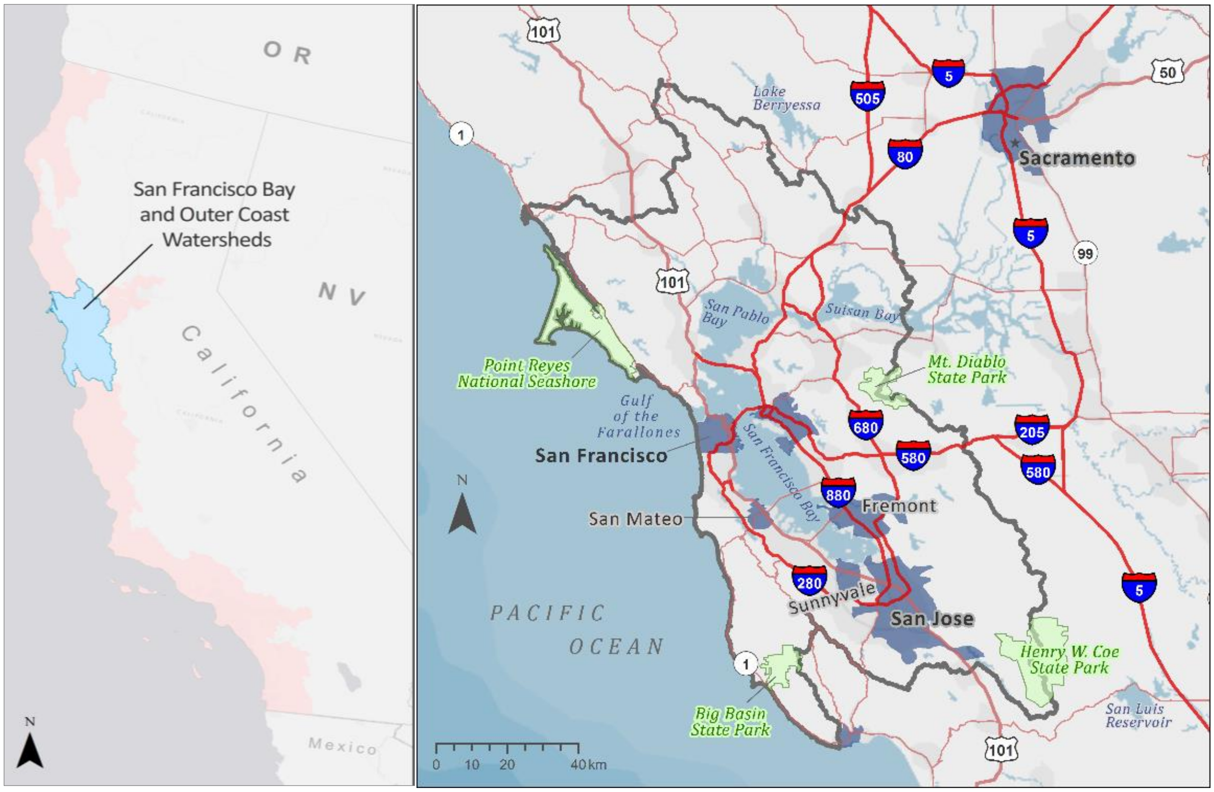
In response to increasing frequency and intensity of coastal storm events, the National Fish and Wildlife Foundation (NFWF) is committed to supporting programs and projects that improve community resilience by reducing communities' vulnerability to these coastal storms, sea-level rise, and flooding through strengthening natural ecosystems and the fish and wildlife habitat they provide. NFWF commissioned NatureServe to conduct coastal resilience assessments that identify areas ideal for implementation of conservation or restoration projects (Narayan et al. 2017) that improve both human community resilience and fish and wildlife habitat before devastating events occur and impact the surrounding community. The assessments were developed in partnership with the National Oceanic and Atmospheric Administration and UNC Asheville's National Environmental Modeling Analysis Center, and in consultation with the U.S. Army Corps of Engineers.

Coastal Resilience Assessments have been conducted at two scales: 1) at a regional level, covering five coastal regions that incorporate all coastal watersheds of the conterminous U.S., and 2) at the local watershed level, targeting eight coastal watersheds. Each of the eight Targeted Watershed Assessments nest within these broader Regional Assessment and provide the opportunity to incorporate local data and knowledge into the larger coastal assessment model.

This assessment focuses on the San Francisco Bay and Outer Coastal Watersheds. By assessing this region's human community assets, threats, stressors and fish and wildlife habitat, this Targeted Watershed Assessment aims to identify opportunities on the landscape to implement restoration or conservation projects that provide benefits to human community resilience and fish and wildlife habitat, ensuring maximum impact of conservation and resilience-related investment.

San Francisco Bay and Outer Coast Watersheds

The San Francisco Bay and Outer Coast Watersheds study area includes a mix of outer coast, estuarine shoreline, and major cities such as San Francisco, Oakland, and San Jose. Throughout the San Francisco Estuary, former tidal marsh and tidal flat habitats have been lost to coastal development. As a result, large numbers of Bay Area residents and assets are at risk from flooding and sea level rise. For instance, San Mateo County is one of the most vulnerable counties to coastal flooding not only in California, but nationwide. With over 100,000 residents potentially impacted by 0.9 m (2.95 ft) of sea level rise (Hauer et al. 2016), San Mateo County's expansive human infrastructure is at considerable risk to flooding (Heberger et al. 2009).



***Location and boundary of the San Francisco Bay and Outer Coast Watersheds study area**. The map on the left shows the watershed study area (blue) in the context of the California Coast Regional Assessment area (orange). In the map on the right, the study area is indicated by the dark gray outline. Note that it consists of the San Francisco Estuary watershed and several other smaller contiguous coastal watersheds.*

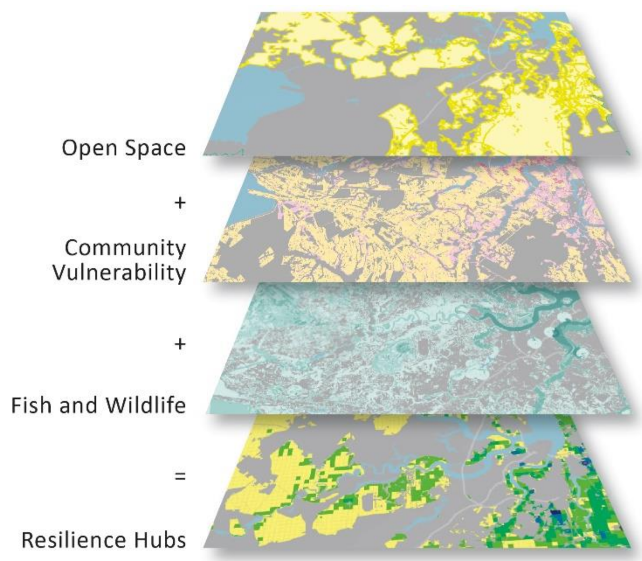
Assessment Objectives

The objectives of this assessment were to:

1. Identify Resilience Hubs or areas on the landscape where implementation of conservation actions will have maximum benefit for human community resilience and fish and wildlife habitat.
2. Account for threats from both coastal and inland storm events.
3. Create contiguous and standardized data sets across the study area.
4. Use local knowledge, data sources, and previously completed studies and plans to customize the Regional Assessment model for this smaller study area.
5. Identify projects in the watershed that have a demonstrated need and local support.
6. Make the products of the assessment broadly available to facilitate integration of resilience planning in a variety of land, resource management, and hazard planning activities.

Assessment Approach

The assessment approach was focused on identifying and evaluating Resilience Hubs, areas of open space and contiguous habitat that can potentially provide mutual resilience benefits to human community assets (HCAs) and fish and wildlife. This assessment was conducted primarily through Geographic Information System (GIS) analyses using existing datasets created by federal, state and local agencies, non-profits, universities, and others. Three categories of data were used as the primary inputs to the assessment: Open Space (protected lands or unprotected privately owned lands), Human Community Vulnerability, and Fish and Wildlife Species and Habitats.



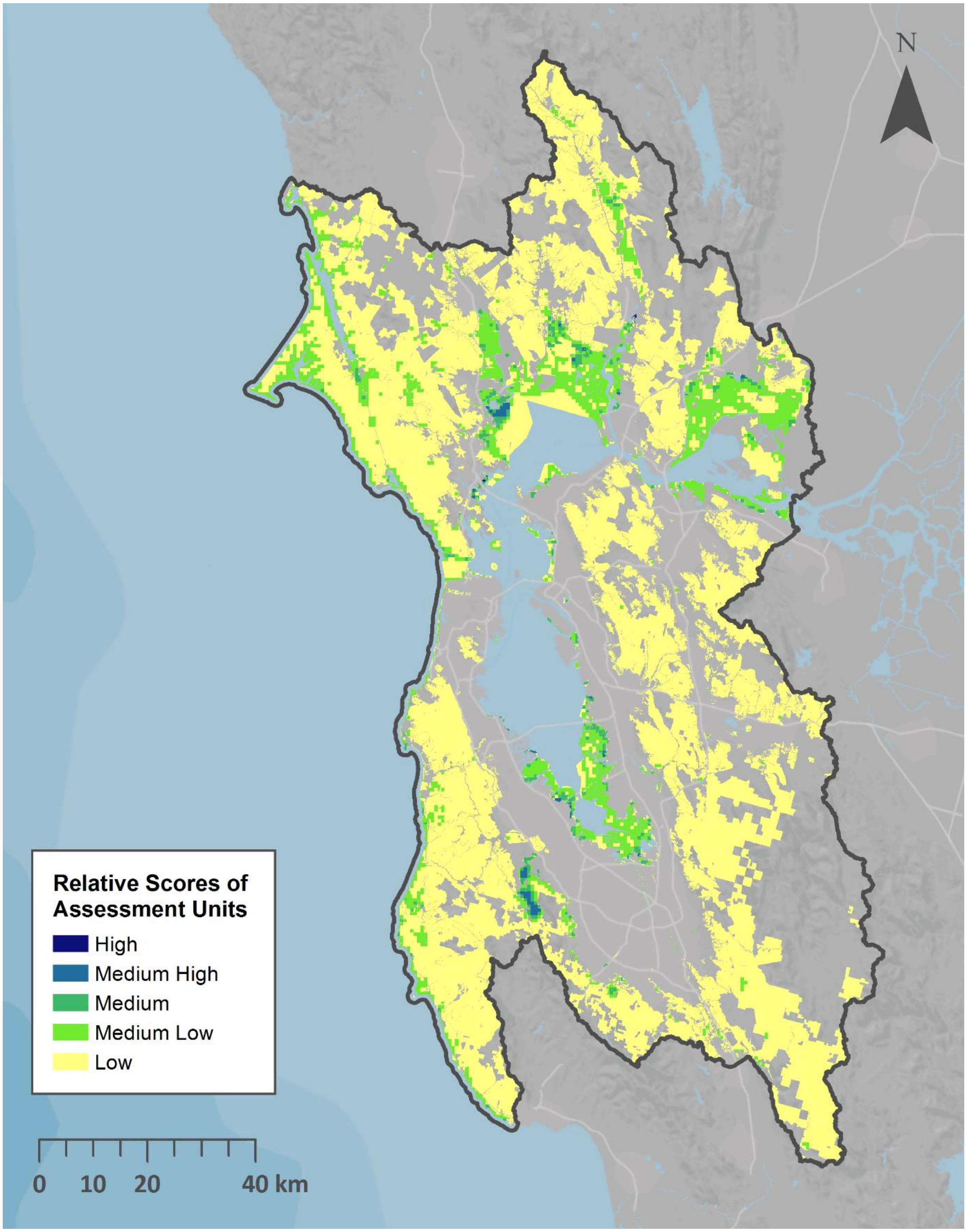
Left: Diagram of the overall approach of this assessment. *Human community asset (HCA) vulnerability and fish and wildlife richness are assessed within all areas of public and private open space. Open space areas in proximity to HCAs with high vulnerability* ***and*** *high fish and wildlife richness are mapped as Resilience Hubs where efforts to preserve or increase resilience to threats are well-justified. From the set of all such Hubs, those scoring highest by these measures represent priority areas for undertaking resilience projects.*

Results

Resilience Hubs

Resilience Hubs are large tracts of contiguous land that, based on the analyses, provide opportunities to increase protection to human communities from storm impacts while also providing important habitat for fish and wildlife. Hubs mapped in the Regional Assessment were evaluated using the Human Community Vulnerability Index and Fish and Wildlife Richness Index. In the map below:

- Parcels in **dark blue** were scored higher because they contain or are near highly vulnerable human population and infrastructure *and* support a diversity of fish and wildlife habitats. It is within or near these higher scoring parcels that restoration projects may be most likely to achieve multiple benefits for human community resilience and fish and wildlife.
- Parcels in **yellow** are scored lower because they are either not proximate to major HCAs or they include habitats that do not currently support large populations of fish and wildlife species identified in this assessment.



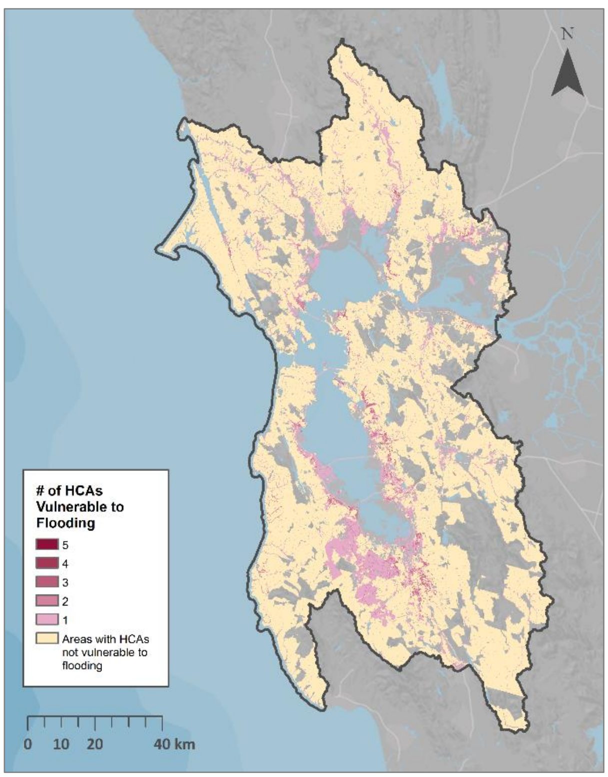
Resilience Hubs assessment unit relative scores for the San Francisco Bay and Outer Coast Watersheds. *Assessment units are 100-acres grids or smaller parcels. Darker shades have higher scores and thus greater potential to achieve both community resilience and fish and wildlife benefits. Gray areas are outside of Hubs.*

Community Vulnerability

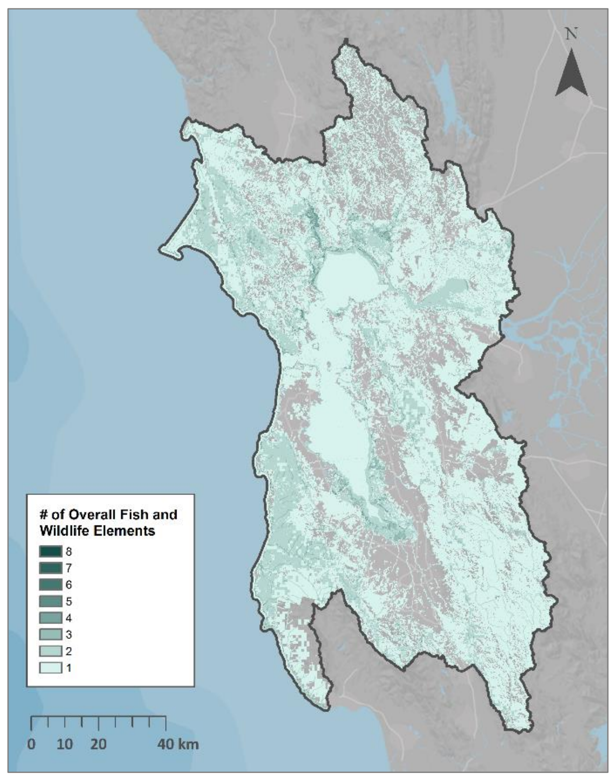
The Community Vulnerability Index (see map below) accounts for approximately half of the scoring of the Resilience Hubs. This index communicates threats to human community assets wherever they occur as well as concentrated areas of threat. Vulnerability is highest in the immediate coastal areas where there are concentrations of populations and infrastructure exposed to most flooding threats. In the San Francisco Estuary, areas of high vulnerability tend to occur in former tidal wetlands that, after two centuries of alteration, have been diked from coastal hydrology and/or filled for development. Areas of vulnerability farther inland are largely due to precipitation-caused flooding threats (flood zones and flat areas with poorly draining soils) and not sea-level rise or storm surge. Much of the immediate shoreline on the outer coast is comprised of higher bluffs and thus less vulnerable to direct flooding from higher sea levels. The high vulnerability areas that are indentified tend to correspond with potential fluvial flooding.

Fish and Wildlife

A total of 30 unique habitats, species, and species aggregations (referred to in this report as 'fish and wildlife elements' or simply 'elements') were included in this analysis. A Richness Index (see below) represents the concentration of fish and wildlife elements in each location.



Community Vulnerability Index for the San Francisco Bay and Outer Coast Watersheds. *Pink to red shades indicate the number of Human Community Assets (HCAs) exposed to flooding related threats. Tan areas indicate areas of low to no impact from the flooding threats. Gray areas within the project boundary have no mapped HCAs.*



Richness of fish and wildlife elements in the San Francisco Bay and Outer Coast Watersheds. *Green shades indicate the number of elements found in a location. Gray areas within the project boundary have no mapped fish or wildlife elements considered in this assessment.*

Resilience Projects

Plans and ideas were gathered from stakeholders for projects that could increase human community resiliency *and* provide fish and wildlife benefits but require funding to implement. The projects were collected to identify conservation and restoration need in the study area and to analyze the utility of the assessment to provide additional information on potential project benefits. The projects span a range of types including resilience planning, conservation of habitats, and habitat restoration. A complete list of projects can be found in Appendix 6. Several project sites were visited before selecting three case studies presented later in this report:

- Case Study 1: South Bay Salt Ponds: Southern Eden Landing
- Case Study 2: Lower Walnut Creek Restoration
- Case Study 3: Bolinas Lagoon North End Wetland Enhancement/Sea Level Rise Adaptation Project

Assessment Products

A rich toolbox of products was generated by this assessment and different audiences will find unique value in each of the tools.

Products from this effort can be obtained from www.nfwf.org/coastalresilience/Pages/regional-coastal-resilience-assessment.aspx and include:

- Final reports for the San Francisco Bay and Outer Coast Watersheds, other local Targeted Watershed Assessments, and the Regional Assessment.
- Coastal Resilience Evaluation and Siting Tool (CREST), an online map viewer and project site evaluation tool that allows stakeholders access to key map products. CREST is available at resilientcoasts.org.
- The GIS data inputs and outputs can be downloaded and used most readily in the Esri ArcGIS platform. Though not required to access or use these data, this project is also enabled with the NatureServe Vista planning software which can be obtained at www.natureserve.org/vista. Vista can support additional customization, assessment, and planning functions.

Products may be used to:

1. Assist funders and agencies to identify where to make investments in conservation and restoration practices to achieve maximum benefits for human community resilience and fish and wildlife.
2. Inform community decisions about where and what actions to take to improve resilience and how actions may also provide benefits to fish and wildlife.
3. Distinguish between and locate different flooding threats that exist on the landscape
4. Identify vulnerable community assets and the threats they face
5. Identify areas that are particularly rich in fish and wildlife species and habitats

6. Understand the condition of fish and wildlife where they are exposed to environmental stressors and how that condition may be impacted by flooding threats.
7. Inform hazard planning to reduce and avoid exposure to flooding threats.
8. Jump start additional assessments and planning using the decision support system.

Introduction

Background

Coastal communities throughout the United States face serious current and future threats from natural events, and these events are predicted to intensify over the short and long term (Bender et al. 2010). Many of these events (e.g., intense hurricanes, extreme flooding) have the potential to devastate both human communities and fish and wildlife, which has been seen in recent years with Hurricanes Florence and Michael (2018); Irma, Harvey, and Maria (2017); Hurricanes Matthew and Hermine and severe storms in coastal LA and Texas (2016).

The National Fish and Wildlife Foundation (NFWF) is committed to supporting programs and projects that improve resilience by reducing communities' vulnerability to these coastal storms, sea-level rise, and flooding events through strengthening natural ecosystems and the fish and wildlife habitat they provide. NFWF's experience in administering a competitive grant program in the wake of Hurricane Sandy (2012), revealed the clear need for thorough coastal resilience assessments to be completed prior to devastating events and that these assessments should include both human community resilience and fish and wildlife benefits to allow grant making to achieve multiple goals. In response, NFWF has developed a Regional Assessment that includes all coastal areas of the contiguous U.S., in addition to Targeted Watershed Assessments in select locations. This will allow for strategic investments to be made in restoration projects today to not only protect communities in the future, but also to benefit fish and wildlife. When events do strike, data and analyses will be readily available for NFWF and other organizations to make informed investment decisions and respond rapidly for maximum impact.

Regional Assessment

Developed through a separate but similar effort, the Regional Assessment (Dobson et al. 2019) explored resilience in five geographic regions of the conterminous United States (**Figure 1**) and aimed to identify areas where habitat restoration, installation of natural and nature-based features (US Army Corps of Engineers 2015), and other such projects that could be implemented to achieve maximum benefit for human community resilience, fish and wildlife populations, and their habitats. The analysis conducted for the Regional Assessment identified Resilience Hubs that represent large areas of contiguous habitat that may provide both protection to the human communities and assets in and around them and support significant fish and wildlife habitat. Enhancing, expanding, restoring, and/or connecting these areas would allow for more effective and cost-efficient implementation of projects that enhance resilience.

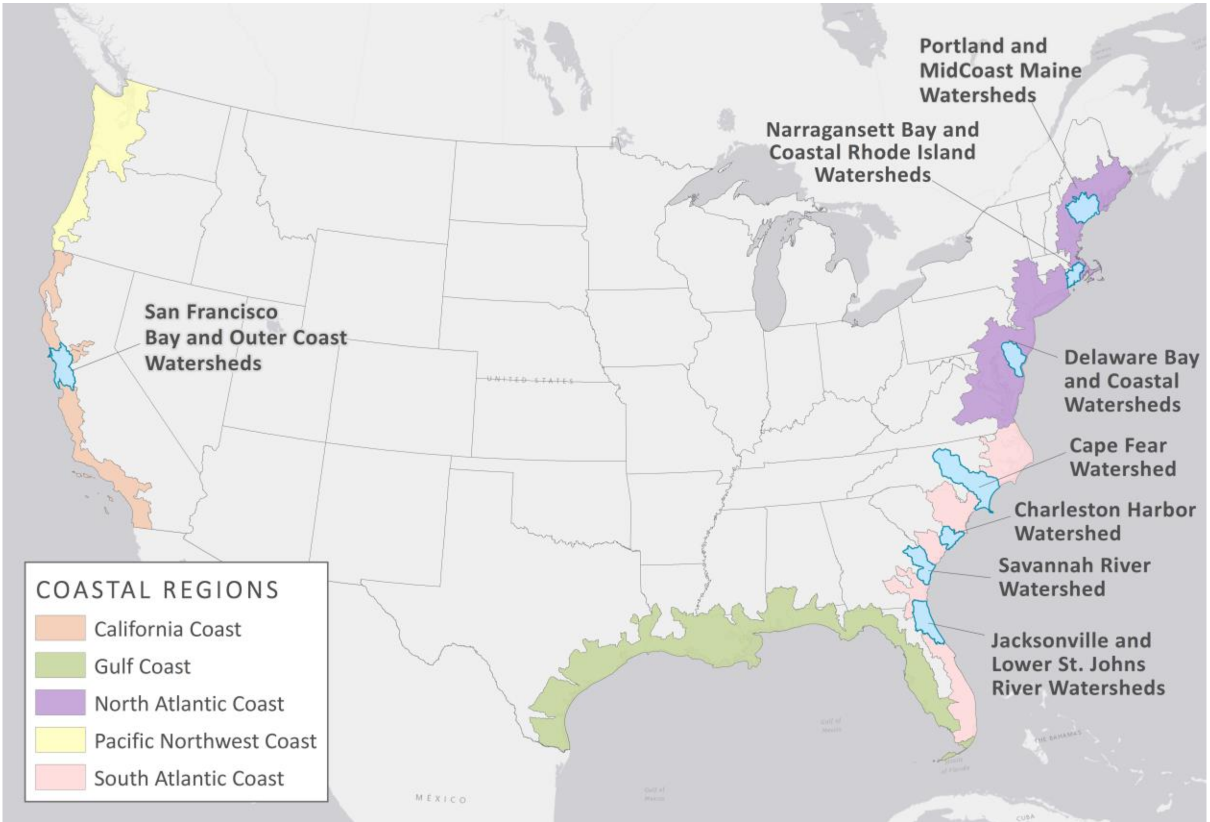


Figure 1. Map showing study areas for the Regional and Targeted Watershed Assessments. *The broad Regional Assessment included five coastal regions. High resolution resilience assessments were carried out in eight coastal Targeted Watershed Assessment study areas (in blue); the Cape Fear Watershed was conducted first as a pilot. The Targeted Watershed Assessments were informed in part by the Regional Assessment.*

Targeted Watershed Assessments

Eight smaller areas were identified for additional, in-depth study in order to build upon the concepts developed in the Regional Assessment while allowing for more detailed local data to be incorporated for a truly customized assessment (**Figure 1**). These areas were selected due to their location relative to large population centers and proximity to significant areas of open space that if restored could not only benefit fish and wildlife, but also human community resilience.

Resilience Hubs

In a model used by both the Regional and Targeted Watershed Assessments, areas of open space are identified and analyzed in terms of human community vulnerability and fish and wildlife richness to inform where projects may be ideally sited for restoration or conservation. The Regional Assessment is designed to do this on a larger scale and use only nationally available datasets, whereas the Targeted Watershed Assessments include more state and local, often higher-resolution datasets.

The Regional Assessment created contiguous and standardized datasets, maps and analyses for U.S. coastlines to support coastal resilience assessment planning, project siting, and implementation at a state, regional, or national scale. This ensures planning agencies and other professionals can compare “apples to apples” across the landscape. Unlike previous studies that quantified impacts to only a thin strip of coastline, the Regional Assessment looks at the full extent of coastal watersheds to analyze the potential impacts of both coastal and inland storm events to include every sub-basin that drains to the sea, and in some places, a sub-basin or two beyond that where they are particularly low lying or tidally influenced.

Targeted Watershed Assessment Objectives

The Regional Assessment was an important first step in the development of the assessment model and ensuring standardization of datasets across U.S. coastal watersheds. Targeted Watershed Assessments such as the one described in this report complemented these assessments by: 1) using finer scale, local data—particularly with regard to fish and wildlife, 2) involving local stakeholders in providing expertise and sourcing important information necessary for understanding more detailed patterns and local context, and 3) identifying projects in the watershed that have a demonstrated need and local support. Three of those projects are presented as case studies.

Assessment Products

The following products from this effort can be obtained from www.nfwf.org/coastalresilience/Pages/regional-coastal-resilience-assessment.aspx.

1. This report (and reports from the other Targeted Watersheds), which includes:
    a. Detailed methodology
    b. Resilience Hub map
    c. Community Vulnerability Map
    d. Fish and Wildlife Richness Map
    e. Case studies on three select projects
    f. List of projects submitted by stakeholders in the watershed
2. The Coastal Resilience Evaluation and Siting Tool (CREST), an online map viewer and project site evaluation tool that allows stakeholders access to key map products. CREST is available at resilientcoasts.org.
3. A zipped file that contains all of the Geographic Information System (GIS) data used in this assessment in the form of an ArcMap project (.mxd) with all associated data inputs and outputs (subject to any data security limitations) including many intermediary and secondary products that are available for download in CREST at resilientcoasts.org/#Download. Though not required to access or use these data, this ArcMap project was designed for use with NatureServe Vista™ planning software (Vista DSS, an extension to ArcGIS), which can be obtained for no charge at www.natureserve.org/vista.

Application of the Assessment

This Targeted Watershed Assessment is a tool to identify potential project sites that can most efficiently increase both fish and wildlife and human community resilience. The insights and products generated can be used by practitioners such as planners, state agency personnel, conservation officials, non-profit staff, community organizations, and others to focus their resources and guide funding decisions to improve a community's resilience in the face of future coastal threats while also benefiting fish and wildlife.

The results and decision support system can inform many future planning activities and are most appropriately used for landscape planning purposes rather than for site-level regulatory decisions. **This is neither an engineering-level assessment of individual Human Community Assets (HCAs) to more precisely gauge risk to individual areas or structures, nor a detailed ecological or species population viability analysis for fish and wildlife elements to estimate current or future viability.**

San Francisco Bay and Outer Coast Watersheds

The San Francisco Bay and Outer Coast Watersheds study area is located on the central coast of California (**Figure 2**).The boundary of the study area follows that of the three United States Geological Survey (USGS) level four hydrological units adjacent to San Francisco Bay (**Figure 2**). The dominant watershed feature is the San Francisco Estuary, which includes San Francisco Bay, San Pablo Bay, and Suisun Bay. Historically, the San Francisco Estuary drained 40 percent of the state's total area including the Sacramento and San Joaquin Rivers. However, much of California's hydrology is now managed for water supply with corresponding impacts and disruptions to native ecological communities. The watershed has a diverse topography as a result of the convergence of the Pacific and North American Plates which. This topographic diversity creates a diversity of microclimates and habitats resulting in a notable biodiversity hotpot within the United States.

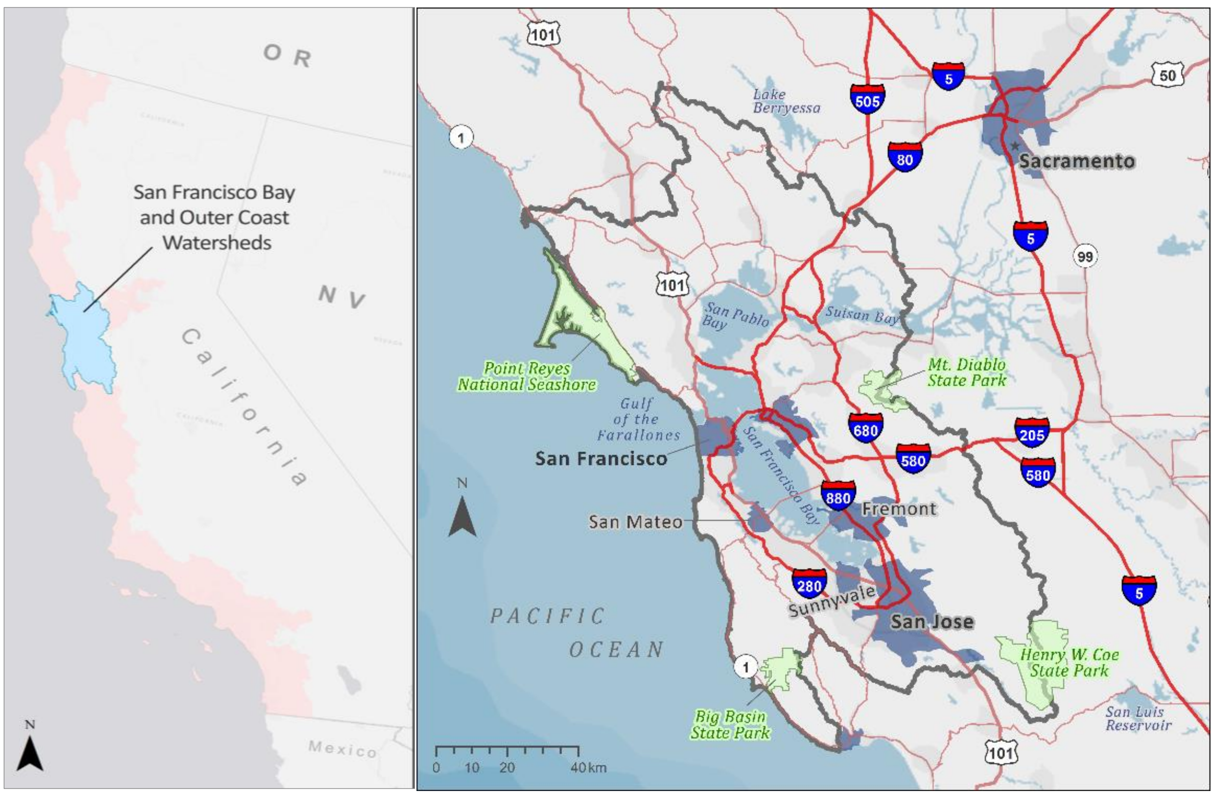


Figure 2. Location and boundary of the San Francisco Bay and Outer Coast Watersheds study area. *The map on the left shows the watershed study area (blue) in the context of the California Coast Regional Assessment area (orange). In the map on the right, the study area is indicated by the dark gray outline. Note that it consists of the San Francisco Estuary watershed and several other smaller contiguous coastal watersheds.*

The San Francisco Bay and Outer Coast Watersheds study area is densely populated and continues to experience fast population growth. As of 2010, over seven million people lived in the Bay Area, which consists of ten counties and 101 cities, including San Francisco, Oakland, and San Jose[1]. The region supports a globally significant economy, featuring nearly 30 Fortune 500 corporations (Walker and

[1] (http://www.bayareacensus.ca.gov/).

Schafran, 2015) and many important industries including technology, major ports, tourism, military, medical, agriculture, and manufacturing.

Historically, the shorelines of the San Francisco Estuary included 240,000 acres of tidal marsh and tidal flat habitat. While these habitats formed several thousand years ago, tidal marsh and tidal flat habitat actually benefited from the Gold Rush, which resulted in a substantial influx of sediment due to upstream hydrological mining (Lowe et al 2015). However, as the area became more populated, much of these historical bayland habitats were lost to diking and fill for agriculture, salt production, and coastal development. Despite decades of extensive development, the region still features large expanses of protected, open space, particularly along the outer coast including the Point Reyes National Seashore, the Golden Gate National Recreation Area, and numerous State Parks.

The San Francisco Bay and Outer Coast Watersheds include a rich diversity of ecosystems. Shoreline areas of the region's estuaries and lagoons support a tremendous amount of biodiversity including state and federally listed species such as the saltmarsh harvest mouse, Ridgway's rail, California black rail, and numerous species of migratory shorebirds and water birds. The San Francisco Estuary's upland habitats range from redwood and Douglas fir forests on the western side of the study area, to oak woodlands, shrublands, and grasslands elsewhere. The distribution of major vegetation types is largely driven by climate gradients. The western side of the study area has a more stable annual climate and soils tend to have a higher moisture content primarily driven by coastal fog. Compared to the immediate coastal regions, areas to the east of the Bay and at higher elevations experience much wider temperature ranges that results in both cooler winters and hotter and drier summers. Native vegetation, fish, and wildlife species have adapted to the diversity in microclimates resulting in significant turnover in community composition as one travereses these graidents.

Historical Impacts from Flooding and Cliff Erosion

Flooding affects many areas along the coastal reaches of the San Francisco Bay and Outer Coast Watersheds. Some of the most extensive flooding has occurred in recent years, both from episodic and chronic events, extensively damaging human assets. Within the watershed, flooding tends to occur more frequently and to greater extent where human development has occurred on top of former tidal wetland habitats that have since subsided below sea level.

- The Alviso neighborhood, which is located in Santa Clara County at the southern tip of the San Francisco Bay, has experienced several extensive flooding events over the past century. Storms with heavy precipitation combined with high astronomical tides, have led to overtopping and breaches of flood control structures surrounding the neighborhood, flooding homes and businesses.
- In 2017, State Route 37, a vital east/west transportation corridor along the northern end of the San Francisco Bay, was closed for several weeks due to numerous extensive winter flooding events. The highway flooded as a result of heavy precipitation combined with the failure of a privately maintained levee.

- Combinations of storm surf and heavy rainfall have contributed to the erosion of coastal properties and coastal highways and infrastructure. Ten homes along Esplanade Drive in Pacifica were condemned and demolished following extreme cliff erosion during the 1997/1998 El Nino winters. A large section of the Great Highway behind Ocean Beach in San Francisco has been steadily eroding over the last several decades.

These same weather events that affect human communities also affect fish and wildlife habitat, resulting in inundated beaches and submerged marshes. Ongoing studies are attempting to document what impacts these storm events have on native ecosystems and to project how these systems will respond to rising sea levels.

Communities, government agencies, and non-governmental organizations throughout the Bay Area have begun planning for the impacts of future sea level rise. These efforts have occurred both locally through city and county-led vulnerability assessments, and also regionally through the Adapting to Rising Tides project led by the San Francisco Bay Conservation and Development Commission.

Methods Overview

This overview is intended to provide the reader with sufficient information to understand the results. Details on methods are provided in the appendices as referenced in each section below to provide deeper understanding and/or aid in the use of the available Vista decision support system (Vista DSS). Process diagrams (e.g., **Figure 4**) use the Charleston, SC region as an example and do not represent inputs or results for this watershed; they are only intended to illustrate methods.

Overall Approach

The overall approach aims to identify Resilience Hubs, places where investments made in conservation or restoration may have the greatest benefit for both human community resilience and fish and wildlife (**Figure 3**). Identifying these areas can support resilience planning by informing the siting and designing of resilience projects. This assessment was conducted primarily through GIS analyses using existing datasets created by federal, state and local agencies, non-profits, universities, and others. Three categories of data were used as the primary inputs to the project: Open Space (protected lands or unprotected privately owned lands), Human Community Vulnerability, and Fish and Wildlife Species and Habitats. Bringing these data together generated many useful assessments, which culminated in the mapping and scoring of Resilience Hubs.

The use of a publicly-available decision support system (NatureServe Vista) to conduct the Targeted Watershed Assessments provides a useful vehicle for delivering the full set of inputs, interim products, and key results to users in a way that allows them to update the results with new information and customize the assessments with additional considerations such as additional Human Community Assets (HCAs) and fish and wildlife elements. Details on the components of the approach are described below and supported by Appendices 2-5.

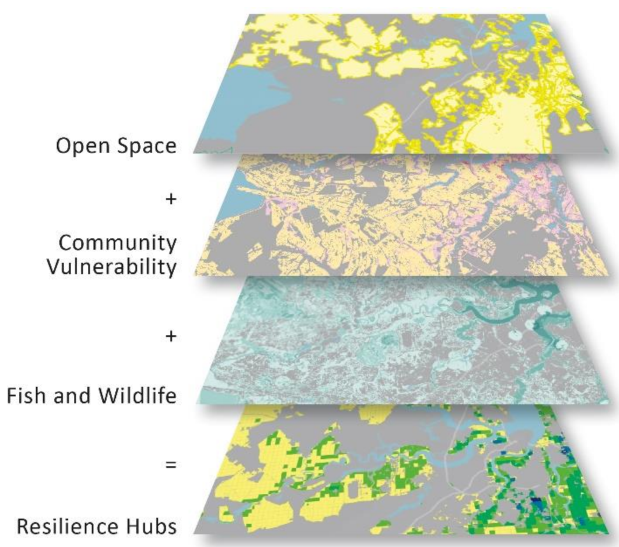


Figure 3. Diagram of the overall approach of this assessment. *Human community asset (HCA) vulnerability and fish and wildlife richness are assessed within all areas of public and private open space. Open space areas with high HCA vulnerability and high fish and wildlife richness are mapped as Resilience Hubs where efforts to preserve or increase resilience to threats are well-justified. From the set of all such Hubs, those scoring highest by these measures represent priority areas for undertaking resilience projects. Diagram represents generic region and is only intended to illustrate methods.*

Stakeholder Participation

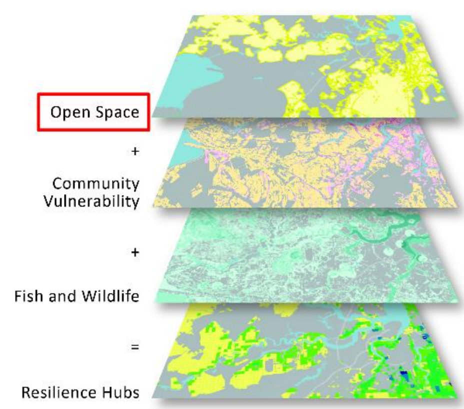
A fundamental part of this Targeted Watershed Assessment was to engage and work with individual and organizational stakeholders and partners within the San Francisco Bay and Outer Coast Watersheds. Stakeholder involvement can improve the quality of decisions and policy—especially in the context of complex environmental and social challenges (Elliott 2016, Reed 2008). The stakeholder engagement process for the San Francisco Bay and Outer Coast Watersheds was designed to address four goals: 1) inform a wide array of stakeholders in the watershed of this assessment, its objectives and potential utility, and opportunities to contribute to it; 2) inform the selection of fish and wildlife habitats and species, and their stressors; 3) identify and access the best existing local data to supplement regional and national data to be used in the spatial assessments; and 4) catalog proposed resilience project plans and ideas.

In addition to the overall Coastal Resilience Assessment Technical and Steering Committees that helped to guide the Targeted Watershed Assessment goals and deliverables and provide feedback at key points in the process (such as reviewing the fish and wildlife habitat layers, resilience project sites for site visits, and final case studies), a San Francisco Bay and Outer Coast Watersheds Committee was formed consisting of local experts from National Oceanic and Atmospheric Administration (NOAA), the California Landscape Conservation Cooperative, the California State Coastal Conservancy, California Sea Grant, U.S. Army Corps of Engineers, and NFWF. This committee helped to identify relevant stakeholders to engage, determine times and places of stakeholder workshops, and compile the initial fish and wildlife element list and associated data. Specific individual and institutional roles and contributions are listed in the 'Acknowledgements' section.

Over 50 participants including federal and state agency representatives, NGO staff, local elected officials and municipal staff, and citizens representing their communities were engaged in the stakeholder process through web meetings, in-person workshops, and follow-up activities such as site visits to proposed resilience project sites. Additional details on key stakeholder inputs, details about the stakeholder process, and the committee structure that guided the assessment can be found in Appendix 1.

Components of the Assessment

For each component described below, an inset of **Figure 3** above is repeated, identifying in red outline the component being described in relation to the other three components.



Open Space

Large contiguous areas of habitat may provide mutual resilience benefits to HCAs and fish and wildlife elements, especially with the implementation of resilience projects. Identifying these areas of open space serves as a first step in identifying high value Resilience Hubs where prospective conservation and restoration projects could contribute to resilience and benefit fish and wildlife. The method for scoring the value of the Hubs using results from the watershed assessments is further described below.

Mapping Open Space

The process of delineating open space is described in the Regional Assessment (Dobson et al. 2019) and incorporates:

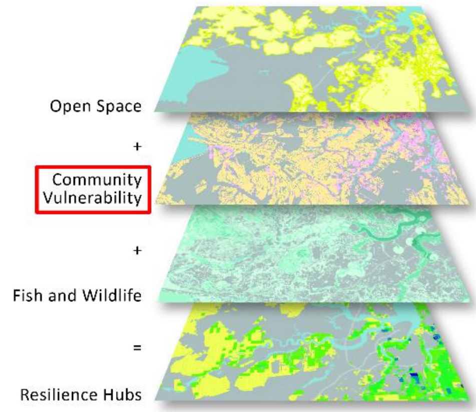
1. Protected areas, which are defined as lands that are part of the USGS Protected Areas Database of the United States (PAD-US).
2. Unprotected, privately owned lands with contiguous habitat, as identified from the USGS National Land Cover Database (NLCD). The open space areas were further processed to remove impervious surfaces and deep marine areas. Within the Regional Assessment methodology, these areas were also analyzed using a community exposure index to highlight areas of higher exposure and areas that are near or adjacent to communities.

Open space areas identified in the regional assessment were refined for this watershed assessment as follows:

1. All protected area polygons from the PAD-US were intersected with the Resilience Hubs as identified in the Regional Assessments to distinguish protected from unprotected areas.
2. Hubs with shorelines (rivers or coastal) were supplemented with the National Hydrography Dataset (NHD) to include waters within a 50-meter (164 ft) buffer to add nearshore habitat areas that could provide locations for aquatic resilience projects such as oyster reefs or marsh protection/restoration.
3. Impervious surfaces were deleted from the Hubs using the National Land Cover Database (Homer et al. 2011) and Topologically Integrated Geographic Encoding and Referencing (TIGER) roads data (U.S. Census 2016). The removed areas might be protected, but have pavement or structures in place that would limit restoration actions.
4. Tracts that were less than five acres (mostly slivers resulting after deleting impervious surfaces and splitting polygons) were removed from consideration. For the purposes of this assessment, areas under this threshold were assumed to have significantly less potential for improving community resilience or supporting fish and wildlife in meaningful, measurable terms.

Community Vulnerability

Assessing community vulnerability is a process of examining where and how assets within a community may be impacted by flooding threats. Understanding where people and infrastructure are most exposed and vulnerable to threats can help communities assess where they are most at risk, and where actions may need to be taken to increase resilience.



Human Community Asset Weighted Richness Index

For the purposes of this assessment, Human Community Assets (HCAs) data were selected to represent: 1) critical infrastructure and facilities essential for community recovery post-storm event, 2) areas of dense human population, and 3) socially vulnerable populations. They are not intended to be comprehensive; for example, not all roads are included and instead focus on storm escape routes. The Regional Assessment identified a suite of HCAs that were used in this Targeted Watershed assessment. The selected HCAs are further described in the Regional Assessment (Dobson et al. 2019) and are listed in **Table 1** below.

For the purposes of this assessment, Human Community Assets (HCAs) data were selected to represent: 1) critical infrastructure and facilities essential for community recovery post-storm event, 2) areas of dense human population, and 3) socially vulnerable populations. They are not intended to be comprehensive; for example, not all roads are included and instead focus on storm escape routes. The Regional Assessment identified a suite of HCAs that were used in this Targeted Watershed assessment. The selected HCAs are defined below (see also the Regional Assessment Report [Dobson et al. 2019]). **Table 1** provides further breakdown of the HCAs as represented in the spatial assessment and the importance weightings derived from the Regional Assessment. **Table 2** provides additional detail on the critical facilities category and sources of data.

Human Community Asset categories are defined as follows:

Critical Facilities. Schools, hospitals, nursing homes, and fire and police stations are just a few of the types of facilities included as critical facilities. These services are considered critical in the operation of other community infrastructure types, such as residences, commercial, industrial, and public properties that themselves are not HCAs in this assessment. Critical facilities were drawn from the National Structures Dataset and include (see **Table 2** for additional detail):

- Schools or educational facilities (class 730) (often used as shelters during disasters)
- Emergency Response and Law Enforcement facilities (class 740)
- Health and Medical facilities (class 800)
- Government and military facilities (class 830)

Critical Infrastructure. A variety of additional infrastructure is included that may help communities with emergency evacuation, building economic resilience, and identifying infrastructure (e.g., dams) that may require more extensive and long-term planning and permitting (**Table 2**). Other critical infrastructure includes airport runways, primary transportation routes, ports, refineries, hazardous chemical facilities, power plants, etc. Coastal infrastructure is expected to be increasingly at risk due to major inundation from storm surge and sea level rise. Infrastructure that was considered an important economic asset was also included, such as fishing ports.

Population Density. These categories were included because denser populations in high-threat areas will lead to more people being exposed to flooding threats. Density was calculated by Census Block for each region based on the 2010 Census.

Social Vulnerability. Social vulnerability varies geographically in coastal areas where there are large socioeconomic disparities. This input is meant to indicate a community's ability to respond to and cope with the effects of hazards, which is important to consider because more disadvantaged households are typically found in more threatened areas of cities, putting them more at risk to flooding, disease, and other chronic stresses. The input considers certain demographic criteria such as minority populations, low-income, high school completion rate, linguistic isolation, and percent of population below five or over 64 years of age. To account for regional differences and remove any unnecessary bias in the modeling, the source data were processed with a quintile distribution with the Weighted Linear Combination method to rank social vulnerability using a weight value range of 0-5 by Census Block Group at the national level.

Table 1. Human Community Assets included in the assessment and their importance weightings.

Human Community Assets	Description	Adjusted Weight
Critical Facilities	Facilities (i.e., schools, hospitals, fire/police stations) providing services that are critical in the operation of a community.	1
Critical Infrastructure (Rank 1)	**Low** spatial concentration of infrastructure (i.e., dams, evacuation routes, water treatment plants, energy plants, etc.).	0.2
Critical Infrastructure (Rank 2)	**Medium** spatial concentration of infrastructure (i.e., dams, evacuation routes, water treatment plants, energy plants, etc.).	0.4
Critical Infrastructure (Rank 3)	**High** spatial concentration of infrastructure (i.e., dams, evacuation routes, water treatment plants, energy plants, etc.)	0.6
Critical Infrastructure (Rank 4)	**Very High** spatial concentration of infrastructure (i.e., dams, evacuation routes, water treatment plants, energy plants, etc.)	0.8
Social Vulnerability	The resilience of communities when confronted by external stresses on human health, stresses such as natural or human-caused disasters, or disease outbreaks.	0.2
Population Density (Rank 1)	***Low*** total density calculated by Census Block for each region based on the 2010 Census.	0.2
Population Density (Rank 2)	***Low-medium*** total density calculated by Census Block for each region based on the 2010 Census.	0.4
Population Density (Rank 3)	***Medium*** total density calculated by Census Block for each region based on the 2010 Census.	0.6
Population Density (Rank 4)	***Medium-high*** total density calculated by Census Block for each region based on the 2010 Census.	0.8
Population Density (Rank 5)	***High*** total density calculated by Census Block for each region based on the 2010 Census.	1

Table 2. Critical infrastructure categories and sources of data.

