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1. Introduction and Background

1.1. Introduction

Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) is located in the south end of the San Francisco Bay in northern California. For the purposes of this document, the Refuge is divided into four management units: Newark, Mowry, Alviso, and West Bay Units. The Refuge supports habitat for migratory birds on the Pacific Flyway and endangered species.

The U.S. Fish and Wildlife Service (Service) prepared this Final Comprehensive Conservation Plan (CCP) to guide refuge management for the next 15 years. The CCP provides a description of the desired future conditions and long-range guidance to accomplish the purposes for which the Refuge was established. The CCP and accompanying Environmental Assessment (EA) address Service legal mandates, policies, goals, and National Environmental Policy Act (NEPA) compliance. This Final CCP was developed through modifications made during the internal and public review processes.

The CCP is divided into six chapters: Chapter 1, Introduction and Background; Chapter 2, The Comprehensive Conservation Planning Process; Chapter 3, Affected Environment; Chapter 4, Current Refuge Management and Programs; Chapter 5, Refuge Management Direction: Objectives and Strategies; and Chapter 6, Plan Implementation.

Aerial view of Bair Island
USFWS

1.2. Purpose and Need

A master plan was developed in 1974 to guide the initial establishment of the Refuge, but no formal management plan currently guides the Refuge. The National Wildlife Refuge System Improvement Act of 1997 (16 United States Code [USC] 668dd-668ee) (1997 Improvement Act) requires that all refuges be managed in accordance with an approved CCP by 2012. Under the 1997 Improvement Act, the National Wildlife Refuge System (Refuge System, NWRS) is to be consistently directed and managed to fulfill the specific purpose(s) for which each refuge was established, as well as the Refuge System mission. The planning process helps the Service achieve the refuge purposes and the Refuge System mission by identifying specific goals, objectives, and strategies to implement on each Refuge. The purposes of this CCP are listed below.

- Provide a clear statement of direction for the management of the Refuge during the lifetime of the CCP.
- Provide long-term continuity in Refuge management.
- Communicate the Service's management priorities for the Refuge to its neighbors and the public.
- Provide an opportunity for the public to help shape the future management of the Refuge.
- Ensure that management programs on the Refuge are consistent with the legal and policy mandates for the Refuge System and the purpose of the Refuge as set forth in establishing documentation.
- Ensure that management of the Refuge is, to the extent practicable, consistent with Federal, State, and local plans.
- Provide a basis for budget requests to support the Refuge's needs for staffing, operations, maintenance, and capital improvements.
- Evaluate existing and proposed uses on each of the Refuges to ensure that they are compatible with the Refuge purpose(s); the Refuge System mission; and the maintenance of biological integrity, biodiversity, and environmental health.

1.3. The U.S. Fish and Wildlife Service and the National Wildlife Refuge System

1.3.1. U.S. Fish and Wildlife Service

The mission of the Service is: "Working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people." The Service is the primary Federal agency responsible for conserving, protecting, and enhancing the Nation's fish, wildlife, and plant populations and their habitats for the continuing benefit of the American people. Although the Service shares this responsibility with other Federal, tribal, State, local, and private entities, the Service has specific responsibilities for migratory birds, threatened and endangered species, interjurisdictional fish, and certain marine mammals. These are referred to as Federal Trust Species. The Service also manages the Refuge System and National fish hatcheries; enforces Federal wildlife laws and international treaties related to importing and exporting wildlife; assists State fish and wildlife programs; and helps other countries develop wildlife conservation programs.

1.3.2. The National Wildlife Refuge System

The National Wildlife Refuge System is the world's largest collection of lands specifically managed for fish and wildlife conservation. Unlike other Federal lands that are managed under a multiple-use mandate (e.g., National forests and lands administered by the U.S. Bureau of Land Management), the Refuge System is managed primarily for the benefit of fish, wildlife, and plant resources and their habitats. The Refuge System consists of 553 units that provide more than 150 million acres of important habitat for native plants and many species of mammals, birds, and fish, including threatened and endangered species.

The mission of the Refuge System is "to administer a national network of lands and waters for the conservation, management and, where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (1997 Improvement Act).

The goals of the National Wildlife Refuge System are as follows:

- *Conserve a diversity of fish, wildlife, and plants and their habitats, including species that are endangered or threatened with becoming endangered.*

- *Develop and maintain a network of habitats for migratory birds, anadromous and interjurisdictional fish, and marine mammal populations that is strategically distributed and carefully managed to meet important life history needs of these species across their ranges.*

- *Conserve those ecosystems; plant communities; wetlands of national or international significance; and landscapes and seascapes that are unique, rare, declining, or underrepresented in existing protection efforts.*

- *Provide and enhance opportunities to participate in compatible wildlife-dependent recreation (hunting, fishing, wildlife observation and photography, and environmental education and interpretation).*

- *Foster understanding and instill appreciation of the diversity and interconnectedness of fish, wildlife, and plants and their habitats.*

1.3.3. Legal Policy and Guidance

Refuges are guided by the purposes of the individual refuge, the mission and goals of the Refuge System, Service policy, laws, and international treaties. Relevant guidance includes the Refuge Recreation Act of 1962, the 1997 Improvement Act, and selected portions of the Code of Federal Regulations and the Service Manual. Refuges are also governed by a variety of other Federal laws, executive orders (EO), treaties, interstate compacts, regulations, and policies pertaining to the conservation and protection of natural and cultural resources (See Appendix M and Service Manual 602 FW 1 (1.3)).

The 1997 Improvement Act's main components include:

- A strong and singular wildlife conservation mission for the Refuge System.
- Recognition of six priority public uses of the Refuge System (hunting, fishing, wildlife observation and photography, and environmental education and interpretation).
- A requirement that the Secretary of the Interior maintain the biological integrity, diversity, and environmental health of Refuge System lands.
- A new process for determining compatible uses on refuges.
- A requirement for preparing a comprehensive conservation plan for each refuge by 2012.

First and foremost, refuges are managed for fish, wildlife, plants, and their habitats. In addition, units of the Refuge System are legally closed to all public access and use, including economic uses, unless and until they are officially opened through an analytical process called the *appropriate use* and *refuge compatibility* process. All refuge uses are subservient to the Refuge System's primary wildlife management responsibility, and they must be determined compatible to be authorized.

1.3.4. Appropriate Use Policy

The appropriate use policy describes the initial decision process the refuge manager follows when first considering whether to allow a proposed use on a refuge. The refuge manager must find a use appropriate before undertaking a compatibility review of the use. An appropriate use as defined by the Appropriate Use Policy (603 FW 1 of the Service Manual) is a proposed or existing use on a refuge that meets at least one of the following four conditions:

- The use is a wildlife-dependent recreational use as identified in the Improvement Act.
- The use contributes to fulfilling the refuge purpose(s), the Refuge System mission, or goals or objectives described in a refuge management plan approved after October 9, 1997, the date the Improvement Act was signed into law.
- The use involves the take of fish and wildlife under State regulations.
- The use has been found to be appropriate as specified in Section 1.11 (603 FW 1 of the Service Manual).

If an existing use is not appropriate, the refuge manager will eliminate or modify the use as expeditiously as practicable. If a new use is not appropriate, the refuge manager will deny the use without determining compatibility. If a use is determined to be an appropriate refuge use, the refuge manager will then determine if the use is compatible (see Compatibility Policy in the following section). Although a use may be both appropriate and compatible, the refuge manager retains the authority to not allow the use or modify the use. Uses that have been administratively determined to be appropriate are the six wildlife-dependent recreational uses (hunting, fishing, wildlife observation and photography, environmental education, and interpretation) and take of fish and wildlife under State regulations.

1.3.5. Compatibility Policy

Lands within the Refuge System are different from other multiple use public lands in that they are closed to all public uses unless deemed compatible and formally allowed. The Improvement Act established the formal process for determining compatibility of wildlife-dependent recreational use or any other public use of a refuge. The Improvement Act states, "...the Secretary shall not initiate or permit a new use of a Refuge or expand, renew, or extend an existing use of a Refuge, unless the Secretary has determined that the use is a compatible use and that the use is not inconsistent with public safety."

A compatible use is one which, in the sound professional judgment of the refuge manager, will not materially interfere with or detract from the fulfillment of refuge purpose(s) or the Refuge System mission. The Service strives to provide wildlife-dependent public uses when compatible. If financial resources are not available to design, operate, and maintain a priority use, the refuge manager will take reasonable steps to obtain outside assistance from the State and other conservation interests.

When a determination is made as to whether a proposed use is compatible or not, this determination is provided in writing and is referred to as a compatibility determination. For compatibility determinations prepared concurrently with a CCP, the opportunity for public review and comment is provided during the public review period for the draft plan and

associated NEPA document. This Final CCP contains several finalized compatibility determinations for uses on the Refuge (Appendix C).

1.3.6. Biological Integrity, Diversity, and Environmental Health Policy

The Improvement Act directs the Service to "ensure that the biological integrity, diversity, and environmental health of the Refuge System are maintained for the benefit of present and future generations of Americans..." To implement this directive, the Service has issued the Biological Integrity, Diversity, and Environmental Health Policy (601 FW 3 of the Service Manual), which provides policy for maintaining and restoring, where appropriate, the biological integrity, diversity, and environmental health of the Refuge System. The policy is an additional directive for refuge managers to follow while achieving the refuge purpose(s) and Refuge System mission. It provides for the consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on refuge and associated ecosystems. Further, it provides refuge managers with an evaluation process to analyze their refuge and recommend the best management direction to prevent further degradation of environmental conditions and restore lost or severely degraded components where appropriate and in concert with refuge purposes and the Refuge System mission. When evaluating the appropriate management direction for refuges, refuge managers will use sound professional judgment to determine their refuges' contribution to biological integrity, diversity, and environmental health at multiple landscape scales.

1.3.7. Wilderness Review

As required by Service planning policy, a review of wilderness areas was conducted for the Refuge in the form of a Wilderness Inventory (Appendix L). None of the lands were eligible for wilderness designation.

1.4. The San Francisco Bay National Wildlife Refuge Complex

The San Francisco Bay (Bay) area has had a significant human presence stretching back thousands of years. A number of Native American tribes have inhabited the area, including the earliest residents, the Ohlone. Later, Spanish settlers immigrated to the area in the late 1700s. The years following the California gold rush in 1849 caused explosive growth and development that placed greater demands on the sensitive lands surrounding the Bay. For example, the salt industry converted tens of thousands of acres of salt marsh into commercial salt ponds.

Conversion of wetlands to support development continued well into the 20th century, and today, more than 90 percent of the Bay's original marshes and shorelines have been altered. With the support of citizens and public officials, seven national wildlife refuges (NWRs) have been created in the San Francisco and Monterey Bay Areas: Farallon NWR (1909), Salinas River NWR (1973), San Pablo Bay NWR (1974), Don Edwards San Francisco Bay NWR (1972), Ellicott Slough NWR (1975), Antioch Dunes NWR (1980), and Marin Islands NWR (1992). These seven refuges, stretching from Monterey Bay to the San Francisco Bay Delta, were combined to create the Refuge Complex (See Figure 1). These refuges provide a variety of critical nesting habitat, overwintering habitat, and resting points for migratory birds of the Pacific Flyway. The refuges also provide breeding and foraging habitat for endangered species and other species of concern. Unlike other refuges located in remote locations, each of the seven refuges shares the task of

Figure 1. San Francisco Bay NWR Complex

pursuing wildlife conservation objectives while providing wildlife-dependent recreation, when compatible, in this highly urbanized area.

1.5. The Don Edwards San Francisco Bay National Wildlife Refuge

1.5.1. Location

The Refuge is part of the San Francisco Estuary, which includes the San Francisco Bay, Suisun Bay, and Delta region (at the confluence of the Sacramento and San Joaquin Rivers). San Francisco Bay is further divided into three units: North Bay, Central Bay, and South Bay (See Figure 2). The Refuge is located at the southern end of the South Bay and extends into Alameda, Santa Clara, and San Mateo Counties. The lands and waters included within the Refuge consist of portions of the urbanized communities of San Lorenzo, Hayward, Union City, Fremont, Newark, Milpitas, San Jose, Sunnyvale, Mountain View, East Palo Alto, Menlo Park, and Redwood City. The Refuge is located in a highly urbanized area with access from Interstate 880, U.S. Highway 101, California State Route 237, and California State Route 84.

Figure 2. San Francisco Bay Sub-regions

1.5.2. Refuge Setting

The Refuge is located in mudflat and tidal marsh that formed between 2,000 and 3,000 years ago (Atwater 1979). San Francisco Bay is one of the most extensive wetland systems along the Pacific coast. This system provided habitat for millions of migratory waterfowl and shorebirds along the Pacific Flyway as well as resident wildlife.

Rapid development of the area began with the discovery of gold in the Sierra Nevada foothills in the 1850s. Hydraulic mining operations contributed huge amounts of sediment to the San Francisco Bay Estuary. For the next hundred years, the marshes were filled, diked, or drained to support the Bay's development as a major center of commerce (Perkins et al. 1991). In the South Bay, the tidal marsh was never extensively diked, but instead reclaimed for salt production beginning around 1860 (Ver Planck 1958).

Today, only 15 percent of the Bay's historic tidal lands remain. Since the 1960s, conservation agencies, non-profit organizations, and local grassroots efforts have worked to restore and protect the Bay.

1.5.3. History of Refuge Establishment and Acquisition

With significant support from the Citizens Committee to Complete the Refuge, Representative Don Edwards, and other constituents, the Refuge was established in 1972 under Public Law 92-330, passed by the 92nd Congress, which directed the Secretary of the Interior to establish a National Wildlife Refuge in the South San Francisco Bay for a total not to exceed 23,000 acres. It was one of the first urban National Wildlife Refuges established in the United States. The law identified 21,662 acres of marshes, tidal flats, salt ponds, submerged, and open waters within four distinct units to be known as Fremont (5,520 acres), Mowry Slough (5,175 acres), Alviso (3,080 acres), and Greco Island (5, 887 acres) appropriate for inclusion within the boundaries of the Refuge (in this CCP, these units are known as: Newark, Mowry, Alviso, and West Bay Units. First lands were acquired in 1974 from Bayshore Freight Lines Inc. The Refuge was officially renamed the Don Edwards San

Table 1. Don Edwards SF Bay NWR Timeline of Major Property Acquisitions

Date	Acreage	Purchase/Lease/Agreement	Acquired from
1974	37.26	Fee	Bayshore Freight Lines Inc
1977	14151.29	Fee	Leslie Salt Company
1978	126.19	Lease	State of California
1981	52.11	Fee	White El Al Walter W
1981	122.4	Fee	County of Santa Clara
1981	50.01	Fee	City of Freemont
1981	25.53	Fee	City of San Jose
1981	1989.19	Lease	State of California
1983	55.16	Fee	The Nature Conservancy
1983	450.72	Fee	Knapp et Al James Gordon
1987	989.64	Lease	State of California
1991	41.83	Easement	Marathon U.S. Realties, Inc
1991	255.21	Fee	Carraf/Sanwa
1992	47.63	Fee	Munster, Irene C.
1993	2639.55	Fee	Holnam, Inc.
1995	107.87	Fee	Mayhew Landing Association
1997	35.1	Fee	Penninsula open space trust
1998	436.94	Fee	Penninsula open space trust
1999	180.46	Fee	Penninsula open space trust
1999	155.12	Fee	Bay Properties
2003	5206.3	Fee/Donation	Cargill, Inc
2007	253.11	Fee	Cargill, Inc
2007	427.13	Fee	Catellus
2011	360	Lease	State of California

Francisco Bay NWR in 1995. It should be noted that Refuge lands include leases of intertidal and subtidal lands that are subject to the California State Lands Commission (CSLC) jurisdiction; the CSLC remains the trustee and responsible agency for these lands. Table 1

provides a timeline of major acquisition for the Refuge. Smaller acquisitions (less than 25 acres) were not included in this table. To date, the Refuge owns and/or manages almost 30,000 acres.

1.5.4. Land Protection

In 1972, Public Law 92-330 authorized and directed the Secretary of Interior to establish a refuge and acquire up to 23,000 acres in South San Francisco Bay by June 30, 1977. Further, it authorized a refuge composed of four units (Mowry Slough, Fremont, Greco Island, and Alviso). Congress approved a refuge boundary map and authorized the Secretary, "…from time to time to make corrections in the boundaries of the refuge…" (PL 92-330)

In 1988, Public Law 100-556 increased the Service's acquisition authority from 23,000 acres to a total of 43,000 acres. Unlike the original legislation (PL 92-330), Congress did not specify a boundary for the 20,000 acre expansion. However, in PL 100-556, Congress did specify that the 20,000 acres be ". . .in the vicinity of . . . and similar to . . ." the existing refuge units, and that they be " . . .necessary to protect fish and wildlife resources." Hence, Congress gave the Service discretion as to which parcels it may acquire.

Following PL 100-556, the Service began a formal planning process to determine which lands would be considered for additions to the refuge. The Service's planning process was conducted pursuant to NEPA and included opportunities for public comment. In 1990, the Service issued the Final Environmental Assessment, Potential Additions to the San Francisco Bay National Wildlife Refuge, Alameda, San Mateo, and Santa Clara Counties, California (Final EA). The preferred alternative in the Final EA included a map and a boundary in which the Refuge could expand to include the additional 20,000 acres authorized by PL 100-556. On March 5, 1990, the Service selected the preferred alternative for implementation in a Finding of No Significant Impact (USFWS 1990). The map and boundary depicted in the 1990 Final EA identified 24,500 acres as "potential additions" because not all of the lands would be added to the Refuge for the following reasons: 1) no more than 20,000 acres out of the 24,500 acres identified would be added to the refuge under existing authorities; 2) Service plans for acquisitions do not preclude lawful, environmentally sound development, as determined by local government; 3) the acquisition cost of some of the lands may be prohibitive; 4) the amount of available funding for acquisition is unknown; and 5) some landowners indicated that they would not be willing sellers.

Figure 3 depicts existing Refuge lands and the areas identified as potential additions. Together, these areas are recognized by the Service through policy as the approved acquisition boundary for the Refuge, and will be referenced as such throughout the remainder of the CCP. According to our national policies, an approved acquisition boundary encloses "those lands that we have authority to acquire, in whole or in part. This boundary often encompasses both public and private land, but does not imply that all private parcels within the boundary are targeted for our acquisition. The approved acquisition boundary can originate from a variety of means (e.g., Executive Order, Congressional Order, Secretarial Order, Public Land Order, Service Director, Regional Director, and Migratory Bird Conservation Commission)" (343 FW 3). The Service has authority to acquire and/or manage lands within the approved acquisition boundary through various agreements, based upon planning and environmental compliance processes.

Approval of an acquisition boundary does not grant the Service jurisdiction or control over lands within the approved acquisition boundary, and it does not make lands within the acquisition boundary part of the National Wildlife Refuge System. In fact, to date, many lands within the approved 1990 boundary have already been converted to urban developments. Lands do not become part of the National Wildlife Refuge System unless they are purchased or are placed under an agreement that provides for management as part of the Refuge System. These acquisition approaches may include technical assistance, cooperative agreements, memoranda of understanding, and acquisition (from willing sellers) of conservation or agricultural easements and fee title interest.

To date, the Service manages almost 30,000 acres within the approved acquisition boundary. Future proposed additions include the 136-acre Deepwater Slough Island located in Redwood Creek and the 88-acre Preserve at Redwood Shores (more detail on these acquisitions is discussed in Chapter 4).

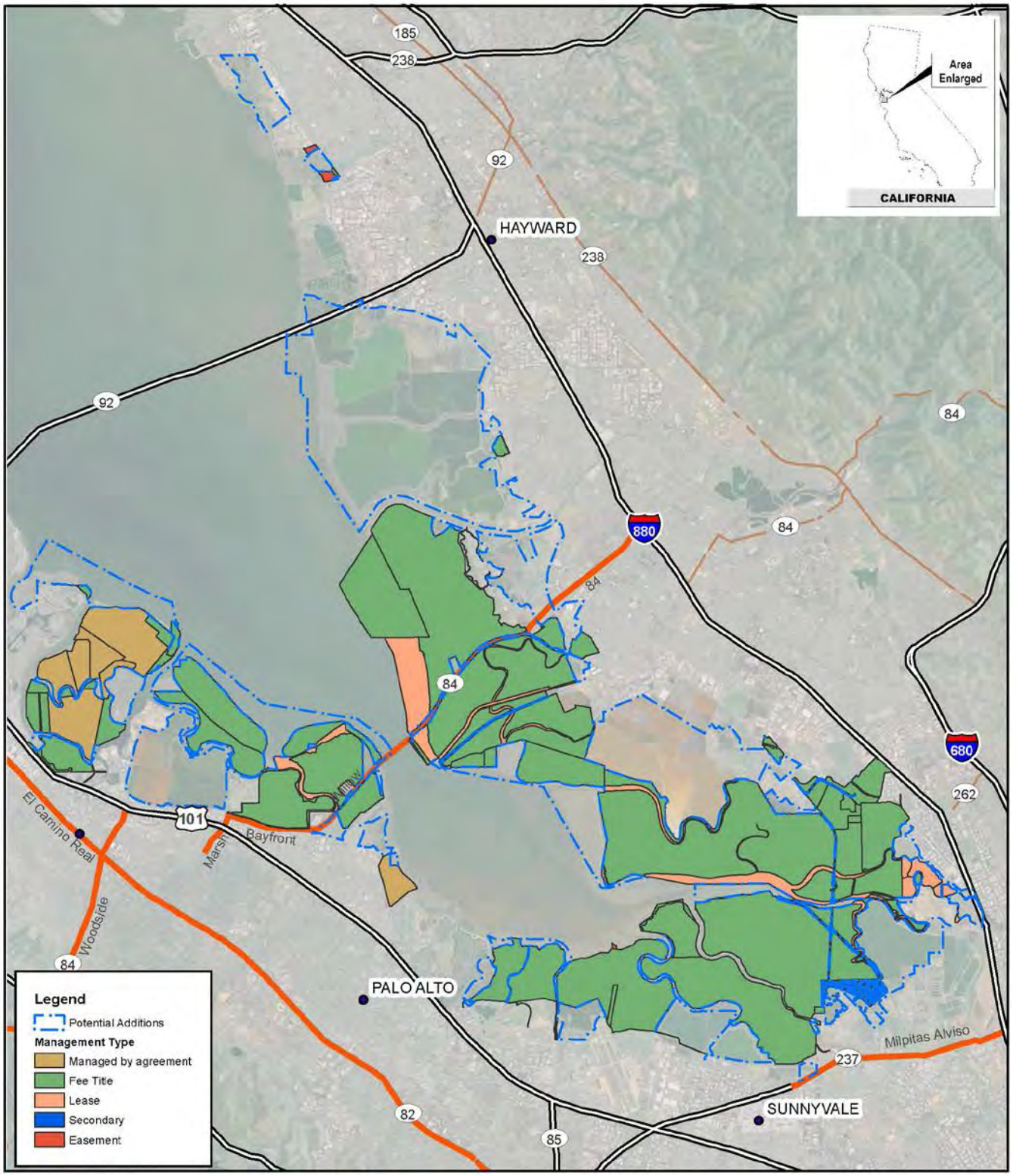
1.5.5. Land Conservation Methods

Working with willing landowners and local and State agencies, the Service may use various means to conserve or manage fish and wildlife and their habitats within the approved acquisition boundary. These may include fee title acquisition, conservation easements, memoranda of understanding and cooperative agreements, financial incentives and technical assistance, and education and outreach. Landowners within the approved acquisition boundary are not required to sell their lands to the Service. The Service acquires lands within the approved acquisition boundary when funding and/or other resources become available. It is the established policy of the Service to seek the minimum degree of interest in property needed to accomplish Refuge land conservation objectives.

In fee title acquisitions, the Service acquires full ownership of property through fee simple purchase, donation, exchange, or transfer from another Federal agency. Land acquired in fee title by the Service is removed from county tax roles. To partially offset this loss, the Service provides annual payments to counties as authorized by the Refuge Revenue Sharing Act (Public Law 95-469). The Service is required under the U.S. Constitution to pay fair market value for property, and purchases are dependent on the availability of funds.

In acquiring a conservation easement, the Service purchases the minimum rights needed to conserve fish and wildlife habitat, while allowing the existing landowner to retain title to the land. Easements may include wetland or waterfowl habitat easements, upland easements, agricultural practices easements, and non-development easements. The easement interest acquired by the Service becomes part of the Refuge and is subject to applicable laws and regulations pertaining to refuges. The easement is a permanent interest in the property that runs with the land, and the landowner remains responsible for all property taxes.

Figure 3. Existing Refuge Lands and Areas for Potential Additions*



*Note: The boundary depicting the existing Refuge lands together with the areas for potential additions are recognized by the Service through policy as the approved acquisition boundary for the Refuge, and will be referenced as such throughout the remainder of the CCP.

The Service may also assist in securing financial incentives for landowners who are not willing to sell an interest in their property but wish to explore conservation or enhancement of fish and wildlife habitats on their property. For example, through the Partners for Fish and Wildlife program, landowners may apply for financial assistance from the Service to protect, enhance, or restore wetland, riparian, or native grassland habitats on their property. In addition, the Service could assist a landowner in securing funds from Farm Bill programs available from the U.S. Department of Agriculture/Natural Resources Conservation Service (NRCS). Potential NRCS programs that could benefit landowners and further Refuge land conservation objectives include the Conservation of Private Grazing Land Program, Environmental Quality Incentives Program, Farmland Protection Program, Wetlands Reserve Program, and Wildlife Habitat Incentives Program. Finally, Service staff are available to provide technical assistance and education and outreach information to willing landowners who are interested in conserving fish and wildlife habitats on their lands.

The Refuge has financed most of its land acquisition and restoration efforts with grants from State and Federal agencies and private organizations. These sources have played a vital role in advancing the Refuge's land conservation and management programs.

1.5.6. Refuge Purposes

Lands within the Refuge System are acquired and managed under a variety of legislative acts and administrative orders and authorities. The official purpose or purposes for a refuge are specified in or derived from the law, proclamation, executive order, agreement, public land order, funding source, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, refuge unit, or refuge subunit. The purpose of a refuge is defined when it is established or when new land is added to an existing refuge. When an addition to a refuge is acquired under an authority different from the authority used to establish the original refuge, the addition takes on the purposes of the original refuge, but the original refuge does not take on the purposes of the addition. Refuge managers must consider all of the purposes. However, purposes that deal with the conservation, management, and restoration of fish, wildlife, and plants and their habitats take precedent over other purposes in the management and administration of a refuge.

The Refuge System Improvement Act directs the Service to manage each refuge to fulfill the mission of the Refuge System, as well as the specific purposes for which that refuge was established. Refuge purposes are the driving force in developing refuge vision statements, goals, objectives, and strategies in the CCP. Refuge purposes are also critical to determining the compatibility of all existing and proposed refuge uses.

The Refuge was established with three major purposes. The most important of these is the preservation of the natural resources of the South Bay, which include among others the habitat of migratory birds, harbor seals, and threatened and endangered species. The second major purpose is to provide environmental education and wildlife interpretation opportunities to Bay Area schools and residents. Third, the Refuge will ensure the protection of an important open space resource and other wildlife-oriented recreation opportunities for the enjoyment of local residents and visitors (EDAW 1974).

Don Edwards San Francisco Bay National Wildlife Refuge was established under several authorities:

86 Stat. 399, dated June 30, 1972 - "...for the preservation and enhancement of highly significant wildlife habitat...for the protection of migratory waterfowl and other wildlife, including species known to be threatened with extinction, and to provide an opportunity for wildlife-oriented recreation and nature study..."

An Act Authorizing the Transfer of Certain Real Property for Wildlife, or other purposes (16 U.S.C. 667b) – "...particular value in carrying out the national migratory bird management program."

Endangered Species Act of 1973 (16 U.S.C. 1534) – "...to conserve (A) fish or wildlife which are listed as endangered species or threatened species...or (B) plants..."

Fish and Wildlife Act of 1956 (16 U.S.C. 742f) - "...for the development, advancement, management, conservation, and protection of fish and wildlife resources..." 16 U.S.C. § 742f(a)(4) "...for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude..."

Tagged California clapper rail
C. Overton

1.6. Related Projects

Several ongoing restoration projects are also in the region where the Refuge is located. These projects are in concert with the aims and mission of the Refuge and are described in the following text.

Initial Stewardship Plan. The Initial Stewardship Plan (ISP) was an interim plan to maintain and enhance the biological and physical conditions within the salt ponds acquired from Cargill Salt in 2003 in the period between the cessation of salt production and the implementation of the long-term restoration plan. The primary objectives of the ISP included:

- cessation of salt concentrating processes within the ponds;
- circulation of Bay water through the ponds and tidally-restore the Island Ponds (Alviso Ponds A19, A20, and A21);
- maintain existing open water and wetland habitat for the benefit of wildlife, including habitat for migratory shorebirds and waterfowl and resident breeding species;
- maintain ponds in a restorable condition to facilitate future long-term restoration;
- meet all regulatory requirements; especially discharge requirements to maintain water quality standards in the South Bay;

- work within existing funding constraints; and
- maintain existing levels of flood control

South Bay Salt Pond Restoration Project. The South Bay Salt Pond Restoration Project (SBSPRP) is the largest tidal wetland restoration project on the West Coast. When complete, the restoration will convert 15,100 acres of former commercial salt ponds at the south end of San Francisco Bay to a mix of tidal marsh, mudflat, managed pond, open water, and other wetland habitats. The property was acquired by the State of California and the Service from Cargill Salt as part of a larger land transaction that included 1,400 acres of salt crystallizer ponds on the east side of the Napa River. This acquisition was accomplished with funding from WCB, the Service, the Coastal Conservancy, and four private foundations. The acquisition of the South Bay salt ponds provides an opportunity for landscape-level wetlands restoration, improving the physical, chemical, and biological health of the San Francisco Bay. The goals of the SBSPRP are to restore and enhance the tidal marsh ecosystem, to provide adequate pond habitat to migratory birds, to provide wildlife-oriented public access and recreation, and to provide for flood management in the South Bay (more detail on these acquisitions is discussed in Chapter 4).

Eden Landing Ecological Reserve Restoration Project. The Eden Landing Ecological Reserve (ELER) Restoration Project was established in May 1996 to restore former salt ponds and crystallizers to tidal salt marsh and seasonal wetlands as well as provide public recreational access. In 1996, CDFG, working with the Wildlife Conservation Board (WCB), East Bay Regional Park District, California Wildlife Foundation, the cities of San Jose, Milpitas and Fremont, and Caltrans, acquired the Baumberg Tract from Cargill Salt at the ELER and began efforts to restore more than 830 acres of former salt ponds to vital habitat. In 2003, DFG acquired an additional 5,500 acres of former salt ponds for ELER as part of the SBSPRP acquisition.

Today, CDFG is actively managing the 6,300 acres of former salt ponds at the ELER and moving forward on its restoration to create a mix of tidal marsh and managed pond habitat. Restoring tidal action to thousands of acres of diked salt ponds throughout the South Bay is essential to bringing back the natural wetland habitat. In April 2004, DFG successfully created an extension of North Creek from the Old Alameda Creek channel. In 2006, North Creek was connected to restore more than 300 acres to tidal action and re-establish several miles of sloughs. Future restoration plans, including linking segments of the Bay Trail, are underway to link more ponds to tidal action and the Bay as part of the SBSPRP.

Shoreline Study. The South San Francisco Bay Shoreline Study (Shoreline Study) was originally authorized by Congress in 1976 to assess the need for flood protection in the South Bay. The results of the original Shoreline Study in 1992 concluded that the U.S. Army Corps of Engineers (Corps) could not economically justify developing a Federal flood management project in the South Bay in large part due to commercial salt pond levees that provided some level of flood protection within the Shoreline Study area. The acquisition in 2003 and eventual restoration planning of 15,100 acres of ponds in the South Bay by the Federal and State government affected the utilization of those pond levees as flood control structures. In 2002, the U.S. House of Representatives requested that the Corps review its previous 1992 Shoreline Study, expanding the scope to include environmental restoration and protection, as well as tidal and fluvial flood damage reduction and related purposes. Initial reconnaissance analysis conducted by the Corps in 2004 determined that due to current and future anticipated conditions to the South Bay, a Federal flood control and ecosystem restoration project would be justified.

In 2005, the Corps, Santa Clara Valley Water District (SCVWD), and the Conservancy kicked off the first study phase of the South San Francisco Bay Shoreline Study and are now in the preliminary stages of beginning environmental review. The project is currently undertaking "scoping" to determine the range of environmental issues to be addressed in the alternative development and analysis process, with a focus on the Alviso area of the South Bay.

San Francisco Estuary Invasive Spartina Project. The San Francisco Estuary Invasive *Spartina* Project was created in 2000 by the California State Coastal Conservancy to develop a regionally coordinated project to address the rapid spread of four introduced and highly invasive *Spartina* (cordgrass) species in the San Francisco Estuary. The Spartina Control Program, the "action arm" of the Spartina Project, was created to arrest and reverse the spread of invasive, non-native cordgrass species in the Estuary to preserve and restore the ecological integrity of the Estuary's intertidal habitats and estuarine ecosystem. The Spartina Project is currently working with the Control Program to develop a set of "best practices" for tidal marsh restoration to minimize the risk of spreading invasive *Spartina* and its hybrids.

Alviso Slough Restoration Project. The SCVWD completed an Environmental Impact Report (EIR) in November 2009 to assess the possible actions for restoring boat access to the Alviso Slough. The EIR recommended vegetation removal along 3.7 acres with dredging to an 8-foot depth that would provide for two-way boat navigation. Since the 1940s, Alviso Slough has been subject to various changes due to subsidence and dynamic interaction of the slough and bay. Over time, sediment has filled in areas of the slough and the vegetation in the slough has grown and thrived, reducing the extent of open water in the slough. In 2004, the SCVWD began planning to control vegetation in the slough, develop long-term plans for providing public access, maintain flood protection, reduce mosquito nuisance, and integrate planning with the SBSPRP.

Lower Guadalupe River Flood Protection Project. This flood protection project was constructed to prepare the channels to handle storm water runoff in the event of a 100-year flood, protect endangered species, preserve fish and migratory bird habitat, and allow for open-space recreation. Beginning in 2003, SCVWD has made flood protection improvements along 6.5 miles of the Guadalupe River from the Interstate 880 bridge north to the Union Pacific Railroad bridge in Alviso.

San Francisquito Creek Restoration Project. The San Francisquito Creek Joint Powers Authority (SFCJPA) is a government agency formed in 1999 by the cities of Palo Alto, Menlo Park, and East Palo Alto, and the SCVWD and San Mateo County Flood Control District. The SFCJPA implements projects that provide multiple communities with flood protection, environmental and recreational benefits, and it coordinates creek maintenance and emergency preparedness and response communication. SFCJPA's first major capital project is moving forward with an expedited design and environmental review process to provide increased flood protection for the East Palo Alto and Palo Alto communities along the flood-prone reach of San Francisquito Creek downstream (east) of U.S. Highway 101.

The project will ultimately improve stream flow from the downstream face of East Bayshore Road all the way to San Francisco Bay. It will reduce local flood risks during storm events, as well as provide the capacity needed for upstream flood protection projects being planned by the SFCJPA.

It will also be designed to provide ecological enhancements for the endangered and other species that call this watershed home, and to allow for new and improved trails for residents and visitors along the creek and near the Bay.

Increasing the creek's flow capacity from San Francisco Bay to the U.S. Highway 101 will be achieved by widening the creek channel within the reach to convey peak flows for 100-year storm events; removing an abandoned levee-type structure to allow flood flows from the creek channel into the Palo Alto Baylands Preserve north of the creek; and constructing an outlet structure for Caltrans' enlargement of the U.S. Highway 101/East Bayshore Road Bridge over San Francisquito Creek. As of 2012, the project has released an Draft Environmental Impact Report, expected to be certified in October 2012 with construction scheduled to begin in late 2012.

1.7. Conservation Priorities

The conservation and restoration plans in place to help guide the direction of the CCP are described in the following text.

Southern Pacific Shorebird Conservation Plan. This conservation plan is one of 11 regional plans associated with the U.S. Shorebird Conservation Plan. The plan identifies information and needs for the conservation of shorebirds on the coast and in the Central Valley of California. The plan identifies several shorebird species, some of which are the Service's species of concern, that rely on the Southern Pacific region. The plan also has developed conservation priorities, some species-specific and other habitat-specific.

San Francisco Bay Joint Venture. The goal of the San Francisco Bay Joint Venture is to protect, restore, increase, and enhance all types of wetlands, riparian habitat, and associated uplands throughout the San Francisco Bay region to benefit birds, fish, and other wildlife. The Joint Venture is made up of a management board consisting of public agencies and private organizations. The Joint Venture has developed objectives for acquiring additional habitat for restoration or protection (See Table 2).

Table 2. Habitat Goals for the San Francisco Bay Joint Venture

SFBJV Habitats		SFBJV Tracked Habitat Goals (acres)			SFBJV Habitat Goals Categories (acres)		
SFBJV Habitat Goal Categories	**Tracked Habitats**	**Acquire**	**Restore**	**Enhance**	**Acquire**	**Restore**	**Enhance**
Bay Habitats	Tidal Marshes	43,000	32,000	20,000	63,000	37,000	35,000
	Tidal Flats	12,000	4,000	6,000			
	Lagoons	1,500	50	1,500			
	Beaches	113	60	35			
	Salt Ponds	6,000	1,000	7,500			
Seasonal Wetland	Diked Wetlands	16,000	6,000	12,000	37,000	7,000	23,000
	Moist	21,000	1,000	11,500			

	Grasslands						
Creeks and Lake	Lakes	3,000	1,000	6,000	7,000	5,000	22,000
	Creeks	4,000	4,000	16,000			

Notes: 1. Numbers are to the nearest thousand. 2. Numbers are double counted in instances where restoration takes place on acquired land. 3. SFBJV is a non-regulatory entity, and thus acquisition goals reflect working cooperatively with a willing seller.

Source: http://www.sfbayjv.org/strategy.php#habitat_goals

Tidal Marsh Recovery Plan. The Service released a Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California in January 2010. This recovery plan is an expansion and revision of the California Clapper Rail and Salt Marsh Harvest Mouse Recovery Plan (USFWS 1984). The recovery plan also encompasses four other threatened and endangered plant species, and 11 species of concern that occur in a variety of tidal marsh habitats. The recovery plan identifies goals, objectives, criteria, and actions needed to recover all focal threatened and endangered species so they can be delisted.

2008–2012 National Invasive Species Management Plan. A revision of the 2001 National Invasive Species Management Plan, the 2008 plan provides direction for Federal efforts to prevent, control, and minimize invasive species and their impacts. It focuses on five strategic goals: prevention, early detection and rapid response, control and management, restoration, and organizational collaboration.

Baylands Ecosystem Habitat Goals Project. Completed in 1999, this report presents findings of the San Francisco Bay Area Wetlands Ecosystem Goals Project. The Goals Project describes historic and present conditions of the baylands (areas around the San Francisco Bay between the lines of high and low tide; they are lands touched by the tides, and lands that the tides would touch in the absence of any levees or other unnatural structures), as well as key habitat types. It also provides guidance for restoration and enhancement of the baylands and adjacent habitats of the San Francisco Estuary. The Project involved assistance from a variety of participants, including Federal agencies, local governments, State agencies, academics, and non-governmental organizations.

Baylands Ecosystem Species and Community Profiles. This document was developed in tandem with the Baylands Ecosystem Habitat Goals Project. Completed in 2000, this report presents findings on the life histories and environmental requirements of key plants, fish, and wildlife of the San Francisco Bay Estuary. The Project involved assistance from a variety of participants, including Federal agencies, local governments, State agencies, academics, and non-governmental organizations.

Uplands Habitat Goals Project. Initiated by the Open Space Council in 2004, the San Francisco Bay Area Upland Habitat Goals project is a science-based planning process designed to recommend the types, amounts and distribution of conservation lands as well as actions needed to sustain diverse and healthy communities of plant, fish and wildlife resources in the nine county Bay Area. The Open Space Council recognized the Bay Area as a leader in open space protection – nearly 1.2 million acres have been conserved as of early 2010 - but noted the region lacked a scientific vision for biodiversity conservation. The Upland Habitat Goals are intended to serve as a guide for public and private conservation practitioners for selecting lands to be conserved.

Subtidal Habitat Goals Project. The San Francisco Bay Subtidal Habitat Goals Project is a collaborative effort to establish a comprehensive, long-term management vision for research, restoration, and management of the subtidal habitats of the San Francisco Bay. Subtidal habitats refer to marine or estuarine environments that lie below mean low-water and are always (or almost always) submerged in a tidally-influenced area. The Project will plan for submerged environments below mean low water to the bottom of San Francisco Bay. The Subtidal Goals Project is an interagency partnership between the San Francisco Bay Conservation and Development Commission, the Coastal Conservancy, the National Oceanic and Atmospheric Administration, and the San Francisco Estuary Partnership. The Subtidal Habitat Goals Report was completed in 2010 and it is designed to give resource managers, regulatory agencies, and other groups the basic information needed to plan conservation, restoration, research, and protection activities related to subtidal habitat in the San Francisco Bay.

2. The Comprehensive Conservation Planning Process

2.1. Introduction

This CCP/EA for the Refuge is intended to meet the dual requirements of compliance with the 1997 Improvement Act and NEPA of 1969 (42 USC 4321). The development of this CCP/EA was also guided by the Refuge Planning Policy outlined in Part 602, Chapters 1, 3, and 4 of the Service Manual (Fish and Wildlife Service 2000). Service policy, the 1997 Improvement Act, and NEPA provide specific guidance for the planning process. For example, Service policy and NEPA require the Service to actively seek public involvement in the preparation of environmental documents such as EAs.

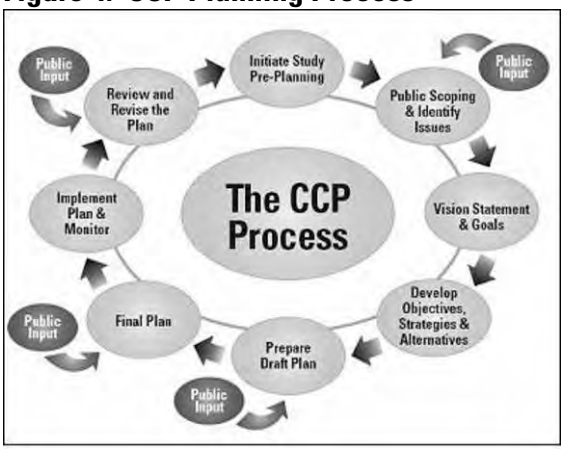
The purpose of the EA is to evaluate the environmental effects of the CCP on the quality of the human environment. NEPA also requires the Service to give serious consideration to all reasonable alternatives, including the "no action" alternative, which represents continuation of current conditions and management practices. Alternative management scenarios were developed as part of the planning process and can be found in Appendix B (Environment Assessment).

2.2. The Planning Process: How this CCP was Developed

Key steps in the CCP planning process are depicted in the following text (see Figure 4) and include:

1. Preplanning
2. Identifying issues and developing a vision statement
3. Gathering information
4. Analyzing resource relationships
5. Developing alternatives and assessing environmental effects
6. Identifying a preferred alternative
7. Publishing the draft plan and NEPA document
8. Documenting public comments on the draft plan
9. Preparing the final plan
10. Securing approval from the regional director
11. Implementing the plan

Figure 4. CCP Planning Process



The CCP may be amended as necessary at any time under an adaptive management strategy. Major revisions, if needed, will require public involvement and NEPA review.

The planning process for this CCP began in October 2008 with preplanning, which involved the collection of pertinent data and selection of team members. A core team and expanded team were formed to integrate stakeholders into the planning process. Refuge staff identified primary areas of focus: wildlife management, habitat management, and public access, interpretation, and environmental education. These focus areas helped shape comments received from the public during the scoping period into potential objectives for the Refuge.

2.3. The Planning Core Team

The planning team responsible for leading the CCP effort included Service biologists, planners, visitor services specialists, and environmental education specialists from the San Francisco Bay NWR Complex. Appendix 0 lists the members of the planning core team.

2.4. Public Involvement in Planning

Public involvement is an important and required component of the CCP and NEPA process. Public scoping meetings allow the Service to define the scope of the issues that need to be addressed and identify significant issues that may shape the proposed action. More importantly, these meetings allow Refuge staff to hear public comments and concerns. Public meetings provide a forum for important discussion and identify important issues regarding the Refuge and its surrounding area.

The Refuge hosted a series of public meetings on October 28, November 3, and November 5 in 2009. Public comments were generated from the public meetings as well as the *Federal Register* notice published on February 23, 2010. A planning update, which introduced the Refuge and the planning process, was mailed to over 200 agency and organization representatives, members of the public, media, and elected representatives of each of the counties. An average of 10 persons attended each of the meetings. A number of individuals provided comments at the meeting, via email, and by postal mail. The following paragraphs describe major comments.

The Refuge hosted another series of public meetings on April 13, 2011, and April 19, 2011, to present management alternatives. An average of 15 persons attended each of these meetings. The Draft CCP/EA was published for public review and comment for a 45-day period from May 16 through July 2, 2012. The document was distributed to Federal, State, and local agencies; interested parties; and private groups. A second planning update was also distribute to interested parties during the public comment period. The Refuge received a total of 18 comment letters on the Draft CCP/EA. The Final CCP/EA has been modified to meet and address the concerns that were raised. Responses to specific comments received are addressed in Appendix P.

2.4.1. Issues, Concerns, and Opportunities

Through public meetings, written public comments, and planning team discussions, the planning team identified a number of issues, concerns, and opportunities. The following is a summary of the issues, concerns, and opportunities categorized in the areas of wildlife management, habitat management, public use and environmental education, and other.

Comments regarding wildlife management include:

- Conduct surveys of rails other than California clapper rails.
- Address species impact issues related to oil spills/contaminants in general/sewage, etc.
- Consider species impacts from dogs.
- Consider species impacts of kayak access and use on Refuge.
- Develop a captive breeding program for threatened and endangered species.
- Consider reintroduction/relocation of species into new areas.
- Develop comprehensive management for species, including threatened and endangered State/Federal species, species of special concern, migratory species, and common species potentially affected by sea level rise. Allocate lands for these species.
- Plan Bay-wide for species in decline.
- Work with other agencies to ensure integrated/consistent policies across jurisdictions.
- Tap into experts, volunteers, "people who know" on how to best manage for specific species.
- Create a series of sanctuaries, new burrows, and sufficient foraging grounds for the burrowing owl.
- Create a continuity of corridors for salt marsh harvest mouse, including synergies with other uses and landowners.
- Develop management programs for salt marsh yellowthroat, black-crowned night heron.
- Develop predator control program; include managing avian predators.
- Control problematic species such as Canada geese, ground squirrels.

Native gray fox with snake
Brian Alfaro

Comments regarding habitat management include:

- Plan for changing habitat needs for species affected by climate change. Propose "do not touch" parameter on Refuge lands in light of climate change and sea-level rise.
- Concerns regarding maintaining habitat for shorebirds/waterfowl/waterbirds, given loss of habitat during pond-to-marsh transition process.
- Consider impacts from nearby planning processes (e.g., Newby Island and Santa Clara Valley Water Pollution Control Plant Master Plan).
- Concern about the CCP piecemealing by not considering the SBSPRP and Bair Island areas. Take a landscape perspective, particularly with the threat of sea level rise. Landscape issues that need to be considered include adjacencies of habitat,

connectivity, corridors, hydrology changes, and potential habitat needs in the acquisition area.

- Habitat enhancements should consider structures, i.e., perches for raptors, nesting boxes, platforms, in addition to islands.
- Need for management plan in regards to weeds and endemic re-vegetation efforts.
- Control phragmites, non-native *Spartina*, pampas grass, tule. Establish buffers/ecotone between marsh and roads to prevent the spread of invasive plants.
- Plant food or create ruderal-like habitats for wildlife.
- Acknowledge mosquito control as a potential issue depending on how land is managed; consider drainage in planning efforts.
- Continue to allow mosquito abatement districts access for inspection and treatment on an as-needed basis.
- Develop collaborative strategies for non-native species control, including partnerships with local agencies through legislation to support goals and objectives and prevent spread.
- Acquire properties to extend goals of the Refuge, support endangered species recovery, and habitat loss from sea-level rise and climate change. Prioritize acquisition of Redwood City Salt Ponds, grasslands, 1990 Map of Proposed Refuge lands, Area 4 in Newark, duck clubs, lands that would create connectivity and corridors for Refuge lands, willow groves (i.e. Patterson Ranch).
- Do not include Cargill Salt's fee-owned lands in the CCP process.

Comments regarding public uses and environmental education include:

- Concern that the increase in public access could lead to degradation in Refuge habitat. Refuge should consider the quality versus quantity question in regards to public access.
- Develop consistent and integrated policies regarding dog recreation along shoreline areas to minimize impact on wildlife.
- Integrate the San Francisco Bay Area Water Trail (SFBAWT) landing ports for non-motorized boats.
- Increase the amount of interpretive and regulatory signage. Provide focused messages based on key points/management issues.
- Importance of outreach to elementary school populations to generate public interest in the Refuge and the outdoors.
- Continue hands-on activities for kids, the salt marsh manual, the mud lab, the entire program. Increase the number of field trips and environmental education at the marina and cannery.
- Develop the Refuge's relationship with the Audubon Society for provision of field trips, programs, beach watch (Gulf of the Farallones), citizen science, bird blinds for wildlife viewing, and photography.
- At the Faber-Laumeister unit, prioritize stewardship, education, and appreciation.
- Educate about residential pesticide use and pyrethroids.
- Provide more consistent outreach and promotion, especially to schools.
- Provide more public education on trash (i.e., plastics in the bay and ocean, the trash gyre in Pacific) and publish best practices about water conservation and rainwater catchment (in ways that would not cause mosquito problems).
- Publish best practices in regards to mosquito abatement issues.

Other comments include:

- Improve accessibility, navigation of the website. Convert brochure information to website pages to make them more accessible.
- Increase Refuge law enforcement in light of development around the Refuge.
- Importance of increased understanding and management techniques for methylmercury and other contaminants. Ensure that water that drains into vernal ponds is free of herbicides, insecticides, and chemicals.
- Trash needs to be addressed along with other pollutants.
- Increase the Refuge's visibility to Bay Area residents to garner increased understanding and support for the Refuge and national wildlife refuges in general.
- What will be done in regards to cultural sites such as the cannery?
- Collaborate and coordinate with neighbors, such as wetland property owners.
- Develop stronger partnerships, coordination, and communication to foster the integrity of habitat and species recovery. In particular, collaborate on studies, outreach and information sharing regarding water quality and management.
- Partnering with smaller habitat managing organizations that could use mentoring, technical expertise.
- Collaborate with universities, professors on Refuge research needs to inform management actions.
- Develop a collaborative consortium of bay habitat managers on research needs to communicate with universities.
- Green Refuge infrastructure and publicize its benefits.

2.5. Development of the Refuge Vision

A vision statement is developed or reviewed for each individual refuge unit as part of the CCP process. Vision statements are grounded in the unifying mission of the Refuge System, and they describe the desired future conditions of the refuge unit in the long term (more than 15 years). They are based on a refuge's specific purposes, the resources present on the refuge, and any other relevant mandates. The vision statement for the Refuge is in Chapter 5.

2.6. Development of the Refuge Goals, Objectives, and Strategies

Refuge goals are necessary for outlining the desired future conditions of a refuge in clear and succinct statements. The Refuge System defines goals as a "descriptive, open-ended, and often broad statement of desired future conditions that conveys a purpose but does not define measurable units" (602 FW 1). Objectives and strategies are then developed to meet those goals. Objectives are defined as a "concise statement of what we want to achieve, how much we want to achieve, when and where we want to achieve it, and who is responsible for the work" (602 FW 1). Strategies are defined as a "specific action, tool, technique, or combination of actions, tools, and techniques used to meet unit objectives" (602 FW 1). Well-written goals, objectives, and strategies direct work toward achieving the Refuge's vision and purpose. Interim refuge goals were developed within the context of the authorities that established the Refuge, Refuge System mission and goals, the Service goals and policies, and ecoregion goals. The existing interim refuge goals are listed in Chapter 1. These goals will be modified through the CCP development process.

2.7. Development of Alternatives

The CCP process includes the development of a range of alternatives that can be implemented to meet the goals of the Refuge System and the purpose of the Refuge. The Refuge System defines alternatives as "different sets of objectives and strategies or means of achieving refuge purposes and goals, helping fulfill the Refuge System mission, and resolving issues" (602 FW 1). The alternatives are developed based on comments from the scoping period, as well as input from the planning team and other Service staff. The EA (Appendix B) describes the development of alternatives, assessment of their environmental effects, and identification of the preferred management alternative (proposed action).

Alternative A: No Action. Under this alternative, the Refuge would continue current management actions, including habitat management, wildlife management, wildlife-oriented opportunities, and environmental education. Habitat and wildlife management activities would emphasize habitat restoration projects, invasive weed management, wildlife surveys, and mammalian predator management. A wide variety of wildlife-oriented opportunities are offered including waterfowl hunting, fishing, wildlife observation, wildlife photography, and interpretation. The environmental education program conducts a variety of topics such as habitat restoration, water conservation, and watershed protection. A few non-wildlife dependent recreational opportunities are permitted. Also, a volunteer program supports the biology, visitor services, environmental education, and management needs of the Refuge. Current staffing and funding would remain the same.

Alternative B: Moderate increase in wildlife management, habitat management, visitor services, and the environmental education program. Under this alternative, the Refuge would moderately expand biological, habitat management, visitor service, and environmental education activities. Additional biological activities include increased survey efforts on the salt marsh harvest mouse (*Reithrodontomys r. raviventris*), baseline surveys on native focal flora and fauna, and avian predator management. Habitat would be improved for the western snowy plover (*Charadrius vociferous nivosus*) and California least tern (*Sterna antillarum browni*). Other habitat management activities include development of a comprehensive weed management plan, additional improvement to tidal marsh units, improving the ecotone/transition zone, and addressing climate change impacts on Refuge resources. The Refuge would also actively work to acquire remaining lands within the approved acquisition boundary from willing sellers.

Wildlife observation opportunities would be expanded through trail enhancements, a bus stop at the headquarters, additional viewing areas, and non-motorized boat launch sites. A wildlife photography permit system would be implemented to encourage wildlife photography. Improved hunt outreach through meetings and an interactive website would facilitate the hunt program. Additional fishing locations would be added. Access for dog walking would be reduced in order to further protect tidal marsh areas. A new visitor center complex would be constructed and additional interpretation activities would be provided. The environmental education program would be updated and expanded in several ways such as through the remodel of the Environmental Education Center (EEC), updating current educator training materials, Spanish translation of materials and curriculum, and adding additional programs at different sites. The volunteer program would be expanded through improving training for volunteers, increasing volunteer participation, and developing permanent stewardship projects. Additional staff and funding would be needed to implement this alternative.

Alternative C: Same as B; and substantial increase in wildlife management, habitat management, visitor services, and the environmental education program. Under this alternative, the Refuge would increase the frequency of baseline monitoring, investigate reintroduction of the salt marsh harvest mouse and the California clapper rail (*Rallus longirostris obsoletus*), survey for other threatened and endangered plant species, and conduct additional research to benefit the salt marsh harvest mouse and the California clapper rail. Additional habitat management actions include additional tidal marsh improvements, more aggressive control of invasive weeds, revegetation of grassland areas, and more aggressive enhancement and restoration of the marsh-upland ecotone. Visitor service opportunities would be improved through actions such as additional interpretive signage, a bus stop at the EEC, constructing a dock for boat access, and constructing universally-accessible photography blinds. A hunt fee would be imposed under this alternative to improve and fund additional hunt blinds. An additional fishing day would be provided at a new fishing site. Dog walking opportunities would be eliminated from the entire Refuge. Interpretation opportunities would be increased such as additional outreach events, creation of an auto tour route, and providing recreational equipment for conducting tours. The environmental education program would be expanded to include a climate change curriculum, accommodating additional students, translation of current curriculum into additional languages, developing new teacher and student resources, training other partners to conduct environmental education programs, and expanding the restoration education program to a variety of school and non-school based groups. Additional staff and funding would be needed to implement this alternative.

2.7.1. Selection of the Refuge Proposed Action

The alternatives were analyzed in the EA (Appendix B) to determine their effects on the Refuge environment. Based on this analysis, we have selected Alternative B as the proposed action because it best achieves the Refuge goals and purposes, as well as the Refuge System and Service missions. Alternative B relies upon existing and new partnerships in the community and increased Refuge staff levels to achieve its objectives.

2.8. Plan Implementation

The CCP will be reviewed by Refuge staff when preparing annual work plans and updating the Refuge Operational Needs System (RONS) database. This database describes the unfunded budget needs for each refuge and is the basis upon which the Refuge receives funding increases for operational needs. The Plan may also be reviewed during routine inspections or programmatic evaluations. Results of the reviews may indicate a need to modify an integral part of the Plan implementation, and management activities may be modified if the desired results are not achieved. If minor changes are required, the level of public involvement and NEPA documentation will be determined by the refuge manager. The CCP will be formally revised approximately every 15 years.

3. Affected Environment

3.1. Introduction

This chapter describes the physical, biological, social, economic, and cultural resources within the Refuge. The affected environment includes important habitats and resources within and surrounding South San Francisco Bay, including those baylands included in and adjacent to the SBSPRP (Figure 5), as well as surrounding lands and isolated parcels. The Refuge is made up four distinct areas known as the Alviso, Mowry, Newark, and West Bay Units, which are depicted in Figure 6.

Figure 5. South Bay Salt Pond Restoration Project and Refuge Boundaries

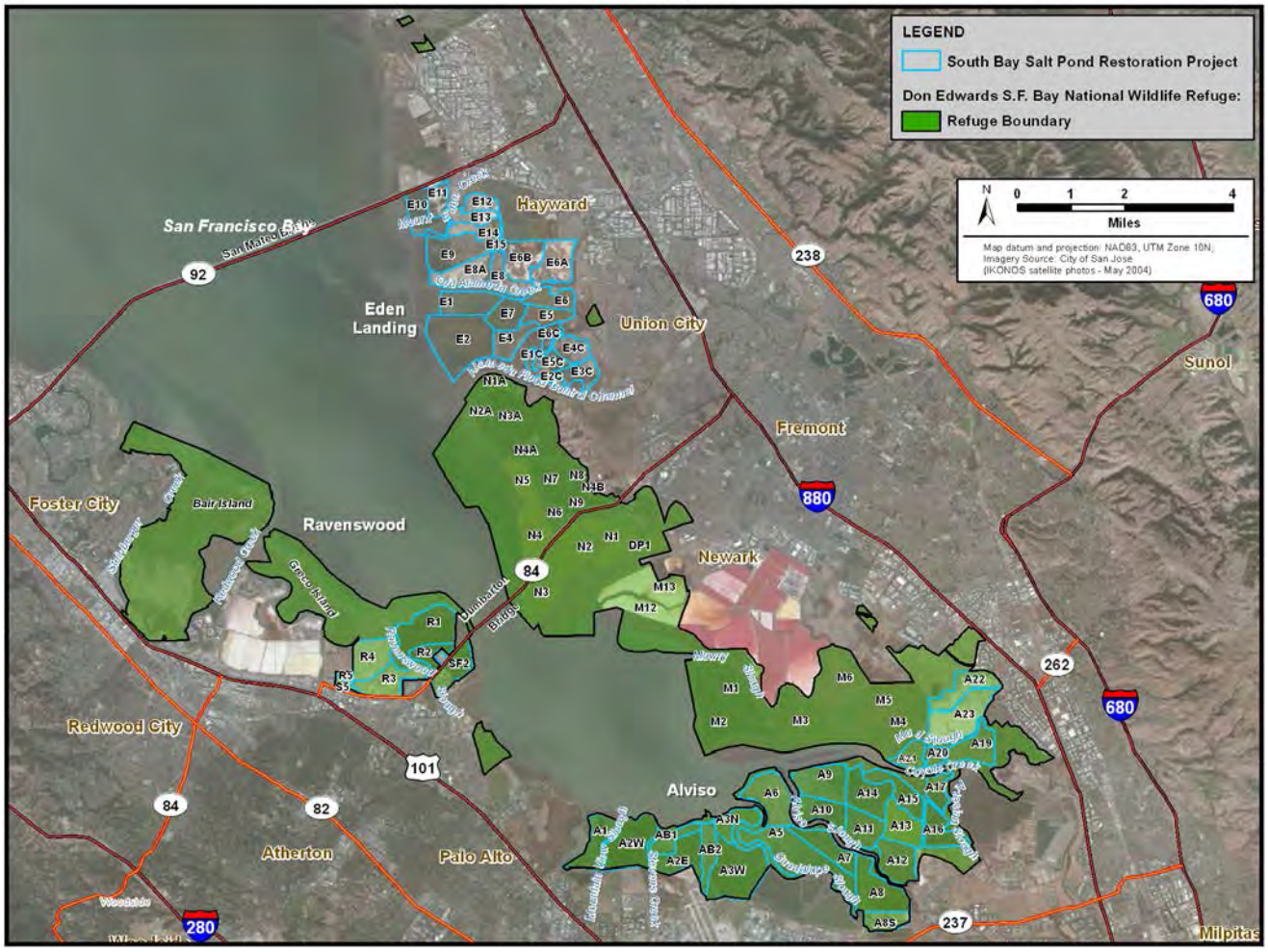
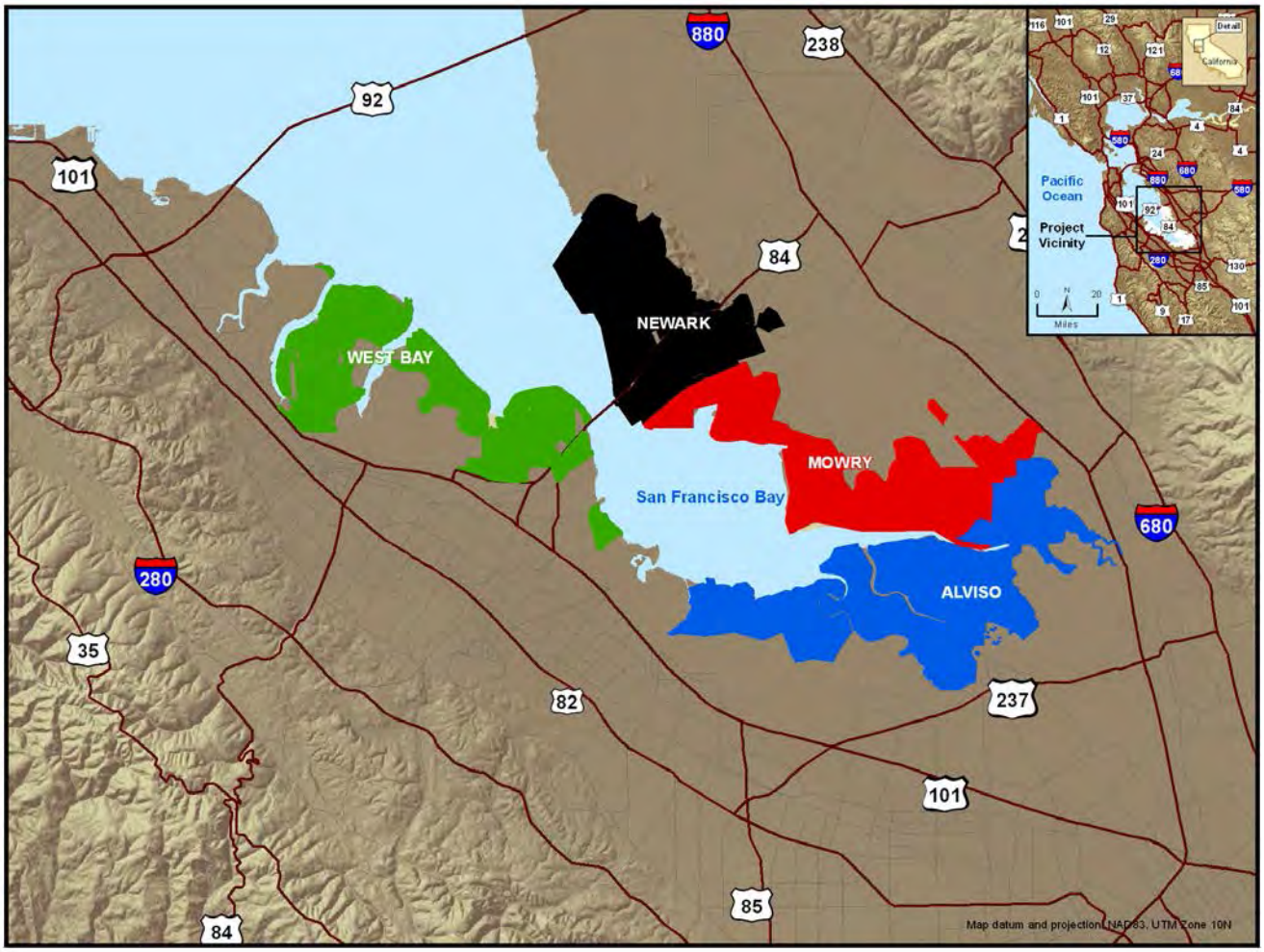


Figure 6. Refuge Units and Vicinity Map



3.2. Regional and Historic Setting

The San Francisco Bay estuary is an extremely productive, diverse ecosystem; yet, one that has been degraded considerably since the 1800s. The estuary has lost more than 90 percent of its original wetlands to diking, draining, and filling, and it has been more heavily invaded by nonnative species than any other aquatic ecosystem in North America (Cohen and Carlton 1998). The South San Francisco Bay (South Bay) is a critical component of the larger estuary. Though surrounded by urban development and highly altered by the diking of wetlands for salt production, the South Bay supports some of the most important habitat remaining in the entire Bay Area for a number of wildlife species.

The Refuge was established in 1972 as the first urban National Wildlife Refuge and is one of seven wildlife refuges in the San Francisco Bay Area. As of 2011, the Refuge owns and/or manages 30,000 acres of the total 43,000 acres located within the approved acquisition boundary.

For the purposes of the CCP, the Refuge is divided into four units that include:

1) **Newark Unit:** along the east shoreline of South Bay between the San Mateo Bridge and Dumbarton Narrows (northern boundary of Audubon Marsh) (Figure 7). The Unit also includes a stretch of shoreline adjacent to San Lorenzo.

   Roughly half of the Newark Unit is occupied by approximately 4,000 acres of commercial salt evaporator ponds (Siegel and Bachand 2002,) converted from high-elevation tidal marsh. These ponds include Ponds N1, N2, N3, N1A, N2A, N3A, N4, N4B, N5, N6, N7, N8, N9, and PP1. The salt ponds are located west of the Coyote Hills and include the Newark Slough area. These salt ponds were constructed starting in the early 20th century (EDAW 2005) and are managed for salt production today by Cargill Salt. Cargill Salt owns the salt-making rights to these ponds and all other rights are owned by the U.S. Government. Under a 1979 agreement between Cargill Salt and the Service, Cargill Salt retains the salt making rights in the Newark Ponds in perpetuity. Cargill plans to continue salt making in these ponds. Some of the adjacent intertidal/sub tidal baylands are a part of the Refuge under a long-term lease from the CSLC, the trustee and responsible agency for these lands (See Figure 7).

   The Newark Unit also contains a narrow strip of fringing marsh, including the 130-acre Ideal Marsh, which was restored from former salt ponds by a natural levee breach around 1930. The Unit also includes much of the wide mudflats that flank its bayside portion.

   Lowland areas to the east and southeast of the Coyote Hills are also part of the Refuge in this Unit. Landward of the salt ponds and the Coyote Hills, the ancient tidal marsh is diked (dates of diking are unknown). Southeast of the Coyote Hills several restoration efforts have established muted tidal systems from the former diked areas. These areas include the 110-acre Mayhew's Landing, 140-acre LaRiviere Marsh, and 10-acre Triangle Marsh (Refuge Entry); restorations were completed in 1994, 1997, and 2001, respectively.

   Although lying approximately six to nine miles north of Alameda Creek Flood Control Channel, the Newark Unit also includes areas of restored marsh along the shoreline of San Lorenzo Creek. These areas include portions of the 170-acre San Leandro Shoreline marshes, 320-acre Oro Loma Marsh, and 100-acre Citation Marsh; restorations were completed in 1995, 1997, and 1999, respectively, by the East Bay Regional Park System, which currently manages the parcels for the Refuge. These restored marshes are bisected by San Lorenzo Creek.

Figure 7. Newark and West Bay Units

2) **Mowry Unit:** along the north shoreline of South Bay from Dumbarton Narrows (northern boundary of Audubon Marsh) to the Southern/Union Pacific railroad. This unit also includes the Warm Springs Seasonal Wetland sub-unit. Some of the adjacent intertidal/subtidal bay lands are a part of the Refuge under a long-term lease from the California State Lands Commission (See Figure 8).

The Mowry Unit is dominated by approximately 6,000 acres of commercial salt ponds (Figure 8) including M1, M2, M3, M4, M5, M6, M12, and M13. Most of these were converted from old high-elevation tidal marsh during the 1920s (EDAW 2005). By 1929, many of the pond levees had been constructed. Cargill Salt became the sole operator of the salt ponds in the Mowry Unit in 1978 and they are functioning today as evaporator, crystallizer, and bittern ponds (Siegel and Bachand 2002). Under a 1979 agreement between Cargill Salt and the Service, Cargill Salt retains the salt making rights in the Mowry Ponds in perpetuity. Cargill plans to continue salt making in these ponds.

The Mowry Unit includes relatively large areas of ancient fringing marsh, and much of the mudflat along this part of South Bay, Coyote Creek, and Mowry Slough. Dumbarton Marsh and Audubon Marsh are located adjacent to outer Newark Slough (Figure 8). Historically, these marshes consisted of high elevation marsh plain fronted by broad mudflats, draped over the buried alluvial fan that created the Dumbarton Narrows (see Geology and Soils section) (PWA 2007). Marshes also fringe Mowry Slough and the northern shore of Coyote Creek including the relatively large Calaveras Point Marsh. Watson (2008) studied the history of Calaveras Point Marsh and showed that the area of marsh expanded by over 250 acres between 1975 and 2005. This expansion is consistent with the assessment of HTH (2007), which showed an overall 250-acre increase in marsh habitat for all the Coyote Creek and Mowry Slough fringing marsh areas (including Mud Slough) in this Unit, between 1989 and 2007.

The Dumbarton Narrows, where the South Bay is only 1.2 miles wide, was an obvious location to build infrastructure connections across the Bay, and also across the Dumbarton marshes. This infrastructure includes: the Hetch Hetchy Aqueduct built in 1896; the Dumbarton Road bridge, completed in 1910 across the Bay to the north of the Hetch Hetchy Aqueduct; and the Dumbarton cutoff railroad constructed in 1910 (disused since 1982), separating Dumbarton Marsh south of the railroad from Audubon Marsh north of the railroad. While remnants of the historic marshes still exist, the infrastructure, particularly the railroad, has caused their fragmentation.

In order to improve tidal connectivity between Audubon Marsh and Dumbarton Marsh, the Dumbarton Marsh Enhancement Conceptual Plan is currently being developed (PWA 2007) as part of the Dumbarton Rail Corridor Project. The initial conceptual 'base plan,' should the rail project go forward, is to excavate three breaches beneath the railroad embankment to reconnect the marshes.

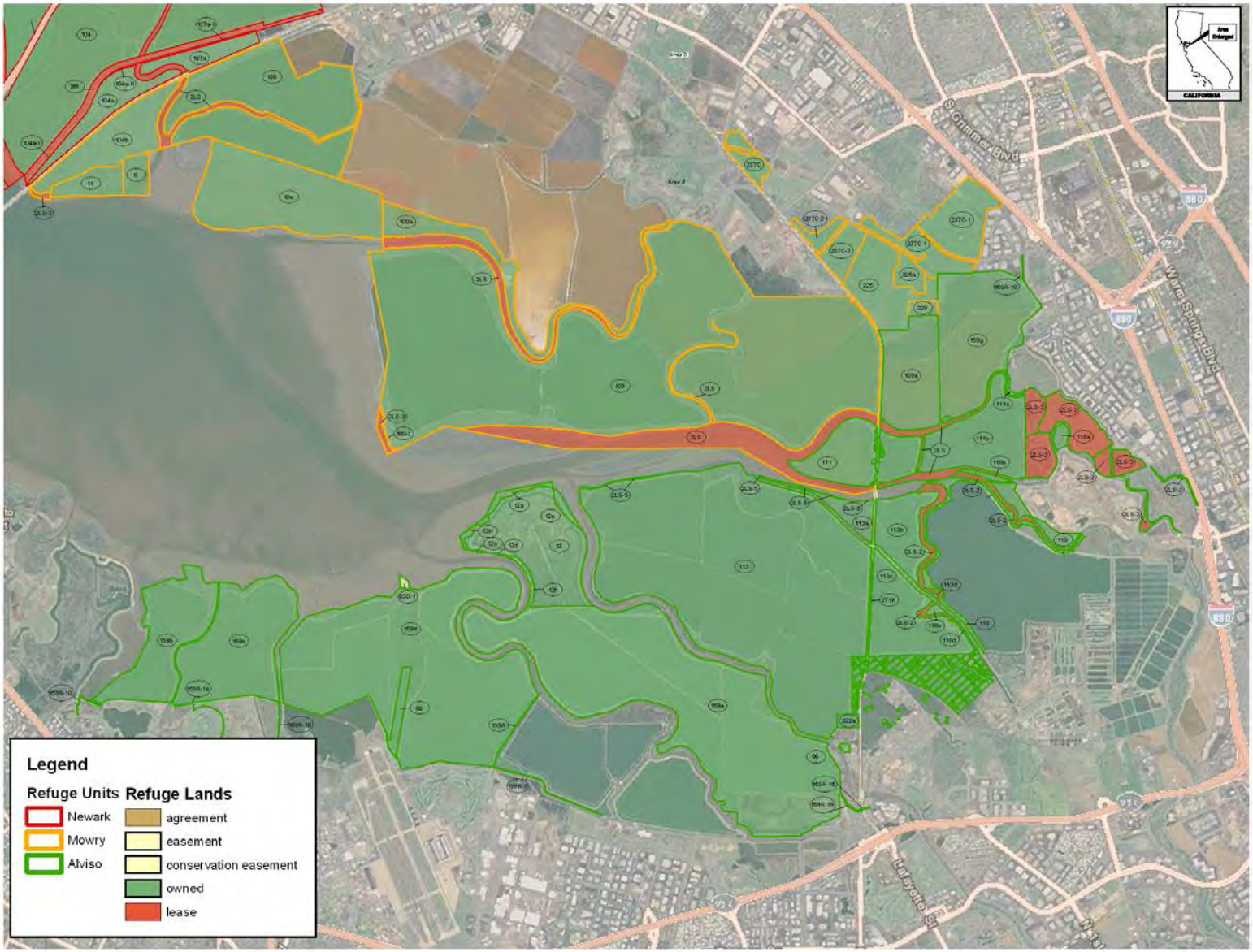
The San Francisco Public Utilities Commission (SFPUC) is currently constructing the new Bay Division Pipeline (BDPL), which consists of a 16-mile-long pipeline and the five-mile Bay Tunnel under San Francisco Bay to help meet the seismic reliability, water delivery, and drought management goals outlined in SFPUC's Water System Improvement Program. The proposed pipeline includes a seven-mile buried pipeline

segment in the East Bay that begins approximately 100 feet east of Mission Boulevard in Fremont near the Irvington Tunnel Portal and continues westward through the cities of Fremont and Newark to the Newark Valve Lot. The proposed Bay Tunnel would begin in Newark, traverse beneath San Francisco Bay, and continue to the Ravenswood Unit, south of Pond SF-2. Both the entrance and exit of the tunnel, including the two construction shaft sites, will be located adjacent to the Refuge.

The Mowry Unit also includes a vernal pool grassland area in South Fremont known as the Warm Springs Seasonal Wetland sub-unit. These 700 acres include both natural and restored vernal pools, and represent a rare habitat type in the Bay Area — the ecotone between saltmarsh and upland. The initial 255 acres of Warm Springs was acquired by the Refuge in 1992. This area has a history of grazing and waterfowl hunting. Upon acquisition of Warm Springs, cattle grazing was halted in order to develop a formal grazing plan and undergo environmental review. Intensive biological monitoring and habitat management, including re-initiation of cattle grazing, began at the site in 2004. In 2008, the Refuge added to the Warm Springs sub-unit with the acquisition of the "Pacific Commons Preserve," a 425-acre restored vernal pool grassland habitat. Pacific Commons was a highly disturbed vernal pool grassland site with a history of farming, a glider airport, and a race track; much of the site had been leveled, although several vernal pools had remained untouched. Beginning in 1999, Catellus Development initiated restoration and protection of the area as mitigation for an adjacent development. Although the Refuge acquired the property in 2008 as fee-title, Catellus has been obligated to manage it until they meet all of their permit requirements. In 2012, management of the Pacific Commons area was turned over to the Refuge, along with a permanent endowment.

Diked marsh areas adjacent to and northeast of the salt ponds are also part of the Refuge in this Unit (dates of diking are difficult to establish) (Figure 8).

Figure 8. Alviso and Mowry Units



3) **Alviso Unit:** along the southern shoreline of South Bay, east of the Union Pacific railroad, then south around to Charleston Slough; also includes Ponds A22, A23, and the Island Ponds (A19-A21). Some of the adjacent intertidal/subtidal bay lands are a part of the Refuge under a long-term lease from the California State Lands Commission (Figure 8).

The majority of the Alviso Unit is approximately 7,600 acres of former salt ponds (Figure 8). These include Ponds A1, A2W, AB1, A2E AB2, A3W, A5, A6 (Knapp Parcel), A7, A8N, A8S, A9, A10, A11, A12, A13, A14, A15, A16, A17, A19, A20, A21, A22 and A23. These ponds are separated by Mud Slough, Coyote Creek, Artesian Slough, Alviso Slough, Guadalupe Slough, and Mountain View Slough. Before the construction of the Alviso salt ponds, this Unit was predominantly old high-elevation tidal marsh. Early failed attempts to convert the land took place up to the 1920s and it is likely the Unit remained predominantly marsh plain up to this time. During the 1920s, several salt companies developed salt ponds, and by 1929 many of the levees in the Alviso Unit had been constructed (EDAW 2005). The construction of levees converted over 8,000 acres of the former marsh into a series of evaporator ponds for salt production (Siegel and Bachand 2002). Cargill Salt became the sole operator of the Alviso ponds in 1978.

In 2003, ownership of the Alviso ponds (apart from Ponds A4, A6, and A18) transferred to the Refuge, and all of these former ponds became part of the SBSPRP (EDAW et al. 2007, Figure 8). Some of the ponds were purchased in fee title and some were already part of the Refuge with salt-making rights purchased from Cargill Salt in 2003. As a part of the 2003 purchase agreement with Cargill Salt, Ponds A22 and A23 were transferred to the Refuge in 2010 (after ceasing salt-making operations on these ponds and criteria for salinity levels were met). These seasonal ponds are managed for endangered western snowy plovers; no current restoration activities are planned, but will be included in the SBSPRP.

The Island Ponds (Pond A19, A20, and A21, Figure 8) were breached to the tidal influence of Coyote Creek in March 2006. PWA et al. (2007), SCVWD et al. (2008), Mark Stacey (University of California, Berkeley) and John Callaway (University of San Francisco) monitored the hydrologic and geomorphic evolution of the ponds over the first 18 months of the restoration. The results show that the excavated breaches are providing tidal circulation in all three ponds. Sediment is accumulating rapidly on the pond surfaces, particularly in Pond A21 where vegetation has quickly colonized.

Pond A6 (Knapp Parcel) was not part of the 2003 acquisition, but has been owned by the Refuge since 1983. The Knapp Parcel was owned by the Knapp family and used as a duck hunting areas (pers. comm., P. Mapelli, 8/20/09). In 1951, the property was leased to Leslie Salt for salt making and duck hunting. The Knapp family later sold this property to the Nature Conservancy, which transferred the property to the Refuge. In 1988, the Refuge discontinued the salt making lease to Cargill Salt (who bought Leslie Salt in 1979) to manage the pond for wildlife.

Prior to development of the long-term restoration plan (SBSPRP completed in 2007 and currently guiding the restoration and management of the ponds purchased in 2003), the

Refuge was operating and maintaining the majority of these ponds through the SBSP ISP, an interim plan to maintain and enhance the habitat values of the ponds. Phases 1–3 of the ISP have already been implemented, which includes the Island Pond breaching. The ISP guided the construction of water control structures allowing the circulation of bay water through most of the Alviso Ponds, operation of some ponds as seasonal wetland ponds, and others as high salinity ponds.

The implementation of Phase 1 of the SBSPRP in the Alviso Unit began in 2010 and will include tidal and managed pond habitat restoration and early experiments for adaptive management. The Phase 1 actions include three projects within the Alviso Unit totaling 2,000 acres and include Ponds A5, A6, A7, A8, A16, and A17 (Figure 8). Tidal restoration was implemented at Pond A6 in December 2010 and controlled tidal restoration occurred at Pond A5, A7, and A8 in June 2011. Pond A16 will be reconfigured as a managed pond with islands along with tidal restoration of Pond A17. The remaining ponds continue to have bay waters circulated through them per the ISP following the 2003 Cargill Salt purchase.

Landward of the salt ponds, several degraded wetlands have been restored or enhanced, including Coyote Creek Lagoon, Mouse Pasture, and New Chicago Marsh (Figure 8). The Mouse Pasture was leased from the California State Lands Commission along with Coyote Creek Lagoon and its public access trail in 1986. The pasture is managed as a diked seasonal wetland to maintain habitat for the salt marsh harvest mouse. Water is brought to the Mouse Pasture through water control structures to maintain harvest mouse habitat. The Coyote Creek Lagoon was breached in 1986 to Coyote Slough and Mud Slough, and has been monitored under a Refuge Special Use Permit to Phyllis Faber and PWA to the present day. They have found that since tidal action was introduced, the site has rapidly filled with sediment; marsh vegetation has established around the perimeter, and is gradually expanding toward the center of the site, which is currently mudflat.

The 390-acre New Chicago Marsh was enhanced to muted tidal marsh in 1994. The Refuge currently manages water levels in the 390-acre New Chicago Marsh under the New Chicago Marsh Management Plan to enhance marsh habitat for the salt marsh harvest mouse and waterbirds (USFWS 2005). An improved water control structure between Pond A16 and New Chicago Marsh as well as an upgraded pump system to maintain water levels during high storm events was completed. This project will enhance the existing water management and habitat quality of New Chicago Marsh through moderation of summer salinity levels and winter flooding depth and duration, and can be implemented following the completion of the A16 restoration.

Several other relatively small areas along the north and south boundaries of the Unit remain diked from tidal inundation. The mudflats and fringing marsh along Coyote Creek are also included in this Unit (Figure 8).

4) **West Bay Unit:** along the west shoreline of South Bay from Redwood City to the Faber Tract in East Palo Alto (south of Dumbarton Narrows, Figure 7). This includes Ponds SF2, R1, R2, R3, R4, R5, RS5, the Faber and Laumeister tidal marsh tracts, Bair Island, and Greco Island. Some of the adjacent sub tidal bay lands are a part of the Refuge under a long-term lease from the California State Lands Commission (Figure 7).

Prior to human development, the West Bay Unit comprised a large complex of tidal salt marsh, tidal sloughs, and mudflats, with a narrow peripheral set of pannes. In the 1940s, Leslie Salt converted the marsh northwest of Dumbarton Narrows transforming it into approximately 3,000 acres of evaporator, crystallizing, and bittern salt ponds (Siegel and Bachand 2002; EDAW 2005). In 2003, nearly 1,500 acres of the evaporator ponds were acquired by the Refuge to either side of Dumbarton Bridge. Some of the ponds were purchased in fee title and some were already part of the Refuge with salt making rights purchased from Cargill Salt in 2003. These ponds, R1, R2, R3, R4, R5, S5, and SF2 (donated by Cargill) (Ravenswood Complex) are currently operated, maintained, and restored as a part of the SBSPRP and ISP. As a part of Phase 1 action of the SBSPRP, the 240-acre Pond SF2 was reconfigured in 2010 to be a managed pond with a portion having muted tidal flow around 30 nesting and roosting islands and a portion managed as a seasonal pond for nesting western snowy plovers. The rest of the Refuge's West Bay ponds are operated as seasonal ponds with rainfall providing most of its water and tidal waters added as needed to meet management objectives.

The tidal marshes of the 3,000-acre Bair Island were diked in the late 1800s and early 1900s for agricultural uses. Bair Island is divided into three parts, with Outer Bair Island along the Bay shoreline separated from Middle Bair Island by Corkscrew Slough and Middle Bair separated from Inner Bair Island by Smith Slough. In the 1940s, Leslie Salt built salt production facilities on all three of the islands (Inner, Middle, and Outer Bair) that comprise Bair Island. When salt production ended in 1965, CDFG purchased part of Outer Bair, and much of the rest of the property was sold for potential development. After several attempts at development were turned down by voters in Redwood City, the Peninsula Open Space Trust (POST), with extensive assistance from private foundations, was able to purchase much of the remaining acres of Bair Island. This property was then transferred to CDFG and the Refuge in the late 1990s. Currently, most of Bair Island is owned by the CDFG (2,000 acres), with smaller areas owned by the Refuge (1,000 acres), San Carlos Airport, and three other privately owned parcels. After salt pond abandonment, tidal inundation was restored to a large portion of Outer Bair through a series of planned and unplanned levee breaches in the late 1970s and early 1980s. The Refuge is restoring approximately 1,400 acres of Bair Island to tidal wetlands to provide habitat for many threatened and endangered tidal marsh species. In addition, the restoration is designed to reduce mosquito breeding and provide public access and educational opportunities. CDFG and Refuge lands on Bair Island are managed as a part of the Refuge following an MOU between the two agencies. A restoration plan completed in June 2006 is currently being implemented to restore all of Bair Island to tidal salt marsh to provide habitat for endangered species and other native wildlife. As a part of this plan, the remaining diked portion of Outer Bair Island was breached to Steinberger Slough in 2009. Because of ground water extraction, Inner Bair Island has subsided 2.5 feet. To prevent an unwanted bird strike hazard for the San Carlos Airport (which owns a portion of Inner Bair Island), dredged and fill material are currently being added to Inner Bair Island before they will be breached to tidal action.

The extensive mature tidal marshes of Greco Island and wide expanses of mudflat also form part of this Unit. Almost half of Greco Island was developed into salt works in the early 1900s and for 20–30 years was managed as the Greco Salt Company (Collins and

Grossinger 2004). By the mid-1940s, much of this area had reverted back to tidal marsh, and by the late 1950s, all of the historical salt works had reverted back to tidal marsh. The bay side of Greco Island is the largest area of relatively undisturbed, historic tidal marsh in the South Bay. A railroad berm (but not the railroad itself) was constructed through it, which can still be seen today (C. Morris, pers. comm.).

Areas of restored marsh in the West Bay Unit are also located in East Palo Alto (south of Dumbarton Bridge). The Faber-Laumeister Tracts located in East Palo Alto are owned by the city of Palo Alto, but managed as part of the Refuge under an MOU with the City of Palo Alto. Faber Tract, a former dredge disposal pond, was restored to tidal marsh in 1969 and, along with Laumeister, provides some of the most extensive tidal marsh habitat for the endangered California clapper rail in the South Bay. Pilot environmental education projects are also conducted at this site as outreach to the local East Palo Alto community. The Laumeister Tract adjacent to the Faber Tract was never diked and though its hydrology has been impacted by adjacent projects, has always been tidal marsh.

3.3. Physical Environment

The following text gives an overview of the physical attributes of the Refuge environment that have influenced habitats in the bay and puts the Refuge into a regional context.

3.3.1. Geology and Soils

San Francisco Bay is a tectonically-formed, drowned river valley. The South Bay was shaped in part by movements of the San Andreas Fault to the west and the Hayward Fault to the east, which caused the intervening block of crust to drop, resulting in a broad region of low topography between segments of the Coast Ranges (Sloan 2006). Bedrock across the South Bay is likely to be dominated by the Franciscan Complex, which outcrops in the Coyote Hills (Newark Unit).

Over the Quaternary Period (1.8 million years to present) the San Francisco Bay 'valley,' including all the areas beneath the Refuge, were filled with sequences of alluvial and estuarine sediments (hundreds to thousands of feet thick), reflecting the interplay between tectonic forces and cyclical changes in sea level associated with glacial and interglacial periods (Atwater et al. 1977; Sloan 2006). During the last glacial period (Wisconsin), the form of the South Bay became largely defined by the extension of the Niles Cone (Alameda Creek) alluvial fan from the east merging with smaller alluvial fans (San Francisquito Creek) spreading from the west. The general curve of the South Bay shores (including the Dumbarton Narrows), the bathymetry, and the position of the main channel probably reflect the historical fan topography and slope.

The most dramatic changes in the South Bay landscape are related to Holocene (last 10,000 years) relative sea-level rise. During the last glacial maximum, more than 15,000 years ago, sea level in California was at least 300 feet lower than today (Atwater 1979; Meyer 2003), and much of the area now occupied by the waters of the South Bay was a broad, inland valley crossed by streams or river channels, and dominated by alluvial deposits (see above). The rising sea entered the Golden Gate around 10,000 years ago, and approximately 5,000 years ago invaded the South Bay depositing Bay Mud on the antecedent alluvial surface.

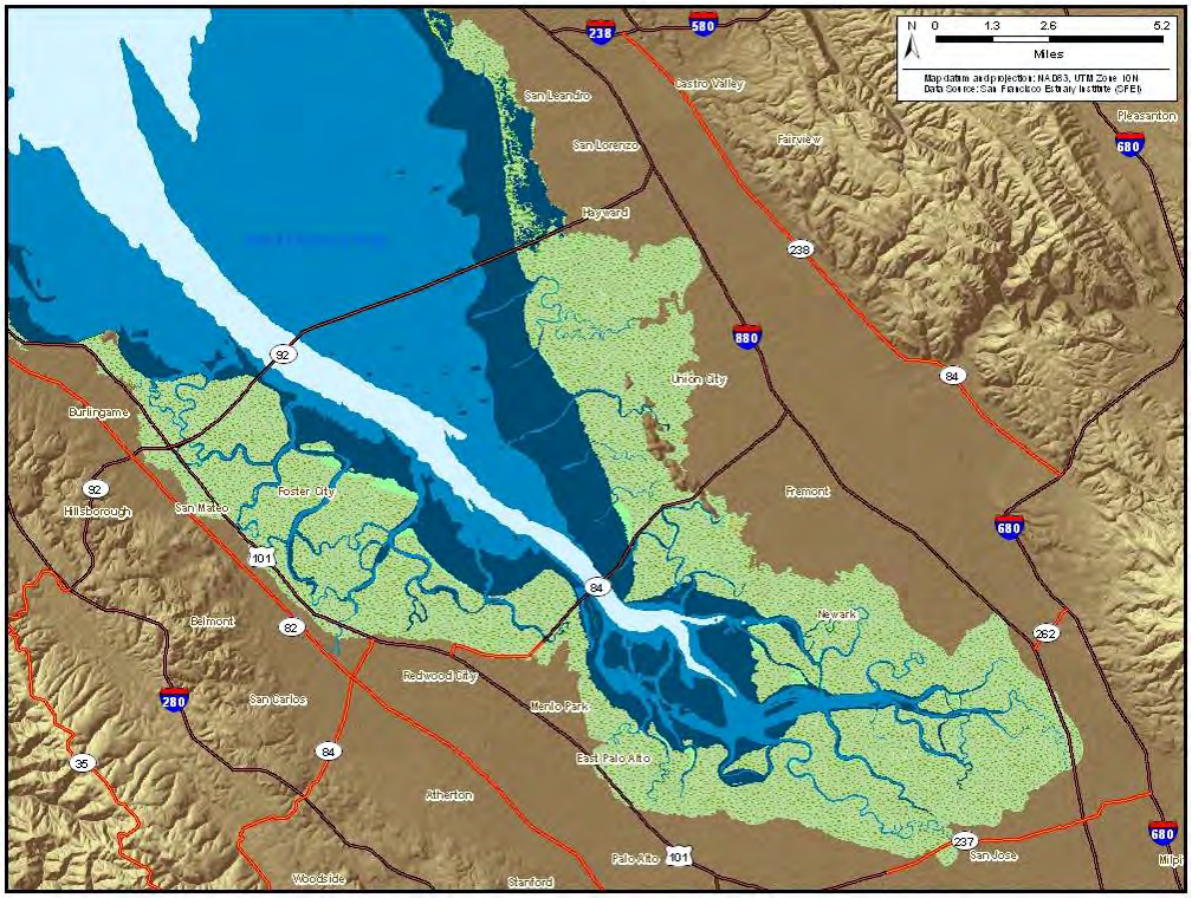
The predominant soil types on the Refuge are the Novato and Reyes Series (USDA, 6-16-10, pers. comm.). These Series types are generally poorly drained. The Reyes Series is alluvium derived from sedimentary rock and defined as nearly level (0–2 percent slope) and consists of silty clay loam, silty clay, or clay with high salinity (NRCS 2010). Similar to the Reyes Series, the Novato series consists of deep, very poorly drained soils that formed in alluvium deposited along the margin of bays (NRCS 2010). Textures are silty clay loam, silty clay, or clay. Novato soils are in tidal marshes and have nearly level slopes (0–2 percent). These soil types are generally saturated with water all times of the year.

The soils of the Warm Springs sub-unit are unique to the Refuge and to the margins of the San Francisco Bay in general. These soils are Pescadero Clays, typically deep, poorly drained soils formed on basin rims in alluvium from sedimentary rock (Soil Conservation Service 1981). These are the soils within the Refuge upon which vernal pools form.

3.3.2. Geomorphic Evolution of the Bay

Prior to human interventions, the margins of the South Bay comprised a landscape of extensive tidal marsh plains and mudflats (Figure 9), which evolved over the past 5,000 years by the interaction of sediments, tidal currents, waves, and rising relative sea-level (Atwater et al. 1979). As the rising sea gradually inundated the gently sloping margins of the Bay, the tidal marshes migrated inland and were able to maintain their elevation at mean higher high water through inorganic sedimentation and the accumulation of organic material creating extensive vegetated marsh plains drained by a complex network of large sinuous tidal channels (Figure 9). Strong wind-wave action gradually eroded the bayfront marsh edge, eventually forming the extensive shallows and mudflat margins of the South Bay. At the inland edge of the migrating marsh, seasonal salt pans formed where tidal drainage was less effective. Freshwater and associated edge habitats, including vernal pools, existed landward of tidal influence.

Figure 9. Historic Baylands



The present-day geomorphology of the South Bay has been dictated to a large extent by historic anthropogenic changes. European-American colonization over the last 200 years has transformed not only the landscape of the South Bay by diking, filling, and groundwater pumping; it has also changed the processes that sustain wetland habitats by altering the sediment dynamics, hydrodynamics, and salinity distribution.

Overall, there are ongoing geomorphic processes that have shaped the modern South Bay landscape and will continue to change the landscape into the future. Some of these changes are in response to long-term processes over the last 10,000 years; whereas other changes have been set in motion by human modifications over the past few centuries. Ongoing physical processes continue to affect the patterns and extents of open water, intertidal mudflats, tidal marsh, and upland transition.

Reclamation of marsh plain for salt pond production

Over the last 150 years, most of the tidal marshes of the South Bay were diked to create ponds for salt production (Goals Project 1999). These ponds form a large part of the Refuge. Other areas were converted for agricultural, hunting clubs, or development purposes. Reclamation removed vegetated tidal marsh functions and associated habitats, specifically marsh plain, perimeter salt pans, and the tidal channels within the marsh. Diking of the marshes also affected physical and sedimentary processes. The tidal prism was reduced, causing tidal sloughs to fill with sediment as fringing marsh outboard of the levees expanded. It appears

that this process is still affecting Coyote Creek, Alviso Slough, and other tidal creeks where the channels are narrowing, and fringing marsh areas are increasing (EDAW et al. 2007; HTH 2007; Watson 2008).

Several outboard levees of former salt ponds have been breached to reintroduce tidal action and move toward restoration of tidal marsh habitat. For example, in March 2006, five breaches were cut along Coyote Creek to inundate the 475-acre Island Ponds (Ponds A19, A20, and A21) (PWA et al. 2007; SCVWD et al. 2008). The excavated breaches are providing tidal circulation in all three ponds, and sediment is accumulating rapidly on the subsided pond surfaces, allowing for vegetated marsh development, particularly in Pond A21.

Changes in mudflat areas

Jaffe and Foxgrover (2006a) showed that between 1858 and 2005 the average area and width of mudflats in the Refuge north of Dumbarton Narrows decreased, while the mudflats south of Dumbarton Narrows increased (Table 3). The mudflats in the Mowry and Alviso Units have gained width and area through sediment accumulation on the subtidal channel margin possibly in response to the major reduction in tidal prism due to salt pond creation in the early to mid-20th century. Between 1983 and 2005 the area of mudflat south of Dumbarton Narrows increased by 35 percent from approximately 17.7 km^2 to 24.2 km^2. Overall, there has been long-term net erosion of the mudflats in the Newark and West Bay Units and net deposition of the mudflats in the Mowry and Alviso Units.

Table 3. Average mudflat areas in the South Bay (km^2) (from Jaffe and Foxgrover 2006a)

Unit	1858	1898	1920	1956	1983	2005
Newark[1]	23.6	18.7	16.2	15.5	12.0	12.0
Mowry	7.0	6.4	6.4	6.4	6.7	7.9
Alviso	8.5	12.5	12.9	13.4	11.0	16.3
San Mateo	13.6	11.2	12.7	11.6	10.1	8.7

[1]estimates include mudflat areas north to San Mateo Bridge

Subsidence due to groundwater extraction

Over the last 1.8 million years, the South Bay filled with up to 1,500 feet of alluvial sediment from erosion of the surrounding uplands. These sediments comprise unconsolidated layers of gravel, sand, silt, and clay. The clays are relatively impervious to water, whereas the sand and gravel layers store and transmit water, forming important aquifers. The withdrawal of water from these aquifers led to the compaction of sediments, which caused land subsidence. Land subsidence measured at San Jose between 1934 and 1967 exceeded eight feet in some areas within the Refuge (Poland and Ireland 1988). The rate of groundwater withdrawals has since been reduced and the aquifers recharged, and currently almost no additional subsidence is occurring in the South Bay due to groundwater extraction (Schmidt and Burgmann 2003). However, many Refuge ponds remain subsided, causing challenges to their restoration in the areas near Alviso and Redwood City (Bair Island).

Changes in sediment supply

Hydraulic mining and watershed disturbance in the Sierra in the 19th century substantially increased sediment delivery and the frequency of flood pulses to the North and Central San Francisco Bay (Gilbert 1917). It is not clear how much of this sediment reached the South Bay. With 19th century grazing, agriculture, and logging, it is likely that sediment delivery

from South Bay watersheds increased significantly. In addition, many local creeks that formerly dissipated flood flows and sediment at the bay margin were channelized directly to the bay (Collins and Grossinger 2004).

3.3.3. Climate

The climate in the South Bay is dominated by the strength and location of a semi-permanent, sub-tropical high-pressure cell over the northeast Pacific Ocean. During the late spring, summer, and early fall when the high-pressure cell is strongest and farthest north, winds flowing from the west and northwest are drawn inland through the Golden Gate and over the lower elevation portions of the South Bay. In winter, when the high-pressure cell is weakest and farthest south, conditions are more variable, and occasional rainstorms occur. The South Bay generally experiences dry, mild summers and cool, wet winters, with an annual mean temperature of 58 degrees Fahrenheit.

3.3.4. Bathymetry

The South Bay is a large, shallow basin, with a relatively deep relict river channel surrounded by broad shoals and mudflats. The width of the Bay adjacent to the Refuge ranges from less than 1.2 miles at the Dumbarton Narrows to more than 12 miles north of the San Mateo Bridge. Analysis by the U.S. Geological Survey (Jaffe and Foxgrover 2006b) shows that in 2005, 70 percent of the area south of Dumbarton Narrows was occupied by intertidal mudflats. North of Dumbarton Narrows, the relative area of mudflat is much less with a greater proportion of the bathymetry between mean lower low water and six feet below mean lower low water (the shallows). The shallows and mudflat areas are collectively referred to as the sweep zone. Seaward of the sweep zone the main channel of South Bay drops to depths of up to 50 feet below mean lower low water.

3.3.5. Tides

Tides propagate through the narrow opening at the Golden Gate as shallow water waves. Once inside the Bay, the amplitudes and phases of the waves are modified by the bathymetry, reflections from the shoreline, the Earth's rotation, and bottom friction. The enclosed nature of the South Bay creates a mix of progressive wave and standing wave behavior, which leads to tidal amplification southward. This amplification causes the diurnal tidal range to increase southward (Table 4 and Figure 10). The tidal characteristics of several stations adjacent to the Refuge are provided in Table 5.