Critical Infrastructure Category	Data Source
Ports	USDOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later)
Power plants	EIA-860, Annual Electric Generator Report, EIA-860M, Monthly Update to the Annual Electric Generator Report and EIA-923, Power Plant Operations Report (2016 or later)
Wastewater treatment facilities	USGS National Structures Dataset File GDB 10.1 or later
Railroads	USDOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later)
Airport runways	National Transportation Atlas Database (2015 or later)
National Highway Planning Network	National Transportation Atlas Database v11.09 (2015) or later; on behalf of the Federal Highway Administration
Evacuation routes	Homeland Security: Homeland Infrastructure Foundation Level Data (2007 or later)
Major dams	USDOT/Bureau of Statistics NTAD (2015 or later)
Petroleum terminals and refineries	EIA-815, "Monthly Bulk Terminal and Blender" Report; *Refineries*: EIA-820 Refinery Capacity Report (2015 or later)
Natural gas terminals and processing plants	EIA, Federal Energy Regulatory Commission, and U.S. Dept. of Transportation; *Processing Plants*: EIA-757, Natural Gas Processing Plant Survey (2015 or later)
National Bridge Inventory	Federal Highway Administration, NBI v.7, NTAD (2015 or later)
Hazardous facilities & sites	EPA Facility Registry Service (2016 or later)

The HCA weighted richness index expresses values based on the number of HCAs present in a location and their importance weights. The HCAs were combined in the Vista DSS using its Conservation Value Summary function[2] by first assigning a weighting factor that approximated the ranked weights used in the Regional Assessment (see **Table 1**). For the purposes of the Targeted Watershed Assessment, the weights used in the Regional Assessments (1 = lowest importance, 5 = highest) were adjusted to a 0-1 scale (1=0.2, 2=0.4, 3=0.6, 4=0.8, 5=1). Next, the HCAs were overlaid, and their adjusted weights summed for each pixel.

Flooding Threats

Flooding threats were used to assess Community Vulnerability (described below) and Fish and Wildlife Vulnerability (described later). The flooding threats used in the Targeted Watershed Assessment are summarized below and illustrated in **Figure 4**. Additional details and assumptions in their use in the vulnerability assessments is provided in Appendix 2.

- Storm surge (surge modeled for annual, 20-year and 100-year storms)

[2] A Conservation Value Summary is a surface of mapped values that are the output of a Vista DSS overlay function that allows for a wide range of calculations based on element layers and user-specified attributes. Examples include richness (the number of overlapping elements at a location) and weighted richness where, for example, a simple richness index is modified by the modeled condition of elements.

- Flood zones (100 and 500-year floodplains and flood-ways)
- Sea level rise (1.6 ft was used to correspond with an approximate 20-30-year planning timeframe)
- Flood prone areas (flat topography with poorly draining soils)
- Moderate to high erosion potential
- Subsidence

Figure 4. Flooding threats used to assess community vulnerability. *This diagram uses the Charleston, SC region as an example and is only intended to illustrate methods.*

The flooding threats used in the Targeted Watershed Assessments differed slightly from those used in the Regional Assessment. Specifically, the Threats Index used in the Regional Assessment was generated using an ordinal combination method and is presented in the Results section of this report for illustration purposes. Unlike the Targeted Watershed Assessments, all inputs used in the Regional Assessment were ranked on a 0-5 scale, representing the risk of impact (not the degree of impact) and included a five-foot sea level rise change. See the Regional Assessment report for more details on methods (Dobson et al. 2019). In this Targeted Watershed Assessment, a 1.6 foot sea level rise change was used, as requested by local stakeholders.

Community Vulnerability Assessment

Unlike the Regional Assessments, this Targeted Watershed Assessment went beyond assessing exposure (which examines which, if any, threats an HCA overlaps with and may include intensity of the threat at different levels of storm surge) by assessing vulnerability to threats. Assessing vulnerability includes consideration of the sensitivity of an HCA to the threat it is exposed to, and its adaptive capacity to recover from the impact of that threat (IPCC 2007). Therefore, in this assessment the coexistence of a threat with an HCA does not necessarily equate to vulnerability. The method for assessing vulnerability of HCAs is illustrated in **Figure 5** and details are provided in Appendix 2 and Appendix 3. The basic steps, implemented through the Vista DSS and illustrated in **Figure 5** are:

1. Intersect HCAs with the flooding threats
2. Apply the HCA vulnerability model
3. Generate individual HCA vulnerability maps
4. Sum the results across all HCAs to develop the Community Vulnerability Index. This provides a sum of the number of vulnerable HCAs for every location.

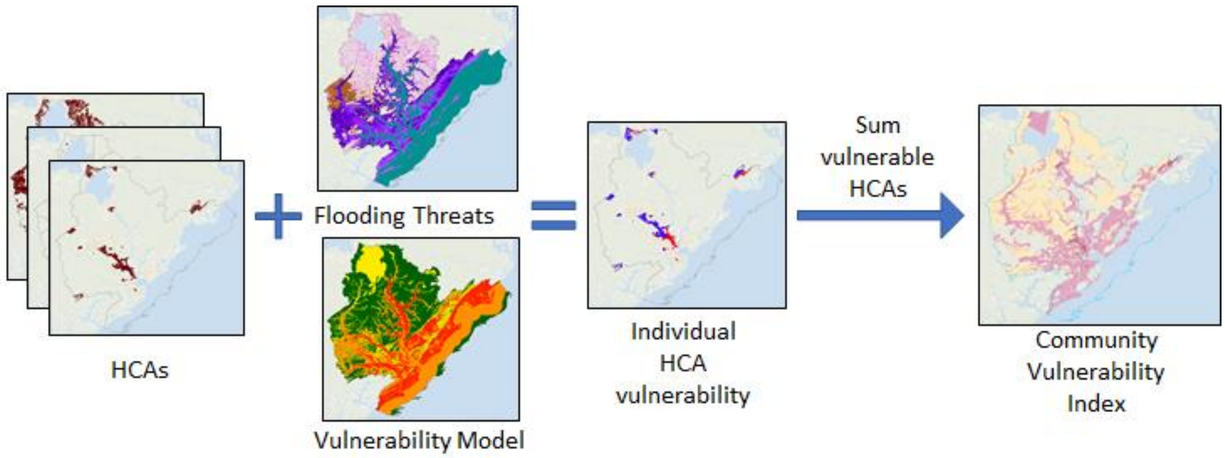
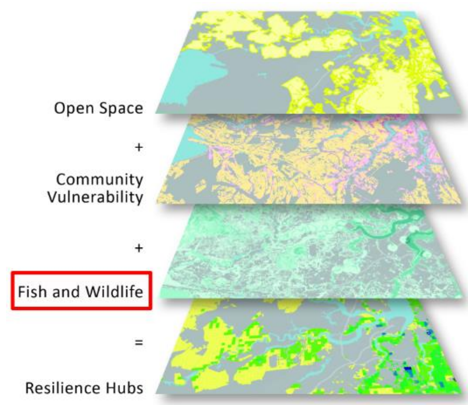


Figure 5. Community vulnerability assessment process. *Human Community Assets (HCAs) are intersected with the flooding threats, a vulnerability model is applied, and individual HCA results are summed to create the Community Vulnerability Index. Diagram represents a generic region as an example and is only intended to illustrate methods.*

Fish and Wildlife



The Regional Assessment only used those fish and wildlife data that were available nationwide. While this allowed for consistent data coverage over the entire study area, nationwide fish and wildlife data are very coarse. Therefore, the Targeted Watershed Assessment substituted national datasets for local data, which facilitated a more accurate and higher resolution fish and wildlife analysis.

To better understand where high value areas of fish, wildlife, and associated habitat exist in the region, several analyses were conducted focused on mappable fish and wildlife species, habitats, and other related features of conservation significance (referred to in this report as "fish and wildlife "elements" or simply "elements"). This section of the report focuses on the fish and wildlife element selection process, and the development of conservation value indices. Specifically, two indices were calculated to inform the Resilience Hubs characterization and scoring used in the Targeted Watershed Assessment (see section below): 1) a Fish and Wildlife Richness Index, and 2) a Fish and Wildlife Condition-Weighted Index. Though not used directly in the hub prioritization, a Fish and Wildlife Vulnerability Index was also conducted and is likely to be of significant interest to stakeholders wanting to extend or further explore coastal resilience and fish and wildlife vulnerability. The Fish and Wildlife Vulnerability Index is described in Appendix 4.

Selection of Fish and Wildlife Elements

To facilitate the identification of areas in the watershed important for fish and wildlife conservation, restoration, and resilience, a set of mapped fish and wildlife elements of interest was first established. This was achieved via the following steps:

1. Establishment of an initial list of fish and wildlife elements based on explicit criteria (see below);
2. Review and refinement of this list based on extensive consultation with a diverse set of local experts and other stakeholders;
3. Identification and evaluation of relevant and appropriate spatial data to represent each element; and
4. Finalization of the element set based on input from local experts, the Watershed Committee, and other stakeholders.

For step one, national and local experts applied several criteria to establish an initial set of target fish and wildlife species, species groups, species habitat segments (e.g., migratory, breeding, or rearing habitat), or broad habitat units of significance occurring in this watershed. For inclusion, elements had to: 1) satisfy at least one of the inclusion criteria listed below, and 2) be mappable via relevant and available spatial data of sufficient coverage and accuracy to fairly represent the element (as determined by expert review).

For inclusion, elements must meet one or more of the following criteria:

- A NOAA Trust Resource[3]
- A formally recognized at-risk species based on its inclusion in one of the following categories at the time of this assessment including:
    - A species listed as 'endangered', 'threatened', or 'candidate' under the provisions of Endangered Species Act (ESA)[4]
    - A species with a NatureServe global imperilment rank of G1, G2, or G3[5]
    - A species with a NatureServe state imperilment rank of S1, S2, or S3
    - A State Species of Greatest Conservation Need (SGCN) as recorded in current State Wildlife Action Plans
- A distinctive ecological system or species congregation area that represents habitat important to at-risk species and/or species of significance to stakeholders in the region. Examples might include heron rookeries that represent important wading bird habitat or tidal marsh representing shrimp nursery areas and diamondback terrapin habitat; or
- A species or population of commercial, recreational, or iconic importance in the watershed. This includes:
    - Fish or wildlife species or populations of significant commercial value,

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[3] NOAA trust resources are living marine resources that include: Commercial and recreational fishery resources (marine fish and shellfish and their habitats); Anadromous species (fish, such as salmon and striped bass, that spawn in freshwater and then migrate to the sea); Endangered and threatened marine species and their habitats; marine mammals, turtles, and their habitats; Marshes, mangroves, seagrass beds, coral reefs, and other coastal habitats; and resources associated with National Marine Sanctuaries and National Estuarine Research Reserves (NOAA 2015).

[4] These categories are established by the **US Endangered Species Act of 1973, as amended through the 100th Congress**. (United States Government 1988) (See this factsheet for further explanation: https://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf)

[5] These categories, used throughout the Americas are documented in the publication **NatureServe Conservation Status Assessments: Methodology for Assigning Ranks (Faber-Langendoen et al. 2012)** (Available here: http://www.natureserve.org/sites/default/files/publications/files/natureserveconservationstatusmethodology_jun12_0.pdf)

- Fish or wildlife-related features that confer resilience to biodiversity or human assets (such as oyster beds which have high economic significance as a fishery component and/or play a valuable role in coastal resilience by virtue of their physical structure which in many cases mitigates destructive wave action and storm surge impacts),
- Fish or wildlife populations or wildlife habitat-related features that provide unique recreational opportunities (such as Atlantic beach and dune habitat that provides key habitat while also providing recreational opportunities for visitors), and/or
- Iconic species that define the watershed and/or distinguish it from other geographies and represent species that have conservation support.

Elements were organized into the following broad categories: NOAA Trust Resources, At-Risk Species and Multi-species Aggregations, Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species, Fish or Wildlife-related Areas of Key Economic, Cultural or Recreational Significance, and Cross-cutting Elements.

Stressors

Current fish and wildlife stressors were identified during stakeholder workshops and available data were identified to represent each. These stressors include land use and infrastructure, roads, and water quality (**Figure 6**). The complete list, descriptions, and data sources for fish and wildlife stressors included in this assessment are presented in Appendix 2.

The response of the fish and wildlife elements to these stressors results in a calculation of current condition as described further in the Fish and Wildlife Vulnerability Assessment section and in Appendix 2 and Appendix 3. The individual fish and wildlife element condition scores are then added together for each location to create the Fish and Wildlife Condition-Weighted Richness Index.

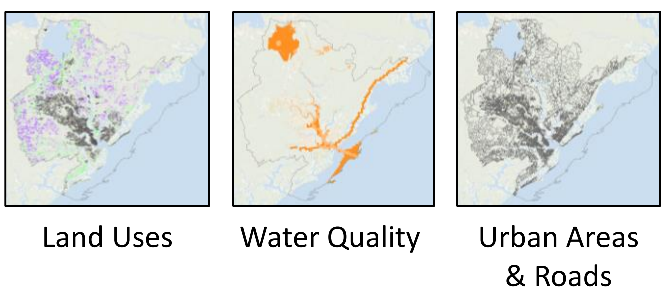


Figure 6. Fish and wildlife stressors used to model current habitat condition. *Diagram represents a generic region as an example and is only intended to illustrate methods.*

Fish and Wildlife Indices

The Fish and Wildlife Richness Index results from a simple overlay and sum of the number of elements occurring in each location. The method for generating the Richness Index is illustrated in (**Figure 7**) and was conducted using the Conservation Value Summary function in the Vista DSS.

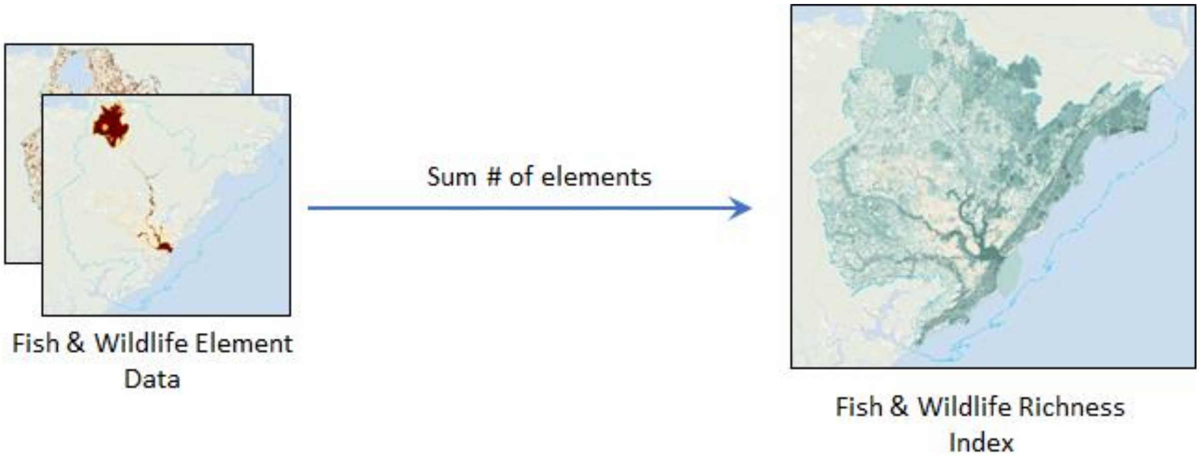


Figure 7. Method for generating the Fish and Wildlife Richness Index. *All elements are overlaid and the sum of elements occurring in a location is calculated. Diagram represents a generic region as an example and is only intended to illustrate methods.*

Condition-Weighted Fish and Wildlife Richness Index

The Condition Weighted Fish and Wildlife Richness Index is a sum of the condition scores for each fish and wildlife element at a location. While the richness index described above conveys the value of a location as a factor of how many fish and wildlife elements occur there, this index modifies the value to consider the current condition of the elements. Condition scores are generated as an intermediate step in a vulnerability assessment modeling process described in Appendix 4. The method is illustrated in **Figure 8**. It consists of the following steps which are further described in Appendix 2 and Appendix 3.

1. Intersect fish and wildlife elements with the fish and wildlife stressors.
2. Apply the relevant element vulnerability models (see Appendix 3 for parameters and assumptions.)
3. Generate individual element condition maps.
4. Sum the condition scores of each element in each pixel to calculate the Index.

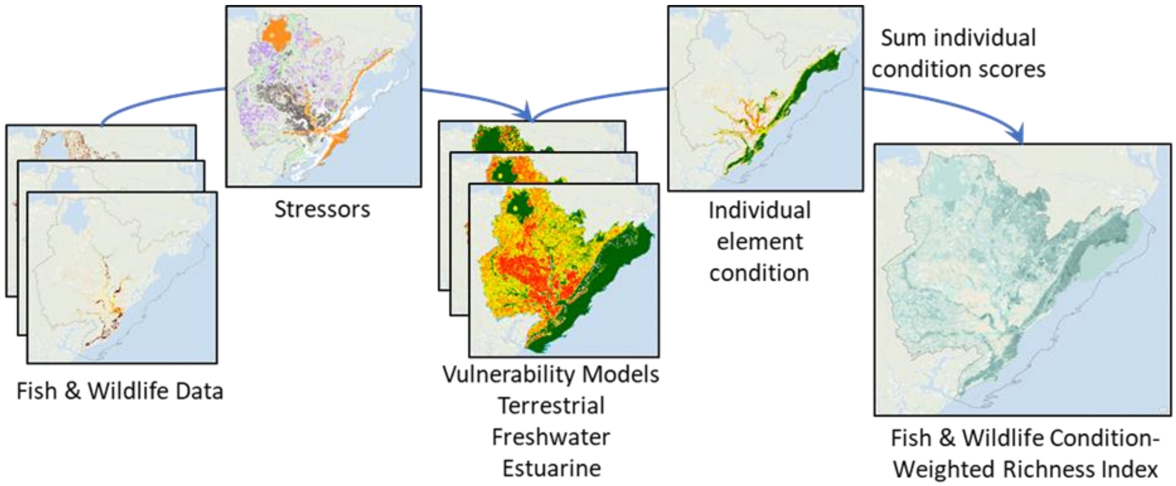
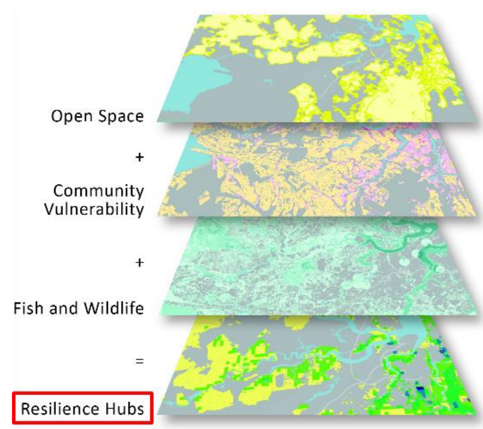


Figure 8. Method for generating the Fish and Wildlife Condition-Weighted Richness Index. *Fish and wildlife elements are intersected with stressors, the vulnerability model is applied, and individual element condition results are summed. Diagram represents a generic region as an example and is only intended to illustrate methods.*

Resilience Hub Characterization and Scoring



Once open space areas were delineated as described above, they were segmented into assessment units. Assessment units are approximately 100-acre subdivisions of the Resilience Hubs to facilitate scoring and understanding of how resilience values differ across the Hubs. Hubs were subdivided by first intersecting the protected areas (USGS GAP 2016) polygons; then remaining polygons larger than 100 acres were segmented by a 100-acre fishnet grid. This provided a relatively uniform size for the assessment units and, therefore, more consistency in scoring (i.e., a very large unit does not accrue a higher value than much smaller units because it contains more fish and wildlife elements as a factor of its size). The 100-acre assessment units provide a reasonable size for distinguishing differences in value across the watershed and directing those developing resilience project proposals to appropriately-sized areas.

Each assessment unit was then assigned a value (using the formula below) for their potential to provide mutual community resilience and fish and wildlife benefits. The scores range from 0.0-1.0 with 1.0 being the highest or most desirable value for the resilience objectives. The methods are illustrated by **Figure 9**.

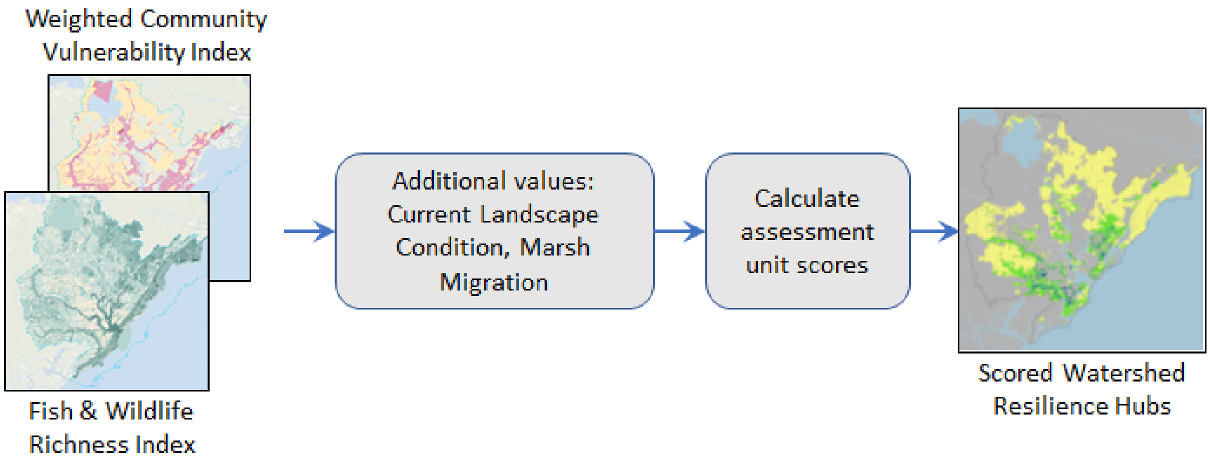


Figure 9. Method for scoring watershed Resilience Hubs. *Resilience Hub assessment units were scored based on their community resilience and fish and wildlife. Diagram represents a generic region as an example and is only intended to illustrate methods.*

The attributes used in the scoring, their rationale, and specific values assigned to each assessment unit are:

- **Weighted Community Vulnerability**: The weighted richness of HCAs with vulnerability to flooding threats falling within each assessment unit. This is a combination of the Community Vulnerability Index and HCA Weighted Richness Index. This attribute was used as a strong attractor of resilience projects to increase resilience to HCAs modeled to be vulnerable. The index has a value of zero if the HCA Flooding Threats Exposure Index is zero, otherwise it is the value from the HCA Weighted Richness. Focal statistics were used to summarize this combined map using a 1 km (0.62 mi) radius and these results were summed to each assessment unit using zonal statistics. This is an intermediate product used only to score Resilience Hubs and therefore not depicted in the Results section.
- **Fish and Wildlife Richness Index**: The number of fish and wildlife elements falling within each assessment unit. This attribute was used to increase the value of areas that could benefit more fish and wildlife elements relative to places with fewer elements.
- **Future Marsh Migration Index**: This attribute is based on NOAA's three-foot sea level rise marsh migration models (NOAA 2018). The rationale is that areas modeled to support future marsh habitat will be able to provide ongoing fish and wildlife value with at least three-feet of sea level rise. While changes (e.g., one foot of sea level rise) may not occur until well into the future, conservation and restoration of these areas should begin now to prepare for future changes. Areas were assigned a one (1) if the assessment unit was projected to have estuarine marshes.
- **Restorability Index:** This attribute is based on the current condition as modeled from the existing fish and wildlife stressors as well as its protection status. Scores the value of an assessment unit based on the average.

- The protected areas assessment units are of interest for ***restoration*** to improve the viability of elements within them (as they are already protected from conversion to more intensive uses). Therefore, they were scored as:
  - 1 (high priority) if the elements are in moderate condition (score > 0.3 and < 0.7) and can be improved through significant restoration action,
  - 0.5 (medium priority) if the elements are currently in good condition (score > 0.7), requiring no to little restoration, or
  - 0 (low priority) for low condition (score < 0.3), considered to have lower prospects/higher cost for successful restoration.
- Private open space areas would benefit from both conservation and restoration and/or protection. Therefore, they were scored as:
  - 1 (high priority) for all moderate to good conditions (score > 0.3), or
  - 0 (low priority) for low condition (score < 0.3), considered to have lower prospects/higher cost for successful restoration and would hold little conservation value.

A final score was calculated for each hub using the above indices. A higher score indicates a higher value. The algorithm used to combine the indices values is:

$$((C/\max(C)) * 4) + (((F/\max(F)) + M) * R)$$

Where: *C* is the Weighted Community Vulnerability
F is the Fish and Wildlife Richness Index
M is the Future Marsh Migration Index and
R is the Restorability Index

The score multipliers in the algorithm emphasize the relative importance of vulnerable HCAs in/near the hub assessment units and restorability of habitat. While the scoring emphasized the objectives of this Targeted Watershed Assessment, the component values from the indices in the assessment units are contained in the Resilience Hubs GIS map and can be used to support other objectives. For example, those most interested in protecting HCAs will be interested in hub areas with highest community vulnerability scores. Similarly, those most interested in fish and wildlife conservation and restoration can likewise find areas to support that objective.

Resilience Projects

Location data and descriptive information about resilience project plans and ideas were gathered from stakeholders (see Stakeholder and Partner Engagement methods and Appendix 1). It is hoped that this list of projects can help match conservation and resilience need to appropriate funding sources and interested implementers. While an extensive outreach effort was conducted to identify relevant projects, it is possible that, at the time of this assessment, additional relevant project plans and ideas existed but were not submitted or otherwise brought to the attention of the project team.

The submitted projects were reviewed for relevance to the assessment objectives, focusing on their ability to provide mutual benefits for community resilience and fish and wildlife. Relevant projects with sufficient ancillary information—including their location and geographic extent—were retained for further evaluation and consideration. Each project was evaluated for the following attributes.

- Calculated size in acres: The size in acres of the polygon representing the project area. Alternatively, submitters could enter an estimated size if project boundaries had not been developed.
- Alignment with NOAA's mission, programs, and priorities
- Alignment with USACE's mission, programs, and priorities
- Addressing stressors and threats mapped in the project polygon
- Project addresses the main threats: Assessed by comparing the list of threats to the proposed actions of the project
- Project proximity to a resilience hub: A Yes/No indicator for whether the project falls within 1 km (0.62 mi) of any resilience hub
- Community Vulnerability Index: The average value of the regional Community Vulnerability Index for the project polygon
- Number of HCAs found within the project polygon
- List of the HCAs mapped within the project polygon
- Number and percentage of the HCAs within the project polygon that are designated non-viable in the Coastal Threats scenario evaluation
- Number of fish and wildlife elements found within the project polygon
- List of the fish and wildlife elements mapped within the project polygon
- Number and percentage of the fish and wildlife elements vulnerable to flooding threats

This information was used to select a subset of projects for site visits and case studies (see Results section). The complete list of projects submitted is presented in Appendix 7.

Site Visits

Five projects were selected for site visits of which three were developed into the case studies found in the Results section. A spreadsheet containing information on all projects provided by the proponents and corresponding indices calculated using the above steps was provided to NFWF. The Technical and Steering Committees analyzed the project information to identify projects most appropriate for site visits. Once selected, site visits were scheduled with project proponents. Watershed and Technical Committee members were invited to participate.

Site visits were conducted by representatives from NOAA, NFWF, and NatureServe. For each site visit, the assessment team spent two to four hours taking photos and compiling answers to a set of questions meant to increase understanding of the project's potential benefits and implementation challenges. Information gathered from the site visits was used to select three projects to be used as the focus for detailed case studies (see Case Studies section below).

Results

This section portrays the key set of products primarily focused on the resulting Resilience Hubs and key indices. Many map and tabular products were generated for this Targeted Watershed Assessment. In addition to this report, key results may be viewed in the Coastal Resilience Evaluation and Siting Tool (CREST), which is an interactiononline mapping tool that includes results for the Regional Assessment and each of the eight Targeted Watersheds (available at resilientcoasts.org). CREST can also be used to download data including the San Francisco Bay Watershed NatureServe Vista decision support project, which includes the input data and useful intermediate products that can be updated and customized. Prior to using these results for any decisions, please see the limitations described in the Conclusions section.

Flooding Threats

The effects of the flooding threats on the vulnerability of Human Community Assets (HCAs) and fish and wildlife elements are treated individually in the assessment model (see Appendix 2); therefore, a separate threats index was not generated. An analog to a threats index can be found in Appendix 2, which contains the results of four models of how wildlife stressors and flooding threats may cumulatively impact the condition of HCAs, terrestrial wildlife, freshwater fish and wildlife, and estuarine fish and wildlife. The Threat Index generated in the Regional Assessment is provided below to illustrate the accumulation of flooding threats across the San Francisco Bay and Outer Coast Watersheds (**Figure 10**). The Threats Index used in the Regional Assessment is a combination of the number and probability of occurrence of the flooding threats in each location (see Dobson et al. 2019 for more information).

Within the San Francisco and Outer Coast Watersheds, high threat index scores occur primarily in areas of historical bayland habitats that have been filled and/or cut off from tidal influence by levees (**Figure 10**). These highly vulnerable areas include much of the south bay shoreline as well as pockets in the central, east, and north bay. Along the outer coast, almost all of the Point Reyes National Seashore was scored with a high-threat index as well as the Linda Mar area of Pacifica and southern Half Moon Bay.

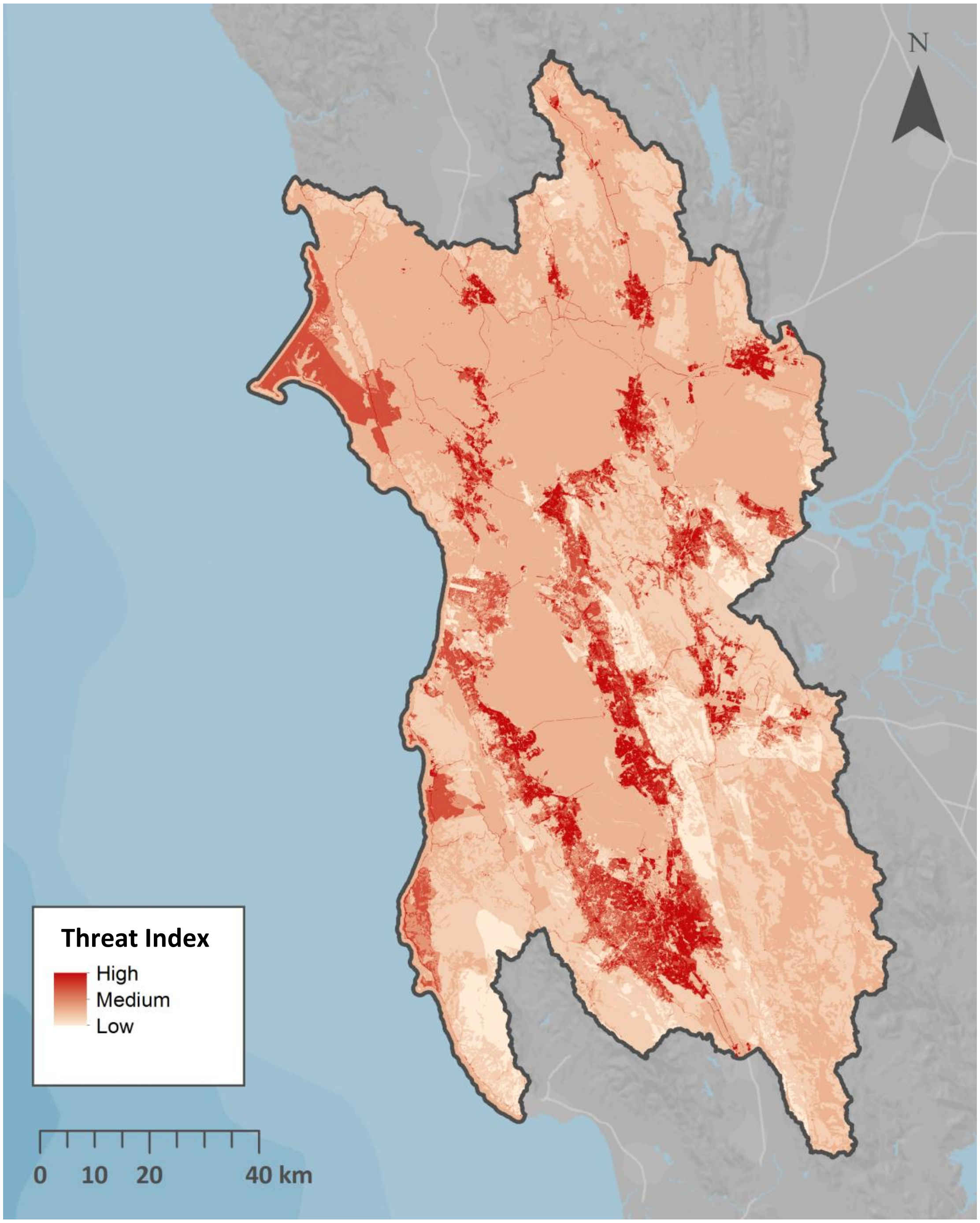


Figure 10. Weighted Threat Index for the San Francisco Bay and Outer Coast Watersheds. *Map shows the number of overlapping threats modified by a weighting based on their probability of occurrence.*

Suggested Uses

Understanding which threats occur in a location can inform whether action needs to be taken, whether proposed actions can mitigate all threats anticipated for an area, and what measures would be most appropriate to mitigate threats if mitigation is even feasible.

Human Community Assets

HCA Weighted Richness Index

This index indicates areas of HCA concentrations (**Figure 11**). HCAs do not tend to overlap so the areas of darker shades are primarily a factor of the HCA importance weighting. High HCA weighted index values are coincident with the largest cities within the watershed including San Francisco, Oakland, San Jose, and much of Silicon Valley including the San Mateo County shoreline.

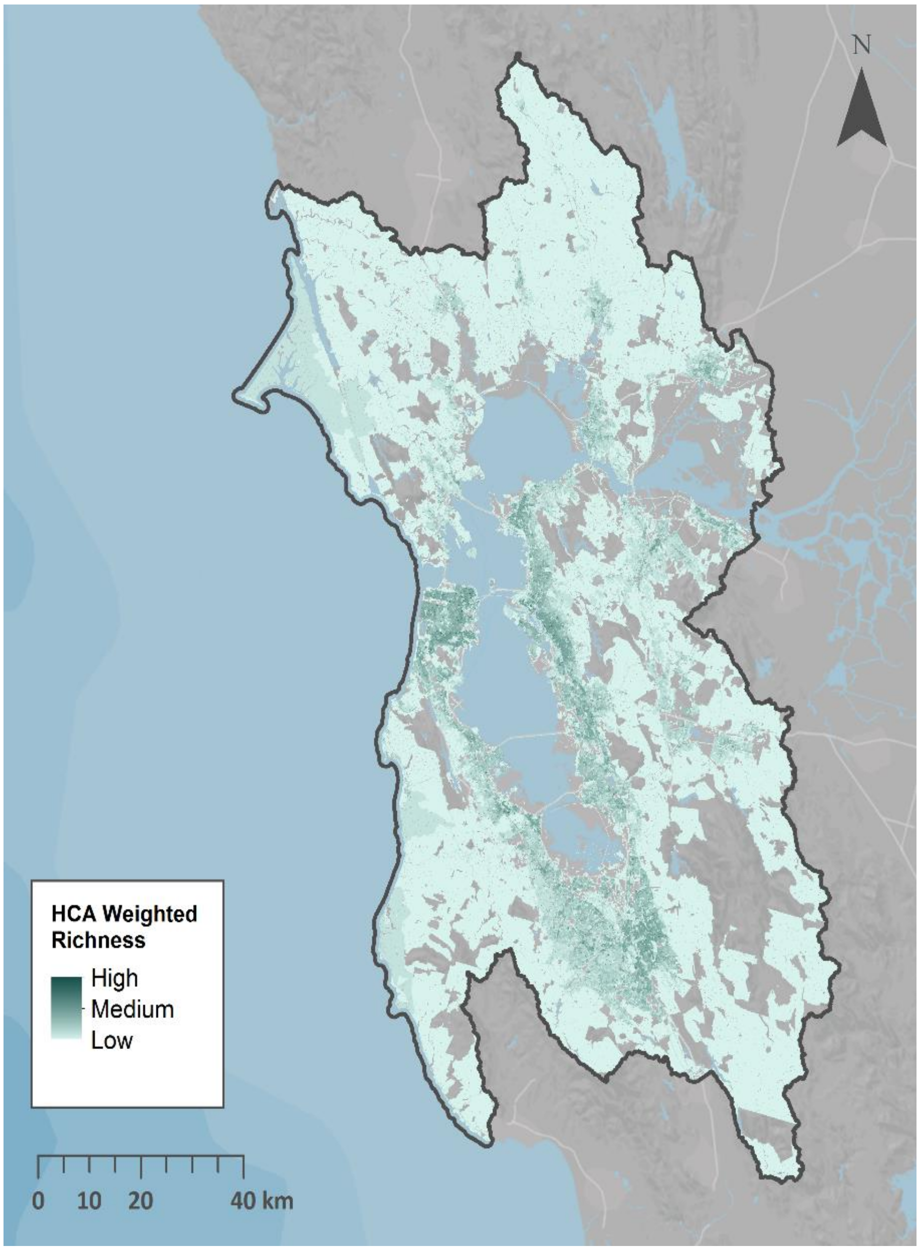


Figure 11. Human Community Asset (HCA) Weighted Richness Index for the San Francisco Bay and Outer Coast Watersheds. *Darker shades indicate higher value based on the number and importance weightings of HCAs in each location. Gray areas within the project boundary represent areas with no mapped HCAs.*

Community Vulnerability Index

This assessment evaluated the vulnerability of the HCAs to flooding threats. The score of any location in the index is based on the number of vulnerable HCAs at that location (**Figure 12**).

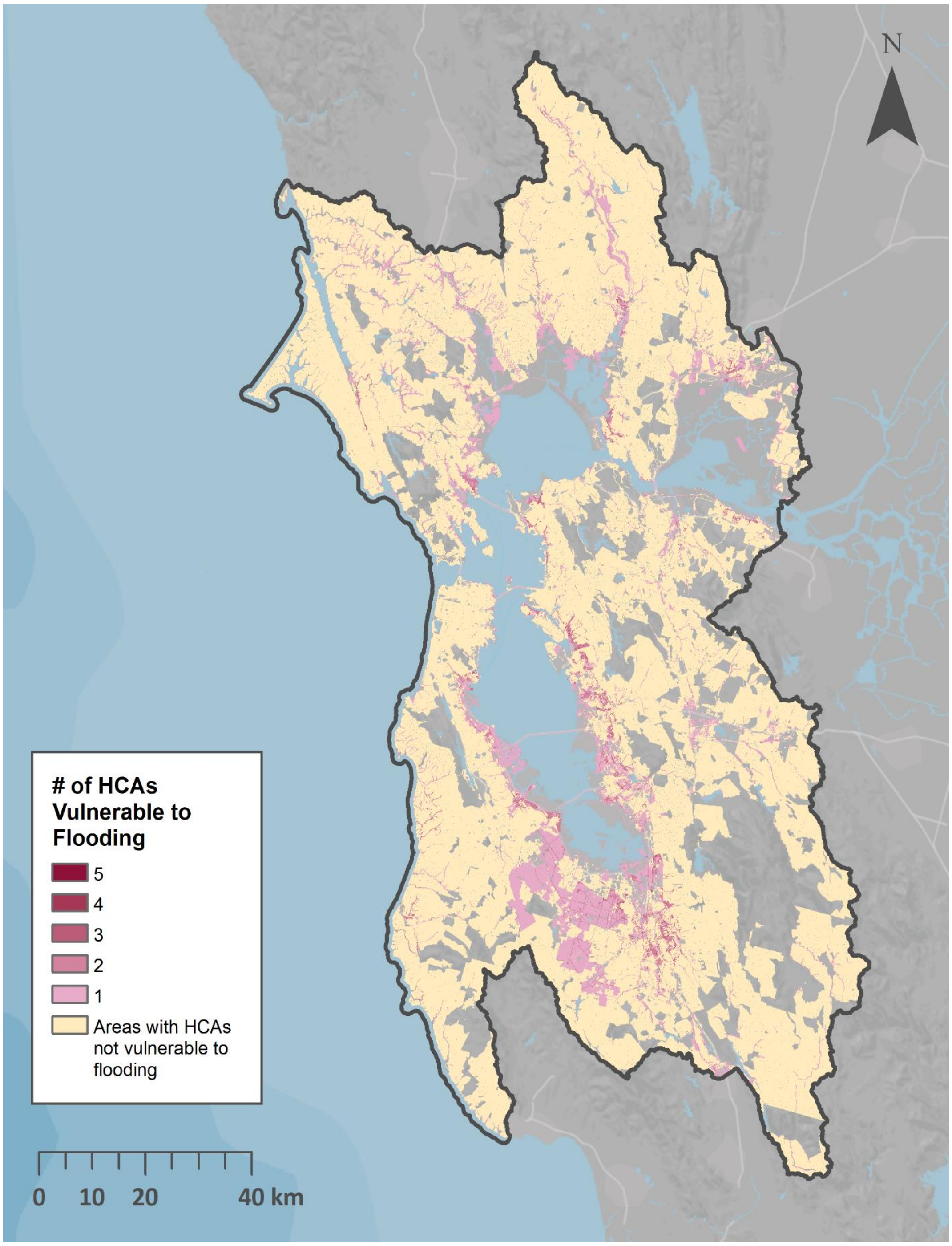


Figure 12. Community Vulnerability Index for the San Francisco Bay and Outer Coast Watersheds. *Pink to red shades indicate the number of Human Community Assets (HCAs) exposed to flooding related threats. Tan areas indicate areas of low to no impact from the flooding threats. Gray within the project boundary represents areas with no mapped HCAs.*

High vulnerability areas occur throughout the study area. Within the San Francisco Estuary, many of the highest threats occur in areas where former tidal habitats have been heavily developed. Notable examples of this type of high vulnerability include the southern Oakland shoreline, the area surrounding the Dumbarton Bridge in San Mateo, and Corte Madera. Comparatively, much of the outer coast has relatively low vulnerability due to a combination of higher elevations along the immediate shore, and lower population densities. However, moderate vulnerability is associated with many of the rivers south of Half Moon Bay, as well as low-lying areas within Point Reyes Station, Bolinas, and Linda Mar State Beach in Pacifica.

Suggested Uses

The HCA Weighted Richness Index can focus planning efforts by directing planners to the areas with concentrations of highest weighted assets or those most important to rebuilding or responding to threats. The Community Vulnerability Index communicates threat to human community assets wherever they occur as well as concentrated areas of threat. Therefore, it can support the intended objectives of siting and designing resilience projects to reduce threats to HCAs. It can also support coastal hazard/emergency management and land use planning to proactively address risks by understanding threatened assets, areas, and types of threats.

Fish and Wildlife Value Indices

Fish and wildlife indices are overlays or combinations of the fish and wildlife elements intended to express value based on where the elements are mapped.

Richness of Fish and Wildlife Elements

This index (**Figure 13**) represents the number of elements that overlap in any location. It conveys value through the concept that areas with more elements (darker green shades) will provide more opportunities for conserving/restoring fish and wildlife than areas with a low number of elements (lighter green shades).

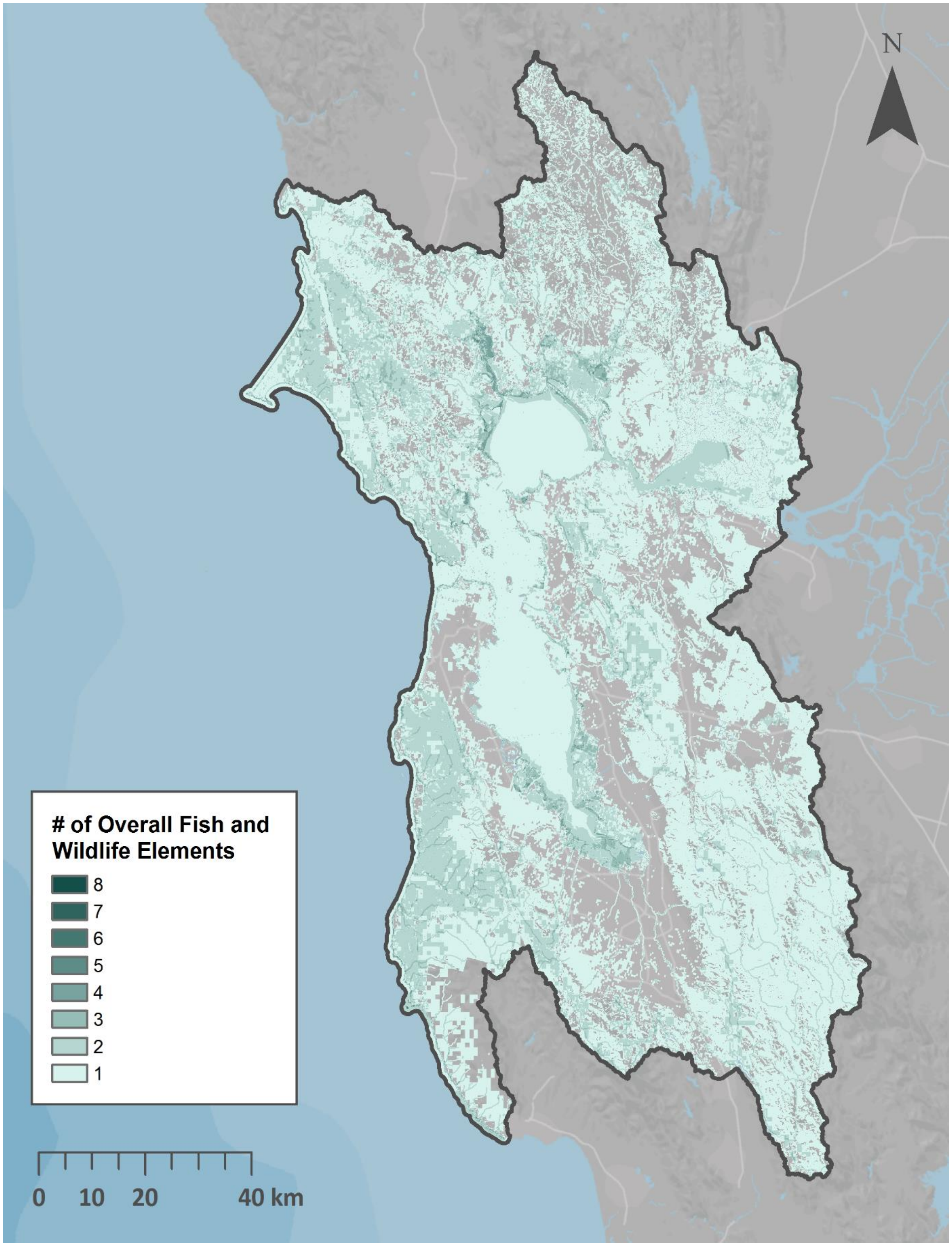


Figure 13. Richness of fish and wildlife elements in the San Francisco Bay and Outer Coast Watersheds. *Green shades indicate the number of elements found in a location. Gray areas within the project boundary have no mapped fish and wildlife elements considered in this assessment.*

Condition-weighted Richness of Fish and Wildlife Elements

The Fish and Wildlife Condition-weighted Richness Index (**Figure 14**) modifies the richness map above by incorporating the modeled condition of elements that overlap in any location. This analysis used a sum of the condition scores of all elements overlapping in a pixel. It conveys value through the concept that areas with more elements of higher condition are important to conserve, while areas with moderate scores may provide opportunities for restoration. Areas of low scores either have few elements or the elements present are in poor condition and therefore, may not represent the highest priorities for future projects with a goal of maximizing fish and wildlife benefits.

High condition-weighted richness areas are found in many of the existing and former tidal marshes throughout the San Francisco Estuary. These scores highlight the need to protect and enhance these existing marshes and restore former marshes. Additionally, high condition-weighted richness areas occur within much of the upper watersheds along the western edge of the study area. These areas overlap with low population densities and illustrate where protection efforts can achieve high-quality biodiversity protection.

Suggested Uses

The primary use of these indices, besides informing the scoring of Hubs and resilience project attributes, is to support fish and wildlife conservation decisions (subject to the limitation that these indices only apply to the elements selected for this assessment). Richness informs areas to target larger numbers of elements. Conversely, the condition-weighted index adds information as to whether a location is amenable to simple protection efforts because it is already in good condition, or if a location may benefit from restoration because its condition and/or function is impaired or less than pristine.

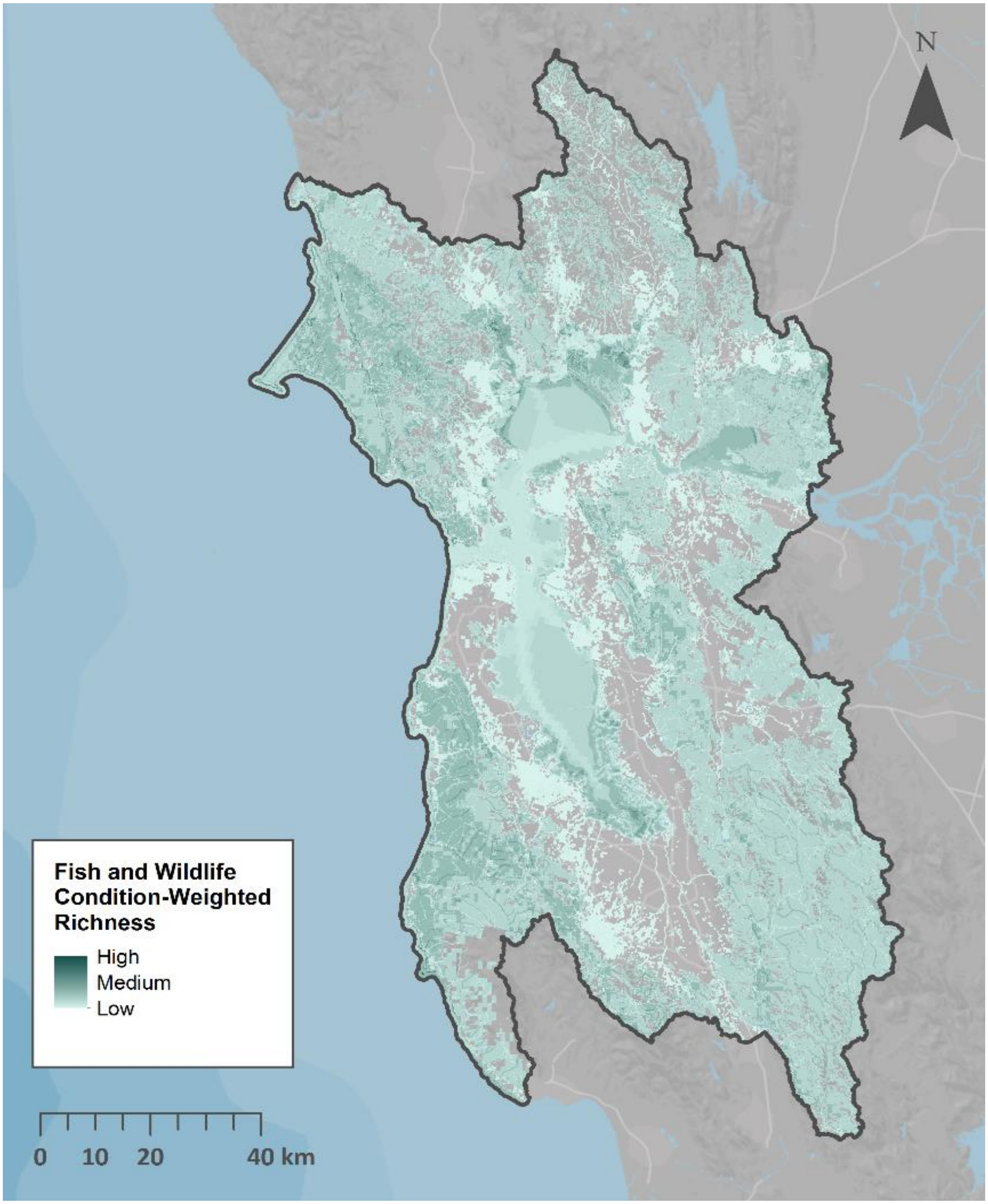


Figure 14. Fish and Wildlife Condition-weighted Richness Index results for the San Francisco Bay and Outer Coast Watersheds*. Green shades indicate the added condition scores of the elements found in a location, with a maximum value of one per element. Grey areas within the project boundary signify areas with no mapped fish and wildlife elements.*

Resilience Hubs

Resilience Hubs are areas of opportunity for conservation actions, such as resilience projects, that have the potential for providing mutual benefits for HCAs and fish and wildlife elements.

The Hubs incorporate community vulnerability and wildlife value, and therefore, they can be an important input to planning for more resilient land use, emergency management, and green infrastructure. As an integrative product, the Resilience Hubs also serve as a vehicle for collaborative planning and action among different agencies and/organizations. Such collaborative approaches can leverage multiple resources to achieve more objectives with significantly greater benefits than uncoordinated actions.

Resilience Hubs are based on undeveloped open spaces of protected or unprotected privately owned lands and waters (**Figure 15**) that are in proximity to concentrations of vulnerable HCAs. These open space areas were segmented into distinct Resilience Hubs based on the Regional Assessment (Dobson et al. 2019). For this Targeted Watershed Assessment, Hubs were further segmented into assessment units (100-acre areas) and scored (**Figure 16**) as explained in the Methods Overview. Scores convey value based on project objectives for siting resilience projects with mutual benefits for HCAs and fish and wildlife. Scoring the assessment units is important because value is not uniform across a Hub; it changes based on proximity to vulnerable HCAs and richness of fish and wildlife elements.

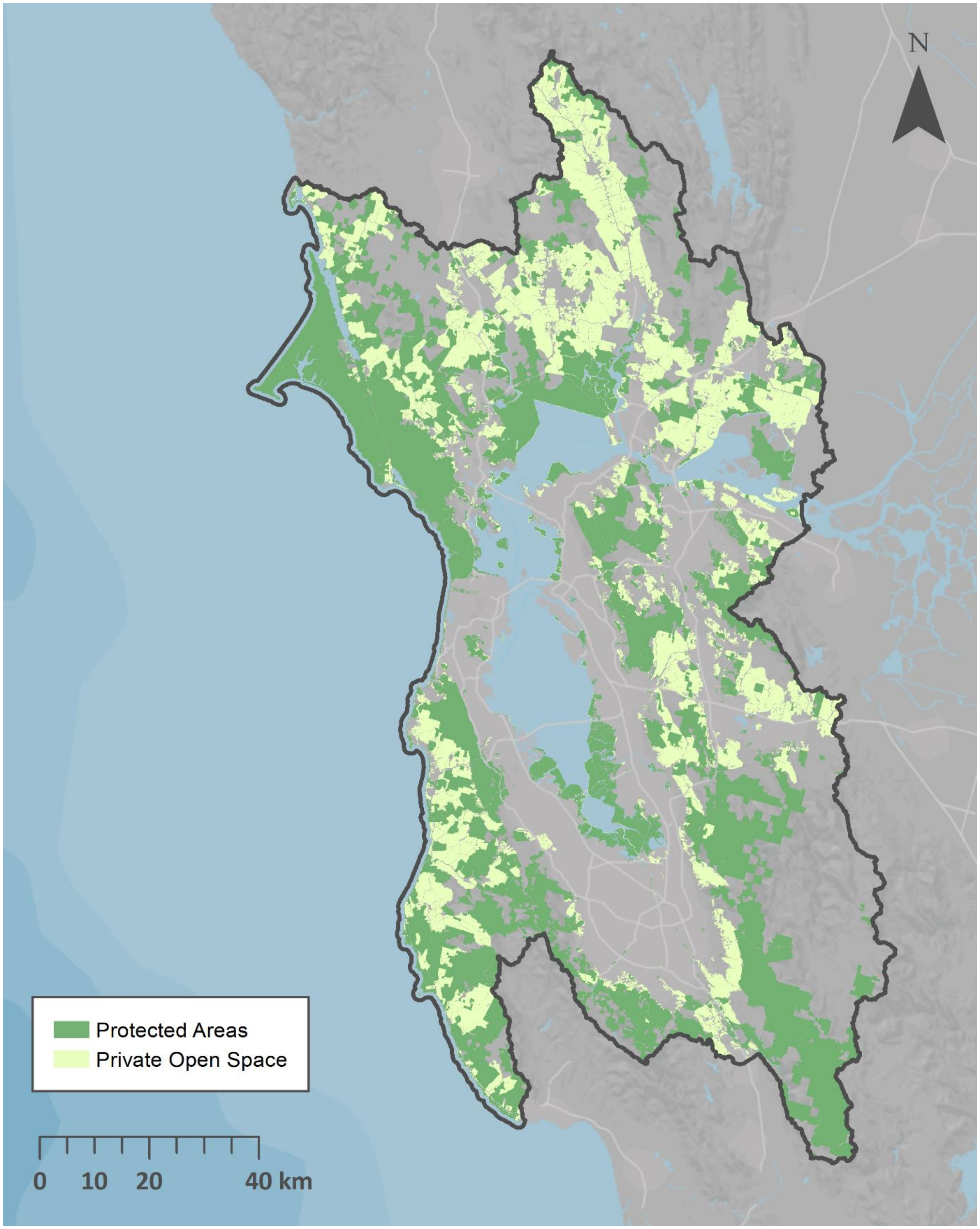


Figure 15. Undeveloped protected areas and unprotected privately owned areas of open space in the San Francisco Bay and Outer Coast Watersheds. *Map displays the distribution these areas within Resilience Hubs identified in the study area and therefore does not include all such areas within the study area.*

By design, Resilience Hubs occur where concentrations of vulnerable HCAs are proximate to open space areas. The size of a Hub does not equate to importance and instead is a factor of available open space near HCA concentrations (see **Figure 16** with assessment unit scoring). Identifying which portions of Hubs are already protected determines what actions may be most suitable. Expanding, restoring the condition of, or increasing connectivity between protected areas can increase resilience in these areas. Unprotected sites, if in good condition, may only need added protection to ensure long-term resilience benefits. In places where conditions are impaired, restoration is often the most appropriate path to increase resilience.

Resilience Hubs Assessment Unit Scores

The scoring of the assessment units of the Resilience Hubs, as described in the Methods Overview, was intended to convey the differing values for providing resilience and fish and wildlife benefits within the Hubs. In total, 29,690 assessment units were analyzed and scored within the San Francisco Bay and Outer Coast Watersheds. Highest scoring assessment units, in dark blue, are located nearest concentrations of vulnerable HCAs, whereas areas that have little benefit to human community resilience or benefit to fish and wildlife are in yellow (**Figure 16**).

The assessment found several areas with a large number of high-scoring Resilience Hubs. One of the largest, high-scoring Hubs is located in the upper watersheds in the east side of the Santa Cruz Mountains, centered on the Monte Bello Open Space Preserve. Several other high-scoring Hubs occur in existing and former bayland habitats throughout the San Francisco Estuary, including the Ravenswood pond complex in the South Bay Salt Ponds, Corte Madera Marsh, the Novato Baylands, and several pockets in the Napa and Sonoma county marshes. The analysis indicated that much of the outer coast shoreline was of medium to medium-high scoring Resilience Hubs. Two high-scoring areas of Resilience Hubs are featured below.

Suggested Uses

The Resilience Hubs map for the San Francisco Bay and Outer Coast Watersheds incorporate many of the key analyses described herein and therefore can inform many uses. The most direct use, as described in the project objectives, is to inform design and siting of, and investment in, resilience projects in areas where they can contribute to community resilience and benefit fish and wildlife. In addition to siting or evaluating the potential benefits of projects, decisions about what type of actions would be most appropriate given the community context, fish and wildlife present, and threats can be supported. This can be done by reviewing the scoring attributes found in the Hubs GIS map, and/or viewing the map in the context of other outputs such as the Community Vulnerability Index. While the scoring emphasizes areas providing mutual benefits, the individual inputs can assist users in identifying areas of value based on other objectives, such as focusing only on community resilience needs or areas that maximize fish and wildlife benefits.

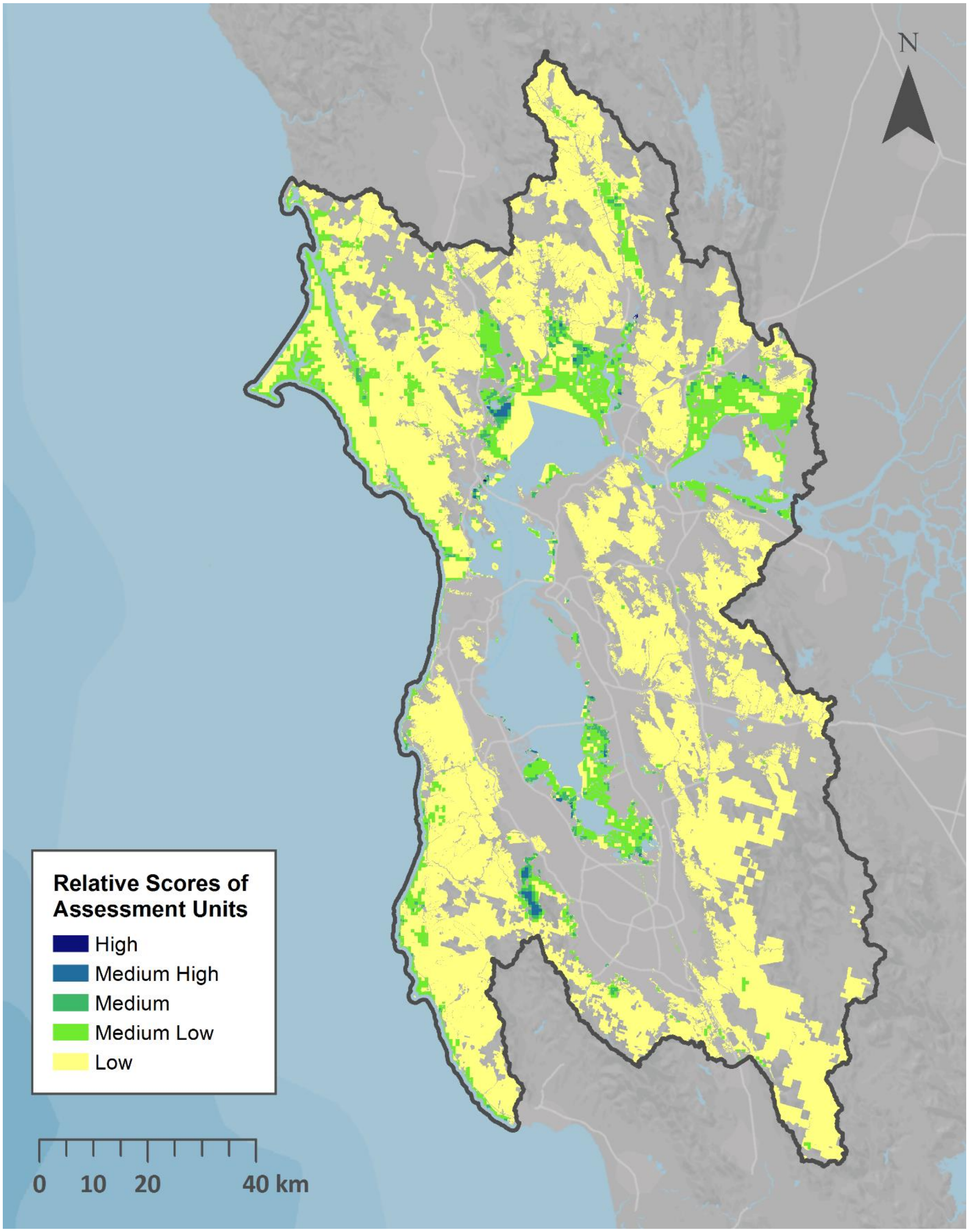


Figure 16. Resilience Hubs assessment unit relative scores for the San Francisco Bay and Outer Coast Watersheds. *Assessment units are 100-acre grids or smaller parcels. Darker shades have higher scores and thus greater potential to achieve both community resilience and fish and wildlife benefits. Gray areas are outside of Hubs.*

Resilience Hubs Example Areas

Two areas of the Resilience Hubs are characterized below to illustrate how the assessment identified potentially valuable places for resilience projects. Note that these results were provided to illustrate how the model scores a location and are not field validated. Additionally, they do not attempt to suggest specific actions that should be taken to increase resilience.

Novato Baylands Resilience Hub Area Example

The Novato Baylands encompasses the historical and existing bayland habitats south of Novato Creek and southeast of the city of Novato (**Figure 17**). Much of the acreage formerly covered by baylands prior to the 19th century have since been disconnected from the San Francisco Bay by levees for purposes of flood control and land reclamation. Following disconnection from the Bay, these former baylands were primarily used for agriculture and were never developed, providing a great opportunity for restoration. Restoration efforts will not only recreate high-value habitat for fish and wildlife, such as the endangered California Ridgway's rail and saltmarsh harvest mouse, but will also help reduce flooding risk for communities along Novato Creek by increasing tidal prism and thereby decreasing the deposition of sediment in the channel. The unit was ranked third out of 29,690 assessment units because it is adjacent to areas with very high human asset vulnerability, moderate fish and wildlife value, and high potential for restoration and future marsh migration.

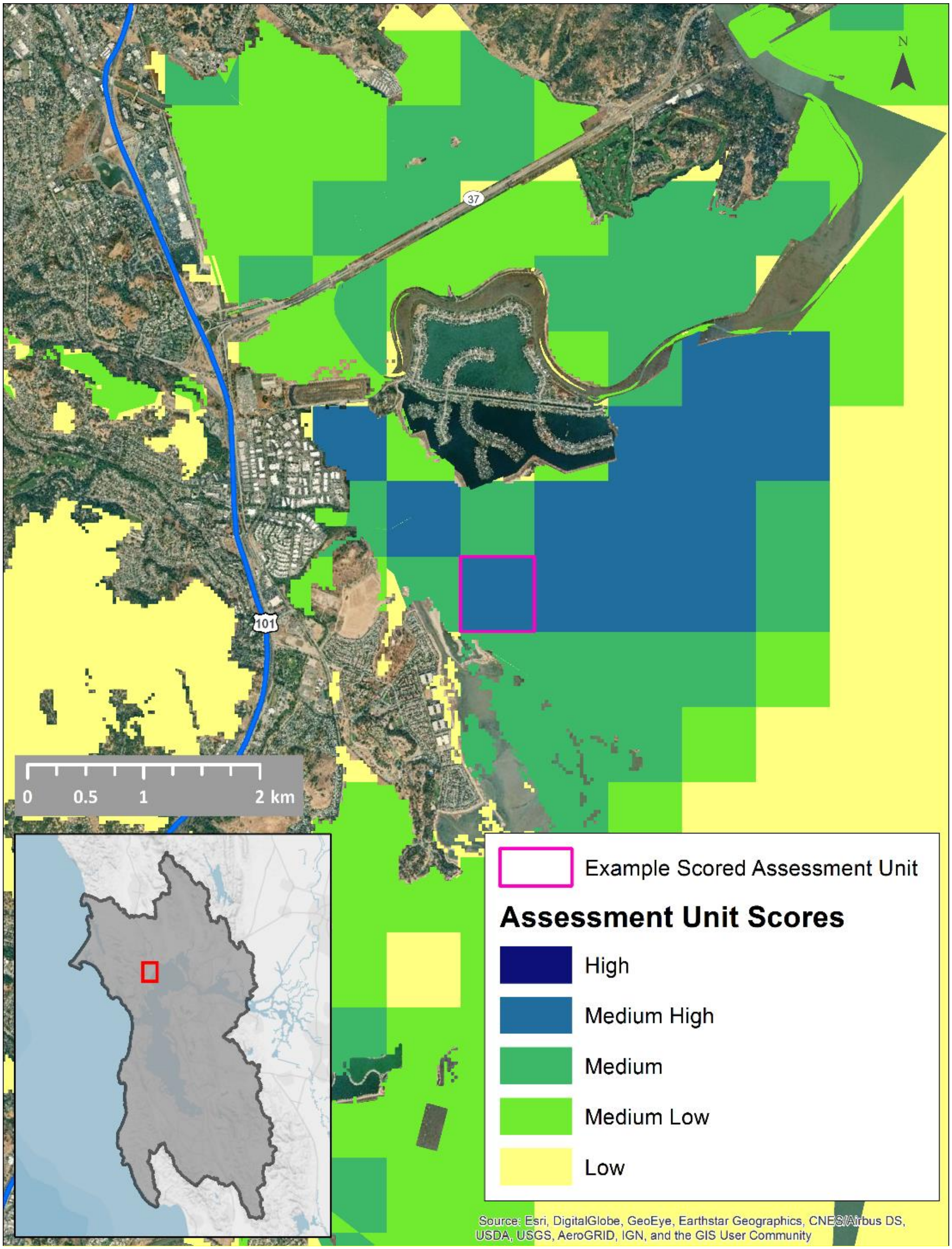


Figure 17. Novato Baylands Resilience Hub area example. *The yellow-blue shaded areas are the scored Resilience Hub assessment units. The hub assessment unit outlined in pink is the one used to characterize the values in this example.*

Elements in this assessment unit:

- Monarch butterfly
- Agricultural areas
- Depressional wetlands
- Snowy plover
- California Ridgway's rail

HCA elements in or near assessment unit:

- Critical Infrastructure Rank 1 (N Hamilton Pkwy, railroad)
- Population Density Ranks 1, 2, 3, 4 and 5.

Table 3. Attributes used to calculate the final score for the Novato Baylands Resilience Hub assessment unit example. *The values for each scoring attribute and the final score correspond to the hub assessment unit outlined in pink in **Figure 17**). See the Methods section for additional details on each scoring attribute.*

Description of Scoring Attributes	Score
Fish and wildlife richness (# of fish/wildlife elements out of 30 possible, max of all assessment units is 13)	5
Presence of modeled marsh migration	1 (yes)
Weighted Human asset vulnerability (normalized to 0-1, mean value of 0.02, standard deviation 0.06)	0.58 (moderately high)
Restorability index	1 (good candidate for restoration)
Average Condition (1= current very high condition)	0.41 (moderate)
Final score	**4.20 (rank #3 out of 29,690 units)**

South Bay Salt Ponds (Alviso complex A1 and A2W Ponds) Resilience Hub Area Example

The South Bay Salt Ponds Hub area is part of the Don Edwards National Fish and Wildlife Refuge located on the northwestern edge of the City of Mountain View in the South Bay (**Figure 18**). The Resilience Hub areas were former tidal marsh habitat that have since been converted to salt ponds. The salt ponds are currently managed to support shorebird and waterfowl habitat, but are planned to be restored to tidal marsh habitat as part of the South Bay Salt Pond Project—the largest wetland restoration project on the west coast of the United States. Just landward of the Resilience Hub is the Shoreline Amphitheater, a popular venue for major concerts, and Google's Googleplex corporate headquarters, emphasizing the high value human community assets in the region. The surrounding area includes multiple recreational opportunities including the Bay Trail, several athletic fields, and a golf course. The Hub area currently supports high richness of fish and wildlife elements (10 versus a maximum of 13 in the study area). Additionally, the site scored highly for restorability and marsh migration potential. The restoration plan for the site will ultimately result in high-quality tidal marsh habitat with high potential for marsh resilience in the face of sea level rise. The restoration plans also include innovative flood control designs that seek to achieve ecosystem benefits. Overall the site receives a moderate priority score.

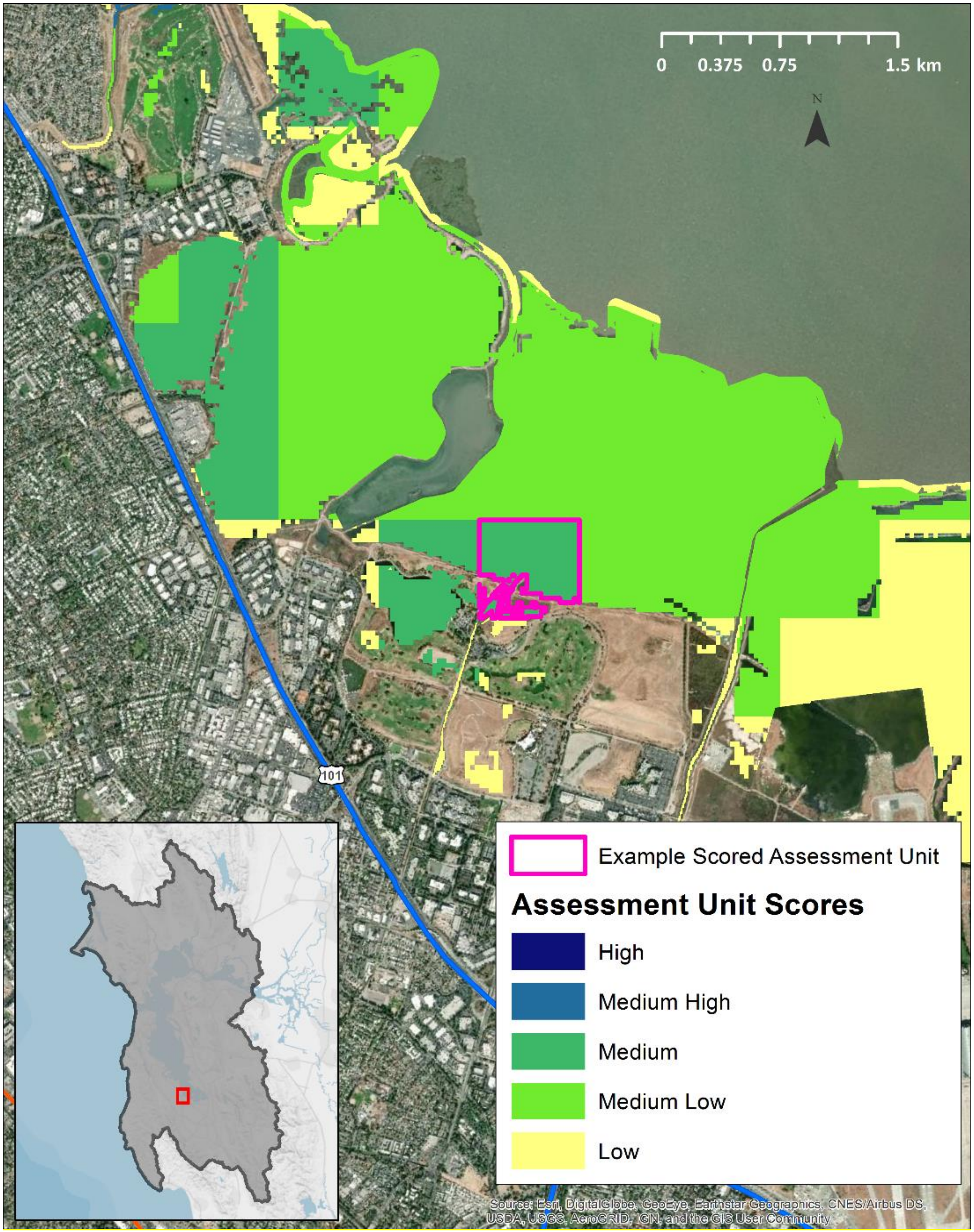


Figure 18. South Bay Salt Ponds Alviso A1 and A2W Resilience Hub area example. *The yellow-green shaded areas are the scored resilience hub assessment units. The hub assessment unit outlined in pink is the one used to characterize the values in this example.*

Elements in this assessment unit:

- Grasslands
- Monarch butterfly
- Tidal marsh
- Tidal flats
- Brown pelican
- Essential fish habitat
- Anadromous fish tributary habitat
- California ridgeway's rail
- Lagoon habitat
- Native oysters

HCA elements in or near assessment unit:

- Critical Infrastructure Rank 1 (Rengstorff House, U.S. National Historic Place)
- Population Density Rank 1

Table 4. Attributes used to calculate the final score for the South Bay Salt Ponds (Alviso complex, A1 and A2W Ponds) Resilience Hub assessment unit example. The values for each scoring attribute and the final score correspond to the hub assessment unit outlined in pink in **Figure 18**. See the Methods section for additional details on each scoring attribute.

Description of Scoring Attributes	Score
Fish and wildlife richness (# of fish/wildlife elements out of 30 possible, max of all assessment units is 13)	10
Presence of modeled marsh migration	1 (yes)
Weighted Human asset vulnerability (normalized to 0-1, mean value of 0.02, standard deviation 0.06)	0.003 (low in immediate area but high in surrounding area)
Restorability	1 (highly restorable)
Average Condition (1= current very high condition)	0.67 (moderately high)
Final Score	**2.28 (high, Rank #349 out of 29,690 units)**

Fish and Wildlife Elements

The final list of elements explicitly represented in the San Francisco Bay and Outer Coast Watersheds analysis is shown in **Table 5** with a brief description of each element's conservation significance, information about data sources used to represent their distributions, and data sources used. See Appendix 5 for a more detailed description of data sources that were and were not used in this assessment.

Table 5. Final list of elements used in the San Francisco Bay and Outer Coast Watersheds assessment.

Fish/Wildlife Element	*Description/Significance*
NOAA Trust Resources	
Pinniped haul-outs	Occur within the Estuary and along the nearshore outer coast for Steller sea lion, California sea lions, northern fur seals, northern elephant seals, and harbor seals. Only natural features such as tidal marsh and beach habitat were included (e.g., no piers or other infrastructure).
Essential Fish Habitat/important habitat for key fish species	Documents key game/commercial fish habitat in near coastal areas. EFH is identified for species managed in Fishery Management Plans under the Magnuson-Stevens Fishery Conservation and Management Act and includes habitat necessary for managed fish to complete their life cycle. This element includes EFH for groundfish (e.g., rockfish and flatfish) and coastal pelagic species (e.g., northern anchovy, Pacific sardine). EFH for salmonids will be incorporated in the data element for anadromous fish habitat.
At-Risk Species, Species of Special Interest, and Multi-species Aggregations *(Note that critical habitat for a number of at-risk fish species are represented by the "Anadromous fish tributary habitat" element in the category below this one)*	
Southern sea otter	The range-wide census is conducted to monitor trends in abundance of the southern sea otter, and thus provide State and Federal resource agencies with the information they need for effective management. Because the censuses represent uncorrected total counts (rather than sample-based surveys), they cannot be considered as accurate estimates of true population abundance. Instead, these data represent a valuable time-series of index counts and provide the means of assessing spatial and temporal trends in relative abundance. Darker colors represent higher density counts within predetermined survey sections.
California Ridgway's rail	This federally endangered species is limited to tidal marsh habitat within San Francisco Bay. This species is valued for its iconic status and its presence and abundance is indicative of healthy tidal marsh habitat.
Snowy plover	Is a federally threatened species under the Endangered Species Act. Primarily found nesting on coastal beaches, a subset of the population nests in San Francisco Bay. Within San Francisco Bay, plovers use dry pond bottoms, isolated islands, and levees in managed ponds as well as active salt ponds for nesting.
Brown pelican	Is an iconic San Francisco Bay species that is most common around the central and northern Bay. Brown pelicans plunge-dive into deeper waters to feed on small fish.
Monarch butterfly	Is an iconic species that roosts in large numbers during the winter often in areas where the public can view them. Monarch's also breed in areas surrounding the San Francisco Estuary and inland.

Fish/Wildlife Element	*Description/Significance*
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species	
Tidal marsh	This element includes marshes spanning the gradient from saline to brackish. Bird species include Ridgway's rail, black rail, three tidal marsh song sparrow subspecies, saltmarsh common yellowthroat, virginia rail, marsh wren, short-eared owl, Northern harrier, yellow rail, dabbling ducks and shorebirds. Mammals include salt marsh harvest mouse, salt-marsh wandering shrew, Suisun shrew, and San Pablo vole.
Tidal wetland-upland transition zone/ecotone	This ecosystem provides essential refuge during high tides and storms for sensitive marsh species such as Ridgway's rail, black rail, and salt marsh harvest mouse. This zone can also provide accommodation space for landward marsh migration as sea levels rise.
Tidal flats	This ecosystem includes tidal marsh pannes and channels. This habitat provides essential foraging habitat for over a million shorebirds during migration and overwintering including large shorebirds (e.g., American avocet, black-necked stilts, long-billed curlew, willet, and marbled godwit), medium shorebirds (e.g., black-bellied plover, short- and long-billed dowitchers) and small shorebirds (e.g., dunlin, western sandpiper, and least sandpiper).
Rocky intertidal and offshore rocks	Includes rocky substrate found between high and low tide water levels typically subject to frequent wave action. The habitat supports a diversity of marine invertebrates (e.g., barnacles, mussels, sea urchins), fish species such as rockfish, Cabazon, and small surfperches, as well as breeding habitat for pinnipeds. It also provides foraging opportunities for waterbirds including great blue herons, great egret, black-crowned night-herons, and wintering shorebirds such as black oystercatchers and spotted sandpipers.
Native oysters	Are important because they are both an iconic feature of the watershed and important habitat. This feature also can harbor habitat for other key fish species, especially as nursery habitat. Data for native oysters only for SF Bay.
Sand and gravel beach	Includes open sand and gravel coastal expanses that provide habitat for a large set of high priority wildlife species such as northern elephant seal, California sea lion, and snowy plover.
Lagoon habitat	Consists of impoundments of water subject to at least occasional or sporadic connection or muted tidal action. They can receive tidal action seasonally and be either vegetated or non-vegetated. Natural lagoons occur due to barrier beaches or dunes whereas unnatural features are modified with levees and tide gates. For the most part, lagoons in the San Francisco Bay Watershed Project Area are perennial and unnatural. Lagoon habitats are important for waterbirds including dabbling ducks (wigeon, gadwall, green-winged teal, mallard, northern pintail, and northern shoveler), and diving ducks (bufflehead, canvasback, common goldeneye, ruddy duck, lesser scaup, greater scaup).
Anadromous fish tributary habitat	Includes freshwater stream spawning grounds and estuarine nursery habitats. The fish species represented in this layer includes salmonids (e.g., Coho, Chinook, Steelhead).

Fish/Wildlife Element	*Description/Significance*
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species	
Colonial seabird nesting sites	Comprises nesting colonies for common murre and other seabird species, double-crested cormorant, least tern, and caspian tern. This layer does not include man-made structures such as bridges and transmission lines that are used for nesting but does include levees, salt ponds, and other modified habitats.
Heron and egret rookeries	Are vital nesting areas for great blue herons, great egrets and snowy egrets who are associated with tidal and non-tidal wetland habitats.
Eelgrass beds	Is a marine aquatic plant that grows in sheltered waters on soft-bottom substrate in lower intertidal and subtidal areas. Eelgrass beds are highly productive, important for Pacific herring and as nursery grounds for many coastal fish species, and foraging habitat for bird species such as surf scoter, greater and lesser scaup, western grebe, Clark's grebe and double-crested cormorants.
Near-shore kelp habitat	Occurs primarily in rocky nearshore environments between 4 - 25 meters (13 ft – 82 ft) in depth and is characterized by species of *Nereocystis*. The habitat supports fish species such as black rockfish, and food sources for a variety of seabirds (e.g., cormorants (Brandt's, Pelagic, and double-crested) Pacific and common loons, western and Clark's grebes) and pinnipeds.
Depressional wetlands	Includes perennial and seasonal depressional wetlands that are not strongly alkaline or saline. This class can include both natural and managed wetlands. These non-tidal wetlands are important habitat for dabbling ducks, herons, and egrets, as well as California red-legged frog, and San Francisco garter snake.
Vernal pools and vernal pool complexes	Seasonal depressional wetland having bedrock or an impervious soil horizon close to the surface and supporting a unique vernal pool flora. Vernal pools provide essential habitat for conservancy shrimp, tadpole shrimp, and California tiger salamander and numerous listed plant species.
Large riparian areas	Are the transitional ecotone between the aquatic zone of freshwater streams and upland areas. They support herbaceous wetland and woody vegetation and are hydrologically connected to the stream through episodic surface flooding or via groundwater. They are highly productive, provide habitat for a breadth of both terrestrial and semi-aquatic species, and support the functioning of the adjacent aquatic zone (e.g., shading and input of large woody debris). Species supported by this habitat element include amphibians such as California red-legged frog, mammals such as beaver and river otter, and bird species such as belted kingfisher, black phoebe, yellow warbler, black-headed grosbeak, Wilson's warbler, common yellowthroat, warbling vireo, tree swallow, and song sparrow.
Lake and pond lacustrine wetlands (and the associated aquatic vegetation bordering these features)	These are typically fresh or brackish and able to support vegetation. Saline or alkaline ponds are included separately under the Playa data element. Species supported by lake and pond habitat include ducks, shorebirds, herons, egrets, and grebes. This habitat also supports Northwestern pond turtle.

Fish/Wildlife Element	*Description/Significance*
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species	
Playas	Are nearly level, shallow, ephemeral (seasonal) or perennial, saline water bodies with very fine-grain sediments of clays and silts. Unlike vernal pools, playas have little or no vascular vegetation within the limits of the water body, though they support sparse peripheral vegetation. Playas can consist of open water, associated vegetation and unvegetated areas without standing water. These features can be either natural or human modified. Unlike the "lake and pond" element, playas are less than 6 ft deep during the dry season, although they can be hundreds of acres in size. Birds associated with playas include dabbling ducks, shorebirds (breeding, overwintering and migrating), California gulls, and nesting snowy plovers and least terns, and eared grebes.
Grasslands	Supports numerous bird species including white-tailed kite, Northern harrier, burrowing owl, loggerhead shrike, grasshopper sparrow, savannah sparrow, and western meadowlark and mammals such as ground squirrels, badgers, coyotes, Alameda Island mole, Angel Island mole, and San Joaquin pocket mouse.
Redwood/Douglas Fir forest	Supports bird species such as marbled murrelet, northern spotted owl, sharp-shinned hawk, olive-sided flycatcher, brown creeper, varied thrush, Steller's jay, and pileated woodpecker and mammals such as gray squirrel, Point Reyes mountain beaver, San Francisco dusky-footed woodrat, bobcat. The creeks within this habitat type are important for anadromous fish.
Oak woodland	Supports species such as acorn woodpecker, California scrub-jay, oak titmouse, western bluebird, lesser goldfinch, and lark sparrow. This habitat also supports mountain lion.
Coastal scrub/chaparral	Supports bird species such as California quail, wrentit, California thrasher, California scrub-jay, blue-gray gnatcatcher, Bewick's wren, California towhee, white-crowned sparrow, and mammals such as brush rabbit and bobcat.
Agricultural habitat (including rice, alfalfa)	Portions that have foraging and nesting habitat value for raptors (e.g., Swainson's hawk).
Cross-cutting Elements	
Bird Diversity Hotspots	Includes areas with high bird species diversity regardless of habitat type. These areas can also be important recreational and iconic areas.

Resilience Projects Portfolio

A portfolio of resilience projects within the San Francisco Bay and Outer Coast Watersheds was compiled from plans and other project documents submitted by stakeholders (**Table 6**). A total of 92 projects were submitted for this watershed. Beyond a review of project documents, projects were further evaluated using several data layers created in the GIS assessments. Through the process of reviewing resilience projects, visiting sites, and meeting with key stakeholders in the region about resilience project ideas, several themes emerged.

1. Given the significant risk posed by climate threats in this watershed and the scope for increasing resilience revealed in this assessment, increasing efforts and resources to develop and execute resilience-related projects would almost certainly result in future returns in the face of increasing risks.
2. There is great interest in reconnecting the hydrology of former intertidal wetland areas to increase the resilience of these habitats and adjacent coastal communities by restoring processes that make the shorelines self-sustaining as sea levels rise.

Table 6. Summary of resilience-related projects identified for the San Francisco Bay and Outer Coast Watersheds study. *Table shows the implementation stage at the time of compilation.*

	Project Phase			
Project Type	**Conceptual**	**Planning Complete**	**Ready to Implement**	**Total**
Acquisition			4	4
Beach or dune restoration	2		1	3
Community resilience planning	3	2	2	7
Fish passage	3	1	1	5
Invasive species removal			1	1
Natural infrastructure	2	1	1	4
Recreation	1	1		2
Riparian/river restoration	3	1	23	27
Sub-tidal habitat restoration	4			4
Tidal marsh restoration	18	4	6	28
Tidal marsh transition zone restoration	1		6	7
Totals	**37**	**10**	**45**	**92**

As can be seen in **Figure 19**, the submitted resilience projects are primarily clustered within the San Francisco Estuary with relatively few projects submitted from the outer coast. Within the Estuary there is a fairly even distribution of projects, with the exception of the central western shore of the

San Francisco Bay, where no projects were submitted. All of the projects within the San Francisco Bay Joint Venture's Project Tracker database[6] as of February 2018 that were classified as 'planned' or 'in progress' were included as potential resilience projects. In addition, the stakeholder engagement process attracted project ideas from a wide range of local stakeholders, including NGO staff and federal, state, and local agencies.

The submitted resilience projects included a wide range of objectives. Tidal marsh and riparian restoration projects were the most common among submitted projects, and tended to have both habitat restoration and flood risk management objectives. Community resilience planning and tidal marsh/upland transition zone restoration were also common among the submitted projects.

[6] https://ecoatlas.org/regions/ecoregion/bay-delta/projects

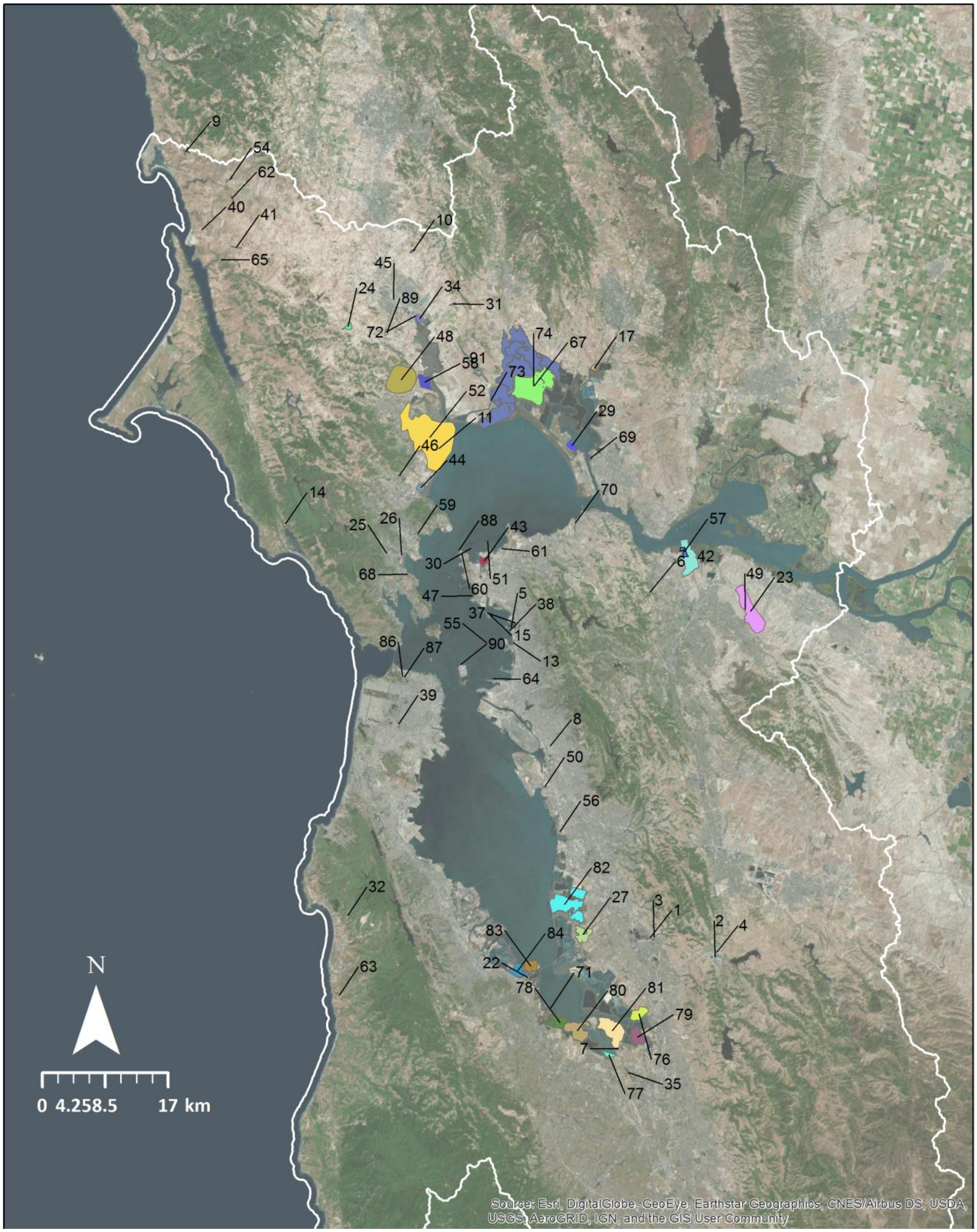


Figure 19. Map showing the location and/or boundaries of resilience projects compiled for the San Francisco Bay and Outer Coast Watersheds study area. *Note that key to project numbers and names is provided on following page. See Appendix 6,* ***Table A6-1*** *for a full list of projects.*

Figure 19 (continued). Key to project numbers presented in map on previous page.

Suggested Uses

The resilience projects database (Appendix 6) provides the names, project boundaries, and summary information about projects that were identified by stakeholders as those that could potentially increase human community resilience and/or enhance fish and wildlife habitat. These project could potentially be implemented rapidly to recover from a flooding event, a high intensity tropical storm, or proactively improve resilience before the next major event.

Case Studies

The three case studies that follow illustrate how proposed resilience projects may benefit fish and wildlife habitat and human communities faced with coastal resilience challenges. In particular, these project may help mitigate challenges related to heavy rainfall events and storm surge that have the potential to negatively affect transportation infrastructure, such as culverts and bridges. The three featured case studies illustrate:

- Restoration efforts can be designed to improve coastal resilience when fish and wildlife resilience and human resilience are integrated from the beginning.
- Each of the projects has the potential to reduce flooding and/or storm surge effects to adjacent human assets such as homes, schools, hospitals, and places of business.

The three case studies are good examples of the types of projects proposed in the watershed that could potentially benefit both human assets and fish and wildlife populations facing increasing coastal threats.

Case Study 1: South Bay Salt Ponds: Southern Eden Landing

Figure CS1-1*. *Example of a managed pond at the Eden Landing Ecological Reserve. *The project aims to restore the area's tidal marsh habitat, which is adjacent to human communities, businesses, and infrastructure.*

Project Overview

Location: Eden Landing Ecological Reserve

Date Visited: February 6, 2019

Contact: John Krause, Environmental Scientist for the California Department of Fish and Wildlife

The South Bay Salt Pond Restoration Project is the largest wetland restoration project on the west coast of the United States. The project is focused on restoring tidal marsh habitat, reconfiguring managed pond habitat, maintaining or improving flood risk management, and providing recreation and public access opportunities. The Eden Landing complex is one of three complexes that make up the South Bay Salt Pond Restoration Project. Eden Landing represents a mosaic of mature tidal marsh, tidal marsh in the process of restoration, and a series of 11 former salt ponds that are currently managed by the California Department of Fish and Wildlife (CDFW) for shorebird and water fowl habitat.

A significant portion of the Eden Landing Ecological Reserve has already been restored. The Southern Eden Landing project described here aims to build on this success by restoring approximately 2,270 acres of former salt ponds to tidal marsh through levee breaches. In addition to breaching several levees, the project will also develop new, gently sloping levees to maintain or improve flood risk management, and will install water control structures for managed pond and fish habitat connectivity. The project will include the creation of habitat islands to increase bird-nesting success, upland transition zone habitat to provide high-water refugia for marsh species, and the creation of deep-water channels to improve habitat quality for juvenile fishes. The project will also seek to provide wildlife-oriented public access and recreational opportunities, including the completion of a new portion of the Bay Trail. The project has just completed a final environmental impact statement and environmental impact report.

In summary, the project will:

- Restore at least 2,270 acres of former industrial salt ponds to tidal marsh by breaching levees.
- Enhance the habitat of remaining ponds to maximize the quality of habitat for shorebirds and waterfowl.
- Construct new and/or enhance existing flood control structures to create gently sloping tidal marsh-upland transition zone habitat. These structures in combination with the wave attenuation provided by the restored marshes will increase resilience for the expansive human community assets adjacent to the project site.

Figure CS1-2. Overview of the Southern Eden Landing project. *The former salt pond boundaries are outlined in red. The inset map shows the project location in relation to the watershed boundary.*

Estimated Cost of the Project

The initial estimate for the total project cost is $35 million, with at least $10 million still needed to complete planning and implementation.

Stressors and Threats

The project would address numerous threats to human community resilience primarily related to both private and public property damage or loss due to bay and fluvial flooding caused by sea level rise and storms. The human community assets that are vulnerable were primarily developed on historic intertidal habitat that has since subsided, exacerbating flooding risks **(Table CS1-1)**. Fish and wildlife stressors primarily are related to the human development that surrounds the project **(Table CS1-1)**. This development also constrains the ability of native habitats and species to migrate landward as sea levels rise.

Table CS1-1. Stressors and flooding threats identified in and near the project site.

Existing Stressors
Developed Open Spaces
High/Medium Density Housing
Low Density Housing (Rural Residential)
Flooding Threats
Storm Surge – Annual, 20-year, 100-year
Sea Level Rise
Frequent Flooded Soils
100-Year Floodplain
Erodibility Moderate
Erodibility Very High
Subsidence Very Low
Flat, Somewhat Poorly Drained
Flat, Poor or Very Poorly Drained

Human Community Assets

The project is adjacent to a significant number of human community assets. A mix of suburban and urban communities in Union City are immediately adjacent to, and within the flood hazard zone of, the project site **(Figure CS1-3)**. In addition, the project site is bounded by the Union Sanitary District Treatment Plant, a county-owned landfill, a privately-owned salt pond, and detention basins and drainage channels owned by Alameda County. Other community assets that are near include several schools, major roads, rail line and community center **(Table CS1-2)**. Adjacent human communities and infrastructure were largely developed on former intertidal wetland habitats and thus are reliant on aging flood control structures that were designed without consideration of future sea level rise threats. Within Union City, approximately 30,000 residents (40% of the city's total population) and 7,800 employees could be exposed to flood hazards with two meters of sea level rise and a 100-year storm[7]. The USGS estimates that the projected flood hazard would put approximately $3.1 billion in property value at risk based on 2010 property tax assessments[7].