Table 4. Diurnal Tidal Ranges (from PWA 2005b, Walters et al. 1985)

Location	Unit	Tidal Range (ft)
Golden Gate	N/A	5.6
San Leandro Marina	Newark (north)	7.4
Redwood City	West Bay	8.2
Dumbarton Bridge	Newark (south)	8.5
Mowry Slough	Mowry	8.6
Coyote Creek	Alviso	9.0

Figure 10. Tidal Cycle

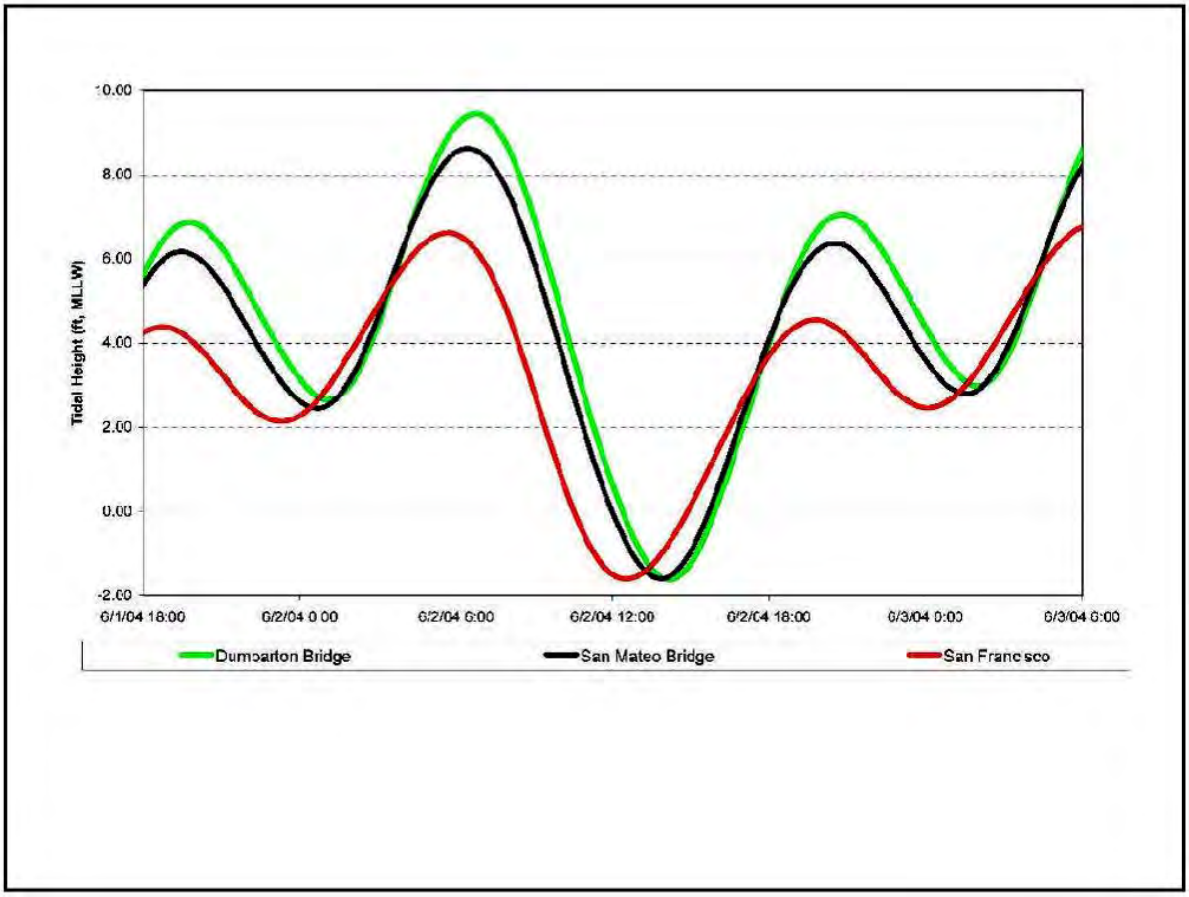


Table 5. Tidal Datum (ft above MLLW) (from PWA 2005b)

Location	San Mateo Bridge West Side Gage ID#9414458	Dumbarton Marsh Gage ID#9414509	Coyote Creek Gage ID#9414575
Tidal Epoch	1983-2001	1983-2001	1983-2001
100-year Estimated Tide (Corps)	10.7	11.5	12.4
10-year Estimated Tide (Corps)	10.2	11.0	11.8
Highest Observed Water Level	10.7	10.2	10.8
Mean Higher High Water (MHHW)	7.7	8.5	9.0
Mean High Water (MHW)	7.1	7.9	8.4
Mean Tide Level (MTL)	4.1	4.5	4.8
Mean Low Water (MLW)	1.2	1.2	1.2
Mean Lower Low Water (MLLW)	0.0	0.0	0.0
Lowest Observed Water Level	-2.9	-2.2	-1.8

The tides in the South Bay are mixed semidiurnal, with two high and two low tides of unequal heights each day (Figure 10). In addition, the tides exhibit strong spring-neap variability, with the spring tides (larger tidal range) occurring approximately every two weeks during the full and new moon. Neap tides (smaller tidal range) occur approximately every two weeks during

the moon's quarters, and exhibit the smallest difference between successive highs and low tides.

3.3.6. Circulation

Currents in the South Bay are a product of tidally-driven residual currents and wind-driven circulation. In tidal circulation, the nature of the standing wave causes slack water to occur at high and low tide, and the maximum currents to occur between high and low tide. Residual flows are generally weak and vary spatially and temporally (Walters et al. 1985). Wind-driven circulation in the South Bay typically results from onshore daytime breezes blowing inland on hot days during the spring and summer. These northwesterly winds create a clockwise, wind-driven circulation pattern, with a southerly flow along the eastern shallows, and a northward flow in the main South Bay channel (PWA 2006). In the winter, weaker southwesterly winds drive a counter-clockwise, wind-driven circulation pattern, with currents toward the northeast along the eastern shallows.

3.3.7. Sea-level Rise

IPCC (2007) estimated a global average sea-level rise over the 20th century of between 1.2 and 2.2 mm/yr. with an average value of 1.7 mm/yr. (0.56 ft/century). Between 1961 and 2003, the rate was estimated at 1.8 mm/yr. (1.3-2.3 mm/yr. or 0.43-0.75 ft/century) rising to 3.1 mm/yr. (2.4-3.8 mm/yr. or 0.79-1.25 ft/century) between 1993 and 2003.

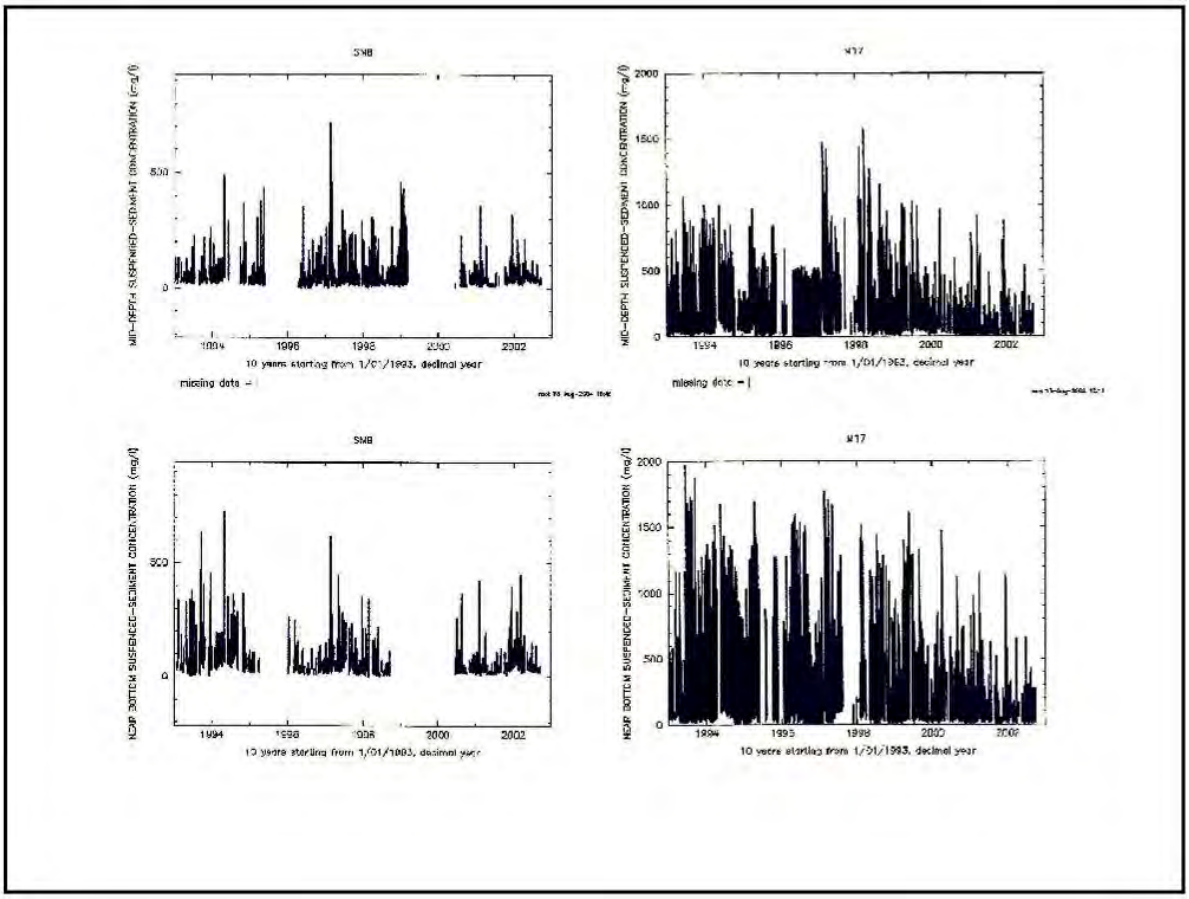
Estimates of future global sea-level rise are currently debated. IPCC (2007) used a variety of atmosphere-ocean general circulation models to predict a full range global average sea-level rise between 1990 and 2100 of 0.6-1.9 feet. The use of a linear empirical relationship (not models) by Rahmstorf (2007) projected higher rates of global sea-level rise of 1.6-4.6 feet during the 21st century. The estimates of Rahmstorf (2007) have been adopted by the Delta Risk Management Strategy (DRMS 2007) and the CALFED Independent Science Board (CALFED ISP 2007). Based on the assessment of Rahmstorf (2007) and the adoptions by DRMS and CALFED, the State of California Resources Agency has recommended using a global sea-level rise of 16 inches (~1.3 feet) by 2050 and 55 inches (~4.6 feet) by 2100 for planning purposes (CRA 2008). San Francisco Bay Conservation and Development Commission (BCDC) also use the same estimates to analyze the effects of sea-level rise on San Francisco Bay.

3.3.8. Sediment Transport

The South Bay receives significant inputs of sediment from local watersheds and from the Central Bay. However, the major source of sediment in circulation within the South Bay is the wave-induced erosion of consolidated mud on the surface of the sweep zone north of the Dumbarton Narrows (PWA 2006). This erosion takes place predominantly in the summer months, during periods of high northwesterly winds, which induce increased wind-wave resuspension and reworking of the sediment across the sweep zone. Suspended sediment concentrations in the South Bay are highly correlated with wind speed (Schoellhamer 1996). In the winter months, when winds are lighter and more variable, the main source of suspended sediment comes from local tributary input and exchange with the Central Bay.

Once sediment is eroded from the sweep zone, it becomes mobile and migrates southward with the prevailing wind-driven circulation through the Dumbarton Narrows. In the far South Bay, the sediment is dispersed on flood tides and deposited on the mudflats and saltmarshes. The shallows and mudflats in the far South Bay have been historically net depositional (Jaffe and Foxgrover 2006b). A portion of the sediment circulates into the subtidal channel, where it is either deposited or moves north out of the South Bay into the Central Bay (Schoellhamer 1996). Suspended sediment concentration data at San Mateo Bridge, Dumbarton Bridge, and Channel Marker 17 in far South Bay show that concentrations increase southward (Figure 11) (PWA 2005a). Concentrations exhibit strong diurnal and spring-neap variability, with the highest concentrations occurring on spring tides.

Figure 11. Suspended Sediment Concentrations



3.3.9. Creek Hydrology and Fluvial Floor Risk

Although there is wide annual variation, the South Bay generally has a wet winter/spring season, and a dry summer/fall season. Therefore, the majority of freshwater tributary inflow from upland runoff sources enters the South Bay during the winter and spring (Life Science! 2003). During the summer months, the major source of freshwater is effluent from municipal wastewater treatment plants. As well as being the purveyors of freshwater to the coastal zone, creeks are also important suppliers of sediment that feeds the mudflats and salt marshes

around the periphery of the South Bay. The primary creeks that discharge through the Refuge are (PWA 2005b):

1. Newark Unit: San Lorenzo Creek and Alameda Creek Flood Control Channel
2. Mowry Unit: Newark Slough, Plummer Creek, and Mowry Slough
3. Alviso Unit: Mud Slough, Coyote Creek**, Guadalupe River* (Alviso Slough), Guadalupe Slough, Permanente Creek** (Mountain View Slough), and Stevens Creek*
4. West Bay Unit: San Francisquito Creek**, Ravenswood Slough, Redwood Creek, and Steinberger Slough.

*Clean Water Act 303d listed (2006), **Clean Water Act 303d proposed for listing (2006).

San Lorenzo Creek

The northern portion of the Newark Unit is bisected by San Lorenzo Creek (Figure 5), which drains a watershed of approximately 50 square miles. The stretch of San Lorenzo Creek adjacent to the Newark Unit is a flood control channel built in 1959 (after major flooding in 1954), with a capacity to hold a flow of 10,400 cubic feet per second (cfs). The 100-year storm event is currently estimated as 16,100 cfs, and hence the channel does not have sufficient water capacity during an event of this magnitude. Federal Emergency Management Agency (FEMA) has issued Flood Insurance Rate Maps (FIRMs) that show flood-prone areas near the flood control channel. Preliminary analyses by the Alameda County Flood Control and Water Conservation District of several feasible flood protection solutions are ongoing that would entail holding more water in the hills during heavy rains, and releasing water slowly when the rains subside. The intention would be to lower the elevation of water flowing through the San Lorenzo Creek flood control channel.

Alameda Creek Flood Control Channel

The Newark Unit is bisected by Alameda Creek Flood Control Channel (ACFCC) (Figure 5). The ACFCC receives flow from the Alameda Creek watershed, the largest in the South Bay region, encompassing almost 650 square miles. The 12-mile long lower flood channel of the ACFCC from the west end of Niles Canyon to the Bay was constructed between 1965 and 1975 following damaging floods in 1955 and 1958 (Life Science! 2003).

Sediment accumulation in the ACFCC has reduced the flow capacity of the channel below its design capacity. The original design capacity was 52,000 cfs, whereas now the maximum capacity is 29,000 cfs (PWA 2005b). Alameda County Flood Control and Water Control District is currently investigating conceptual-level alternatives to modify the ACFCC to reduce peak water levels and improve its flood management performance while integrating with the SBSPRP (PWA 2008). PWA (2008) concluded that breaching the north ACFCC levee separating the creek from former commercial salt ponds purchased by the State of California from Cargill Salt in 2003 would provide the most significant flood management benefit. Flood flows would be diverted from the ACFCC to these adjacent northern ponds, lowering peak water levels in the channel. A secondary benefit would be the channel deepening and widening associated with increased tidal flows, which would increase channel conveyance at the mouth of the ACFCC without the need for channel dredging.

Newark Slough
Newark Slough connects to the Bay just south of the Dumbarton Narrows. It receives limited freshwater runoff from drainage canals from developed upland areas of Newark.

Plummer Creek
Plummer Creek connects to the Bay just south of Newark Slough. It receives limited freshwater input from drainage canals from developed upland areas of Newark.

Mowry Slough
Mowry Slough connects to the Bay south of Newark Slough and Plummer Creek. It receives limited freshwater runoff from drainage canals from agricultural, salt pond industrial areas, and developed upland areas of Newark.

Mud Slough
Mud Slough connects to Coyote Creek near the Island Ponds (A19, A20, and A21), and receives limited freshwater input from Laguna Creek during all seasons (Life Science! 2003, 2004).

Coyote Creek
The largest tributary in the Alviso Unit is Coyote Creek (Figure 5), which provides a substantial amount of freshwater during winter and spring, particularly during wet years. Coyote Creek drains a 322 square mile watershed, and also receives freshwater inflow from the San Jose-Santa Clara WPCP. Following major flooding in 1982, a major channel remediation project was completed for the lower seven miles of Coyote Creek, which included levee setbacks and excavation of an overflow and bypass channel to reduce flood hazards. The implemented project prevented potential damages caused by flooding during record runoff in 1997 and 1998 (PWA 2005b). The Mid Coyote Creek Flood Protection Project is currently in the planning stage, to provide flood protection for areas adjacent to Coyote Creek for the six miles stretch upstream of the remediation project.

Guadalupe River (Alviso Slough)
The Guadalupe River receives runoff from a steep upper watershed and an urbanized lower watershed, with a total area of 170 square miles. The Guadalupe River enters the Alviso Unit as Alviso Slough (Figure 5). Historically, many floods have occurred along the Guadalupe River, resulting in construction of major flood protection infrastructure consisting of channel modifications, bank stabilization, and new levees. The Lower Guadalupe River Flood Protection Project was completed between Interstate 880 and Alviso in 2004, providing 100-year flood protection along the lower river system. The Downtown Guadalupe River Project was completed in 2008 and provides 100-year flood protection benefits, improved habitat, and improved recreational opportunities along the Guadalupe River between Interstate Highway 280 and Interstate Highway 880. The Upper Guadalupe River Project begins at Interstate Highway 280, at the edge of downtown San Jose, and extends south for approximately 5.5 miles. A few reaches have been constructed, but construction is ongoing for the Upper Guadalupe River Project.

California Least Tern
USFWS

Guadalupe Slough
Guadalupe Slough drains an 85-square-mile watershed. Historically, the Guadalupe River drained through Guadalupe Slough to the Bay. The river was diverted to Alviso Slough in the early 1900s during construction of the salt ponds. Guadalupe Slough now conveys flow from San Tomas Aquino Creek, Calabazas Creek, and Sunnyvale East and West Channels and pumped flow from the storm-drainage systems of Sunnyvale. Guadalupe Slough continues to lose capacity as marsh vegetation and sediment deposits accumulate in the channel. Since 1950, flooding has occurred during several major storms. As a result, flood protection projects were constructed on San Tomas Aquino Creek and Calabazas Creek, increasing the channel capacities to the 100-year event. SCVWD is currently planning to upgrade the Sunnyvale East and West Channels to protect against the 100-year flood.

Permanente Creek (Mountain Creek Slough)
Permanente Creek watershed encompasses 28 square miles. The channel becomes Mountain View Slough as it enters the Alviso Unit. Permanente Creek has a history of recurring floods in Los Altos and Mountain View, in particular during the winters of 1955 and 1958. In response to these floods, several sections of the creek were altered, including channel lining and construction of the Permanente Diversion to Stevens Creek. The diversion currently reroutes nearly all flood flows to Stevens Creek. Low flows are intended to remain in the Permanente Creek. While Permanente Creek does not have 100-year capacity throughout the channel, work has begun on additional projects to increase channel capacity.

Stevens Creek
Stevens Creek consists of approximately 20 miles (32 km) of channel, and enters the San Francisco Estuary near Long Point, north of Moffett Field Naval Air Station, at Whisman Slough between Mountain View's Shoreline Park and Stevens Creek Shoreline Nature Study Area. It drains a watershed of approximately 29 square miles. Stevens Creek was historically one of the prime steelhead trout (*Oncorhynchus mykiss*) habitats within the county. However, there are significant barriers for this anadromous fish. In a 1994 study, the SCVWD found fish ladders at the Central Expressway and U.S. Highway 101 often had insufficient flow and/or were clogged with debris and sediment.

San Francisquito Creek
San Francisquito Creek drains a watershed area of 48 square miles entering the Bay at Faber Marsh, which is owned by the City of Palo Alto and managed by the Refuge. In normal

winters, the creek runs sluggishly in a deep gulley; in summer, it is usually dry. However, it is capable of flooding, and the risk has become more severe with increased urbanization within the watershed. During storms in 1998, the creek overtopped its banks resulting in flood damage in the cities of Palo Alto, Menlo Park, and East Palo Alto. Currently, the San Francisquito Creek Flood Damage Reduction and ecosystem Restoration Project is aiming to develop solutions to flooding of the lower creek during a 100-year event. The 100-year flow rate of the creek at its downstream end is approximately 9,500 cfs.

Ravenswood Slough
Ravenswood Slough receives limited localized runoff from the adjacent terrain. Relatively little freshwater input is discharged from the slough into the Bay (EDAW et al. 2007).

Redwood Creek
Redwood Creek drains 9.3 square miles of a largely developed watershed, almost entirely within the limits of Redwood City. The U.S. Highway 101 bridge over Redwood Creek is well above the 100-year tide and allows for unrestricted passage of high flows as they drain to the Bay. Redwood City began a major storm drain improvement and channelization project on Redwood Creek in 1967, which extended and enlarged the storm drain system, added pump stations, and lined portions of the creek channel with concrete.

Most of the flows from low-lying areas of the Redwood Creek watershed are collected by nine pump stations, eight of which discharge directly to Redwood Creek. The remaining pump station drains into a leveed storage basin between U.S. Highway 101 and Inner Bair Island, and then through a culvert to the eastern Inner Bair borrow-ditch. A limited area drains to Redwood Creek via gravity drainage (HTH and PWA 2004).

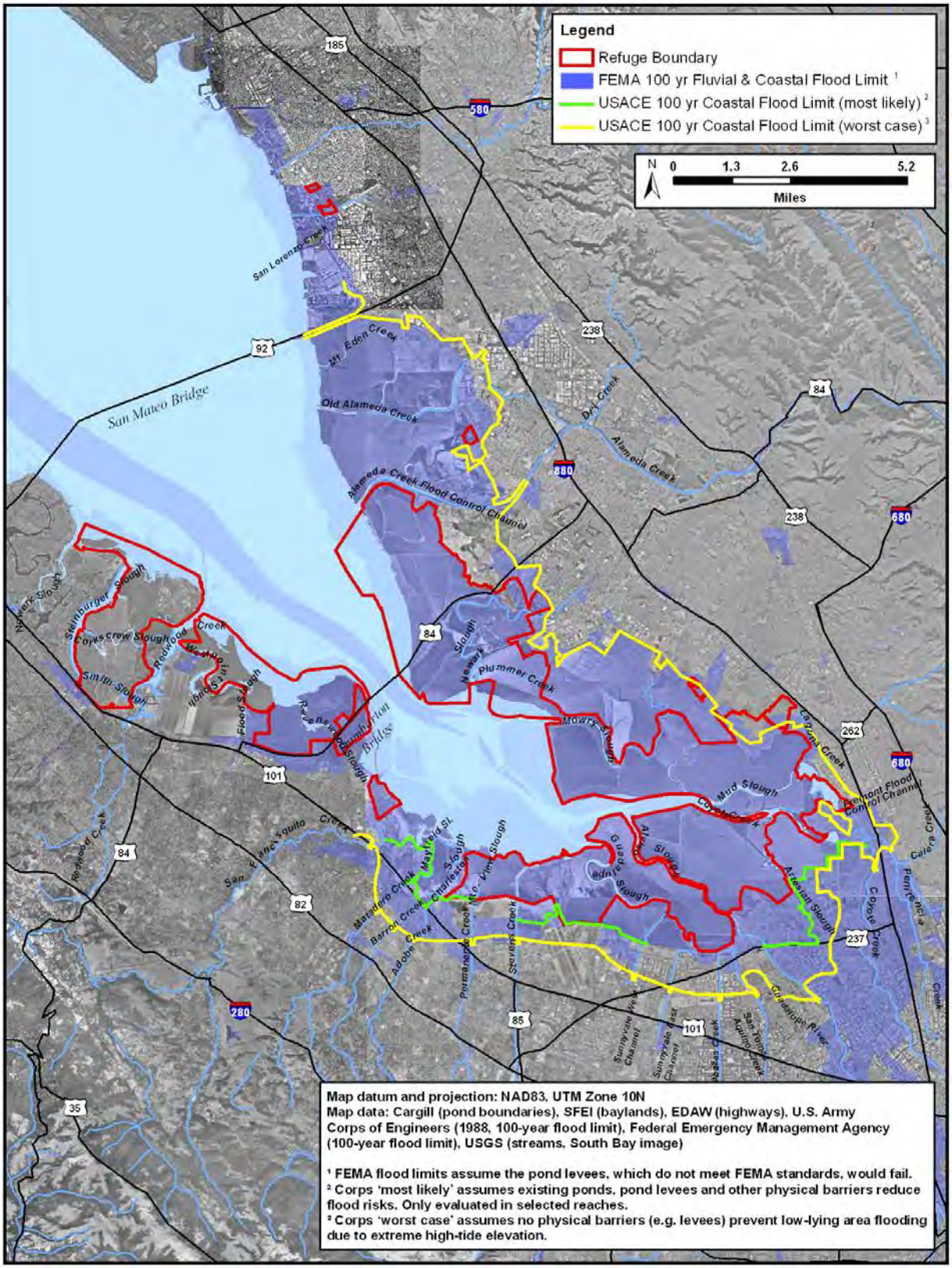
Steinberger Slough
Three main drainage areas northwest of Bair Island discharge to Steinberger Slough or directly to San Francisco Bay. Storm water runoff from San Carlos Airport is accommodated by several on-site pump stations that drain directly to Steinberger Slough. Runoff from northern San Carlos and Belmont drains to a holding pond in Phelps Slough, before being pumped into Steinberger Slough. Runoff from Redwood Shores is routed to a controlled interior lagoon, from which flows are collected by pump stations or stored until they can be released via gravity drainage at low tide to Steinberger Slough and eventually the Bay (HTH and PWA 2004).

3.3.10. Coastal Flood Risk

Much of the Refuge is within the FEMA and the Corps (Corps 1988) 100-year coastal floodplains (Figure 12). Coastal flooding in the South Bay occurs due to the combined effects of high bay water levels and wind waves, leading to erosion and/or overtopping of coastal levees. The highest bay water levels typically occur in the winter when storm surges are coincident with higher astronomical tides. Storm surge is an increase in water level caused by low barometric pressure and strong winds over shallow areas, which combine to raise water elevations along the Bayshore.

The primary climatic condition affecting San Francisco Bay flood risk is El Niño in the Pacific Ocean. The highest water levels measured by tide gauges in San Francisco Bay occurred during the 1982–83 and 1997–98 El Niño events, which resulted in flooding in many areas. A

Figure 12. Predicted 100-year Floodplain for the South San Francisco Bay Region



Map datum and projection: NAD83, UTM Zone 10N
Map data: Cargill (pond boundaries), SFEI (baylands), EDAW (highways), U.S. Army Corps of Engineers (1988, 100-year flood limit), Federal Emergency Management Agency (100-year flood limit), USGS (streams, South Bay image)

[1] FEMA flood limits assume the pond levees, which do not meet FEMA standards, would fail.
[2] Corps 'most likely' assumes existing ponds, pond levees and other physical barriers reduce flood risks. Only evaluated in selected reaches.
[3] Corps 'worst case' assumes no physical barriers (e.g. levees) prevent low-lying area flooding due to extreme high-tide elevation.

peak water level of 10.88 ft NAVD88 was measured on Coyote Creek at Alviso Slough on December 3, 1983.

South Bay Coastal Floodplains
FEMA and the Corps of Engineers have developed flood maps for the South Bay region that show a predicted 100-year floodplain (Corps 1988; FEMA 1997, 1998, 1999, 1998a, 1998b, 1999a, 1999b, 2000; EDAW et al. 2007) (Figure 12). FEMA delineation of the coastal floodplain in the South Bay assumes that the existing non-engineered pond levees provide for a reduction of wave action, but do not prevent inundation from high bay water levels. Therefore, the coastal floodplain subject to the National Flood Insurance Program (NFIP) is based on a projection of the 100-year Base Flood Elevation (BFE) onto the surrounding landscape.

The Corps (Corps 1988) report for Southern Alameda and Santa Clara County presents both a 'worst case' scenario and a 'most likely' condition in defining the 100-year coastal floodplain (Figure 12). The 'worst-case' scenario assumes that all low-lying areas which are not completely protected from tidal flooding would be flooded during extreme high tides to the elevation of the tide. This scenario ignores any factors that would decrease the extent of tidal flooding such as physical barriers between the Bay and the low-lying areas and water-volume limitations.

Great horned owl
Bill Purcell

Although most of the shoreline in the South Bay consists of levees that do not meet FEMA or Corps flood protection standards, the absence of a history of significant tidal flooding indicates that these levees do provide flood protection (Corps 1988). The Corps' 'most likely' condition, therefore, evaluated the extent of tidal flooding most likely to occur given the existence of the ponds, pond levees, high ground and other non-engineered and engineered levees. The Corps evaluated actual tides, storm surge, wind waves, physiographic conditions (e.g., water depths and fetch), levee conditions, levee overtopping, floodplain storage, and existing topography. Figure 12 shows the most likely 100-year coastal floodplain in those reaches where the Corps determined a reduced flood risk under their 'most likely' condition analysis.

The Corps is currently undertaking the Congressionally-authorized Shoreline Study, which has identified Federal funding one project for flood damage reduction, ecosystem restoration, and related purposes such as public access. The Shoreline Study area includes the Alviso area as well as shoreline and floodplain and other Refuge owned property in Santa Clara County (EDAW et al. 2007).

Newark and Mowry Units
The Newark and Mowry Units are exposed to wind wave action due to westerly and northwesterly winds crossing the Bay. Consequently, the outboard levees and exposed tidal marshes are prone to erosion. However, flood studies completed by the Corps in the 1980s found little risk of coastal flood damage in the vicinity of the Newark and Mowry Units due to the lack of adjacent development and the presumption that the levees would be maintained to facilitate salt production (Corps 1988).

Alviso Unit
The Corps (1988) study determined that tidal flooding is a hazard in the Alviso Unit due to the potential for overtopping of the outboard pond levees near Alviso Slough and lower Coyote Creek (downstream of Artesian Slough). Historic coastal flooding in the area has been limited by the existence of pond levees. During storm events in 1982 and 1983 (the latter of which included the highest tides on record), flooding occurred in northern Santa Clara County and the Alviso area. However, the relative importance of the high tides versus fluvial flows in causing the floods was not determined, as it is not known whether the peak tides during these events coincided with the peak discharges (Corps 1988). Figure 12 shows the potential 100-year floodplain extending well inland of the Alviso Unit.

West Bay Unit
Flooding in the West Bay Unit occurs when rainfall events coincide with high tides. Existing unengineered salt pond levees do not meet FEMA standards for flood protection and the entire West Bay Unit and inland areas are within the FEMA floodplain (Figure 12). The West Bay Unit was outside of the Corps (1988) study area and is therefore not included within the Corps 100-year coastal floodplains. Currently the City of San Jose does not maintain its Mosley Tract levee, which has been breached by tidal action. This breach results in high tide flooding of the Dumbarton Bridge western access road. Caltrans under the Dumbarton Bridge Retrofit Project is installing sheet piles and a pump system to resolve the flooding issue along this access road, which should be complete in 2012.

3.3.11. Surface Water and Sediment Quality

South Bay Salinity
Salinity in the South Bay is governed by the salinity in the Central Bay, exchange between the South and Central Bays, freshwater tributary inflows, and evaporation. During wet winters and early spring, freshwater from the Delta can intrude into the South Bay, creating stratified conditions in the main South Bay channel. High inflows from the local tributaries in the far South Bay can also set up stratification in the main channel. Winter and spring salinity conditions are often dynamic, characterized by unsteady flows, variable salinity, and periodic vertical stratification (Life Science! 2003). As Delta and local tributary inflows decrease in the late spring, the salinity in the South Bay gradually increases to near oceanic salinities. During summer, the largest source of freshwater to the South Bay comes from the local municipal wastewater treatment plants, and their flows are on the same order as evaporation in the

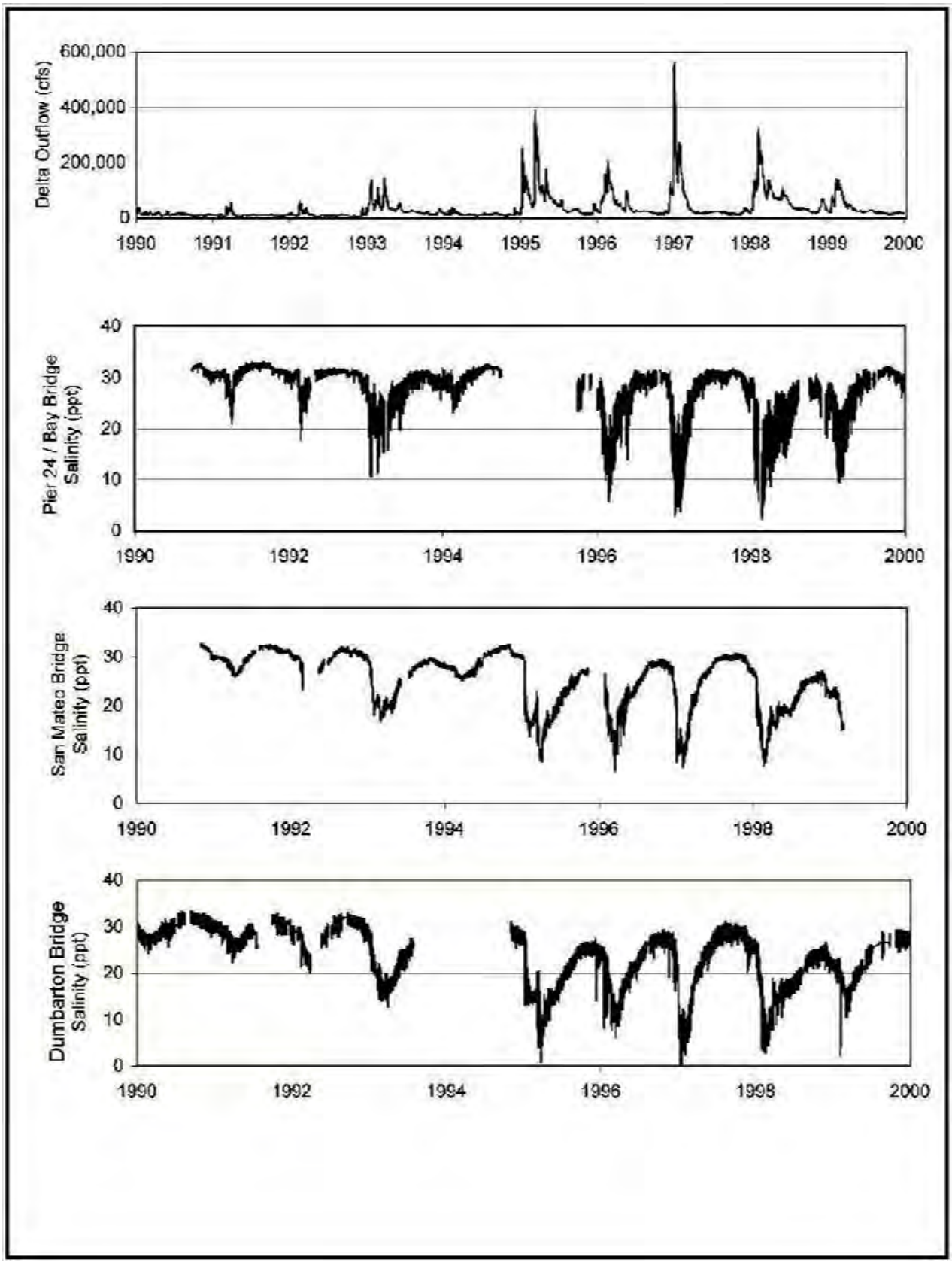
South Bay (Life Science! 2003). As a result, salinity is relatively uniform and near oceanic during summer and fall.

Figure 13 compares Delta outflow with near surface salinity at the Oakland-Bay Bridge, San Mateo Bridge, and Dumbarton Bridge over a period of ten years containing both wet years (1995 through 1998) and dry years (1990 through 1994). The data show that during dry years when Delta outflows are small, near surface salinity in the South Bay is greater than 20 ppt (parts per thousand) (average oceanic salinities are 35 ppt). However, during wet years when Delta outflow exceeds approximately 200,000 cfs, freshwater from the Delta intrudes into the South Bay, reducing surface salinities below 10 ppt.

Salinity of Former Salt Ponds

The ISP was implemented to operate and maintain the ponds during the development of the long-term restoration plan (SBSPRP). Under the ISP implementation and now under Phase 1 of the SBSPRP, the majority of the ponds operate as 'system' ponds, in which bay water is continuously circulated through a series of ponds and discharged back into the Bay at salinities that do not exceed 44 ppt in order to meet discharge salinity requirements. Other ponds are managed as either high salinity 'batch' ponds (A12, A13, and A15) or 'seasonal' (A3N, A8N, A8S, most West Bay Ponds, A22, and A23) ponds. Batch ponds are actively managed to achieve high salinities of up to 120–150 ppt in order to support food production for certain bird populations. Seasonal ponds are managed as seasonal wetlands. They receive direct precipitation and groundwater inflows during the wet season and bay water through water control structures as necessary. In the dry season, seasonal ponds are allowed to dry out due to evaporation. Salinities in the seasonal ponds fluctuate widely, with the highest salinities occurring in the dry season and the lowest salinities occurring in the wet season.

Figure 13. Delta Outflow and its Effects on Salinity Level in San Francisco Bay



Mercury
Mercury enters the South Bay in runoff from legacy mercury contamination in creek sediments accumulated from abandoned mercury mining sites in the watershed, as well as from the contemporary urban landscape. Surface sediments in the South Bay generally contain total mercury concentrations either similar to or slightly greater than the ambient mercury criteria established by the San Francisco Regional Water Quality Control Board (Brown and Caldwell 2005). The Guadalupe River/Alviso Slough system is one of the principal sources of mercury to the South Bay, capturing drainage from the New Almaden Mining District (Conaway et al. 2007). Thus, the Guadalupe River/Alviso Slough system and adjacent ponds have experienced the highest exposure to mercury of all the areas in the South Bay (SFEI 2005). In particular, Pond A8 had the highest mercury levels in biosentinels of all SBSPRP ponds studied and had higher mercury levels, in both habitats and biosentinels, than in the adjacent Alviso Slough (Grenier et al. 2010). Most of the mercury is mobilized with sediments disturbed during high flow events, thus opening former salt ponds to tidal action and increasing tidal prism in channels, such as Alviso Slough, may increase the availability of mercury to organisms in the South Bay.

However, the relationship between mercury and potential adverse ecological effects is complicated by several factors, including its ability to enter the food web. Mercury in South Bay sediments and water can be present in dissolved or particulate forms. Under appropriate conditions, such as non-tidal ponds, bacteria can convert inorganic mercury to the organic form, methylmercury, which is the form of primary concern from a human health and ecological perspective due to its greater toxicity and ability to bind with organic tissue and bioaccumulate in the food web. Therefore, although opening ponds like Pond A8 to tidal flow may increase the mobilization of mercury, the amount of methylmercury could decrease in the pond, since tidal marshes likely produce less organic matter consumed by methylating bacteria than non-tidal ponds, resulting in less methylmercury production (Grenier et al. 2010).

Ecotoxicology studies have demonstrated that bioaccumulation of methylmercury can impair reproduction of birds in the South Bay (Ackerman et al. 2007a). Waterbirds are particularly susceptible to mercury because they use wetland areas where methylation occurs. Bioaccumulation and subsequent risk to methylmercury is related to prey selection, where birds that feed at higher trophic levels are more likely to be exposed to higher concentrations of contaminants (Ackerman et al. 2007a). In particular, approximately half the population of Forster's tern (*Sterna forsteri*), a pisciverous waterbird that breeds in the Bay, is at risk due to the effects methylmercury contamination (Eagles-Smith et al. 2009). The adverse effects on reproduction include eggs that fail to hatch or are abandoned and low survivorship of hatched chicks (Eagles-Smith et al. 2009; Herring et al. 2010). However, differential habitat use within foraging guilds influences mercury concentration in birds as well. Although closely related, black-necked stilts (*Himantopus mexicanus*) were found to have mercury concentrations that were five times higher than American avocets (*Recurvirostra americana*) (Eagles-Smith et al. 2009). This is attributed to differential habitat use since avocets use more tidal habitats and stilts use more non-tidal marshes that are vegetated with pickleweed (Ackerman et al. 2007b) that are more likely to produce more methylmercury than wetlands that experience tidal flushing (Eagles-Smith et al. 2009).

Point Reyes bird's-beak
USFWS

The 2009 report of the Regional Monitoring Program for Water Quality in the San Francisco Estuary, written by the San Francisco Estuary Institute, continues to identify mercury contamination as one of the top water quality concerns in the Estuary. The report notes that waters from the Lower South Bay (where the Refuge is located) had the highest average concentration of methylmercury by far (0.12ng/L) of any part of the Estuary from 2006–2008 (SFEI 2009). The South Bay (also where the Refuge is located) has the next highest average (0.05 ng/L) (SFEI 2009). Sediments south of the Bay Bridge have also had consistently higher concentrations of methylmercury than in the northern Estuary. Long-term average concentrations have been highest in South Bay (0.75 ppb) and Lower South Bay (0.74 ppb), and lowest in Suisun Bay (0.20 ppb) and San Pablo Bay (0.28 ppb) (SFEI 2009). Long-term average total mercury concentrations in sediment generally have been highest in Lower South Bay and San Pablo Bay (both averaging 0.27 ppm) (SFEI 2009). A study of mercury in small fish also found concentrations in the Lower South Bay high compared to the rest of the Estuary (SFEI 2009). Current mercury level studies of water, sediment, and biosentinels continue as part of the SBSPRP.

Polychlorinated Biphenyls, PBDEs, Selenium, and PAHs
Polychlorinated biphenyl (PCBs) continues to be one of the greatest water quality contaminants in the Estuary because they bioaccumulate in some Bay fish and pose health risks to consumers of those fish as well as fish themselves. Average PCB concentrations in Bay sediment measured from 2004–2008 were highest in the southern reach of the Estuary: Lower South Bay (8.6 ppb), South Bay (7.9 ppb), and Central Bay (8.0 ppb) (SFEI 2009). A pilot study in 2007 conducted under the Regional Monitoring Program found high concentrations of PCBs in small fish (e.g., topsmelt [*Atherinops affinus*]). PBDEs, a class of bromine-containing flame retardants have increased rapidly in the Estuary through the 1990s and are now a pollutant of concern. While PBDE concentrations in the Estuary waters are highest in Suisun Bay, long-term average concentrations of BDE 47 (one of the most abundant types of PBDE) in sediment from 2004–2008 were highest in Lower South Bay (0.75 ppb).

Selenium concentrations are also a continuing concern in the Estuary. Selenium accumulates in diving ducks and poses a potential health risk to human consumers as well as wildlife. Recent studies also suggest that selenium concentrations may be high enough to cause deformities, growth impairment, and mortality in early life-stages of Sacramento splittail and white sturgeon (SFEI 2009). While selenium concentrations in water (from 2002–2008) are well below the water quality objective established by the California Toxics Rule (5 μg/L),

Lower South Bay had a higher average concentration of 0.25 μg/L from 2002–2008 compared to other parts of the Bay (where averages were between 0.12 and 0.13 μg/L) (SFEI 2009).

Polycyclic aromatic hydrocarbons (PAHs) are included on the 303(d) List for several Bay locations. Sourced from deposition of combustion products from air directly into the Bay and from air to roadway stormwater runoff into the Bay, concentrations in sediment are highest along the southwestern shoreline of the Central Bay from 2002–2008 (SFEI 2009). South Bay had the next highest average concentration (2.2 ppm), followed by the southern end of the South Bay (1.7 ppm).

3.3.12. Groundwater Hydrology and Salinity

South Bay Aquifer
The Quaternary sediments of the South Bay comprise unconsolidated layers of gravel, sand, silt, and clay. The clays are relatively impervious to water; whereas the sand and gravel layers store and transmit water, forming important groundwater aquifers. Groundwater and surface water are often hydraulically connected to some degree. Surface water may infiltrate and become groundwater, or groundwater may discharge to the surface and become surface water. Groundwater levels in the South Bay fluctuate seasonally with no apparent tidal influence (Brown and Caldwell 2005).

Salt Water Intrusion
Under natural conditions, precipitation infiltrates the alluvial deposits, and groundwater in the South Bay flows toward discharge areas at the Bay. When these natural conditions are altered, salt water intrusion may occur. Salt water intrusion was a significant problem in the South Bay in the early to mid-20th century. Over-pumping of groundwater in some local areas caused a drop in the groundwater table, creating a reversal of gradient that caused salt water to flow inland. Areas within the South Bay that had significant salt water intrusion problems include the Niles Cone area to the east of the Dumbarton Bridge, and in San Mateo to the north of the San Mateo Bridge.

In recent years, groundwater pumping in the area has significantly decreased. As a result, groundwater levels in the region have recovered, which has halted local salt water intrusion problems. While a zone of salt water intrusion can still be found in the South Bay, the zone appears to be stable and is not migrating further inland. Groundwater in the South Bay currently flows toward the Bay, and if this continues, salt water intrusion should not be as significant a problem as it has been in the past.

Flooding due to Groundwater
In addition to fluvial and coastal flooding, the frequency, depth, and duration of the tides adjacent to flood protection levees may result in high groundwater elevations. Seepage through and underneath the levees may increase the groundwater table. This form of flooding is of particular concern in topographically low-lying areas where ponded surface water is a flood hazard.

3.3.13. Air Quality

The Refuge is located within the southern portion of the San Francisco Bay Area Air Basin (SFBAAB). The SFBAAB encompasses seven Bay Area counties: Contra Costa, Marin,

Napa, San Francisco, Alameda, Santa Clara, and San Mateo and portions of Sonoma and Solano counties. Ambient (outdoor) air quality within the SFBAAB is dictated by the amount of pollutant emissions and the extent to which the atmospheric conditions transport or dilute these emissions. The ability of the atmosphere to transport and dilute emissions is affected by such natural factors as topography, wind, atmospheric stability, and amount of sunlight.

A Mediterranean climate in the SFBAAB provides mild winters and summers, with temperatures moderated by the nearby Pacific Ocean. The area is bounded by coastal mountain ranges (the Coast Ranges to the north, Diablo Range to the east and south) and the Pacific Ocean to the west. Within the bounded area are inland valleys and the San Francisco Bay. A high-pressure system over the Pacific Ocean as well as variation in circulation patterns from seasonal temperature changes determines local wind speed and direction. These winds (or lack thereof) help determine local air quality as they can carry pollutants away from or allow them to concentrate in an area.

A meteorological effect known as inversion can also change pollutant concentrations. Air temperature normally decreases as altitude increases; however, if colder air becomes trapped beneath warmer air an inversion forms, restricting the air masses' ability to mix. This affects air dispersion and can allow pollutants to concentrate. These inversions often form in the Refuge area during summer mornings and afternoons as well as during winter nights and mornings.

Air quality at a given location is determined by the concentrations of pollutants in the atmosphere. These measurements are given in units of parts per million (ppm) or micrograms per cubic meter (µg/m3). Air pollution is associated with a number of detrimental health effects, and to help reduce these effects, the Environmental Protection Agency (EPA), California Air Resources Board (CARB), and Bay Area Air Quality Management District (BAAQMD) have set ambient air quality standards. These regulations apply to short-term construction, long-term regional (operational), local mobile source, odor, and toxic air contaminant emissions.

The Federal Clean Air Act (42 U.S.C. §§ 7401-7671q) defines the responsibility of the EPA to set National Ambient Air Quality Standards (AAQS). States are allowed to enact their own standards, although they cannot be weaker than national standards. The California Clean Air Act also sets State AAQS, which specify the concentration of pollutants the public can be exposed to. The standards are set to protect the people most sensitive to air pollution, such as children and the elderly.

The responsibility of carrying out air pollution control programs associated with the AAQS in California is divided between three organizations: the EPA, CARB, and BAAQMD. CARB sets the California AAQS and shares the regulation of mobile sources with EPA. It also sets emission reduction standards for gasoline and emission standards for motor vehicles sold in California. BAAQMD generally regulates stationary sources of air pollution, as well as measures ambient air quality conditions throughout the SFBAAB at over 20 different monitoring stations. The nearest monitoring stations to the Refuge are located in Redwood City, Sunnyvale, Fremont, Hayward, and San Leandro.

National standards have been established for sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), particulate matter equal to or less than 10 microns in size (PM10), fine particulate matter equal to or less than 2.5 microns in size (PM2.5), and lead (Pb).

California AAQS set parameters for certain pollutants, such as particulate matter and ozone, which provide stricter standards to protect health than corresponding national standards. California also set standards for some pollutants that are not addressed by Federal standards, including sulfates (SO4), hydrogen sulfide (H2S), and visibility reducing particles.

For each pollutant, areas are either classified "attainment" or "nonattainment" based on a comparison with national and State AAQS. Compliance with these standards means an area is designated an attainment area, noncompliance means it is designated as a nonattainment area. The SFBAAB is currently designated by the State of California and the EPA as a nonattainment area for ozone. It is also designated by the EPA as a nonattainment area for 24-hour fine (PM2.5) particulate matter and designated by the State of California as a nonattainment area for both fine and respirable (PM10) particulate matter.

Avocet parents and newly hatched chicks
Judy Irving © Pelican Media

Ozone is a respiratory irritant that increases susceptibility to respiratory infections and an oxidant that can cause substantial damage to vegetation and synthetic rubber. While it does serve a beneficial purpose in the upper atmosphere by reducing incoming ultraviolet radiation, its harmful effects occur when high concentrations occur in the lower atmosphere. Ozone itself is not emitted, but rather ozone precursors, including nitrogen oxides (NOX) and reactive organic gases (ROG). These precursors undergo a photochemical reaction in the atmosphere when exposed to sunlight to create ozone, especially during the summer months when amounts of sunlight increase. Mobile and stationary combustion equipment is the greatest emitter of ozone precursors. Particulate matter (fine and respirable), as well as chemicals attached to the particulate matter, is linked to respiratory problems and other adverse health effects. It may also damage vegetation, reduce visibility, and corrode materials. These particles are released from agricultural activities, industrial emissions, dust from vehicle traffic, wood burning, diesel fuel, and secondary aerosols formed by reactions in the atmosphere.

In order to reduce ozone levels and comply with the California Clean Air Act, the BAAQMD along with the Metropolitan Transportation Commission and Association of Bay Area Governments prepared and adopted the 2005 Ozone Strategy. This comprehensive document describes the strategy being implemented to meet State one-hour ozone standards and reduce

overall air pollution emissions. The strategy includes regulations for stationary sources, incentive programs for mobile sources, and transportation control measures being implemented in cooperation with other local agencies.