[7] https://www.usgs.gov/apps/hera

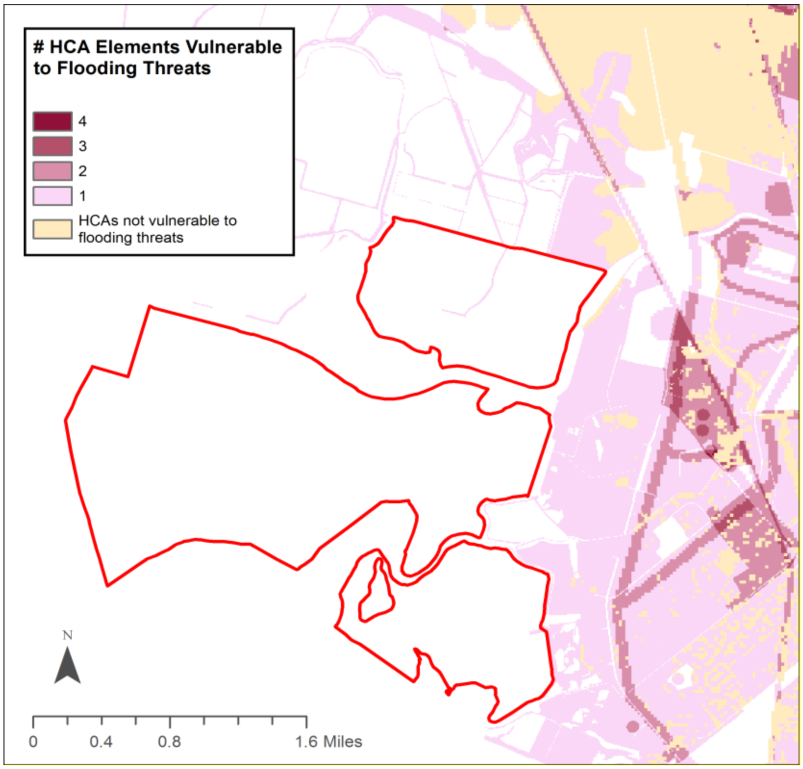


Figure CS1-3. Human Community Asset (HCA) elements vulnerable to flooding threats. *Darker pink/red shades signifies concentrations of vulnerable HCA elements. Tan color indicates areas with HCAs that are not categorized as vulnerable for the purposes of this assessment. Note that, although there are no vulnerable HCAs within the project footprint itself, there are highly vulnerable HCAs just outside of the project footprint that could benefit from this project.*

Table CS1-2. Human Community Assets identified within or near the project boundary.

Categories of Human Assets Identified within Project Boundary
High to low density populated areas in Union City Critical Infrastructure Critical Facilities Environmental Justice areas
Mapped Community/Human Assets within Project Boundary
Old Alvarado, California Union City Boulevard, Dyer St, Alvarado Blvd, and rail line Alvarado Elementary School Itliong-Vera Cruz Middle School Holly Community Center

Fish and Wildlife

Within the project footprint and adjacent areas, there is a high diversity of fish and wildlife species that would benefit from the implementation of the proposed project (**Table CS1-3** and **Figure CS1-4**). The project aims to restore up to 2,270 acres of tidal marsh habitat important to many salt-marsh dependent species including Ridgway's rail, black rail, and salt marsh harvest mouse. The project also provides important aquatic habitat connectivity for longfin smelt and steelhead. Some of the former salt ponds will continue to be managed for shorebirds, such as Western sandpiper, dunlin, American avocets, and black-necked stilts.

Table CS1-3. Fish and wildlife habitats and example species for each habitat that potentially occur in the project area.*

Fish/Wildlife Habitat *	Species of Interest to Stakeholders that may be Represented by these Habitat Types **
Grasslands	Northern harrier, monarch Butterfly
Playas	Western snowy plover, least terns
Depressional wetlands	Gadwall, northern shoveler, great blue heron
Tidal marsh	Ridgway's rail, black rail, salt marsh harvest mouse
Tidal flats	American avocet, black-necked stilts
Essential fish habitat	Anchovy, starry flounder
Anadromous fish habitat	Steelhead
Heron and egret rookeries / tidal hardwood swamp forest	Great blue heron

**Based on modeled data (some of these habitats may not actually exist in the project boundary area or may be potential habitat if the habitat were improved or historic occurrences)*
*** Not meant to be an exhaustive list of all species that benefit from this habitat, but instead contains some example species that are likely represented by this layer of information and identified by stakeholders as priority species in the watershed.*

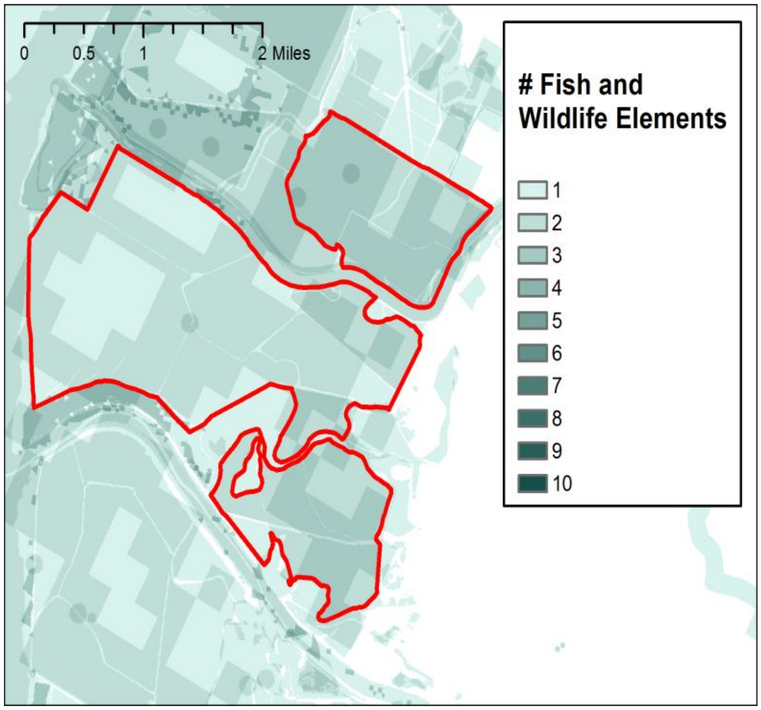


Figure CS1-4. Density of fish and wildlife elements in project area. *Map of all fish and wildlife elements combined (darker green signifies more elements/value). Red outline is the project boundary.*

Expected Project Impact

The project will not only restore a substantial amount of tidal marsh habitat, but will also enhance habitat for mudflat and aquatic species. If implemented, it will also provide connectivity between the restored habitat and mature habitats adjacent to the project site (**Figure CS1-5**).

Figure CS1-5. Whale's Tail Marsh, part of the Eden Landing Ecological Reserve, as seen from the existing levee that separates the Southern Eden Landing project from the mature marsh habitat and bay hydrology. *This levee would be breached as part of the project to restore tidal and habitat connectivity.*

In addition, the project will maintain or enhance flood control risk management within the Eden Landing complex. New gently sloping levees will be constructed with a design meant to be resilient to sea level rise and provide transition zone habitat and high tide refugia for marsh species. As the restored marshes mature, the increased elevation and vegetation structure will help attenuate waves thus providing erosion control and overtopping benefits to project levees. The project will also expand public access and recreation opportunities, including hiking, biking, fishing, and hunting.

Case Study 2: Lower Walnut Creek Restoration

Figure CS2-1*. *Lower Walnut Creek Restoration Project from the north end of the project boundary and edge of Pacheco Marsh looking south up the Lower Walnut Creek Watershed. *Also visible are the Tesoro Golden Eagle Refinery (center left of the photo) and the Acme Landfill (central right of the photo) that are adjacent to the project boundaries. The project will create a mix of restored tidal marsh and public access trails throughout the land in the foreground.*

Project Overview

Location: Lowest four miles of Walnut Creek and Pacheco Creek

Date Visited: February 6, 2019

Contact: Paul Detjens, Senior Civil Engineer, Contra Costa County Flood Control and Water Conservation District.

The primary goal of the Lower Walnut Creek Restoration project is to restore wetland and associated habitats in the Lower Walnut Creek and to provide sustainable flood management. The channel along the lower portions of the creek will be widened to increase floodwater capacity and to create floodplains. The newly constructed levees will be gently sloping, providing additional habitat for species, particularly during high flow events. The project will also reconnect the hydrology to former wetland habitats, particularly Pacheco Marsh, thus providing continuous marsh connectivity between Peyton Marsh, Pacheco Marsh, and the Point Edith Marsh.

The existing channel and associated flood control structures were designed to follow Army Corps of Engineer standards. However, the original design underestimated the amount of sediment that would be deposited in the creek, requiring the Contra Costa Flood Control District to repeatedly fund costly channel dredging. Additionally, frequent channel dredging is challenging because sensitive wildlife habitat and species frequently re-establish themselves creating significant regulatory hurdles to future channel dredging. In 2014, President Obama “deauthorized” the channel so that the local flood control district could design, implement, and manage a new flood control channel.

In summary, the project will:

- Restore wetland habitats for fish and wildlife along 2.5 miles of the lower Walnut Creek and 1.5 miles of Pacheco Creek.
- Maintain or improve existing levels of flood protection for adjacent private property by designing a system that works with natural processes to reduce or eliminate maintenance costs and that is resilient to future sea level rise.
- Provide public access, education, and recreational opportunities.

Figure CS2-2*. *Wetland areas that are disconnected hydrologically from tidal waters by levees and flood gates. *The Acme Landfill (elevated green area, left center) and the Union Pacific Railroad (railroad passes between the utility poles, right center) are adjacent to these wetlands.*

Figure CS2-3. Aerial view of the study area. *Project boundary is outlined in red. Pacheco Creek (south west corner of project boundary) drains into Walnut Creek which then drains into Suisun Bay. The Point Edith Wildlife Area marsh is located to the east of the project boundary along the shoreline. .Bullhead Marsh abuts the project on the western shoreline.*

Estimated Cost of the Project

The total cost of the project is approximately $14 million. The County Flood Control District currently has $7-8 million solicited in proposals that are likely to be funded. The project proponents estimate that they still need an additional $1-2 million to complete the project.

Stressors and Threats

The main threat to the surrounding community is that the existing channel and associated flood control structures were intended to provide protection from 100-year flood events **(Table CS2-1)**. However, because of higher than anticipated rates of sedimentation, existing flood control structures can only meet 100-year flood protection if the channel is repeatedly dredged. The dredging is too costly for the local flood control district to maintain indefinitely and the sedimentation has created habitat for special status species that would be destroyed through dredging operations. There are several large industrial facilities and related transporation infrastructure adjacent to the project that may contribute to low water quality and constrain the restoration and enhancement of native habitat **(Table CS2-1)**.

Table CS2-1. Threats identified in and near the project site.

Existing Stressors
Developed Open Spaces
High/Medium Density Housing
Low Density Housing (Rural Residential)
Commercial & Industrial Areas (incl. Airports)
Railroads, Bridges/Culverts
Local Neighborhood and Connecting Roads
Water Quality - Low
Flooding Threats
Storm Surge – Annual, 20-year, 100-year
Sea Level Rise
100-year Floodplain
500 Year Floodplain
Erodibility Very Low
Erodibility Moderate
Erodibility High
Subsidence Low
Flat, Somewhat Poorly Drained
Flat, Poor or Very Poorly Drained

Community Assets

There are number of important community assets within and adjacent to the project site (**Figure CS2-4** and **Table CS2-2**). The Tesoro Golden Eagle Refinery is a working oil refinery along the entire eastern boundary of the project. The Acme Landfill occurs along the central to southwestern edge of the project. The Union Pacific Railroad and BNSF Railroad run through or are adjacent to the project boundaries. In addition, there are several private companies that are located within or adjacent to the site. While many of the industrial facilities within or adjacent to the project were designed to accommodate low-levels of flooding, flooding of increased frequency could threaten the sustainability of these opertations. Almost all of the neighboring industries/companies are supportive of the project.

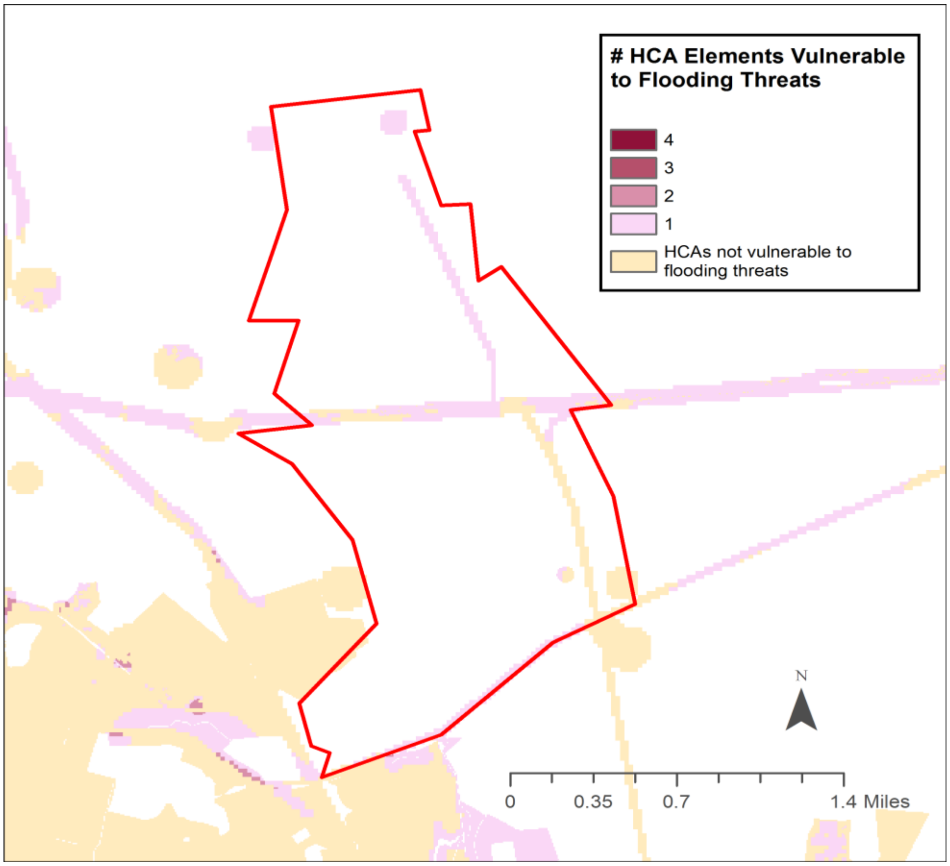


Figure CS2-4. Human Community Asset (HCA) elements vlunerable to flooding threats. *Map of areas where there are human community values and high levels of threat (darker pink/red signifies higher threat to human community assets). Tan color indicates areas with HCAs that are not categorized as vulnerable for the purposes of this assessment.*

Table CS2-2. Human Community Assets identified within the project boundary.

Categories of Human Assets Identified within Project Boundary
Moderately High to Low Population Density Critical infrastructure Critical facilities
Mapped Community/Human Assets within Project Boundary
I-680 Foster Wheeler Martinez (electric utility company) Tesoro Golden Eagle Refinery Waterfront Rd and bridge, Solano Way in Avon Las Juntas Elementary School Vine Hill, California Mt View Sanitary District Acme Landfill Union Pacific Railroad BNSF Railroad

Fish and Wildlife

Approximately 252 acres of tidal marsh habitat will be enhanced or created through restoration activities associated with the project. This habitat will support populations of the federally endangered salt marsh harvest mouse and the California state threatened California black rail **(Table CS2-3)**. As opposed to many other tidal marsh restoration projects within the estuary, the project has significant elevation capitol meaning that there is potential for the creation of immediate high tide refugia for the marsh species that will inhabitat the restored Pacheco Marsh as well as individuals that occur withi the neighboring marshes. Restoration of Pacheco marsh effectively connects the highly biodiverse marshes to the east and west of the project **(Figure CS2-5).** The restored tidal marshes may also provide rearing habitat for Chinook salmon and steelhead. Other special status species that have historically occurred at the project site include Suisun song sparrow, salt marsh common yellowthroat, and longfin smelt. The project site also supports many shorebird and waterfowl species.

Table CS2-3. Fish and wildlife habitats and example species for each habitat that potentially occur in the project area.*

Fish/Wildlife Habitat *	**Species of Interest to Stakeholders that may be Represented by these Habitat Types ****
Grasslands	Northern harrier, monarch butterfly
Playas	Least tern
Depressional wetlands	Gadwal, Northern shoveler, great blue heron
Tidal marsh	Black rail, California Ridgway's rail*, salt marsh harvest mouse, Chinook salmon, steelhead,
Tidal flats	American avocet, black-necked stilts
Essential Fish Habitat	Anchovy, starry flounder
Tidal wetland-upland transition area	Saltmarsh harvest mouse, Seaside song sparrow
Lagoon habitat	Mallard, lesser Scaup

**Based on modeled data (some of these habitats may not actually exist in the project boundary area or may be potential future or historical occurrences).*

*** Not meant to be an exhaustive list of all species that benefit from this habitat, but instead contains some example species that are likely represented by this layer of information and identified by stakeholders as priority species in the watershed.*

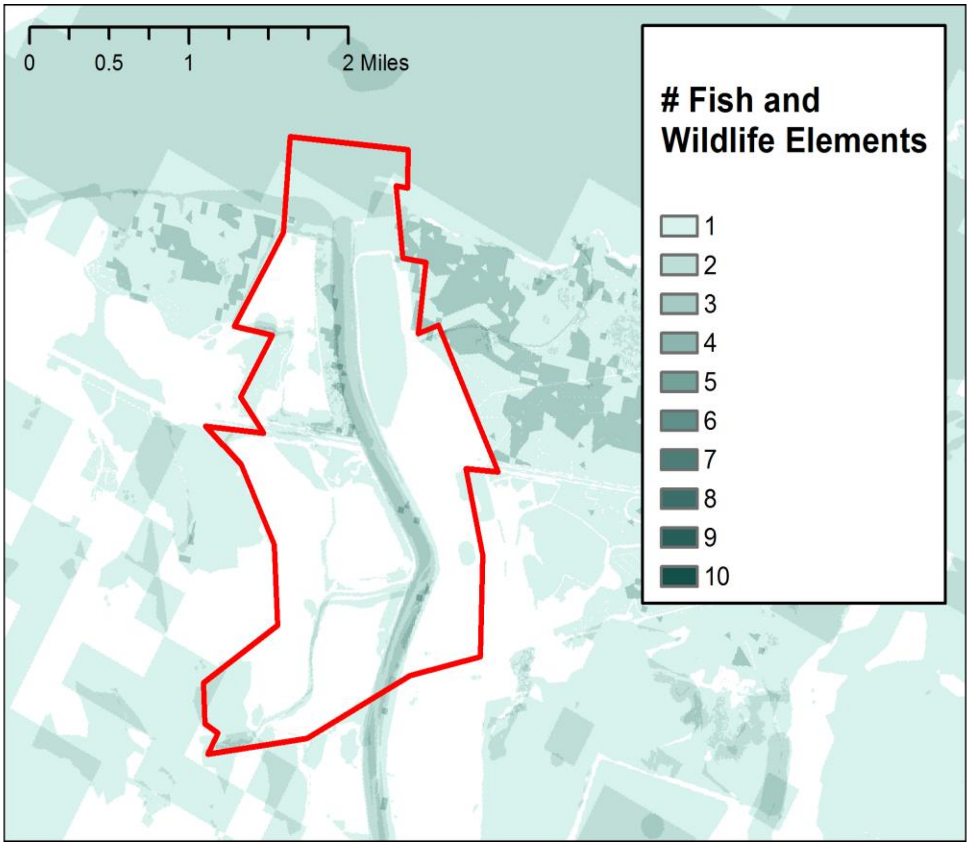


Figure CS2-5. Density of fish and wildlife elemeents in project area. *Map of all fish and wildlife elements combined (darker green signifies more elements/value). Red outlines are project boundary.*

Expected Project Impact

The Walnut Creek Restoration Project will restore approximately 252 acres of tidal marsh providing high quality habitat to a range of fish and wildlife species. The site has some of the highest elevational ranges of any potentially restored site in the San Francisco Estuary, increasing the probability that restoration will be resilient to sea level rise threats and provide high tide refugia. The project also provides important wildlife connectivity to existing marshes to the east and west of the project boundaries.

At the same time, restoring more of a natural hydrology to the study site will make future flood risk management more sustainable by allowing natural processes to move sediment and water flows through the system. The project will result in a reduction in maintenance costs for the flood control district with a corresponding improvement in flood risk management.

The project will also create high quality opportunities for partners to create public access to the site. Project partners have already developed plans to create recreational opportunities within the site, including connection to the Bay and Ironhorse Trails.

Case Study 3: Bolinas Lagoon North End Wetland Enhancement/SLR Adaptation Project

***Figure CS3-1**. **Intersection of Highway 1 and Fairfax-Bolinas Rd.** The road obstructs the hydrology between the lagoon and streams on the other side of the road.*

Project Overview

Location: Highway 1 east of Bolinas.

Date Visited: February 7, 2019

Contact: Veronica Pearson, Marin County Bolinas Lagoon Restoration Project Manager.

The goal of the Bolinas Lagoon Wetland Enhancement/Adaptation Plan is to develop and construct a wetland enhancement project for the north end of Bolinas Lagoon that reconnects Lewis and Wilkins Gulch Creeks to their floodplains by removing a crossover road that connects Olema-Bolinas Road and Highway 1. The project will install a creek crossing along the Olema-Bolinas road, redirecting the stream channel and re-establishing fish passage to high quality upstream spawning habitat. The project will also stabilize Lewis Gulch Creek using natural materials that will also improve fish habitat. The project will improve the resilience of the main access roads into Bolinas by realigning or raising the road while maintaining hydrological connectivity.

The proposed project is divided into two phases. During the first phase of the project, the Crossover Road will be removed, thereby reconnecting Lewis Culch Creek to its historical floodplain. Native vegetation will also be established to expand the existing tidal marsh habitat (**Figure CS3-2**). In addition, the Olema-Bolinas Road will be elevated to reduce frequent and significant roadway flooding during storm events (**Figure CS3-2**). During the second phase of the project, Highway 1 will be raised to reconnect Wilkins Gulch to its historical floodplain, allowing the wetlands adjacent to Bolinas Lagoon to migrate inland and upslope as sea level rises (**Figure CS3-2**).

In summary, the project will:

- Reconnect the hydrology between Bolinas Lagoon and several local creeks. These connections provide important water and sediment to the lagoon, but also connectivity for fish and wildlife species as well as spaces for the wetland habitats to migrate as sea level rises.
- Alleviate chronic flooding along the main access roads into the town of Bolinas by realigning the roadway and raising it up on bridges where necessary.

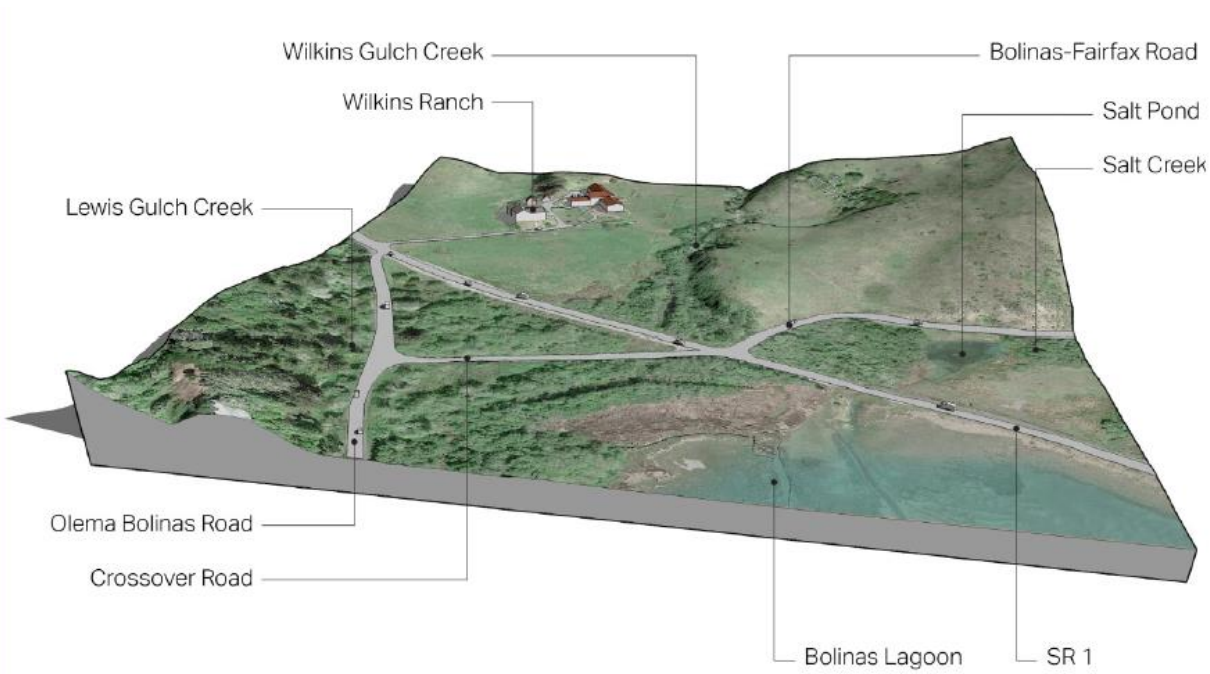


Figure CS3-2*. *Map showing the project area with existing conditions. *The proposed project will remove the Crossover Road and raise portions of Highway 1 (SR1) and Olema Bolinas Road to reconnect the creeks to their floodplain and allow wetland habitats to migrate upslope to Wilkins Gulch Creek and Salt Creek as sea level rises (Figure by AECOM, 2017).*

Figure CS3-3. Aerial view of the study area. *The project boundary is outlined in red.*

Estimated Cost of the Project

The project team has already secured $664,000 for design and environmental review for the first portion of the project, which will commence in 2019. The team estimates that implementation will cost an additional $6-8 million, of which they have secured approximately $800,000 to date. Phase II of the project will likely cost between $40-50 million.

Stressors and Threats

The main threat the project addresses is to relieve chronic flooding of the main access roads into the Town of Bolinas (Olema-Bolinas Road) and Highway 1, which is the main transportation artery connecting the town of Stinson Beach to the north **(Table CS3-1)**. Making these transportation corridors more resilient to sea level rise and storms is vital to both Stinson Beach for maintaining access to work and other community services, but also for providing access to emergency services, particularly during natural disasters such as storms or fires. The area is very rural and surrounded by the ocean, lagoon, and steep topography limiting other options for alternative transportation. The project also reconnects several local creeks with Bolinas lagoon providing connectivity for fish and wildlife species between the lagoon and upper watershed.

Table CS3-1. Stressors and flooding threats identified in and near the project site.

Existing Stressors
Developed Open Spaces
Secondary Roads
Local Neighborhood and Connecting Roads
Dirt/Private Roads
Flooding Threats
Storm Surge – Annual, 20-year, 100-year
Sea Level Rise
Occasional Flooded Soils
Erodibility Very Low
Erodibility Moderate
Erodibility High
Subsidence Low
Subsidence Moderate

Human Community Assets

As discussed above, the main community assets protected through the project are the main transportation arteries connecting the Towns of Bolinas and Stinson Beach to other communities and resources to the north. In addition, both Bolinas and Stinson Beach are popular recreation destinations serving the rest of the Bay Area and making these critical transportation corridors more resilient to sea level rise and flooding will ensure future public access for recreation.

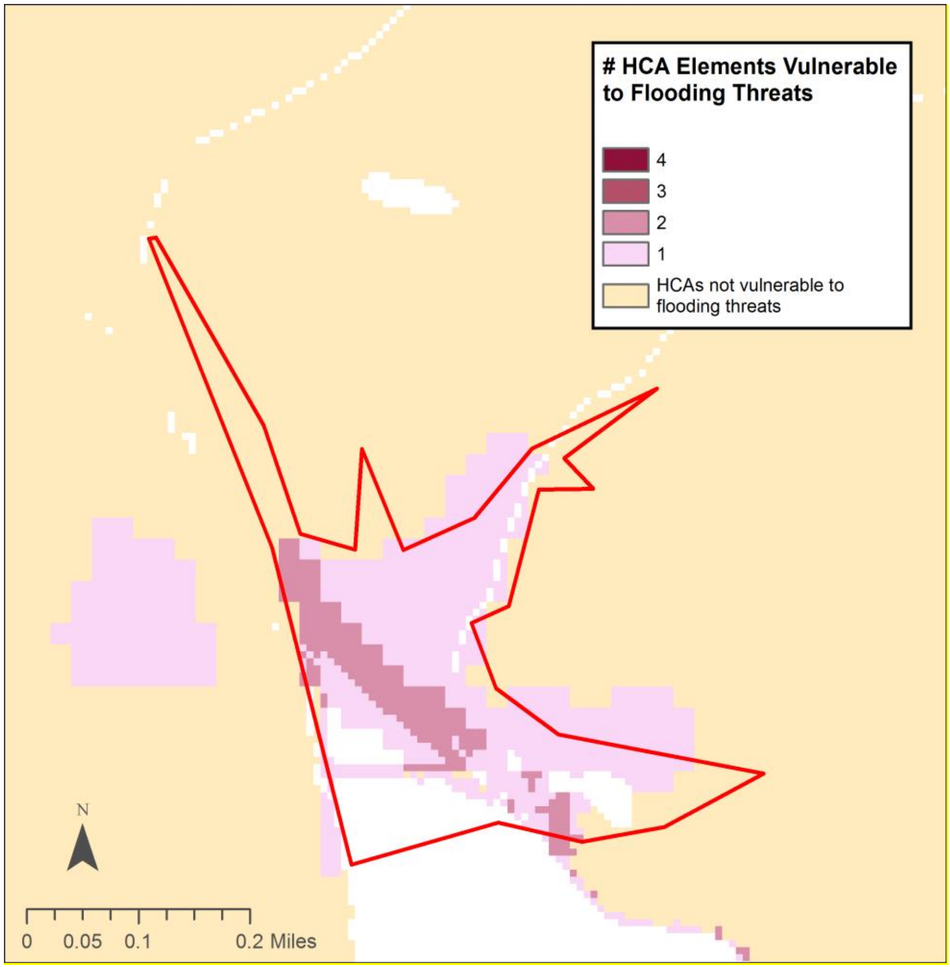


Figure CS3-4. Human Community Asset (HCA) elements vulnerable to flooding threats. *Map of areas where there are human community values AND high levels of threat (darker pink/red signifies higher threat to human community assets). The darker red areas in the map overlap with the main transportation arteries that are vulnerable to flooding from storms and sea level rise. Tan color indicates areas with HCAs that are not categorized as vulnerable for the purposes of this assessment.*

Table CS3-2. Human Community Assets identified within the project boundary.

Categories of Human Assets Identified within Project Boundary
Low density populated areas (Rank 1) Critical infrastructure
Mapped Community/Human Assets within Project Boundary
Shoreline Highway

Fish and Wildlife

The Bolinas Lagoon is an important hot spot for shorebirds and seabirds and other migrants that use the Pacific Flyway. The lagoon also provides year-round resting sites and important pupping habitat for harbor seals. By reconnecting the creeks to their floodplains, the project will restore habitat for Coho salmon and steelhead and provide access to high quality upstream spawning habitat. The project site contains a mix of priority habitats identifies by stakeholders **(Table CS3-3, Figure CS3-5)**. The wetland habitats within the project will also improve conditions for red-legged frog and giant California salamander. In addition, restoring tidal marsh habitat and enabling opportunities for habitat migration under sea level rise will improve the resilience of California black rail.

Table CS3-3. Fish and wildlife habitats and example species for each habitat that potentially occur in the project area.*

Fish/Wildlife Habitat *	**Species of Interest to Stakeholders that may be Represented by these Habitat Types ****
Grasslands	Northern harrier, white-tailed kite
Redwood-Douglas Fir forest	Brown creeper, olive-sided flycatcher, gray squirrel
Bird diversity hotspot	American crow, Nuttal's woodpecker, yellow-rumped warbler
Monarch butterfly	Atlantic sturgeon, blueback herring, American shad
Large riparian areas	Black-headed grosbeak, Wilson's warbler
Depressional wetlands	Red-legged frog, giant California salamander
Tidal flats	American avocet, American wigeon, Least sandpiper
Essential Fish Habitat	Coho salmon
Anadromous fish tributary habitat	Coho salmon, steelhead
Tidal Wetland-upland Transition Zone	Black rail, song sparrow, common yellowthroat

**Based on modeled data (some of these habitats may not actually exist in the project boundary area or may be potential future or historical occurrences).*

*** Not meant to be an exhaustive list of all species that benefit from this habitat, but instead contains some example species that are likely represented by this layer of information and identified by stakeholders as priority species in the watershed.*

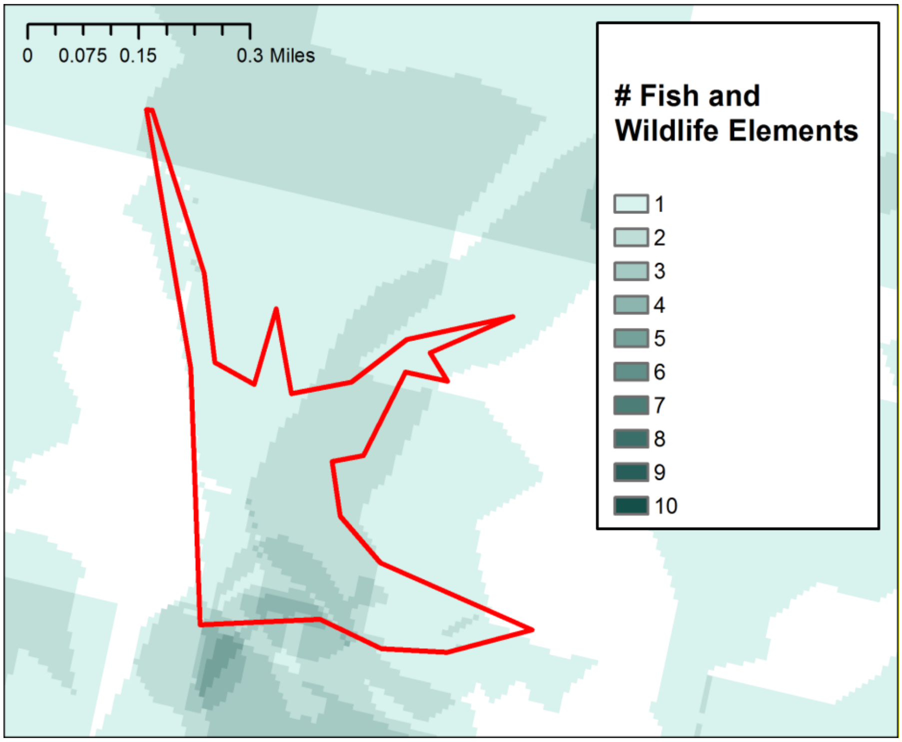


Figure CS2-5. Density of fish and wildlife elements in project area. *Map of all fish and wildlife elements combined (darker green signifies more elements/value). Red outlines are project boundary.*

Expected Project Impact

The Bolinas Lagoon North End Wetland Enhancement Project will drastically improve the resilience of two critically important transportation corridors for the Bolinas and Stinson Beach communities. The project will relieve chronic flooding for these roads during storms, while also reducing threats from sea level rise. Protecting these roads will not only ensure connectivity to critical resources for the local communities, but also allows access to these important recreation hot spots for the rest of the Bay Area. The incorporation of wetland habitat restoration as part of the project design will also reduce erosion impacts to critical infrastructure within the project area.

The project will also improve and expand the existing wetland habitat for species that inhabit the Bolinas Lagoon and adjacent habitats. The site is an important stop on the Pacific Flyway for many species of shorebirds and waterfowl and reconnecting the creeks draining into the lagoon will improve the hydrologic and geomorphic processes that in turn should improve the habitat for these species. In addition, the project will improve connections to spawning habitat for Coho salmon and steelhead.

Conclusions

This report and accompanying products are the result of an approximately 12-month stakeholder engagement and rapid assessment process. Using a combination of expert-identified and stakeholder-nominated data, the assessment aims to: 1) understand the value and vulnerability of human community assets and fish and wildlife elements (habitats and species), 2) map areas with potential for improving resilience (Resilience Hubs) for these assets and elements, and 3) gather and characterize stakeholder-proposed resilience projects.

The mapping of the Resilience Hubs is intended to inform potential new locations for resilience projects that can provide mutual benefits to community resilience and fish and wildlife. The large spatial extent of open space areas in the San Francisco Bay region generated many Resilience Hubs and potential opportunities for improving resilience in the watershed. The final scoring of the Resilience Hubs and their assessment units indicate several focal areas of particularly high potential for offering natural and nature-based resilience.

The San Francisco Bay and Outer Coast Watersheds Coastal Resilience Assessment and associated datasets are intended to support the development of additional resilience project ideas and can provide the basis for analyses to support project siting, planning, and implementation. The accompanying Coastal Resilience Evaluation and Siting Tool (CREST) was developed to allow users to view, download, and interact with the inputs and results of this assessment (available at resilientcoasts.org). Furthermore, the use of the Vista decision support system (DSS) will enable a variety of additional planning activities to integrate these data into plans for land use, conservation, emergency management, and infrastructure as well as supporting local customization.

Key Findings

The spatial analyses in this assessment confirm what is generally known and routinely experienced in the San Francisco Bay and Outer Coast Watersheds —that community vulnerability in many locations in the watershed is very high owing to exposure to flooding threats and the extensive development that has occurred within low elevation areas adjacent to the bays and ocean. Approximately 90% of historical intertidal wetland habitats that once ringed the San Francisco Bay are lost to development for homes and businesses and for resource extraction such as agriculture and salt production. The resulting human community assets are reliant on aging flood control infrastructure that was not designed to withstand threats from sea level rise.

There are many good opportunities for nature-based resilience projects in the natural shorelines, marshes, and adjacent low uplands between the coastal communities and the bay and ocean shore. Stakeholders within the San Francisco Estuary have set ambitious targets to restore 100,000 acres of tidal marsh habitat. Recent studies have found that restoring these marshes by 2030 will provide the greatest probability of the marshes reaching and maintaining tidal marsh elevation in the case of high rates of sea level rise. These restoration projects are frequently adjacent to high density human communities. This presents an opportunity to incorporate innovative flood risk management designs that take advantage of the protective services provided by natural habitats to provide both adequate flood protection and reduced maintenance costs. These novel designs will also benefit fish and wildlife populations through the restoration of critical habitat, while also providing refugia from high-water events and space for habitats to move as sea level rises. In addition, many of the resilience projects include the reconnection or restoration of hydrologic and geomorphic processes that allow habitats to be self-sustaining as environmental conditions change and sea levels rise. These nature-based resilience opportunities are best illustrated via the three case studies featured in this report, which highlight the following opportunities for improving resilience while benefiting fish and wildlife:

- Reconnecting the hydrology of former intertidal wetland areas increases the resilience of these habitats and adjacent coastal communities by restoring processes that make these shorelines self-sustaining as sea levels rise.
- Reconnecting streams and creeks to their historical floodplains to improve the flow of water and delivering sediment and other resources to places that need it most.

The case studies are meant to highlight a few options for nature-based actions to build resilience and, combined with the full database of all resilience projects submitted, can serve as a starting point for agencies and funders interested in supporting projects. In addition, the case studies and other submitted projects can serve as examples of potential project ideas that can be implemented within the areas that the analysis identified as Resilience Hubs. Finally, the case studies can serve as models that coastal planners can use outside the region in their own adaptation planning efforts.

Summary of Limitations

This project conducted a rapid assessment using available data. As such, there are several limitations to be aware of when applying these results to decision-making or other applications. Despite these limitations, the project represents an important set of data and results that can inform many applications and be further refined, updated, and applied to local purposes.

1. This assessment is not a plan and is not intended to assess or supplant any plans for the area (such as those summarized in Appendix 7).
2. The modeling of vulnerability of HCAs and fish and wildlife elements used a simple model and expert knowledge to set parameters of how stressors and threats impact select features. This is neither an engineering-level assessment of individual HCAs to more precisely gauge risk to individual areas or structures, nor a detailed ecological or species population viability analysis for fish and wildlife elements to estimate current or future viability.
3. The spatial data used in this assessment are those that could be readily obtained and that were suitable for the analyses. In general, secondary processing or modeling of the data was not conducted. In a GIS analysis, data availability, precision, resolution, age, interpretation, and integration into a model undoubtedly result in some areas being mistakenly identified for providing natural and nature-based resilience. As with all GIS analyses, the results should be ground-truthed prior to finalizing decisions at the site level.
4. Precise and complete water quality data were not available for this area. The project relied on three sources and methods for approximating water quality: EPA Impaired Waters data was used along with commercial vessel traffic data. This was supplemented with an offsite or distance effect setting in the Vista DSS landscape condition model that extrapolates impacts of

nearby stressors (i.e., land uses) to aquatic elements (see Appendix 2 and Appendix 3 for details on this method). This approach has some limitations such as extrapolating impacts in all directions instead of only downslope, only affecting water bodies within the distance effect (e.g., no mixing), and not accounting for downstream accumulation or mixing.

5. The selection of fish and wildlife elements was geared to the specific objectives of this assessment and, therefore, does not represent biodiversity generally or necessarily all fish and wildlife of conservation interest. Not all nominated elements could be represented at the preferred level of precision. A list of elements for which data was not available or was deemed insufficient for appropriately representing the element is provided in Appendix 5. That said, no elements can be assumed to have complete and accurate distributions. The Vista DSS project can be amended with additional elements of interest.

Putting this Assessment to Work

The products represented by this report, the online viewer and portal, and the Vista decision support system (DSS) provide opportunities for application by a variety of users. Potential uses range from those interested in becoming more informed about vulnerability and resilience opportunities in the watershed to those that wish to conduct additional assessment and planning. The use of the online map viewer or the decision support system can allow further exploration of the results and inputs across the watershed or for particular areas of interest.

Addressing the flooding threats assessed in this project is one of the most daunting activities for communities. Fortunately, concepts, examples, and guidance have been in development for several years and continue to improve as more communities confront these challenges. Some potential directions and implementation resources that may be useful include:

- Utilizing a community engagement approach to discuss specific ways to act on the findings of this assessment. One source for information on how to do this can be found here, including guidance on running a community workshop: https://www.communityresiliencebuilding.com/.
- The Adapting to Rising Tides program provides portfolio of Bay Area specific resources for addressing threats from climate change: https://www.adaptingtorisingtides.org/
- High resolution maps of sea level rise and storm flooding threats for the San Fracisco Bay and outer coast: www.ourcoastourfuture.org.
- Reviewing the U.S. Climate Resilience Toolkit (https://toolkit.climate.gov/) to explore other case studies, guidance, and tools to incorporate.
- Implementing living shorelines instead of relying on expensive shoreline armoring. Guidance for Considering the Use of Living Shorelines found at https://www.habitatblueprint.noaa.gov/wp-content/uploads/2018/01/NOAA-Guidance-for-Considering-the-Use-of-Living-Shorelines_2015.pdf.
- Weighing nature-based options for addressing shoreline erosion. For individual property owners a good starting point is: Weighing Your Options: How to Protect Your Property from Shoreline Erosion found at https://www.nccoast.org/wp-content/uploads/2014/12/Weighing-Your-Options.pdf.
- Exploring ideas from other regions to see if they can be applied to San Francisco Bay and Outer Coast Watersheds. Many guides and reports developed for other areas may also provide great examples and ideas to adapt for local application. For example this one from New Jersey found at https://www.nwf.org/CoastalSolutionsGuideNJ.

Above all, readers are encouraged to embrace this assessment as a useful tool to build community resilience using natural and nature-based solutions. Ample recent experience and forecasts tell us that more frequent and more serious flooding threats will occur, and that seas are rising. The best time to plan for resilience is before the next event turns into catastrophe. Data, tools, guidance, and support exist to inform and plan actions that can build resilience in ways that can also benefit the watershed’s fish and wildlife resources.

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Additional Stakeholders

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Alameda County Public Works
Alameda County Resource Conservation District
Alameda County Transportation Authority
Association of Bay Area Governments
Audubon California
Audubon Marin County
Audubon Santa Clara Valley
Bay Conservation and Development Commission
Bay Planning Coalition
CA Coastal Commission
CA Department of Fish and Wildlife
CA Department of Transportation
CA Landscape Conservation Partnership
CA State Parks

California State University, San Francisco
California Coastal Conservancy
Citizens Committee
City of Berkeley
City of Mountain View Public Works
City of San Jose
Contra Costa County Flood Control District
Ducks Unlimited
East Bay Regional Park District
Friends of Five Creeks
GAIA Consulting
Greater Farallones National Marine Sanctuary
ICF
Invasive Spartina Project
Marin Audubon Society
Marin County Open Space District
Napa County Flood Control
Natural Capitol Project (Stanford)
National Fish and Wildlife Foundation (NFWF)
National Oceanic and Atmospheric Administration
San Francisco Bay Bird Observatory
San Francisco Bay Joint Venture
San Francisco Estuary Partnership
San Mateo County
San Francisco Bay Joint Venture
San Francisco Bay National Wildlife Refuge Complex (USFWS)
San Francisco Bay Regional Water Quality Control Board
San Francisco Estuary Institute
San Francisco Estuary Partnership
San Francisquito Creek Joint Powers Authority
Save the Bay
Sierra Club
Sonoma Land Trust
Sonoma Resource Conservation District
University of California, Berkeley
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. National Park Service

Appendices

Appendix 1. Watershed Committee and Stakeholder Engagement Mechanisms and Process

Local guidance and meaningful stakeholder participation were a key part of the Targeted Watershed Assessment process. Their input provided critical information and insights reflecting local knowledge and priorities.

Watershed Committee

The purpose of the Watershed Committee was to provide guidance to the assessment in terms of:

- Identifying dates and venues for initial stakeholder webinars and in-person workshops;
- Developing an inclusive list of individuals invited to participate as stakeholders;
- Approving the final list of fish and wildlife elements and priorities to be included in the assessment; and
- Providing initial leads for appropriate datasets for representing fish and wildlife elements and other data used in the assessment (Appendix 5).

By including a broad range of participants from different organizations (see Acknowledgements for full list), the committee was able to represent the interests and perspectives of the national organizations involved in the assessment as well as those of local watershed organizations.

Stakeholders

Stakeholders provided relevant plans and studies to establish baseline context, ideas, and feedback on the selection of relevant fish and wildlife elements, identification of key stressors and threats, and identified the most appropriate data sets for use in the assessment. In addition, stakeholders were the key source of coastal resilience project plans and ideas. The stakeholder engagement process was designed to be as inclusive as possible and to maximize involvement of participants who could contribute a range of opinions and inputs. Stakeholders were defined as those individuals or groups who have one or more of the following:

- an interest in using and/or providing data to improve the assessment,
- expertise in and/or are working to conserve fish and wildlife species and habitat,
- are involved in designing, constructing, or funding resilience projects, especially nature-based resilience projects, or
- are leading efforts to improve resilience within their communities.

Representatives from federal and state agency personnel, non-profit organizations, local government agencies, academic institutions, and interested private citizens were all invited to participate in the assessment process. Of 355 invited participants, 30 participated in the in-person stakeholder workshops, but many others followed up with additional information and input after the workshops, providing critical data leads and resilience project ideas. (See Acknowledgments section for a list of the agencies represented in the stakeholder process.)

Project Outreach and Coordination Resources

Several resources were developed to inform and support input by stakeholders.

- National and watershed-specific fact sheets to convey project goals.
- A Data Basin portal (https://databasin.org/) for the watershed to keep all stakeholders informed and to provide an online space for information submission, etc. (sign up was required via the South Atlantic LCC Conservation Planning Atlas).
- Dynamic project submission forms with step by step instructions for contributing data and resilience projects.
- A draft list of fish and wildlife data elements that were targets for inclusion in the project.

Watershed Webinars and Stakeholder Workshops

Webinars and in-person workshops were scheduled to maximize involvement from stakeholders throughout the watershed and to keep participants informed about project progress throughout the project timeline. Stakeholders were invited to attend one of two workshops which were preceded by an introductory webinar to provide background in advance of the workshops (see **Table A1-1** for more information on specific engagement opportunities and the Acknowledgements section for more information on the groups represented in the stakeholder process).

After an initial introduction to the proposed analysis and the project timeline, participants were offered a variety of mechanisms in which to provide input, ideas, and comments. In particular, participants were encouraged to:

- Submit ideas for fish and wildlife elements of particular importance in this watershed.
- Highlight important datasets to use in the analysis (both on fish and wildlife, stressors, and coastal threats).
- Submit resilience project ideas.

Table A1-1. List of webinars and in-person meetings with watershed committee and/or stakeholders.

Name of Engagement Activity	Participation	Date
First Watershed Committee meeting (by webinar)	Watershed Committee	September 18, 2017
Pre-stakeholder webinar	Stakeholders, Watershed Committee	November 29, 2017
In-person stakeholder workshops	Stakeholders, Watershed Committee	December 13-14, 2017
Post workshop follow-up to summarize workshop results	Watershed Committee	January 16, 2018
Review of fish and wildlife and vulnerability assets	Watershed Committee	January 16, 2018
Draft results webinar to discuss GIS analysis and obtain final input from all stakeholders that wish to participate	Stakeholders, Watershed Committee	December 7, 2018

Post-workshop Activities

Workshop input and discussion was used to finalize fish and wildlife species and project submissions for the assessment. In addition, the workshops helped to:

- Identify iconic or culturally/economically important species and any other species nominated by stakeholders to the list of fish and wildlife elements for consideration in the assessment.
- Aggregate the fish and wildlife species list into habitat groupings and/or guilds to ensure key habitats were covered in the analyses.
- Capture resilience project ideas submitted during the stakeholder workshops so that core team members could follow-up with project proponents later to collect all information to properly represent each resilience project in the database.