The adopted *BAAQMD CEQA Guidelines* (2011) provides procedures for evaluating possible air quality impacts for proposed projects and plans consistent with CEQA requirements. BAAQMD also released *Adopted Air Quality CEQA Thresholds of Significance* (June 2010), which includes updated thresholds for criteria air pollutants and toxic air contaminants (TACs).

3.4. Biological Resources

The following text gives an overview of the historical activities that have influenced habitats in the Bay and puts the Refuge into a regional context. The text also describes the predominant habitat types that are found within the Refuge as well as the approved acquisition boundary, and discusses the various organisms that are supported by each habitat type.

3.4.1. Historical and Regional Context

Overview of Historical Habitat Changes in the Bay
The Refuge encompasses a variety of habitat types that have been developed and altered by a diverse land use history, its hydrologic placement within the landscape, and its range of abiotic soil variables. Habitat types present within the Refuge historically consisted of riparian fluvial drainages that contributed to freshwater, brackish, and salt marsh habitat. These habitat types have been converted over time to more developed habitat types, from vast areas of urbanized land and drainages lined with concrete culverts to diked salt ponds, managed ponds, agricultural areas, and diked marshes surrounded by extensive levee systems.

The assessment of habitats that historically occurred along the South Bay provides a context in which to examine the existing conditions of the South San Francisco Bay. Historical ecological communities of the South Bay are described in detail in the South Bay Salt Ponds Biology and Habitats Existing Conditions Report (H.T. Harvey & Associates et al. 2005), in Collins and Grossinger (2004), and in Grossinger et al. (2006). Historically, the margins of the San Francisco Bay were surrounded by a mosaic of wetland habitat types dominated by tidal salt marsh with large expanses of transitional upland habitats, internal marsh ponds, salt pannes, sinuous channel networks, beaches, lagoons, and sausals (willow grove) (Collins and Grossinger 2004; Figure 9).

Collins and Grossinger (2004) describe three major historical South Bay landscapes: saline tidal marsh, riparian tidal marsh, and salt pond. Grasslands with vernal pools also historically occurred in the South Bay particularly in the Warm Springs Areas (Goals Project 1999). The South Bay saline tidal marsh landscape once consisted of marshlands with high channel density, abundant marsh pannes and salinas (area encrusted with salt) , moist grasslands along the backshore, large sausals, and extensive tidal flats. The South Bay riparian tidal marsh landscape existed along a salinity gradient from fresh to saline or brackish waters, influenced by perennial creeks such as Coyote Creek and the Guadalupe River. These riparian tidal marsh areas had large marsh pannes instead of a dense network of channels in the vicinity of major freshwater sources. The current South Bay salt pond landscape was formerly comprised of tidal marshlands, including natural or semi-natural salt ponds. Native

Americans developed these early ponds from salinas and marsh pannes by using low berms and weirs to control the length of time that water was ponded within them. Tidal marsh and salt pond habitats were historically roughly equally distributed in the South Bay, with minimal tidal channel network development within them. Small salinas and marsh panne habitats were located adjacent to these salt ponds, with moist grassland habitat occurring along the backshore, transitioning to true upland habitat types. Saltgrass-alkali meadow habitat existed in the complex transition zone between the tidal marsh and the wet meadows of the bottomlands of the South Bay. Unusually high concentrations of salt in the soils that originated within the floodplains of creeks and rivers near the Bay created favorable conditions for uniquely adapted plant communities. These plant communities shared characteristics of high tidal marsh, alkali flats, and vernal pool habitat types (Grossinger et al. 2006).

The majority of these historical communities have been greatly reduced in size due primarily to land use changes in the South Bay related to the conversion of marshes to other habitats through the construction of levees, the addition of fill material, and the construction of intricate drainage systems. These initial impacts to the South Bay's natural habitat types allowed for extensive residential development, agricultural use, salt production, and further flood protection construction. South Bay marshes were further significantly modified via diking to retain and concentrate bay water for salt production. Beginning in the mid- to late-1800s through the 1940s, levee construction led to the direct loss of tens of thousands of acres of tidal marsh in the South Bay (Collins and Grossinger 2004). Apart from these direct impacts, this construction led to dramatic changes in the physical processes influencing marsh development. By diking off these large expanses of marsh habitat, the tidal prism (volume of water that moves in and out of an area during a tidal cycle) was drastically reduced. The decrease in tidal prism are still being observed in the South Bay, particularly in the Alviso pond complex (H.T. Harvey & Associates 2007a).

Regional Context

The San Francisco Estuary is a productive, diverse ecosystem. Despite the loss of more than 90 percent of historic tidal wetlands in the Bay Area to diking, draining, and filling (Goals Project 1999), wildlife diversity is high, with more than 250 species of birds, 120 species of fish, 81 species of mammals, 30 species of reptiles, and 14 species of amphibians regularly occurring in the estuary (Siegel and Bachand 2002). More importantly, the San Francisco Bay supports populations of a number of species of regional, hemispheric, or even global importance. Numerous endemic, endangered, threatened, and rare wildlife species or subspecies reside in the San Francisco Bay Area. The Estuary also supports a wide variety of subtidal, tidal marsh, and upland ecotone plant species, including several special status species.

The Refuge is located in South San Francisco Bay (South Bay), which is a vital component of the larger San Francisco estuary. The South Bay is typically used to refer to the portion of the San Francisco Bay south of Coyote Point on the western shore of the Bay and San Leandro Marina on the eastern shore of the Bay (Goals Project 1999). The South Bay supports some of the most important habitat remaining in the entire Bay Area for a number of plant and wildlife species, in spite of the surrounding areas being highly urbanized and the Bay itself having been dramatically altered by the diking and filling of wetlands for salt production and urban development (Goals Project 1999).

The Refuge is bordered by the open waters of the South San Francisco Bay and by urban development on all other sides. Figure 14 and Figure 15 provide an overview of the predominant habitat categories within the Refuge and within the approved acquisition boundary, respectively. The majority of lands in the Refuge are managed ponds, followed by tidal wetlands, subtidal and mudflat (bay), grasslands, and developed. A more detailed analysis of habitats within the Refuge is provided in Table 6 and Table 7, and is described in Section 3.4.3.

Figure 14. Distribution of Habitat Categories within the Service-Owned and Managed Lands

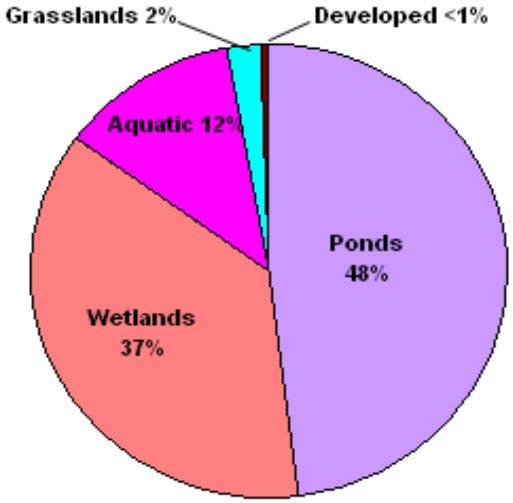
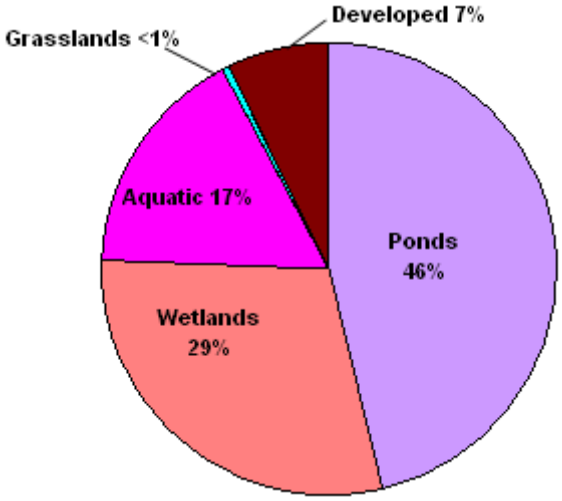


Figure 15. Distribution of Habitat Categories within the Approved Acquisition Boundary



Not all the ponds within the refuge boundary are entirely owned or managed by the Refuge. Through an agreement Cargill Salt continues their salt making rights on several ponds owned by the Refuge (notably in the Newark Unit).

Table 6. Habitat Types within the Refuge (estimated acreages)

Habitat Type		Acreage	Percentage
Ponds	Active Salt Ponds	7661	
	Managed Ponds	243	
	Water/Sewage Treatment	<1	
	Related Projects (Ponds)	5	
	Salt Ponds to be Restored	6605	
	Sub-Total	**14,514**	**48%**
Wetlands	Tidal Wetland	6340	
	Planned or On-Going Tidal Restoration	2713	
	Muted Tidal/Diked Marsh	2158	
	Fresh Water Marsh	0	
	Sub-Total	**11,211**	**37%**
Aquatic	Subtidal	173	
	Mudflat	3459	
	Sub-Total	**3632**	**12%**
Grasslands	Vernal Pools/Grassland	674	
	Upland/Grassland	40	
	Sub-Total	**715**	**2%**
Developed	Agricultural	0	
	Urban Development	159	
	Sub-Total	**159**	**<1%**
Total		**30,231**	**100%**

Table 7. Habitat Types within the Approved Acquisition Boundary

Habitat Type		Acreage	Percentage
Ponds	Active Salt Ponds	3679	
	Managed Ponds	447	
	Water/Sewage Treatment	24	
	Related Projects (Ponds)	1414	
	Salt Ponds to be Restored	4041	
	Sub-Total	**9,605**	**46%**
Wetlands	Tidal Wetland	1875	
	Planned or On-Going Tidal Restoration	1666	
	Muted Tidal/Diked Marsh	2041	
	Fresh Water Marsh	562	
	Sub-Total	**6144**	**29%**
Aquatic	Subtidal	630	
	Mudflat	2856	
	Sub-Total	**3486**	**17%**
Grasslands	Vernal Pools/Grassland	<1	
	Upland/Grassland	164	
	Sub-Total	**165**	**<1%**

Developed	Agricultural	876	
	Urban Development	604	
	Sub-Total	**1480**	**7%**
Total		**20,881**	**100%**

3.4.2. Summary of Habitat Categories within the Refuge

The following text summarizes the predominant habitat types present within the Refuge. Fifteen habitat types within five broad-scale habitats were used to map existing conditions within the Refuge (Table 6). These habitat categories include:

1) pond habitats (active salt ponds, managed ponds, related projects [ponds], salt ponds to be restored),
2) vegetated wetland habitats (tidal wetland, planned or on-going tidal restoration, muted tidal/diked marsh, fresh water marsh),
3) subtidal and mudflat aquatic habitats,
4) grassland habitats (vernal pools within grassland habitat and upland/grassland habitat), and
5) developed habitats (agricultural and urban development).

Each of these habitat categories is briefly described below. Locations and estimated acreage of each habitat category, as well as habitat types within each habitat category, are depicted within each Refuge unit (Alviso, Mowry, Newark, and West Bay) in Figure 16.

The broad-scale mapping found in Figure 16 provides the context for the future management of the Refuge; however, it is important to note that small inclusions of different habitat types are present within these mapping categories, but do not change the overall makeup or use of the habitat as described. In particular, upland transitional habitat (largely on narrow levee slopes) is not depicted due to the scale of the mapping and, thus, would appear only on fine-scale maps of specific areas of the Refuge. However, these upland transitional habitats are of particular importance to certain plant species as well as to wildlife resources, especially during high tide events.

Pond Habitats. Pond habitats encompass more than half of the total area within the Refuge (14,514 acres; 48 percent) (Figure 14). Many of these ponds are slowly being restored to tidal influence and/or manage for wildlife, especially migratory birds. Generally, ponds in the South Bay are characterized by expanses of non-tidal open water, bare mud, or bare salt flats surrounded by mostly bare levees. Several algae types are present in the ponds, including macroscopic green algae (particularly *Rhizoclonium* spp. and *Enteromorpha* spp.), unicellular algae (e.g., *Stichococcus bacilaris*), and microscopic algae and diatoms (EDAW et al. 2007). Occasionally, wigeon grass (*Ruppia maritima*) is also present. Vegetation is sparse and, where it does occur, it is limited primarily to the levees that surround the ponds. Active salt ponds are located in the Mowry (approximately 7,661 acres) and Newark Units (approximately 4,000 acres). Most of the ponds in the Refuge (14,015 acres) are part of the SBSPRP. These ponds are found in the Alviso and West Bay Units within the Refuge (Figure 16).

Vegetated Wetland Habitats. Total wetland habitat inside the Refuge includes 11,211 acres (37 percent), over one-quarter of the total area in the Refuge (Table 6). Generally, these are

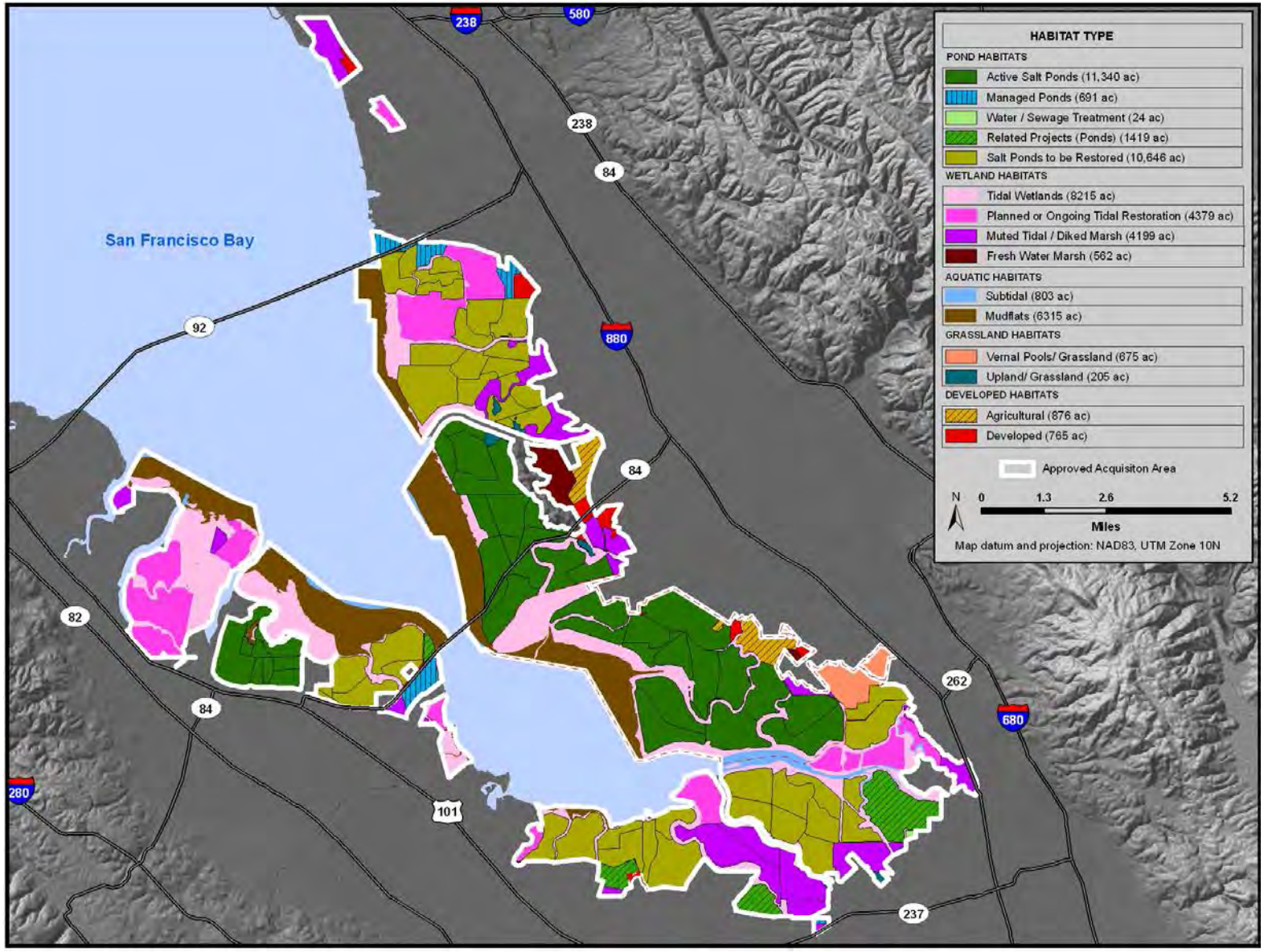
lowland areas that are periodically or regularly flooded and have wetland-dependent vegetation.

Tidal wetland habitat accounts for the greatest acreage of vegetated habitat adjacent to the pond habitat described above, occupying 6,340 acres within the Refuge and found in all the units (Table 6). For the purposes of this document, tidal vegetated wetland habitat includes salt marsh, brackish marsh, and freshwater marsh habitats. Planned or ongoing tidal restoration (2,713 acres) habitats are formerly disturbed marshes including former salt ponds that are actively undergoing tidal restoration or restoration planning that will be restored to salt and/or brackish marsh habitat. Approximately half of this acreage is at Bair Island (USFWS and CDFG 2006) in the West Bay Unit (Figure 16).

Salt marsh habitat occurs primarily along the outboard (tidal) side of existing levees separating the ponds from the Bay. The salt marsh habitat in the South Bay consists primarily of low and middle marsh and is dominated by perennial pickleweed (*Sarcocornia pacifica*, formerly *Salicornia virginica*) and cordgrass. There are two species of cordgrass in the South Bay, the native Pacific cordgrass (*Spartina foliosa*) that grows predominantly in the middle marsh, and smooth cordgrass (*S. alterniflora*), a non-native species from the east coast of North America that can grow farther down into the low marsh and mudflats. Smooth cordgrass can easily hybridize with the native cordgrass, causing widespread distribution of the hybridized species within a short amount of time. Smooth cordgrass and its hybrids are one of the dominant invasive plant species found in the tidal marshes south of the San Francisco Bay Bridge. A multi-agency effort under the Invasive *Spartina* Project is underway to eliminate *S. alternaflora* and its hybrids. A mixture of perennial pickleweed, gumplant (*Grindelia stricta*), saltgrass (*Distichlis spicata*), alkali heath (*Frankenia salina*), sea lavender (*Limonium californicum*), and other moderately halophytic species that can tolerate occasional high tides dominate the high marsh.

Brackish marsh habitat typically occurs in the low-to-mid intertidal reaches of sloughs and creeks draining into the Bay where vegetation is subject to tidal inundation diluted by freshwater flows from upstream. As such, the average soil-water salinity of tidal brackish marsh is lower than in salt marshes, ranging from 15 to 20 parts per thousand in the South Bay (H. T. Harvey & Associates 2002b). Water-surface elevation can vary by as much as 10 feet depending on daily tidal activity and seasonal freshwater flows from upstream. The vegetation in brackish marsh habitat is dominated by emergent, vascular plant species adapted to intermediate (brackish) soil water salinities and supports brackish marsh species including short bulrushes such as alkali bulrush (*Scirpus robustus*) and saltmarsh bulrush (*Scirpus maritimus*). These species dominate lower to mid brackish marsh habitat where sediment deposits have formed terraced floodplains between the low-flow channels and levees. Pepperweed (*Lepidium latifolium*) has rapidly become one of the dominant invasive species in this habitat.

Figure 16. Habitat Map of Lands Within the Approved Acquisition Boundary



The construction of levees and installation of water control structures throughout the South Bay has converted some salt marsh and brackish marsh habitat to muted tidal/diked marsh habitat. Muted tidal/diked marsh habitat occupies approximately 2,158 acres within the Refuge, including New Chicago Marsh in the Alviso Unit and several marshes in the Mowry and West Bay Units adjacent to active and former salt ponds (Figure 16). Muted tidal/diked marshes have limited tidal exchange due to the presence of levees around the perimeter of bay waters/salt ponds. Water exchange is limited, so that the range in water level in the muted tidal marsh is small (usually a few inches) compared to the range of tidal change in other marsh areas (several feet). Muted tidal marshes exhibit many of the same features as fully tidal marshes, but they often have lower plant diversity and more invasive plant species due to the limited range in tidal action.

Subtidal and Mudflat Aquatic Habitats. Total aquatic habitat inside the Refuge includes 3,632 acres, or around 12 percent of the total area (Table 6). This habitat classification includes subtidal (173 acres) and mudflat (3,459 acres) habitat, both of which have substrates that are either permanently flooded or mostly submerged by tidal water. Subtidal habitat refers to those areas of open water permanently below low tide. Within the Refuge, there are only a few areas of subtidal habitat, in the West Bay, Alviso, and Newark Units. These areas consist of open water areas on the Bay-side of Refuge property or within tidal channels. Eelgrass (*Zostera pacifica*), an important submerged plant species, has the potential to occur in areas containing subtidal habitat.

Mudflat habitat found in the Refuge primarily occurs in the West Bay, Newark, and Mowry units (Figure 16). These habitats are largely on the bayside of the Newark and West Bay Units. Narrow mudflats occur along the edges of the tidal sloughs and channels and on the outboard side of some pond levees, while much more extensive flats are present at the mouths of the major sloughs and along the edge of the Bay. Mudflat habitat occurs in intertidal areas from below MLLW to Mean Tide Level (MTL) just beyond the edge of wetlands along the Bay and between the low-flow channel and edge of wetlands within the tidal reaches of slough and creek channels that drain to the Bay. These flats are generally covered by shallow water during high tide, but are uncovered at low tide. Mudflats are dynamic depositional features, changing in extent and location depending on the nature of erosion and deposition of sediments. This habitat typically supports less than 10 percent cover of vascular emergent vegetation, typically in the form of cordgrass (*Spartina* spp.) and annual pickleweed (*Salicornia europaea*) that is too sparse to map as distinct salt marsh habitat. The mudflat substrate comprises primarily fine-grained silts and clays that support an extensive community of diatoms, worms, shellfish, and algal flora as well as serve as feeding grounds for hundreds of thousands of shorebirds.

Grassland Habitats. Grassland habitat within the Refuge includes 715 acres, or approximately 2 percent, of the entire area (Table 6). This habitat category consists of those areas dominated by vernal pool, grassland, or other upland vegetation.

Vernal pools are seasonally flooded depressions that occur on ancient soils that thinly cover an impermeable substrate of hardpan, clay, or bedrock above the tideline. The impermeable substrate causes the vernal pools to retain rainwater and local runoff seasonally, drying as evaporation drains their shallow topography. Because vernal pools are essentially temporary wetlands, they undergo distinct vegetative phases: aquatic, flowering, and drought. During

the aquatic phase of the vernal pool habitat, algae and other vernal pool plant species may flourish. After the winter rainstorms have ended, the pools will begin to dry and annual vernal pool plant species will flower, producing colorful blooms around the shrinking pool of water. During the summer and fall drought phase, vernal pools remain dry and annual plants have dessicated, resulting in pools that contain bare earth, dried hydrophytes (i.e., water-loving plants), and residual algal matting. The vast majority of this habitat type has been lost regionally, and the few remaining areas are in decline due to invasion by non-native plant species, development, and agricultural disturbance.

Areas mapped as vernal pool/grassland habitat (674 acres) consists of vernal pools that are surrounded by grassland habitat. Vernal pool habitat is located in the Warm Springs area of the Mowry Unit of the Refuge (Figure 16). The vernal pool complex is adjacent to the backshore of historical tidal marshlands located near Warm Springs and consists mostly of small, distinct depressions among more diffuse swales. These vernal pools provide habitat for Contra Costa goldfields (*Lasthenia conjugens*), which are Federally endangered. In 2008, 425 acres of restored vernal pools formerly known as the Pacific Commons Preserve were donated to the Service (and incorporated into the existing Warm Springs sub-unit) as mitigation for adjacent development. Upland grassland habitat containing vernal pool habitat is located landward from the ponds, between the ponds and urbanized areas.

Upland/grassland habitat (40 acres) is found primarily in the Newark Unit of the Refuge (Table 6) and mainly consists of assemblages of annual, non-native plants that thrive in disturbed areas (ruderal species). The predominant upland species surrounding ponds in this area include Italian ryegrass (*Lolium multiflorum*), ripgut brome (*Bromus diandrus*), soft chess (*Bromus hordeaceous*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*), wild oats (*Avena fatua*), black mustard (*Brassica nigra*), Italian thistle (*Carduus pynocephalus*), common sow thistle (*Sonchus oleraceus*), bull thistle (*Cirsium vulgare*), bristly ox-tongue (*Picris echioides*), brass buttons (*Cotula coronopifolia*), alkali heath, salt grass, and coyote brush (*Baccharis pilularis*). There are only a few areas in the entire South Bay that contain upland grassland habitat adjacent to marsh habitat; these are primarily located within the Refuge at the Complex headquarters office, adjacent to the EEC in Alviso (on an old landfill), Mayhews Landing, and the Warm Springs sub-unit of the Refuge. These upland transition zones represent an important habitat type largely absent from the South Bay.

Developed Habitats. Approximately 159 acres of developed areas are found within the Refuge, or almost 1 percent of the entire Refuge area (Table 6 and Figure 14). Developed areas are found in small parcels of all four Refuge Units and include parking areas, building complexes, and roadways. Such areas are typically maintained free of vegetation, but may occasionally support isolated ruderal upland /grassland vegetation including wild oats, Italian thistle, coyote brush, and other ruderal species. There are no agricultural areas within the Refuge.

3.4.3. Summary of Habitat Categories within the Approved Acquisition Boundary (not managed by the Refuge)

Pond Habitats. Pond habitats account for approximately half of the acreage within the approved acquisition boundary (9,605 acres; 46 percent) (Figure 15). Approximately half of the pond habitats in this boundary are former salt ponds (4,041 acres) located in the Newark area. These ponds are part of the ELER and are managed by CDFG for wildlife habitat as part of the SBSPRP. Active salt ponds (3,679 acres) are located in Fremont and Redwood City and are still managed for salt production (by Cargill Salt). Habitat mapped as related project ponds (1,414 acres) are former salt ponds primarily in the Alviso area (e.g., Ponds A4 and A18), but are not part of the SBSPRP. These ponds were taken out of salt pond production and transferred to public entities (e.g., City of San Jose). Owners of these related project ponds are currently considering future management of these ponds, which may include, but are not limited to, tidal restoration, managed pond, and diked or muted tidal wetland.

The majority of the managed ponds (447 acres) in the approved acquisition boundary are located in Eden Landing and they are managed according to the salinity and hydrologic circulation regimes outlined in the ISP (Life Science! 2004). The remainder of the pond habitats consist of 24 acres of water/sewage treatment ponds, primarily located in Alviso and is found at the San Jose/Santa Clara WPCP (Table 7). Water/sewage treatment ponds are characterized by open fresh water with no emergent wetland vegetation.

La Riviere Marsh in the foreground
USFWS

Vegetated Wetland Habitats. Muted tidal/diked marsh habitats make up the majority (2,041 acres) of all the vegetated wetland habitats (6,144 acres) in the approved acquisition boundary. Tidal wetlands (1,875 acres) also occur in the approved acquisition boundary, and similar to the tidal wetlands in the Refuge, they occur primarily along the outboard side of existing levees. There are approximately 1,666 acres of planned or ongoing tidal restoration projects south of the San Mateo Bridge (State Route 92) within the approved acquisition boundary, including a large tidal restoration in the ELER.

Freshwater marsh habitat (562 acres) also occurs in the approved acquisition boundary, primarily in Newark within the Demonstration Urban Stormwater Treatment (D.U.S.T.) Marsh located within the Coyote Hills Regional Park (Figure 16). Freshwater marsh habitat

typically occurs in the upper reaches of sloughs and creeks draining into the Bay, located outside of the Refuge. The water-surface elevation within reaches of freshwater marsh habitat may also vary by as much as 10 feet depending on daily tidal activity and seasonal, freshwater flows from upstream habitats. Broad-leaf cattail (*Typha latifolia*) and taller bulrushes, including California bulrush (*Scirpus californicus*) and hard-stem bulrush (Scirpus *acutus* var. *occidentalis*), typically dominate the freshwater marsh habitat. Due to regular inundation, these species often form dense stands. Patches of the invasive perennial pepperweed and thickets of native California blackberry (*Rubus ursinus*) and other ruderal species also occur within and adjacent to brackish and freshwater marsh habitat.

Subtidal and Mudflat Aquatic Habitats. Within the approved acquisition boundary, large expanses of accreting mudflat occurs adjacent to Calaveras Point and the mouth of Mountain View Slough in the Alviso and Fremont areas, while large expanses of existing mudflat are also in Newark and on the west shoreline of the South Bay. This habitat comprises the majority of aquatic habitat in the approved acquisition boundary (2,856 acres). Most of the subtidal regions (630 acres) occur in Coyote Creek, in the Alviso and Fremont areas.

Grassland Habitats. Vernal pool/grassland habitats (440 acres) in the approved acquisition boundary are located in Fremont (Area 4), northwest of the Warm Springs sub-unit within the approved acquisition boundary. There is also approximately 430 acres of upland/grassland habitat in the approved acquisition boundary are located in Newark (Patterson Ranch).

Developed Habitats. Approximately 1,480 acres of urban development is found within the approved acquisition boundary (Table 7), and includes parking areas, building complexes, and roadways. Some larger developed parcels are located on the edge of urbanized areas within Newark and Fremont. Two large parcels containing agricultural lands (876 acres total) also occur within these areas.

3.4.4. Plants

Overview of Plant Resources

A comprehensive inventory of all plant species that occur within the Refuge has not been completed. However, directed searches within accessible habitat are periodically conducted, especially within the Warm Springs sub-unit in Fremont within the Mowry Unit of the Refuge (see Appendix D for a current list of native plant species). Historically, special-status plant species were neither common nor widely distributed within the upper zones of the tidal salt marsh and brackish marshes of the San Francisco Bay. However, those special-status species with broad soil tolerances were, and are today, locally common. For example, marsh gumplant is limited to the upper marsh zone of the Bay, but tolerates disturbed fill soils; it is abundant within South Bay marshes and was recently removed from the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants (2008). Similarly, Congdon's tarplant (*Centromadia parryi* ssp. *congdonii*), while limited in distribution, is associated with alkaline upper marsh habitats as well as with low-lying alkaline soils; large stands of this plant occur well east of the San Francisco Bay.

Conversely, plants with highly restrictive growth requirements, such as for coarse substrates on high-energy shorelines, salt panne edges, or channel edges within tidal brackish marsh, are now extremely rare in the urban estuary of the Bay due to the limited acreage and distribution

of these habitat types within the area. CNDDB (2008) lists four sensitive habitat vegetation types as occurring within five miles of the Refuge: Northern Coastal salt marsh, serpentine bunchgrass, valley and needle grass grassland, and valley oak woodland. Of these, only Northern Coastal salt marsh habitat occurs within the Refuge (within all units of the Refuge). The continued persistence of the special-status plant species that these habitat types support is further threatened by non-native, invasive plant species, particularly perennial pepperweed, which generally thrive under disturbed conditions with increased urban runoff (H.T. Harvey et al. 2005).

Special-status Plant Species
The California Natural Diversity Database (CNDDB 2008) was queried to identify special-status plant species potentially occurring within the Palo Alto, Mountain View, and Milpitas USGS 7.5 minute quadrangles in which the majority of the Refuge occurs, as well as the Newark and Redwood Point USGS 7.5 minute quadrangles that contain very small portions of the Refuge. In addition, the CNPS database (http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi; accessed 3 October 2008) was queried for valley and foothill grassland, marsh and swamp, and vernal pool habitats in Alameda, San Mateo, and Santa Clara Counties to be inclusive of all species that may occur within the Refuge.

According to the CNDDB, numerous occurrences of six species, including Hall's bush-mallow (*Malacothamnus hallii*), prostrate vernal pool Navarretia (*Navarretia prostrata*), California seablite (*Suaeda californiaca*), saline clover (*Trifolium depauperatum* var. *hydrophilum*), Hoover's button-celery (*Eryngium aristulatum* var. *hooveri*), Congdon's tarplant, alkali milk-vetch (*Astragalus tener* var. *tener*), Contra Costa goldfields, brittlescale (*Atriplex depressa*), and San Joaquin spearscale (*Atriplex joaquiniana*), are found on the Refuge primarily from the Warm Springs sub-unit in Fremont within the Mowry Unit of the Refuge. Historical (likely extirpated [extinct or no longer present]) populations of alkali milk-vetch and Point Reyes bird's-beak are documented in the vicinity of Alviso (CNDDB 2008). A population of Point Reyes bird's-beak was discovered in 2010 in La Riviere Marsh, a former commercial salt pond restored to tidal action in the Newark Unit. The CNDDB occurrence of California seablite is likely to be erroneous. Surveys on the Refuge (at Warm Springs) indicate that this species was likely to have been incorrectly identified (actually *Suaeda moquinii* (alkali blite or bush seepweed)). Further, California seablite has not been documented in annual surveys at Warm Springs.

Contra Costa goldfield
USFWS

According to the CNPS rare plant database, thirty-three of the species are considered likely to occur due to the range of habitat types and ecotones present on-site; these species are described in Table 8. These include ten species that are known to occur in the Refuge ("present"); four species that are not known from extant occurences in the South Bay, but which could potentially occur in the Refuge ("potential"); 15 species that are unlikely to occur in the Refuge ("unlikely," but surveys for these species have not been conducted); and two species that are considered absent from the Refuge, which probably has never provided suitable habitat for these two species ("absent"). The ecology, distribution, and known records of these species are provided below. A more detailed description of these species, including the potential for their re-introduction to the habitats found within the Refuge, can be found in the SBSP Environmental Impact Report (EDAW et al. 2007) and the Shoreline Study Existing Conditions Report (H. T. Harvey & Associates 2007b).

Table 8. Special-status plant species, their status, and potential occurrence in and around the Don Edwards National Wildlife Refuge

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Federal or State Threatened or Endangered Species			
Palmate-bracted bird's-beak (*Cordylanthus palmatus*)	FE, SE, CNPS 1B.1	Chenopod scrub, Valley and foothill grassland/alkaline. Known from Alameda, Colusa, Fresno, Glenn, Madera, and Yolo Counties. Believed to be extirpated from San Joaquin County. Annual hemiparasitic herb that blooms May through October at elevations from 16 to 508 ft.	**Unlikely.** Due to the general degraded nature or lack of alkaline flat substrate within the Refuge, the occurrence of Palmate-bracted bird's-beak within the Refuge is unlikely. There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge.
Contra Costa goldfields (*Lasthenia conjugens*)	FE, CNPS 1B.1	Saline/alkaline vernal pools, mesic areas within grassland. Known from Alameda, Solano, Monterey, Contra Costa, and Napa counties. Annual; blooms March through June at elevations from 0 to 1,542 ft.	**Present.** There are four records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and 19 listed as occurring within the Refuge. This species has been documented throughout the Warm Springs sub-unit in annual surveys. It also occurs in disjunct populations in Monterey and North Bay. Warm Springs provides suitable habitat and is included within the vernal pool critical habitat for Contra Costa Goldfields (Unit 8).
Point Reyes meadowfoam (*Limnanthes douglasii* ssp. *sulphurea*)	SE; CNPS 1B.2	Coastal prairie, mesic meadows and seeps, freshwater marshes and swamps, and vernal pools. Annual herb; blooms March to May at elevations from 3 to 460 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. All records listed in the Consortium of California Herbaria (2008) occur in Marin County. CNPS shows an occurrence within the Franklin Point USGS 7.5 minute quadrangle in San Mateo County south of the Refuge and states that the species is known from fewer than 15 occurrences. However, suitable vernal pool habitat occurs in Warm Springs.
California seablite (*Suaeda californica*)	FE, CNPS 1B.1	Coastal salt marshes. Perennial; blooms from July to October from sea level to 50 ft.	**Unlikely.** There are four records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and 25 listed as occurring within the Refuge. The records are mapped near the salt flats of the Palo Alto Yacht Harbor (1971) and north of Mud Slough, east of the Southern Pacific Railroad track (1986). However, surveys on the Refuge (at Warm Springs) indicate that this species is likely to have been incorrectly identified (actually *Suaeda moquinii* (alkali blite or bush seepweed)). This species has not been documented in annual surveys at Warm Springs.
State Rare and CNPS Species			

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Coastal marsh milk-vetch (*Astragalus pycnostachyus* var. *pycnostachyus*)	CNPS 1B.2	Coastal salt marshes, streamsides, and mesic coastal dunes in Marin, San Mateo, and Humboldt Counties. Perennial; blooms April to October at elevations from 0 to 98 ft.	**Absent.** There is one record of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. Extant populations associated with maritime salt marsh. CNPS records (2008) occur south of the Refuge.
Alkali milk-vetch (*Astragalus tener* var. *tener*)	CNPS 1B.2	Alkaline soils in playas, vernal pools, and adobe clay areas within grassland. Alameda, Merced, Solano, and Yolo counties. Annual; blooms March to June at elevations from 3 to 197 ft.	**Present**. There are 26 records of the species listed in the CNDDB (2008) as occurring within the Refuge. Recently rediscovered in seasonal wetlands near Fremont, on Warm Springs. Considered extirpated from Santa Clara County.
Heartscale (*Atriplex cordulata*)	CNPS 1B.2	Chenopod scrub, meadows and seeps, and sandy valley and foothill grassland habitats in saline or alkaline soils. Annual herb; blooms April to October at elevations from 3 to 1,230 ft.	**Unlikely.** There are nine records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. All records listed in CNPS (2008) and the Consortium of Herbaria (2008) occur east of the Refuge. However, saline and alkaline soils occur within the Refuge and the species is known from Alameda County
Crownscale (*Atriplex coronata* var. *coronata*)	CNPS 4.2	Chenopod scrub, valley and foothill grassland, and vernal pool habitat in alkaline soils. Annual herb; blooms from March to October at elevations from 3 to 1936 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. All records that occur in Alameda County in the Consortium of Herbaria (2008) occur within the Coast Range, outside of the Refuge. However, suitable vernal pool habitat occurs in Warm Springs.
Brittlescale (*Atriplex depressa*)	CNPS 1B.2	Chenopod scrub, meadows and seeps, playas, valley and foothill grassland, and vernal pool habitats in alkaline, clay soils. Blooms from April to October at elevations from 1 to 1,050 ft.	**Present.** There is one record of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and four records listed as occurring within the Refuge within Warm Springs growing on eroded areas.
San Joaquin spearscale (*Atriplex joaquiniana*)	CNPS 1B.2	Alkaline soils within chenopod scrub, meadows, playas, and grasslands in 14 central California counties. Annual; blooms April through October.	**Present.** There are three records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and 12 records listed as occurring within the Refuge. Occurs in seasonal wetlands in Warm Springs.
Congdon's tarplant (*Centromadia parryi* ssp. *congdonii*)	CNPS 1B.2	Moist, alkaline soils within grassland. Tolerates disturbance. Annual; blooms June through November. Known from Alameda, Monterey, San Luis Obispo, and Santa Clara counties.	**Present.** There are 14 records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and 20 records listed as occurring within the Refuge. Occurs in seasonal wetlands in Warm Springs. Also recently recorded in Alviso and at Sunnyvale Baylands Park. May occur in peripheral halophyte or disturbed upland zones within the Refuge, but not currently associated with salt marsh.

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Pappose tarplant (*Centromadia parryi* ssp. *parryi*)	CNPS 1B.2	Chaparral, coastal prairie, meadows and seeps, coastal salt marshes and swamps, and vernally mesic valley and foothill grassland habitats in alkaline soils. Annual herb; blooms from May to November at elevations from 6 to 1,378 ft.	**Potential.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. One record is listed in the Consortium of California Herbaria (2008) as occurring in San Mateo County on the seashore between Salada and Mussel Beach, west of the Refuge and CNPS (2008) shows several records occurring near the Refuge. Suitable habitat occurs in Warm Springs and in other areas of the Refuge with alkaline soils.
Point Reyes bird's-beak (*Cordylanthus maritimus* ssp. *palustris*)	CNPS 1B.2	Marshes and swamps; annual herb; blooms from June to October; occurs at elevations from sea level to 33 ft.	**Present.** There are six records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and 86 listed as occurring within the Refuge; however, all of these records are historic (from the early 1900s) and are considered to be extirpated with the exception of a population found in the Refuge's restored LaRiviere Marsh in 2010.
Hispid bird's-beak (*Cordylanthus mollis* ssp. *hispidus*)	CNPS 1B.1	Meadows and seeps, Playas, Valley and foothill grassland/alkaline. Known from Alameda, Fresno, Kern, Merced, Placer, and Solano counties. Annual hemiparasitic herb that blooms June through September at elevations from 3 to 510 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. Due to the general degraded nature or lack of saline flats substrate within the Refuge, the occurrence of Hispid bird's-beak within the Refuge is unlikely.
Recurved larkspur (*Delphinium recurvatum*)	CNPS 1B.2	Chenopod scrub, Cismontane woodland, Valley and foothill grassland/alkaline. Known from Alameda, Contra Costa, Fresno, Glenn Glenn, Kings, Kern, Madera, Merced, Monterey, San Joaquin, San Luis Obispo, Solano, and Tulare Counties. It is believed to be extirpated from Butte and Colusa counties. Perennial herb that blooms from March through June at elevations from 10 to 2,460 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. Due to the general degraded nature or lack of grassland habitat with alkaline soils within the Refuge, the occurrence of recurved larkspur within the Refuge is unlikely.
Hoover's button-celery (*Eryngium aristulatum* var. *Hooveri*)	CNPS 1B.1	Occurs in vernal pools; annual/perennial herb; blooms in July at elevations of 9 to 148 ft.	**Present.** There are five records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and 18 records from within the Refuge. One population occurs at Warm Springs. Historic occurrences from the early part of last century were recorded in Alviso, Agnews, and Palo Alto.

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Diamond-petaled California poppy (*Eschscholzia rhombipetala*)	CNPS 1B.1	Valley and foothill grassland habitat in alkaline, clay soils. Annual herb; blooms March to April at elevations from 0 to 4,000 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and all records within the Consortium of California Herbaria occur east of the Refuge. However, suitable alkaline, clay soils occur within the Refuge and CNPS (2008) lists the species as occurring in Alameda County east of the Refuge.
Hogwallow starfish (*Hesperevax caulescens*)	CNPS 4.2	Valley and foothill grassland habitat in mesic, clay soils and in shallow vernal pool habitat. Annual herb; blooms from March to June at elevations from 0 to 1,657 ft.	**Potential.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. In addition, both the CNPS (2008) and the Consortium of California Herbaria (2008) list the species as occurring east of the Refuge in Alameda County. However, Hesperevax sp. has been documented (exact species unknown) at Warm Springs.
Vernal barley (*Hordeum intercedens*)	CNPS 3.2	Coastal dunes, coastal scrub, saline flats, depressions in valley, and foothill grassland habitat, and vernal pool habitats. Annual herb; flowers from March to June at elevations from 16 to 3,280 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. All records listed within the Consortium of California Herbaria (2008) occur within Southern California and all records listed within CNPS (2008) occur south of the Refuge in San Benito County or in Southern California, although San Mateo County is listed as a potential location for the species to occur. Suitable habitat occurs within Warm Springs.
Ferris' goldfields (*Lasthenia ferrisiae*)	CNPS 4.2	Alkaline vernal pools with clay soils. Annual herb; blooms February to May at elevations from 66 to 2,297 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. CNPS (2008) lists the species as occurring in Alameda County and the Consortium of California Herbaria (2008) lists four records occurring east of the Refuge within the Springtown Wetlands Preserve in the Livermore Valley. However, suitable habitat occurs within Warm Springs.
Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*)	CNPS 1B.2	High marsh zone in brackish and freshwater marshes. Known from Suisun Marsh (Sacramento, San Joaquin, Solano, and Contra Costa counties) and Napa marshes. Perennial; blooms May through September at elevations from 0 to 13 ft.	**Potential.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. Historical and current records are from the North Bay only. However, marginal habitat is present within the Refuge, and there is some potential for occurrence.
Legenere (*Legenere limosa*)	CNPS 1B.1	Vernal pool habitat. Annual herb; blooms April to June at elevations from 3 to 2,887 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. CNPS (2008) lists the species as occurring in Santa Clara, San Mateo, and Alameda Counties and the Consortium of California Herbaria (2008) lists records east of the Refuge. Suitable habitat is present within Warm Springs.

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Mason's lilaeopsis (*Lilaeopsis masonii*)	SR, CNPS 1B.1	Exposed banks of tidal meanders and channels within brackish to freshwater marsh. Locally common in Suisun Marsh. Perennial; blooms April through November at elevations from 0 to 33 ft.	**Absent.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. Not known to occur in the South Bay; historical and current records in Suisun Bay only.
Hall's bush-mallow (*Malacothamnus hallii*)	CNPS 1B.2	Chaparral and coastal scrub habitats. Perennial; blooms from May to September and sometimes into October at elevations of 33 to 2495 ft.	**Present.** There are two records of the species listed in the CNDDB (2008) from within the Refuge located near the South Bay Yacht Club along Alviso Slough growing in disturbed habitat.
Little mousetail (*Myosurus minimus* ssp. *apus*)	CNPS 3.1	Valley and foothill grassland habitat and alkaline vernal pools. Annual herb; blooms from March to June at elevations from 66 to 2,100 ft.	**Potential.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. All of the records listed in the Consortium of California Herbaria (2008) occur south of the Refuge. All records listed in Alameda County in CNPS (2008) occur east of the Refuge. However, *Myosurus minimus* sp. (exact species unknown) has been documented within Warm Springs.
Prostrate navarretia (*Navarretia prostrata*)	CNPS 1B.1	Seasonal wetlands and vernal pools within grassland and coastal scrub. Ranges from Monterey County south to San Diego. Annual; blooms April through July at elevations from 50 to 2,296 ft.	**Present.** There are two records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge and six records from within the Refuge. In South Bay, known only from Warm Springs.
Gairdner's yampah (*Perideridia gairdneri* ssp. *gairdneri*)	CNPS 4.2	Broadleaved upland forest, chaparral, coastal prairie, valley and foothill grassland, and vernal pool habitats in vernally mesic soils. Perennial herb; blooms June to October at elevations from 0 to 1,198 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. CNPS (2008) lists the species as occurring in Santa Clara County and potentially extirpated from San Mateo County. The Consortium of California Herbaria (2008) list records west and east of the Refuge. However, suitable vernal pool habitat occurs in Warm Springs.
Hickman's popcorn-flower (*Plagiobothrys chorisianus* var. *hickmanii*)	CNPS 4.2	Close-cone coniferous forest, chaparral, coastal scrub, marshes and swamps, and vernal pool habitats. Annual herb; blooms April to June at elevations from 50 to 607 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. The Consortium of California Herbaria (2008) lists all records as occurring west of the Refuge. However, CNPS (2008) lists the species as occurring in Santa Clara County and potentially extirpated from San Mateo County. Suitable vernal pool habitat occurs in Warm Springs.

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Hairless popcorn flower (*Plagiobothrys glaber*)	CNPS 1A	Alkaline meadows and seeps and coastal salt marshes. Annual herb; blooms March to May at elevations from 50 to 590 ft.	**Unlikely.** There are three records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge mapped just northeast of the junction of Alvarado Blvd. and the Interstate 880 freeway; however, these were last seen in 1896. The species is considered by CNPS (2008) to be extinct in California.
Delta woolly-marbles (*Psilocarphus brevissimus* var. *multiflorus*)	CNPS 4.2	Dried beds of vernal pools and flats, especially in grasslands, in Alameda and Santa Clara counties north to Yolo County. Annual; blooms April to June at elevations from 33 to 1,640 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. Currently, Warm Springs presents potentially suitable habitat within the Refuge.
Lobb's aquatic buttercup (*Ranunculus lobbii*)	CNPS 4.2	Cismontane woodland, North Coast coniferous forest, valley and foothill grassland, and vernal pool habitats in mesic soils. Aquatic annual herb; blooms February to May at elevations from 50 to 1,542 ft.	**Unlikely.** There are no records of the species listed in the CNDDB (2008) from within 5 mi of the Refuge. CNPS (2008) lists the species as occurring in Alameda County and potentially extirpated from San Mateo County. The Consortium of California Herbaria (2008) list records within San Mateo County near Crystal Springs Reservoir, west of the Refuge. However, suitable vernal pool habitat occurs within Warm Springs.
Saline clover (*Trifolium depauperatum* var. *hydrophilum*)	CNPS 1B.2	Edges of salt marshes, alkali meadows, and vernal pools along the coast from Sonoma County south to San Luis Obispo, as well as in the inland counties of Solano and Colusa. Annual; blooms April through June at elevations from 0 to 984 ft.	**Present.** Recorded at Warm Springs as recently as 2011 (I. Loredo, pers. comm.). There is one record of the species listed in the CNDDB (2008) from within 5 mi of the Refuge; however, it is a historical collection (type locality) from Belmont; not recorded since 1886 in South Bay.
Caper-fruited Tropidocarpum (*Tropidocarpum capparideum*)	CNPS 1B.1	Alkaline valley and foothill grassland habitat. Annual herb; blooms March to April at elevations from 3 to 1,493 ft.	**Unlikely.** There is one record of the species listed in the CNDDB (2008) from within 5 mi of the Refuge in the foothills near Stanford that was last seen in 1902.

CNPS LISTS:
1A - Presumed extinct in California
1B - Plants rare, threatened, or endangered in California and elsewhere
3 - Plants about which information is needed-a review list
4 - Plants of limited distribution-a watch list
.1 - seriously endangered in California
.2 - fairly endangered in California

Status:
FE – Federally Endangered
SR – State Rare
SE – State Endangered

Non-native and Invasive Plant Species

Several invasive and myriad non-native weeds are known to occur or may potentially occur within the Refuge (See Appendix D, Refuge Plant List). The most invasive of these plant species are listed in Table 9. Many of these species out-compete native plants, displacing entire communities of plants and associated wildlife. Control of these species is important throughout the South Bay. Weed management must prioritize for control the most invasive and problematic weeds that occur within the Refuge, as well as re-vegetation plans for impacted habitats. The California Invasive Plant Council (Cal-IPC) maintains a list of all of the non-native weed species in the state by habitat type, with ratings for invasiveness, distribution, and impact on the natural environment for each species (http://www.cal-ipc.org/ip/inventory/weedlist.php).