Once these steps were completed, the Watershed Committee and stakeholders were given updates on the process via webinars to review draft products (**Table A1-1**).

Gathering Candidate Projects

Candidate resilience projects were gathered from stakeholders both at the in-person workshops and afterwards via the online portal, email, and phone. These project submissions became the pool from which several were selected for site visits and ultimately the final three case studies featured in this report.

Appendix 2. Condition and Vulnerability Technical Approach and Modeling Methods

This appendix provides additional detail to the Methods Overview and is supported by Appendix 3, which describes the vulnerability assessment model parameters and assumptions. These appendices also provide the details for the condition modeling, which generated some of the indices as an intermediate product of the vulnerability assessment. Not all technical details are described, for more extensive explanation of these, see the Vista Decision Support System (DSS) user manual (see GIS Tools section below). The vulnerability assessment methods for Human Community Assets (HCAs) and fish and wildlife elements were the same and used the same technical approach in the Vista DSS. *Elements* is the common term used in the Vista DSS for all features of assessment and planning interest, so from here-on, *elements* will be used to refer to both HCAs and fish and wildlife elements.

GIS Tools

The extensive and complex spatial assessments required for this project were conducted using the following Geographic Information Systems (GIS) tools:

ArcMap 10.6 is a geographic information system (GIS) developed by Esri (http://www.esri.com) as part of their ArcGIS Desktop product. The Spatial Analyst extension was required for this project.

NatureServe Vista (http://www.natureserve.org/conservation-tools/natureserve-vista) is an extension to ArcGIS that supports complex assessment and planning. Vista was used because it has the functions to support the types of analyses required to meet project objectives. It also serves as a platform to deliver the spatial data, results, and support additional work by stakeholders such as updating, re-prioritizing, and/or expanding the analyses to meet specific planning objectives.

Modeling Approach

A key concept in the Targeted Watershed Assessments is that the Vista DSS uses a *scenario-based* approach. This means that stressors and threats are aggregated into specific scenarios against which vulnerability of elements is assessed. These scenarios were illustrated in the stressor and threat groupings (**Figure 6**) in the Methods Overview. To assess vulnerability, condition of the elements must first be modeled by applying the model parameters in Appendix 3 to the scenario of interest. These condition results were used in several indices. From there, a condition threshold is applied to the condition map and values below the threshold are marked as vulnerable (non-viable in Vista DSS terminology).

The process steps used are listed and described below.

1. Define the scenarios in which stressors and threats are compiled
2. Build response models for how elements respond to the stressors and threats within the scenarios
3. Model condition of elements under each scenario
4. Apply the element condition thresholds and generate vulnerability maps of each element
5. Create vulnerability indices for element groups by summing the number of vulnerable elements at each location (pixel)

Definition of Scenarios

A scenario is a collection of maps of all the stressors and threats identified by stakeholders (for which adequate data existed) that can affect the condition of the elements. These stressors and threats are described as either fish and wildlife *stressors* (such as water quality) that only affect fish and wildlife elements and flooding *threats* that may affect all elements differentially (e.g., soils subject to flooding may affect HCAs but not the natural habitat already adapted to flooding that may occur there). Stressors and threats' effects on elements are evaluated using the assessment models described in the next section. Three scenarios were created and assessed, details on stressors and threats within each are described below.

1. **Baseline** depicts the current stressors within the watershed and supports assessment of the current condition of the fish and wildlife elements to understand how element condition may change in the future based on future threats or restoration actions.
2. **Threats** only includes the flooding threats and supports assessment of how these threats alone may impact element condition. In other words, without considering the current baseline condition, to what extent is a given element impacted by flooding threats.
3. **Combined** combines the baseline and threats scenarios into a cumulative scenario to understand how current and flooding threats may combine to impact fish and wildlife element condition.

Scenarios were built within the Vista DSS using the Scenario Generation function where data attributes were cross-walked to a classification of scenario stressors and threats. Data layers were added and grouped as to whether a feature overrode or dominated stressors and threats below it or combined with other stressors and threats. The objective of that process is to provide the most accurate scenario in terms of whether scenario stressors and threats co-occur in the same location or the presence of a feature precludes the presence of another feature (e.g., where there is a road there is not also agriculture). A large volume of stressor and threat data were gathered, evaluated, and integrated in the Vista DSS to map each of the scenarios. Details on scenario data are described below and the use of individual stressors and threats in each scenario is shown in **Table 1** and **Figure 6** in the Methods Overview.

Table A2-1. List of Stressors and threats indicating in which scenarios each was used.

Fish and Wildlife Stressors	**Scenario**		
	Baseline	**Threats**	**Combined**
Land use, including different levels of housing development, commercial/industrial areas, agriculture, and forestry	X		X
Infrastructure, including different size roadways, railroads, dams, pipelines, and electrical transmission corridors	X		X
Water quality or stressors that can affect water quality	X		X
Flooding Threats	**Baseline**	**Threats**	**Combined**
Sea level Rise		X	X
Storm surge potential		X	X
Subsidence		X	X
Erosion potential		X	X
Flat and poorly drained soils		X	X
Flood prone areas		X	X

Stressor and Threat Data

The full list of stressors and threats used in the vulnerability assessments is in **Table A2-2** at the end of this appendix, along with the data source used. If no data source was found for a stakeholder-identified fish and wildlife stressor that is noted. This assessment used the flooding threats data developed in the Regional Assessment (Dobson et al. 2019). The following is a brief description of each flooding threat included.

<u>Soil Erodibility</u>

To assess the erodibility of soils throughout the coastal watersheds, the USDA-NRCS Soil Survey Geographic Database (SSURGO) classification kffact was used. The kffact score represents the susceptibility of soil particles to detachment by water. Soil erosion resulting from flooding can drastically alter the landscape and impact wildlife habitat. Erosion can be devastating in extreme flood events. In this assessment, soil erodibility varies tremendously across regions and is dependent on soil type. Also highlighted in this input are beaches and dunes that are migratory by nature. Although these landforms can help buffer a community from flooding, the risk of erosivity is fairly high.[8]

<u>Impermeable Soils</u>

This input was included because it influences the period of time that coastal lands are inundated after a storm event. Poorly drained soils are typically wetland soils or clays and high density development is also considered very poorly drained because of pavement and rooftops. In many cases the USDA-NRCS SSURGO database is lacking data in urban areas. To account for the obvious impermeable nature of these areas, the National Land Cover Database developed land cover classes are included. To be

[8]Gornitz, V.M., Daniels, R.C., White, T.W., and Birdwell, K.R., 1994, The development of a Coastal Vulnerability Assessment Database: Vulnerability to sea-level rise in the U.S. Southeast: Journal of Coastal Research Special Issue No. 12, p. 330.

considered a “very high” rank, the landscape must be a poorly or very poorly drained soil type and mapped as a developed land use.

Sea Level Rise

Sea level rise is occurring at different rates across the U.S. Coasts, for example relative sea level rise along the western portion of the Gulf Coast and a large portion of the North Atlantic Coast will be greater than the Pacific Northwest Coast as a result of groundwater and fossil fuel withdrawals.[9] The sea level rise scenarios modeled by NOAA can inform coastal decision-makers and wildlife managers. Gornitz et al. (1994) cited many studies as early as 1989 that demonstrated the potential vulnerability of the barrier islands and wetlands within the South Atlantic region to changing environmental conditions and other episodic flood events.[10] Scenarios for a 1-5 foot rise in sea level were used in the Regional Assessment but a lower level was used in this Targeted Watershed Assessment (see Methods Overview).

Storm Surge

Surge from hurricanes is the greatest threat to life and property from a storm. Like sea level rise, storm surge varies by region. The width and slope of the continental shelf play an important role in the variation between regions. A shallow slope will potentially produce a greater storm surge than a steep shelf. For example, a Category 4 storm hitting the Louisiana coastline, which has a very wide and shallow continental shelf, may produce a 20-foot storm surge, while the same hurricane in a place like Miami Beach, Florida, where the continental shelf drops off very quickly, might see an eight- or nine-foot surge.

Areas of Low Slope

As the slope of the terrain decreases, more land areas become prone to pooling of water, which can allow for prolonged coastal flooding. This input was created using the Brunn Rule, which indicates that every foot rise in water will result in a 100-foot loss of sandy beach. In this case, a one percent slope or less is likely to be inundated with a one-foot rise in water. This rule provides insight for low-lying coastal areas that are more susceptible to inundation and changing coastal conditions.

Geologic Stressors

It is common to consider landslides as occurring exclusively on the Pacific Coast in the United States. However, landslides occur in all 50 states and in 2005 damages totaled around $3.5 billion per year.[11] As a general rule, at least 10 inches of seasonal rainfall are needed to make southern California hillsides susceptible to debris flows.[12] The data input used in this model delineates areas where large numbers of landslides have occurred and areas which are susceptible to landsliding. Although landslides are commonly thought of as occurring because of extreme precipitation events or earthquakes, they often accompany floods.

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[9]NOAA, *Global and Regional Sea Level Rise Scenarios for the United States* (2017), 30.

[10]Gornitz, V.M., Daniels, R.C., White, T.W., and Birdwell, K.R., 1994, The development of a Coastal Vulnerability Assessment Database: Vulnerability to sea-level rise in the U.S. Southeast: Journal of Coastal Research Special Issue No. 12, p. 330.

[11]USGS, *Landslide Hazards- A National Threat*, 2005.

[12]USGS, *Southern California Landslides-An Overview*, 2005.

Additional stressors on fish and wildlife were identified by stakeholders in the workshops (Appendix 1). Distribution data were submitted by stakeholders and evaluated against data criteria and other regional/national datasets known to the GIS team. The best available data were then used to build each scenario based on currency, completeness, and resolution. Stakeholders, Watershed Committee members, and attendees of any of the review sessions were invited to review data sources and gaps. They were provided with a link to an online form allowing them to enter information on additional data sources that might be of use as well as a link to a Dropbox folder for uploading data. Requirements for data submissions included:

- Data must be georeferenced and use a defined projection.
- Data should be complete for the full extent of project area and not just a subset of it.
- Data must either be represented as an area (e.g., polygon shapefile, raster) or, if in point or line format, have an explicit buffering rule (either a single distance from all features or variably calculated based on an attribute of each feature).
- Data should be submitted to contain FGDC compliant metadata (strongly preferred). Exceptions were made, but most data lacking metadata did not make it through the initial screening process.

All data sources were further evaluated according to project data requirements. Evaluation included completeness of data across the watershed, precision of data, and accuracy of data compared to other sources or imagery. Where necessary, data were projected to the project standard, clipped/masked to the project boundary, and rasterized if necessary. For readers interested in using these datasets, they can be found in the packaged NatureServe Vista project resource available through NFWF's Coastal Resilience Evaluation and Siting Tool (CREST), available at resilientcoasts.org.

Table A2-2. Fish and wildlife stressors and threats identified by stakeholders. *Table identifies the primary category, secondary category (which was mapped if suitable data was found), data sources identified (if any), and the scenarios in which each was used.*

Stressor/Threat Primary & Secondary Categories		Data Sources	Scenarios
Residential & Commercial Development	High/Medium Density Housing (high imperviousness > 50%)	USGS Roadless Landcover (Soulard & Acevedo 2016)	Baseline, Combined
	Low Density Housing (moderate imperviousness 20%-40%)		
	Developed Open Spaces (parks, cemeteries, etc.) (low imperviousness < 20%)		
	Commercial & Industrial Areas (e.g., airports, energy transfer terminals, etc.)	National Transportation Atlas Database (2015 or later); *Petroleum terminals and refineries (2015 or later)*: Terminals: EIA-815, "Monthly Bulk Terminal and Blender" Report; Refineries: EIA-820 Refinery Capacity Report; *Natural Gas Terminals and Processing Plants (2015 or later)*: *Terminals*: EIA, Federal Energy Regulatory Commission, and U.S. Dept. of Transportation; *Processing Plants*: EIA-757, Natural Gas Processing Plant Survey	
Agriculture and Aquaculture	Silviculture – Intensive	No Data	N/A
	Silviculture – Sustainable	California Department of Water Resources crop mapping	Baseline, Combined
	Intensive Agriculture		
	Ruderal (maintained pasture, old field)	California Department of Water Resources crop mapping; NatureServe Systems Map (Comer 2009)	
	Aquaculture	No data	N/A
Energy Production and Mining	Solar Arrays	No data	N/A
	Wind		
	Oil and Gas Fields		
	Mining		
Transportation and Service Corridors	Primary Roads	Tiger roads (U.S. Census 2016)	Baseline, Combined
	Secondary Roads		
	Local, neighborhood and connecting roads, bridges/culverts		
	Dirt/Private roads/culverts		

Stressor/Threat Primary & Secondary Categories		Data Sources	Scenarios
	Railroads, bridges, culverts	USDOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later); Federal Highway Administration, NBI v.7, NTAD (2015 or later)	
	Utility & Service Lines (overhead transmission, cell towers, etc.)	No data	N/A
Dredge Material Placement Areas		No data	N/A
Dams & Reservoirs		USDOT/Bureau of Statistics' NTAD (2015 or later)	Baseline, Combined
Sea Level Rise – 1.6 ft		*dataname* (PointBlue, *year*)	Flooding Threats, Combined
Storm Surge	Annual	*dataname* (PointBlue, *year*)	Flooding Threats, Combined
	20 year		
	100-year		
Water Quality	Moderate	EPA Impaired Waters AIS Commercial Vessel Traffic Density (MarineCadaster.gov 2012, obtained from Rua Mordecai pers. comm.)	Baseline, Combined
	Low		
Invasive Species	Terrestrial	No data	N/A
	Aquatic		
Landslide Susceptibility	High Susceptibility, Moderate Incidence	No data	N/A
	High Incidence		
Subsidence	Moderate	UNAVCO Subsidence Data	Flooding Threats, Combined
	High		
	Very High		
Poorly drained areas	Flat & Somewhat Poorly Drained	NRCS SSURGO	Flooding Threats, Combined
	Flat & Poorly or Very Poorly Drained		
Erosion	High Erodibility	NRCS SSURGO Soil Erodibility Data	Flooding Threats, Combined
	Very High Erodibility		
Flood Prone Areas	Occasional Flooded Soils	FEMA National Flood Hazard Layer	Flooding Threats, Combined
	Frequent Flooded Soils		
	500 Year Floodplain		
	100-year Floodplain		
	Floodway*		

**A "Regulatory Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height (https://www.fema.gov/floodway).*

Building Element Response Models

Response models reflect how each element responds in the presence, or within a certain distance, of a scenario feature. Four response models were developed to model element condition and assess their vulnerability. One model was developed for HCAs; fish and wildlife elements were put into three groups, assuming that the elements within a group respond similarly to the stressors and threats: a Terrestrial Elements model (models condition of all terrestrial wildlife elements), a Freshwater Elements model (models condition of all freshwater wetlands, stream and lake habitats, and aquatic freshwater animal species), and an Estuarine Elements model (models condition of all elements adapted to brackish and saltwater conditions—wetland, submerged aquatic habitats, estuarine habitats, and aquatic marine animal species). For each of these four groups of elements, parameters for the models included an element condition threshold (where condition drops below a state viable for the element), site intensity impacts (within the immediate footprint of stressors/threats relevant to a given scenario), and distance effects (to what extent impacts from a given stressor or threat extend out from mappable features). The threshold score is a subjective value (between 0.0 and 1.0) that is assigned based on the relative sensitivity of the element category such that a high threshold (e.g., 0.8) would indicate an element that is very intolerant of disturbance, whereas a low threshold, (e.g., 0.5) would indicate an element that can remain viable with a considerable amount of disturbance. In the case of this project, "viable" should be interpreted as the ability to persist if conditions remain constant regarding a given scenario or the ability to recover from impacts without intervention in a relatively short time. Settings for each parameter were informed by Hak and Comer (2017), Powell et al. (2017), and prior experience of the NatureServe assessment team with input from the San Francisco Bay and Outer Coast Watersheds Committee and other stakeholders. Model inputs and assumptions are described in Appendices 2 and 3.

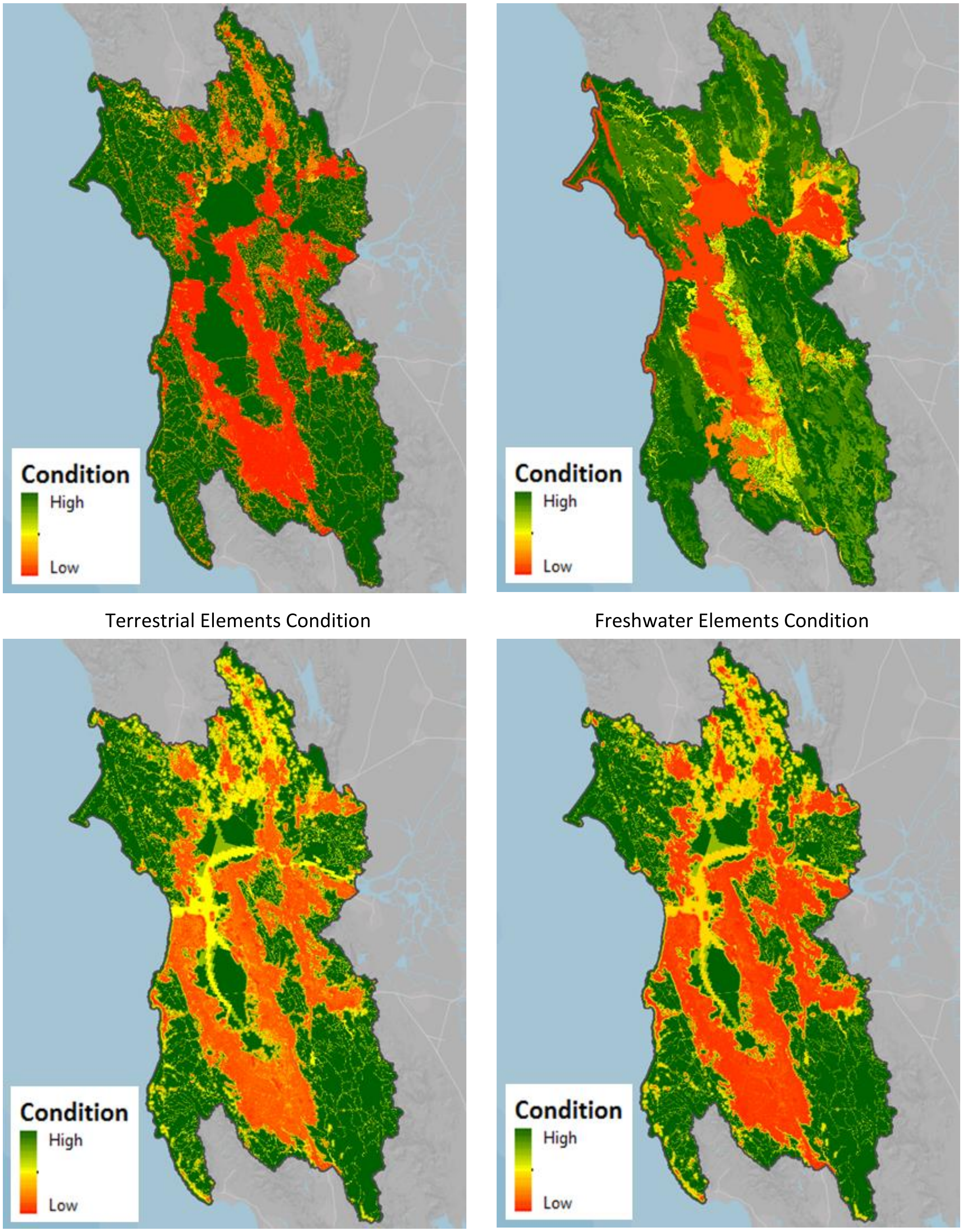
Model Element Condition

Modeling element condition is the first step to assess vulnerability, but the intermediate product of element condition was also used in the Fish and Wildlife Condition-Weighted Index and as a factor in the ranking of *resilience hubs*. The spatial analyses were conducted using the "landscape condition model" (LCM) within the Vista DSS which is based on a model developed by Hak and Comer (2017). The condition of each element was assessed under the relevant scenarios described above by applying the appropriate response model to generate a set of condition maps that cover the entire watershed. HCAs were only assessed against the *threats scenario* with the assumption that current HCAs are compatible with other human development and wildlife stressors and are only impacted by the flooding threats. Fish and wildlife elements were assessed against all three scenarios to inform their current condition under the baseline scenario, the potential impacts from just the flooding threats, and the cumulative impacts of the stressors in the baseline scenario and the flooding threats in the Combined Scenario.

The LCM calculates the condition score of every pixel in the watershed as depicted in the four maps below (**Figure A2-1**) using the relevant response models per above. The LCM first calculates the response scores on each individual scenario feature (site intensity within the scenario feature footprint and the distance effect offsite) and then overlapping feature responses are multiplied to calculate a cumulative effect. For example, where a condition score of 0.7 in a pixel resulting from one stressor overlaps with a condition score of 0.6 from an overlapping stressor, the scores are multiplied to obtain a combined score of 0.42 reflecting the cumulative impact of the two stressors. Vista then intersects the watershed-wide condition map with each relevant element distribution map to attribute the element's condition on a pixel basis (every pixel within an element's distribution receives a condition score). The condition maps and intermediate layers for each element are available in the Vista DSS project.

Model Element Vulnerability

To assess vulnerability, the individual element results from the condition modeling above were subjected to the condition threshold for the same element groups described above in Building Element Response Models (see Appendix 3 for thresholds). All pixels below the threshold were attributed as non-viable (vulnerable); those above as viable (not vulnerable). For example, all HCAs were assigned a condition threshold of 0.5 indicating that when enough cumulative stressors reduce the condition of a pixel below 0.5, any HCAs falling within that pixel would be marked as non-viable. The elements were overlaid together and the non-viable pixels were summed across elements to generate a raster index where the value of a pixel is the count of the number of vulnerable elements in each pixel. This resulted in the Human Community Vulnerability Index and the Fish and Wildlife Vulnerability Index (described further in Appendix 4). The Vista DSS also accommodates the use of a minimum viable patch/occurrence size for elements to further define viability, but this was not used in the project. For example, one can specify a minimum size for a marsh type at 100 acres. A patch would then need to have at least 100 acres of viable pixels to be viable or the entire patch is marked vulnerable. That function is available for users to add that parameter to the model and update the results.



Terrestrial Elements Condition

Freshwater Elements Condition

Estuarine Elements Condition

HCA Elements Condition

Figure A2-1. Landscape condition model outputs for the San Francisco Bay and Outer Coast Watersheds. *These maps depict the watershed-wide results of each of the four landscape condition models used in the assessments.*

Appendix 3. Structure, Parameters, and Assumptions for Condition and Vulnerability Models

This appendix provides the model settings and details established in the condition modeling and vulnerability assessments (Appendix 4) so users may better understand the results and may consider refining the settings based on additional local knowledge or different objectives. Hereon, the term *elements* is used to describe both fish and wildlife and HCAs as that is the functional term used in the Vista DSS for all features of assessment/planning interest. While some literature was used to inform the model parameters, these are primarily subjective, expert knowledge-informed settings for which empirical data do not generally exist. Instead, assumptions are provided so they may be challenged and refined when better information or knowledge becomes available.

The four models' parameters described in the tables below are provided as four separate tables in the following order:

1. **Table A3-1**: Terrestrial Vulnerability Model
2. **Table A3-2**: Freshwater Vulnerability Model
3. **Table A3-3**: Estuarine Vulnerability Model
4. **Table A3-4**: Human Asset Vulnerability Model

While Vista allows response models tailored to individual elements, for this rapid assessment, grouping the elements was an efficient way to generate reasonable models and end products. Each table is organized according to the following column headings and categories.

- ***Key Assumptions of this Model***: Describes which elements the model applies to and the general assumption for how effects of scenario stressors and threats were scored.
- ***Importance Weighting:*** Only applicable to HCAs (**Table A3-4**) and only for the weighted richness index, but weights can be assigned to any of the elements if desired.
- ***Element Condition Threshold***: Score, between 0.0 and 1.0, representing the relative sensitivity of an element to stressors and threats. Relatively high numbers (e.g., 0.8) indicate high sensitivity/low adaptive capacity to disturbance while low numbers (e.g., 0.4) would indicate low sensitivity/high adaptive capacity.

The next section of each table provides the classification of the stressors and threats including both Primary Category and Secondary Category, the response parameters of the elements in the group to those stressors and threats, and the assumptions made in those responses. The following column headings indicate:

- ***Response Type***: Column represents one of three possible parameter types used in the Vista Scenario Evaluation model:
    - ***Categorical Response*** is set as negative (negative impact from the stressor/threat) neutral (no effect), and positive (a beneficial effect—this only applies to the list of actions established for resilience projects). This response was not directly used in the assessment but serves two purposes—first to inform the setting of the other responses by narrowing whether they should be above or below the condition

threshold; second to support use of the Vista project for planning purposes where it allows rapid testing of proposed actions at the site scale (in the Vista DSS see the Site Explorer function).

- *LCM Site Intensity* indicates how much of an element's condition would be left if the stressor/threat fell directly on the element. This setting assumes a starting condition of 1.0 (high or perfect condition in the absence of other stressors). This is an important assumption to understand in Vista, that without a mapped stressor, condition will be perfect. While ultimately whether the score is above or below the threshold determines viability of the element at a location, the gradient is useful to understand how much above or below the threshold the element condition is to inform decisions about conservation and restoration. The model does not allow a setting of 0.0, so .05 is generally used to indicate complete removal/reduction of condition.
- *LCM Distance* indicates the distance in meters from the edge of a stressor that the impacts may extend. The LCM does not use a buffer but instead models an S-shaped curve where the impacts start off high from the edge, drop off steeply, then level out to no effect at the specified distance.

- ***Responses:*** Column indicates the settings established by the project team.
- ***Response Assumptions:*** Provides a short description of the team's assumptions of the setting.

Storm surge effects modeling

Because only a single threats scenario was assessed in this rapid assessment, all 5 categories of storm surge had to be combined and treated simultaneously. The scores for the site intensity (impact) for each category of storm surge were, therefore, set with this combination in mind versus scoring each independently. The scores are described in the tables below, but the general logic of the combination is that where category 1 surge overlaps with all other categories and, therefore, deeper flooding and higher energy water movement, the impact is highest; where there is category 5 surge (not overlapping any other categories) and thus the shallowest, lowest energy fringe area of flooding (furthest inland), the impact is lowest. Categories 2-4 will have intermediate levels of impact from high to low respectively. While the individual impact scores are not severe, the multiplication of them, where they overlap, equates to high impact. To illustrate, the impact on human assets from a category 5 surge that overlaps with the category 1-4 surges (that area closest to the coast) would be scored as category 1 (0.65) x category 2 (0.7) x category 3 (0.75) x category 4 (0.8) x category 5 (0.85) = a cumulative impact score of 0.23 which is far below the vulnerability threshold of 0.5. If the Vista DSS user wished to create separate scenarios for each category of storm surge, the settings should be adjusted to reflect the anticipated level of each category independently.

Table A3-1. Terrestrial Exposure Model Structure and Assumptions.

Key Assumptions of this Model			
Applies to Terrestrial Habitats and Species		Is focused more on keeping the habitat intact for resilience to flooding impacts and understanding current condition relative to flood mitigation than for biotic component retention	
Importance Weighting (Optional, used only for the CVS)	Values range from: 0.0 (Low) to 1.0 (High). There may be as many weighting systems as desired based on rarity, cultural or economic value, etc. Value based on G-rank can be automatically populated if G-rank attribute is provided	N/A	Importance weighting not set for fish and wildlife elements. Assumption is that all are equally important.
Element Condition Threshold	Values range from: 0.0 (Low) to 1.0 (High). This value will determine the LCM result threshold under which a species is no longer viable in a pixel. Nearing 0.0 indicates increasing resilience to stressors and nearing 1.0 indicates increasing sensitivity.	0.6	Sensitivity Assumptions: Terrestrial habitats may sustain significant impacts from stressors and threats and still provide the desired functions for controlling runoff volume and pollutants and generally maintaining same habitat type but not necessarily all ecosystem biotic components.
Land Use Intents (term used in Vista 3.x for all land uses, infrastructure, other stressors and threats, and conservation management and practices anticipated under any scenario). The IUCN/CMP classification list (v3.1, 2011) of direct threats and conservation practices was modified to meet the needs of this project.			

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Residential & Commercial Development	High/Medium Density Housing (high imperviousness >50%)	Categorical Response	Negative	Assume total loss.
		LCM Site Intensity	0.05	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Low Density Housing (moderate imperviousness 20-49%)	Categorical Response	Negative	In NLCD, individual houses or groups of houses are mapped as this type so habitat type may have significant modification and fragmentation, considerable runoff and pollution can impact nearby aquatic systems. Impact less than high/moderate density because pixels do incorporate adjacent undeveloped areas. If local data suggests different densities of development and imperviousness, these assumptions and scores can be modified.
		LCM Site Intensity	0.2	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Developed open spaces (parks, cemeteries, etc.) (low imperviousness <20%)	Categorical Response	Negative	Assume nearly complete conversion to maintained landscape but with some potential for restoration, particularly to land cover with more habitat value if not original habitat type. Some increased runoff generated in volume and pollutants from landscape maintenance.
		LCM Site Intensity	0.3	
		LCM Distance	50	Relatively small distance effect because of vegetative cover reducing pollutant runoff.
	Commercial & Industrial Areas (e.g., airports, energy transfer terminals, etc.)	Categorical Response	Negative	Assume total loss.
		LCM Site Intensity	0.05	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
Agriculture and Aquaculture	Silviculture - Sustainable	Categorical Response	Neutral	Not significant impact on ecosystem process/hydrologic function, some impact on habitat quality/diversity, but would remain viable in absence of other stressors. High restorability
		LCM Site Intensity	0.7	
		LCM Distance	0	Negligible distance effect because of expected continuous vegetation coverage.
	Intensive Agriculture	Categorical Response	Negative	Complete habitat conversion, but some maintenance of hydrologic function. Potential long-term restorability.
		LCM Site Intensity	0.2	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Ruderal (maintained pasture, old field)	Categorical Response	Negative	Near complete conversion to managed landscape, but with some significant natural vegetation maintained in portions. May have herbicide applied for weed control, but otherwise hydrologic function would be closer to natural than more intensive agriculture types.
		LCM Site Intensity	0.4	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Aquaculture	Categorical Response	Negative	Only assesses impact of adjacent aquaculture on terrestrial habitat vs. conversion to aquaculture. Assume clearing and hydrologic process impacts, difficult to restore to original habitat type.
		LCM Site Intensity	0.3	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change
Energy Production and Mining: assume on land	Solar arrays	Categorical Response	Negative	Cleared but not paved footprint, potential for restoration.
		LCM Site Intensity	0.3	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Wind	Categorical Response	Negative	Assumption is for a wind field, not individual wind towers. Less footprint clearing and maintaining than solar and greater restorability with more remaining natural cover.
		LCM Site Intensity	0.4	
		LCM Distance	300	Height of towers leading to larger visual and noise avoidance impacts will be highly variable.
	Oil and Gas Fields	Categorical Response	Negative	Assumptions for well field, not individual pads. Assume dispersed clearing, maintained dirt pads, roads, noise but with mostly natural habitat in between and fairly high restorability.
		LCM Site Intensity	0.4	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Mining	Categorical Response	Negative	Assumption for pit type mining. Effects can include complete removal of habitat, deep excavation, noise, dust, runoff of sediment, vehicle traffic. Difficult to restore to original ecosystem type.
		LCM Site Intensity	0.1	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Transportation and Service Corridors	Primary roads, e.g., Interstates, high traffic/volume, wide roads, bridges	Categorical Response	Negative	Complete clearing, pavement, vehicular visual and noise disturbance, wildlife mortality, fragmentation, loss of connectivity.
		LCM Site Intensity	0.05	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Secondary roads, e.g., moderate traffic/volume state highways, bridges	Categorical Response	Negative	Somewhat reduced footprint and traffic impacts than a primary road but still highly significant.
		LCM Site Intensity	0.2	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among others) resulting in changes to existing habitat type.
	Local, neighborhood and connecting roads, bridges/culverts	Categorical Response	Negative	Similar effects as secondary road.
		LCM Site Intensity	0.2	
		LCM Distance	50	Smaller distance effect due to narrower footprint and reduced traffic volume.
	Dirt/Private roads/culverts	Categorical Response	Negative	Very narrow footprint, very low traffic volume, and can have continuous forest canopy over road, higher potential for restorability than wider/public roads.
		LCM Site Intensity	0.4	
		LCM Distance	30	Narrow footprint, low traffic volume, and potential for continuous forest canopy means smaller distance effect.
	Railroads, bridges, culverts	Categorical Response	Negative	Similar effects as secondary road.
		LCM Site Intensity	0.2	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among others) resulting in changes to existing habitat type.
	Utility & Service Lines (overhead transmission, cell towers, etc.)	Categorical Response	Negative	Localized clearing and maintained artificial clearing but not paved, variable effects on animal behavior, potential for invasive introductions, fairly high restorability.
		LCM Site Intensity	0.4	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among others) resulting in changes to existing habitat type.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Dredge Material Placement Areas	Locations where dredge material is permanently deposited	Categorical Response	Negative	Assumption that any habitat is likely to experience recurring dredge deposition with associated salt and other pollutants. Moderate effort required to restore vegetative cover.
		LCM Site Intensity	0.3	
		LCM Distance	0	Assume no offsite effects on terrestrial elements.
Dams and Reservoirs	Any mapped dams and reservoirs	Categorical Response	Negative	Conversion from natural habitat but some potential for restoration through restored connectivity/dam removal.
		LCM Site Intensity	0.3	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among others) resulting in changes to existing habitat type.
Sea Level Rise	See flooding threats table for level used.	Categorical Response	Negative	Complete and irreversible habitat conversion.
		LCM Site Intensity	0.05	
		LCM Distance	50	Some typical edge effect of habitat conversion, plus allowance for groundwater backup and/or saltwater intrusion causing effects beyond the inundation point.
Other threats	Water Quality - Moderate	Categorical Response	Neutral	Assume no effect on terrestrial elements.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Water Quality - Low	Categorical Response	Neutral	Assume no effect on terrestrial elements.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Invasive Species - Aquatic	Categorical Response	Neutral	Assume no effect on terrestrial elements.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Invasive Species - Terrestrial	Categorical Response	Negative	Effects can change biotic composition and sometimes habitat structure, which may lead to increased erosion, occasionally change an entire habitat type (to invasives dominated). Score is at threshold, so viability will be retained, but will benefit from control of invasives.
		LCM Site Intensity	0.6	
		LCM Distance	100	Indicates potential for spread over relatively short time without control depending on species.
	High Subsidence (Rank 4)	Categorical Response	Neutral	Assume minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restorability not feasible.
		LCM Site Intensity	0.97	
		LCM Distance	0	Assume no offsite effect.
	Very High Subsidence (Rank 5)	Categorical Response	Neutral	Assume minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restorability not feasible.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
Erosion	High Erodibility	Categorical Response	Neutral	Assume slightly less impact than for Very High Erodibility below.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
	Very High Erodibility	Categorical Response	Neutral	Assume exposure to Category 3 storm surge in combination with very erodible soils would result in reduction of condition to just below threshold necessitating restoration for near term recovery. See assumptions for storm surge categories.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.
Flood Prone Areas	500 Year Floodplain	Categorical Response	Negative	Assume enough damage to habitat through soil erosion or deposition to require some restoration to bring back habitat and species viability or several years for natural recovery.
		LCM Site Intensity	0.5	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	100-year Floodplain	Categorical Response	Neutral	Assume elements are adapted to this flood level.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Floodway	Categorical Response	Neutral	Assume elements are adapted to this flood level.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Conservation Areas	Areas limited to conservation use	Categorical Response	Positive	No stressors inherent in this use other than those overlapping from other categories. Supports condition and allows for natural restoration.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Resilience Project Protection/ Restoration Actions	Living shoreline implementation	Categorical Response	Positive	Project enacts a shoreline management strategy for controlling erosion and enhancing water quality by providing long-term protection, restoration, or enhancement of vegetated or non-vegetated shoreline habitats. Restoration practices uniformly indicating positive response for human assets, understanding that in some cases some individual structures might potentially be removed for purposes such as allowing for marsh expansion, but at this time it is quite unlikely.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Beach or dune restoration	Categorical Response	Positive	Projects with on-the-ground actions focused on improving beach or dune conditions. May reduce impacts of storm surge and effects of sea level rise and coastal erosion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect
	Marsh restorations.	Categorical Response	Positive	Projects with on-the-ground actions that improve marsh conditions and/or expand marsh area by means of hydrology and thin layer dredge activities that are designed to enhance ecological assets may reduce flooding by slowing and lowering height of storm surge, reducing coastal erosion, and reducing effects of sea level rise.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Restoration of aquatic connectivity	Categorical Response	Positive	Projects with on-the-ground actions in riverine settings that remove or replace man-made barriers to water flow and fish movement (e.g., dams and culverts) may reduce flooding threats and culvert/road failures.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Upland restoration	Categorical Response	Positive	Projects with on-the-ground actions that improve upland conditions and/or expand natural upland area by means that are designed to enhance ecological assets may reduce flooding effects from precipitation-caused flooding upstream.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Riparian and floodplain restoration	Categorical Response	Positive	Projects with on-the-ground actions to improve conditions and/or expand floodplain or riparian area by means that are designed to enhance ecological assets will reduce/prevent erosion and may reduce flooding effects.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Storm Surge	Annual	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.5	
		LCM Distance	0	Assume no offsite effect.
	20-year	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.55	
		LCM Distance	0	Assume no offsite effect.
	100-year	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.6	
		LCM Distance	0	Assume no offsite effect.

Table A3-2. Freshwater Exposure Model structure and assumptions.

<table>
<tr><th colspan="4">Key Assumptions of this Model</th></tr>
<tr><td colspan="2">Applies to any consistently wet habitats or species adapted to freshwater environments.</td><td colspan="2">Responses to stressors focused on water quality impacts, increased salinization, physical impacts on submerged aquatic vegetation, and the potential for other biotic impacts.</td></tr>
<tr><td>Importance Weighting (Optional, used only for the CVS)</td><td>Values range from: 0.0 (Low) to 1.0 (High). There may be as many weighting systems as desired based on rarity, cultural or economic value, etc. Value based on G-rank can be automatically populated if G-rank attribute is provided.</td><td>N/A</td><td>Importance weighting is not set for fish and wildlife elements. Assumption is that that all fish and wildlife elements are equally important.</td></tr>
<tr><td>Element Condition Threshold</td><td>Values range from: 0.0 (Low) to 1.0 (High). This value will determine the LCM result threshold under which a species is no longer viable in a pixel. Nearing 0.0 indicates increasing resilience and nearing 1.0 indicates increasing sensitivity.</td><td>0.7</td><td>Assumption is that freshwater elements have less adaptive capacity to the stressors and threats in this assessment (flooding scour, erosion, salinization) than terrestrial elements. Therefore, they require better condition to maintain function.</td></tr>
<tr><td colspan="4">Land Use Intents (term used in Vista 3.x for all land uses, infrastructure, other stressors and threats, and conservation management and practices anticipated under any scenario). The IUCN/CMP classification list (v3.1, 2011) of direct threats and conservation practices was modified to meet the needs of this project.</td></tr>
</table>

<table>
<tr><th>Primary Category</th><th>Secondary Category</th><th>Response Types</th><th>Responses</th><th>Response Assumptions</th></tr>
<tr><td rowspan="9">Residential & Commercial Development</td><td rowspan="3">High/Medium Density Housing (high imperviousness >50%)</td><td>Categorical Response</td><td>Negative</td><td rowspan="2">Developed/armored shorelines, heavy runoff volume and pollutants, lack of shading with temperature increases. Low restorability.</td></tr>
<tr><td>LCM Site Intensity</td><td>0.2</td></tr>
<tr><td>LCM Distance</td><td>1000</td><td>Long distance effect to compensate for lack of water quality data.</td></tr>
<tr><td rowspan="3">Low Density Housing (moderate imperviousness 20-49%)</td><td>Categorical Response</td><td>Negative</td><td rowspan="2">Septic tank pollutants, effects of clearing such as loss of tree cover and temperature increases, and increased runoff volume and landscape chemicals. Low restorability in general although there is potential to restore hydrologic connectivity and vegetation along streams.</td></tr>
<tr><td>LCM Site Intensity</td><td>0.3</td></tr>
<tr><td>LCM Distance</td><td>300</td><td>Long distance effect to compensate for lack of water quality data.</td></tr>
<tr><td rowspan="3">Developed open spaces (parks, cemeteries, etc.) (low imperviousness <20%)</td><td>Categorical Response</td><td>Negative</td><td rowspan="2">Clearing and temperature increases, human access, and landscaping (runoff volume, pollutants) will degrade habitat below threshold but high restorability potential.</td></tr>
<tr><td>LCM Site Intensity</td><td>0.5</td></tr>
<tr><td>LCM Distance</td><td>100</td><td>Moderate distance effect to compensate for lack of water quality data.</td></tr>
</table>

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Commercial & Industrial Areas (e.g., airports, energy transfer terminals, etc.)	Categorical Response	Negative	Developed/armored shorelines, heavy runoff of freshwater and pollutants may include effects such as waterfowl hazing and noise impacts that would greatly reduce condition Very low potential for restoration.
		LCM Site Intensity	0.2	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
Agriculture and Aquaculture	Silviculture - Intensive	Categorical Response	Negative	Periodic clearing with high impacts on habitat, some impacts on hydrology through sedimentation and potential chemical application.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Silviculture - Sustainable	Categorical Response	Neutral	Small runoff effects from these practices.
		LCM Site Intensity	0.9	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
	Intensive Agriculture	Categorical Response	Negative	Agricultural chemical runoff, sediment runoff, and shoreline erosion may stress elements below the viability threshold. Where agriculture occurs directly on wetlands, significant restoration would be required to bring it back.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Ruderal (maintained pasture, old field)	Categorical Response	Neutral	NOAA indicated some agriculture chemicals used on pastures. Runoff is anticipated to be low, but sediment may runoff depending on uses, and shoreline erosion may stress these elements up to their viability threshold.
		LCM Site Intensity	0.7	
		LCM Distance	300	Long distance effect to compensate for lack of water quality data.
	Aquaculture	Categorical Response	Negative	Habitat alteration, infrastructure, ongoing impacts of waste, nitrogen, and pathogens but high restorability.
		LCM Site Intensity	0.5	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Energy Production and Mining: assume on land	Solar arrays	Categorical Response	Negative	Assessed for impacts from adjacent solar arrays, not within the aquatic elements. More intensive clearing and maintaining of barren ground affects temperature, sedimentation, and some herbicide runoff but with fairly high restorability to natural vegetative cover.
		LCM Site Intensity	0.4	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
Energy Production and Mining: assume on land	Wind	Categorical Response	Negative	Assumption is for a wind field not individual wind towers. Less footprint clearing and maintaining than solar and greater restorability with more remaining natural cover, but height and visual/noise effects may lead to overall similar effect as solar.
		LCM Site Intensity	0.4	
		LCM Distance	300	Height of towers leading to larger visual and noise avoidance impacts will be highly variable.
	Oil and Gas Fields	Categorical Response	Negative	Assumptions for well field, not individual pads. Assume dispersed clearing, maintained dirt pads, roads, noise but with mostly natural habitat in between. Some pollutant runoff expected but fairly high restorability.
		LCM Site Intensity	0.4	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
	Mining	Categorical Response	Negative	Assumption for pit type mining. Effects can include complete removal of habitat, deep excavation, noise, dust, runoff of sediment, vehicle traffic. Difficult restorability and typically to different ecosystem type.
		LCM Site Intensity	0.1	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
Transportation and Service Corridors	Primary roads, e.g., Interstates, high traffic/volume, wide roads, bridges	Categorical Response	Negative	Complete clearing, pavement, vehicular visual and noise disturbance, wildlife mortality, fragmentation, loss of connectivity, and pollutant runoff.
		LCM Site Intensity	0.05	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Transportation and Service Corridors	Secondary roads, e.g., moderate traffic/volume state highways, bridges	Categorical Response	Negative	Assume over water assume bridge with in water and shoreline structures, and clearing leading to altered hydrology, shading, and noise impacts. Assume these impacts will drop immediate area to just below viability threshold.
		LCM Site Intensity	0.6	
		LCM Distance	50	Smaller distance effect with assumed smaller size, volume, and runoff.
	Local, neighborhood and connecting roads, bridges/culverts	Categorical Response	Negative	Assume culvert instead of bridge with in water and shoreline structures, and clearing, altered hydrology, shading, and noise impacts, in addition to the loss of ecological connectivity. Likely more dense than other road types. Assume these impacts will drop immediate area to just below viability threshold.
		LCM Site Intensity	0.6	
		LCM Distance	50	Smaller distance effect with assumed smaller size, volume, and runoff.
	Dirt/Private roads/culverts	Categorical Response	Negative	Assume culverts with intensive onsite impact, shoreline structures, and clearing, altered hydrology, shading, noise, dirt runoff, and impacted connectivity. Assume some restorability.
		LCM Site Intensity	0.5	
		LCM Distance	50	Smaller distance effect with assumed smaller size, volume, and runoff.
	Railroads, bridges, culverts	Categorical Response	Negative	Over water assume bridge with in-water and shoreline structures, and clearing, altered hydrology, shading, and noise impacts. Assume these impacts will drop immediate area to just below viability threshold and low restorability.
		LCM Site Intensity	0.6	
		LCM Distance	50	Smaller distance effect with assumed smaller size, volume, and runoff.
	Utility & Service Lines (overhead transmission, cell towers, etc.)	Categorical Response	Neutral	Assume over water feature with in-water support structures, infrequent maintenance, and noise impacts. High restorability.
		LCM Site Intensity	0.9	
		LCM Distance	20	Very small distance effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Dredge Material Placement Areas		Categorical Response	Negative	Assumption is not for dredge materials to be placed within aquatic systems, but offsite effects would include chemical and sediment runoff. Moderate restorability to vegetative cover that would reduce impacts to adjacent aquatic systems.
		LCM Site Intensity	0.3	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
Dams & Reservoirs	All dams and reservoirs	Categorical Response	Negative	Significant change of ecosystem type, hydrology, connectivity, long term sedimentation and significant costs to restore
		LCM Site Intensity	0.2	
		LCM Distance	300	Fairly long-distance effect in terms of changed water chemistry and temperature, disrupted connectivity, and reduced natural sedimentation.
Sea Level Rise	See flooding threats table for level used.	Categorical Response	Negative	Conversion to saline adapted habitat, no ability to restore.
		LCM Site Intensity	0.05	
		LCM Distance	30	Distance effects include groundwater backup and saline intrusion, and edge effects of habitat conversion. Impacts will be highly variable based on topography and groundwater formations.
Storm Surge	Annual	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.75	
		LCM Distance	0	Assume no offsite effect.
	20-year	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.7	
		LCM Distance	0	Assume no offsite effect.
	100-year	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.7	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Other threats	Water Quality - Moderate	Categorical Response	Neutral	Assume moderate water quality will just maintain viability.
		LCM Site Intensity	0.7	
		LCM Distance	100	For partial water quality data, distance effect can extrapolate further, optional distance effect depending on the nature of data.
	Water Quality - Low	Categorical Response	Negative	These levels set to indicate restoration even with improved water quality may be difficult to remediate, since contaminated sediments have ongoing long-term effects.
		LCM Site Intensity	0.4	
		LCM Distance	100	For partial water quality data, distance effect can extrapolate further, optional distance effect depending on the nature of data.
	Invasive Species - Aquatic	Categorical Response	Negative	Aquatic species cause biotic and sometimes habitat level effects and are difficult to control.
		LCM Site Intensity	0.5	
		LCM Distance	300	Indicates potential for spread of invasives over a large distance depending on species and conditions.
Subsidence	High Subsidence (Rank 4)	Categorical Response	Neutral	Minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have a small multiplicative effect.
		LCM Site Intensity	0.97	
		LCM Distance	0	Assume no offsite effect.
	Very High Subsidence (Rank 5)	Categorical Response	Neutral	Minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
Erosion	High Erodibility	Categorical Response	Neutral	Freshwater wetland systems would be less exposed to erosion events, so in combination with Storm Surge Category 4 would drop below viability threshold.
		LCM Site Intensity	0.85	
		LCM Distance	0	Assume no offsite effect.
	Very High Erodibility	Categorical Response	Neutral	Freshwater wetland systems would be less exposed to erosion events, so in combination with Storm Surge Category 4 would drop below viability threshold.
		LCM Site Intensity	0.85	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Flood Prone Areas	500 Year Floodplain	Categorical Response	Negative	Impact at just below viability threshold to indicate that some restoration action and/or years may be needed to restore viability from erosion, sedimentation, deposition of pollutants and anthropogenic debris, dispersal of invasives, and other severe impacts on species life histories/populations.
		LCM Site Intensity	0.6	
		LCM Distance	0	No offsite effect.
Conservation Areas		Categorical Response	Positive	No stressors inherent in this use other than those overlapping from other categories. Supports condition and allows for natural restoration.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Resilience Project Protection/ Restoration Actions *(categories needed for Scenario breakouts)*	Living shoreline implementation	Categorical Response	Neutral	Project enacts a shoreline management strategy for controlling erosion and enhancing water quality by providing long-term protection, and restoration or enhancement of vegetated or non-vegetated shoreline habitats. Restoration practices uniformly indicate positive response for human assets, understanding that in some cases individual structures might be removed for purposes such as allowing for marsh expansion in the future.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.
	Beach or dune restoration	Categorical Response	Positive	Projects with on-the-ground actions focused on improving beach or dune conditions may reduce impacts of storm surge and effects of sea level rise and coastal erosion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Marsh restorations	Categorical Response	Positive	Projects with on-the-ground actions that improve marsh conditions and/or expand marsh area by means of hydrologic restoration and thin layer sediment deposition can enhance ecological assets and reduce flooding by slowing and lowering height of storm surge, reducing coastal erosion, and reducing the effects of sea level rise.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	**Secondary Category**	**Response Types**	**Responses**	**Response Assumptions**
	Restoration of aquatic connectivity	Categorical Response	Positive	Projects with on-the-ground actions in riverine settings that remove or replace man-made barriers to water flow and fish movement (e.g., dams and culverts) may reduce flooding threats and culvert/road failures.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Upland restoration	Categorical Response	Positive	Projects with on-the-ground actions that improve upland conditions and/or expand natural upland area by means designed to enhance ecological assets may reduce flooding effects from precipitation-caused flooding upstream.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Riparian and floodplain restoration	Categorical Response	Positive	Projects with on-the-ground actions to improve conditions and/or expand floodplain or riparian area by means designed to enhance ecological assets may reduce/prevent erosion and may reduce flooding effects.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Table A3-3. Estuarine exposure model structure and assumptions.

Key Assumptions of this Model			
Applies to any consistently wet habitats or species adapted to brackish conditions but not necessarily ocean-level salinity so may be sensitive to storm surges and sea level rise.		Responses to stressors focused on water quality impacts, increased salinization, physical impacts on submerged aquatic vegetation, and the potential for other biotic impacts.	
Importance Weighting (Optional, used only for the CVS)	Values range from: 0.0 (Low) to 1.0 (High). There may be as many weighting systems as desired based on rarity, cultural or economic value, etc. Value based on G-rank can be automatically populated if G-rank attribute is provided.	N/A	Importance weighting not set for fish and wildlife elements. The assumption is all are equally important.
Element Condition Threshold	Values range from: 0.0 (Low) to 1.0 (High). This value will determine the LCM result threshold under which a species is no longer viable in a pixel. Nearing 0.0 indicates increasing resilience and nearing 1.0 indicates increasing sensitivity.	0.6	Assume that saltwater/brackish habitats for this project's consideration are better adapted to the types of flooding impacts and will have greater connectivity and ability to recover from impacts.
Land Use Intents (term used in Vista 3.x for all land uses, infrastructure, other stressors and threats, and conservation management and practices anticipated under any scenario). The IUCN/CMP classification list (v3.1, 2011) of direct threats and conservation practices was modified to meet the needs of this project.			

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Residential & Commercial Development	High/Medium Density Housing (high imperviousness>50%)	Categorical Response	Negative	Developed/armored shorelines, clearing, heavy runoff volume and pollutants (more dilution capability than FW systems assumed), very low restorability.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Low Density Housing (moderate imperviousness 20-49%)	Categorical Response	Negative	Assume primary impacts are septic tank pollutants, effects of clearing such as loss of tree cover and temperature increases, and increased runoff volume and landscape chemicals. In brackish systems, impacts may also include shoreline armoring and dock structures within habitats. Some restoration possible depending on density of development to restore hydrologic connectivity and shoreline vegetation.
		LCM Site Intensity	0.5	
		LCM Distance	300	Long distance effect to compensate for lack of water quality data.
	Developed open spaces (parks, cemeteries, etc.) (low imperviousness <20%)	Categorical Response	Neutral	Assume clearing and temperature increases, human access, and landscaping (runoff volume, pollutants) will degrade below viability threshold but high restorability.
		LCM Site Intensity	0.5	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Commercial & Industrial Areas (e.g., airports, energy transfer terminals, etc.)	Categorical Response	Negative	Assume developed/armored shorelines and heavy runoff of freshwater and pollutants may cause effects, such as waterfowl hazing and noise that would greatly reduce condition below viability. Substantial restoration required to bring back viability, and in some cases successful restoration might not be possible.
		LCM Site Intensity	0.2	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
Agriculture and Aquaculture	Silviculture - Intensive	Categorical Response	Neutral	Assume periodic clearing with high impacts on habitat, some on hydrology, sedimentation, and from chemical application. It would induce stress well below the viability threshold and require significant restoration.
		LCM Site Intensity	0.6	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Silviculture - Sustainable	Categorical Response	Neutral	Small runoff effects from these practices.
		LCM Site Intensity	0.9	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
	Intensive Agriculture	Categorical Response	Negative	Assume no agriculture directly in brackish elements, so expect sediment and pesticide runoff from adjacent land use. Estuarine elements assumed to have somewhat less sensitivity to runoff than freshwater elements. Restoration potential is high.
		LCM Site Intensity	0.5	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Ruderal (maintained pasture, old field)	Categorical Response	Negative	NOAA indicated some agriculture chemicals used on pastures. Runoff is anticipated to be low, but some sediment may runoff depending on uses, and shoreline erosion may stress these elements to their viability threshold making them not viable.
		LCM Site Intensity	0.7	
		LCM Distance	300	Long distance effect to compensate for lack of water quality data.
	Aquaculture	Categorical Response	Negative	Assume habitat alteration, infrastructure, ongoing impacts of waste, nitrogen, and pathogens. Somewhat less impact relative to the viability threshold than on freshwater habitats due to dilution effect. High restorability.
		LCM Site Intensity	0.5	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Energy Production and Mining: assume on land	Solar arrays	Categorical Response	Negative	Assessed for impacts from adjacent solar arrays, not within the aquatic elements. Assume more intensive clearing and maintaining of barren ground affects temperature, sedimentation, and potential for some herbicide runoff but with fairly high restorability to natural vegetative cover.
		LCM Site Intensity	0.4	
		LCM Distance	50	Moderate distance effect to compensate for lack of water quality data.
	Wind	Categorical Response	Neutral	Assume a wind generation field, not individual turbines that can have intensive site impacts that take condition to the viability threshold but with high restorability.
		LCM Site Intensity	0.6	
		LCM Distance	300	Height of towers leading to larger visual and noise avoidance by some species.
	Oil and Gas Fields	Categorical Response	Negative	Assume well field, not individual pads, requires clearing, maintained dirt pads, roads affecting hydrology (changed grades, culverts), and creates noise. These activities are likely to increased runoff, sedimentation, and toxins, potentially armored shorelines. Moderate restorability.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Mining	Categorical Response	Negative	Assume land-based mining. Effects can include noise, dust, runoff of sediment, vehicle traffic, and the installation of culverts. Hydrology is Difficult restorability typically to different ecosystem type.
		LCM Site Intensity	0.3	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
Transportation and Service Corridors	Primary roads, e.g., Interstates, high traffic/volume, wide roads, bridges	Categorical Response	Neutral	Assume over water bridge will have in-water and shoreline structures, shoreline clearing, altered hydrology, shading, and noise impacts. The impacts will drop immediate area to just below viability threshold. Restorability unlikely for public roads.
		LCM Site Intensity	0.4	
		LCM Distance	50	Somewhat longer distance effect when lack of water quality data.
	Secondary roads e.g., moderate traffic/volume state highways, bridges	Categorical Response	Negative	Assume over water bridge will have in-water and shoreline structures, shoreline clearing, altered hydrology, shading, and noise impacts. The impacts will drop immediate area to just below viability threshold. Restorability unlikely for public roads.
		LCM Site Intensity	0.5	
		LCM Distance	30	Relatively small distance effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Local, neighborhood and connecting roads, bridges/culverts	Categorical Response	Negative	Assume mostly culverts instead of bridges with in-water and shoreline structures, clearing, altered hydrology, shading, and noise impacts, and loss of ecological connectivity. Likely more dense than other road types causing the immediate area to drop just below the viability threshold.
		LCM Site Intensity	0.5	
		LCM Distance	50	Relatively small distance effect.
	Dirt/Private roads/culverts	Categorical Response	Negative	Assume culverts with intensive onsite impact, shoreline structures, clearing, altered hydrology, shading, noise impacts, dirt runoff, and impacted connectivity. Assume some restorability possible.
		LCM Site Intensity	0.5	
		LCM Distance	50	Relatively small distance effect.
	Railroads, bridges, culverts	Categorical Response	Negative	Assume bridge with in-water and shoreline structures, clearing, altered hydrology, shading, and noise impacts. Assume these impacts will drop immediately affected area to just below viability threshold.
		LCM Site Intensity	0.5	
		LCM Distance	50	Relatively small distance effect.
	Utility & Service Lines (overhead transmission, cell towers, etc.)	Categorical Response	Neutral	Assume over-water feature with some in-water support structures, but infrequent maintenance or noise. High restorability.
		LCM Site Intensity	0.9	
		LCM Distance	20	Relatively small distance effect.
Dredge Material Placement Areas		Categorical Response	Negative	Assume dredge materials will not be placed within aquatic systems. Offsite effects could include chemical and sediment runoff. Moderate restorability for vegetative cover that would reduce impacts to adjacent aquatic systems.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Dams & Reservoirs	Any mapped dams and reservoirs	Categorical Response	Negative	Assume dam is on a stream that feeds into an estuarine habitat (although GIS only assessing distance effect from dam itself). Impacts include changes in hydrology/freshwater flow, reduction of sediment, temperature changes, potential increased salinity, and reduced connectivity for anadromous fish. Some potential for restoration through restored connectivity/dam removal.
		LCM Site Intensity	0.4	
		LCM Distance	300	Distance effect in terms of changed water chemistry and temperature, disrupted connectivity, and reduced natural sedimentation.
Sea Level Rise	See flooding threats table for level used.	Categorical Response	Negative	Assume water column will deepen affecting light, increased salinity and wave action. For the SLR level used in assessment, assume some adaptive capacity for marshes to accrete and maintain elevation, but habitat type conversion is likely. Total loss is not expected. The effect will be highly variable depending on the location and type of element. Restorability possible for techniques such as thin layer deposition to assist adaptation.
		LCM Site Intensity	0.4	
		LCM Distance	30	Distance effects include groundwater backup and saline intrusion, and edge effects of habitat conversion. The effects will be highly variable based on topography and groundwater formations.
Storm Surge	Annual	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.65	
		LCM Distance	0	Assume no offsite effect.
	20 year	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect.
	100-year	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Other threats	Water Quality - Moderate	Categorical Response	Neutral	Assume moderate water quality is just above element viability threshold, so viability is maintained. Restoration is possible if sources impairing water quality are addressed.
		LCM Site Intensity	0.7	
		LCM Distance	100	Extrapolates incomplete water quality data to surrounding waters.
	Water Quality - Low	Categorical Response	Negative	Assume impact relative to threshold is somewhat less than freshwater. It Assume greater dilution/flushing action. Restorability is possible if sources impairing water quality are addressed.
		LCM Site Intensity	0.5	
		LCM Distance	100	Extrapolates incomplete water quality data to surrounding waters.
	Invasive Species - Aquatic	Categorical Response	Negative	Assume aquatic species are much more difficult to control in an open marine/estuarine system compared to streams/lakes. Restorability is low because it is difficult to manage and effectively remove aquatic species from a given habitat.
		LCM Site Intensity	0.3	
		LCM Distance	300	Indicates a potentially large distance of spread of invasives depending on species and conditions.
	Invasive Species - Terrestrial	Categorical Response	Neutral	No anticipated effect.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Subsidence	High Subsidence (Rank 4)	Categorical Response	Neutral	Assume minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restorability not feasible.
		LCM Site Intensity	0.97	
		LCM Distance	0	Assume no offsite effect.
	Very High Subsidence (Rank 5)	Categorical Response	Neutral	Assume minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restorability not feasible.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Erosion	High Erodibility	Categorical Response	Neutral	Assume estuarine wetland systems are better adapted to currents from tidal action so the element would be above the viability threshold, however if erosion is combined with e Storm Surge Category 3, it would drop below the viability threshold. Restorability is high.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect.
	Very High Erodibility	Categorical Response	Neutral	Assume estuarine wetland systems are better adapted to currents from tidal action so the element would be above the viability threshold, however if erosion is combined with Storm Surge Category 3, it would drop below the viability threshold. Restorability is high.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect
Flood Prone Areas	500 Year Floodplain	Categorical Response	Negative	Assume impact right at viability threshold. Experience from Hurricane Harvey indicated nearshore (and deeper) habitat impacts from high levels of freshwater input that occurred for an extensive period of time and traveled long distances in plumes. Assume will recover on own over time. Other impacts can include sedimentation, deposition of pollutants and anthropogenic debris, some impacts on species life histories/populations, and vegetation from freshwater exposure. Note: Because floodplain effects not mapped into marine areas, not capable of mapping the distance effect currently. Restorability would require extensive work and investment.
		LCM Site Intensity	0.6	
		LCM Distance	0	Assume no offsite effect.
Conservation Areas		Categorical Response	Positive	Assume no stressors inherent in this use other than those overlapping from other categories. Supports condition and allows for natural restoration. Restorability is high.
		LCM Site Intensity	1	Assume no offsite effect.
		LCM Distance	0	

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Resilience Project Protection/ Restoration Actions (categories needed for Scenario breakouts)	Living shoreline implementation	Categorical Response	Positive	Assume project enacts a management strategy for controlling erosion and enhancing water quality by providing long-term protection, and restoration or enhancement of vegetated or non-vegetated shoreline habitats Restoration practices uniformly indicate positive response for human assets, understanding that in some cases individual structures might be removed in the future for purposes, such as allowing for marsh expansion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Beach or dune restoration	Categorical Response	Positive	Assume projects with on-the-ground actions focused on improving beach or dune conditions may reduce impacts of storm surge and effects of sea level rise and coastal erosion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Marsh restorations.	Categorical Response	Positive	Assume projects with on-the-ground actions that improve marsh conditions and/or expand marsh area by means of hydrology and thin layer dredge activities are designed to enhance ecological assets. They may reduce flooding by slowing and lowering height of storm surge, reducing coastal erosion, and reducing effects of sea level rise.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Restoration of aquatic connectivity	Categorical Response	Positive	Assume projects with on-the-ground actions in riverine settings that remove or replace man-made barriers to water flow and fish movement (e.g., dams and culverts) may reduce flooding threats and culvert/road failures.
		LCM Site Intensity	1	Assume no offsite effect.
		LCM Distance	0	
	Upland restoration	Categorical Response	Positive	Assume projects with on-the-ground actions that improve upland conditions and/or expand natural upland area by means designed to enhance ecological assets may reduce flooding effects from precipitation-caused flooding upstream.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Riparian and floodplain restoration	Categorical Response	Positive	Assume projects with on-the-ground actions to improve conditions and/or expand floodplain or riparian area by means designed to enhance ecological assets should reduce/prevent erosion and may reduce flooding effects.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Table A3-4. Human Asset Exposure Model Structure and Assumptions.

<table>
<tr><th colspan="4">Key Assumptions of this Model</th></tr>
<tr><td colspan="2">Applies to all human community assets</td><td colspan="2">Responses to stressors focused on physical damage/loss from flooding</td></tr>
<tr><td colspan="4">Note: elevated roads/bridges were not separated from surface roads is the source data, so they are treated equally.
Note: because built infrastructure used for baseline stressors are Human Assets there is no response/impact and those stressors are not included in this table.</td></tr>
<tr><td rowspan="10">Importance Weighting (Optional, used only for the CVS)</td><td rowspan="10">Values range from: 0.0 (Low) to 1.0 (High). These ratings were approximated from those used in the regional coastal resilience assessment.</td><td>0.2</td><td>Critical Infrastructure (Rank 1)</td></tr>
<tr><td>0.2</td><td>Environmental Justice Rank 1</td></tr>
<tr><td>0.2</td><td>Population Density (Rank 1)</td></tr>
<tr><td>0.4</td><td>Critical Infrastructure (Rank 2)</td></tr>
<tr><td>0.4</td><td>Population Density (Rank 2)</td></tr>
<tr><td>0.6</td><td>Critical Infrastructure (Rank 3)</td></tr>
<tr><td>0.6</td><td>Population Density (Rank 3)</td></tr>
<tr><td>0.8</td><td>Population Density (Rank 4)</td></tr>
<tr><td>1.0</td><td>Critical Facilities</td></tr>
<tr><td>1.0</td><td>Population Density (Rank 5)</td></tr>
<tr><td>Element Condition Threshold</td><td>Values range from: 0.0 (Low) to 1.0 (High). This value will determine the LCM result threshold under which a species is no longer viable in a pixel. Nearing 0.0 indicates increasing resilience and nearing 1.0 indicates increasing sensitivity.</td><td>0.5</td><td>Assume human assets have moderate sensitivity owing to their ability to repair/rebuild vs. ecological features that can rarely be restored to original type/health or take a very long time to recover naturally.</td></tr>
<tr><td colspan="4">Land Use Intents (term used in Vista 3.x for all land uses, infrastructure, other stressors and threats, and conservation management and practices anticipated under any scenario). The IUCN/CMP classification list (v3.1, 2011) of direct threats and conservation practices was modified to meet the needs of this project.</td></tr>
</table>

<table>
<tr><th>Primary Category</th><th>Secondary Category</th><th>Response Types</th><th>Responses</th><th>Response Assumptions
(Restorability is not included because assets are not natural features to be restored.)</th></tr>
<tr><td rowspan="3">Sea Level Rise</td><td rowspan="3">U se 1-foot SLR in targeted watersheds to represent 2050 timeframe for planning purposes.</td><td>Categorical Response</td><td>Negative</td><td rowspan="2">Assume severe impact but not complete loss if there is built protection for key assets. This may include raising structures, converting key roads to causeways, etc.</td></tr>
<tr><td>LCM Site Intensity</td><td>0.2</td></tr>
<tr><td>LCM Distance</td><td>50</td><td>Distance indicating impacts from backup of groundwater can flood/destabilize foundations of structures and increase susceptibility to wave action.</td></tr>
<tr><td rowspan="3">Storm Surge</td><td rowspan="3">Annual</td><td>Categorical Response</td><td>Negative</td><td rowspan="2">See assumptions in Appendix introduction.</td></tr>
<tr><td>LCM Site Intensity</td><td>0.6</td></tr>
<tr><td>LCM Distance</td><td>0</td><td>Assume no offsite effect.</td></tr>
</table>

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions *(Restorability is not included because assets are not natural features to be restored.)*
	20 year	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.65	
		LCM Distance	0	Assume no offsite effect.
	100-year	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.7	
		LCM Distance	0	Assume no offsite effect.
		LCM Site Intensity	0.99	
		LCM Distance	0	Assume no offsite effect.
Subsidence	High Subsidence (Rank 4)	Categorical Response	Neutral	Assume minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restorability not feasible.
		LCM Site Intensity	0.97	
		LCM Distance	0	Assume no offsite effect.
	Very High Subsidence (Rank 5)	Categorical Response	Neutral	Assume minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restorability not feasible.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
Flat (Slope <=0.75%) & Poor Drainage	Flat & Somewhat poorly drained	Categorical Response	Neutral	Assume areas of flattest slope and somewhat poorly draining soils under extreme precipitation events will lead to flooding. It could approach the 100-year floodplain in level of impact.
		LCM Site Intensity	0.6	
		LCM Distance	0	Assume no offsite effect.
	Flat & Poor or Very poorly drained	Categorical Response	Neutral	Assume areas of flattest slope and poorest draining soils under extreme precipitation events may lead to flooding approaching that of a 100-year floodplain.
		LCM Site Intensity	0.5	
		LCM Distance	0	Assume no offsite effect.
Erosion	High Erodibility	Categorical Response	Neutral	Assume only a minor impact on human community assets that may require some remediation.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.
	Very High Erodibility	Categorical Response	Neutral	Assume that in combination with Storm Surge Category 3, expect condition to drop below the viability threshold.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions *(Restorability is not included because assets are not natural features to be restored.)*
Flood Prone Areas	Occasional Flooded Soils	Categorical Response	Neutral	Assume structures may be vulnerable but will remain viable unless there are additional stressors or threats in these areas.
		LCM Site Intensity	0.5	
		LCM Distance	0	Assume no offsite effect.
	Frequent Flooded Soils	Categorical Response	Negative	Assume conditions should indicate older structures as just barely non-viable because newer structures built in floodplain areas are probably designed for them.
		LCM Site Intensity	0.4	
		LCM Distance	0	Assume no offsite effect.
	500 Year Floodplain	Categorical Response	Negative	Assume similar impacts to full cumulative storm surge.
		LCM Site Intensity	0.2	
		LCM Distance	0	Assume no offsite effect.
	100-year Floodplain	Categorical Response	Negative	Assume structures in these areas will sustain some damage bringing them to just below the viability threshold. Therefore, if flooded, the structures would require repair to remain viable.
		LCM Site Intensity	0.4	
		LCM Distance	0	Assume no offsite effect.
	Floodway	Categorical Response	Neutral	Assume it is highly unlikely to have human community assets directly within the floodway. A score of .9 was applied to assets in the floodway. They are vulnerable, however, likely to remain viable because they were designed with the anticipation of flooding in the area.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.
Conservation Areas	Areas designated for conservation use	Categorical Response	Positive	Assume no stressors inherent in this use other than those overlapping from other categories. Conservation areas will support condition and allow for natural restoration.
		LCM Site Intensity	1.0	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	**Response Assumptions** *(Restorability is not included because assets are not natural features to be restored.)*
Resilience Project Protection/ Restoration Actions *(categories needed for Scenario breakouts)*	Living shoreline implementation	Categorical Response	Positive	Assume project enacts a shoreline management strategy for controlling erosion and enhancing water quality by providing long-term protection, restoration, or enhancement of vegetated or non-vegetated shoreline habitats.
		LCM Site Intensity	1	Restoration practices uniformly indicating positive response for human assets, understanding that in some cases individual structures might be removed in the future to promote and maintain resilience of the human or natural communities. For example, marsh expansion that would help mitigate flooding.
		LCM Distance	0	Assume no offsite effect.
	Beach or dune restoration	Categorical Response	Positive	Projects with on-the-ground actions focused on improving beach or dune conditions. May reduce impacts of storm surge and effects of sea level rise and coastal erosion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect
	Marsh restorations	Categorical Response	Positive	Assume projects with on-the-ground actions that improve marsh conditions and/or expand marsh area by means of hydrology and thin layer dredge activities are designed to enhance ecological assets. They may reduce flooding by slowing and lowering the height of storm surge, as well as reducing coastal erosion, and the effects of sea level rise.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Restoration of aquatic connectivity	Categorical Response	Positive	Assume projects with on-the-ground actions in riverine settings that remove or replace man-made barriers to water flow and fish movement (e.g., dams and culverts) may reduce flooding threats and culvert/road failures.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	**Secondary Category**	**Response Types**	**Responses**	**Response Assumptions** *(Restorability is not included because assets are not natural features to be restored.)*
	Upland restoration	Categorical Response	Positive	Assume projects with on-the-ground actions that improve upland conditions and/or expand natural upland area by means designed to enhance ecological assets may reduce flooding effects from precipitation-caused flooding upstream
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.2
	Riparian and floodplain restoration	Categorical Response	Positive	Assume projects with on-the-ground actions to improve conditions and/or expand floodplain or riparian area by means designed to enhance ecological assets may reduce/prevent erosion and may reduce flooding effects.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Appendix 4. Fish and Wildlife Vulnerability Index

The purpose of the fish and wildlife vulnerability index analyses is to understand how condition (and therefore vulnerability) of the fish and wildlife elements may be impacted from the stressors and threats. The modeling of the elements' current condition informed scoring of the Resilience Hubs but vulnerability to stressors and threats was also modeled. These assessments can be informative for several uses. Most directly, they can inform resilience project design to understand what stressors and threats fish and wildlife located at the project site may be subject to and, therefore, what actions will be needed to mitigate those threats. The flooding threats assessment can also inform the potential lifespan of resilience projects relative to fish and wildlife; in particular whether the area is subject to sea level rise over the 20-30 year timespan of this assessment. Separate from the intended co-benefits of building nature-based community resilience projects, this index can also be very useful for those organizations primarily concerned with fish and wildlife conservation by informing areas of high value but also vulnerability and the nature of stressors and threats in those areas.

Methods

Vulnerability is calculated based on the effect of stressors and threats on condition, subject to application of a threshold where condition scores below a specified level equate to vulnerability. The three scenarios under which vulnerability were assessed are:

1. Current vulnerability (where elements are subject to current stressors such as land uses and impaired water quality),
2. Vulnerability to flooding threats (where elements are subject to flooding threats only), and
3. Combined vulnerability (where elements are subject to the cumulative effects of all stressors and threats).

This analysis goes beyond an exposure assessment by combining element exposure, sensitivity, and adaptive capacity in the model. Specifically, the objectives were to:

1. Understand the current condition for selected fish and wildlife elements by assessing their vulnerability to the fish and wildlife stressors. The current condition of elements can help inform actions for areas based on: 1) whether protection alone is adequate to maintain the viability of elements (good condition), 2) areas where restoration is practical and would return elements to a viable state (intermediate condition), and 3) areas that may have a poor return on conservation or restoration investment (poor condition) because mitigation of stressors is either not practical or cost prohibitive.
2. Understand where and how element condition may change from flooding threats. This analysis can inform how these threats alone may impact element viability, if action is practical in threatened areas, and, if so, what type of action and over what time frame may be effective.
3. Understand where and how current stressors and flooding threats may act cumulatively to further reduce condition of elements to non-viable states. For example, where an element is currently viable, but experiencing moderate impacts from water quality such that it may become non-viable when the threat of storm surge is added. This information can inform

decisions about actions in terms of the ability to keep elements in a viable state when stressors and threats combine and for what duration a viable state may be sustained (i.e., relative to the assessed sea level rise).

The method for assessing vulnerability under each group of stressors and threats is the same as described and depicted in the steps and **Figure A4-1** below.

The steps of the process, detailed in Appendix 2 and Appendix 3, are outlined below:

1. Assemble fish and wildlife element distribution data and viability requirements.
2. Compile the relevant fish and wildlife stressors (stressors) and flooding threats (threats) data in scenarios to be assessed (current stressors, threats, combined stressors, and threats).

Steps to model element vulnerability under each scenario:

1. Select fish and wildlife elements to be assessed.
2. Select the stressors and threats scenarios to assess the elements vulnerability.
3. Populate vulnerability (condition) models of how each element group (terrestrial, freshwater, estuarine) responds to each stressor and threat that can occur in a scenario (see Appendix 3 for model parameters).
4. Apply the vulnerability models to the scenario to generate watershed-wide condition maps.
5. Intersect fish and wildlife distributions with the resulting watershed condition maps to generate condition maps for each element and apply the condition threshold (see Appendix 3) to each element condition map to identify areas falling below the threshold. This indicates what areas of the element's distribution is vulnerable.
6. Sum the vulnerable elements in each area to generate the index.

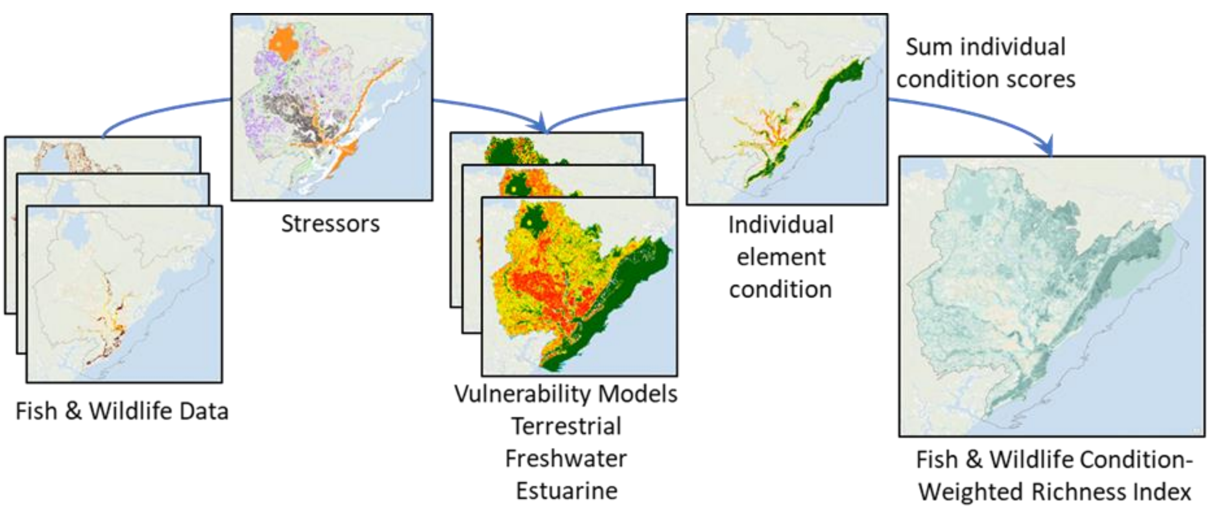


Figure A4-1. Method for calculating fish and wildlife vulnerability indices*. Elements are intersected with stressors and/or threats, the vulnerability model is applied, and individual element vulnerability results are summed to create each index. Diagram represents Charleston, SC as an example and is only intended to illustrate methods.*

Results

This set of analyses represents vulnerability of fish and wildlife elements based on current stressors in the watershed, flooding threats, and the combination of those stressors and threats to model the potential synergies among them. Each of these analyses, illustrated and described below, provides unique information to inform actions to conserve or restore fish and wildlife habitat.

1. **Baseline Vulnerability Analysis.** This analysis evaluated the effects of current stressors on fish and wildlife elements and illustrates currently impacted areas that may be targeted for mitigation of stressors and restoration actions.

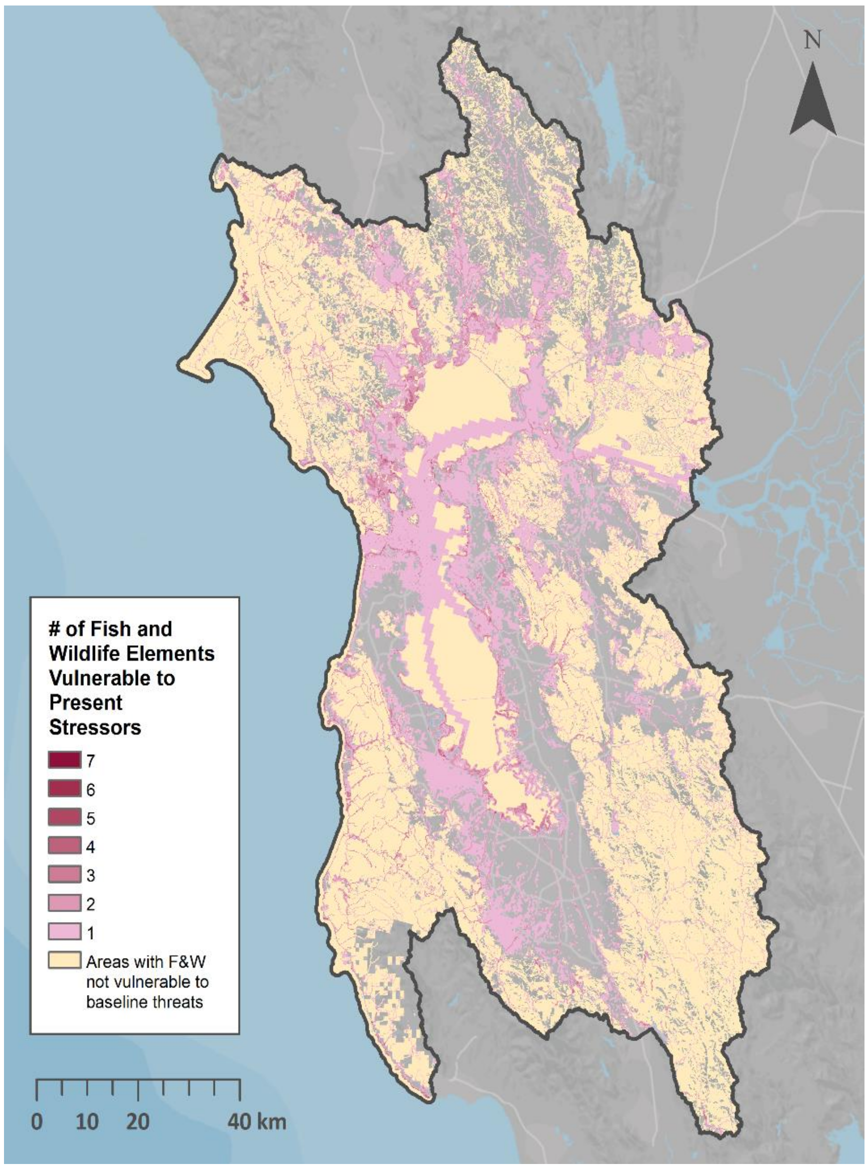


Figure A4-2. Fish and Wildlife Baseline Vulnerability for the San Francisco Bay and Outer Coast Watersheds. *This map is an overlay or index of all fish and wildlife elements that are vulnerable to the existing mapped stressors. Gray areas within the project boundary represent areas with no mapped fish and wildlife elements.*

2. **Fish and wildlife vulnerability to flooding threats**. This index models the vulnerability of fish and wildlife elements to flooding threats. It illustrates areas where, regardless of current condition, fish and wildlife populations and habitat may be significantly impacted by flooding threats (for example, bird nesting habitat and fish spawning substrate may be altered or destroyed). It also identifies areas where the benefits of conservation or restoration actions may ultimately be reduced by flooding. The Essential Fish Habitat element is the single element throughout the bays that are indicated as vulnerable in Figure A4-3 and this is primarily due to sea level rise (SLR). While pelagic habitats are not expected to be impacted by SLR, near-shore habitats such as nursery areas for fish may be. This assessment was mostly concerned with areas within 50m of shorelines so that zone was used to assess SLR vulnerability. Because the element's map extends throughout the bays, they are indicated as vulnerable throughout.

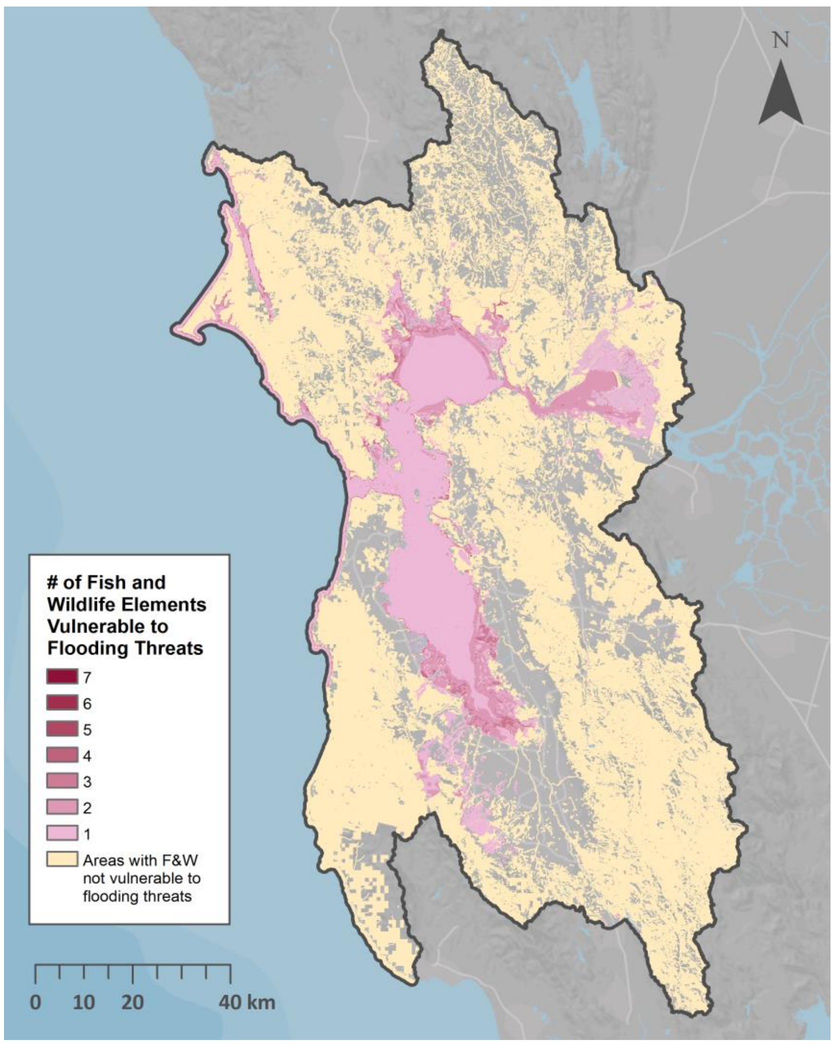


Figure A4-3. Fish and wildlife vulnerability to flooding threats in the San Francisco Bay and Outer Coast Watersheds*. Pink to red shades indicate the number of elements vulnerable to flooding threats. Tan areas indicate areas of low to no impact. Gray areas within the project boundary represent areas with no mapped fish and wildlife elements.*

3. **Combined Fish and Wildlife Vulnerability Index**. This index combines the results of the above two analyses to model the cumulative effects of current stressors and flooding threats. This index illustrates areas where cumulative effects may increase the vulnerability of fish and wildlife.

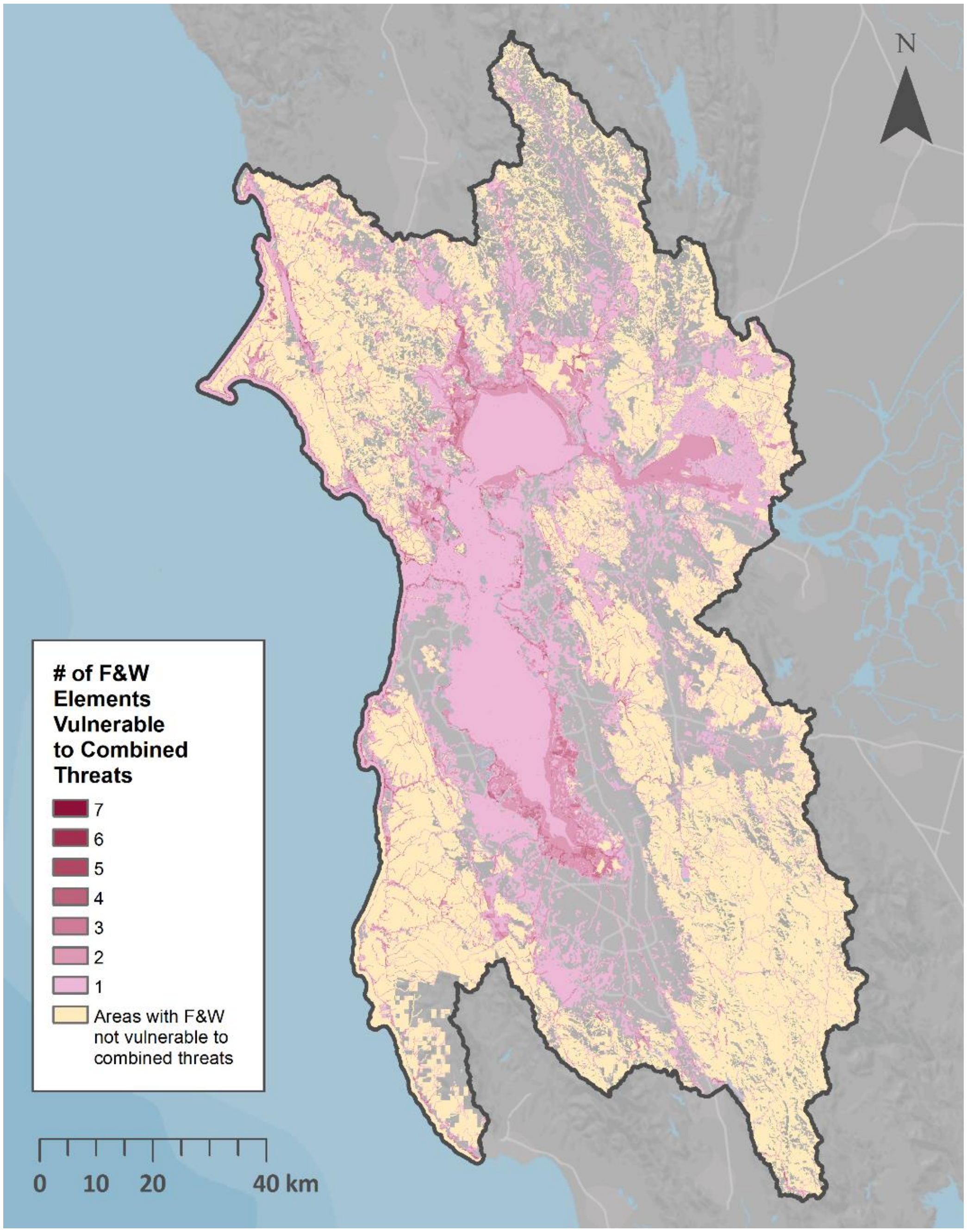


Figure A4-4. Fish and wildlife elements vulnerability to combined stressors and flooding threats for the San Francisco Bay and Outer Coast Watersheds. *Pink to red shades indicate the number of elements vulnerable to threats. Tan areas indicate areas of low to no impact from the baseline threats. Gray areas within the project boundary represent areas with no mapped fish and wildlife elements.*

As observed in these results, there are areas of vulnerability to stressors associated with human uses and impaired water quality throughout much of the watershed. The combination of stressors and flooding threats intensifies vulnerability in the areas closest to the coast and extending up the rivers.

These results may be accessed through the Vista project.

Limitations

These analyses are subject to limitations of the available data and decisions about the selection of fish and wildlife stressors and the flooding threats. The vulnerability indices used a relatively simple model. Limitations expressed in the Fish and Wildlife Assessments methods are incorporated in these limitations. In addition to those limitations, the setting of condition thresholds for the three fish and wildlife groups (terrestrial, freshwater, and estuarine) is subjective; whether an element is calculated as vulnerable in a location is highly sensitive to the threshold set.

Appendix 5. Fish and Wildlife Element Selection and Inventory of Elements

This appendix includes additional detailed information about the fish and wildlife elements used in the Fish and Wildlife Richness Index.

Table A5-1. Data sources used and preparation notes for spatial data used to represent fish and wildlife elements in this assessment. *Where relevant, notes are provided on filtering and/or other data preparation steps applied to generate final data layers. For all elements included in the assessment, the available data was used. No data was found and rejected for included elements; elements with inadequate data were not included in the assessment.*

Fish/Wildlife Element	Data Source(s) Used
NOAA Trust Resources	
Pinniped haul-outs	Merged: • Critical habitat data for Stellar sea lion (NOAA) • Statewide pinniped haul-out and rookery point data and count data on California sea lions, Northern fur seals, Northern elephant seals and harbor seals based on survey data from various sources (NOAA)
Essential Fish Habitat/important habitat for key fish species	West coast essential fish habitat for salmon EFH, coastal pelagic species and groundfish (NOAA)
At-Risk Species, Species of Special Interest, and Multi-species Aggregations	
Southern sea otter	USGS Annual California Sea Otter census
California Ridgway's rail	Models of Ridgway's rail density based on 8 years of annual surveys of Point Blue and partners. A density cut off of greater than 0 was used to make a binary distribution layer.
Snowy plover	Compilation of current and recent Snowy plover nesting locations from Point Blue and San Francisco Bay Bird Observatory
Brown pelican	Citizen science observations of brown pelican from eBird.
Monarch butterfly	Western monarch butterfly predicted habitat suitability provided by USFWS. A threshold of 0.8 was used as a cutoff to make the layer binary.
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species	
Tidal marsh	Mapped tidal marsh habitat from San Francisco Estuary Institute (SFEI) California Aquatic Resources Inventory
Tidal wetland-upland transition zone/ecotone	Merged: • Mapped transition zone habitat in the San Francisco Estuary from Brian Fulfrost. • Expert opinion maps from Peter Baye for other estuaries in the study region.
Tidal flats	Mapped tidal flats from the Bay Area Aquatic Resources Inventory (SFEI)
Rocky intertidal and offshore rocks	NOAA Environmental Sensitivity Index
Native oysters	San Francisco Bay Subtidal Habitat Goals (CA State Coastal Conservancy)
Sand and gravel beach	NOAA Environmental Sensitivity Index
Lagoon habitat	Mapped lagoon habitat from San Francisco Estuary Institute (SFEI) California Aquatic Resources Inventory

Fish/Wildlife Element	Data Source(s) Used
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species	
Anadromous fish tributary habitat	Merged • Salmon and steelhead DPS/ESU and population data (NOAA) • Conservation Lands Network (CLN) priority 1 or 2 streams • Coho core areas from Public Draft Recovery Plan (NOAA, NMFS) • Critical habitat for Steelhead, Chinook and Coho salmon in California (NOAA, NMFS)
Colonial seabird nesting sites	Compiled multi-species seabird nesting colonies from surveys by USFWS, Point Blue, expert opinion and published maps.
Heron and egret rookeries	Point locations of known heron and egret breeding locations throughout the Bay Area (Audubon Canyon Ranch)
Eelgrass beds	Merged • Mapped eelgrass habitat CADFW • Mapped eelgrass habitat SFEI
Near-shore kelp habitat	Mapped near-shore kelp habitat from multi-spectral remote sensing imagery (CADFW)
Depressional wetlands	Mapped depressional wetland habitat from San Francisco Estuary Institute (SFEI) California Aquatic Resources Inventory
Vernal pools and vernal pool complexes	Mapped vernal pools and vernal pool complexes from San Francisco Estuary Institute (SFEI) California Aquatic Resources Inventory V2
Large riparian areas	Large riparian areas mapped by CalVeg (CLN)
Lake and pond lacustrine wetlands (and the associated aquatic vegetation bordering these features)	Mapped lacustrine habitat from San Francisco Estuary Institute (SFEI) California Aquatic Resources Inventory
Playas	Mapped playa habitat from San Francisco Estuary Institute (SFEI) California Aquatic Resources Inventory V2
Grasslands	Mapped grassland habitat (CLN)
Redwood/Douglas Fir forest	Mapped Redwood/Douglas Fir Forest (CLN)
Oak woodland	Mapped Oak Woodland (CLN)
Coastal scrub/chaparral	Mapped Coastal scrub/chaparral (CLN)
Agricultural habitat (including rice, alfalfa)	Agricultural habitat types (rice and alfalfa) mapped by the CA Department of Water Resources using NAIP imagery.
Cross-cutting Elements	
Bird Diversity Hotspots	Derived from a model of bird species richness based on 200 models of bird species distribution across the state of California. A value of 60 was used to convert the layer to a binary layer.

Table A5-2. Fish and wildlife elements proposed but ultimately <u>not included</u> in the assessment. *For each element, a brief description is provided explaining why it was not included.*

Fish/Wildlife Element Proposed for Inclusion	Reason Element Not Included in Assessment
Brine shrimp	We could not find location data were for the study area.
California mussel	We could not find location data were for the study area.
California newt	We could not find location data were for the study area.
Colonial waterbird nesting	Many species were covered under seabird layer. Recent colonial nesting shorebird breeding locations were only available for portions of South San Francisco Bay
Common murre	Covered by seabird layer.
Red abalone	We could not find location data were for the study area.
Red sea urchin	We could not find location data were for the study area.
Salt marsh harvest mouse	Experts were unwilling to share their data. They were concerned that exisisting data was insufficient for the analysis.

Appendix 6. Resilience Project Information

Appendix provides additional information about the resilience projects submitted by stakeholders.