Table 9. Most Invasive Non-native Weeds on Refuge

Common Name	Scientific Name
smooth cordgrass	*Spartina alterniflora*
perennial pepperweed	*Lepidium latifolium*
Algerian sea lavender	*Limonium ramosissimum*
stinkwort	*Dittichia graveolens*
yellow starthistle	*Centaurea solstitialis*
purple starthistle	*Centaurea calcitrapa*
alkalia Russian thistle	*Salsola soda*
pampasgrass and jubatagrass	*Cortaderia sellanoa* and *Cortaderia jubata*
common reed and giant reed	*Phragmites australis* and *Arrundo donax*
Italian thistle and slenderflower thistle	*Carduus pycnocephalus* and *Carduus tenuiflorus*
French broom	*Genista monspessulana*
poison hemlock	*Conium maculatum*
fennel	*Foeniculum vulgare*

The following weed species are considered the most invasive and/or aggressive non-native weeds on the Refuge:

1) smooth cordgrass (and hybrids) alters both the physical structure and biological function of tidal marshes, mudflats, and slough channels;
2) perennial pepperweed invades intact native ecosytems and can form complete monocultures, displacing native vegetation and wildlife in a multitude of habitat types including tidal marsh and marsh/upland ecotone;
3) Algerian sea lavender is a relatively new invasive weed to the Refuge, detected first in 2006 in the San Francisco Bay, and competes with native plants in high marsh habitats;
4) stinkwort is spreading throughout the Refuge and across California at an unprecedented rate, and forms dense monocultures in disturbed areas including uplands and marsh/upland ecotones;
5) yellow starthistle is one of the most widespread invasive broadleaf weeds on rangelands and natural areas in the United States, and is found primarily in disturbed uplands and grasslands on the Refuge;
6) purple starthistle occurs only at two locations within the Refuge and is therefore a priority for control;
7) alkalia Russian thistle invades wetlands including vernal pools, tidal marshes, and mudflats, and though it is mostly found in disturbed areas, it has been found in undisturbed upper marsh habitat in San Francisco Bay;

8) pampasgrass and jubatagrass considered noxious weeds in some areas of California, especially along the coast and in other wet environments;
9) common reed and giant reed form dense stands in upland and marsh/upland ecotones that increase flooding and siltation, but only occur in a few isolated locations within the Refuge and are therefore a priority for control;
10) Italian thistle and slenderflower thistle are aggressive annuals that can spread quickly through, and dominate in, disturbed uplands;
11) French broom displaces native plant species, and occurs in uplands on the Refuge;
12) poison hemlock can spread quickly in disturbed uplands and marsh/upland ecotones and is highly competitive with native vegetation once it is established; and
13) fennel will invade disturbed uplands and can exclude or prevent re-establishment of native plant species if left uncontrolled. The distribution and abundance of infestations of these species on the Refuge are documented and will be tracked annually.

3.4.5. Wildlife

Special-status Wildlife Species
The legal status of special-status animal species and the likelihood of occurrence in the Refuge and adjacent habitats are given in Table 10.

A number of special-status species occur in the Refuge as visitors or migrants, but are not known or expected to breed in the immediate area. Animals that occasionally occur within the Refuge and breed in upland habitats in the greater South Bay Area, but occur only in the Refuge as uncommon to rare foragers, include the bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), Vaux's swift (*Chaetura vauxi*), bank swallow (*Riparia riparia*), yellow-breasted chat (*Icteria virens*), and pallid bat (*Antrozous pallidus*). Species that occur in the Refuge regularly as foragers, but have special status only at nesting sites elsewhere in California, include the common loon (*Gavia immer*), American white pelican (*Pelecanus erythrorthynchos*), and Barrow's goldeneye (*Bucephala islandica*). More information on most of these species can be found in the Goals Project Baylands Ecosystem Species and Community Profiles (Goals Project 2000).

Table 10. Special-status animal species, their status, and potential occurrence in and around the Don Edwards National Wildlife Refuge

NAME	STATUS*	HABITAT	POTENTIAL FOR OCCURRENCE ON SITE
FEDERAL OR STATE THREATENED OR ENDANGERED SPECIES			
Vernal Pool Tadpole Shrimp (*Lepidurus packardi*)	FE	Freshwater vernal pools in grasslands.	**Present.** Present in vernal pools in Warm Springs.
North American green sturgeon *(Acipenser medirostris)*	FT	Spawns in freshwater rivers, spends much of life in nearshore oceanic waters and estuaries.	**Unlikely.** Green sturgeon juveniles are found throughout the Sacramento/San Joaquin River delta and San Francisco Bay (Randy Baxter, CDFG, unpublished data). Occurrence in the South San Francisco Bay is expected to be infrequent.
Steelhead – California Central Coast ESU *(Oncorhynchus mykiss)*	FT	Cool streams with suitable spawning habitat and conditions allowing migration, as well as marine habitats.	**Present.** Known to be present in several South Bay creeks (including Coyote, Stevens, and San Francisquito Creeks, and the Guadalupe River). Steelhead are expected to occur in associated marshes and small channels within the Refuge Boundary, especially as habitat for smolts as they transition to life in a marine environment. Suitable spawning habitat is not present in the Refuge, but adults move through the area to spawn upstream.
California Tiger Salamander *(Ambystoma californiense)*	FT, CSSC	Vernal or temporary pools in annual grasslands, or open stages of woodlands.	**Present.** Several populations are present in Warm Springs.
American Peregrine Falcon (*Falco peregrinus anatum*)	SE, SP	Forages in many habitats; nests on cliffs and similar human-made structures.	**Present.** Regular forager (on other birds) within the Refuge, primarily during migration and winter. Nested in 2006, 2007, and 2009 in old raven nests on transmission towers in the Alviso and Mowry pond complexes and on towers adjacent to the Dumbarton Bridge in 2011.
Bald Eagle (*Haliaeetus leucocephalus*)	SE, SP	Occurs mainly along seacoasts, rivers, and lakes; nests in tall trees or in cliffs. Feeds mostly on fish.	**Present.** Occasional visitor, primarily during winter, to the Refuge. May occasionally forage, but does not nest, in the Refuge.
Bank Swallow (*Riparia riparia*)	ST	Colonial nester on vertical banks or cliffs with fine-textured soils near water.	**Present.** Observed within the Refuge as rare transient; no suitable breeding habitat available.
California Clapper Rail (*Rallus longirostris obsoletus*)	FE, SE, SP	Salt and brackish marsh habitat usually dominated by pickleweed and cordgrass.	**Present.** Resident in many tidal marshes within the Refuge.

NAME	STATUS*	HABITAT	POTENTIAL FOR OCCURRENCE ON SITE
California Black Rail (*Laterallus jamaicensis coturniculus*)	ST, SP	Breeds in fresh, brackish, and tidal salt marsh.	**Present.** Non-breeding individuals winter in small numbers in tidal marsh within the Refuge. Present during 2012 breeding season in Alviso and Newark Units.
California Least Tern (*Sterna antillarum browni*)	FE, SE, SP	Nests along the coast on bare or sparsely vegetated flat substrates.	**Present.** The South Bay is an important post-breeding staging area for least terns. Recent breeding by small numbers has occurred in the Refuge at the Eden Landing complex. Forages and roosts in a number of ponds in the Refuge, especially Alviso ponds in the vicinity of Moffett Field. Current Bay colony exists on the runway at the former Alameda Naval Air Station.
Western Snowy Plover (*Charadrius alexandrinus nivosus*)	FT, CSSC	Nests on sandy beaches and salt panne habitats.	**Present.** Breeds and forages at several sites within the Refuge, primarily at the Eden Landing, Ravenswood, and West Bay complexes. Additional birds occur in the Refuge during winter.
Salt Marsh Harvest Mouse (*Reithrodontomys r. raviventris*)	FE, SE, SP	Salt marsh habitat dominated by pickleweed.	**Present.** Resident in many tidal marshes within the Refuge. Also occurs in brackish marshes, diked marshes, and transitional habitat adjoining tidal or diked marshes.
CALIFORNIA SPECIES OF SPECIAL CONCERN			
Central Valley Fall- and Late Fall-run Chinook Salmon (*Oncorhynchus tshawytscha*)	CSSC (Late Fall-run only)	Cool rivers and large streams that reach the ocean and that have shallow, partly shaded pools, riffles, and runs.	**Present.** Central Valley Fall-Run Chinook salmon are known to be present in several South Bay creeks (including Coyote Creek, Alameda Creek, and the Guadalupe River) and associated marshes and small channels within the Refuge, especially as habitat for smolts as they transition to life in a marine environment. Suitable spawning habitat is not present within the Refuge, but this species moves through the area to spawn upstream.
Western Pond Turtle (*Clemmys marmorata*)	CSSC	Permanent or nearly permanent fresh or brackish water in a variety of habitats.	**Potential.** Uncommon along the inshore side of pond A3W. May occur rarely in freshwater and brackish creeks and sloughs elsewhere within the Refuge.
Alameda Song Sparrow (*Melospiza melodia pusillula*)	CSSC	Breeds in salt marsh, primarily in marsh gumplant and cordgrass along channels.	**Present.** Breeds and forages in tidal salt marsh, particularly with taller vegetation along tidal channels.
American White Pelican (*Pelecanus erythrorhnchos*)	CSSC (nesting)	Forages in freshwater lakes and rivers, nests on islands in lakes.	**Present.** Common non-breeder, foraging primarily on ponds in the Refuge. Regular visitor from late summer to spring; does not breed within the Refuge.

NAME	STATUS*	HABITAT	POTENTIAL FOR OCCURRENCE ON SITE
Barrow's Goldeneye (*Bucephala islandica*)	CSSC (nesting)	Nests in freshwater marshes, winters in coastal marine habitats.	**Present.** Occasional winter visitor; does not breed within the Refuge.
Black Skimmer (*Rynchops niger)*	CSSC (nesting)	Nests on abandoned levees and islands in ponds and marshes.	**Present.** A few pairs breed and forage within the Refuge, on islands in ponds.
Bryant's Savannah Sparrow (*Passerculus sandwichensis alaudinus*)	CSSC	Breeds and forages in grasslands and high-marsh habitat in the San Francisco Bay area and along the central and northern California coast.	**Present.** Forages, and likely breeds, in high-marsh habitat, grasslands, and possibly ruderal vegetation within the Refuge.
California Yellow Warbler (*Dendroica petechia brewsteri*)	CSSC (nesting)	Breeds in riparian woodlands, particularly those dominated by willows and cottonwoods.	**Present.** Occasional visitor; nests in riparian corridor of Coyote Creek and other riparian areas outside of the Refuge.
Common Loon (*Gavia immer*)	CSSC (nesting)	Nests in freshwater marshes, winters in coastal marine habitats.	**Present.** Occasional winter visitor; does not breed within the Refuge.
Loggerhead Shrike (*Lanius ludovicianus*)	CSSC (nesting)	Nests in dense shrubs and trees, forages in grasslands, marshes, and ruderal habitats.	**Present.** Resident in low numbers within the Refuge.
Northern Harrier (*Circus cyaneus*)	CSSC (nesting)	Nests and forages in marshes, grasslands, and ruderal habitats.	**Present.** Breeds in marsh habitats within the Refuge, forages in a variety of habitats.
San Francisco Common Yellowthroat (*Geothlypis trichas sinuosa*)	CSSC	Breeds primarily in fresh and brackish marshes in tall grass, tules, willows; uses salt marshes more in winter.	**Present.** Common resident, breeding in freshwater and brackish marshes (and possibly to a limited extent in salt marshes), and foraging in all marsh types during the non-breeding season.
Short-eared Owl (*Asio flammeus*)	CSSC (nesting)	Nests on ground in tall emergent vegetation or grasses, forages over a variety of open habitats.	**Present.** Uncommon visitor during winter and migration. Has bred in small numbers within the Refuge, although current breeding status unknown.
Tricolored Blackbird (*Agelaius tricolor*)	CSSC (nesting)	Breeds near fresh water in dense emergent vegetation.	**Present.** Has bred in the South Bay at the San Jose-Santa Clara WPCP, but occurs in the Refuge primarily as a non-breeding forager.
Vaux's Swift (*Chaetura vauxi*)	CSSC (nesting)	Nests in snags in coastal coniferous forests or, occasionally, in chimneys; forages aerially.	**Present.** Forages over the Refuge and other parts of the South Bay in migration. No nesting habitat within area.
Western Burrowing Owl (*Athene cunicularia hypugea*)	CSSC	Flat grasslands and ruderal habitats.	**Present.** Breeds at several upland sites within the Refuge, primarily within Warm Springs and the Alviso area.

NAME	STATUS*	HABITAT	POTENTIAL FOR OCCURRENCE ON SITE
Yellow-breasted Chat (*Icteria virens*)	CSSC	Riparian brush and woodlands.	**Potential.** Rare non-breeding visitor to riparian habitats near the Refuge during migration.
Salt Marsh Wandering Shrew (*Sorex vagrans halicoetes*)	CSSC	Medium high marsh with abundant driftwood and pickleweed.	**Present.** May occur in salt marshes throughout the Refuge, although numbers have declined, and current status is unknown.
STATE PROTECTED SPECIES OR CNPS SPECIES			
Golden Eagle (*Aquila chrysaetos*)	SP	Breeds on cliffs or in large trees or electrical towers, forages in open areas.	**Present.** Occasional forager, primarily during the non-breeding season. No nesting records within the Refuge.
White-tailed Kite (*Elanus caeruleus*)	SP (nesting)	Nests in tall shrubs and trees, forages in grasslands, marshes, and ruderal habitats.	**Present.** Common resident; breeds within the Refuge where suitable nesting habitat occurs.

FE = Federally Endangered
FT = Federally Threatened
SE = State Endangered
ST = State Threatened
CSSC = California Species of Special Concern
SP = State Fully Protected Species

Birds

The San Francisco Bay area is important to breeding birds and, particularly, to migratory waterbirds in the Pacific Flyway. The Bay provides important foraging and roosting habitat for more than one million waterbirds each year, supporting large proportions of the populations of some shorebird and duck species (Accurso 1992; Harrington and Perry 1995; Page et al. 1999; Stenzel et al. 1989; Stenzel and Page 1988; Takekawa et al. 2001). With its extensive mudflats, remnant salt marsh, and ponds, the South Bay in particular supports very high diversity and abundance of waterbirds (Harvey et al. 1992; Takekawa et al. 2000; Warnock 2004). The high waterbird diversity in the South Bay is a function of the diversity of wetlands in the region, while high bird abundance is a function of the high productivity of the South Bay estuary. Despite the extensive loss and degradation of the South Bay's tidal marsh, and the invasion of the South Bay benthic invertebrate community by non-native species, this system is still extremely productive. The remnant tidal marshes not only provide habitat for marsh obligates such as the California clapper rail, they also play important roles as sources of nutrients and carbon for the aquatic system, resulting in high abundance of invertebrates on the mudflats and shallow subtidal areas (Warwick and Price 1975), and ultimately high fish abundance. These invertebrates and fish serve as prey to the myriad of shorebirds, waterfowl, herons, egrets, gulls, terns, grebes, and other waterbirds that use the South Bay.

Former salt ponds, active salt ponds, and other non-tidal open water habitats (such as artificial ponds and lakes, water treatment plant settling and oxidation ponds, muted and managed marshes, and managed ponds) provide important habitat for waterbirds in the South Bay (Hanson and Kopec 1994; Harvey et al. 1992; Stralberg et al. 2003; Takekawa et al. 2000; Takekawa et al. 2001; Warnock 2004). Salt ponds (former and active) provide roosting habitat for waterbirds, particularly during higher tides when tidally-influenced habitats are not available for foraging. Additionally, some ponds concentrate invertebrates and fish resulting in suitable foraging conditions for a variety of waterbirds. For some species, such as the Wilson's phalarope (*Phalaropus tricolor*), red-necked phalarope (*Phalaropus lobatus*), black-necked stilt, American avocet, western snowy plover, Bonaparte's gull (*Larus philadelphia*), American white pelican, and breeding gulls and terns, these ponds provide higher-quality nesting and/or foraging habitat than the existing tidal marshes or intertidal habitats.

Birds in the South Bay overlap considerably in habitat preference and resource use, but general groups of species can be distinguished based on their physical adaptations, habitat associations, foraging behavior, dietary requirements and prey, the ways in which they use the South Bay (e.g., for nesting, foraging, or roosting), and their temporal occurrence in the Refuge. For the purposes of describing the existing conditions of the bird community in the South Bay, six general groups of species have been identified:

1) shorebirds;
2) waterfowl (ducks and geese);
3) large waders (herons, egrets, and ibis) and other piscivores (fish-eating grebes, cormorants, and pelicans);
4) colonial-nesting waterbirds (gulls, terns, and some shorebirds);
5) other waterbirds (eared grebes (*Podiceps migricollis*), coots, and rails); and
6) landbirds (including raptors and passerines).

Each of these groups is discussed below (Table 11). A list of birds that occur on the Refuge can be viewed in Appendix E and available data on waterbird use in the South Bay ponds can be viewed in Appendix G.

Table 11. Birds on the Refuge

Species Group	Residency Status	Habitat Use	Example Species
Shorebirds	Present winter to spring	Mudflats, ponds	Small shorebirds: western sandpiper, Medium shorebirds: marbled godwit, High salinity specialists: phalaropes
Waterfowl	Present winter to spring	Open bay, ponds, sloughs, and marsh channels	Dabbling ducks: northern shoveler; Diving ducks: ruddy ducks; Geese
Large waders and other piscivores	Includes migrants and residents	Open bay, ponds, sloughs, and marsh channels	Great egret, snowy egret, pied-billed grebe, gull species
Colonial-nesting waterbirds	Present spring to summer	Islands and levees in ponds, man-made structures	Forster's tern, California gull, double-crested cormorant
Other waterbirds	Largely residents	Tidal and managed marshes, sloughs, marsh channels	American coot, eared grebes, California clapper rail, black rail
Landbirds (passerines and raptors)	Includes migrants and residents	All habitats within the Refuge (excluding open water)	marsh wren, common yellowthroat, white-crowned sparrow, northern harrier, white-tailed kite, burrowing owl

Shorebirds. The San Francisco Bay supports more than one million shorebirds in spring and hundreds of thousands in the fall and winter (Stenzel et al. 1989). As a result of these numbers, the San Francisco/San Pablo Bay area has been designated as a site of hemispheric importance by the Western Hemisphere Shorebird Reserve Network (Harrington and Perry 1995), and the Refuge has been designated a Globally Important Bird Area by the American Bird Conservancy (2004). More than 36 species of shorebirds use habitats within the San Francisco Bay.

Most shorebird species in the South Bay are mudflat specialists, foraging primarily on intertidal mudflats when these flats are available at low tide (Anderson 1970; Kelly and Cogswell 1979; Recher 1966; Stralberg et al. 2003; Swarth et al. 1982; Warnock et al. 1995; Warnock et al. 2002). These birds often concentrate at the edge of the receding tideline, where worms, crustaceans, and bivalves occur close to the surface. Near the waterline, shorebird microhabitat use typically depends on each species' leg length, as well as the size and shape of their bills. For example, the very shortest-billed semipalmated (*Charadrius semipalmatus*) and black-bellied (*Pluvialis squatarola*) plovers feed on recently exposed mud, small sandpipers such as western and least sandpipers (*Calidris mauri and C. minutilla*) forage on recently uncovered mud and shallow water, mid-sized birds such as dunlin (*C. alpina*), red knots (*C. canutus*), and dowitchers (*Limnodramus* spp.) forage in slightly deeper water, and larger shorebirds such as willets (*Catoptrophorus semipalmatus*), long-billed curlews (*Numenius americanus*), and marbled godwits (*Limos fedoa*) probe in deeper water.

Shorebird use of active and former salt ponds for foraging varies considerably among species, and for some species, it varies among individuals, seasons, and possibly age classes. Of the mudflat specialist species, most of the individuals observed in ponds at high tide are roosting rather than foraging, such as long-billed curlews, marbled godwits, and black-bellied plovers (Warnock et al. 2002). Most western sandpipers and dunlin use ponds primarily for roosting, but forage on moist mud and in shallow water within ponds to a greater extent. A greater proportion of least sandpipers appear to use ponds for foraging than is observed in other mudflat specialists (Steve Rottenborn, pers. obs.).

Greater yellowlegs (*Tringa melanoleuca*) and lesser yellowlegs (*T. flavipes*) forage in a variety of habitats in the South Bay, including ponds and marshes, and occur less frequently on tidal mudflats.

Some shorebird species are considered "ponds specialists" as they are more likely to be found using pond habitats. Wilson's and red-necked phalaropes occur in the South Bay primarily in ponds, foraging in open water and rarely in tidal habitats. These birds typically use high salinity ponds, where they feed on brine shrimp (*Artemia franciscana*), brine flies (*Ephydra* spp. and *Lipochaeta slossonae*), and other abundant invertebrates. Black-necked stilt, American avocet, and western snowy plover roost, forage, and nest along levees and islands in ponds (see *colonial-nesting waterbirds*, as follows). American avocets and black-necked stilts were first recorded as breeders in Bay Area salt ponds in the 1920s (Gill 1977; Harvey et al. 1992) and populations have experienced a dramatic increase since initial observations. Recent survey counts indicate 1,184 black-neck stilts and 2,765 American avocets reside in the South Bay (Rintoul et al. 2003). Concentrations of breeding stilts and avocets occur in New Chicago Marsh, various Alviso and Ravenswood ponds (A12, A16, R1, SF2, and others), the ELER (E4 and E7 and others), on sludge ponds (Steve Rottenborn, pers. obs.), and other various ponds and marshes throughout the South Bay.

Black-necked stilt, with brine flies
Judy Irving © Pelican Media

Within the ponds, water depth and salinity influence the distribution of foraging shorebirds. The abundant invertebrates of the mid- and high-salinity ponds (60–200 ppt), namely brine shrimp, brine flies, and reticulate water boatmen (*Trichocorixa reticulata*), are important food sources for shorebirds (Larsson 2000; Maffei 2000; Stralberg et al. 2003; Warnock et al. 2002), but their availability to most shorebirds is limited by water depth. Thus, only the moist soils along the edges of ponds, and moist soil or very shallow water within the ponds, provide

suitable foraging habitat for these wading species. The extent of shorebird foraging habitat present within the ponds varies considerably among ponds and seasons, but at any given time a relatively small proportion of the pond complexes provides suitable conditions (e.g., moist soil or shallow water <10 cm deep) for foraging by most shorebirds.

Most vegetated tidal marsh receives little use by foraging shorebirds because of the height and/or density of marsh vegetation. However, more open areas within the marsh are used for foraging by some species. Willets forage in the vegetated portions of tidal marshes (Gerstenberg 1979; Kelly and Cogswell 1979; Long and Ralph 2001), particularly when these areas are flooded during very high tides, but occasionally even during low tide (Kelly and Cogswell 1979). Long-billed curlews, marbled godwits, yellowlegs, least sandpipers, and other species occasionally forage in vegetated tidal marsh areas as well, usually in more sparsely vegetated areas, but occasionally in dense (but short) pickleweed. Large numbers forage on intertidal flats along the larger sloughs within marshes when the flats are exposed, but most shorebirds avoid areas with dense, tall vegetation, and therefore do not forage in most of the marsh plain. These birds will forage, sometimes abundantly, in shallow marsh ponds and pannes within the high marsh, and in areas where bare mud and shallow water is interspersed with short pickleweed vegetation (H. T. Harvey & Associates 2007b).

Shorebirds in the South Bay eat a wide variety of invertebrates and occasionally small fish. Brine shrimp, brine flies, and reticulate water boatmen probably compose the bulk of the prey taken in ponds, although *Corophium* spp., annelids, polychaetes, and other invertebrates are known to be taken in ponds as well (Anderson 1970). *Corophium* spp., polychaetes, bivalves, and snails likely compose the bulk of the prey taken on mudflats (Harvey et al. 1992; Recher 1966; Swarth et al. 1982). Shorebirds are very flexible and opportunistic in their diets, with considerable dietary overlap among species and foraging guilds (Skagen and Oman 1996). They often take prey in accordance with availability, concentrating where prey is most dense (Goss-Custard 1970; Goss-Custard 1977; Goss-Custard 1979). Thus, the hydrologic regimes and ecosystem processes that maintain abundant invertebrate populations are more important than the specific invertebrate taxa available. As a result, shorebirds are still abundant in the South Bay, and still show a preference for foraging on intertidal mudflats, despite the widespread and pervasive invasions of the South Bay benthic invertebrate community by nonnative species.

Shorebirds generally roost when they are not foraging. Many mudflat specialists roost on the upper flats after initially foraging on the receding tide, then fly to alternate habitats to roost as the mudflats flood. In the South Bay, the most commonly used high-tide roosts for both pond specialists and mudflat specialists are shallows and bare sediment within ponds, levees surrounding and (especially) between ponds, and islands and artificial structures such as boardwalks within these ponds (Warnock et al. 2002). Shallowly flooded marsh ponds, marsh pannes, managed marshes, and water treatment plant drying ponds are also used for roosting, and American avocets, willets, long-billed curlews, marbled godwits, dunlin, and dowitchers roost to some extent in tidal marshes with short vegetation (PRBO Conservation Science 2004; Storer 1951).

Waterfowl. More than 32 species of waterfowl may use habitats within the Refuge for breeding, wintering, or during migration. Of these, eight species breed regularly (with populations augmented considerably during the non-breeding season), nine additional species

occur regularly during migration and winter, and at least 15 more occur irregularly and/or in very low numbers in the baylands as non-breeders. Harvey et al. (1988) reported that wintering waterfowl in the South Bay in 1981 exceeded 75,000 individuals, with more ducks on ponds than in the bay, especially from January through April. Surveys in 1987–1990 revealed approximately 57,000 dabbling ducks (ducks that feed without submerging their entire bodies) and 220,000 diving ducks (Goals Project 1999) in the Bay area. The South Bay ponds were found to support up to 76,000 wintering waterfowl, representing more than one-quarter of the Bay's waterfowl population. The more abundant species in South Bay ponds include 89 percent of the Bay's northern shovelers (*Anas clypeata*), 67 percent of the ruddy ducks (*Oxyura jamaicensis*)), half of the buffleheads (*Bucephala albeola*), and 17 percent of the canvasbacks (*Aythya valisineria*) wintering in the Bay (Accurso 1992; Takekawa et al. 2000).

The habitats of the South Bay support eight regularly nesting waterfowl species: the mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), and Canada goose (*Branta canadensis*) are fairly common breeders, while the cinnamon teal (*Anas cyanoptera*), northern pintail (*Anas acuta*), ruddy duck, lesser scaup (*Aythya affinis*), and northern shoveler breed in smaller numbers. Several other species, including the green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), canvasback, and redhead (*Aythya americana*), have been recorded breeding only a few times in the South Bay (Breeding Bird Atlas of Santa Clara County 2007).

Important breeding areas for waterfowl in the South Bay combine freshwater or brackish seasonal wetlands with extensive grassy or ruderal vegetation for nesting and fresh, brackish, or low-salinity ponds and marshes for brooding of young. In the South Bay, several waterfowl breeding areas occur near, or adjacent to the Refuge. These include the former Whistling Wings and Pintail Duck Clubs in Newark, Palo Alto Flood Control Basin and vicinity, the Sunnyvale and San Jose-Santa Clara WPCPs, the Sunnyvale Baylands, and the Coyote Creek Reach 1A waterbird pond. Other areas within the Refuge, like the Moffett Field/Crittenden Marsh and Warm Springs sub-unit, as well as some pond islands and levees provide limited breeding habitat for waterfowl.

Habitats within the Refuge are important foraging areas for migrant and wintering waterfowl. All of the breeding species are present in much greater abundance during the non-breeding season than during summer, and they are joined by other species that occur in the South Bay solely as non-breeders. Duck abundance in the South Bay increases in August and September as migrants, particularly northern shovelers, arrive in ponds and marshes. Numbers of other dabbling ducks and several species of diving ducks increase through the fall and into winter, and remain high into March (Santa Clara County Bird Data, unpublished; USGS, unpublished data; SFBBO unpublished data; and Takekawa et al. 2005).

Diving ducks are the most abundant wintering waterfowl in the South Bay and within the Refuge. Common species include the lesser scaup, greater scaup (*Aythya marila*), ruddy duck, canvasback, bufflehead, surf scoter (*Melanitta perspicillata*), and common goldeneye (*Bucephala clangula*). Bivalves, including large numbers of Baltic clams, are a favored food item for diving ducks such as scaup, canvasbacks, and surf scoters, and canvasbacks often congregate over bivalve beds (Miles 2000b; Takekawa and Marn 2000; White et al. 1988). Ruddy ducks forage on aquatic vegetation (such as wigeon grass), which grows primarily in lower-salinity ponds, and invertebrates, including mollusks and water boatmen (Anderson 1970; Miles 2000a). Brine fly larvae/pupae are important to lesser scaup foraging on South

Bay ponds (Anderson 1970). Diving ducks are common in the open waters of the Bay, larger sloughs, and ponds, where large flocks of lesser and greater scaup, canvasbacks, and other species often congregate to roost.

Dabbling ducks forage in a variety of habitats in the South Bay, including mudflats, shallow subtidal habitats, tidal sloughs and marsh channels, marsh ponds, managed and muted tidal marsh, seasonal wetlands, managed ponds, low salinity salt ponds, and water treatment plants. In these areas, dabbling ducks feed on a variety of aquatic plants and invertebrates. Because these species do not typically dive for food, dabbling ducks usually forage in water less than 30 centimeters deep (Page 2001). The most abundant dabbling ducks wintering in the South Bay are the northern shoveler, American wigeon (*Anas americana*), northern pintail, mallard, and gadwall (Takekawa et al. 2005). Shovelers are both abundant and flexible in habitat use in the South Bay, although they do not use tidal habitats frequently (Swarth et al. 1982). Swarth et al. (1982) found shovelers to be much more abundant on ponds than in tidal habitats. In contrast, these observers found American wigeon, canvasback, scaup, and surf scoters to be much more abundant on the Bay than in ponds.

Bufflehead pair
Glenn Nevill

Although total numbers of waterfowl are higher on the Bay than in ponds in the South Bay, pond habitat, especially lower-salinity ponds (20–63 ppt) of moderate size (50–175 ha), supports the highest densities of waterfowl in the Refuge (Siegel and Bachand 2002). Dabbling ducks tend to dominate the pond bird communities, with northern shovelers accounting for 41–46 percent of all birds in ponds at low tide (Warnock et al. 2002). Ruddy ducks are the second most abundant duck wintering on South Bay ponds (primarily on low-salinity ponds), with up to 19,000 recorded on these ponds (Accurso 1992). Recent mid-winter waterfowl survey data shows much higher numbers of ruddy ducks in ponds than in tidal habitats (FWS, unpublished data). In contrast to shorebirds, the vast majority of which use the ponds primarily at high tide, duck numbers on South Bay ponds are similar at high and low tides (Warnock et al. 2002).

Large waders and other piscivores. This category includes a diverse group of approximately 40 species of piscivorous (i.e., fish-eating) waterbirds that occur in the South Bay of which 20 are common. This list includes pied-billed grebes (*Podilymbus podiceps*), western grebes (*Aechmophorus occidentalis*), Clark's grebes (*A. clarkii*), loons (which are uncommon to rare visitors), American white pelicans, brown pelicans (*Pelecanus occidentalis*), and large waders (i.e., herons, egrets, and ibis). Several other species, including gulls, terns, cormorants,

mergansers, and belted kingfishers (*Ceryle alcyon*) also forage for fish in the Refuge but are treated in other categories.

While a number of piscivores breed in the South Bay, numbers of most of these species are highest during the non-breeding season. With the exception of a single Clark's grebe nest on an Alviso pond in 2011, Western and Clark's grebes do not nest in the baylands of the South Bay but may occur in the area, particularly on ponds and in the open bay, year-round (being most abundant in winter). California brown pelicans typically occur in San Francisco Bay as post-breeding dispersants during summer and fall (Ainley 2000a). American white pelicans are most abundant from June through December, but are present year-round especially in the Alviso ponds. Pied-billed grebes, which typically build floating nests of vegetation in freshwater wetlands, breed in scattered wetlands within the Refuge. Herons and egrets, with varied sized colonies and small rookeries, nest in the Refuge as well, typically in trees, shrubs, or in structures including transmission towers and duck hunting blinds (Robinson-Nilsen 2009a).

The piscivorous birds of the South Bay forage in a variety of habitats and locations where prey fish are available. The low-salinity ponds that support fish, tidal sloughs and channels, edges of intertidal mudflats, non-tidal ponds and channels, and artificial lakes such as Shoreline Lake (in Mountain View) provide the highest-quality foraging areas, and large frenzies of feeding activity may be observed at these locations, presumably when conditions result in large fish concentrations (H. T. Harvey & Associates 2007b). Brown pelicans usually plunge-dive for fish and, therefore, require water several feet deep, but American white pelicans and cormorants swim while feeding and can thus feed in shallower water. Although western and Clark's grebes and brown pelicans forage to varying degrees within the open waters of the Bay, American white pelicans apparently do not, instead preferring non-tidal waterbodies; large numbers of white pelicans forage and roost on ponds (Cogswell 2000; Harvey et al. 1988). Large wading birds are constrained by water depth, and are usually seen foraging from the edges of a body of water or wading within the shallows. Pied-billed grebes and most of the herons and egrets often forage along freshwater streams and in smaller ponds in the South Bay, and great blue herons and great egrets occasionally forage for small mammals in upland fields and ruderal areas.

Within ponds, the fish commonly taken by piscivores include the longjaw mudsucker (*Gillichthys mirablis*), topsmelt, Pacific staghorn sculpin (*Leptocottus armatus*), and threespine stickleback (*Gasterosteus aculeatus*) (Cogswell 2000; Harvey et al. 1988). These fish can be found in water having salt concentrations up to 70–80 ppt, although most cannot tolerate salinity >40 ppt (Carpelan 1957; Lonzarich 1989). As a result, most piscivore use of ponds is concentrated in ponds with lower salinities (Anderson 1970; Swarth et al. 1982). Approximately 94 percent of the pelicans and double-crested cormorants recorded by Swarth et al. (1982) were in low-salinity ponds, though most of the cormorants used these ponds only for roosting (primarily on wooden pilings and platforms within the ponds). Herons and egrets forage primarily in sloughs and marshes, with only some birds moving to ponds at high tide (Anderson 1970; Swarth et al. 1982). However, where temporary concentrations of fish were present (generally in low-salinity ponds in fall), these waders occurred in large concentrations.

Surveys of the South Bay ponds by U.S. Geological Survey (USGS) (Takekawa et al. 2005) indicate that species richness of piscivores is more or less constant throughout the year,

though abundance is highest in late summer and fall due to the presence of high numbers of herons, egrets, and American white pelicans foraging in ponds at this time. Piscivore abundance is highest in low salinity ponds.

Colonial-nesting waterbirds. The Federally threatened western snowy plover also uses ponds for breeding habitat in the South Bay. Snowy plovers were first recorded breeding in ponds in 1918 (Harvey et al. 1992), and they currently nest on sparsely vegetated pond levees and islands, at pond edges, and on salt panne areas within diked marsh in the South Bay (Page et al. 2000), with the highest concentration of breeding occurring at the ELER. Although unknown if snowy plovers bred in San Francisco Bay prior to commercial salt pond production, by 1990, approximately 10 percent of the California snowy plover population bred in the San Francisco Bay ponds, primarily in the South Bay (Page et al. 1991; Page et al. 2000). Since the 1970s, the South Bay breeding population appears to be declining, possibly due to increased predation from avian predators (Page et al. 2000, Robinson-Nilsen et al. 2009b). A window survey in 2009 recorded 147 snowy plovers in the San Francisco Bay, with the highest concentrations in Pond E8A in the ELER (SFBBO 2009) with a significant number breeding at ponds A8, SF2, and in other Refuge ponds (C. Morris, pers. obs.). The majority of nest failures in the South Bay can be attributed to depredation; and a chick fledgling rate of just 24.8 percent was observed in 2009 (SFBBO 2009). Remote camera monitoring has revealed depredation of nests by a variety of species including California gulls (*Larus californicus*), common ravens (*Corvus corax*), northern harriers (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicenis*), and gray fox (*Urocyon cinereoargenteus*) (SFBBO unpublished data).

Although larids (i.e., gulls, terns, and skimmers) have always used the South Bay for foraging during winter and migration, the use of this area has undoubtedly increased as a result of salt pond creation and, for gulls, the provision of food at landfills, and several species have begun nesting in the South Bay over the last century as a result (H. T. Harvey & Associates 2007b). Currently, gull populations in the Bay are highest in winter due to the presence of tens of thousands of (if not 100,000+) wintering gulls of at least 12 different species.

California gull populations in the South Bay have increased exponentially in the past two decades, increasing from hundreds of birds in 1982 to over 46,800 in 2008 (Strong et al. 2004). The increase has largely been attributed to the abundance of food available at several landfills in the area. Radio-marked California gulls had core areas within their home ranges that centered around landfills and attendance at landfills corresponded with operating hours (Ackerman et al. 2009). California gulls have been documented depredating shorebird eggs and are considered a major predator of American avocet and black-necked stilt chicks and western snowy plovers (Ackerman et al. 2007, Robinson-Nilsen 2009b), and likely prey on other species as well. The breach of Pond A6, as part of the SBSPRP, displaced the largest gull colony (>26,000 birds) and displaced gulls re-colonized surrounding areas, joining existing colonies (SFBBO, unpublished data).

Western gulls (*Larus occidentalis*) nest in small numbers in the South Bay, within California gull colonies or on bridges and other structures (SFBBO unpub. data). During the non-breeding season, nesting populations of western and California gulls within the South Bay are augmented by non-breeders of those species (likely including 10,000+ more California gulls and hundreds to 1,000+ western gulls).

Large numbers of herring (tens of thousands), Thayer's (*L. thayeri*; thousands), ring-billed (*L. delawarensis*; thousands to 10,000+), mew (*L. canus*; thousands), glaucous-winged (*L. glaucescens*; hundreds to 1,000+), and Bonaparte's (thousands) gulls winter in the South Bay. With the exception of the Bonaparte's gull, which forages primarily on invertebrates in ponds and sewage treatment plants, these gulls are opportunistic foragers. They eat a wide variety of animal matter, including invertebrates, fish, small mammals and birds, and carrion, as well as processed food in landfills. Many gulls forage or roost on intertidal mudflats at low tide (Warnock et al. 2002).

Terns are generally more abundant in the South Bay during the breeding season. On ELER, several pairs of least terns attempted to breed in pond E8A in 2007 and two nests were observed in 2008 and 2009 (C. Robinson pers. comm.), although the nests were depredated soon after initiation. One of the depredated least tern nests was recorded by a camera system in 2009 and the predator was identified as a northern harrier (SFBBO 2009). The South Bay, including the Refuge's Alviso and Mowry Ponds, are consistently used as post-breeding foraging sites for least terns, typically in late June through late August, prior to their southward migration. California least terns occasionally forage in Eden Landing ponds including E10, E9, and E8A typically in late summer. Highs include 305 in August of 2006, although an average of 18 birds may forage in these three ponds in the summer (USGS, prelim. data). Both adult and juvenile least terns roost on pond levees (both outboard levees and interior levees between ponds), as well as, boardwalks and other structures within ponds.

Other terns in the South Bay include post-breeding elegant terns (*Sterna elegans*), occasionally common terns (*Sterna hirundo*), and breeding Forster's and Caspian terns (*Sterna caspia*). Breeding Forster's and Caspian terns forage primarily on small fish within the open waters of the Bay and in low-salinity ponds, as well as tidal sloughs and freshwater and brackish channels and ponds. Caspian and Forster's terns often forage at inland ponds and lakes as well, even during the breeding season. Terns may roost on intertidal mudflats at low tide, whereas at high tide and at night they roost primarily on isolated levees, islands, and exposed mud surrounded by water within shallow ponds. Forster's terns in particular appear to prefer pond habitats over others in the South Bay, for foraging and nesting (Storng 2004). Numbers of Caspian terns have been declining in recent years and the only substantial colony in the Bay Area is now Brooks Island (East Bay Regional Parks District, Richmond; C. Strong pers. comm.).

The black skimmer (*Rynchops niger*) occurs in the South Bay. Black skimmers nest primarily on the coasts of the southeast United States, the Gulf of California, and the Pacific Coast of Baja, California, north to San Diego, and in California, they are considered Species of Special Concern only at nesting sites. Until the mid-1990s, the black skimmer was considered a very rare non-breeding visitor to the San Francisco Bay area. However, the species was documented nesting in San Francisco Bay in 1994, when one pair nested in Pond AB2 in Santa Clara County, and one pair nested at Hayward Regional Shoreline in Alameda County (Layne et al. 1996). Since 1994, this species has occurred in the South Bay every year and has nested at several additional sites, including ponds A1, A2W, AB1, A8, A16, E4C, E10, N2A, and R1 (Strong 2004). In these areas, black skimmers have usually nested among Forster's terns, on small dredge-spoil islands (including both bare islands and islands vegetated, sometimes heavily, with pickleweed) in ponds. Exact nesting locations vary from year to year. Within the

Refuge, the species is most abundant in the vicinity of the Alviso Complex and most post-breeding flocks have been recorded in this area (e.g., on Pond A8 and in Charleston Slough).

Double-crested cormorants nest on electrical transmission towers at several locations in the South Bay, including large colonies in towers over ponds A3N and A3W and adjacent to Steinburger Slough at Bair Island, and on the levee between Ponds A9 and A10 in Alviso. Approximately 94 percent of the double-crested cormorants recorded by Swarth et al. (1982) were in low-salinity ponds, though most of the cormorants used these ponds only for roosting (primarily on wooden pilings and platforms within the ponds). Although cormorants may take advantage of local concentrations of fish within ponds, most apparently feed in the Bay (Ainley 2000b; Anderson 1970).

Double-crested cormorant
Bill Purcell

Other Waterbirds (eared grebes, coots, and rails). The eared grebe and other species in the family Rallidae, which includes the American coot (*Fulica americana*), common moorhen (*Gallinula chloropus*), and several species of rails, are combined into a separate group. The eared grebe is a small diving bird that occurs abundantly as a non-breeding forager from October to April, only breeding occasionally in small numbers in the South Bay. (Cogswell 2000; Santa Clara County Bird Data, unpublished). Non-breeding eared grebes in the South Bay are closely tied to deeper, higher-salinity ponds such as the Mowry Ponds, where they feed on brine shrimp, brine flies, and reticulate water boatmen (Anderson 1970). Censuses of eared grebes suggest that the total Bay Area wintering/migrant population could be as high as 50,000 to 100,000 birds (Cogswell 2000).

American coots and, in much lower abundance, common moorhens breed in freshwater wetlands, channels, and ponds in and around emergent vegetation in a number of locations throughout the South Bay. These birds are omnivorous, eating a wide variety of plant and animal (particularly invertebrate) material. Coot populations are augmented substantially during winter, when this species occurs by the hundreds or low thousands on lower-salinity ponds (Anderson 1970), sewage treatment plant ponds, Shoreline Lake, and other open-water locations.

Two special-status rail species can be found in the South Bay: the California clapper rail and California black rail. The Federal and State endangered California clapper rail is a secretive marsh bird endemic to the marshes of San Francisco Bay. With the filling, diking, or

conversion of most of California clapper rail former habitat, the population has declined severely. Clapper rails nest in salt and brackish marshes along the edge of the Bay, and are most abundant in extensive salt marshes and brackish marshes dominated by cordgrass, pickleweed, and marsh gumplant, and containing complex networks of tidal channels (Harvey 1980). Shrubby areas adjacent to or within tidal marshes are important for predator avoidance at high tides. California clapper rails are non-migratory, although juveniles disperse around the Bay during late summer and autumn. Adults are territorial, and maintain territories throughout the year. Breeding-season surveys of South San Francisco Bay marshes for California clapper rails through the early 1990s indicated that the most substantial populations of clapper rails in the South Bay were, predictably, in the largest sections of tidal salt marsh. Clapper Rails occur in other marshes including Mowry Marsh and Dumbarton Marsh (in the East Bay between the Dumbarton Bridge and Mowry Slough), the Faber/Laumeister Tracts, Greco Island in Redwood City, Ideal Marsh (adjacent to Cargill Salt Pond N5), Calaveras Marsh (adjacent to Cargill Salt Ponds M2 and M3), Triangle Marsh in Alviso, southern Whale's Tale Marsh, and adjacent to the ponds as well (Foin et al. 1997; Krause, pers. comm.).

The California black rail, listed as threatened in California, is a small rail that inhabits tidal, brackish, and freshwater marshes. Black rails reportedly bred in the Alviso area in the early 1900s (Wheelock 1916), but currently it is not known to breed in the South Bay. In the San Francisco Bay area, this small rail currently breeds primarily in marshes in the north San Francisco Bay Area (i.e., San Pablo Bay and Suisun Bay). After breeding, some black rails apparently disperse into the South Bay, accounting for most records of the species in this area. Most observations of black rails in the South Bay consist of only a few birds observed seeking high-tide refugial cover at the edges of salt marsh in a few areas during winter tides from November to February. Many black rail sightings occurred outside the Refuge, although late-season (April) calling black rails have been reported near the east end of the Dumbarton Bridge, and in spring 2004, individuals were heard in brackish marsh about one mile up Old Alameda Creek, near the ELER Pond E6A (two birds) and near the mouth of the Alameda Creek Flood Control Channel (J. Alberston, pers. comm; C. Morris, pers. comm.). In summer 2009, one individual was heard in Triangle Marsh, north of Alviso Pond A15 for three weeks in a row (K. Henderson, pers. comm.). In the spring of 2012, individuals were heard repeatedly calling from LaRiviere Marsh and Ecology Marsh (R. Tertes, pers. comm.).

Two other rails occur regularly in the South Bay. Both the sora (*Porzana carolina*) and Virginia rail (*Rallus limicola*) may breed in very small numbers in freshwater wetlands around the South Bay, and to a limited extent within the Refuge, and they occur much more commonly as non-breeders from August to May. During the non-breeding season, these secretive species occur in a wide variety of tidal and non-tidal salt, brackish, and freshwater marsh habitats, being most abundant in freshwater and brackish areas. Here, these species forage primarily on invertebrates.

Landbirds. Three passerines, considered Species of Special Concern in California, may breed in marshes within the Refuge: the Alameda song sparrow (*Melospiza melodia pusillula*), Bryant's savannah sparrow (*Passerculus sandwichensis alaudinus*), and San Francisco common yellowthroat (*Geothlypis trichas sinuosa*). The Alameda song sparrow is one of three subspecies of song sparrow breeding only in salt marsh habitats in the San Francisco Bay Area. Locally, it is most abundant in the taller vegetation found along tidal sloughs, including

cordgrass and marsh gumplant. Populations of the Alameda song sparrow have declined due to the loss of salt marshes around the Bay, although within suitable habitat it is still fairly common. The location of the interface between populations of the Alameda song sparrow and those of the race breeding in freshwater riparian habitats (*M. m. gouldii*) along most creeks is not known due to difficulties in distinguishing individuals of these two races in the field. Optimum habitat for this subspecies is tidal salt marsh, although it occurs in tidal brackish marsh, seasonal wetlands, pond complexes and other adjacent habitats. Alameda song sparrows commonly occur throughout the South Bay and are particularly abundant in more extensive marshes but also occurring commonly in narrower marshes along tidal sloughs as long as taller herbaceous vegetation for nesting is present (Chan and Spautz 2008).

Bryant's savannah sparrow is one of 17 subspecies of savannah sparrows in North America, four of which breed in California. The Bryant's savannah sparrow nests in pickleweed and peripheral halophytes in the upper portions of tidal and diked saltmarsh, along vegetated levees, and in adjacent upland transitional zones. Several subspecies of savannah sparrow occur within the region during the non-breeding season, but Bryant's is the only race that breeds here. Although abundance estimates are not available, it appears that within the Refuge, Bryant's savannah sparrow is a fairly common breeder in high-marsh habitats dominated by pickleweed, saltgrass, and other short vegetation. It also breeds in grasslands adjacent to salt marshes, and in more upland grasslands in hills surrounding the South Bay (Fitton 2008).

The San Francisco common yellowthroat is one of at least 13 subspecies of common yellowthroat. It is an endemic small songbird that inhabits emergent vegetation, primarily in fresh and brackish marshes, and associated upland areas in the San Francisco Bay Area. This species is a fairly common breeder in fresh and brackish marsh habitats virtually wherever they occur, although very small patches of marsh often lack this species. Within the Refuge, large populations occur in brackish and fresh marshes in the Mowry and Alviso Units (e.g., along the middle and upper reaches of the major sloughs and in the Warm Springs/Alviso marshes) and along Alameda Creek and the Alameda Flood Control Channel in the ELER (Gardali and Evens 2008).

Other nesting passerines include red-winged blackbirds (*Agelaius phoeniceus*) that nest in freshwater marsh within the Refuge, and loggerhead shrikes (*Lanius ludovicianus*), California towhees (*Pipilo crissalis*), and American goldfinch (*Carduelis tristis*) that nest in scattered small trees and shrubs along pond levees and upland edges. Western meadowlarks (*Sturnella neglecta*) and mourning doves (*Zenaida macroura*) may nest in annual grasslands in the Refuge. Barn swallows (*Hirundo rustica*) and cliff swallows (*Petrochelidon pyrrhonota*) breed on artificial structures within and adjacent to the baylands and forage commonly for flying insects over marshes and ponds within the Refuge.

Birds in developed areas face not only regular human disturbance, but also unique foraging and nesting opportunities. Those that are well adapted to such habitats commonly breed here. These species include the house finch (*Carpodacus mexicanus*), mourning dove, barn swallow, cliff swallow, black phoebe (*Sayornis nigricans*), and non-natives such as European starling (*Sturnus vulgaris*), rock pigeon (*Columba livia*), and house sparrow (*Passer domesticus*).

Seed-eating birds that frequent more open habitats during migration and winter include horned larks (*Eremophila alpestris actia*), American pipits (*Anthus rubescens*), western meadowlarks, lesser goldfinches (*Carduelis psaltria*), white-crowned sparrow (*Zonotrichia albicollis*), golden-crowned sparrow (*Zonotrichia atricapilla*), Lincoln's sparrow (*Melospiza lincolnii*), and fox sparrow (*Passerella iliaca*).

A variety of raptors also are found on the Refuge including the white-tailed kite (*Elanus leucurus*), which nest in scattered small trees and shrubs along pond levees and upland edges. Northern harriers, a Species of Special Concern in California, also nest within tidal salt marshes in broad vegetated marsh plains. This species is a common forager over San Francisco Bay marshes, drier ponds, and extensive areas of ruderal habitat immediately surrounding the Bay, particularly during the non-breeding season (winter) when migrant and wintering birds augment the local resident population. Northern harriers breed in small numbers within the Refuge, nesting in the larger expanses of tidal marsh that remain, such as Triangle Marsh in Alviso, the Warm Springs marshes, along Old Alameda Creek and the Alameda Flood Control Channel, Greco Island, and Bair Island. Northern harriers are important predators of nesting shorebirds and terns in the South Bay, with individuals or pairs "keying in" on certain areas having concentrations of nesting waterbirds. This species has been known to take both adult and young snowy plovers in the ELER (Davis and Niemela 2008, Robinson-Nilsen 2009b).