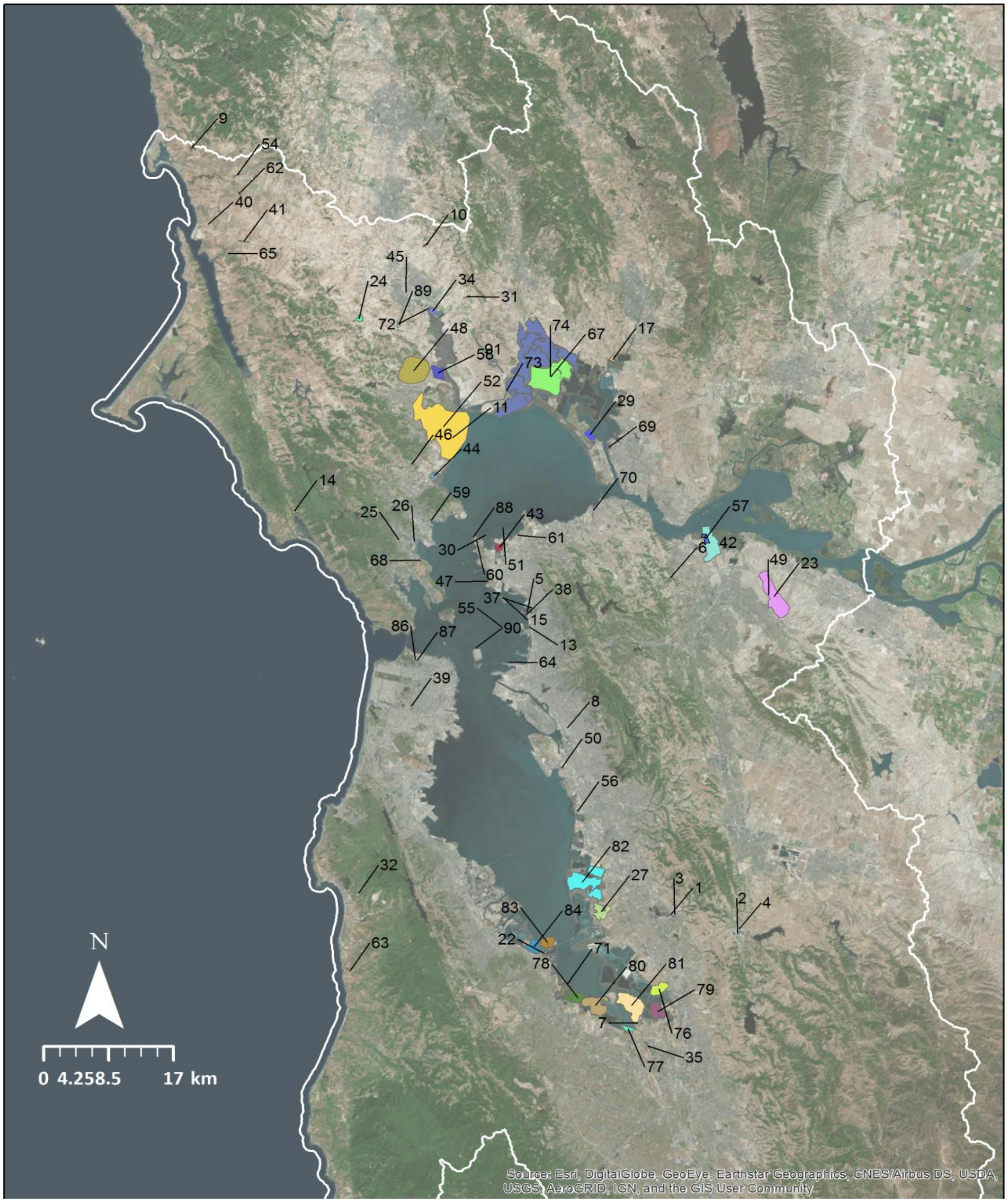


Figure A6-1. Map showing the location and boundaries of resilience projects compiled in the San Francisco Bay and Outer Coast Watersheds study area. *Note that the key to project numbers and names is provided on following page. See* ***Table A6-1*** *for a full list of projects submitted.*

Project Number and Name

- 1: Alameda Creek Fish Screens at ACWD Diversions
- 2: Alameda Creek PG&E Pipeline Crossing
- 3: Alameda Creek Upper Rubber Dam Fish Ladder
- 4: Alameda/San Antonio Creeks Sunol Mining Permit Lease Restoration
- 5: Albany Beach Restoration and Public Access Project - McLaughlin Eastshore State Park
- 6: Alhambra Valley Creek Coalition Restoration Project
- 7: Alviso Marina County Park
- 8: Arroyo Viejo Creek Watershed Awareness Program
- 9: Bay Hill Ranch
- 10: Bees Rock
- 11: Bel Marin Keys V Wetlands Restoration
- 13: Berkeley North Basin Strip - McLaughlin Eastshore State Park
- 14: Bolinas Lagoon North End Wetland Enhancement/SLR Adaptation Project
- 15: Brooks Island Habitat Improvement Project
- 17: Bull Island
- 18: Calero County Park 1
- 19: Calero County Park 2
- 22: Community-Based Restoration and Stewardship - Ravenswood Salt Ponds
- 23: Concord NWS Wetlands Restoration
- 24: Corda
- 25: Corte Madera Creek Watershed Plan
- 26: Corte Madera Ecological Reserve Expansion and Restoration
- 27: Coyote Hills Regional Park - Restoration and Public Access Project
- 29: Cullinan Ranch East
- 30: Eelgrass Protection and Creation Project - McLaughlin Eastshore State Park
- 31: Five Springs
- 32: Frenchmans Creek Fish Passage Improvement Project
- 34: Gray's Ranch
- 35: Guadalupe River Restoration
- 37: Hoffman Marsh Restoration Project - McLaughlin Eastshore State Park
- 38: Intertidal Habitat Improvement Project - McLaughlin Eastshore State Park
- 39: Islais Creek - Glen Canyon
- 40: Lawson Entire Site
- 41: Long Meadow Ranch
- 42: Lower Walnut Creek Restoration
- 43: Lower Wildcat Creek
- 44: McInnis Marsh Habitat Restoration
- 45: McNear's Landing
- 46: Miler Creek
- 47: Miller Knox Regional Shoreline - Lagoon and Marsh Restoration
- 48: Mount Burdell Preserve
- 49: Mount Diablo Creek Watershed Coordinated Steelhead Passage Project
- 50: Multi-Benefit Treatment Wetland along the San Leandro Shoreline
- 51: North Richmond Shoreline - San Pablo Marsh Restoration
- 52: Novato Baylands
- 54: Ocean Breeze Dairy
- 55: Off-shore Bird Habitat Project - McLaughlin Eastshore State Park
- 56: Oro Loma Project Area
- 57: Pacheco Marsh Restoration
- 58: Petaluma River Wildlife Area, Burdell Unit Restoration Project
- 59: Pickleweed Park
- 60: Point Molate Regional Shoreline - Restoration and Public Access Project
- 61: Point Pinole Regional Shoreline - Lower Rheem Creek Restoration
- 62: Pozzi Ranch
- 63: Purisima Farms Acquisition
- 64: Radio Beach Expansion Project - McLaughlin Eastshore State Park
- 65: Raiser Ranch - Full site
- 67: Restoration Strategy For Lower Sonoma Creek
- 68: Ring Mountain - Full Site
- 69: River Park
- 70: Rodeo Creek
- 71: SAFER Bay Project
- 72: Schoelenberger
- 73: Sear's Point Dixon Unit
- 74: Skaggs Island and Haire Ranch Restoration
- 76: South Bay Salt Ponds: A22,
- 77: South Bay Salt Ponds: Alviso - A8 Pond Cluster - Ponds A8, A8S, A5, A7
- 78: South Bay Salt Ponds: Alviso - Mountain View Ponds - A1, A2W
- 79: South Bay Salt Ponds: Alviso - Pond A18
- 80: South Bay Salt Ponds: Alviso - Ponds A2E, A3N, A3W, AB1, AB2
- 81: South Bay Salt Ponds: Alviso - Ponds A9, A10, A11, A12, A13, A14,
- 82: South Bay Salt Ponds: Eden Landing - Southern Eden Landing
- 83: South Bay Salt Ponds: Ravenswood - Ponds R1, R2
- 84: South Bay Salt Ponds: Ravenswood Complex - Ponds R3, R4, R5, S5, S5W
- 86: Tennessee Hollow: Western Tributary
- 87: Tennessee Hollow: Remnant Reach
- 88: Terminal 4 Wharf Removal Project
- 89: Tara Firma Farms
- 90: Treasure Island
- 91: Tolay Entire Site
- Project Boundary

Figure A6-1 (continued). Key to project numbers presented in map on previous page.

***Table A6-1**. **All resilience projects submitted for the San Francisco Bay and Outer Coast Watersheds and the number of assets/elements mapped within each project boundary.** Sorted in order of Community Exposure Index, from greatest to least.*

Project Name	Community Exposure Index	Number of Human Assets Mapped	Fish/Wildlife Elements within project boundary	Map ID Number
Alameda Creek Fish Screens at ACWD Diversions	5.00	1	1	1
Alameda Creek PG&E Pipeline Crossing	0.00	1	1	2
Alameda Creek Upper Rubber Dam Fish Ladder	0.00	0	1	3
Alameda/San Antonio Creeks Sunol Mining Permit Lease Restoration	0.00	1	1	4
Albany Beach Restoration and Public Access Project - McLaughlin Eastshore State Park	7.80	1	7	5
Alhambra Valley Creek Coalition Restoration Project	7.68	2	2	6
Alviso Marina County Park	8.00	1	3	7
Arroyo Viejo Creek Watershed Awareness Program	0.00	3	1	8
Bay Hill Ranch	2.98	1	2	9
Bees Rock	2.51	1	2	10
Bel Marin Keys Wetland Restoration	7.88	1	13	11
Benicia Urban Waterfront Enhancement and Master Plan	No spatial data provided			12
Berkeley North Basin Strip - McLaughlin Eastshore State Park	3.06	2	5	13
Bolinas Lagoon North End Wetland Enhancement/SLR Adaptation Project	6.07	2	12	14
Brooks Island Habitat Improvement Project	0.00	0	2	15
Browder	No spatial data provided			16
Bull Island	7.99	0	7	17
Calero County Park 1	2.00	1	2	18
Calero County Park 2	2.00	1	4	19
City of Benicia Vulnerability Assessment and Adaptation Plan	No spatial data provided			20
Coastal Regional Sediment Management Report, Sonoma and Marin Counties	No spatial data provided			21

Project Name	Community Exposure Index	Number of Human Assets Mapped	Fish/Wildlife Elements within project boundary	Map ID Number
Community-Based Restoration and Stewardship -Ravenswood Salt Ponds	0.00	1	1	22
Concord NWS Wetlands Restoration	2.67	3	5	23
Corda	4.32	1	7	24
Corte Madera Creek Watershed Plan	0.00	2	3	25
Corte Madera Ecological Reserve Expansion and Restoration	9.03	2	7	26
Coyote Hills Regional Park - Restoration and Public Access Project	6.30	0	7	27
Coyote Point Eastern Promenade Rejuvenation Project	No spatial data provided			28
Cullinan Ranch Restoration Project	8.12	1	6	29
Eelgrass Protection and Creation Project - McLaughlin Eastshore State Park	6.00	0	1	30
Five Springs	2.76	1	1	31
Frenchmans Creek Fish Passage Improvement Project	2.00	1	3	32
Gateway Park	No spatial data provided			33
Gray's Ranch	7.79	0	9	34
Guadalupe River Restoration	8.52	3	4	35
Highway 37 and the San Pablo Baylands	No spatial data provided			36
Hoffman Marsh Restoration Project - Mclaughlin Eastshore State Park	0.00	0	3	37
Intertidal Habitat Improvement Project - McLaughlin Eastshore State Park	6.80	2	6	38
Islais Creek - Glen Canyon	0.00	2	1	39
Lawson	4.18	1	1	40
Long Meadow Ranch	5.56	1	3	41
Lower Walnut Creek Restoration	6.71	4	13	42
Lower Wildcat Creek	10.00	2	10	43
McInnis Marsh Habitat Restoration	7.77	1	8	44
Mcnear's Landing	10.00	0	1	45
Miller Creek	7.11	1	2	46

Project Name	**Community Exposure Index**	**Number of Human Assets Mapped**	**Fish/Wildlife Elements within project boundary**	**Map ID Number**
Miller Knox Regional Shoreline - Lagoon and Marsh Restoration	8.01	2	5	47
Mount Burdell	4.69	3	5	48
Mount Diablo Creek Watershed Coordinated Steelhead Passage Project	0.00	0	2	49
Multi-Benefit Treatment Wetland along the San Leandro Shoreline for Contaminant Removal and Sea Level Rise Adaptation	7.40	2	4	50
North Richmond Shoreline - San Pablo Marsh Restoration	6.00	0	2	51
Novato Balands	8.12	10	19	52
Ocean Beach Master Plan	No spatial data provided			53
Ocean Breeze Dairy	6.11	2	3	54
Off-shore Bird Habitat Project - McLaughlin Eastshore State Park	0.00	0	1	55
Oro Loma Horizontal Levee Project	10.00	1	3	56
Pacheco Marsh Restoration	8.00	1	9	57
Petaluma River Wildlife Area, Burdell Unit Restoration Project	7.96	1	6	58
Pickleweed Park	9.25	2	4	59
Point Molate Regional Shoreline - Restoration and Public Access Project	0.00	0	2	60
Point Pinole Regional Shoreline - Lower Rheem Creek Restoration	0.00	0	2	61
Pozzi Ranch	4.04	1	1	62
Purisma Farms Acquisition	0.00	2	1	63
Radio Beach Expansion Project - McLaughlin Eastshore State Park	0.00	1	2	64
Raiser Ranch	5.83	1	3	65
Ravenswood Bay Trail Connection Project	No spatial data provided			66
Restoration Strategy for Lower Sonoma Creek	7.91	3	13	67
Ring Mountain	8.98	1	8	68
River Park	9.12	4	5	69
Rodeo Creek	10.00	4	5	70
SAFER Bay Project	7.89	7	14	71
Schoelenberger	8.00	0	9	72
Sear's Point Dixon Unit	8.04	1	7	73

Project Name	Community Exposure Index	Number of Human Assets Mapped	Fish/Wildlife Elements within project boundary	Map ID Number
Skaggs Island and Haire Ranch Restoration	7.99	2	10	74
South Bay Salt Pond Restoration Project	No spatial data provided			75
South Bay Salt Ponds: A22, A23	7.94	1	7	76
South Bay Salt Ponds: Alviso - A8 Pond Cluster - Ponds A8, A8S, A5, A7	7.90	1	5	77
South Bay Salt Ponds: Alviso - Mountain View Ponds - A1, A2W	7.89	0	10	78
South Bay Salt Ponds: Alviso - Pond A18	7.96	1	12	79
South Bay Salt Ponds: Alviso - Ponds A2E, A3N, A3W, AB1, AB2	7.92	0	12	80
South Bay Salt Ponds: Alviso - Ponds A9, A10, A11, A12, A13, A14, A15	7.97	2	11	81
South Bay Salt Ponds: Eden Land - Southern Eden Landing	7.92	1	13	82
South Bay Salt Ponds: Ravenswood - Ponds R1, R2	7.99	0	9	83
South Bay Salt Ponds: Ravenswood Complex - Ponds R3, R4, R5, S5, S5W	8.03	3	9	84
South San Francisco Bay Shoreline Project	No spatial data provided			85
Tennessee Hollow : Western Tributary	2.00	1	1	86
Tennessee Hollow: Remnant Reach	2.08	2	2	87
Terminal Four Wharf Removal Project	5.40	3	8	88
Terra Firma Farms	4.54	1	3	89
Treasure Island	9.10	5	0	90
Upper Tolay Creek	3.62	2	4	91
Yosemite Slough Restoration and Development Phase 2	No spatial data provided			92

Project ID# 1
Name: Alameda Creek Fish Screens at ACWD Diversions
Submitted by: Jeff Miller (Alameda Creek Alliance), Tim Ramirez (San Francisco Public Utilities Commission)
Organization: Alameda Creek Alliance
Project Type: Fish passage
Description: The Kaiser Pond Fish Screen project includes the construction a new diversion pipeline and cylindrical fish screen that will replace an existing unscreened water diversion. The fish screen system will consist of one self-cleaning cylindrical screen with a track system on a concrete pad along the bank of the Alameda Creek Flood Control Channel (ACFCC) and will prevent juvenile steelhead trout from being trapped in Kaiser Pond. The screen system and diversion intake will be used to divert water from the ACFCC to Kaiser Pond. The project also includes security fencing, controls, and slight modification of the trail around the facility. The Shinn Pond Fish Screen project includes the construction of new diversion pipelines and cylindrical fish screens that will replace the existing unscreened diversion pipes. The fish screen system will consist of several self-cleaning cylindrical screens with a track system on concrete pads along the bank of the Alameda Creek Flood Control Channel and will prevent juvenile steelhead trout from being trapped in Shinn Pond. The screened diversion facility will be used to divert water from the ACFCC to Shinn Pond. The project also includes security fencing, controls, and modification of the trail around the facility.

Project ID# 2
Name: Alameda Creek PG&E Pipeline Crossing
Submitted by: Jeff Miller (Alameda Creek Alliance), David Thomas (PG&E Company)
Organization: Alameda Creek Alliance
Project Type: Fish passage
Description: A cement armored PG&E gas pipeline crossing of Alameda Creek in the Sunol Valley poses a barrier for fish migration at most water flows. PG&E will provide fish passage at this site by removing the concrete mat from the channel and burying the pipeline deeper under the creek.

Project ID# 3
Name: Alameda Creek Upper Rubber Dam Fish Ladder
Submitted by: Jeff Miller (Alameda Creek Alliance)
Organization: Alameda Creek Alliance
Project Type: Fish passage
Description: This fish passage project includes the design and installation of a fish ladder northern embankment of the flood control channel and Alameda County Water District's Rubber Dam No. 3. The fish ladder will help facilitate fish migration through the lower section of Alameda Creek. The project is intended to enhance steelhead and salmon access through the constructed flood control channel to historical upstream spawning and rearing habitats.

Project ID# 4
Name: Alameda/San Antonio Creeks Sunol Mining Permit Lease Restoration
Submitted by: Tim Ramirez (San Francisco Public Utilities Commission)
Organization: San Francisco Public Utilities Commission
Project Type: Riparian vegetation restoration
Description: Oliver de Silva, Inc., lease-holder of a gravel mining permit on San Francisco Public Utilities Commission land (Surface Mining Permit 30), will implement restoration projects to restore Alameda Creek and

San Antonio Creek adjacent to the SMP-30 gravel mining pit. As part of a conservation plan and lease conditions, Oliver de Silva will plant riparian vegetation along the stream banks of both creeks adjacent to the mining pit to restore more natural stream function and enhance habitat quality; and also install a cut-off wall adjacent to the quarry to minimize percolation loss of Alameda Creek flow into the mining pit, improving surface flows in Alameda Creek.

Project ID# 5
Name: Albany Beach Restoration and Public Access Project - McLaughlin Eastshore State Park
Submitted by: Tiffany Margulici (East Bay Regional Park District), Chris Barton (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Beach and dune restoration
Description: The project will enhance Albany Beach by arresting beach erosion, expanding dune and wetlands, constructing wetland and rain garden features to improve water quality, complete a key segment of the SF Bay Trail, expand shoreline access area available to the public and construct visitor amenities.

Project ID# 6
Name: Alhambra Valley Creek Coalition Restoration Project
Submitted by: Jamie Menasco (Alhambra Valley Creek Coalition)
Organization: Alhambra Valley Creek Coalition
Project Type: Riparian restoration
Description: The project will stabilize severe erosion along the creek and replace invasive plants with native species. It will also improve fish passage and in-stream habitat for native steelhead trout and reduce flood impact.

Project ID# 7
Name: Alviso Marina County Park
Submitted by: John Parodi
Organization: Point Blue
Project Type: Tidal marsh transition zone restoration
Description: This project will revegetate the tidal marsh transition zone segments on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 8
Name: Arroyo Viejo Creek Watershed Awareness Program
Submitted by: San Francisco Bay Joint Venture
Organization: San Francisco Bay Joint Venture
Project Type: Community resilience planning
Description: The Arroyo Viejo Watershed Awareness (the Program) will provide an opportunity for citizens to play a role in the management of their watershed and to learn about the uniqueness and importance of riparian corridors. Drawing from existing community organizations and creekside property owners the Program will

create and maintain a Friends of Arroyo Viejo Creek group and develop a Watershed Management Action Plan in collaboration with this group and other community groups and stakeholders in the Watershed.

Project ID# 9
Name: Bay Hill Ranch
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 10
Name: Bees Rock
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 11
Name: Bel Marin Keys Wetland Restoration
Submitted by: Michelle Orr
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: The 1,584-acre Bel Marin Keys Unit V (BMKV) property was acquired by the Coastal Conservancy in 2001 with the intent to add the site to the adjacent Hamilton Wetland Restoration project. Congress added restoration of BMKV to the authorized Hamilton project in the Water Resources Development Act of 2007, after the completion of a Feasibility Study and Supplemental EIS/R by the U.S. Army Corps of Engineers and Conservancy. The combined Hamilton-Bel Marin Wetlands Restoration Project will restore over 2,500 acres of wetlands, provide a beneficial reuse of up to 24 million cubic yards of dredged material, convert a former military base into a treasured public resource, and complete over 3.5 miles of the San Francisco Bay Trail. Construction of the first phase of restoration of the Bel Marin Keys Unit V property is anticipated to begin in 2018, starting with a new levee setback from the existing bayfront levee and dividing BMKV into two areas - an enhanced seasonal wetlands area behind the levee and a larger area for tidal wetlands restoration. In order to accelerate the evolution of vegetated tidal marsh, dredged sediment will be used to raise the elevation of the

site. The amount of dredged material that will be placed on the site will depend on costs. After acting as a site for beneficial use of dredged material, BMKV will likely be opened to tidal action in the 2020s, with an adaptive management and monitoring period after the site is restored.

Project ID# 12
Name: Benicia Urban Waterfront Enhancement and Master Plan
Submitted by: Vic Randall
Organization: City of Benicia
Project Type: Natural infrastructure
Description: The 16 acre Waterfront Park site is subject to extensive current flooding during king tide and large storm events. Adaptation to sea-level rise will be incorporated into a range of project elements, which include a shared Bay Trail/Ridge Trail/Delta Trail segment, stormwater raingardens, wetland restoration, plazas, and elevated street and parking enhancements. These elements will be designed to minimize the likelihood of flooding of the park and adjacent mixed use downtown neighborhood through expanded green infrastructure, increased elevations, and improved stormwater management. In essence, flood mitigation will be baked into public access enhancements that will be designed to withstand sea-level rise, protecting the public access investments themselves as well as the adjacent inland section of downtown Benicia.

Project ID# 13
Name: Berkeley North Basin Strip - McLaughlin Eastshore State Park
Submitted by: San Francisco Bay Joint Venture
Organization: East Bay Regional Park District
Project Type: Riparian Restoration
Description: This project will rehabilitate Berkeley's North Basin Strip and daylight Schoolhouse Creek, stabilize eroding shoreline, remove weeds, plant natural turf and riparian vegetation, improve public access to the restored area, and construct 0.22 miles of public access Bay Trail.

Project ID# 14
Name: Bolinas Lagoon North End Wetland Enhancement/SLR Adaptation Project
Submitted by: Chris Barton (East Bay Regional Park District), Tiffany Margulici (East Bay Regional Park District), Laura Thompson (Association of Bay Area Governments), Susan Schwartz (Friends of Five Creeks), Donna Ball (Save The Bay)
Organization: Marin County Parks
Project Type: Tidal and riparian wetland restoration
Description: The project goal of the Bolinas Lagoon Wetland Enhancement/Adapation Plan is to develop and construct a wetland enhancement project for the north end of Bolinas Lagoon that allows for estuarine and riparian wetland enhancement and expansion, and protects access to the town of Bolinas as sea level rises. The objectives of the project are to improve habitat for shoreline birds, waterfowl, and fish, including special status species; improve tidal flow access to uplands, and connect creeks to their floodplains; to allow for the migration of inter-tidal marshes and enhance transition zones; improve geomorphic processes and hydrologic functions for Wilkins and Lewis Creek; remove non-native invasive species and enhance wetland and riparian vegetation; and to realign Olema-Bolinas Road, Bolinas-Fairfax Road, and Highway One to allow for SLR and to improve traffic management and circulation. The specific tasks that would be undertaken are as follows: develop and conduct baseline studies of hydrologic, geomorphic, and biologic conditions at the site; evaluate existing cultural and archeological resources and the potential for their discovery within the vicinity; develop an opportunities and

constraints analysis with an evaluation of existing and potential site constraints (i.e. environmental, re-location of infrastructure, property ownership); develop three conceptual restoration/SLR adaptation alternatives; evaluate the potential environmental, traffic and circulation impacts associated with removal and replacement of portions of Olema-Bolinas Road, Bolinas-Fairfax Road, and Highway One; conduct environmental review under CEQA/NEPA; and, implement phased construction of the project. Status 11/16: will have three conceptual designs completed by March of 2017 and will be putting out an RFP around February for drafting the final designs. Funding need estimate is based on phase 1 the Bolinas Y.

Project ID# 15
Name: Brooks Island Habitat Improvement Project
Submitted by: Tiffany Margulici (East Bay Regional Park District), Chris Barton (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Intertidal and upland habitat restoration
Description: The proposed project will enhance intertidal and upland habitats along the San Francisco Bay shoreline. It will remove existing inorganic debris, protect eroding areas, create ground-nesting bird habitat, remove non-native vegetation and control predators along more than three miles of San Francisco Bay shoreline. The Project will also provided for improved management of existing public access and creation of new interpretive and wildlife observation facilities to enhance the publics understanding of wildlife. Brooks Island and surrounding San Francisco Bay waters are one of the areas most heavily impacted by the Cosco Busan Oil spill. The Islands entire 3.23 mile perimeter was oiled. These impacts are of particular significance for the Caspian tern breeding colony on the island, which is the largest breeding colony in California. The US Fish and Wildlife Service and Army Corps of Engineers identified improvement of Brooks Island as a high priority location for conservation of Caspian tern in North America. These birds are heavily dependent upon the Bay's fisheries for their successful production. Rocky intertidal, sand flat and mudflat areas that ring the island also provide habitat for many benthic organisms which support large numbers of shorebirds. A weed abatement program will be implemented to keep ground-nesting locations open. A predator control program will be implemented to control species which prey upon ground-nesting birds. Nearby raptor perch sites will be removed. Shell, sand or dredged materials may be imported to expand beaches to provide more areas for ground-nesting birds and foraging habitat for shorebirds. Low native dune and scrub vegetation will be planted in other areas to reduce the effects of wind and wave erosion. Eroding rocky intertidal habitat will also be improved by removing inorganic debris and protecting actively eroding areas. Primary goals are to restore, expand, protect, and develop viewing areas for the Caspian Tern nesting area.

Project ID# 16
Name: Browder
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 17
Name: Bull Island
Submitted by: John Hoffnagle (Land Trust of Napa County)
Organization: Land Trust of Napa County
Project Type: Acquisition
Description: 109-acre tidal marsh/wetland on the Napa River near Cuttings Wharf; transferred to the California Department of Fish and Game and the State Lands Commission.

Project ID# 18
Name: Calero County Park 1
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 19
Name: Calero County Park 2
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 20
Name: City of Benicia Vulnerability Assessment and Adaptation Plan
Submitted by: Amy Million
Organization: City of Benicia
Project Type: Community resilience planning
Description: Conducted a local vulnerability assessment to determine how climate-related risks will affect shoreline and community assets including watersheds, shoreline parks and trails, the Port of Benicia, and the Benicia Industrial Park. The Coastal Conservancy provided a grant of $150,000 of Prop 84 funds to the City of Benicia to conduct a local vulnerability assessment to determine how climate related risks will affect shoreline and community assets including watersheds, shoreline parks and trails, the Port of Benicia, and the Benicia Industrial Park. The vulnerability and risk assessment incorporated work already underway for the waterfront to

evaluate existing conditions by creating an asset inventory that outlines vulnerabilities and risks based on best available science and information combined with best professional judgment and expert input. Based on this assessment, the City developed an adaptation plan to mitigate those risks, including proposed adaptation responses (11 priority adaptation responses and 121 total adaptation responses), based on the asset inventory and implementation options to help prepare for the impacts identified throughout the planning process. The assessment and plan also included a legal memo, and a case study on a business in the industrial park.

Project ID# 21
Name: Coastal Regional Sediment Management Report, Sonoma and Marin Counties
Submitted by: Douglas George
Organization: Greater Farallones Association
Project Type: Beach or dune restoration, Community resilience planning, Dam removal/fish passage, Living shoreline implementation, Sediment management planning, multiple strategies
Description: A Coastal Regional Sediment Management Plan (CRSMP) is a guidance and policy document that discusses how Regional Sediment Management (RSM) can be applied in a rapid, cost-effective, and resource-protective manner. The Greater Farallones National Marine Sanctuary (GFNMS) Advisory Council established a working group composed of scientists, landowners, local stakeholders (see Working Group Members, p.ii) and agency representatives to develop coastal sediment management recommendations for the Sonoma and Marin County outer coasts. Seventeen regional recommendations and 14 site-specific recommendations were developed including beach nourishment, dune restoration, living shorelines, culvert and fish passage work, and terrestrial land management. The report will guide the next step of developing an action plan to implement the recommendations across the 340-mile stretch of coastline.

Project ID# 22
Name: Community-Based Restoration and Stewardship -Ravenswood Salt Ponds
Submitted by: Donna Ball (Save The Bay)
Organization: Save The Bay
Project Type: Transition zone restoration
Description: this project is one of the first public access habitat restoration events of the South Bay Salt Ponds project--the largest urban habitat restoration project in the country! We are helping improve salt pond and wetland habitat by removing non-native plants such as ice plant, fennel and radish along with trash that has accumulated at this former salt pond. During the winter planting season we will be planting native plants such as the salt marsh gumplant, to help provide the first succession of marsh habitat. The US Fish and Wildlife Service is currently conducting larger, earth-moving restoration at this retired salt pond by initiating tidal flow and creating nesting islands for the threatened snowy plover. Our re-vegetation efforts at this site are critical components to the larger restoration of this tidal system.

Project ID# 23
Name: Concord NWS Wetlands Restoration
Submitted by: Brian Holt (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Tidal marsh restoration
Description: This 700-acre restoration project is part of the Concord Naval Weapons Station reuse plan, which includes an approved public conveyance for a new 2,540-acre regional park.

Project ID# 24
Name: Corda
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 25
Name: Corte Madera Creek Watershed Plan
Submitted by: Sandra Guldman (Friends of Corte Madera Creek Watershed)
Organization: Friends of Corte Madera Creek Watershed
Project Type: Resilience planning
Description: A comprehensive watershed plan with goals and priorities for long-term actions will promote cooperation among landowners, land managers, and governmental agencies to enhance and protect the watershed and benefit all the communities served by the Corte Madera Creek, human and natural.

Project ID# 26
Name: Corte Madera Ecological Reserve Expansion and Restoration
Submitted by: Barbara Salzman (Marin Audubon Society)
Organization: Marin Audubon Society
Project Type: Tidal marsh restoration
Description: Marin Audubon acquired and is restoring this five acre tidal marsh property adjacent to the Corte Madera Ecological Reserve. The property is surrounded on three sides (north, east and south) by the Corte Madera Ecological Reserve and on the west side by a trail and Shorebird Marsh, owned by the Town of Corte Madera. This property provides critical tidal marsh habitat adjacent to a core population of endangered Ridgway's rails that inhabits the Reserve. Marin Audubon acquired the property in January 2015. Project goals are to restore it to tidal marsh habitat by removing fill, to provide refuge for the California Ridgway's rail, and to provide environmentally sensitive public access. Other activities will include coarse material placement along shorelines to reduce erosion and feed sediment, and vegetation enhancements in the upland transition zone to provide high tide refuge to wildlife as well as shoreline protection. As of spring 2018, construction was completed and habitat enhancements were underway.

Project ID# 27
Name: Coyote Hills Regional Park - Restoration and Public Access Project
Submitted by: Chris Barton (East Bay Regional Park District), Tiffany Margulici (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Tidal marsh restoration

Description: This project will restore marsh, seasonal wetlands, and coastal prairie, improve water circulation and quality, enhance habitat for the endangered salt marsh harvest mouse and Ridgway's Rail, and acquire lands to protect wildlife and develop public access to restored areas.

Project ID# 28
Name: Coyote Point Eastern Promenade Rejuvenation Project
Submitted by: Marlene Finley
Organization: County of San Mateo
Project Type: Community resilience planning
Green infrastructure implementations
public access, ADA accessibility
Description: The 5.5 acre Coyote Point Eastern Promenade Project includes the following project elements along the approximately 1,000 ft-long shoreline. The Project will:
1. Create a crenulate-shaped bay and flat, perched sandy beach, approximately 1,000 ft long and 50 to 125 ft wide;
2. Reconfigure and reconstruct a paved 1,000 ft long, 15 ft wide eastern Promenade Trail with a 1ft tall linear seating wall that connects to the adjacent 850 ft long western Promenade Trail and San Francisco Bay Trail to the west and Bluff Trail to the east;
3. Reconfigure and reconstruct lower and middle parking areas with ADA and ADA van-accessible parking spaces by the restroom and beach access ramps and create a new upper parking area to replace lost parking due to reconfiguration of the new bay, beach and parking areas for a total of 191 parking spaces representing 15 over existing conditions;
4. Install new prefabricated restroom facility of masonry materials with men's and women's rooms with changing benches, outside shower tower and drinking fountain;
This is a universal access project with an ADA-accessible Promenade Trail, ADA-accessible beach using ramps and beach mats, car and van ADA-accessible parking in the lower and middle parking areas and an ADA-accessible restroom facilitiy.
All landscaping areas will be planted with native grasses, shrubs and trees. Other park site furniture includes linear seatwall and benches along the Promenade. Access ramps, beach mats and other transition areas from Promenade to the beach. Bike racks, shower tower, trach receptacles and LED lights on 25 ft tall poles.

Project ID# 29
Name: Cullinan Ranch Restoration Project
Submitted by: Don Brubaker
Organization: U.S. Fish and Wildlife Service - San Pablo Bay National Wildlife Refuge
Project Type: Tidal marsh restoration
Description: The Cullinan Ranch Restoration Project will restore approximately 1,500 acres in the San Pablo Bay National Wildlife Refuge. In 1991, the U.S. Fish and Wildlife Service purchased the property under the authority of the Endangered Species Act, with an intent to restore the area to tidal marsh for the benefit of federally listed species such as the salt marsh harvest mouse and Ridgway's rail (formerly known as the California Clapper rail). Like much of the land adjacent to the Bay and cut off from tidal action, Cullinan Ranch is subsided. The years of agriculture have resulted in the land being 5 to 6 feet below sea level. It is expected that the process of allowing sediment to accumulate naturally would take 60 years before the site would be able to support tidal marsh vegetation. In order to accelerate the accretion rate and habitat development, project partners plan to import up to 2.8 million cubic yards of material to the project site. This material will create another 290 acres of tidal

marsh habitat, in the near term. So far, 80,000 cubic yards of material have been imported to the site and were delivered via barge which traveled up Dutchman slough, moored adjacent to the project site, and lifted the material over the perimeter levee, to deposit it in the 290-acre dredge material containment area.

Project ID# 30
Name: Eelgrass Protection and Creation Project - McLaughlin Eastshore State Park
Submitted by: Chris Barton (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Sub-tidal habitat enhancement
Description: Point Pinole and Miller-Knox Regional Shorelines. The proposed project will provide for the acquisition, protection, creation and enhancement of existing and new eelgrass beds along the East Bay Shoreline. Recent studies conducted by the California Department of Transportation have documented that 80 to 90% of all the eelgrass in the San Francisco Bay is along the north Richmond Shoreline. Much of this area is in private ownership and is subject to future development, including development of a proposed casino on Point Molate, and construction of new deepwater piers in the Richmond area. Development in upland areas is contributing fine sediments to the San Francisco Bay that increase suspended sediments, adversely affecting water clarity and photosynthesis within eelgrass beds. Acquisition and protection of privately owned eelgrass habitat and adjacent upland areas will be a first step in protecting this fragile ecosystem. Areas that are acquired will be protected by eliminating potential development threats, such as dredging and Bay fill. Restoring and protecting adjacent wetland and upland habitats will reduce the volume of fine sediments and pollutants entering San Francisco Bay eelgrass beds. Artificial eelgrass beds could be created by placing dredged sand in shallow subtidal areas to create a substrate and water depth suitable for eelgrass establishment. The California Department of Transportation is currently monitoring a pilot eelgrass project at Eastshore State Park which will inform the design of eelgrass protection and creation efforts for this project and elsewhere in the East Bay.Expansion of existing or creation of new eelgrass beds could occur at several locations, including the North and South Richmond Shorelines, Albany Beach, Berkeley North Basin and Brickyard Cove, and the Emeryville Crescent.

Project ID# 31
Name: Five Springs
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue’s Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 32
Name: Frenchmans Creek Fish Passage Improvement Project
Submitted by: Janet Diehl (State Coastal Conservancy)
Organization: CA Coastal Conservancy
Project Type: Fish passage
Description: Structural and functional goals of project were to re-open fish passage to at least 2.1 miles of spawning habitat by 2007; reduce vertical jump feet to 0 ft. at agricultural crossing by 2007; re-establish the water flow to be creek-wide with no change in velocity at the agricultural crossing by 2007. The project removed a perched culvert at an agricultural creek crossing and replaced it with a clearspan bridge and boulder weir step pools. Previous conditions prevented all steelhead migration above the culvert, eliminating access to the upper 2.1 miles of the creek, the most valuable rearing and spawning habitat within this stream system. Fish now have access to about 4.4 miles of the creek, from the ocean to a natural waterfall.

Project ID# 33
Name: Gateway Park
Submitted by: Ron McMillian
Organization: Bay Area Toll Authority
Project Type: Recreation
Description: The creation of a new park is proposed at the east touchdown of the San Francisco-Oakland Bay Bridge in Oakland, California. When completed, the project will open some 45 acres of parkland along the waterfront near the eastern end of the new Bay Bridge East Span. The park will provide a distinct entryway to the East Bay that connects to the bicycle/pedestrian path on the bridge, and will open safe, multimodal public access to the shoreline, with its amazing vistas of the bay and the new bridge. Gateway Park will highlight the industry, infrastructure and ecology that have shaped the history of this spectacular stretch of shoreline.

Project ID# 34
Name: Gray’s Ranch
Submitted by: Sue Worley (Petaluma Wetlands Alliance)
Organization: Petaluma Wetlands Alliance
Project Type: Acquisition
Description: Over two years of efforts by the Petaluma Wetlands Park Alliance (PWPA), the Bay Institute and Madrone Audubon were finally rewarded on September 8, when the Petaluma City Council voted 5-0 to buy Gray's Ranch for $4,000,000. Of the 261 acres, 45 will be devoted to filtration (polishing) wetlands as part of the city's planned wastewater treatment system. The property will also provide 3.5 miles of new trails linking with Shollenberger Park and numerous blinds and overlooks. There's talk too of Audubon refurbishing the old Gray farmhouse and use it as a nature-based education center.

Project ID# 35
Name: Guadalupe River Restoration
Submitted by: Ngoc Nguyen (Santa Clara Valley Water District)
Organization: Santa Clara Valley Water District
Project Type: River restoration
Description: Fisheries restoration - including needed rerouting of the Guadalupe River and wetlands creation. The project will significantly lower water temperatures in the Guadalupe River that is designated critical habitat for steelhead trout and chinook salmon. It would also remove some key sources of mercury. Phase 1 includes the installation of riparian vegetation and SRA at various locations along the project reaches.

Project ID# 36
Name: Highway 37 and the San Pablo Baylands
Submitted by: Wendy Eliot
Organization: Sonoma Land Trust
Project Type: Community resilience planning, Wetlands restored/enhanced
Description: The purpose of this project is to promote the development of a State Route 37 design that improves the climate resilience of both the built infrastructure and natural ecosystems by advancing the ecological restoration and conservation goals for the San Pablo Baylands while achieving transportation objectives. State Route (SR) 37 is a 21-mile highway that runs through the ecologically rich San Pablo Baylands, which provide important wildlife habitat including a principal stop on the Pacific Flyway migration corridor that supports millions of migrating waterfowl and shorebirds. The State Coastal Conservancy (Conservancy), Sonoma Land Trust, and many other partners have invested over $600 million in acquisition, restoration and enhancement of roughly 30,000 acres to advance the goals set by the ecological restoration community. As flooding in February 2017 that closed the highway revealed, SR 37 is highly vulnerable to both near-term flooding and permanent inundation due to sea level rise. The road is also severely congested, particularly along a two-lane segment from Highway 121 in Sonoma County to Mare Island in Solano County. In June 2017, in response to the acceleration of plans to redesign and rebuild SR 37, the Sonoma Land Trust convened a group composed of North Bay wetland land managers, ecological restoration practitioners, and other stakeholders interested in the conservation and restoration of the San Pablo Baylands. The group, now known as the SR 37 – Baylands Group, reached consensus that the redesign of SR 37 represents both a major opportunity and potential threat to North Bay ecosystems, particularly in light of future sea level rise.

Project ID# 37
Name: Hoffman Marsh Restoration Project - Mclaughlin Eastshore State Park
Submitted by: Chris Barton (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Tidal marsh restoration
Description: Restore up to 40 acres of tidal wetlands and adjacent upland for threatened and endangered species by removing fill, potential contaminants and non-natives; planting natives; and improving connectivity to adjacent tidal marshes.

Project ID# 38
Name: Intertidal Habitat Improvement Project - McLaughlin Eastshore State Park
Submitted by: Chris Barton (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Sub-tidal habitat enhancement
Description: The proposed project will enhance intertidal habitat along the San Francisco Bay shoreline in Berkeley North Basin, Berkeley, California. It will remove existing concrete, asphalt, metal, foundry slag, creosote timbers, plastic and other inorganic debris from about 6,000 linear feet of shoreline. Slope protection will be installed to create a "living shoreline" for intertidal habitat for fish, wildlife and plants. Methods could include natural rock riprap, interlocking blocks, bioengineered slope protection and other methods compatible with creating rocky intertidal habitat. A gentle transitional aquatic-to-upland gradient will be created by laying-back portions of the shoreline.The project will reduce Bay sedimentation by stabilizing failing and eroding shoreline areas. It will stop the potential release of soil and groundwater contaminants into the Bay. Residual oil contamination from the Cosco Busan Oil Spill will be removed during project implementation. The esthetic environment will be improved by providing better visual access to the San Francisco Bay by eliminating debris which often obstructs views of the shoreline and its associated wildlife. The project will allow for planned public access to the Bay to increase the public's understanding and appreciation of wildlife.

Project ID# 39
Name: Islais Creek - Glen Canyon
Submitted by: Richard Craib (Friends of Glen Canyon)
Organization: Friends of Glen Canyon
Project Type: Riparian restoration
Description: Revegetation and trail projects, creek restoration

Project ID# 40
Name: Lawson
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 41
Name: Long Meadow Ranch
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary.

Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 42
Name: Lower Walnut Creek Restoration
Submitted by: Paul Detjens (Contra Costa County Flood Control and Water Conservation District)
Organization: Contra Costa County Flood Control and Water Conservation District
Project Type: Riparian restoration to improve fish habitat and reduce flooding threats
Description: Masterplan enhancement followed by restoration, levee setback, sediment removal to clear portion of channel, acquisition of adjacent wetland for salt marsh harvest mouse and trails adjacent to creek. The Lower Walnut Creek Project incorporates a new way of approaching the traditional methods of operating and maintaining a flood control facility. The existing channel is a classic Army Corps of Engineers trapezoidal earth channel that requires ongoing de-silting maintenance. The alternative approach will be to move the channel levees back in the lower reaches to provide additional capacity for floodwaters and to create floodplains. This approach will provide the necessary capacity to handle floodwaters while reducing de-silting costs and creating additional wetlands, riparian habitat and revegetation potential. Other project components include improving fish passage and habitat and increasing recreational opportunities by extending EBRPD regional trails. Lower Walnut Creek also interfaces closely with the Pacheco Marsh restoration, located adjacent to the mouth of Lower Walnut Creek. As of 2017, project goals include the enhancement and restoration of wetlands and riparian habitat along four miles of Walnut Creek and Pacheco Creeks to restore and enhance habitat, provide sustainable flood protection, and allow opportunities for public access and recreation. Restoring wetlands will improve ecological function and habitat quantity, quality and connectivity; and create sustainable benefits that consider environmental changes such as sea level rise and sedimentation. Project is located directly adjacent to the Pacheco Marsh Restoration, and will likely be combined for implementation. Website: www.lowerwalnutcreek.org.

Project ID# 43
Name: Lower Wildcat Creek
Submitted by: Tiffany Margulici (East Bay Regional Park District), Paul Detjens (Contra Costa County Flood Control and Water Conservation District), Ann Riley (San Francisco Bay Regional Water Quality Control Board)
Organization: East Bay Regional Park District
Project Type: River restoration
Description: This project will restore degraded portions of Wildcat Creek channel, remove barriers to fish passage, and improve public access to restored areas.

Project ID# 44
Name: McInnis Marsh Habitat Restoration
Submitted by: James Raives (Marin County Parks and Open Space), Jeff Melby (State Coastal Conservancy), Laura Thompson (Association of Bay Area Governments)
Organization: San Francisco Bay Joint Venture
Project Type: Tidal wetland restoration
Description: The McInnis marsh is located within McInnis County Park approximately 20 miles north of San Francisco, Marin County. The site is at the east end of Smith Ranch Road, immediately north of Gallinas Creek and south of Miller Creek. The eastern portion of the park consists of approximately 200 acres of seasonal diked wetlands. This area is surrounded by San Pablo Bay (tidal salt marsh and offshore open water) to the east, Miller Creek to the north, and Gallinas Creek to the south. Historically, Gallinas and Miller Creeks flowed into the San Pablo Bay through vast network of tidal wetland. This delta delivered water and sediment over a broad swath of transitional bay margin, including seasonal and tidal wetlands. With the onset of agricultural practice and the channelization of these creeks in the early 1900s, this hydraulic connection was largely lost. The project will reconnect Gallinas and Miller Creek with restored wetlands that provide rearing, resident, and migratory habitats for state and federally listed threatened and endangered species, including steelhead trout, green sturgeon, California clapper rail, black rail, and the salt marsh harvest mouse. In addition, it will provide important nursery habitat for marine fisheries and wintering areas for numerous migratory birds. Specifically, the project will provide the following benefits:

1. Improve flood and sediment conveyance efficiencies for Miller Creek;
2. Re-establish an ecologically contiguous bay/marsh/creek transition zone able to support the natural gradation of habitats anticipated in response to sea level rise;
3. Increase creek/bay connectivity to support salmonid rearing and migration between bay and creek ecosystems;
4. Increase creek/floodplain/marsh continuity and maximize available transitional estuarine habitats

Add tidal prism in Gallinas Creek increasing the sustainability of subtidal habitats, and reducing the need for downstream dredging. Estimates for design and environmental review is approximately $1 Million. Construction estimates are around $5 Million.

Project ID# 45
Name: Mcnear's Landing
Submitted by: John Parodi
Organization: Point Blue
Project Type: Tidal marsh transition zone restoration
Description: This project will revegetate the tidal marsh transition zone segments on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 46
Name: Miller Creek
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 47
Name: Miller Knox Regional Shoreline - Lagoon and Marsh Restoration
Submitted by: Matthew Graul (East Bay Regional Park District), Chris Barton (East Bay Regional Park District), Tiffany Margulici (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Tidal marsh restoration
Description: This project will establish wetlands, creating tidal lagoon, marsh and freshwater habitats by reconnecting creeks to their headwaters and reinstating tidal exchange between the lagoon, creek and bay. Additional work will stabilize eroding shoreline, improve drainage, and provide public access.

Project ID# 48
Name: Mount Burdell
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 49
Name: Mount Diablo Creek Watershed Coordinated Steelhead Passage Project
Submitted by: Ben Wallace (Contra Costa Resource Conservation District), Cyndy Shafer (California State Parks)
Organization: San Francisco Bay Joint Venture
Project Type: Fish passage
Description: Until the 1980s, the Mt. Diablo Creek watershed supported a steelhead trout population. In the 1980s, earth moving related to subterranean pipelines near the mouth of Mt. Diablo Creek at Suisun Bay blocked access to the entire watershed. A debris gate in the middle watershed, modified in 2002, may block passage at some flows. Two dams were removed as part of the Mitchell Creek Riparian Restoration project. A culvert still

remains. This project will plan, design, and implement the necessary fish passage projects through out the watershed to restore steelhead access to 15 miles of stream habitat. An existing watershed inventory identifies removal of these barriers as critical to steelhead repopulation. The watershed assessment produced in coordination with the stakeholder-driven planning process identifies the potential for restoring steelhead to the watershed and called for detailed studies to restore passage.

Project ID# 50
Name: Multi-Benefit Treatment Wetland along the San Leandro Shoreline for Contaminant Removal and Sea Level Rise Adaptation
Submitted by: Sally Barros (City of San Leandro), Dean Wilson (City of San Leandro)
Organization: City of San Leandro
Project Type: Natural infrastructure
Description: Phase 1 of this project involves planning and permitting for the restoration of a 4.3-acre storage basin adjacent to the San Leandro Water Pollution Control Plant to a multi-benefit treatment wetland for removal of wastewater-borne nutrients and contaminants of emerging concern. Additional benefits include enhancement of wetland habitat along the Bay Trail within a disadvantaged community for increased educational opportunities, and demonstration of cost-effective contaminant removal/sea level rise adaptation strategies along the shoreline via green infrastructure. Additional objectives include community-based planning a Phase 2 shoreline resiliency project involving increased utilization of treated wastewater to an ecotone levee, accompanied by enhancement of tidal marsh resources across multiple landowning entities.

Project ID# 51
Name: North Richmond Shoreline - San Pablo Marsh Restoration
Submitted by: Tiffany Margulici (East Bay Regional Park District), Laura Thompson (Association of Bay Area Governments), Chris Barton (East Bay Regional Park District), Rich Walkling (Restoration Design Group, LLC), Paul Detjens (Contra Costa County Flood Control and W
Organization: East Bay Regional Park District
Project Type: Tidal marsh enhancement
Description: Project goals are the preservation and enhancement of San Pablo Marsh, improvement of Ridgway's Rail habitat, removal of imported fill, stabilization of eroding shoreline, establishment of upland-Bay transitional areas, and development of public access for wildlife viewing and education.

Project ID# 52
Name: Novato Balands
Submitted by: Laura Thompson (Association of Bay Area Governments), Liz Lewis (Marin County Public Works Department)
Organization: Marin County Public Works
Project Type: Natural infrastructure creek flood protection, tidal wetland restoration
Description: The proposed scope of work includes the following tasks: 1) Update and extend existing HEC-RAS model from Stafford Lake to the Bay. Existing HEC – RAS model was developed for the Bel Marin Keys Unit V Expansion of the Hamilton Wetland Restoration Project, 2003. The model was further refined in the Hydrologic and Hydraulic Study – Phase II for the U.S. Army Corps of Engineers, 2006. These models provide a foundation but do not include the full extent of the proposed study area nor do they evaluate the appropriate range of variables. 2) Prepare a technical memo that identifies potential adjustments in flood management practices that would increase opportunities for wetland and habitat restoration. This analysis should consider the following

variables affecting Novato Creek including: 1) Identification of levee improvements/additions/modifications to increase tidal prism to promote channel scour and reduce flooding. In some areas levees could be set back or realigned and in some areas channel benches constructed. The updated creek models would update flood conveyance; evaluate sediment transport, opportunities for habitat enhancement and water quality benefits, water surface elevations and possible reduction in the frequency of dredging for flood control maintenance. 2) Evaluate channel bottlenecks including Highway 37 and the RR Bridge crossings and their impact to restoration alternatives. Evaluate proposed improvements such as detention ponds for temporary storage of flood waters and associated bypass facilities, weirs, pump stations etc. 3) Evaluate potential increases in levee height/ water storage elevations on local drainage and other opportunities to reduce flooding and increase habitat. As of April 2017 (RA update), project goal is the implementation of a natural flood protection approach to reduce flooding, increase sea level rise resiliency, and increase tidal wetland and other wetland habitat along lower Novato Creek. Potential future restoration may include opportunities for new Bay trail alignment.