White-tailed kite
USFWS

Transmission towers within the marshes and ponds in the South Bay provide nesting sites for red-tailed hawks and common ravens. These species prey on small mammals, rails, waterfowl, and shorebirds in the South Bay. Common ravens are particularly notorious predators of eggs and young of a variety of birds and are known to predate snowy plover nests (Robinson-Nilsen 2009). Populations of ravens, as well as American crows (*Corvus brachyrhynchos*), have increased markedly in recent decades throughout the Bay area, feeding heavily at landfills and dumpsters around the South Bay but also preying on other wildlife species. American crows and common ravens have been documented as the most significant predators of California least terns and western snowy plovers in several locations in California (Liebezeit and George 2002). In the South Bay, common ravens have been observed foraging on the California clapper rail (S. Rottenborn pers. obs.) and the western snowy plover (SFBBO unpublished data). Peregrine falcons (*Falco peregrinus anatum*) have recently used old hawk and raven nests on transmission towers within the Refuge. In the Alviso Complex, one to two pairs of peregrines have nested on transmission towers since at least 2006. The increase in the

number of raptor and corvid predators breeding in the South Bay has unknown effects on other survivorship, distribution, and recruitment levels in other bird species.

During the non-breeding season, additional raptors occur in the baylands. Short-eared owls (*Asio flammeus*), which formerly nested in South Bay marshes, occur regularly in small numbers in the more extensive marshes in winter (e.g. Mowry Marsh, Bair Island, and Greco Island), foraging on small mammals and birds. Merlins (*Falco columbarius*), and other raptors, forage for waterfowl and shorebirds throughout the South Bay, particularly during migration. Small numbers of golden eagle, bald eagle, and prairie falcon (*Falco mexicanus*) are seen on the Refuge during the winter.

Non-native grasslands and the Warm Spring vernal pool grasslands in the South Bay support populations of burrowing owl (*Athene cunicularia*). Burrowing owls are Species of Special Concern in California due to habitat destruction and local extirpation, including in the San Francisco Bay Area where the South Bay population has been declining sharply. This species does quite well in highly modified landscape. Primarily a grassland species, burrowing owls can thrive provided there are suitable burrows for roosting and nesting with sufficient surrounding short vegetation, as well as adequate food supplies (i.e., insects and small mammals). Since the re-initiation of grazing at Warm Springs in 2004, the ground squirrel population has increased, providing an abundance of natural burrows for burrowing owls. In addition, grazing has kept the vegetation shorter than in the past, which the owls prefer. Although quantitative burrowing owl surveys have not been regularly conducted at Warm Springs, it does appear as if the burrowing owl population has increased in recent years (Loredo, pers. comm). Culverts, pipes, and nest boxes may also be used by owls as nest sites (Gervais et al. 2008). Burrowing owls have also been seen duing the breeding season in the Alviso area, especially in and near New Chicago Marsh.

Burrowing Owl
Aric Crabb

Nesting burrowing owls in the greater San Francisco Bay area and especially in the South Bay have been declining at a rapid pace largely due to habitat loss. Within the Final Santa Clara County Habitat Conservation Plan, conservation efforts for the burrowing owl are focused in the north San José/Baylands region because of the existing colonies there and the potential for expansion of the population (Santa Clara County 2012). In 2009, the three largest colonies of burrowing owls in the South Bay (San José International Airport, and Moffett Airfield, and Shoreline Park) had a total of 51 adults. The Refuge is adjacent to both Moffett Airfield and Shoreline Park, although no known burrowing owls are on Refuge lands in that area.

Mammals
Relatively few species of mammals occur in the South Bay, owing to the intense disturbance and habitat conversion that has occurred within the area. Within the Refuge, most research attention on mammals has focused on special-status salt marsh associated species (i.e., the salt marsh harvest mouse) and salt marsh wandering shrew (*Sorex vagrans halicoetes*), along with other small mammals using salt marshes), the use of South Bay waters and tidal habitats by the Pacific harbor seal (*Phoca vitulina richardsi*), and the presence and impacts of non-native mammals. Upland habitats within the Refuge are primarily ruderal, most of which occurs along levee edges and at the urban interface, with some non-native grassland habitat and riparian corridor supporting a variety of small mammal species.

Salt marsh harvest mice and salt marsh wandering shrews occur in the Refuge primarily in pickleweed-dominated salt marshes. The Federally endangered salt marsh harvest mouse is a small mouse endemic to salt marshes of San Francisco Bay. These mice are dependent on dense vegetative cover, usually in the form of pickleweed and other salt dependent or salt tolerant vegetation in tidal and diked salt marshes (Fisler 1965; Shellhammer 1982; Shellhammer 2000a; Shellhammer and others 1988; Shellhammer and others 1982). Grasslands adjacent to pickleweed marshes are used in the spring when new growth affords suitable cover and possibly forage (Johnson and Shellhammer 1988). Salt marsh harvest mice may also use adjacent grasslands regularly to avoid high tide events. However, only a small percentage of the edge of the South Bay has grassland or other adjacent cover. On the highest winter tides, the lack of high-tide refugia exposes salt marsh harvest mice to intense predation, and numerous small mammals (many of which are likely salt marsh harvest mice) have been observed being depredated by gulls, herons, egrets, and raptors on such high tides in the South Bay (C. Morris, pers. comm.). Marshes without appropriate cover, and narrow marshes without refugia zones into which the mice can escape during flooding or high tides, generally lack salt marsh harvest mice. The most fundamental reason for the decline of the salt marsh harvest mouse is loss of habitat through filling (i.e., destruction), subsidence, and vegetation changes (USFWS 1984, Bias and Morrison 1993, and Shellhammer 2000).

Salt marsh harvest mouse
Judy Irving © Pelican Media

Trapping studies for the salt marsh harvest mouse in the South Bay have revealed much about the status of other small mammals in marsh habitats of the region. House mice (*Mus musculus*) and California voles (*Microtus californicus*), the most abundant mammals trapped during the studies, are common in diked and tidal salt marshes, particularly in the pickleweed-dominated high marsh and the peripheral halophyte zone, where the western harvest mouse (*Reithrodontomys megalotis*) also occurs in the high marsh (Environmental Science Associates 1991; H. T. Harvey & Associates 1988; 1989; 1990; 1991; Harvey and Stanley Associates 1985; 1986; Muench 1985; Shellhammer et al. 1988; Wondolleck et al. 1972).

The salt marsh wandering shrew, a Species of Special Concern in California, was formerly more widely distributed in the Bay Area; however this small insectivorous mammal is likely confined to salt marshes of the South Bay (Findley 1955). Salt marsh wandering shrews occur most often in medium-high wet tidal marsh (6 to 8 feet above sea level), with abundant driftwood and other debris for cover (Shellhammer 2000b). This species is typically found in fairly tall pickleweed, in which these shrews build nests, and they have also been recorded occasionally in diked marsh. As of 1986, there were only four locations in the Refuge, including Bair Island, the Alameda Creek mouth, Dumbarton Point, and Mowry Slough, where this species had been positively identified between 1980 and 1985, although the species was considered likely present in a number of other marshes in the South Bay (Western Ecological Services Company [WESCO] 1986). Like the salt marsh harvest mouse, the lack of extensive salt marsh with high-tide refugia and the effects of habitat fragmentation and barriers to dispersal likely contribute to low populations numbers of this species.

Harbor seals, the only marine mammals that regularly occur in the South Bay, forage in bay waters and sloughs, and breed and loaf on the edges of tidal marshes and mudflats. Haul-out sites are typically mudflats far from areas used regularly by humans, and near deeper water, where seals forage. Mowry Slough, within the Refuge, is the most extensively used site in the South Bay. This site produced 78 pups in 1999, 90 in 2000, 102 in 2001, and 144 in both 2002 and 2003 (Green et al. 2004). Surveys in April 2004 found 283 seals, including 59 pups, at Mowry Slough and 34 seals, including nine pups, near the mouth of Coyote Creek at Calaveras Point. Peak counts in April 2009 found 168 seals, including 69 pups, at Mowry Slough and 67 seals, including 15 pups, near the mouth of Coyote Creek at Calaveras Point (N. Bell, unpub. data). At both these sites, mudflats and adjacent pickleweed marsh at various locations may be used at any particular time. Other haul-out sites in the Refuge has varied over time, including Guadalupe Slough near the northeastern end of Pond A3N, the mouth of the Alameda Flood Control Channel, Newark Slough, Corkscrew Slough at Bair Island, and Greco Island are currently used or have been important haul-outs historically (Bell, unpublished data; Fancher and Alcorn 1982; Kopec and Harvey 1995).

Native gray fox
Judy Irving © Pelican Media

Native mammals such as the California vole, western harvest mouse, deer mouse (*Peromyscus maniculatus*), Botta's pocket gopher (*Thomomys bottae*), California ground squirrel (*Spermophilus beecheyi*), black-tailed jack rabbit (*Lepus californicus*), Audubon's cottontail (*Sylvilagus audubonii*), brush rabbit (*Sylvilagus bachmani*), gray fox, raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), wester spotted skunk (*Spilogale gracilis*), and long-tailed weasel (*Mustela frenata*) occur on pond levees, at the margins of marshes, and in upland and vernal pool grassland habitats (See Appendix E for a Refuge Species List). A mountain lion (*Puma concolor*) has also been observed once at the Refuge in Fremont area around the Hetch Hetchy Pipline, Coyote Hills Regional Park, and along the Alameda Flood Control Channel (C. Morris, pers comm). Several species of bats, such as the Mexican free-tailed bat (*Tadarida brasiliensis*), forage over the ponds, marshes, and grasslands of the South Bay. A former silo on the Refuge's Mayhews Landing tract was converted to a large bat silo in 2007 by Meadowsweet Dairy of Marin County and Dr. Dave Johnston, Santa Clara University. Dr. Johnston is monitoring the silo to determine the extent if any of use of the silo by bats.

Several non-native mammal species occur in the South Bay, including the red fox (*Vulpes vulpes regalis*), Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), feral cat (*Felis felis*), and Virginia opossum (*Didelphis virginiana*). These species have the potential to negatively impact populations of California clapper rails and other native species, such as the Federally threatened western snowy plover, in the South Bay.

Reptiles and Amphibians
Relatively few species of reptiles and amphibians occur in the Refuge, and consequently, there has been little study of these taxa within the Refuge. The western fence lizard (*Sceloporus occidentialis*), a ubiquitous lizard in California, occurs in a variety of habitats in the Refuge. Other reptile species that occur within the Refuge include garter snakes (*Thamnophis couchi*, *T. elegans*, and *T. sirtalis*), gopher snakes (*Pituophis melanoleucus*), and southern alligator lizards (*Elgaria multicaranata*), all of which occur along edges of vegetated levees and in grassland and ruderal habitats.

A small, isolated population of western pond turtles, a Species of Special Concern in California, occurs in brackish habitats in the northern channel near Moffett Field, as well as the nearby Sunnyvale WPCP outside the Refuge. Small numbers of a several species of non-

native turtles, most likely former pets that have been released, are present in South Bay streams as well.

California tiger salamanders, a Federally threatened species, occur in vernal pool habitats in the Warm Springs sub-unit. The tiger salamander has an obligate biphasic life cycle (Shaffer et al. 2004). Although the larvae develop in the vernal pools and ponds in which they are born, tiger salamanders are otherwise terrestrial and spend most of their post-metamorphic lives in widely dispersed underground retreats (Shaffer et al. 2004; Trenham et al. 2001). Juvenile and adult tiger salamanders typically spend the dry summer and fall months in the burrows of small mammals, such as California ground squirrels and Botta's pocket gopher (Storer 1925; Loredo and Van Vuren 1996; Petranka 1998; Trenham 1998a). Most of the tiger salamander natural historic habitat (vernal pool grasslands) available in this region has been lost due to urbanization and conversion to intensive agriculture (Keeler-Wolf et al. 1998). Pacific treefrogs (*Pseudocris regilla*) also breed in the vernal pools of the Warm Springs sub-unit and are present in other areas of the Refuge. Slender salamanders (*Batrachoseps attenuates*) are also present on the Refuge.

California tiger salamander
USFWS

Terrestrial Invertebrates

Upland Invertebrate Communities. When considering ecosystem function, upland invertebrates are separated into four groups:

1) soil fauna, responsible for consuming decayed organic matter (detrivores),
2) phytophagous invertebrates, which consume tissue from living plants,
3) zoophagous invertebrates, which predate or parasitize other invertebrates or larger animals; and
4) pollinators, responsible for reproduction of many flowering plants.

Some representative examples of soil macrofauna that may occur in the Refuge include colonial insects such as ants (Hymenoptera: Formicidae) and termites (Isoptera). Many beetles are also present in the soil, including dung beetles such as the European dung beetle (*Aphodius fimetarius*, Coleoptera: Scarabidae). Although not well known as a group due to their tiny size, entognathous (internal mouth-part) insects (orders Protura, Diplura, and Collembola) are extremely numerous in all non-saturated soil samples, and are concomitantly some of the most important detrivores. There are also large, common, non-hexapodous invertebrates such as earthworms, millipedes, centipedes, and pillbugs.

Phytophagous invertebrates likely to occur in the Refuge include numerous insect species in the Coleoptera (e.g., weevils, leaf beetles, bark beetles), Homoptera (hoppers, cicadas, aphids, whiteflies, and scale insects), Hemiptera (e.g., seed bugs and leaf bugs), Thysanoptera (thrips), larval Lepidoptera (caterpillars), Orthoptera (grasshoppers, crickets, and katydids), Phasmida (walking sticks and leaf insects), Psocoptera (woodlice and booklice), and Neuroptera (lacewings), as well as arachnid mites (Acarina), and terrestrial gastropods (snails and slugs).

Zoophagous invertebrates include both those groups that feed on other invertebrates, as well as those adapted to be parasites of larger animals such as birds and mammals (e.g., ticks, lice, and fleas). This group includes many species within the Diptera (e.g., asilid and tabanid flies), Neuroptera (e.g., snakeflies, antlions, and dobsonflies), Hymenoptera (parasitic and predatory wasps, ants, and bees), Strepsiptera (twisted wing parasites), Mantoidea (mantises), Hemiptera (assassin bugs and toe biters), and Coleoptera (e.g., ladybugs and tiger beetles). Another categorization within the zoophagous invertebrates includes those species that are parasites of birds and mammals, such as biting lice (Mallophaga), sucking lice (Anoplura), Siphonaptera (fleas), dipterans such as mosquitos (Diptera:Culicidae), biting gnats (Diptera:Ceratopoginidae), and Acarina (ticks). These species are important vectors of mammalian and avian diseases.

Those invertebrates that serve as potential pollinators in the upland habitats within the Refuge include insects in the Orders Hymenoptera, Diptera, Lepidoptera, and Coleoptera. European honeybees (*Apis mellifera*, Hymenoptera: Apidae) are extremely important naturalized pollinators of many South Bay plants. Native bees include bumblebees (*Bombus sp*., Hymenoptera: Apidae), the short leafcutter bee (*Megachile brevis*, Hymenoptera: Megachilidae), loosely colonial minute sweat bees (*Halictus* and *Lasioglossum sp*., Hymenoptera: Halictidae), and common burrowing bees (*Andrena sp*., Hymenoptera: Andrenidae). Wasps (Vespidae, Specidae, Tiphidae) are other hymenopterans that may pollinate plants, but also predate upon or parasitize other insects for their larva. Several flies in the Syrphidae (flower flies) and Bombyliidae (bee flies) are also pollinators, although these are often generally considered less competent at pollen movement than bees.

Aquatic Invertebrates

Subtidal/Intertidal Invertebrate Communities. A variety of clams and mussels, many of which are introduced, occur in the South Bay and Refuge. Of the native species, the Baltic clam (*Macoma balthica*) is the only one that is still common. In the mid-1800s, the eastern oyster (*Crassostrea virginica*) and Pacific oyster (*C. gigas*) were introduced into San Francisco Bay, replacing much of the fishery for the native oyster (*Ostrea lurida*). Limited recolonization of native oysters has occurred and efforts are underway to restore oyster beds in the Bay. Two native caridean shrimps, the California bay shrimp (*Crangon franciscorum*) and blacktail bay shrimp (*C. nigricauda*), are common in tidal sloughs and in the Bay itself. The California bay shrimp supports the only commercial fishery remaining in the South Bay. Harvest of brine shrimp from select refuge ponds including Mowry and Alviso ponds ended in 2007 when the contract expired.

Crabs of South Bay tidal habitats include the yellow shore crab (*Hemigrapsus oregonensis*), lined shore crab (*Pachygrapsus crassipes*), Dungeness crab (*Cancer magister*), brown rock crab (*Cancer antennarius*), red rock crab (*Cancer productus*), and several introduced species,

including the xanthid crab (*Rothropanopeus harrisii*), Chinese mitten crab (*Eriocheir sinensis*), and European green crab (*Carcinus maenas*) (Josselyn and San Francisco State Univ. 1983). Most of these species forage both in tidal sloughs and on mudflats and deeper waters of the South Bay.

Tidal Marsh Invertebrate Communities. Within tidal salt marshes found in the Refuge, common invertebrates include the ribbed mussel (*Ischadium demissum*), the Baltic clam, the mud snail (*Illyanassa obsoleta*), and the yellow shore crab (*Hemigrapsus oregonensis*) (Niesen and Lyke 1981). The introduced ribbed mussel is common within the lower (cordgrass) zone of tidal marshes, and the Baltic clam may occur up into the cordgrass zone as well (Josselyn and San Francisco State Univ. 1983; Vassallo 1969). The mud snail is abundant in intertidal habitats and sloughs.

Terrestrial invertebrate assemblages of salt marshes are dominated by a variety of insects and spiders. Diptera (true flies) are a major component of cordgrass/pickleweed marshes that occur in the Refuge, while the orders Homoptera (plant hoppers and aphids) and Lepidoptera (butterflies and moths) are also well represented (Lane 1969). Reticulate water boatmen, brine flies, chironomid midges (Chironomidae), and other species dominate open-water areas such as marsh ponds within the tidal marsh (Barnby et al. 1985; Maffei 2000).

More than 20 species of mosquitoes occur in the San Francisco Bay area, but five of these, the summer salt marsh mosquito (*Aedes dorsalis*), winter salt marsh mosquito (*Aedes squamiger*), Washino's mosquito (*Aedes washinoi*), western encephalitis mosquito (*Culex tarsalis*), and winter marsh mosquito (*Culiseta inornata*), are routinely controlled by the mosquito and vector control agencies within each of the counties of South San Francisco Bay. Within the Refuge under Refuge Special Use Permits, the Alameda County Mosquito Abatement District, San Mateo County Mosquito Abatement District, and the Santa Clara Vector Control District are responsible for managing the populations of mosquitoes for their respective communities.

Pond Invertebrate Communities. Arthropods are the dominant, and ecologically most important, group of invertebrates inhabiting South Bay ponds. The brine shrimp is the predominant animal in higher-salinity ponds. Although it can occur in salinities near that of seawater (Persoone and Sorgeloos 1980), the brine shrimp's aquatic predators (e.g., insects such as water boatmen) are more abundant in less saline water (Wurtsbaugh 1992), allowing brine shrimp to reach high densities only in their optimal hypersaline environments (70 to 170 ppt) (Carpelan 1957). Brine flies (*Diptera: Ephydridae*) occur in large numbers in tidal marsh and along pond edges. Brine flies and brine shrimp are both important food resources for birds. In lower-salinity ponds, numerous nematodes occur in decaying organic matter and mud. The most prevalent worm in lower-salinity ponds is the polychaete *Polydora ligni*. Carpelan (1957) found few mollusks within the ponds.

Freshwater Macroinvertebrate Communities. In the vernal pool habitats located in the Mowry Unit in the Warm Springs area, studies of invertebrates have focused primarily on the Federally endangered vernal pool tadpole shrimp (VPTS). VPTS are a member of the aquatic crustacean order Notostraca. This shrimp is generally found in sparsely-vegetated, grass-bottomed swales on old alluvial soils that are underlain by hardpan, or in mud-bottomed pools containing highly turbid water. The pools are usually six inches or more, and typically retain

water longer than shallower vernal pools. The life history of the VPTS is linked to the phenology of its vernal pool habitat. VPTS spend the majority of their lives as dormant cysts, which may remain viable for up to 10 years. As rainfall fills the vernal pools, some of these drought-resistant cysts (eggs) will hatch. In 3–8 weeks, shrimp will reach sexual maturity. After VPTS mate, females deposit eggs on vegetation and other objects on the bottom of pools. These new eggs are able to hatch during the same winter season, but may wait till the next winter. The cysts can remain dormant and viable for up to 10 years embedded in the top layer of vernal pool soil sediments until conditions are favorable. Ahl (1991) found that egg cysts hatch within 11 to 26 days (mean = 17 days) after pools refill with water. In contrast to most fairy shrimp, juvenile VPTS develop slowly and require a minimum hydroperiod of about 7 to 8 weeks to reach reproductive maturity in the field (Gallagher 1996, Helm 1998). VPTS are considered an ancient species. Fossilized tadpole shrimp that lived millions of years ago look almost exactly like the ones we see today. The shrimp lived on Earth before there were fish and they never evolved defenses against fish predators. So, like fairy shrimp, tadpole shrimp now can live only where fish do not—in temporary pools.

Warm Springs also supports the versatile fairy shrimp *(Branchinecta lindahli)* of the family Branchinectidae. This species is not Federally listed and is the most commonly collected and widespread anastracon in California. They can be found in ephemeral and vernal pools and have a shorter lifecycle than VPTS, thus can use pools with shorter inundation times. Their cysts are resistant to extreme heat, cold, and dehydration and can survive passing through the digestive tract of many birds and other animals, aiding in dispersement and gene flow.

Invasive Invertebrates. At least 212 species, 69 percent of which are invertebrates, have been introduced to the Bay and delta since 1850 (Cohen and Carlton 2003). The most ecologically important include a number of clams, many of which were introduced into the Bay via releases of ballast water (Cohen and Carlton 1995), such as the introduced Asian species of *Venerupis* and *Musculista*, and the Atlantic clam *Gemma*. With the exception of the Baltic clam, the numerically dominant mollusks of the South Bay are all non-native species (Nichols and Pamatmat 1988). A carnivorous opisthobranch, *Philine auriformis*, invaded the South Bay in 1982, and has been noted in abundance in bottom trawls by the Marine Sciences Institute (Thompson and Shouse 2004). The polychaete worm *Streblospio benedicti* was first detected in the Bay in 1932. This species readily colonizes the Bay in both deep and shallow intertidal habitats, and is consistently one of the dominant species on South Bay mudflats.

The dominant crustaceans of the South Bay are all introduced as well. The tube-dwelling amphipod *Ampelisca abdita* was first detected in the Bay in the 1950s. Since then, it has increased in abundance, and can achieve very dense beds at a variety of depths. The other dominant crustaceans in the South Bay include several burrowing amphipods, including *Grandidierella japonica* and several non-native *Corophium* species. The European green crab became established in the San Francisco Bay in 1989–1990. This opportunistic omnivore eats a variety of plant and animal matter, including bivalves and shore crabs, and has the potential to impact native species (Josselyn et al. 2004).

Two non-native invertebrate species, the Australian-New Zealand boring isopod (*Sphaeroma quoyanum*) and Chinese mitten crab, could physically impact South Bay marshes, levees, streambanks, and other structures. The Australian-New Zealand boring isopod burrows into mud banks and levees throughout the Bay, potentially weakening these features and making

them prone to erosion (Talley et al. 2001). Another burrowing species that may cause the same problem is the Chinese mitten crab, which has been known to accelerate bank erosions in Germany. First detected in the Bay in 1992, the mitten crab has undergone rapid population increases throughout the Bay and its tributaries.

Fish

Fishes play very important ecological roles in the South Bay system. A dataset from the CDFG and several other studies provide information on fishes of the South Bay's tidal habitats, while several studies have identified the fish present in South Bay ponds (Anderson 1970; Carpelan 1957; Lonzarich 1989; Takekawa et al. 2005). Information on key species is also available in the Goals Project's Baylands Ecosystem Species and Community Profiles (Goals Project 2000).

Fish Communities of Tidal Habitats. More than 100 fish species have been recorded in the tidal waters of the South Bay (Laine, pers. comm.). Numerically, the dominant fish since 1980 have been the northern anchovy (*Engraulis mordax*), shiner surfperch (*Cymatogaster aggregata*), longfin smelt (*Spirinchus thaleichthys*), white croaker (*Genyonemus lineatus*), Pacific staghorn sculpin, bay goby (*Lepidogobius lepidus*), plainfin midshipman (*Porichthys notatus*), English sole (*Parophrys vetulus*), cheekspot goby (*Ilypnus gilberti*), and Pacific herring (*Clupea pallasi*) (CDFG data in Life Science 2004).

Kinnetics (1987) collected fish from two locations in Coyote Creek and one location in Guadalupe Slough between 1982 and 1985. The dominant species collected from these sloughs included the staghorn sculpin, northern anchovy, starry flounder (*Platichthys stellatus*), shiner surfperch, yellowfin goby (*Acanthogobius flavimanus*), threadfin shad (*Dorosma petenense*), and longfin smelt.

Surveys of South Bay tidal sloughs by the USGS (Takekawa et al. 2005) from March 2004 to June 2005 recorded a total of 16 fish species in Alviso Slough, Coyote Creek, and Stevens Creek. Northern anchovies and topsmelt were by far the most abundant species caught; the American shad (*Alosa sapidissima),* threadfin shad, longjaw mudsucker, longfin smelt, common carp (*Cyprinus carpio*), starry flounder, rainwater killifish (*Lucania parva*), bat ray (*Myliobat*is *californica*), leopard shark (*Triakis semifasciata*), Sacramento sucker (*Catostomus occidentalis occidentalis*), striped bass (*Morone saxatilis*), staghorn sculpin, shiner surfperch, and yellowfin goby were also recorded. Many of the fish recorded in the South Bay, including the bat ray, leopard shark, northern anchovy, gobies, and many others, occur in tidal channels within marshes, in sloughs, and/or on mudflats at high tide when they are inundated. These tidal channels and mudflats are productive foraging habitats for estuarine fish in this system (Harvey 1988). See Appendix E for a fish species list.

The degree by which different species use the Bay for breeding and foraging vary widely among species. The South Bay is particularly important to the leopard shark, given that pupping (live birth) in the San Francisco Bay occurs almost exclusively in the South Bay (CDFG Bay trawl data cited in McGowan (2000)). The Bay is also important for northern anchovies, which spawn in the South Bay (McGowan 1986), as well as jacksmelt (*Atherinopsis californiensis*). Adult topsmelt enter shallow sloughs and mudflats to spawn in late spring and summer (Saiki 2000a). The Pacific staghorn sculpin is most abundant in central and north San Francisco Bay, but in some years it occurs commonly in the South Bay as well (CDFG

1987 in Tasto (2000a)) and spawns from November to March. The arrow goby (*Clevelandia ios*) occurs on shallow intertidal flats and in salt-marsh channels throughout much of the South Bay and breeds primarily in spring and early summer (Hieb 2000a). The bay goby occurs in somewhat deeper-water habitats than the arrow goby, and is also a common breeding species in the South Bay (Hieb 2000b). The longjaw mudsucker resides on mudflats and in tidal channels and sloughs and spawns from November through June in the South Bay (Hieb 2000c).

Pacific herring occur in the North Bay from November through March when spawning occurs; larvae and juveniles occur in other parts of the Bay, including the South Bay (Tasto 2000b). Longfin smelt occur in the South Bay year-round as pre-spawning adults and yearling juveniles (Wernette 2000). Striped bass were introduced into the San Francisco Estuary in 1879, and are now the most important sport fish in the San Francisco Estuary (Sommer 2000). Striped bass in the South Bay are likely foraging subadults, as this species is not known to breed within the Refuge or other parts of the South Bay. The California halibut (*Paralichthys californicus*) and juvenile starry flounders forages to some extent in the South Bay, but are not known to breed anywhere inside San Francisco Bay (Saiki 2000b). Other species forage in the South Bay but are not known to breed here.

The Federally threatened green sturgeon (*Acipenser medirostris*) (Southern Distinct Populations Unit) is a long-lived, slow-growing fish and the most marine-oriented of the sturgeon species. The green sturgeon ranges from Ensenada, Mexico, to the Bering Sea in marine waters, and commonly occurs in coastal waters from San Francisco Bay to Canada. The actual historical and current distribution of where this species spawns is unclear because their original spawning distribution may have been reduced due to harvest and other anthropogenic effects and because they make non-spawning movements into estuaries during summer and fall (Adams et al. 2007). Historically, excessive fishing mortality for white sturgeon likely caused an accompanying decline in green sturgeon, but the degree of green sturgeon decline is unknown (Adams et al., in press). Potential threats or risk factors for the green sturgeon include the concentration of spawning in the Sacramento River and the apparent small population size; loss of spawning habitat; harvest bycatch concerns; potentially lethal water temperatures for larval green sturgeon; entrainment by water projects in the Central Valley; and the adverse effects of toxic materials and exotic species (Adams et al. 2002).

The Federally threatened steelhead trout migrate through the South Bay and Refuge into freshwater streams as adults typically from December through April. Outmigration of smolts mainly occurs from February through June (Roessler et al. 2001, SCVWD unpublished data). The Central California Coast Distinct Population Segment steelhead are not known to occur within any of the ponds, but they are present in Alviso slough, Old Alameda Creek, Coyote Creek, San Francisquito Creek, and other watersheds in the South Bay (Leidy et al. 2005). Steelhead populations in the South Bay and other areas have declined due to degradation of spawning habitat, introduction of barriers to upstream migration, over-harvesting by recreational fisheries, and reduction in winter flows due to damming and spring flows due to water diversion (USFWS 2008).

Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley Fall-Run ESU (a Federal Species of Concern), also migrate through the Refuge during adult upstream migration from

August through December, and during the downstream migration of juveniles typically from February through June (Roessler et al. 2001, SCVWD unpublished data). Chinook salmon did not historically spawn in streams flowing into South San Francisco Bay. Since the mid-1980s, however, small numbers of fall-run Chinook salmon have been found in several such streams, including Coyote Creek, Los Gatos Creek, and the Guadalupe River (Leidy et al. 2003), and the species has recently been recorded along lower Alameda Creek as well. These fish are of Central Valley origin; fish sampled from Santa Clara Valley streams are most closely related to Central Valley fall-run hatchery fish (Hedgecock 2002). Tidal marshes within the Refuge may be important in the lifecycle of Chinook salmon because juveniles may spend a significant amount of time, up to 189 days (Simenstad et al. 1982), foraging in estuarine habitats, showing significant growth in some estuaries (MacDonald et al. 1987) as they adapt physiologically to higher-salinity environments (Maragni 2000).

Pond Fish Communities. Fish community composition and abundance within the ponds of the South Bay are primarily a function of salinity, with more diverse communities and greater abundance in lower-salinity ponds, and generally no fish surviving salinities greater than 100 ppt. Surveys by USGS (Takekawa et al. 2005) recorded 14 fish species in Alviso ponds between March 2004 and June 2005; these results are similar to those of Lonzarich and Smith (1997), with longjaw mudsucker, rainwater killifish, topsmelt, and yellowfin goby being the most abundant fish, although very few threespine sticklebacks were caught by USGS. Other species recorded in the Alviso ponds by USGS included northern anchovy, bay pipefish (*Syngnathus leptorhynchus*), staghorn sculpin, chameleon goby (*Tridentiger trigonocephalus*), leopard shark, shiner surfperch, striped bass, starry flounder, and bat ray.

Essential Fish Habitat. The Magnuson-Stevens Fishery Conservation and Management Act requires Federal fishery management plans (FMPs) to describe the habitat essential to the fish being managed and describe threats to that habitat from both fishing and non-fishing activities. In addition, in order to protect this Essential Fish Habitat (EFH), Federal agencies are required to consult with National Marine Fisheries Service (NMFS) on activities that may adversely affect EFH.

The South Bay, including parts within the Refuge, includes EFH from three FMPs, the Coastal Pelagic, West Coast Groundfish, and Pacific Coast Salmon FMPs. Fish species covered under these plans that occur in the South Bay are listed in Table 12.

Table 12. Fisheries Management Plan (FMP) species in the South Bay

Common Name	Scientific Name	Occurrence
Coastal Pelagic FMP		
Northern Anchovy	*Engraulis mordax*	Abundant from South to Central Bay; adults and juveniles present in South and South-Central Bay, adults, juveniles, larvae, and eggs present in Central Bay
Pacific Sardine	*Sardinops sagax*	Present in South and South-central Bay and rare in Central Bay; adults and juveniles present
Jack Mackerel	*Trachurus symmetricus*	Present in Central Bay; eggs and larvae
Pacific Groundfish FMP (Estuarine Composite EFH)		
Leopard Shark	*Trikakis semifasciata*	Present from South Bay to Central Bay; adults and juveniles present
Soupfin Shark	*Galeorhinus galeus*	Present in South-central and Central Bay and rare in

Common Name	Scientific Name	Occurrence
		South Bay; adults and juveniles present in Central Bay and rare in South Bay, less known about life stages in South-central Bay
Spiny Dogfish	*Squalus acanthias*	Present from South Bay to Central Bay; adults and juveniles in South and Central Bay, less known about life stages in South-central Bay
Big Skate	*Raja binoculata*	Present from South Bay to Central Bay; adults and juveniles present in Central Bay, less known about other life stages present in South and South-central Bay
California Skate	*Raja inornata*	Present in South Bay (probably rare)
Lingcod	*Ophiodon elongatus*	Present from South to Central Bay but rare in South-central Bay; adults and juveniles present in Central Bay, less known about life stages present in South Bay
Kelp Greenling	*Hexagrammos decagrammus*	Present in Central Bay; juveniles and adults
Pacific Whiting (hake)	*Merluccius productus*	Present in Central Bay; eggs and larvae
Brown Rockfish	*Sebastes auriculatus*	Present from South to Central Bay; juveniles present in South and South-Central Bay, adults and juveniles present in Central Bay
Curlfin Sole	*Pleuronichthys decurrens*	Present in Central Bay; juveniles
English Sole	*Parophrys vetulus*	Abundant from South to Central Bay; adults and juveniles present
Pacific Sanddab	*Cintharichthys sordidus*	Present from South to Central Bay; adults, juvenile, larvae, and eggs present in Central Bay, less known about life stages in South Bay
Sand Sole	*Psettichthys melanostictus*	Present in South and Central Bay but rare in South-central Bay; adults, juveniles, and larvae present
Starry Flounder	*Platichthys stellatus*	Present from South to South-central Bay and abundant in Central Bay; adults and juveniles present in South Bay and adults, juveniles, larvae, and eggs present in Central Bay
Cabezon	*Scorpaenichthys marmoratus*	Rare to few from South to Central Bay; juveniles present in South and South-Central Bay, adults and juveniles present in Central Bay
Bocaccio	*Sebastes paucispinis*	Rare in Central Bay, less known about presence and life stages elsewhere in Bay
Calico Rockfish	*Sebastes dalli*	Rare in South Bay, life stages unknown
Rex sole	*Glyptocephalus zachirus*	Rare in South Bay, life stages unknown
Pacific Coast Salmon FMP (Estuarine Composite EFH)		
Chinook Salmon Central Valley fall- and late fall-run ESU (evolutionary significant unit)	*Oncorhynchus tshawytscha*	Spawns in several South Bay streams, including Coyote Creek and the Guadalupe River

3.5. Cultural Resources

3.5.1. Introduction

Cultural resources (e.g., Native American middens, historic salt industry infrastructure, Alviso Cannery, and the Town of Drawbridge) have been identified within the boundaries of the Newark, Mowry, Alviso, and West Bay Units. No sites within the Refuge are currently

listed on the National Register of Historic Places (NRHP), although sites in the vicinity of the Refuge are listed or have been deemed eligible for listing on the NRHP. Additionally, other cultural resources may be present within the Refuge that have not yet been identified.

Old photograph of Drawbridge
USFWS

The legal context for determining inclusion in the NHRP is guided by 36 CFR 60.4 of the National Historic Preservation Act (NHPA), which takes into consideration the quality of the property's significance in American history, architecture, archaeology, culture, and the property's known or likely ability to yield information important in prehistory or history. Responsibility of inventory, nomination, protection, and preservation for Federally-owned cultural resources is set by the NHPA as well as requirements for Federal agencies to take into account the effects of their actions on items or sites listed or eligible for listing in the NRHP. A historical property must also retain the integrity of its physical identity that existed during the property's period of significance, which is determined with regard to the original location, design, setting, materials, workmanship, feeling, and association.

The NHPA amendments (Section 110(d) (6) (A)) specify that properties of traditional religious and cultural importance to an Indian Tribe or traditional Native Hawaiian organization may meet the criteria for listing on the NRHP.

3.5.2. Overview of the Native American History and Landscape

The earliest recognized period of California prehistory is referred to as Paleo-Indian (10,000 to 6,000 B.C.) and represents the entry and spread of humans into California. Most archaeological sites found in the San Francisco Bay area represent the Middle Archaic (3,000 to 500 B.C.) or more recent periods, with few dating back to the Paleo-Indian or Lower Archaic (6,000 to 3,000 B.C.). The scarcity of sites from these older periods may be due to high sedimentation rates in the Bay, which would cover earlier sites and leave them inaccessible.

During the Middle Archaic Period, the broad regional patterns of foraging subsistence strategies gave way to more intensive procurement practices. Subsistence economies were more diversified, possibly including the introduction of acorn processing technology, as well as use of the dart and atlatl (spear throwing device) for hunting. Populations were growing and occupying more diverse settings. Permanent villages that were occupied throughout the year

were established, primarily along major waterways. The onset of status distinctions and other indicators of growing sociopolitical complexity mark the Upper Archaic Period.

The Refuge and its vicinity were most recently occupied by a people originally referred to as Costanoan; which is derived from a Spanish word meaning coast people or coastal dwellers. They occupied the area from the San Francisco Bay in the north to near Carmel in the south. The Costanoans, whose descendants now refer to themselves as the Ohlone, entered the Bay Area approximately 1,500 years ago, coming in from the Delta region and displacing earlier Hokan speakers living there.

Organized politically into tribelets of 50 to 500 people, the Costanoans were mainly a hunter-gatherer society that relied on local marine and terrestrial resources. Each tribelet, governed by either a male or female chief, had its own unique cultural traditions and usually had one or more villages and a number of seasonal camps within its territory. The acorn was the predominant food source, but local mammals, waterfowl, fish, and plants supplemented the diet. The Costanoans may have also gathered naturally-forming rock salt from the salt flats to use as a resource and trading commodity.

At the time of European contact around 1770, there were an estimated 7,000 to 10,000 Native Americans living near the Bay. The displacement of the Ohlone culture started around this time, when the Spanish arrived and began establishing the Mission system. The results of this were disastrous; by 1832 the population had been reduced by approximately 80 percent due to disease, a declining birthrate, and changes in lifestyle.

3.5.3. Early Euro-American History

This historic background provides information on the development of the Refuge area from the time of European contact onward. The Refuge is located within three counties: Alameda, Santa Clara, and San Mateo. A complete history of each county and city is too exhaustive for this report; therefore, a general history of development for the South Bay is presented.

Spanish explorers began establishing a presence in Alta California (roughly the modern state of California, separate from Baja California) around the 1770s, establishing a system of missions and presidios (military posts) up and down the territory. By the 1820s, the Jesuits and then the Franciscans had established 21 missions and four presidios all within a day's ride of each other. Typically, the local Native American populations were enticed to join the missions, where they were converted to Catholicism and employed as a labor force. The mission system upset the established political and cultural system of the Costanoans as local leaders lost power to the Spanish and entire communities moved to the missions.

Mexico achieved independence from Spain in 1821 and in 1822 Alta California was declared a territory of the Mexican republic. Soon after, the Mexican government began secularizing the missions and divided their land into large ranchos, establishing a pastoral and agricultural economy in the South Bay. During this time, the Native Americans were released from missionary control, although many found themselves working as laborers in the ranchos, where their populations continued to decline. More European-Americans arrived in California during this time, where they could marry into Mexican families and become eligible for land grants.

During the mid-1800s, settlers from the United States arrived in California and commercial activity between the two regions increased. Conflicts between the settlers and Native Americans escalated during the Mexican War in 1846, which ended two years later with the Treaty of Guadalupe Hidalgo and the cession of California to the United States.

It was that same year that gold was discovered in California, leading to a rush of miners, prospectors, settlers, and supporting industries. New settlements appeared overnight and cities like San Francisco benefited as centers of transportation and commerce. This influx of new residents helped lead the entrance of California into the Union as a state in 1850.

Incorporated in 1850, the City of San José was California's first capital and the county seat, hosting the first and second sessions of the State Legislature before it moved to Vallejo, then Benicia, and eventually Sacramento. In 1864, the completion of a railroad between San Francisco and San José created a link that would foster growth in both regions as well as the birth of new cities along its tracks.

For the next century, most South Bay communities moved from agricultural regions to more urbanized areas. Proximity to the Bay and other transportation corridors encouraged development and the growth of numerous industries, eventually leading to the technological sector of today.

The following section highlights areas within or adjacent to the Refuge that are discussed more extensively due to their historical connections to the area.

Salt Industry
Salt harvesting occurred along the Bay for most of its inhabited history. The Costanoans, Spaniards, and eventually American settlers all took advantage of the naturally occurring salt flats. During the mid to late 1800s, commercial salt production began to establish, starting with failed gold-miner John Johnson in 1853. Smaller operations soon occupied most of the East Bay shoreline south of San Lorenzo Creek. These first operations were simple levees built around natural salt flats in Alameda County that used intensive manual labor to produce and harvest the salt. In the early 1900s, mergers of the smaller operations left only two companies: Leslie Salt Company and Oliver Salt Company. By mid-century, 85 percent of wetlands in the San Francisco Bay had been filled, dried out, or converted to salt ponds. Eventually Oliver Salt Co. merged with Leslie Salt Co. to create Leslie Salt Company; the largest salt-producer in the San Francisco Bay. In 1979, Leslie Salt Co. was purchased by Cargill Salt, who would eventually provide much of the land for the Refuge. Though most of the former commercial salt ponds within the Refuge have been acquired by the Refuge, Cargill Salt still operates a salt production process on Refuge ponds within the Mowry Unit. Cargill Salt owns the salt making rights to these ponds while the Refuge owns all other rights.

Town of Drawbridge
Drawbridge is located on Station Island, an isolated, windswept mud formation in the marshes and ponds of the southeast corner of San Francisco Bay between Mud Slough on the north and Coyote Creek on the south. Established originally with one small shack for the drawbridge operator, the town existed from 1876 to 1979 and grew mainly as a seasonal area for hunters. It soon expanded into a small, permanent town with at least 90 cabins and five passenger train stops per day. In the early 1900s, two hotels operated in Drawbridge, and the town gained a

reputation as one outside the law; where a blind eye was turned to gambling, drinking, and prostitution.

Drawbridge building
USFWS

Town of Alviso
Alviso is located on the south side of San Francisco Bay in Santa Clara County, near what was once the Embarcadero de Santa Clara. This served as one of the major landings for Mission Santa Clara and was a prosperous shipping port. The port at Alviso was established in 1840 and served the increasing trade coming up the Guadalupe River, much of which was from the mercury mines at New Almaden for use in the gold mining process. Until the completion of the San José-San Francisco railroad in 1864, Alviso remained a main passenger and freight link between San Francisco and the South Bay, with a regular steamboat service. After the railroad completion, industry slowed in Alviso, and the town never fulfilled its prosperous dream.

Naval Air Station, Moffett Field
Naval Air Station, Moffett Field opened in 1933 and was originally known as Naval Air Station Sunnyvale, California. Located at the southern tip of San Francisco Bay, the air station encompasses 2,200 acres and is bordered on the north by salt evaporation ponds. The air station was originally built to house lighter-than-air craft. The success of lighter-than-air craft in World War I inspired the Navy to develop a fleet of giant dirigibles that they hoped would become successful battleships of the air. The first lighter-than-air craft were built in the early 1920s; it was intended that one of these, the USS Macon, would be based on the west coast. It was based at Moffett Field for a brief period of time, until, in 1935, it crashed into the Pacific Ocean off Monterey Bay during fleet maneuvers. To accommodate these air craft, Moffett Field contained a number of large hangers, including the massive Hanger One, which is one of the world's largest freestanding buildings and covers an area of eight acres.

3.5.4. Archaeological Resources

A literature search of relevant documents pertaining to properties inside and within the vicinity of the Refuge was completed to determine if any archaeological surveys have taken place and if any archaeological resources have been located in the Refuge area. No Refuge-specific archaeological field inventories were completed as part of this effort. Given the large and varied amount of property the Refuge encompasses, archaeological information was not available for the entire area. The results of the survey indicate that a variety of site types are present in and around the vicinity of the Refuge, including archaeological remains mostly in the form of mounds, temporary and permanent occupation sites, and shell middens.

Numerous historical and archaeological surveys have been conducted throughout the Refuge over the years and are too numerous to list here. Qualified individuals may review them at the Northwest Information Center (NWIC).

Records of surveys and personal accounts indicate that there were far more archaeological sites along the Bay in the late 1800s than there are at present. The first wave of archaeological investigations in the early 1900s focused on the obvious sites; large earthen mounds and shell middens. It is possible that many of these sites were disturbed or destroyed for agricultural purposes or used as fill.

Newark Unit: Near the Newark Unit are a number of sites indicating occupation of the area for at least the past 3,000 years. These sites include the Emeryville site (CA-ALA-309), the Ellis Landing site (CA-CCO-295), the Fernandez site (CA-CCO-295), and the West Berkeley site (CA-ALA-307). Nearby is the Coyote Hills cluster (CA-ALA-12, -13, -312, -313, -328, -329), which includes numerous important sites. Of these, site CA-ALA-13 is a recorded prehistoric shell mound site estimated circa. 265–85 A.D. to circa. 1400 A.D. The site was officially recorded in 1949 as a dark shell midden structure with human bones on the surface, cultural features, and artifacts. This site has been determined eligible for separate listing on the NRHP by a consensus determination (despite the loss of some integrity due to past excavations and construction of a nearby flood control channel) and is therefore automatically listed on the California Register of Historical Resources (CRHR). The site was relocated in 1991 within a fenced area under the control of the Alameda County Flood District (Patterson Ranch Planned District Draft EIR) (Newark Area 2 Draft EIR). Other recorded prehistoric sites near Newark include CA-ALA-485 and 486, both of which are midden deposits (SBSPRP).

Mowry Unit: The literature search did not indicate any archaeological resources within the Mowry Unit; however, sites may be present here.

Alviso Unit: Located near the Alviso Unit is the prehistoric site CA-SCL-23; a midden mound and occupation site, along with SCL-268, -485, and -528; which includes midden mounds, occupation sites, and historic ceramic fragments.

West Bay Unit: Many prehistoric sites exist within or near the West Bay Unit. Three sites within the cities of Belmont and Redwood City are known shell middens of some type (CA-SMA-150, -240, -335/H). The cities of Palo Alto and Mountain View contain numerous prehistoric sites, including occupation sites (SCL-5, -6, -13, -14, -15, -16, -17, -18, -19, -20) and midden sites (SCL-21, -24, -25).

Based on the results of the literature search, it is possible that other subsurface archaeological resources exist within the Refuge that have not yet been located.

3.5.5. Historic Resources

Historic research was completed by examining listings for Alameda, Santa Clara, and San Mateo Counties on the National Register of Historic Places Web site as well as the California Inventory of Historic Resources, California Points of Historical Interest, and the California

Historical Landmarks. Also, a literature search for historical resources was completed for properties in the Refuge and its vicinity.

Within the Refuge, there are numerous sites and objects of historic interest, some of which have not been evaluated for the NRHP or been deemed ineligible. Other resources have been evaluated and included or deemed eligible for the NHRP or CRHR. Listing in the NRHP automatically lists a resource in the CRHR as well. This section provides a summary that will characterize the general type of historic resources as well as highlight several notable sites. Not all historical resources or potential resources are listed.

Salt Industry
The commercial salt industry dates back to the 1850s in the South Bay and the existing network of ponds is at least 50 years old. These sites contain evaporation and crystallization ponds, as well as buildings, structures, levees, and land used for salt production. Various remnants of the salt industry can be found in all four Refuge Units.

Naval Air Station, Moffett Field
The Shenandoah Plaza, a campus-like area including landscaping, a large number of buildings, and Hangar One, was accepted into the NRHP as a Historic District in 1994 under the name of the United States Naval Air Station Sunnyvale, California (also the U.S. Naval Air Station Moffett Field – Central Historic District) (United States Department of the Interior 1991). Hangar One is also listed as a Naval Historic Monument and a California Civil Engineering Historic Landmark. Located in the nearby NASA Ames Research Center is the Unitary Plan Wind Tunnel, registered in the NRHP under reference number #85002799. Completed in 1955, this wind tunnel was an important test facility for the aviation and space industry on the West Coast in the years following World War II.

Drawbridge
Most of the Town of Drawbridge is owned by the Refuge with a small number of private in-holdings. Since the last resident left Drawbridge in 1979, the town has been slowly sinking into the marsh. Many of the structures have been burned down, vandalized, or have simply collapsed through neglect. The integrity of these buildings may no longer be sufficient enough to be eligible for the NRHP or the CRHR, although none of the buildings at Drawbridge have been formally evaluated for the NRHP or the CRHR. The Refuge has no plans to restore the town; rather it will allow the salt marsh to reclaim the area.

Alviso
In 1973, the community of Alviso was listed in the NRHP and CRHR as an historic district (#73000449). Although it is now technically a part of San Jose, Alviso retains much of its historic fabric and, therefore, still retains the character of a small town, isolated by its location. In addition, many of the buildings in the historic district exhibit architectural styles prevalent throughout the San Francisco region. The 60-acre Historic District contains eleven significant structures, including: Wade's Round the Horn House (1855), the Union Warehouse (1858), Tilden/Laine grocery store (1860), LaMontagne Boarding House (1870), Alviso Railroad Depot (1904), Alviso Yacht Club (1905), and the Bayside Cannery (1906). Other buildings reflect the industrial history of the town, such as the brick Wade Warehouse and Bayside Canning Company buildings. The Bayside Cannery, a property eligible for inclusion in the National Register of Historic Places, is currently owned by the Refuge. In 2002 and 2004, funds were

used to shore up the building preventing the building from collapsing. The Refuge is currently working with a private land owner to swap this property for seasonal wetland and upland habitat connected to New Chicago Marsh (Advisory Council on Historic Preservation 1998).

The Port of Alviso (CA-SCL-810H) is a historic shipping area located near the Refuge. The Port has been in operation since the mid-1700s, replacing the Embarcadero de Santa Clara as the primary port in the South Bay. Serving as the main transportation link between San Francisco and San José, the port served a steady stream of traffic until the railroad arrived in 1864; which decreased the influx of boats. In 1973, the Port was included when Alviso was designated a Historic District in the NRHP. It is no longer a functional port.