Project ID# 53
Name: Ocean Beach Master Plan
Submitted by: Ben Grant
Organization: SPUR
Project Type: Community resilience planning, Addresses major issues at Ocean Beach including: climate change, sea level rise, erosion, natural resources, public access
Description: In May of 2010, the Conservancy granted $300,000 to SPUR to develop an Ocean Beach Master Plan. Ocean Beach lies along the west side of San Francisco, and is one of the longest urban beaches in the country (5 miles). Ocean Beach has the potential to become one of the most spectacular metropolitan beaches in the world, but currently suffers from erosion, neglect and a lack of amenities. The Master Plan effort has achieved an unprecedented level of cooperation and consensus among the management agencies and key stakeholders at Ocean Beach. The Master Plan recommendations reflect a robust process involving many stakeholders and have received broad, enthusiastic support. The recommendations address major issues and processes at Ocean Beach, including climate change and sea level rise; erosion; natural resources protection; public access and recreation; vehicular, bicycle, and pedestrian access and circulation; and implementation, management and maintenance. In January of 2012, the Conservancy granted $400,000 to SPUR to pursue implementation of recommendations in the Ocean Beach Master Plan by conducting a traffic circulation and access study, developing a joint coastal management framework, and developing a joint open space management agreement among the multiple management entities. The Master Plan is a non-regulatory guidance document and its implementation will depend on sustained engagement of stakeholders and management agencies. This grant enables SPUR to pursue implementation of the recommendations in coordination with the appropriate partner agency while keeping the public engaged and political support high, and working to secure implementation funding.

Project ID# 54
Name: Ocean Breeze Dairy
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement

and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 55
Name: Off-shore Bird Habitat Project - McLaughlin Eastshore State Park
Submitted by: Chris Barton (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Transition zone restoration
Description: The proposed project will construct new off-shore structures and islands for shorebird roosting and possibly nesting. This will include restoring old piers, installing new structures and creating new islands using dredged sand or other suitable materials. This type of habitat is very scarce in the East Bay given the very few number of islands and suitable structures available. As described in the McLaughlin Eastshore State Park General Plan, potential locations for new roosting and nesting habitat include the Emeryville Crescent, Albany Mudflats and North Point Isabel in Richmond.

Project ID# 56
Name: Oro Loma Horizontal Levee Project
Submitted by: Jason Warner
Organization: Oro Loma Sanitary District
Project Type: Natural infrastructure
Description: A 10-acre field adjacent to the Oro Loma wastewater treatment and purification plant in San Lorenzo will be the site of an experiment testing ways in which the plant can use a basin to accommodate peak flows while taking a more natural approach to shoreline protection. If it works, experts hope the project can be a new model for adapting critical infrastructure at the Bay's edge to climate change. Oro Loma's project will turn a degraded diked bayland behind a wastewater treatment plant into an outdoor laboratory. On this flat, weedy field, construction crews will create two things: 1) a two-acre wetland basin that can both remove nutrients from wastewater and provide extra wet weather storage capacity; 2) on one side of the basin, the experimental levee. Wastewater that has already undergone secondary treatment (required by Clean Water Act protections to prepare it for discharge into San Francisco Bay) will pass first across the surface of the basin and treatment wetland, and second through the levee and down into the sub-layers of 1.4 acres of experimental habitat slope. The idea is that the combination of treatment wetlands and newly designed habitats, and surface and sub-surface filtering processes, will support native plants and purify the water enough so that one day this kind of system can be directly connected to the Bay edge.

Project ID# 57
Name: Pacheco Marsh Restoration
Submitted by: Paul Detjens (Contra Costa County Flood Control and Water Conservation District)
Organization: Contra Costa County Flood Control and Water Conservation District
Project Type: Tidal wetland restoration, transition zone restoration, flood protection
Description: The Muir Heritage Land Trust, Contra Costa County Flood Control District and the East Bay Regional Park District have acquired (2002) the 122 acre Pacheco Marsh to restore the property to its historical tidal wetland flow. The goal is to maximize wetland and wildlife habitat for a variety of plant and animal species, including the 12 special status species that would benefit from this restoration. Adjacent to Lower Walnut Creek

Restoration. As of April 2017 (RA update), project involves restoration of tidal wetland areas, reestablishment of habitat for sensitive wildlife, and creation of public access and interpretation opportunities. Plan includes new tidal channels, levee breaches and removal, and grading of gentle upland transitions to facilitate habitat type adaptation to rising tides. Adjacent to Lower Walnut Creek Restoration, and at least part of Pacheco Marsh will likely be combined for implementation.

Project ID# 58
Name: Petaluma River Wildlife Area, Burdell Unit Restoration Project
Submitted by: Natalie Washburn (Ducks Unlimited, Inc.), Renee Spenst (Ducks Unlimited, Inc.), Karen Taylor (California Department of Fish and Wildlife)
Organization: Ducks Unlimited, Inc.
Project Type: Tidal wetland restoration
Description: The Burdell Unit of the Petaluma Marsh Wildlife Area currently contains diked seasonal, freshwater wetlands fed by runoff from the adjacent hills to the west. The site is currently dominated by seasonal wetlands surrounded by aging levees that have repeatedly failed and been repaired. The landowner, California Department of Fish and Wildlife, seeks to assess the feasibility of restoring tidal wetlands. The area is surrounded by the largest remaining natural tidal brackish marsh in California within the Petaluma River Unit and Black John Slough Unit of the Wildlife Area. Tidal wetland restoration at Burdell would connect current tidal marsh from the north and east and increase connectivity for tidal marsh species, including: the California Ridgway's rail, California black rail, and the salt marsh harvest mouse.

Project ID# 59
Name: Pickleweed Park
Submitted by: John Parodi
Organization: Point Blue
Project Type: Tidal marsh transition zone restoration
Description: This project will revegetate the tidal marsh transition zone segments on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 60
Name: Point Molate Regional Shoreline - Restoration and Public Access Project
Submitted by: Laura Thompson (Association of Bay Area Governments), Tiffany Margulici (East Bay Regional Park District), Chris Barton (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Acquisition
Description: This project will acquire and protect the largest eelgrass beds in SF Bay and adjacent uplands, stabilize eroding shorelines, remove Bay fill, and develop public access to restored areas. The reconstructed shoreline will be better able to adapt to sea level rise.

Project ID# 61
Name: Point Pinole Regional Shoreline - Lower Rheem Creek Restoration
Submitted by: Tiffany Margulici (East Bay Regional Park District), Chris Barton (East Bay Regional Park District), Paul Detjens (Contra Costa County Flood Control and Water Conservation District)
Organization: East Bay Regional Park District
Project Type: River restoration
Description: The project goals are to realign and restore about 0.5 mile of Rheem Creek, connect it with the restored Breuner Marsh, and acquire land to protect wildlife.

Project ID# 62
Name: Pozzi Ranch
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 63
Name: Purisma Farms Acquisition
Submitted by: Tim Duff (State Coastal Conservancy)
Organization: CA Coastal Conservancy
Project Type: Acquisition
Description: Acquire conservation and trail easements on a 534-acre property in unincorporated San Mateo County to protect the site's agricultural, natural resource, scenic and recreation values, with potential to serve as a critical junction for connections between the California Coastal Trail and the San Francisco Bay and Ridge Trails.

Project ID# 64
Name: Radio Beach Expansion Project - McLaughlin Eastshore State Park
Submitted by: Chris Barton (East Bay Regional Park District)
Organization: East Bay Regional Park District
Project Type: Beach restoration
Description: The proposed project will enhance and expand Radio Beach, which is located on the southern edge of Eastshore State Park at the Emeryville Crescent in Emeryville, California. The project will remove existing debris and non-native vegetation, and import sand to expand two one-acre beaches and adjacent dune complex to about four-acres. Native dune vegetation will be planted to stabilize the upper beach and dunes, and to prevent wind erosion. Upland dune areas will also be expanded by use of imported sand. Coastal beach and dune complexes have been virtually eliminated along the East Bay shoreline. In small, scattered locations beaches and dunes have been reestablishing. However, most of these areas lack any native vegetation. Many special-status plants historically occurred only in such areas, but are presently absent from the East Bay. Plants such as robust spineflower, Nuttal's locoweed and sea blite could be reintroduced into the expanded beach and

dune complex. In partnership with the East Bay Regional Park District, the US Fish and Wildlife Service is introducing sea blite into the Emeryville Crescent at Eastshore State Park.

Project ID# 65
Name: Raiser Ranch
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 66
Name: Ravenswood Bay Trail Connection Project
Submitted by: San Francisco Bay Joint Venture
Organization: Midpeninsula Regional Open Space District
Project Type: Recreation
Description: The project will complete a 0.6 mile gap in the San Francisco Bay Trail at the boundary of Menlo Park and East Palo Alto. This critical segment will open 80 continuous miles of Bay Trail for region-wide bicycle commuters, nature and recreation enthusiasts, and for residents of East Palo Alto and east Menlo Park, two communities with a significant deficit in recreational opportunities. Over the last decade, the District has planned the alignment, conducted public and agency outreach, and negotiated with and acquired a trail easement from the property owner, San Francisco Public Utilities Commission.

Project ID# 67
Name: Restoration Strategy for Lower Sonoma Creek
Submitted by: Kendall Webster
Organization: Sonoma Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Marsh restoration, Restoration of aquatic connectivity, Riparian and floodplain restoration, Upland restoration, Wetlands created, Wetlands restored/enhanced
Description: For this project, Sonoma Land Trust and our partners will prepare a Restoration Strategy for Lower Sonoma Creek. The Restoration Strategy for Lower Sonoma Creek will:

1. Draw upon pre-existing studies and field knowledge;
2. Identify conceptual restoration options (e.g. freshwater or tidal marsh) on specific parcels which landowners have expressed willingness to sell;
3. Identify properties for upland watershed connections and marsh migration;
4. Analyze the impact of these options on flooding and groundwater quality (salinity);
5. Analyze the feasibility of these options in connection with the redesign of SR 37;
6. Make recommendations for the redesign of SR 37 that ensure resilience of future wetlands and compatibility with restoration objectives; and

7. Recommend sequencing for priority acquisitions and identify preferred restoration methods.

Project ID# 68
Name: Ring Mountain
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 69
Name: River Park
Submitted by: Steve Pressley (Greater Vallejo Recreation District)
Organization: Greater Vallejo Recreation District
Project Type: Tidal marsh restoration
Description: restoration of 22 acres of tidal marsh and 26 acres of upland habitat on Napa River near bridge to Mare Island

Project ID# 70
Name: Rodeo Creek
Submitted by: Paul Detjens (Contra Costa County Flood Control and Water Conservation District)
Organization: Contra Costa County Flood Control and Water Conservation District
Project Type: Riparian restoration
Description: enhance existing flood control channel by planting vegetation and creating riparian habitat

Project ID# 71
Name: SAFER Bay Project
Submitted by: Len Materman
Organization: San Francisquito Creek Joint Powers Authority
Project Type: Community resilience planning
Description: The Conservancy provided a Climate Ready grant of $200,000 to the San Francisquito Creek Joint Powers Authority to evaluate, design, and provide for environmental documentation to demonstrate shoreline resilience and extend flood protection to a larger portion of State Highway 84 and provide for greater ecosystem improvements in concert with the South Bay Salt Pond Restoration Project. The intent of the project was to serve as a pilot project for design of coastal flood protection that incorporates tidal marsh uplands transition zone and uplands ecotone habitat enhancement in the San Francisco Bay region to close a gap in the existing Bay Trail alignment. However, the grantee only complete a portion of the design work (levee alignment and geotechnical investigations) before the grant expired.

Project ID# 72
Name: Schoelenberger
Submitted by: John Parodi
Organization: Point Blue
Project Type: Tidal marsh transition zone restoration
Description: This project will revegetate the tidal marsh transition zone segments on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 73
Name: Sear's Point Dixon Unit
Submitted by: John Parodi
Organization: Point Blue
Project Type: Tidal marsh transition zone restoration
Description: This project will revegetate the tidal marsh transition zone segments on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 74
Name: Skaggs Island and Haire Ranch Restoration
Submitted by: Don Brubaker
Organization: U.S. Fish and Wildlife Service - San Pablo Bay National Wildlife Refuge
Project Type: Tidal marsh restoration
Description: Skaggs Island Acquisition involved transfer of Naval Reserve site from US Navy to USFWS for tidal wetland restoration and inclusion in San Pablo Bay NWR. Issues involved demolition and remediation of 60-acre campus structure and restoration to tidal marsh and the requirement of the property owner to protect the adjacent Haire Ranch from flooding. Haire Ranch subsequently acquired and restoration planning of both Skaggs and Haireis in early stages. As of April 2017 (RA update), project involves the restoration of the 3,300 acre Skaggs Island (a former military base) and the adjacent 1,100 acre Haire Ranch to wetlands to benefit endangered species and other wildlife, and the creation of recreational trails and public access for wildlife viewing. Trail construction (6.5 miles of SF Bay Trail) is part of the tidal wetland restoration.

Project ID# 75
Name: South Bay Salt Pond Restoration Project
Submitted by: Renee Spenst
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration

Description: The 2016 authorization enabled the Conservancy to commence the second phase of project implementation of the South Bay Salt Pond Restoration Project, a multiagency effort to restore 15,100 acres of former salt evaporation ponds in South San Francisco Bay. By providing Duck Unlimited, Inc. (DU) with up to $13,817,333 for Phase 2 construction, in the Alviso Mt. View Ponds (Pond A1 and A2W), 670 acres of restored tidal wetland habitat, 20 acres of upland transition zone, and 1.3 miles of a new trails were created, including a Bay Trail spur out to the open bay along the eastern levee of Pond A2W; and, in the Ravenswood pond complex, a 355-acre mosaic of tidal wetlands, upland transition zone, and managed pond habitats along with a new half mile trail with interpretive features were constructed. Both Phase 2 projects improved flood protection and provide public access, overlook platforms and environmental interpretation. Phase 2 actions were designed to benefit threatened and endangered species including salt marsh harvest mouse, Ridgway's rail, steelhead trout and snowy plover. By allowing an additional $1,067,500 to be used for engineering and environmental services, project management, including Executive Project Manager and Lead Scientist services, public outreach, website and data management and applied studies, the Conservancy continues its extensive support for the SBSP Restoration Project's public engagement and adaptive management. The 2017 authorization provided Save the Bay with $500,000 for implementing a volunteer program to vegetate 10 acres of habitat transition zone at Ravenswood.

Project ID# 76
Name: South Bay Salt Ponds: A22, A23
Submitted by: John Bourgeois
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: Ponds A22 (275 acres) and A23 (445 acres) included in this project are scheduled for future restoration and/or enhancement. Both ponds are planned as pond habitat in the 50/50 restoration/enhancement alternative, and are planned as restored tidal marsh in the 90/10 restoration/enhancement alternative.

Project ID# 77
Name: South Bay Salt Ponds: Alviso - A8 Pond Cluster - Ponds A8, A8S, A5, A7
Submitted by: John Bourgeois
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: The Alviso-A8 Pond cluster consists of Ponds A8, A8S, A5 and A7 and the levees surrounding each pond. Restoration activities include controlled tidal restoration for endangered and aquatic species and management of ponds for migratory shorebirds and waterfowl. All 4 Ponds were linked in the Phase 1 actions. These ponds were made reversibly muted tidal habitat by removing parts of the levees and associated vehicle access between them and between A8 and the adjacent ponds A5/A7 to the west. A 40-foot long reversible, armored concrete notch (less than a full breach) was made in the eastern levee of Pond A8 to allow some muted tidal exchange and to allow the USFWS to vary the size of the notched opening using 8 large metal gates in the notch. Opening the gates will allow tidal waters to flow into the Guadalupe River (Alviso Slough) near the Gold Street Bridge. The notch has three goals. First, introducing tidal action into the river is estimated to widen its channel by 90 ft and deepen it by 2 ft, restoring it to more natural historical conditions. Second, raising the salinity of the river is expected to kill or slow the growth of bulrushes and cattails that have choked the river over the past 30 years, making boating easier in the lower Guadalupe river. The notch project will allow scientists to obtain more precise information about how much mercury is buried in the mud of the river and salt ponds, how

it behaves chemically when disturbed, and what effects it has on fish, birds and insects. This experiment will guide the restoration of other former Cargill salt ponds from Hayward to Redwood City. Pond A8 and A8S are also used as flood storage basins during high-rainfall events. Pond A8 contains an overflow weir that will allow for flood storage during flood events greater than a 10-year flood in the lower Guadalupe River and Alviso Slough. There are no recreation or public access features at these ponds. SCVWD is construction manager/agent. As of May 2017, additional work including the creation of 20 acres of ecotone habitat along the southern edge of Pond A8 is underway. Construction is estimated to take place in 2018-2019.

Project ID# 78
Name: South Bay Salt Ponds: Alviso - Mountain View Ponds - A1, A2W
Submitted by: John Bourgeois
Organization: State Coastal Conservancy, US Fish and Wildlife Service
Project Type: Tidal wetland restoration, natural infrastructure flood protection
Description: The goal for these former salt ponds is to complete a large-scale tidal marsh restoration, maintain or improve flood protection to adjacent residences and businesses, and improve recreation and public access. This will be accomplished by altering or breaching levees, and creating wildlife habitat features.

Project ID# 79
Name: South Bay Salt Ponds: Alviso - Pond A18
Submitted by: John Bourgeois
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: The goal for these former salt ponds is to complete a large-scale tidal marsh restoration, maintain or improve flood protection to adjacent residences and businesses, and improve recreation and public access. This will be accomplished by altering or breaching levees, and creating wildlife habitat features.

Project ID# 80
Name: South Bay Salt Ponds: Alviso - Ponds A2E, A3N, A3W, AB1, AB2
Submitted by: John Bourgeois
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: The goal for these former salt ponds is to complete a large-scale tidal marsh restoration, maintain or improve flood protection to adjacent residences and businesses, and improve recreation and public access. This will be accomplished by altering or breaching levees, and creating wildlife habitat features.

Project ID# 81
Name: South Bay Salt Ponds: Alviso - Ponds A9, A10, A11, A12, A13, A14, A15
Submitted by: John Bourgeois
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: The goal for these former salt ponds is to complete a large-scale tidal marsh restoration, maintain or improve flood protection to adjacent residences and businesses, and improve recreation and public access. This will be accomplished by altering or breaching levees, and creating wildlife habitat features.

Project ID# 82
Name: South Bay Salt Ponds: Eden Land - Southern Eden Landing
Submitted by: John Bourgeois
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: This 2,500-acre project will restore at least four former salt ponds to tidal marsh through levee breaches, add habitat islands to increase bird-nesting success and create deep-water channels to improve habitat quality for juvenile fish. Other project activities include innovative flood protection elements, and completion of the Bay Trail.

Project ID# 83
Name: South Bay Salt Ponds: Ravenswood - Ponds R1, R2
Submitted by: John Bourgeois
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: The goal for these former salt ponds is to complete a large-scale tidal marsh restoration, maintain or improve flood protection to adjacent residences and businesses, and improve recreation and public access. This will be accomplished by altering or breaching levees, and creating wildlife habitat features.

Project ID# 84
Name: South Bay Salt Ponds: Ravenswood Complex - Ponds R3, R4, R5, S5, S5W
Submitted by: John Bourgeois
Organization: State Coastal Conservancy
Project Type: Tidal marsh restoration
Description: The goal of this project is to restore seasonal ponds to tidal marsh and managed ponds, maintain or improve flood protection, improve habitat for western snowy plover, and create public access.

Project ID# 85
Name: South San Francisco Bay Shoreline Project
Submitted by: Yves Zsutty
Organization: CA State Coastal Conservancy
Project Type: Wetlands restored/enhanced
Description: This project is an effort to provide flood protection, restore 2,900 acres of former salt evaporation ponds, and improve public access in the Alviso area of South San Francisco Bay. The State Coastal Conservancy has participated in the Shoreline Project for over a decade because it will implement the restoration, flood protection, and public recreation goals of the South Bay Salt Pond Restoration Project in the Alviso area.
The Conservancy, Santa Clara Valley Water District, and the US Army Corps of Engineers embarked on the South San Francisco Bay Shoreline Study, a federal feasibility study of the existing flood threat and biological conditions of the Santa Clara County shoreline in 2006. The Corps approved the Study at its September 11, 2015 Civil Works Review Board. With the Conservancy's May 22, 2016 approval to enter into a Design Agreement with the U.S. Army Corps of Engineers (Corps) and SCVWD, the Shoreline Study moved into the implementation stage and became the South San Francisco Bay Shoreline Project (Shoreline Project). On March 22, 2018, the Conservancy authorized $200,000 for engineering and environmental services and a trail feasibility study as well as signing a Project Partnership Agreement in order to support implementation of the South San Francisco Bay Shoreline Project.

Project ID# 86
Name: Tennessee Hollow, Western Tributary
Submitted by: Lewis Stringer (Presidio Trust)
Organization: Presidio Trust
Project Type: River restoration
Description: This project will upgrade and/or restore an intermittent stream, a landfill, and a degraded ball field.

Project ID# 87
Name: Tennessee Hollow, Remnant Reach
Submitted by: Lewis Stringer (Presidio Trust)
Organization: Presidio Trust
Project Type: Invasive species removal
Description: Remnant Reach, one of the few natural channel reaches in the Tennessee Hollow watershed, sustains willows and has a small perennial flow. Planned enhancement work includes removal of non-native trees and invasive species to increase the quality of the habitat. Additional plans to improve public access are also in the works.

Project ID# 88
Name: Terminal Four Wharf Removal Project
Submitted by: David Halsing
Organization: URS Corporation
Project Type: Subtidatl habitat enhancement
Description: Develop a 60% engineering plan set, permit applications, and CEQA for removal of creosote pilings at the Terminal Four Wharf Removal site in the City of Richmond, San Francisco Bay, including plans, specifications, construction schedule, equipment, access considerations, and cost estimates.The Conservancy retained a consulting firm in 2014 to develop 30% engineering plan set for removal of creosote pilings at the Terminal 4 and Red Rock warehouse/Richmond whaling station site in the City of Richmond, San Francisco Bay. Next phase starting May 2017 is to develop 60% designs, permit applications, and environmental documentation for the Project.

Project ID# 89
Name: Terra Firma Farms
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 90
Name: Treasure Island
Submitted by: Noreen Weeden (Golden Gate Audubon Society)
Organization: Golden Gate Audubon Society
Project Type: Wetland creation
Description: Constructed wetland on north-east corner of island as part of redevelopment -- for habitat, storm-water treatment and education.

Project ID# 91
Name: Upper Tolay Creek
Submitted by: John Parodi
Organization: Point Blue
Project Type: Riparian restoration
Description: This project will revegetate the riparian drainages on site, using Point Blue's Climate Smart Restoration framework, tools and practices, with additional invasive plant management practices if necessary. Project benefits will include increasing the carbon sequestration capacity on site, water quality improvement and flood potential reduction by reducing excess sediment/nutrient inputs into the system, and increasing the quality and acreage of habitat, enhancing connectivity to extend suitable ranges for wildlife. In addition, these expanding ranges will allow for critical species and genetic migration necessary for resiliency in response to predicted changes in climate.

Project ID# 92
Name: Yosemite Slough Restoration and Development Phase 2
Submitted by: Rachel Norton
Organization: CA Department of Parks and Recreation
Project Type: Wetlands restored/enhanced
Increase access, provide recreational and educational opportunities
Description: The Phase 2 project transformed the 21-acre project site, part of Candlestick Point State Recreation Area (CPSRA), into parkland that is used by approximately 200,000 visitors per year, including adjacent Bayview-Hunters Point residents, local school groups, and community groups. The project was part of a comprehensive effort to restore wetland and wildlife habitat and clean up contaminated areas in CPSRA, as well as increase access to the CPSRA's waterfront and provide recreational and educational oppourtunities for the local community. The project included planting 150 native trees, 17,000 shrubs, eight acres of native grasses, and one-acre of recreational lawn. The native shrubs were planted to establish coastal scrub habitat, as well as enhance entryways and plaza gardens and were incorporated into biorentation areas established to treat stormwater throughout the project site. California State Parks Foundation contracted with Literacy for Environmental Justice to grow a portion of the plants at their native plant nursery, adjacent to the project site. LEJs paid high school-aged interns, and youth program participants assisted in the plant propagation, as well as plant installation and maintenance. Visitor facilities developed as part of the project included a zero-net energy Education Center, a 2,000 foot segment of the San Francisco Bay Trail, ADA-accessible park viewing and picnic areas, an outdoor ampitheater, and a parking lot for 35 cars. The selection and design of visitor facilities were developed after a series of community meetings that were held in the early 2000s. In 2016, an Interpretation Master Plan and education programming was developed that incorporated extensive community input and is guiding programming at the Education Center and was used in the development of interpretive features installed at the site.

Appendix 7. Summary of Additional Studies and Plans

A component of the Targeted Watershed Assessment was to compile and summarize existing studies and plans to serve as an inventory and quick reference for stakeholders. The table below is the result of a rapid assessment to identify and summarize relevant documents through a keyword search and those identified by the local Watershed Committee and stakeholders. The use of “N/A” indicates “not applicable” meaning that the information represented by that column was not found in a search of relevant terms in that document. It may be the case that the subject matter is included but did not use the terms searched.

Table A7-1. A review of plans to identify key resilience concerns in terms of areas, key infrastructure features, species, and habitats.

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Bay Area Integrated Regional Water Management Plan Bay Area Integrated Regional Water Management Plan. Prepared by Kennedy/Jenks Consultants in association with Environmental Science Associates, Kearns & West, Zentraal. September 2013. http://bayareairwmp.org/wp-content/uploads/2017/05/san-francisco-bay-area-irwmp-final_september-2013a.pdf	San Francisco, Bays and outer coast Marin and San Mateo counties	Estuarine and marine water quality	Hunting, fishing, and other water-based recreation.	Flooding vulnerability assessment
Bayland Ecosystem Habitat Goals Update *Goals Project. 2015. The Baylands and Climate Change: What We Can Do. Baylands Ecosystem Habitat Goals Science Update 2015. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.* *http://www.baylandsgoal.org*	*San Francisco Bay*	*Threats and strategies for multiple taxa*	*Recreation and nature-based adaptation measures*	*N/A*
Baylands Ecosystem Habitat Goals Report *Monroe M, Olofson PR, Collins JN, Grossinger RM, Haltiner J, Wilcox C. 1999. Baylands Ecosystem Habitat Goals.* *http://www.sfei.org/documents/baylands-goals*	*San Francisco Bay*	*Threats and strategies for multiple taxa*	*Recreation and nature-based adaptation measures*	*N/A*

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Bay Conservation and Development Commission Bay Plan 2012 *San Francisco Bay Plan. 2008. San Francisco Bay Conservation and Development Commission. San Francisco, CA.* *http://www.bcdc.ca.gov/pdf/bayplan/bayplan.pdf*	*San Francisco Bay*	*Fish & wildlife, subtidal, tidal marsh, tidal flats*	*Developed areas, Transportation, commercial uses, managed wetlands, salt ponds*	*Sea level rise, flood vulnerability assessment*
Subtidal Habitat Goals; *San Francisco Bay Subtidal Habitat Goals Report. 2010.;* *http://www.sfbaysubtidal.org/PDFS/Full%20Report.pdf*	*San Francisco Bay*	*Goals for the restoration and conservation of SF Bay subtidal habitats and species*	*Docks, piers, pilings*	*Flooding threats to natural resources*

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California; U.S. Fish and Wildlife Service. 2013. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Sacramento, California. xviii + 605 pp.; https://www.fws.gov/sacramento/es/recovery-planning/tidal-marsh/es_recovery_tidal-marsh-recovery.htm	Northern and Central California Coasts	Ridgway's rail (*Rallus longirostris obsoletus*), salt marsh harvest mouse (*Reithrodontomys raviventris*), Suisun thistle (*Cirsium hydrophilum var. hydrophilum*), soft bird's-beak (*Chloropyron molle ssp. molle*), and California sea-blite (*Suaeda californica*)	N/A	Flooding threats to natural resources
Conservation Lands Network; Bay Area Open Space Council. 2011. The Conservation Lands Network: San Francisco Bay Area Upland Habitat Goals Project Report. Berkeley, CA.; http://www.bayarealands.org//wp-content/uploads/2017/07/CLN-1.0-Original-Report.pdf	San Francisco Bay	Riparian (fish), mammals, birds, amphibians	N/A	Flooding threats to natural resources
South San Francisco Bay Shoreline Study; South San Francisco Bay Shoreline Phase 1 Study. Final Integrated Document. Final Interim Feasibility Study with Environmental Impact Statement/Environmental Impact Report. U.S. Army Corps of Engineers San Francisco; http://www.spn.usace.army.mil/Portals/68/docs/FOIA%20Hot%20Topic%20Docs/SSF%20Bay%20Shoreline%20Study/Final%20Shoreline%20Main%20Report.pdf Francisco District. 1455 Market St. San Francisco, CA 94103. Prepared for U.S. Army Corps of Engineers by: HDR Engineering, Inc. Sacramento, CA 95833	South San Francisco Bay	Sea level rise and other climate change related impacts to wildlife	Multi-benefit projects that protect human infrastructure	Sea level rise

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
San Francisquito Creek: SAFER Bay Project; Public Draft Feasibility Report SAFER Bay Project. Strategies to Advance Flood protection, Ecosystems and Recreation along San Francisco Bay. East Palo Alto and Menlo Park. October 2016. San Francisquito; http://www.sfcjpa.org/documents/SAFER_Bay_Public_Draft_Feasibility_Report_Summary_Oct._2016_.pdf Creek Joint Powers Authority. 615 B Menlo Avenue, Menlo Park, CA 94025. Prepared By: Libby Mesbah, Lance Jones, Edwin Woo (HDR Engineering, Inc.), Matt Brennan (ESA PWA), Ron Duke, Max Busnardo (H.T. Harvey & Associates)	East Palo Alto/Menlo Park Bay shoreline	Sea level rise and other climate change related impacts to wildlife	Multi-benefit projects that protect human infrastructure	Flood reduction project
City of Benicia Adaptation Plan; Climate Change Adaptation Plan. Preparing Benicia for a Resilient Future. Prepared for the City of Benicia. Prepared by ICF International, Place Works, Moffat & Nichol, Michael Baker International. October 2016; https://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/Final_Adaptation_Plan(1).pdf	City of Benicia	Includes assessment of habitat (tidal marsh, mudflats) but doesn't explicitly address individual species	addresses flood risk and reduction for human infrastructure (homes, businesses, transportation, services)	Flooding vulnerability and adaptation strategies

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Supporting Climate Adaptation Decisions for Estuarine Ecosystems of the San Francisco Bay; Mattsson BJ, Huning B, Block G, Robinson K, Sloop C, Cummings J. 2015. Developing a spatially-explicit climate adaptation framework for estuarine; http://climate.calcommons.org/sites/default/files/basic/SFCADS_Phase_1_Report_2015.pdf ecosystems of the San Francisco Bay: Climate Adaptation for Decision Support. San Francisco Bay	San Francisco Bay	Threats and needs of estuarine species	includes multi-benefit strategies that protect human assets	Flooding threats to natural resources
San Pablo Bay National Wildlife Refuge Climate Adaptation Plan; Veloz, S., J. Wood, D. Jongsomjit, G. Block, and K. F. Robinson. 2016. San Pablo Bay National Wildlife Refuge Climate Adaptation Plan. USFW National Wildlife Refuge System, Petaluma, CA.; http://climate.calcommons.org/bib/san-pablo-bay-national-wildlife-refuge-climate-adaptation-plan	San Pablo Bay	Federal T&E species	N/A	Flooding threats to natural resources
South Bay Salt Pond Restoration Project Adaptive Management Plan; USFWS and CDFW. 2007. South Bay Salt Pond (SBSP) Restoration Project FINAL Environmental Impact Statement/Environmental Impact Report.; http://www.southbayrestoration.org/pdf_files/SBSP_EIR_Final/Appendix%20D%20Final%20AMP.pdf	South San Francisco Bay	Multiple fish and wildlife taxa addressed	Multi-benefit flood reduction strategies	Flooding threats to natural and human resources

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
U.S. Fish and Wildlife Service Pacific Region (Region One) Seabird Plan; Mills, K.L., M. Naughton, G. Elliott. 2005. Seabird conservation planning the Pacific Region. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.; https://www.fs.fed.us/psw/publications/documents/psw_gtr191/psw_gtr191_0157-0160_mills.pdfhttps://www.fs.fed.us/psw/publications/documents/psw_gtr191/psw_gtr191_0157-0160_mills.pdf	Pacific region	Seabirds	N/A	N/A
Southern Pacific Shorebird Conservation Plan; Hickey, C., W.D. Shuford, G.W. Page, and S. Warnock. 2003. Version 1.1. The Southern Pacific Shorebird Conservation Plan: A strategy for supporting California's Central Valley and coastal shorebird populations. PRBO Conservation Science, Stinson Beach, CA.; https://drive.google.com/file/d/0B7D0wQi_slFpZUdORDlQejJRdHM/view?usp=sharing	Southern Pacific Region	Shorebirds	N/A	N/A
California Bird Species of Special Concern; Shuford WD, Gardali T, editors. 2008. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.; https://www.wildlife.ca.gov/Conservation/SSC/Birds	California	Multiple bird taxa- status, needs, conservation strategies and actions	N/A	N/A

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Our Coast Our Future; Ballard, G., Barnard, P.L., Erikson, L., Fitzgibbon, M., Moody, D., Higgason, K., Psaros, M., Veloz, S., Wood, J. 2016. Our Coast Our Future (OCOF). [web application]. Petaluma, California. www.ourcoastourfuture.org. (Accessed: Date [e.g., August 2016]).; www.pointblue.org/ocof	Coastal California	N/A	Flooding vulnerability to human assets under combined storm and sea level rise scenarios	Maps of flooding vulnerability
Future San Francisco Bay Marshes; Veloz S, Fitzgibbon M, Stralberg D, Michaile S, Jongsomjit D, Moody D, Nur N, Salas L, Wood J, Elrod M, Ballard G. 2014. Future San Francisco Bay Tidal Marshes: A climate-smart planning tool. [web application]. Petaluma, California.; www.pointblue.org/sfbayslr	San Francisco Bay	Tidal marsh habitat and bird species vulnerability to sea level rise	N/A	N/A
Impacts of predicted sea-level rise and extreme storm events on the transportation infrastructure in the San Francisco Bay Region; Biging, Greg S., John D. Radke, and Jun Hak Lee (University of California, Berkeley). 2012. Impacts of Predicted Sea-Level Rise and Extreme Storm Events on the Transportation Infrastructure in the San Francisco Bay Region. California Energy Commission. Publication number: CEC-500-2012-040.; http://ucciee.org/downloads/Impacts%20of%20Sea%20Level%20Rise%20on%20the%20Transportation%20Infrastructure%20in%20the%20Bay%20Area.pdf	San Francisco Bay	N/A	Transportation infrastructure	Flooding vulnerability assessment

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Plan Bay Area 2040 Final; Metropolitan Transportation Commission, Association of Bay Area Governments. 2017. Plan Bay Area 2040 Final. Available from: http://2040.planbayarea.org/reports. ; http://2040.planbayarea.org/cdn/farfuture/u_7TKELkH2s3AAiOhCyh9Q9QlWEZIdYcJzi2QDCZuIs/1510696833/sites/default/files/2017-11/Final_Plan_Bay_Area_2040.pdf	San Francisco Bay	N/A	Transportation sector	Flooding vulnerability and adaptation plan
State of the Estuary 2015; The State of the Estuary 2015, San Francisco Estuary Partnership; http://www.sfestuary.org/wp-content/uploads/2015/10/SOTER_2.pdf	San Francisco Bay	Multiple taxa (birds, fish, mammals) status, trends, threats and conservation recommendations	N/A	Flooding threats to natural resources
Surviving the Storm; Surviving the Storm. 2015. Bay Area Council Economic Institute. San Francisco, CA.; http://documents.bayareacouncil.org/survivingthestorm.pdf	San Francisco Bay	N/A	Multiple human asset vulnerabilities (commercial, residential, transportation, services)	Flooding vulnerability and flood risk reduction strategies
Suisun Marsh Habitat Management, Preservation and Restoration; Suisun Marsh Habitat Management, Preservation, and Restoration Plan: Environmental Impact Statement. 2011. U.S. Bureau of Reclamation; https://www.federalregister.gov/documents/2010/10/29/2010-27364/suisun-marsh-habitat-management-preservation-and-restoration-plan-california	Suisun Marsh	Addresses status and conservation needs for multiple fish and wildlife taxa	Vulnerability and strategies for protecting human assets (transportation, working lands, commercial and residential)	Vulnerability assessment and adaptation strategies

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Restoring the Estuary- San Francisco Bay Joint Venture Implementation Plan; Restoring the Estuary: An Implementation Strategy for the San Francisco Bay Joint Venture. (2001.) San Francisco Bay Joint Venture.; http://www.sfbayjv.org/pdfs/strategy/Restoring_The_Estuary_Full.pdf	San Francisco Bay	Addresses status and needs for multiple fish and wildlife taxa	N/A	N/A
California EcoAtlas; San Francisco Estuary Institute. 2016. EcoAtlas: Enhancing Regional Capacity for Habitat Restoration Project Tracking, Assessment and Reporting.; http://www.ecoatlas.org/	California	Online maps of habitat extent (land cover types)	N/A	N/A
Adapting to Rising Tides; San Francisco Bay Conservation Development Commission (BCDC). 2012a. Adapting to Rising Tides; http://www.adaptingtorisingtides.org/	San Francisco Bay	Habitat vulnerability assessment	Vulnerability assessment and adaptation strategies for human infrastructure	Vulnerability assessment and adaptation strategies
Resilient by Design Bay Area Challenge; http://www.resilientbayarea.org/	San Francisco Bay	Description of benefit to fish and wildlife from multi-benefit flood risk reduction projects	Innovative shoreline development projects that protect human infrastructure	Adaptation projects

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Climate-Smart Adaptation for North-central California Coastal Habitats; Hutto SV, editor. 2016. Climate-Smart Adaptation for North-central California Coastal Habitats. Report of the Climate-Smart Adaptation Working Group of the Greater Farallones National Marine Sanctuary Advisory Council. San Francisco, CA. 47 pp.; http://climate.calcommons.org/sites/default/files/Climate-Smart%20Adaptation%20Report_March%202016.pdf	San Mateo - Sonoma County outer coast	Describes actions that benefit marine fish, birds, and mammal species	Addresses benefit to transportation, commercial, residential assets from habitat adaptation projects, strategies	Flooding reduction strategies for wildlife and habitats
Climate Change Vulnerability Assessment for the North-central California Coast and Ocean; Hutto, SV, Higgason KD, Kershner JM, Reynier WA, Gregg DS. 2015. Climate Change Vulnerability Assessment for the North-central California Coast and Ocean. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 473 pp.; https://sanctuaries.noaa.gov/science/conservation/pdfs/vulnerability-assessment-gfnms.pdf	San Mateo - Sonoma County outer coast	Describes threats to marine fish, birds, and mammal species	N/A	Flooding vulnerability of wildlife and habitats
CALTRANS Climate Change Vulnerability Assessment Summary Report District 4; http://www.dot.ca.gov/paffairs/pr/2017/prs/17pr132.html	9 county bay area	N/A	Transportation sector	FLooding vulnerability assessment

Title, Citation, and Link (if available)	**Geography covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
County of Solano Sea level rise Strategic Program; https://www.solanocounty.com/civicax/filebank/blobdload.aspx?BlobID=11108	Solano County	Limited description of fish and wildlife benefits	Vulnerabilities and adaptation strategies for multiple human asset sectors	Vulnerability assessment and flood risk reduction strategies
Marin Ocean Coast Sea Level Rise Vulnerability Assessment; https://www.marincounty.org/~/media/files/departments/cd/planning/slr/vulnerability-assessment/part-01_draft_marin_coast_slr_va_v2.pdf?la=en	Marin county outer coast	Examples of birds and other wildlife that depend on natural resources	Parcels and buildings, transportation networks, utilities, working lands, recreational activities, emergency services, and historical and archaeological resources	Flooding vulnerability assessment
Bay Waterfront Adaptation & Vulnerability Evaluation (BayWAVE);Prepared by BVB Consulting for Marin County Department of Public Works June 2017| County of Marin, CA | marinslr.org; https://www.marincounty.org/-/media/files/departments/cd/planning/slr/baywave/vulnerability-assessment-final/final_allpages_bvbconsulting_reduced.pdf?la=en&hash=BACAD9ADF94663DA16E6E3324563B1BD28F484F3	Marin Bay Shoreline	Asset description includes fish and wildlife species (Ridgway's rail, soft bird's-beak, white-rayed pentachaeta, salt-marsh harvest mouse, tidewater goby)	Parcels and buildings, transportation networks, utilities, working lands, recreational activities, emergency services, and historical and archaeological resources	Flood risk reduction strategies
County of San Mateo Sea Level Rise Vulnerability Assessment; http://seachangesmc.com/wp-content/uploads/2018/03/2018-03-12_SLR_VA_Report_2.2018_WEB_FINAL.pdf	San Mateo County	Lists fish and wildlife species impacted by sea level rise	Wide range of human assets addressed	Flooding vulnerability assessment

Glossary and Key to Acronyms and Abbreviations Used in this Report

At-risk species: All species formally included in one of the following categories at the time of this assessment:

- A species listed as 'endangered', 'threatened', or 'candidate' under the provisions of Endangered Species Act (ESA)[13]
- A species with a NatureServe global imperilment rank of G1, G2, or G3[14]
- A species with a NatureServe state imperilment rank of S1, S2, or S3
- A State Species of Greatest Conservation Need (SGCN) as recorded in current State Wildlife Action Plans [15]

Community Vulnerability Index: An index of the number of Human Community Assets (HCAs) with vulnerability to flooding threats.

Condition: The results obtained from applying the landscape condition model to either the fish and wildlife elements or the HCAs to calculate a condition score for fish and wildlife elements or HCAs ranging from 0.0 (low condition) to 1.0 (high condition).

Conservation Value Summary: Mapped values that are the output of a Vista DSS overlay function that allows for a wide range of calculations based on element layers and user-specified attributes. Examples include richness (the number of overlapping elements at a location) and weighted richness where, for example, a simple richness index is modified by the modeled condition of elements. Several indices calculated for this assessment are conservation value summaries.

CVS: See Conservation Value Summary.

Distance effect: The off-site impacts from a stressor or threat used in the Landscape Condition Model (LCM) to estimate the condition of elements and assets.

Distinctive ecological systems: Mid- to local- scale ecological units useful for standardized mapping and conservation assessments of habitat diversity and landscape conditions. Ecological systems reflect similar physical environments, similar species composition, and similar ecological processes.

Element: A fish or wildlife habitat type, species, or species aggregation.

Element Occurrence (EO): An area of land and/or water in which a species or natural community is, or was, present. An EO should have practical conservation value for the element as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location.

EO: See Element Occurrence.

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[13] These categories are established by the **US Endangered Species Act of 1973, as amended through the 100th Congress**. (United States Government 1988) (See this factsheet for further explanation: https://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf)

[14] These categories, used throughout the Americas are documented in the publication **NatureServe Conservation Status Assessments: Methodology for Assigning Ranks (Faber-Langendoen et al. 2012)** (Available here: http://www.natureserve.org/sites/default/files/publications/files/natureserveconservationstatusmethodology_jun12_0.pdf)

[15] The basis for this designation varies by state.

EPA: Environmental Protection Agency

ESA: Endangered Species Act

Essential Fish Habitat (EFH): Those waters and substrate necessary for the spawning, breeding, feeding, or growth to maturity of a species of fish.

GIS: Geographic information system

G-Rank or Global Rank: NatureServe rank based on assessment of how imperiled a species or community is throughout its entire range (G1-G5 with G1 being most imperiled and G5 being most secure).

Habitat Area of Particular Concern (HAPC): NOAA-designated areas that provide important ecological functions and/or are especially vulnerable to degradation. HAPCs are a discrete subset of the Essential Fish Habitat for a species of fish.

HCA: See Human Community Asset.

HUC: See Hydrologic unit code.

HUC8 Units (also called Level 4 hydrologic units or subbasins): A hierarchical 'level' of hydrologic unit often used for establishing the boundaries in natural resource and agricultural assessment, planning, management, and monitoring. HUC8 units served as the framework for defining targeted watersheds in this assessment. They have an average size of approximately 700 square miles.

Hydrologic Unit Code (HUC): A systematic code used as a unique identifier for hydrological units of different scales. There are six levels of units that nest within each other in a spatial hierarchy. (For more information, see this useful resource: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1042207.pdf)

Human Community Asset (HCA): Human populations and/or critical infrastructure or facilities.

Important bird areas: Areas identified using an internationally agreed set of criteria as being globally important for the conservation of bird populations.

LCC: See Landscape conservation cooperative.

Landscape condition model: A model of ecological condition reflecting information about the interaction of one or more conservation targets with phenomena known or estimated to impact their condition in an explicit way (change agents). A landscape condition model uses available spatial data to transparently express interactions between targets and change agents. Change agent selection and effects can be based on published literature and/or expert knowledge.

Landscape Conservation Cooperative: A cooperative effort that brings stakeholders together around landscape-scale conservation objectives that require broad coordination (often at the scale of multiple states).

LCM: See Landscape condition model.

Living shoreline: is broad term that encompasses a range of shoreline stabilization techniques along estuarine coasts, bays, sheltered coastlines, and tributaries. A living shoreline has a footprint that is made up mostly of native material. It incorporates vegetation or other living, natural “soft” elements alone or in combination with some type of harder shoreline structure (e.g. oyster reefs or rock sills) for added stability. Living shorelines maintain continuity of the natural land–water interface and reduce erosion while providing habitat value and enhancing coastal resilience.

National Hydrography Dataset: “A comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of surface water (lakes, ponds, and reservoirs), paths through which water flows (canals, ditches, streams, and rivers), and related entities such as point features (springs, wells, stream gages, and dams)” (USGS 2017).

Natural and Nature-Based Solutions: “Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” as defined by IUCN.

NatureServe Vista: A software extension to ArcGIS used in this assessment to store, manage, and conduct a variety of analyses with relevant spatial data.

NEMAC: National Environmental Modeling and Analysis Center

NFWF: National Fish and Wildlife Foundation

NHD: see National Hydrography Dataset.

NOAA: National Oceanic and Atmospheric Administration

NOAA Trust Resource: Living marine resources that include: commercial and recreational fishery resources (marine fish and shellfish and their habitats); anadromous species (fish, such as salmon and striped bass, that spawn in freshwater and then migrate to the sea); endangered and threatened marine species and their habitats; marine mammals, turtles, and their habitats; marshes, mangroves, seagrass beds, coral reefs, and other coastal habitats; and resources associated with National Marine Sanctuaries and National Estuarine Research Reserves.

NWI: National Wetlands Inventory (USFWS product)

Resilience: The ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events, as defined by the National Academies of Science. For fish and wildlife, this can mean the ability to recover to a viable and functioning state, either naturally or through restoration actions.

Resilience Hub: Large patches of contiguous, natural areas that provide communities with protection and buffering from the growing impacts of sea-level rise, changing flood patterns, increased frequency and intensity of storms, and other environmental stressors while supporting populations of fish and wildlife habitat and species.

Resilience Project: A planned or proposed nature-based project that has not yet been undertaken and that would have mutual benefits for human community assets and fish and wildlife elements when implemented.

SGCN: See Species of Greatest Conservation Need.

Site Intensity: The on-site condition remaining in the presence of a stressor/threat used in the Landscape Condition Model (LCM). Values range from 0 (low condition) to 1 (high condition) and are applied to the footprint of the stressor/threat as defined by the scenario.

SLR: Sea level rise

Species congregation area: A place where individuals of one or more species congregate in high numbers for nesting, roosting, or foraging.

Species of Greatest Conservation Need: Those species identified by state wildlife agencies as priorities for conservation in their State Wildlife Action Plans.

S-Rank or State rank: NatureServe rank based on assessment of how imperiled a species or community is within South Carolina (S1-S5 with S1 being most imperiled and S5 being most secure).

SCDNR: South Carolina Department of Natural Resources

SWAP: State Wildlife Action Plan

TNC: The Nature Conservancy

USACE: U.S. Army Corps of Engineers

USFWS: U.S. Fish and Wildlife Service

Vista DSS: See NatureServe Vista, DSS stands for Decision Support System

Vulnerability: The risk or possibility of an HCA or element to experience stressors and/or threats causing its condition to drop below a defined threshold of viability.

Watershed: a region or area bounded by a divide and draining ultimately into a watercourse or body of water, often mapped with HUCs.