The historic South Pacific Coast Railroad, now the Union Pacific Railroad, which crosses through the Alviso Unit is also of historical interest, although it has not been formally evaluated for the NRHP or the CRHR.

3.6. Social and Economic Environment

3.6.1. Land Use

This section presents an overview of the existing land uses that occur within and immediately surrounding the Refuge. The Refuge is made up four distinct areas known as the Alviso, Mowry, Newark, and West Bay Units, which are depicted in Figure 6. Also shown are the relevant land use policies of the five municipalities that surround the Refuge and the other regional policies that affect land use in the immediate vicinity.

Current Land Uses on Each Refuge Unit
The Refuge encompasses lands throughout South San Francisco Bay in Alameda, Santa Clara, and San Mateo Counties in California. The lands and waters included within the Refuge consist of portions of the urbanized communities of San Lorenzo, Hayward, Union City, Fremont, Newark, Milpitas, San Jose, Sunnyvale, Mountain View, East Palo Alto, Menlo Park, and Redwood City.

Newark Unit: The Newark Unit is located along the east shoreline of South Bay between Alameda Creek Flood Control Channel and Dumbarton Narrows (northern boundary of Audubon Marsh). The Unit also includes a stretch of shoreline adjacent to San Lorenzo.

The main part of the Newark Unit is occupied by approximately 4,000 acres of operational evaporator salt ponds converted from high-elevation tidal marsh. The salt ponds are located west of the Coyote Hills and are bisected by Newark Slough. These salt ponds were constructed starting in the early 20th century and are managed for salt production today by Cargill Salt. Cargill Salt owns the salt-making rights to these ponds and the Refuge owns all other rights.

The Newark Unit contains a narrow strip of fringing marsh, including the 130-acre Ideal Marsh, which was restored from former salt ponds by a natural levee breach around 1930. The Unit also includes much of the wide mudflats that flank its bayside portion.

Lowland areas to the east and southeast of the Coyote Hills are also part of the Refuge in this Unit. Landward of the salt ponds and the Coyote Hills, the ancient tidal marsh is diked.

Southeast of the Coyote Hills several restoration efforts have established muted tidal systems from the former diked areas. These areas include the 110-acre Mayhew's Landing, 140-acre LaRiviere Marsh, and 10-acre Triangle Marsh (Refuge Entry); restorations were completed in 1994, 1997, and 2001, respectively.

Within the Newark Unit are two community interpretive centers: the Visitor Center and the Learning Center. The Visitor Center, located along Marshlands Road in Fremont, includes an information desk, restrooms, exhibits, and bookstore, which is run by the Wildlife Society. Proceeds from the sale of books, posters, and other educational items in the bookstore benefit the Refuge's education programs. It also serves as the hub of an extensive system of bridges, boardwalks, and trails open to the public to see and explore the San Francisco Bay habitats. The Learning Center, located on Newark Slough just south of the Dumbarton Bridge Toll Plaza in Fremont near the Visitor Center, is perched on a hillside above salt marsh, tidal sloughs, mudflats, and salt ponds. It is home to the Pumphouse, an amphitheater, and the Environmental Education Pavilion.

Mowry Unit: The Mowry Unit is located along the north shoreline of South Bay from the Dumbarton Narrows (northern boundary of Audubon Marsh) to the Union Pacific railroad line at the Island Ponds A19, A20, and A21.

The Mowry Unit is dominated by approximately 6,000 acres of operational salt ponds that were converted from old high-elevation tidal marsh during the 1920s. While the Service owns these ponds in fee title, the Service and Cargill Salt entered an agreement in 1979 where Cargill Salt maintains salt making rights to these ponds in perpetuity. In March 2006, the Island Ponds (A19, A20, and A21) were restored to tidal actions as part of the SBSPRP.

The Mowry Unit includes relatively large areas of ancient fringe marsh, and much of the mudflats along this part of South Bay, Coyote Creek, and Mowry Slough. Dumbarton Marsh and Audubon Marsh are located adjacent to outer Newark Slough. Marshes also fringe Mowry Slough and the northern shore of Coyote Creek including the Calaveras Point Marsh.

The Hetch Hetchy Aqueduct is located in this Unit, crossing through the Dumbarton marshes and the Bay. North of the aqueduct is the Dumbarton Road bridge which also crosses the Bay. The Dumbarton cutoff railroad (service discontinued in 1982) separates Dumbarton Marsh south of the railroad from Audubon Marsh, north of the railroad. While remnants of the historic marshes still exist, the infrastructure, particularly the railroad, has caused their fragmentation. In order to improve tidal connectivity between Audubon Marsh and Dumbarton Marsh, the Dumbarton Marsh Enhancement Conceptual Plan is currently underway as part of the Dumbarton Rail Corridor Project. The initial conceptual 'base plan' is to excavate three breaches beneath the railroad embankment to reconnect the marshes.

Diked marsh areas adjacent to and northeast of the salt ponds are also part of the Refuge in this Unit. The Warm Springs sub-unit, a vernal pool grassland habitat, is also part of the Refuge in this Unit. This land is currently grazed by cattle as part of its habitat management.

Alviso Unit: The Alviso Unit is located along the south shoreline of the South Bay, between Charleston Slough and Pond A20, and the north shoreline east of the Union Pacific railroad.

Most of the Alviso Unit is approximately 7,600 acres of former salt ponds. In 2003, ownership of the Alviso ponds (apart from Ponds A4, A6, and A18) transferred to the Refuge, and all of these former ponds became part of the SBSPRP. These ponds are bisected by Mud Slough, Coyote Creek, Artesian Slough, Alviso Slough, Guadalupe Slough, and Mountain View Slough.

Currently, the Refuge is operating and maintaining the majority of those ponds through the SBSPRP and previously, the SBSP ISP, an interim plan to maintain and enhance the habitat values of the ponds. Phase 1–3 of the ISP have already been implemented. The ISP management actions that took place at the Alviso ponds include circulation of bay water through water control structures, operation of some ponds as seasonal wetlands, and others as high salinity ponds. In addition, the Island Ponds (Ponds A19, A20, and A21, Figure 5) were breached to Coyote Creek and tidal action in March 2006. As a part of the 2003 purchase agreement with Cargill Salt, Ponds A22 and A23 were transferred to the Refuge in 2010 (after ceasing salt-making operations on these ponds and criteria for salinity levels were met). These seasonal ponds are managed for western snowy plovers; no current restoration activities are planned, but future actions will be included under the SBSPRP.

The implementation of Phase 1 of the SBSPRP in the Alviso Unit includes tidal and managed pond habitat restoration and early experiments for adaptive management. The Phase 1 actions include three restoration projects within the Alviso Unit totaling 2,000 acres and include Ponds A6, A8, and A16 (Figure 5). Restoration of Ponds A6 and A8 to tidal action are complete. Construction of islands in Pond A16 is underway. The other ponds continue to be managed as seasonal ponds or muted tidal ponds that have bay waters circulating through water control structures as they did during the ISP period. Other Alviso ponds will be addressed during the Phase 2 planning efforts for the SBSPRP, which is currently underway.

The Alviso Unit is also home to the Environmental Education Center, located near the town of Alviso. The building, designed as an educational facility, contains two classrooms, an auditorium, and an enclosed observation tower. Trails and a new boardwalk through the seasonal wetland habitat allow visitors to see and explore the South Bay.

Landward of the salt ponds, several diked wetlands have been restored or enhanced, including Coyote Creek Lagoon, New Chicago Marsh, and the Mouse Pasture. The Coyote Creek Lagoon was breached in 1986 to Coyote Slough and Mud Slough, and to the present day, has been monitored under a Refuge Special Use Permit to Phyllis Farber and ESA PWA. They have found that the site has rapidly filled with sediment since tidal action was introduced; and marsh has been established around the perimeter. The marsh is gradually expanding into mudflats at the center of the site.

Within the diked New Chicago Marsh, the Refuge currently manages water levels under the New Chicago Marsh Management Plan to enhance marsh habitat for the salt marsh harvest mouse and waterbirds. Work to enhance New Chicago Marsh with an improved water control structure between Pond A16 and New Chicago Marsh was constructed in fall 2011. This project will enhance the existing water management and habitat quality of New Chicago Marsh through moderation of summer salinity levels and winter flooding depth and duration.

The Mouse Pasture was leased from the CSLC along with Coyote Creek Lagoon and its public access trail in 1986. The pasture is managed as a diked seasonal wetland to maintain habitat

for the salt marsh harvest mouse. Water is brought to the Mouse Pasture through water control structures to maintain the mouse habitat.

Several other relatively small areas along the north and south boundaries of the Unit remain diked from tidal inundation. The mudflats and fringing marsh along Coyote Creek are also included in this Unit.

West Bay Unit: The West Bay Unit is located along the west shoreline of the South Bay from Redwood City to Faber Tract.

Prior to human development, the West Bay Unit comprised a large complex of tidal salt marsh, tidal sloughs, and mudflats, with a narrow peripheral set of pannes. In the 1940s, Leslie Salt converted the marsh northwest of Dumbarton Narrows transforming it into approximately 3,000 acres of evaporator, crystallizing, and bittern salt ponds. In 2003, approximately 1,500 acres of the evaporator ponds were acquired by the Refuge on either side of the Dumbarton Bridge. Currently, the Refuge is operating and maintaining the Ravenswood Complex ponds following the SBSP Restoration Plan. The SBSPRP Phase 1 action to reconfigure the 240-acre Pond SF2 to a managed pond was completed in 2010, which introduced muted tidal flow through water control structures. Roosting and nesting islands were also constructed in the inundated portion of the pond. The other portion of the pond is managed to provide habitat for western snowy plovers. It receives water through rainfall or a small amount of tidal flow, as needed. The other Ravenswood Ponds are maintained as seasonal ponds with tidal flow occasionally permitted to meet management objectives.

The tidal marshes of the 3,000-acre Bair Island were diked in the late 1800s and early 1900s for agricultural uses. In the 1940s, Leslie Salt built levees that divided Bair Island into three sections, known today as Inner, Middle, and Outer Bair, and used the islands as salt evaporation ponds. In 1965, the ponds were abandoned and currently most of Bair Island is owned by the CDFG, with smaller areas owned by the Refuge, the Peninsula Open Space Trust (POST), San Carlos Airport, and three privately-owned parcels. After salt pond abandonment, tidal inundation was restored to a large portion of Outer Bair through a series of planned and unplanned levee breaches in the late 1970s and early 1980s. CDFG and Refuge lands on Bair Island are managed as a part of the Refuge following an MOU between the two agencies. Outer Bair Island was restored to tidal action in 2010. The Bair Island Restoration and Management Plan calls for Inner and Middle Bair Islands to be restored to tidal action in the future. Bair Island is currently closed to the public due to tidal marsh restoration efforts, but the restoration plan calls for a hiking trail with interpretive exhibits to be constructed on Inner Bair Island. Middle Bair Island restoration should be completed in 2013.

The extensive ancient tidal marshes of Greco Island and wide expanses of mudflat also form part of this Unit. Greco Island is the largest area of relatively undisturbed (only partially diked), historic tidal marsh in the South Bay.

Areas of restored marsh in this Unit are located at the Faber-Laumeister Tract and Cooley Landing (south of Dumbarton Bridge). The Faber-Laumeister Tracts located in East Palo Alto are owned by the City of Palo Alto, but managed as part of the Refuge following an MOU with City of Palo Alto.

Surrounding Land Uses

Existing Uses Surrounding the Newark Unit

Land uses surrounding the Newark Unit are in the cities of San Leandro, Hayward, Union City, and Newark. The two northernmost parcels within the approved acquisition boundary of this Unit are surrounded by a mix of uses including two golf courses (Tony Lema Golf Course and Skywest Golf Course), the Hayward Regional Shoreline Park (managed by the East Bay Regional Park District), residential communities to the east and southeast, industrial facilities, and the San Leandro WPCP. Land uses around the main part of the Newark Unit include various residential, office, and industrial uses. Other surrounding land uses include operational salt ponds (some of which are owned by the Refuge with Cargill Salt retaining the right to produce salt and some owned soley by Cargill Salt), the Union Sanitary District and Alvarado Effluent Pump Station to the east in Union City, and recreational uses such as boating, fishing, and hunting in the waters of the Bay to the west. Within the southern portion of the Unit, extending from the Alameda County Flood Control Channel to State Route 84, is the Coyote Hills Regional Park (not including the adjacent Newark Ponds that are owned by the Refuge). At the southern border of the Unit, a portion of the Hetch-Hetchy Aqueduct is located parallel to the Dumbarton Bridge and separates the Newark from the Mowry Unit. In 2010, the City of San Francisco began constructing a tunnel under the Refuge and the Bay to replace the aging aboveground Hetch Hetchy pipelines with new underground pipelines.

Although lying approximately six to nine miles north of Alameda Creek Flood Control Channel, the Refuge acquisition boundary includes areas of restored marsh along the shoreline of San Lorenzo. These areas include portions of the 170-acre San Leandro Shoreline marsh, 320-acre Oro Loma Marsh, and 100-acre Citation Marsh; restorations were completed in 1995, 1997, and 1999, respectively. These restored marshes are bisected by San Lorenzo Creek. There is also a 650-unit residential development located west of the Union Pacific railroad and north of San Lorenzo Creek on approximately 70 acres within approved acquisition boundary.

Potential Future Development around the Newark Unit

The northernmost approved acquisition boundary parcel in the Newark Unit is bordered by properties in the City of San Leandro, any future development/redevelopment would occur in accordance with the San Leandro General Plan. No adjacent properties are in the San Leandro Redevelopment Project Areas and currently no major development is planned (City of San Leandro 2007). The smaller parcel to the south is located in the City of Hayward, where future surrounding land uses would occur in accordance with the Hayward General Plan. Shoreline properties to the west of the parcel would also have to comply with the Hayward Area Shoreline Planning Program; a joint-agency program designed to coordinate activities and policies affecting the Hayward shoreline. Land uses to the east of the parcel must also comply with the Hayward Executive Airport Master Plan because of the proximity to the airport flight zone.

Land uses surrounding the section of the main Newark Unit north of Old Alameda Creek are under the jurisdiction of the City of Hayward from and within the jurisdiction of Union City south of Old Alameda Creek until the Alameda Creek Flood Control Channel. No properties in the vicinity of the Refuge occur within redevelopment project areas of either city (City of Hayward 2006; City of Union City, undated).

Near the Newark Unit is the Patterson Ranch property (not within the Refuge). In October 2009, the draft environmental review for a development proposal named Patterson Ranch was released. Located on land east of Coyote Hills Regional Park, the proposal seeks to build a 500-home residential development called the Patterson Ranch was approved by the Fremont City Council in 2010 east of Coyote Hills Regional Park along Paseo Padre and Ardenwood Boulevard. The environmental review for this development has not been finalized at the time of the writing.

Located at the southeast corner of the Newark Unit is the proposed Dumbarton Transit Oriented Development (formerly Newark Area 2). The project area includes 233-acres with land uses that include industrial, manufacturing, chemical processing and salt production facilities. A commuter rail station is planned to connect to the proposed Dumbarton Rail Corridor, which would link the east and west shores of the San Francisco Bay via a rebuilt Dumbarton Rail Bridge. Alongside the station would be a new development planned around increased accessibility to public transit. This development would include residential units, mixed residential/retail, research and development (R&D), and a performing arts/community center.

Existing Uses Surrounding the Mowry Unit

Land uses surrounding the Mowry Unit are in the cities of Newark and Fremont. East of the Hetch-Hetchy Aqueduct, which marks the northern boundary of the Unit, adjacent land uses include office, light industrial, and agricultural/undeveloped uses. Between Mowry Avenue and Morton Avenue, along the approved acquisition boundary, are a series of salt evaporation ponds and related facilities owned by Cargill Salt. Land uses east of Mowry Avenue are mostly office and industrial uses. The Tri-Cities Landfill facility, located at the end of Auto Mall Parkway in Fremont, has recently closed to the public but is still in operation as a transfer station.

Potential Future Development around the Mowry Unit

The northwestern area of the Mowry Unit is bordered by the previously mentioned Dumbarton Transit Oriented Development project site. Northeast of the Unit is the Newark Area 3 and 4 Specific Plan project, which includes land within the approved acquisition boundary and adjacent to Refuge-owned lands along Mowry Slough. Current uses include light industrial, agricultural, educational (Ohlone College), park land, the City of Newark fire station, and a community center. Current proposals include development of housing and a golf course on this site. The Specific Plan for the area is being created to guide future development of a golf course, approximately 1,200 housing units, an elementary school, open space areas (some within the approved acquisition boundary), as well as the retention of some existing uses (light industrial, educational, park land, etc.).

Existing Uses Surrounding the Alviso Unit

Land uses surrounding the Alviso Unit are in the cities of Fremont, San Jose, Sunnyvale, Mountain View, and Palo Alto. Pond A18 borders the Alviso Unit. The City of San Jose purchased the 860-acre Pond A18 from Cargill Salt in 2005, and this pond is undergoing a separate planning process to the SBSPRP as part of the San Jose/Santa Clara WPCP's Master Plan. Current city management of Pond A18 is to introduce tidal hydrology and maintain open-water habitat through two breaches to Artesian Slough (breached in 2005). The city is currently developing a Land-Use Master Plan for the WPCP lands, including Pond A18.

Pond A4 (310 acres) is owned by SCVWD, who is currently planning restoration. It should be noted that the Pond A18 levee adjacent to Artesian Slough is owned by the Refuge.

Artesian Slough
USFWS

The Unit is bordered to the northwest by the Palo Alto Baylands Nature Preserve. Adjacent land uses include Moffett Federal Airfield, NASA Ames Research facilities, and the nearby Santa Clara Municipal Golf Course, as well as two transportation corridors for California State Route 237 to the south and Interstate 880 to the east. Located southwest of the Unit in Shoreline Park at Mountain View, which includes the Shoreline Golf Course, and the Shoreline Amphitheatre. The San Jose/Santa Clara WPCP is located to the southeast and is the largest treatment center in the Bay handling the wastewater of over 1,500,000 people. The Bay Counties Waste Services facility is located south of the Unit. Between Devils Slough and Moffett Channel, outside the approved acquisition boundaries are the Sunnyvale Treatment Ponds used by the WPCP. Southeast of the Unit are Zanker Road Resource Recovery Operation and Landfill (ZRRROL) and the Zanker Material Processing Facility (ZMPF), both on the site of the former Nine Par Landfill. The Newby Island Landfill, one of the largest landfills on the Bay, is east and surrounded on three sides by the Alviso Unit. Treated sewage sludge from the nearby WPCP is trucked to Newby Island Landfill and mixed with trash as a cover. Between the WPCP and State Route 237 are a mixture of residential and office properties, as well as a large church and school/youth center.

Potential Future Development around the Alviso Unit
The northwestern Palo Alto Baylands Nature Preserve, which forms the northwest border of the Unit, is zoned as publicly owned conservation land. The Baylands Master Plan states that these areas will remain protected wetlands (City of Palo Alto 2008). Located along the southwestern edge of the Alviso Unit, a portion of the NASA Research Center at Moffett Federal Airfield will be the site for a new 75-acre education and research center. NASA and a collection of universities named University Associates—Silicon Valley LLC., have entered an agreement to construct a new facility that will include classrooms, laboratories, residential housing, and light industrial space. The facility is expected to open in 2014.

Land uses adjacent the Unit in Mountain View, from San Antonio Road to the NASA Ames Research Center, are mostly zoned public facility for open space/parks and any future development/redevelopment will occur in accordance with the Mountain View General Plan. Adjacent land south of the Unit in Sunnyvale is zoned as public facilities, which includes a

recycling center, sewage treatment plant, and transfer station (City of Sunnyvale 2008). The area around these facilities is listed by the City of Sunnyvale as future open space (City of Sunnyvale 2001).

Further east, the San Jose/Santa Clara WPCP is undergoing plans to create a Master Plan document that will guide development at the site in the future, as well as development along Highway 237 and Coyote Creek. Topics include land usage on the site, technological choices about treatment processes to use, and decisions about future expansion or growth. The City of San José is encouraging community participation in the creation of this Plan. Adjacent to the WPCP facility is the site of a proposed Dry-Fermentation Anaerobic Digestion Facility. Located on a 96-acre property, the facility will occupy approximately 40 acres with the rest designated as wetlands and not suitable for development. At full capacity, the facility is expected to handle over 150,000 tons per year of organic municipal waste that it will use to create biogas (carbon dioxide and methane) for energy production. The nearby Newby Island Landfill has applied for a Planned Development rezoning for the facility. This rezoning would increase the maximum height of the active section of landfill from 150 to 245 feet, allowing the facility to increase capacity by approximately 15 million cubic yards. Other development in San José around the Unit would occur in accordance with the Alviso Master Plan and the San José General Plan.

The land surrounding the northeastern area of the Alviso Unit from Interstate 880 to Cushing Parkway is under the jurisdiction of the City of Fremont and most of the property is subject to development under the Industrial Redevelopment Plan (City of Fremont 2005). Encompassing 3,000 acres, the redevelopment plan was created to improve local Interstate 880 interchanges in order to encourage new business growth. Properties are currently zoned general or restricted industrial, although the eventual redevelopment goal is to develop a high technology business district and learning center (City of Fremont 1998).

Also near the southeastern portion of the Alviso Unit, a Draft EIR has been released for development of a commercial retail center named Creekside Landing and extension of Fremont Boulevard/SF Bay Trail to Dixon Landing Road. The 147-acre site is located between Newby Island Landfill and Interstate 880 in the City of Fremont, with approximately 59-acres of developable land and 88-acres of restoration marshlands. These marshlands were restored under the Bayside Business Park Phase II project in conjunction with the Refuge. The local population of salt marsh harvest mice (a Federally listed endangered species) were moved by H.T. Harvey & Assoc. to the "Mouse Meadow" on the Bayside Business Park Phase I project site.

Existing Uses Surrounding the West Bay Unit

Land uses surrounding the West Bay Unit are in the cities of East Palo Alto, Menlo Park, San Carlos, and Redwood City. These land uses include the Palo Alto Municipal Golf Course, U.S. Highway 101, and two airports: the San Carlos Airport to the west and the Palo Alto Airport to southeast. Between the Bair Island and Ravenswood areas of the Unit is the Port of Redwood City, which provides both commercial and recreational access to the Bay. Located in Menlo Park and surrounded by the Unit is Bedwell Bayfront Park, a former landfill that was closed and converted to parkland in the 1980s. Toward the northwestern end of the Unit is the South Bay System Authority (SBSA) regional wastewater treatment facility, which handles

and recycles local wastewater. A major SBSA sewage line passes through the Refuge's Inner Bair Island on the way to their treatment plant.

Near the West Bay Unit, located west of the Refuge's Ravenswood ponds, are 1,400 acres of active salt-producing crystallizer and bittern ponds under Cargill Salt ownership. According to aerial count data taken in the 1980s, thousands of migratory shorebirds, waterfowl, and other waterbirds have used the Redwood City Plant site. No recent data is available for this area (USFWS, unpub. data). Also near the West Bay Unit is The Preserve at Redwood Shores in Redwood City, an approximately 114.5-acre development of which 90 acres are restored wetland and public access trails. Located within the northwestern portion of the West Bay Unit, the development includes approximately 150 town homes, an elementary school, and a neighborhood park.

Potential Future Development around the West Bay Unit

One of three redevelopment areas within Redwood City, the Seaport Subarea is located in the center of the West Bay Unit (Redwood City Redevelopment Agency 2008). Mostly zoned "General and Restricted Industrial," the area includes the Port of Redwood City (Port). It is the only deepwater port in the South Bay and the nearest to Silicon Valley (Redwood City Planning Department 2008). Currently, the Port is beginning an environmental review for a major renovation of its facilities. The project involves such upgrades as replacing one of the major wharves, construction of a 12-foot seawall, and an update of the electrical system. These renovations will eventually allow the Port to handle increased shipping traffic. Cargill Salt is in the process of preparing a development plan for the 1,400 acres of salt-producing crystallizer and bittern ponds in Redwood City.

Near the southeastern corner of the West Bay Unit, the Menlo Park Dumbarton Transit Station Area Plan is in the initial survey stages of determining land use around a new proposed commuter rail station. Located near the intersection of Willow Road and State Route 84 (Bayfront Expressway), the station would connect to other stations in Fremont and Newark as part of the proposed Dumbarton Rail Project.

In East Palo Alto, along the southern end of the West Bay Unit, is the Ravenswood Business District (RBD). Formed in 1990 and encompassing land adjacent and within the approved acquisition boundary, the area is part of the East Palo Alto Bay Access Master Plan (BAMP) (City of East Palo Alto 2007).

A major goal of the BAMP is to balance development with continued public access to the Bay and the Refuge. Zoning in the RBD area consists of light and heavy industrial uses, including properties designated as resource management areas inside the approved acquisition boundary. Redevelopment plans propose turning the area into a community with office, R&D, and commercial and residential land use. Also included in BAMP are development plans for Cooley Landing, an approximately 9-acre former landfill at the end of Bay Road extending eastward into the San Francisco Bay from the West Bay Unit. Plans include construction of a park, visitor center, and trail system. The City of East Palo Alto has also expressed interest in creating a rail station linked to the Dumbarton Rail Project in the RBD and is researching possibilities.

Regional Habitat Conservation Planning
The Baylands Ecosystem Habitat Goals Report from the San Francisco Bay Area Wetlands Ecosystem Goals Project establishes regional goals for maintaining healthy wetlands ecosystems (Goals Project 1999). Coordinated in 1994 by the San Francisco Estuary Institute, the project receives support and funding from State, Federal, and non-governmental organizations. The goals and information generated are available to the public and any party interested in implementing them; they are not required to be implemented but instead serve as recommendations to guide informed decisions. Encompassing the majority of the San Francisco baylands, the project focuses on four primary sub regions and further divides these into geographic segments. The Refuge and its approved acquisition boundary are located in Segments M (San Mateo) through S (Hayward) as depicted in Figure 17.

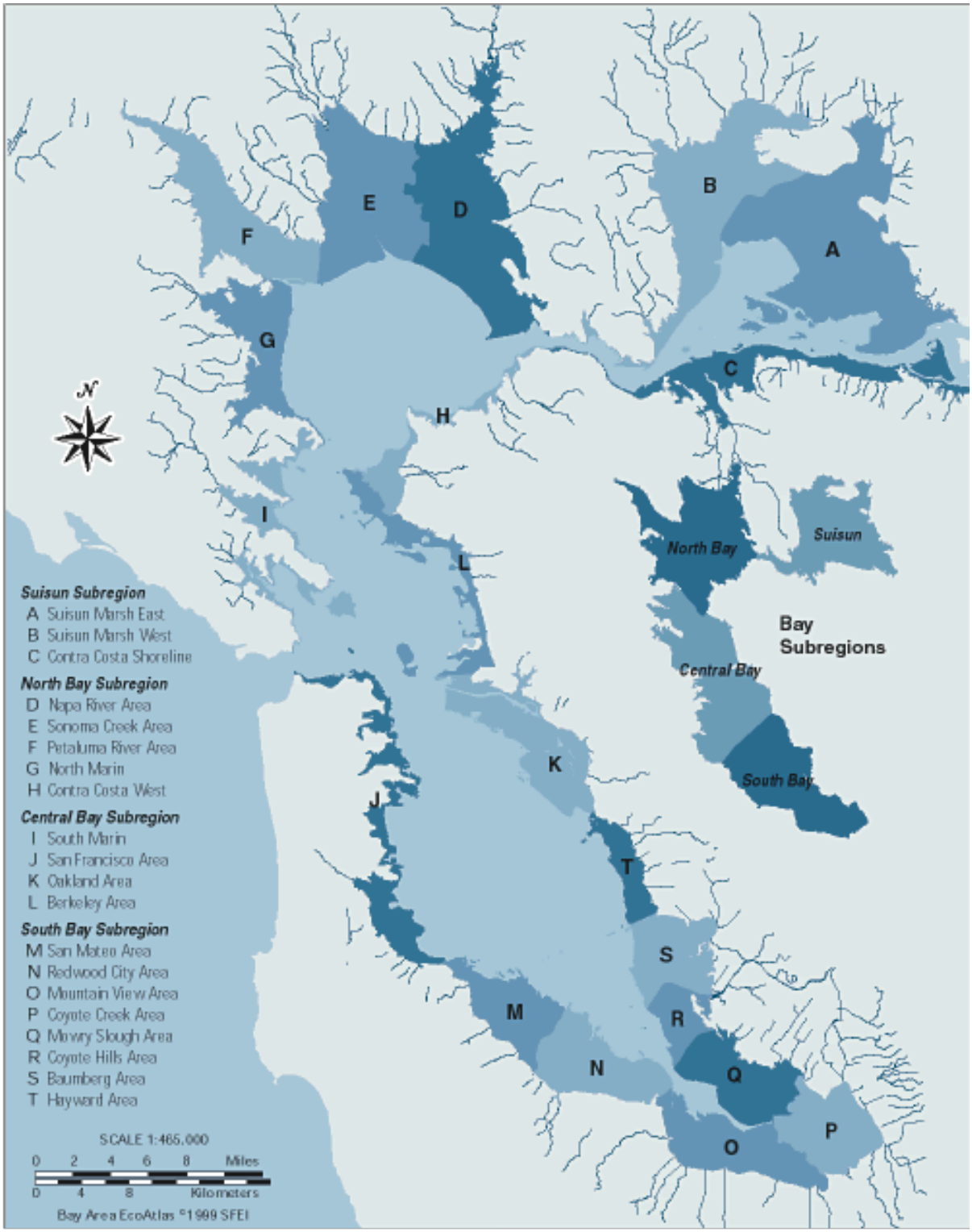
In 2012, a group of local and Federal organizations developed the Santa Clara Valley Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP), which created a unified regional framework for protecting ecological diversity as well as improving efficiency in the regulatory process. The project area does not include locations within the Refuge or the approved acquisition boundaries, although it does include areas in the near vicinity. Other regional HCPs that do not specifically include the Refuge are the East Contra Costa County HCP/NCCP, the San Bruno Mountain HCP, PG&E Bay Area Operations and Maintenance HCP, and the SFPUC Alameda Watershed HCP.

Many other environmental planning efforts that include the Refuge exist. The San Francisco Estuary Invasive *Spartina* Project is an effort among local, State, and Federal groups to combat the spread of invasive *S. alterniflora* (cordgrass) throughout the Bay (San Francisco Estuary 2008). Started in 2000, the ISP plans to eliminate and reduce the expansion of *Spartina* populations through a combination of chemical and physical treatment methods. Nearly all *S. alterniflora* has been eliminated and control of hybrid (native crossed with invasive) *Spartina* is underway.

The SBSPRP is currently the largest tidal wetland restoration project on the West Coast, working to restore and enhance over 1,500 acres of salt ponds. Adopted in 2008, the plan was a result of the purchase of these salt ponds from Cargill Salt. The project includes ponds in the Alviso Unit, the Ravenswood area of the West Bay Unit, and the Eden Landing section of the Newark Unit. Restoration will include tidal marsh and enhancement of ponds for wildlife.

The South Bay Shoreline Study is a joint effort between the Corps and local organizations to identify potential flood damage reduction, ecosystem restoration, or public access projects for Federal funding. Incorporating findings from the SBSPRP, the Corps is working toward establishing projects that benefit both local ecosystems and flood protection. The revised study area currently incorporates the Alviso Unit.

Figure 17. Subregions and Segments of the San Francisco Baylands from the San Francisco Bay Area Wetlands Ecosystem Goals Project



Source: Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of the habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. First Reprint. U.S. Environmental Protection Agency, San Francisco, CA./S.F. Bay Regional Water Quality Control Board, Oakland, CA.

Agricultural Resources
Most of the Refuge is not suitable for agriculture, although in the past some areas supported both farming and ranching. The South Bay is situated in a Mediterranean climate zone, which is generally favorable for agricultural production with warm dry summers and cool wet winters. However, much of the soil consists of Reyes Clay, a soil not appropriate for most agricultural operations. Most of the areas within the vicinity of the Refuge have been built-over or urbanized and are also no longer suitable for agricultural purposes. Today, only a few small areas within and near the Refuge are considered prime farmland, which the California Department of Conservation defines as soil that has the best combination of physical and chemical features able to sustain long-term agricultural production and has been used for irrigated agricultural production sometime in the past four years.

Newark Unit: Areas within the approved acquisition boundary of the Newark Unit are identified as agriculturally important on the 2008 Alameda County Important Farmland Map (Gustafson and Gregory 2001). This includes approximately 450 acres of both Prime Farmland and Grazing Land along the Alameda Creek Flood Control Channel near Coyote Hills Regional Park. The soil composition is primarily drained Omni Silty Clay Loam and drained Sycamore Silt Loam. This land was originally part of a major ranch in the 1800s named Rancho Potrero de Los Cerritos, used primarily for dairy and grain cultivation. Outside of the approved acquisition boundaries just to the east is also approximately 100 acres of Prime Farmland consisting of mainly Omni Silty Clay Loam.

Mowry Unit: No areas in the Mowry Unit are identified as agriculturally important on the 2008 Alameda County Important Farmland Map (Alameda County 2009). Approximately 250 acres of land to the east of the Unit boundary near Mowry Landing and the Union Pacific Railroad tracks are identified as Grazing Land consisting of strongly saline Omni Silty Clay Loam. Grazing does occur on approximately 680 acres of the Warm Springs sub-unit.

Alviso Unit: No areas in the Alviso Unit are identified as agriculturally important on the 2008 Santa Clara County Important Farmland Map (Santa Clara County 2009). Approximately 500 acres of disconnected land southeast of the Unit boundary near Milpitas are identified as Prime Farmland, Unique Farmland, Farmland of Local Importance, and Grazing Land. This land was part of a major ranch in the 1800s named Rancho Rincon de Los Esteros. Primarily a cattle ranch after the original founding, the land was later used for orchards and eventually to grow lettuce before most was lost to development.

West Bay Unit: No areas in the West Bay Unit are designated as agriculturally important on the 2008 San Mateo County Important Farmland Map (San Mateo County 2009). Areas within the West Bay Unit have historically been used for both grazing and agricultural purposes, including extensive operations on Bair Island.

Aircraft Operations
There are three major public airports operating in the San Francisco Bay area: Norman Y. Mineta San Jose International Airport (SJC), Oakland International Airport (OAK), and San Francisco International Airport (SFO). These airports experience heavy flight traffic, and combined, they facilitate over a million operations each year. Adjacent to the Alviso Unit is Moffett Federal Airfield, owned by the National Aeronautics and Space Administration

(NASA) and not currently open to the public. Flights to and from these airports regularly cross the skies above the Refuge, primarily from arrivals to San Francisco and Oakland and departures from San Jose and Moffett Airfield. Approaches to these airfields are typically aligned northeast/southwest and are made using instrument landing systems (ILS) and global positioning systems (GPS), as well as the coded tactical air navigation facility (TACAN) at Moffett Airfield for military aircraft (Metropolitan Transportation Commission 2003). Other regional public airports in the proximity of the Refuge with enough traffic to warrant an air traffic control tower include Palo Alto Airport located between the West Bay and Alviso Units, Hayward Executive Airport north of the Newark Unit, and San Carlos Airport adjacent the West Bay Unit.

The approach path for planes landing at San Carlos Airport occurs over a western section of Inner Bair Island. Required by the Federal Aviation Administration (FAA) to maintain a runway protection zone (RPZ), the airport owns a section of property on the island. FAA guidelines require that the RPZ remain clear of structures or stationary objects, and that emergency vehicles should be able to access the site. Current restoration efforts on Bair Island will maintain this RPZ by improving levee access and potentially moving the site to a safer location onsite.

Military Operations
Few military operations still exist in the proximity of the Refuge. Most notable is Moffett Federal Airfield, which is a joint civil-military airfield adjacent to the Alviso Unit. Once a United States Naval Facility, it is now owned by NASA and houses the NASA Ames Research Center. Two military units are still based at the airfield, the 129th Rescue Wing of the California National Guard and the 7th Psychological Operations Group of the United States Army Reserve. No longer considered an active military base, Moffett Community Housing still provides residence to a number of military families. The San Francisco Bay is also home to United States Coast Guard (USCG) operations. Stations include the Golden Gate Station, the Yerba Buena Island Station, Air Station San Francisco located at SFO, and the Integrated Support Command (ISC) Alameda located on Coast Guard Island. Servicing the waters around of the Bay including those of the Refuge, the San Francisco Group of the USCG provides search and rescue, law enforcement, and military services.

3.6.2. Public Uses

The Refuge offers a wide variety of public activities that drew an average of 803,000 visitors to the Refuge each year during 2006 to 2008. Ranging from environmental education and interpretive hikes to hunting and fishing, visitors have many opportunities to participate in outdoor activities. More detail about the Refuge's public use activities is described in Chapter 4, "Current Management." This section will cover recreational activities and access surrounding the Refuge.

Boating
There are a few public launching ramps located near, but none on the Refuge. Launching sites can be found at the Port of Redwood City and Palo Alto Baylands Park (non-motorized boats only) near the West Bay Unit, both with parking and restroom facilities. The Alviso Marina near the Alviso Unit also provides access to the Refuge, having recently opened a boat ramp that enters Alviso Slough. This site provides parking and restroom facilities. Just outside the Refuge Complex headquarters, Jarvis Landing boat ramp owned by Cargill Salt in the

Newark Unit has a paved parking lot but no restroom facilities. Plans are also underway to construct a kayak launch ramp at the ELER (CDFG) that will provide further boat access. Sanctioned by the California State Legislature in 2005, work has begun to create the San Francisco Bay Area Water Trail, which will link new and existing launch and camping sites all around the Bay. The eventual goal is a continuous ring of services that will allow for multi-day, non-motorized boating trips. One or two of these sites may be planned for the Refuge. Any site development on the Refuge would need the Refuge's approval.

San Francisco Bay Trail
The San Francisco Bay Trail Plan is an ongoing plan to create a hiking and bicycling trail around the San Francisco and San Pablo Bays. Adopted in 1989 by the Association of Bay Area Governments (ABAG), the *Bay Trail Plan* includes a proposed alignment, a set of policies to guide the future development of routes, and strategies for implementation and financing. By linking existing trail systems and developing new trails to connect gaps, the Bay Trail will eventually total a continuous 500 miles through nine counties (ABAG 1999). Inside and around the Refuge, the *Bay Trail Plan* incorporates existing trails as well as the construction of over 50 miles of new trails.

The following discussion describes the amount of new trail construction and improvement planned within each Refuge Unit by ABAG. The Refuge will work with ABAG and others to accommodate these trail plans when compatible with Refuge mission and goals.

Newark Unit: Approximately 12 miles of proposed construction and improvement.

Mowry Unit: Approximately 15 miles of proposed construction and improvement.

Alviso Unit: Approximately 17 miles of proposed construction and improvement.

West Bay Unit: Approximately 9 miles of proposed construction and improvement.

Developed Park Land
The area around the Refuge includes a number of active parks such as Sunnyvale Baylands Park and Alviso Marina County Park near the southern end of the Alviso Unit, Coyote Hills Regional Park near the visitor center in the Newark Unit, and Bedwell Bay Front Park near the intersection of the U.S. Highway 101 and State Route 84 in the West Bay Unit. Other parks include Hayward Regional Shoreline Park at the north end of the Newark Unit, the Mountain View Shoreline Park, Steven's Creek Shoreline Nature Study Area, and Byxbee Park between West Bay and Alviso Units.

3.6.3. Traffic Circulation/Parking

There is a lack of public transit to the Refuge units; car and bike are the primary methods to travel to the Refuge. Access to destinations on the Refuge is available via local streets and regional transportation corridors. Parking for destination-related activities is offered in numerous locations throughout and near the Refuge. Information regarding current traffic volumes and parking availability, as well as predictions for future traffic volumes, is provided to assist in determining effects of changes in Refuge use on nearby traffic circulation and parking demand.

Traffic Circulation
The Refuge has seen an average of 783,000 visitors per year between 2006 and 2010, most of whom come to participate in recreational activities and educational programs. Though the Refuge encompasses a vast area, many activities are focused in specific locations (such as the EEC and surrounding trail network located in the Alviso Unit). Trips generated as a result of these recreational activities, as well as employee, volunteer, and service-related trips, are accommodated by local streets and regional transportation corridors.

A number of major roadways provide regional access to the Refuge, including: U.S. Highway 101, Interstate 880, State Route 84, State Route 92, and State Route 237. The following section summarizes available traffic volume data from Caltrans (2008) at relevant sections along these roadways, which are used to access the Refuge. Traffic volume data is presented as Average Annual Daily Traffic (AADT, total annual volume in both directions divided by 365 days) and Peak Hour (total volume in both directions during the peak hour), both in thousands of cars.

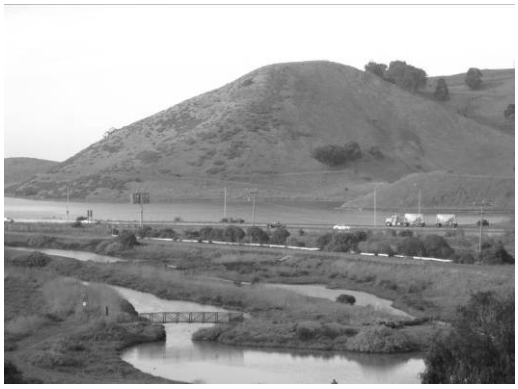
U.S. Highway 101 is a State Highway that provides regional access to this section of the West Bay Unit and Alviso Unit. This highway travels in a north-south direction through California, to the west of both Units. Traffic volumes along this freeway include 392 AADT and 26.3 Peak Hour at University Avenue in East Palo Alto.

Interstate 880 is an Interstate Highway in the San Francisco Bay Area that provides regional access to the Newark, Mowry, and Alviso Units. This highway travels in a north-south direction from Oakland to San José, to the east of these three units. Traffic volumes along this freeway include 386 AADT and 26.5 Peak Hour at the Mowry Avenue Interchange in Fremont.

State Route 92 is a highway in the San Francisco Bay Area that provides regional access to the West Bay and Newark Units. This highway travels in an east-west direction from Half Moon Bay to Hayward, located north of the West Bay Unit then spanning the Bay (via the San Mateo-Hayward Bridge) into the northern portion of the Newark Unit. Traffic volumes along this freeway include 176 AADT and 15.2 Peak Hour at the San Mateo-Hayward Bridge.

The southern section of State Route 84 is a highway in the San Francisco Bay Area that provides regional access to the West Bay, Newark, and Mowry Units. This highway travels in an east-west direction from San Gregorio to Livermore, located through the West Bay Unit and spanning the Bay (via the Dumbarton Bridge) into the southern portion of the Newark Unit. Traffic volumes along this freeway include 116 AADT and 9.9 Peak Hour at the Dumbarton Bridge Toll Plaza.

State Route 237 is a highway in the San Francisco Bay Area that provides regional access to the Alviso Unit. This highway travels in an east-west direction from Milpitas to Sunnyvale, to the south of the Alviso Unit. Traffic volumes along this freeway include 277 AADT and 22.2 Peak Hour at the Zanker Road Interchange in San José.



Refuge in the foreground with State Route 84 in the background
USFWS

Traffic at intersections is described using standards known as "level of service" (LOS), which is a measurement of traffic flow based on factors such as speed, travel time, delay, and freedom to maneuver. There are six levels of service, from LOS A, which represents the most ideal operating conditions, to LOS F, which represents the worst operating conditions and delays. LOS E normally corresponds to operation "at capacity," and many areas consider LOS D to be the minimum acceptable level of service. Projects that degrade the LOS of an intersection may be seen as having a significant impact on the traffic congestion of that area. Future development in the Refuge is unlikely to significantly degrade the LOS standard of local intersections. Increased traffic from restoration projects is likely to occur on less frequently used streets and increased traffic from recreational activities will most often occur on weekends when traffic levels are lower.

Besides the regional roadways, a series of local streets provides access to Units within the Refuge for recreational and staff purposes.

Newark Unit: The Visitor Center generates vehicle trips, which is accessed by Thornton Avenue from State Route 84, and then the smaller Marshlands Road. Other areas of the Unit are accessed via local streets in the cities of San Leandro, Hayward, Union City, and Newark.

Mowry Unit: There are currently no recreational activities within the Mowry Unit that generate public trips; however access can be accommodated by streets such as Mowry Avenue, Stevenson Boulevard, and Auto Mall Parkway. Other areas of the Unit are accessed via local streets in the cities of Newark and Fremont.

Alviso Unit: Major regional access to the Alviso Unit is provided by State Route 237, U.S. Highway 101, and Interstate 880. As most of the Unit is open to the public for recreational activities (e.g., hiking, hunting, wildlife viewing), there are numerous access points along local roads, although only some of these are open to vehicle traffic during hunting season. Another area that generates public and staff trips is the EEC and surrounding recreational activities, located on EEC Access Road off of Los Esteros Road near State Route 237. Other areas of the Unit are accessed via local streets in the cities of Fremont, San Jose, Sunnyvale, and Mountain View.

West Bay Unit: Major attractions within the West Bay Unit include Bair Island and Ravenswood area. Although currently closed to recreational activities, access to Bair Island is

normally provided by Bayshore Road, located at the intersection of Whipple Avenue and U.S. Highway 101. Hiking and other recreational activities in the Ravenswood area are accessed by State Route 84 and University Avenue, as well as Bay Road. Other areas of the Unit are accessed via local streets in the cities of East Palo Alto, Menlo Park, and Redwood City.

Parking

Newark Unit: The Headquarters located on Marshlands Road near Thornton Avenue and at the east end of the Dumbarton Bridge, has a large, paved parking lot with 65 marked parking spaces. There are two additional paved parking lots along Marshlands Road that provide parking for nearby trails such as the LaRiviere Marsh Trail. One lot provides 27 marked spaces and the other provides six marked spaces. Public parking for the Dumbarton Fishing Pier is found on Marshlands Road past the Visitor Center where the road dead-ends in a large parking lot. This road may be closed from April until August for nesting birds, in which case a free shuttle is offered on weekends. Public parking at the Coyote Hills Regional Park Visitor Center on Patterson Ranch Road provides access to trails that connect with those in the Newark Unit. The East Bay Regional Park District maintains a paved parking lot with 27 marked spaces providing access to Alameda Creek Regional Trail. This parking lot is located south of the Union City Boulevard and Lowry Road intersection adjacent to the Alameda Creek Flood Control Channel (ACFCC).

Mowry Unit: There is currently no public parking in the Mowry Unit.

Alviso Unit: Visitors accessing the EEC or the nearby trail network are provided with a large 42-space parking lot in front of the building. The Alviso EEC is located off of Los Esteros Road at the end of EEC Access Road. Public parking for fishing at Coyote Creek Lagoon is provided at the southern dead-end of Fremont Boulevard, where a small parking lot offers 14 marked spaces. The southern portion of the Alviso Unit can also be accessed through the Alviso Marina County Park (managed by Santa Clara County Parks), which is located at the end of Hope Street and contains a paved parking lot with 107 spaces. Nearby Sunnyvale Baylands park also provides over 200 parking spaces. Further to the west, the Mountain View Shoreline Park and Shoreline Amphitheater Overflow Parking provides over 400 parking spaces for visitors accessing the Refuge's Stevens Creek East and Moffett Bay Trails. Limited parking for the Moffett Bay Trail is also found at the Sunnyvale Treatment Plant located on Borregas Avenue and Carl Road.

West Bay Unit: Though currently closed to visitors, parking for Bair Island is located at a developed parking lot at the end of Bair Island Road near the Whipple Avenue and U.S. Highway 101 Freeway intersection. Parking for access to Ravenswood Slough Trail is available at the northwestern side of the Dumbarton Bridge. Parking access for the Pond SF-2 trail is found on the southwestern side of the Dumbarton Bridge Highway 84. Parking for the Refuge's Faber-Laumeister Tract Trail is on Runnymede Street, East Palo Alto, and the Palo Alto Baylands Park in Palo Alto. Parking for the Bay Trail that runs along Bayfront Expressway on the south side of Ponds R3, R5, and S5 is at Bedwell Bayfront Park in Menlo Park.

3.6.4. Public Utilities/Easements

Newark Unit: Public utilities within the Newark Unit include a 115 kV PG&E overhead power transmission line that enters the northeast corner of the Unit and extends southeast over the Eden Landing site. PG&E maintains a 60-foot-wide easement underneath the lines and surrounding the towers that support the high voltage lines (City of Newark 2008). Running from the west shore of the Bay and paralleling the San Mateo Bridge, a 230 kV PG&E overhead transmission line crosses the Unit before continuing east. There are no PG&E access points for reconductoring within the pond complex. A pipeline serving as part of the East Bay Dischargers Authority (EBDA) effluent disposal system traverses the Newark Unit as it transports effluent from the Union Sanitary District north toward the EBDA Bay outfall. This sewer force main enters the Unit from the southeast and runs northwest along the eastern perimeter and into the Eden Landing site. Additionally, there are three storm water lift stations located along Old Alameda Creek (OAC). Storm water outfalls discharging via gravity flow in the Eden Landing pond complex drain to OAC and ACFCC (U.S. Dept of the Interior, 1991).

The Hetch-Hetchy Aqueduct, a 110-foot-wide right-of-way owned by the San Francisco Public Utilities Commission, traverses east/west through the southern portion of the Newark Unit. The aqueduct is located underground through the east half of the Unit, transitioning to the surface through the Refuge's tidal marshes after crossing to the north side of the railroad right-of-way. The City of San Francisco is currently constructing a Hetch Hetchy pipeline tunnel under the entire crossing of the Refuge in this Unit. The Refuge has encouraged the City to remove the above ground Hetch Hetchy infrastructure in the Refuge's marshes once the underground project is completed. The Dumbarton Rail Corridor (DRC) also operates in an east/west direction through the Newark Unit, nearly parallel to the Hetch-Hetchy Aqueduct. The DRC is a 100-foot wide right-of-way owned by San Mateo County Transit Authority (City of San Leandro, 2007). Union Pacific Railroad tracks run north/south along multiple sections of the Newark Unit eastern boundary.

Under a 1979 agreement between Cargill Salt and the Service, Cargill Salt retains the salt making rights in the Newark Ponds in perpetuity. Cargill also retains drainage and utility easement through the Coyote Tracts 102 and 103.

Mowry Unit: Public utilities within the Mowry Unit include PG&E overhead transmission lines and a sewer force main. The power lines enter the Unit in the northwest, southwest, and southeast corners. Adjacent to the approved acquisition boundary on Nobel Drive is a PG&E substation where the transmission lines intersect. Power distribution lines break off of the main transmission lines in numerous locations. Union Pacific Railroad tracks that run north/south along sections of the Newark Unit boundary extend into the Mowry Unit. Entering in the northeastern corner of the approved acquisition boundary, the tracks continue southward across Mud Slough and Coyote Creek into the Alviso Unit. An East Bay Dischargers Authority (EBDA) sewer force main crosses two sections of the approved acquisition boundary, paralleling the railroad tracks between Stevenson Boulevard and Auto Mall Parkway, and near Cushing Parkway in a section eastward.

Under a 1979 agreement between Cargill Salt and the Service, Cargill Salt retains the salt making rights in the Mowry Ponds in perpetuity.

Alviso Unit: Public utilities within the Alviso Unit include both 115 kV and 230 kV PG&E overhead transmission lines that traverse through the Alviso Unit in several areas. The main line splits into two at the northeast border of the Mowry and Alviso Units. One line enters the Unit from the northeast and the other forms a semi-circle around the Unit perimeter as it extends south. It then continues to the west and re-enters the Unit near Moffett Field to reconvene with the first transmission line at the end of the Guadalupe Slough. From here, the transmission lines extend westward and then exit the Unit continuing northwest toward the Ravenswood area of the West Bay Unit. Power distribution lines break off of the main transmission lines in numerous locations to serve pumps. These distribution lines extend southward from the main transmission line near the northeast corner of the Unit. Another distribution line extends northward from the main transmission line near the Sunnyvale Baylands Park along an internal levee toward Alviso Slough. PG&E has seven reconductoring access points located on levees or immediately adjacent to ponds within the Alviso Unit (U.S. Dept of the Interior, 1991).

No water or wastewater pipelines are located in the Alviso Unit; however, several storm water lift stations are located just outside the Unit and discharge to tidal sloughs and channels in the Refuge. Two South Bay wastewater treatment plants are adjacent to the Alviso Unit and also discharge to sloughs within the pond complex. The San Jose/Santa Clara WPCP is located between Artesian Slough and Coyote Creek just outside of the Unit. It is operated by the City of San Jose Environmental Services Department and provides treatment services to the cities of San Jose, Santa Clara, Milpitas, Campbell, Cupertino, Los Gatos, Saratoga, and Monte Sereno. Treated effluent from the WPCP is discharged to Artesian Slough. The Sunnyvale WPCP is located just south of the Alviso Unit near the Sunnyvale Baylands Park and discharges into Moffett Channel, which eventually connects to Guadalupe Slough. Within the Alviso Unit there are several storm drain outfalls that influence waters in the Refuge. Found on Coyote Creek, Guadalupe River, Alviso Slough, Sunnyvale East and West Channels, Moffett Channel, Calabazas Creek, Permanente Creek, Stevens Creek, and Penitencia Creek, outfalls are located along these channels at various inverts (Moffatt & Nichol Engineers 2005).

West Bay Unit: Infrastructure within the Bair Island area of the West Bay Unit includes a South Bayside System Authority (SBSA) sewer force line, Pacific Gas and Electric (PG&E) transmission towers, and overhead lines. The SBSA line easement runs northwest underneath the Inner Bair Island levee from the Whipple Avenue interchange, across the western Inner Bair Island Pulgas Creek borrow-ditch, and along San Carlos Airport property. PG&E has an easement that runs through portions of Bair Island including the adjacent Bair Island parking lot. There are two parallel electrical transmission lines, a 230-kilovolt (kV) line and a 115-kV line, both suspended from steel truss towers approximately 204 feet in height located adjacent to the Bair Island parking lot. The two towers in the parking lot connect to a PG&E substation adjacent to Seaport Boulevard to the east, and to towers on Bair Island to the west. One of the PG&E transmission towers is located on the Inner Bair Island levee, near the eastern tip of the island. The transmission lines then run northeast toward the Bay where it meets a 230kV line running north/south to the Ravenswood area (USFWS 2006).

Infrastructure within the Ravenswood area of the West Bay Unit includes a PG&E substation and overhead transmission lines. These transmission lines enter the Ravenswood area from the northwest, east, and south. A power distribution line breaks off from the transmission

lines and extends northwestward along the eastern bank of Ravenswood Slough. No municipal water or wastewater pipelines are located within the Ravenswood area. Running through the southern end of the West Bay Unit is the Hetch Hetchy Aqueduct, which carries water from the Sierra Nevada to the City of San Francisco and other communities on the Peninsula and the South Bay area. The San Francisco Public Utilities Commission, which owns the aqueduct, maintains a 110-foot-wide right-of-way. A buried section of the aqueduct enters the Bay on the eastern shore and emerges on the western shore in the Unit. Also in the Ravenswood area, gravity storm water lines feeding Atherton Channel and Bayfront Canal drain to Flood Slough (EDAW et al. 2007).

3.6.5. Economics/Employment

The cities surrounding the Refuge have a diverse economic base that includes strong professional and manufacturing sectors (partly due to the proximity to the Silicon Valley). Educational services, health care, and social assistance also play a major role in the local industries. The population, population growth, area, and leading industries of each city are in Table 13.

Table 13. Population, Areas, and Leading Industries (US Census Bureau)

	Population 2009[1]	Population 2000	Change in Population 2000–2009	Area (in Square Miles)	Leading Industries[2]
Jurisdiction					
San Leandro	82,472	79,452	3,020	13	4,1,2
San Lorenzo	N/A[3]	21,898	N/A[3]	2.8	4,2,3
Hayward	150,878	140,030	10,848	63	4,1,2
Union City	73,977	66,869	7,108	18	1,4,3
Fremont	215,636	203,413	12,223	92	1,3,4
Newark	44,035	42,471	1,564	13	4,3,1
Milpitas	70,817	62,698	8,119	14	1,3,4
San Jose	1,006,892	894,943	111,949	178	1,4,3
Sunnyvale	138,826	131,760	7,066	23	3,1,4
Mountain View	74,762	70,708	4,054	12	3,4,1
East Palo Alto	33,174	29,506	3,668	3	4,3,2
Menlo Park	31,865	30,785	1,080	17	4,3,1
Redwood City	77,819	75,402	2,417	34	4,3,2

[1]California Department of Finance, Demographics Research Unit, http://www.dof.ca.gov/research/demographic/reports/estimates
[2](1) Manufacturing, (2) Retail trade, (3) Professional, scientific, management, and administrative and waste management services, (4) Educational services, and health care and social assistance.
[3]San Lorenzo is a census-designated place (CDP) and no current population data is available.

3.6.6. Environmental Justice

The definition of environmental justice is to offer the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment for every person where they live, learn, and work. It involves the fair treatment and meaningful involvement of all people regardless of color, race, national origin, or income with respect to the implementation, development, and enforcement of environmental laws, regulations, and policies. No group of people should bear a

disproportionate amount of negative environmental consequences from municipal, industrial, and commercial activities or the implementation of local, State, and Federal policies and programs.

Traditionally, low-income and minority communities were the site of environmental hazards that put residents at risk for serious health problems. In 1994, in response to increased public concern and awareness about such inequities, Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations) was issued. This Executive Order requires each Federal agency to make achieving environmental justice part of its mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its program, policies, and activities on minority and low-income populations.

To understand potential effects of the Refuge as they relate to environmental justice, information regarding the economic and ethnic background of communities surrounding the Refuge is below.

According to the U.S. Census Bureau, low income is defined as less than $50,000 and moderately low income as $50,000–$69,999. By this definition one city (East Palo Alto) has a Low Median Household Income and two areas (San Lorenzo and Hayward) have Moderately Low Median Household Incomes. The City of East Palo Alto also has a significant number of families below the poverty line (14 percent). Most of the surrounding cities fall into the Moderately High Median Household Income ($70,000-$89,999) category.

The percent of individuals employed in the labor force, median household income, and percent of families below the poverty line are in Table 14. The ethnic composite of the areas that surrounds the Refuge are in Table 15.

Table 14. Economics

	Labor Force	Median Household Income[1]	Families Below Poverty Level
Jurisdiction			
San Leandro	67%	62,113	6%
San Lorenzo	63%	67,929	5%
Hayward	67%	58,357	8%
Union City	66%	84,384	8%
Fremont	68%	88,645	7%
Newark	68%	78,367	4%
Milpitas	64%	85,668	5%
San Jose	67%	76,354	7%
Sunnyvale	69%	82,622	5%
Mountain View	72%	82,904	4%
East Palo Alto	70%	49,267	14%
Menlo Park	70%	103,702	3%
Redwood City	66%	72,679	6%

[1]The US Census Bureau defines income levels as follows:
Low Income (less than $50,000)
Moderately Low Income ($50,000–$69,999)
Moderately High Income ($70,000–$89,999)
High Income ($90,000 or more)

Table 15. Existing Demographics in the Project Area (US Census Bureau)

	African American	American Indian	Asian	Pacific Islander	White	Other	Multi Racial	Hispanic (of any race)[1]
San Leandro	13%	1%	28%	1%	47%	8%	4%	23%
San Lorenzo	8%	1%	24%	<1%	52%	10%	5%	30%
Hayward	14%	<1%	24%	2%	35%	21%	4%	36%
Union City	6%	<1%	49%	<1%	29%	12%	3%	22%
Fremont	3%	<1%	46%	2%	38%	8%	3%	15%
Newark	3%	<1%	25%	1%	47%	19%	5%	36%
Milpitas	3%	<1%	59%	<1%	25%	9%	3%	15%
San Jose	3%	<1%	31%	<1%	49%	13%	3%	31%
Sunnyvale	3%	<1%	36%	<1%	47%	6%	2%	18%
Mountain View	2%	<1%	25%	<1%	56%	11%	3%	21%
East Palo Alto	20%	0%	7%	8%	55%	7%	<1%	55%
Menlo Park	7%	<1%	8%	<1%	78%	5%	3%	17%
Redwood City	3%	<1%	9%	1%	76%	8%	2%	36%

Note: Numbers may not total 100% due to rounding. Some entries are actual based upon reported data, while others are estimated.

[1] "Hispanic or Latino" is not considered a "race" by the Census. Rather, it is a cultural/ethnic classification that overlaps with race. Persons who identified themselves as "Hispanic or Latino" also identified themselves with a race or combination of races.

4. Current Management

4.1. Introduction

This chapter describes the current refuge management activities that take place on the Refuge (see Chapter 5 for Planned Management Direction). Current activities focus on endangered species and migratory bird surveys; wildlife habitat restoration and enhancement; grassland and vernal pool management; non-native species control; environmental education; interpretation; and offering opportunities for hunting, fishing, wildlife observation, and photography.

Current staffing of the Refuge includes 12 permanent positions (refuge manager, wildlife refuge specialist, two maintenance workers, one wildlife biologist, one part-time wildlife biologist, part-time wildlife refuge specialist, environmental education specialist, two part-time environmental education specialists, interpretive park ranger, and one part-time outdoor recreation planner). Law enforcement staff assigned to the overall San Francisco Bay NWR Complex provides intermittent patrols of the Refuge. The Refuge also receives administrative, maintenance, biological, and visitor services support through staff from the Complex.

4.2. Habitat Enhancement and Restoration

A number of large-scale, site specific tidal marsh restoration and managed pond enhancement projects have been conducted on the Refuge and more are planned. These projects focus on restoring or enhancing hydrology and associated estuarine-dependent plant and animal communities. Restoration will provide key habitat components for endangered species and other native plant and wildlife species. Existing and planned enhancement or restoration projects on the Refuge include the SBSPRP, Bair Island Restoration Project, New Chicago Marsh Restoration Project, Mayhew's Landing Restoration Project, and Faber-Laumeister Restoration and Monitoring Project.

South Bay Salt Pond Restoration Project

The SBSPRP is the largest tidal wetland restoration project on the West Coast. When complete, the restoration will convert 15,100 acres of former commercial salt ponds at the south end of San Francisco Bay to a mix of tidal marsh, mudflat, managed pond, open water, and other wetland habitats. The property was purchased by the State of California and the Service from Cargill Salt as part of a larger land transaction that included 1,400 acres of salt crystallizer ponds on the east side of the Napa River. The acquisition of the South Bay salt ponds provides an opportunity for landscape-level wetlands restoration, improving the physical, chemical, and biological health of the San Francisco Bay. The goals of the SBSPRP are to restore and enhance the tidal marsh and pond ecosystem, to provide wildlife-oriented public access and recreation, and to provide for flood management in the South Bay.

Kite-photography aerial of new nesting islands at Pond SF2
© Charles Benton

The Project Management Team is overseeing the restoration planning process, which includes habitat restoration, public access, and flood management. The Team is comprised of the Coastal Conservancy, the CDFG, the Service, SCVWD, Alameda County Flood Control and Water Conservation District (ACFCWCD), and the Corps, as well as the Lead Scientist (USGS) and Center of Collaborative Policy (a unit of the College of Social Sciences and Interdisciplinary Studies at California State University, Sacramento) Coordinator. The Project Management Team expects that restoration of a portion of the salt ponds to tidal marsh and management of the remainder of ponds will benefit a diversity of wildlife, particularly endangered species, such as the California clapper rail, the salt marsh harvest mouse, and several fish and aquatic species. Managed ponds will continue to provide important feeding and resting habitat for migratory shorebirds and waterfowl—a function that is already provided by many of the existing ponds. The SBSPRP consists of several Phase 1 actions that have been completed or are underway. The SBSPRP is being guided by a separate planning process from the CCP for the Refuge. However, because many of the SBSPRP actions are being implemented on the Refuge, it is important to highlight the actions (described below). More detailed information for each of these actions can be found at: http://www.southbayrestoration.org/index.html.

- Pond SF2 Restoration Action - The goal of Pond SF2 was to enhance a 240-acre pond in order to create 155 acres of shallow water habitat for feeding dabbling ducks and shorebirds. The enhancement included 30 nesting islands for nesting and resting shorebirds, and 85 acres of habitat for nesting threatened western snowy plovers. Construction began in March 2009 and was completed in August 2010. Another goal of Pond SF2 was to construct 0.7 mile of trail and build two new viewing platforms. This trail was completed and opened in fall 2010.

- Pond A6 Restoration Action - The goal of Pond A6 was to create approximately 330 acres of tidal salt marsh and tidal channel habitat that will sediment in and vegetate over time and provide high-quality breeding and foraging habitat for the endangered California clapper rail and other marsh associated species. Construction was completed in December 2010. Seeding of the upland ecotone (along levee edges) was conducted in October 2011.

- Pond A17/A16 Restoration Action - The goal of Pond A17/A16 is to enhance 240 acres of shallow ponds with 50 nesting islands for migrating shorebirds. Construction began in fall 2011 and is expected to be finished in fall 2013.

- Pond A8/A7/A5 Restoration Action - The goal of Pond A8/A7/A5 was to hydrologically connect 1,400 acres of ponds to the San Francisco Bay, that will sediment in and vegetate over time and create new marsh and shallow water habitats for the benefit of migratory birds and marsh species. Construction was completed in fall 2010 and the area was opened to muted tidal action in June 2011.

The SBSPRP Project Management Team met in May 2010 to develop a preliminary suite of options/scenarios for the next phase of restoration actions (Phase 2 actions) and a preliminary timeline to implement these actions based on criteria such as available funding, public support, likelihood of success, readiness to proceed, and many others. Once the SBSPRP Project Management Team has identified the preliminary possibilities for restoration, they will vet these actions and any other actions through a public participation process. Opportunities for public participation will be identified at: http://www.southbayrestoration.org/index.html.

Bair Island Restoration Project

Bair Island is part of the West Bay Unit of the Refuge, located adjacent to the San Francisco Bay in Redwood City, San Mateo County, California. The Bair Island complex is divided into three distinct areas separated by slough channels: Inner, Middle, and Outer Bair Islands. The Refuge is in the process of restoring former salt evaporator ponds on the Bair Island complex to tidal habitats. An EIS/EIR was completed for this project in 2006. The objectives of the proposed project are: (1) to restore 1,400 acres of high quality tidal marsh habitat, mudflat/aquatic habitat, and uplands habitat, (2) maximize the function and values of tidal marsh habitats in a timely manner in order to provide habitat for endangered species and other native wildlife, and (3) enhance the public's appreciation and awareness of the unique resources of Bair Island. Once restored, the site will assist with the preservation and recovery of the endangered California clapper rail and salt marsh harvest mouse. The restoration of Bair Island would take place in phases.

- Phase 1: Breach Outer Bair Island – Approximately 468 acres of Outer Bair Island was reconnected to the San Francisco Bay through renewed tidal action when it was breached to Steinberger Slough in January 2009. Since then, salt marsh and mudflat habitat has been developing and providing habitat for a variety of wildlife species.

- Phase 2: Inner Bair Island elevation increase - Phase 2 will raise the level of Inner Bair Island so that when tidal action is re-introduced, the area will return to vegetated marsh more rapidly. To raise the island's level, over one million cubic yards of dirt fill is required on the island. The "clean" fill will consist of beneficial re-use of dredged materials from local projects. Due to volume of the fill material to be delivered to the site this part is expected to continue for an estimated three to five years.

- Phase 3: Build flow restrictors/blocks in Corkscrew and Smith Sloughs in order to breach Outer, Middle, and Inner Bair Islands - The Refuge proposes to construct flow restrictors (in Corkscrew Slough and along Inner Bair) and a flow block (in Smith Slough) to restore tidal flow to the 896-acre Middle Bair Island. When completed, this will restore 673 acres of high quality tidal salt marsh habitat, 203 acres of mudflat/aquatic habitat, and 20 acres of uplands habitat to Middle Bair Island. It is anticipated that construction will begin in 2012.

- Phase 4: Public Access improvements on Inner Bair Island - Once the initial phases of restoration are under way, public access improvement will begin. They include a rebuilt trail, pedestrian bridge, observation platforms, and other amenities. An ADA accessible pedestrian bridge will be constructed at the eastern edge of Inner Bair Island at Pete's Harbor. This bridge will be built from Bair Island Road, near the existing approved parking lot, onto Bair Island.

Large levee breach to main tidal channel at Outer Bair Island
Judy Irving © Pelican Media

New Chicago Marsh Restoration Project

New Chicago Marsh, in the Alviso Unit of the Refuge, is located near the EEC, in Santa Clara County, California. The Refuge proposes to improve water management capabilities in New Chicago Marsh to provide additional water during summer months by installing an inverted siphon in the New Chicago Marsh/ Pond A16 levee. This project will also provide water evacuation capability by increasing the capacity and size of an existing pump and discharge line between New Chicago Marsh and Artesian Slough. The goal of the project is to improve habitat for the endangered salt marsh harvest mouse and other wildlife species. New Chicago Marsh is currently dominated by pickleweed vegetation and contains historic slough channels. Limited tidal flow was reintroduced to the marsh in 1992 through the installation of a manually controlled 48-inch-wide screw-gate intake from Triangle Marsh to a 100-foot long culvert running the length of Pond A16, entering New Chicago Marsh at the northwest corner. However, the culvert that was installed was undersized and is currently completely overgrown with vegetation, extensively limiting tidal exchange. This results in hypersaline conditions and insufficient water levels during summer months. In addition, New Chicago Marsh is inundated with urban runoff during winter months. During flood years, inflow has reached levels that have caused mortality of endangered salt marsh harvest mice by drowning. Project design began in fall 2008 and environmental permits were secured by 2010. Construction was completed fall 2011, but water management cannot begin until construction at Pond A16 is completed.

Mayhew's Landing Restoration Planning

The Refuge proposes to improve the Mayhew's Landing site located near the City of Newark in Alameda County, California. Mayhew's Landing is a 125-acre parcel owned by the Refuge that currently provides marginal habitat for the salt marsh harvest mouse. Although some marginal tidal marsh habitat already exists, the site also contains a wealth of non-native plant species, is adjacent to a housing development without adequate predator protection, and has evidence of "social trails." In addition, Mayhew's Landing provides the Refuge with a rare opportunity to

create and manage upland transition zone adjacent to tidal marsh and freshwater habitats. One of the goals for the site is to protect and contribute to the recovery of the salt marsh harvest mouse by restoring and managing habitat (including breeding habitat and upland transition areas) for this species and other wetland dependent wildlife. Other goals for this site include enhancement of wetlands for the benefit of migratory waterfowl and shorebirds, and enhancement of upland areas to provide nesting habitat for burrowing owls. Because of the freshwater input in the form of stormwater runoff into the site, another goal here is to establish a small riparian corridor at the northern end of the site for the benefit of migratory songbirds and other species. The Refuge is still in the preliminary stages of planning this restoration project and environmental documentation will need to be completed. Planning efforts for this project will occur over the next three to five years.

Faber-Laumeister Restoration and Monitoring Project

The Faber and Laumeister Tracts are managed by the Refuge under a cooperative agreement with the City of Palo Alto (owner). The tracts are within the municipal boundary of East Palo Alto. The Laumeister Tract was never isolated from tidal action; the Faber Tract was historically diked but restored in the 1970s. The tidal marsh-upland ecotone has been colonized by non-native plants, thus reducing its habitat quality for native plants and tidal marsh wildlife. The salt marshes at Faber-Laumeister provide exceptional habitat for the California clapper rail, whose populations are greater here than anywhere else on the Refuge. Ecotone habitat along the border of the upper marsh provides high tide refugia for the clapper rail, which becomes a limiting factor for survival of this species at the highest of high tides. Active vegetation management is required to establish a native-dominated plant community and enhance the habitat quality. The Refuge is currently planning habitat enhancements for these tracts. The plan will describe a multi-year approach to manage weeds as well as seed and plant natives. Currently, vegetation management is going on with the Service'sYouth Conservation Corps and Save the Bay in order to enlist the surrounding communities and promote stewardship. Future phases of work may include enhancing visitor access and protection of natural resources by constructing a boardwalk along the central levee after restoration.

4.3. Climate Change

The Refuge is currently working with a researcher to assess climate change effects on Refuge resources. The research will seek to inform management decisions on habitat and wildlife resources. A modeling effort was also conducted in 2010 to assess habitat changes as a result of climate change on the Refuge (Clough and Larson 2010). The Sea Level Affecting Marsh Model (SLAMM) identified habitat changes on the Refuge units that may be expected as a result of sea-level rise. The model predicts that the Refuge will incur a conversion of irregularly flooded marshes into regularly flood salt marshes (and even tidal flats) under higher rates of sea-level rise. The model also predicted a conversion of dry lands to open water on the Refuge. However, there were a number of assumptions that were made, suggesting the need to consider other modeling efforts to confirm these findings. Other models for the San Francisco Bay (by USGS, PRBO Conservation Science) have also been done. Staff are currently reviewing this modeling to determine management implications.

4.4. Acquisitions

Acquisitions are a method of increasing habitat for Refuge wildlife and habitat resources. In addition, global warming and impending sea level rise may require that the Refuge seek lands

adjacent to its current holdings to provide wildlife and habitat resources into the future. The Refuge has been involved with several ongoing acquisition opportunities.

Deepwater Slough Island
Efforts are underway to facilitate transfer of Deepwater Slough Island to the Refuge. The approximately 136-acre Deepwater Slough Island is located on Redwood Creek, on the west side of Middle Bair Island, in San Mateo County, California. The Refuge has been in negotiations with Pacific Shores Investors, LLC., to acquire the property to manage the restored tidal marsh habitat in perpetuity pursuant to the Deepwater Slough Endowment Agreement and Donation Agreement. It is anticipated that the Refuge will complete the transfer by fall 2012.

The Preserve at Redwood Shores
Located in the West Bay Unit of the Refuge, the Preserve is a residential development project that includes a component to restore approximately 90 acres to tidal wetlands. This site has the potential to support the California clapper rail and the salt marsh harvest mouse. The Refuge has been working with the developer to acquire the property once conditions are met regarding the restoration of the tidal wetlands. It is anticipated that this property will be transferred to the Refuge in 2016 if restoration standards are met.

Plummer Creek
Plummer Creek is a 26-acre mitigation site that is currently owned by Wildlands, Inc. This parcel is north of, and contiguous to, the current Refuge on the east side of San Francisco Bay. Wildlands completed restoration of this previously undeveloped pasture in 2001, and Plummer Creek now consists of nine acres of tidal wetlands, 11 acres of seasonal or enhanced wetlands, and about six acres of ecotone/grassland/upland. Wildlands has proposed donating this parcel to the Refuge; however, at this time negotiations are halted due to a BCDC requirement that Wildlands transfer a bond to the Refuge for completing public access at the parcel. The Refuge does not want to create public access until Plummer Creek is joined to the Bay Trail or to an access trail with the adjacent Refuge land. At the time when the Refuge is ready to do this, negotiations concerning the transfer may re-commence.

Cannery
Established in 1906, Thomas Foon Chew took over his father's Precita Canning Company, renaming it The Bayside Canning Company, turning it into the third largest cannery in the world. This was Alviso's most successful operation, employing hundreds of workers who could live in company-owned housing nearby. After Chew's death in 1931 and the Great Depression, the cannery slowed production and finally closed in 1936. The cannery was purchased in 1977 with the original intent of converting the property into an environmental education center. For unknown reasons, this did not occur and the building has virtually been left vacant since then. In 2002 and 2004, funds were used to shore up the building preventing it from collapsing. The Refuge is currently working with a private landowner to exchange this property for seasonal wetland and upland habitat connected to New Chicago Marsh.

4.5. Monitoring

California Clapper Rail and Salt Marsh Harvest Mouse
Clapper rail surveys are conducted in marshes of the South Bay to track annual changes in clapper rail numbers for each marsh and to develop a rail population estimate for the South Bay. This information is used to evaluate the success of current management and to focus future

management efforts to benefit the clapper rail. In conjunction with these surveys, observers record other rail species and both avian and mammalian predators. Two types of rail survey methods are used to collect data; the winter high tide survey; and the breeding season call count survey.

Winter high tide airboat surveys for clapper rails are conducted during the highest predicted tides, generally in December and January. Surveys are conducted by Refuge personnel and volunteers, using two airboats to access marsh areas. Typically, each airboat crew consists of a driver and two observers, with one observer recording all rail species observations on a map. Total numbers of rails in each marsh are calculated after the entire marsh has been surveyed. Each marsh is surveyed in parallel transects and all vegetation not covered by the high tide (e.g. gumplant) is searched.

California clapper rail survey
USFWS

Breeding season call count surveys follow the methods of Zembal and Massey (1981) and the Service's Draft Protocol (2000) and are used to estimate the density of breeding rails and locations of rail home ranges within the marsh. Surveys are conducted at sunrise or sunset between mid-February and mid-April in selected marshes. Contiguous portions of each marsh are censused on successive days if possible. Each marsh generally requires 3–5 census days for complete coverage. Complete surveys are conducted at least two weeks apart.

Each call count survey involves trained observers walking on levees adjacent to the marsh to pre-determined listening stations 200 m apart. Observers record location, time, and type of each call on a map. Observers spend ten minutes at each station as follows: the observer listens passively for five minutes, broadcasts a recording of a clapper rail call ("kek") for one minute, followed by another passive listening for four minutes before moving to the next station. Playback recordings are only used if rails do not vocalize after five minutes of passive listening at a station. If rails respond to the playback, it is stopped immediately. New protocols developing by the I&M Program are being tested now in order to standardize rail surveys around the Bay and nationwide.

Surveys for salt marsh harvest mice and other small mammal species are conducted using standard small mammal trapping techniques within trapping grids or at random point locations.

Small mammals are sampled using live-trapping (Sherman traps) techniques set in 25-m x 25-m grid arrays (N = 25 traps, 5-m intervals) for three to four consecutive nights (Wilson et. al. 1996). Trapping occurs at low tides (≤ 6.0 feet), opened at dawn and closed at dusk. Traps are provided with food (bird seed and walnuts) and cotton batting insulation. Dried crickets (1–2) or other invertebrate food are added to each trap for shrews. Captured individuals are marked by clipping a small portion of the dorsal fur to identify recaptures, or by ear tagging with a numbered tag. Traps are checked within two hours of sunrise and re-opened within two hours of sunset. To further reduce risk of mortality due to water and sun exposure, traps are placed above the ground in pickleweed vegetation and covered with cedar shingles.

Setting live mammal traps
USFWS

Records of mammal captures include species, age, sex, reproductive condition, and weight. Additional body measurements are taken from individuals identified to the genus Reithrodontomys or Sorex (body, tail, ear, foot). Data summaries include species composition by location and a capture index (capture probability). Given a constant trapping effort, capture indices assume changes in captures over time represent proportional changes in abundance. Surveys for small mammals have been conducted throughout the Refuge in relation to regional or local scientific studies or as part of restoration monitoring programs.

Western Snowy Plovers
The San Francisco Bay Bird Observatory (SFBBO) is contracted to conduct most of the snowy plover monitoring on the Refuge. From March 1 to August 31, dry salt ponds and levees are surveyed weekly by driving or walking levees, stopping to scan for snowy plovers with spotting scopes approximately every 0.3 miles. During each survey, observers record the sex, number, and behavior of adult plovers (Page et. al. 1991), and mark its location on a map. Observers also record the number of nests, the number of chicks, and the color-band combinations for any banded plovers. Volunteers and biologists perform surveys; however, only biologists approach nests and/or birds.

To determine reproductive success of snowy plovers, biologists locate nests by visually searching for incubating females during weekly surveys. Nests are searched for on foot and nest location recorded with a GPS unit (Garmin® GPS 60). Nests are monitored weekly until the fate of the nest is determined. On each visit, nest activity is recorded (eggs present and adults incubating), and the number of eggs or chicks in the nest. Eggs are floated (Hays and LeCroy 1971) to estimate egg age and using the known egg age, nest initiation date is calculated as well as a

predicted hatch date. Nest fates include: hatched, depredated, flooded, abandoned, lost at hatch, or unknown.

Biologists band snowy plover chicks to study their movements and to estimate fledging success rates for the South Bay. To band chicks, biologists check nests daily, starting four days before the estimated hatch date. Snowy plover chicks are precocial (species in which the young are relatively mature and mobile from the moment of birth or hatching); therefore, arrival at the nests is timed to when chicks have just hatched, but have not yet left the nest scrape. Each chick is banded with a unique four-color combination, placing two bands on each lower leg of a chick. Each combination consists of three darvic color bands and one silver Service band wrapped in auto pin-striping tape to act as the fourth color in the combination.

Vernal Pools

Vernal pools are monitored at the Warm Springs sub-unit of the Refuge. Once the pools fill in the winter, they are monitored every four weeks until they dry. Data are taken on pool hydrology including date of pool filling, inundation time, and maximum depths. Dipnets are used to survey for aquatic organisms, in particular the Federally endangered VPTS and the larvae of the Federally threatened California tiger salamander. Data are also taken on non-listed species including the vernal pool fairy shrimp, Pacific treefrog tadpoles, and aquatic invertebrates.

Vernal pool tadpole shrimp
USFWS

In the spring, vernal pool vegetation is surveyed using two methods. Large plots (approximately 15m x 15m) are set up in vernal pools and every plant species within the plot is recorded and its percent cover is estimated (Releve method). In addition, smaller (4m x 4m) paired plots are monitored using a point intercept method with a 0.25m grid, In these plots, one of each side-by-side pair is completely fenced creating a grazing exclosure. These plots clearly demonstrate the effects of grazing on vernal pool vegetation because they allow examination of the same vernal pool in the same year under different conditions (grazed vs. ungrazed).

Grassland

Grassland vegetation is monitored at the Warm Springs sub-unit using three methods. In mid May, grasslands are surveyed using a point-intercept method along several 50m transects. Later, in the summer, surveys are conducted specifically for invasive weed species, many of which have later germination times than other grassland species. These surveys are conducted using 6m

radius plots along transects. Conducting grassland surveys in the spring and in the summer allows for a more accurate and complete inventory of the grassland vegetation. Finally, quarterly photo points are taken at several locations throughout Warm Springs to provide a visual documentation of the grasslands through time.

Weed Mapping
Beginning in 2010, refuge biologists and interns conduct comprehensive inventories and annual monitoring surveys on the Refuge, according to protocols outlined in the Draft Refuge Weed Inventory and Management Plan (2011). Inventories, using mapping, are recommended every 5 to 10 years in order to track the distribution and abundance of the most invasive weeds on the Refuge. Visual monitoring surveys are conducted annually between May and November, and are used to gather information on weed treatment method success, previously undetected new species that may have colonized the Refuge, and spread of priority invasive weeds into previously documented uninfested areas.

Vegetation Mapping
The Habitat Evolution Mapping Project (HEP) for the SBSPRP is conducted through contractors. Utilizing a combination of satellite image analysis, manual interpretation, and ground truthing, the spatial extent and distribution of vegetation yearly over a three year period (2009–2012) in both restored tidal areas and existing habitats in the South Bay is being mapped. Habitat classifications used and generated from the analysis will be based on the California Manual of Vegetation (Sawyer and Keeler-Wolf 1995) naming system for comparison and integration into similar restoration projects in the San Francisco Bay region and elsewhere. The habitat data will be produced for visualization and analysis in a GIS (e.g. as an ESRI shape file). The habitat data produced from the mapping efforts will be used to inform research and restoration projects.

The one-meter multispectral imagery acquired from the Ikonos satellite is being used to develop, test, and calibrate a multi-method "habitat mapping model," based on habitat characteristics derived from the satellite imagery and verified by ground truthing. The model will assist in automating part of the habitat mapping process. During the first year, the spatial extent and distribution of "changes areas" from the pre-existing baseline (pre 2005) was mapped. During the second and third years, the "changes areas" from previous study years as well as from the baseline are identified. At the end of the study, how the mosaics of habitat types are changing in spatial and thematic terms will also be quantified and visualized. Final report is expected in 2012.

Migratory Bird Surveys
Refuge biologists from the Refuge Complex and volunteers participate in the annual aerial Pacific Flyway Mid-winter Waterfowl Surveys conducted annually in January. These surveys monitor populations and allow annual comparisons of wintering waterfowl populations within and across sites along the Pacific Flyway, which includes the San Francisco/San Pablo/Suisun and outer coast estuaries. Refuge biologists have also participated in an estuary-wide shorebird survey conducted by PRBO Conservation Science for the last two years and one other survey ten years ago. USGS and SFBBO conduct monthly migratory bird surveys that include surveying the ponds of the Refuge and the SBSPRP in order to determine bird use of ponds with varying salinities and depth, as well as avian diversity and abundance.

Fish and Sub-tidal Invertebrate Surveys
Fish and aquatic invertebrate monitoring of the Refuge is not currently conducted by Refuge staff. The CDFG conduct several long-term studies monitoring fish and invertebrates in the San Francisco Bay Estuary (IEP 2008). The San Francisco Bay Study conducted by CDFG samples demersal (bottom-dwelling) fish, pelagic fish, shrimp, and crabs from South Bay to the western Delta. The USGS conducts a survey of the South Bay and ponds. As part of the SBSPRP, fish sampling is currently being done in newly restored tidal habitats, ponds, and adjacent sloughs by UC Davis.

4.6. Wildlife and Habitat Management

The primary tools used by the Refuge to conserve or improve endangered species populations or habitat include: restoration or enhancement of habitats; reduction or elimination of human disturbance; outreach; and promotion of research that provides new information about particular species or habitats and associated management implications. Restoration and enhancement efforts include reintroduction of tidal waters to diked baylands, removal of tidal water impoundments, invasive plant control, native plant restoration, and predator management.

4.6.1. Weed Control

Refuge staff currently use mechanical, cultural, thermal, and chemical weed control methods on the most invasive or problematic species throughout the Refuge. However, some control techniques are limited to occasional treatments on specific units of the Refuge, whereas other methods are used commonly within many areas. The Refuge staff is currently developing a weed management plan that will facilitate systematic removal of targeted populations using a combination of control techniques, and will provide an adaptive management system for assessing control method efficacy, and for modifying these treatments if they are found to be ineffective.

Refuge biology staff head out for a weed surveys on Bair Island
USFWS

Mechanical
Techniques such as hand pulling, cutting, digging, chopping, uprooting (weed wrenching), sawing, weedwhacking, and mowing have been used throughout the Refuge since its establishment in 1972. Weed whacking and mowing are primarily used for trail maintenance, fire breaks, and aesthetics, not as a control measure. However, mowing and weed whacking

have been used effectively on specific populations of thistles: for controlling annuals and for eliminating seed set of perennials by cutting off the flower heads. Pulling is also used by Refuge staff in sensitive habitats where it is less invasive than other techniques, or with small populations that are easily treated this way. However, mechanical methods are generally not preferred because they are not cost effective given the immensity of the weed infestation and limited resources (staffing and funding).

Volunteer conducting weed removal
© Jennifer Fraga

Cultural
Cultural weed control is the modification of weed-colonized habitat to encourage the competitiveness of desired species. This may be done by reducing weed access to available sunlight, nutrients, and moisture, or changing soil pH, water regimes, or temperature. Cultural methods of weed control are shading, grazing, flooding, salinization, and direct competition with other plants (as discussed in the re-vegetation section). Refuge staff use all of the above mentioned techniques to control weeds on the Refuge.

- *Shading.* Shading is a form of cultural control wherein various materials are used to suppress/prevent weed growth by blocking light needed to germinate. Various materials may be used, including sheet mulching (cardboard or newspaper), black plastic, or wood chips/straw/even mature weeds that are cut and left where they fall. Refuge staff use this method, though not often, as it is extremely time intensive and requires close monitoring. It is used primarily as a preparation treatment at restoration sites.

- *Salinization.* Salinization has only been used since 2009 and is still in the experimental stages as an enhancement for native plants. Salinization has been used by irrigating high marsh and ecotone habitat with saline water, and by applying granular salt directly to weeds in these habitats just before the rainy season. Salinization discourages weed growth without impacting salt tolerant native plants, and may become a more common weed control method in the future if shown to be effective and efficient.

- *Grazing.* Cattle grazing currently occurs at the Warm Springs sub-unit and has occurred there throughout much of the 20th century. However, upon acquisition of Warm Springs in 1992, the Refuge ceased all grazing practices in the absence of a formal management plan. Over the next ten years, non-native annual grasses accumulated in vernal pools,

significantly altering plant community dynamics and wildlife habitat. Observations by Refuge staff revealed an apparent decline in abundance of native vernal pool plants and wildlife after suspension of grazing. These negative trends were consistent with available information from other vernal pool ecosystems that have experienced a sudden cessation of grazing. After extensive literature review and consultation with rangeland and vernal pool experts, the Refuge began the process to re-introduce grazing to Warm Springs. In 2004, grazing was reintroduced to the site and biological monitoring was expanded. The herd grew slowly each year as new pastures were added to the program, from 20 cows in 2004 to approximately 108 in 2010. Cows are rotated seasonally throughout ten different refuge pastures. The grazing program at Warm Springs is conducted through a Cooperative Land Management Agreement with a local rancher. In exchange for grazing rights on the land, the cooperator provides the Refuge with services-in-kind equivalent to 100 percent of the value of the grazing land. Grazing is having a positive impact on native vernal pool and upland vegetation. In 2012, the effects of the grazing program will be comprehensively analyzed using years of collected biological monitoring data. The Refuge will continue to monitor the vegetation and wildlife at Warm Springs, and make management changes as necessary to adapt to changing conditions and new information.

Thermal

Thermal control involves heating or burning plant tissue. Techniques include prescribed burning, flaming, and steaming. Of these techniques, Refuge staff use only prescribed burning and flaming, though neither to a significant extent. Flaming uses propane gas burners to produce a carefully controlled and directed flame that briefly passes over weeds, searing the leaves, and causing the weed to wilt and die. This technique may offer an effective management tool under certain circumstances, but is not used extensively on the Refuge because it is time intensive and is not practical for treatment of large populations or areas.

- *Prescribed burn*. Generally, the Refuge does not conduct burning for management purposes. However, in September 2010, the Refuge conducted its first prescribed burn, in the last remaining ungrazed pasture of the Warm Springs sub-unit. The prescribed burn effectively reduced residual dry matter (RDM), which is the above ground vegetative matter left at the end of the growing season. Reducing RDM has been shown to improve germination conditions for vernal pool plants. Vegetation monitoring in 2011 will provide valuable data on the effects of the prescribed burn. Based on the monitoring results, refuge staff will decide whether to continue to conduct prescribed burns and in which areas.

Prescribed burn at the Warm Springs Sub-unit
USFWS

Chemical
Refuge staff use herbicides to control invasive and other non-native weeds throughout most units of the Refuge. Herbicides have been used only sporadically (with the exception of Warm Springs sub-unit and around Headquarters Hill) to treat relatively small infestations (<0.25 acre) or spot populations of weeds such as perennial pepperweed, stinkwort, thistles, mustard, and nettle. Chemical treatment has been effective at controlling growth of treated populations, but has not been used systematically to eradicate infestations with the exception of the *Spartina alterniflora* control program.

4.6.2. Revegetation

Although several native plant communities passively restore themselves once abiotic conditions are favorable, many require active revegetation techniques to establish. The extent of impacts to their regional abundances from centuries of agriculture and urbanization appear to have reached a point where they are unable to propagate themselves well enough to compete with non-native species that are currently widespread, likely due to lack of local seed source and presence of non-natives. Refuge habitats that are generally believed to passively restore themselves are restricted to intertidal habitats (low, mid, and high marshes), although there are some specific questions related to diversity and management goals of these areas as well. The tidal marsh ecotone and surrounding uplands require active management to revegetate and, in some cases, require significant ongoing management to meet Refuge goals.

For the past five years, the Refuge and partners have been conducting applied research to develop feasible methods and materials to restore tidal marsh-upland ecotone (ecotone) plant communities. These habitats are known to provide critical functions and values to tidal marsh ecosystem obligate species, such as the California clapper rail and the salt marsh harvest mouse, and as such, they are considered a vital part of that system. The Refuge has hundreds of acres of ecotone that require active restoration management, due to centuries of agricultural, industrial, and urban management that has selected against native plants. Plant communities in the surrounding region are now dominated by non-native species that easily colonize ecotone habitats.

Current research activities are primarily conducted at the EEC and have included testing various weed management strategies, native species of seed, sowing techniques, and materials for mulching. Revegetation methods include direct seeding and container plant propagation. Direct seeding is an efficient way of introducing pioneers (primary succession) and disturbance-oriented (secondary succession) native species. Propagation by container plantings can be an efficient way of introducing later seral species that do not perform well from seed. Container plantings are produced in the Refuge's native plant nurseries (at Headquarters and the EEC) as well as being produced for the Refuge by other partners in the region, (e.g., Save the Bay). The research has found that pioneering natives can colonize the Refuge's highly disturbed ecotones, provide favorable direct competition against weeds, and perhaps provide the functions of a nurse crop (or make soil conditions more favorable for later seral species) while creating their own seedbank to be competitive after future disturbances. The work has shown promise and are being tested at several new sites including Pond A6, LaRiviere Marsh, and the Faber-Laumeister Tract. These projects also include further testing of weed management techniques and testing of the sequencing with container plantings. If results continue to be favorable, these techniques will be used throughout the Refuge as funding becomes available.

Hydroseeding
USFWS

4.6.3. Predator Management

The Refuge predator management program uses a combination of barriers, trapping, and shooting to reduce predation levels on listed species and nesting waterbirds through selective predator removal within selected locations on and adjacent to the Refuge. Non-lethal techniques (i.e., barriers, live-trapping, and release off-site) are attempted prior to lethal removal of selected predators. Lethal controls are used when demonstrably necessary, and as humanely and selectively as possible. The predator management program is consistent with the following goals:

1) to increase the California clapper rail population to a Refuge goal of 1.2 rails/ha,
2) to increase salt marsh harvest mouse populations, and
3) to increase nesting success of the threatened western snowy plover to one chick fledged per male.

Emphasis is focused on the removal of rats, red foxes, feral cats, skunks, and raccoons from areas of highest value to endangered species and nesting birds. The use of several capture and removal techniques allows flexibility in the program and maximizes effectiveness while

minimizing associated costs. Predator barriers, such as water, fences, or other structures that physically limit predator movements are installed in selected locations as appropriate.

The Refuge contracts with USDA Wildlife Services for all predator removal on Refuge property. In addition, predator management on adjacent properties may be conducted given the approval of the appropriate landowner. Most activities are conducted away from areas that are in close association with urban developments or areas with high public use. See Appendix I for the Mammalian Predator Management Plan and Appendix J of the Avian Predator Management Plan.

4.6.4. Mosquito Management

Mosquito management activities occur throughout the San Francisco Bay region where a large (>6 million) human population occurs and where there is a long history of mosquito management and documented mosquito-borne disease transmission to humans and wildlife. It is well known that mosquitoes can be vectors of disease to both humans and wildlife and, in some cases, can cause death. Ten California species of mosquito that are known vectors of arboviruses or as major pests were evaluated for West Nile Virus (WNV) transmission in 2002. All ten species were infected with WNV and were able to transmit the disease at some level (Goddard et al. 2002). Western encephalitis mosquito is considered one of the most efficient laboratory vectors of WNV tested from North America and is abundant in California and much of western North America, where it is involved in the maintenance and amplification of western equine encephalomyelitis virus and Saint Louis encephalitis virus (Goddard et al. 2002). Western encephalitis mosquito larvae are typically found in irrigation ditches, ponds, and storm sewers, and other areas that usually contain abundant organic material. Of the ten mosquito species studied by Goddard et al. 2002, western encephalitis mosquito showed the greatest potential to amplify and maintain WNV in California. In 2010, WNV was detected in dead birds and mosquito samples in counties whose boundaries lie within the nine-county San Francisco Bay region.

As of 2011, 326 bird species have been listed in the Center for Disease Control WNV avian mortality database. The list includes wildlife that inhabit tidal marshes of the Refuge such as waterfowl, grebes, heron, egrets, cormorants, songbirds (wrens, yellowthroats, song sparrows), and rails (Virginia rail, common moorhen, American coot). Other vertebrates known to be infected by WNV include horses, bats, chipmunks, skunks, rabbits, and squirrels.

With the spread of WNV and the potential for spread of other mosquito-borne disease across the country, there is increasing pressure to manage mosquito populations that occur on lands of the National Wildlife Refuge System (NWRS), especially in urban areas such as the San Francisco Bay region. The Service understands that mosquitoes are a natural component of wetlands, but we also recognize that they may pose a threat to human and/or wildlife health. As a result, mosquito control has long been an existing action on Refuges. Since establishment of the Refuge, the Service has monitored and regulated mosquito control on the Refuge through annual Pesticide Use Proposals for consistency with departmental, Service, regional, and state policies. Refuge staff works cooperatively with three mosquito abatement districts (MADs) to manage mosquito populations on the Refuge: Alameda County Mosquito Abatement District, Santa Clara County Mosquito Abatement District, and San Mateo County Mosquito Abatement District. See Appendix K, the Mosquito Management Plan

4.7. Other Management Activities

The Refuge continually works with adjacent landowners in conducting biological programs, environmental education, and outreach. The Refuge's activities may affect neighbors, so every effort is made to seek input for all aspects of the Refuge programs that could have implications beyond the Refuge boundaries. Conversely, there are actions that may take place on adjacent lands that may affect the Refuge. The Refuge has succeeded in maintaining open communication and partnering on projects in order to reduce negative impacts and to reduce effort on both parts to fulfill Refuge mission and promote good stewardship on neighboring lands. Some adjacent landowners include Redwood Shores, City of San Carlos, Redwood City, City of East Palo Alto, City of Mountain View, City of Sunnyvale, City of San Jose, City of Fremont, City of Newark, National Aeronautics and Space Administration (Ames Research Center), CDFG, Peninsula Open Space Trust, Midpeninsula Regional Open Space District, East Bay Regional Park District, and Cargill Salt.

The Refuge and CDFG have a specific relationship to manage a patchwork of lands across the South Bay. Current partnerships with CDFG include several tidal restoration and research projects, which are part of the SBSPRP. Productive relationships with our neighbors have resulted in the upcoming transfer of several pieces of land into the Refuge including Deepwater Slough Island by Pacific Shores LLC.

4.8. Fire Prevention and Hazard Reduction

The Refuge does not have on-site fire management staff, only a fire cache (e.g., personal protective equipment and fire tools). Nonetheless, fire prevention and containment on the Refuge is a high priority, especially given its proximity to commercial and residential properties. Man-made fires are a primary concern given the urban nature of this Refuge. Wildfires do not frequently occur on large portions of the Refuge due to the low flammability of the dominant habitat types (ponds, salt marsh, seasonal wetlands, mudflats, and open water). The Refuge completed a Fire Management Plan in 2004 with the main objective to suppress all wildland fires regardless of cause. Because there are no on-site trained fire management staff, all wildland fires are suppressed by local city fire departments.

During the past five years, three fires are known to have occurred on the Refuge. In 2007, a fire (cause unknown) occurred on the west side of Pond A2W, underneath a PG&E tower on a levee, and burned approximately 0.1 acres (was not suppressed). In 2009, the local Newark Fire Department responded to a fire (cause unknown) on the hillside at the headquarters. Approximately 1.6 acres of grassland was burned. In 2011, a boat fire occurred in the Pond A15 water discharge channel in a tidal marsh area, burning less than one acre (was not suppressed).

Use of fire to reduce hazardous fuel loads is generally not conducted on the Refuge. Prescribed fire was used on the Warm Springs sub-unit in 2010 to reduce residual dry matter (old plant material) for the benefit of the vernal pool grassland ecosystem. See *Prescribed Burning* under the *Wildlife and Habitat Management* section.

4.9. Law Enforcement and Resource Protection

The Refuge receives law enforcement support from the San Francisco Bay NWR Complex. Law enforcement patrols the Refuge to ensure protection of wildlife and habitat as well as ensures that public uses (e.g., wildlife observation, hunting, and fishing) are in compliance with Federal and State regulations. The Refuge also receives some support from CDFG during waterfowl hunting season.

Law enforcement performing hunter checks
USFWS

Law enforcement also safeguards the visiting public, staff, facilities, and natural and cultural resources from criminal action, accidents, vandalism, and negligence by providing a law enforcement presence.

4.10. Building and Other Infrastructure Maintenance

There are a number of buildings and other infrastructure that require regular maintenance and repair at the Refuge. Buildings are located at two primary areas on the Refuge: the headquarters site located in Fremont and the EEC in Alviso.

Headquarters
The Refuge is administered from the Complex headquarters in Fremont. The headquarters includes the main administrative office as well as additional office facilities for law enforcement, visitor services, and the Common Murre Restoration Project. A visitor contact station, maintenance facilities, a nursery, and intern and staff residences located at the headquarters also support the Refuge. A full renovation of the 9,022 square foot Complex headquarters office was completed in 2010. During the renovation, a separate office facility was also constructed to house law enforcement and visitor services staff. All these facilities and their surroundings require considerable upkeep by maintenance staff.

Headquarters office
USFWS

The headquarters area is a primary point of public access with extensive infrastructure such as parking lots, trails/levees, viewpoints, an old hunters' cabin, a pavilion, and a pumphouse to facilitate wildlife observation, interpretation, and environmental education. The Visitor Center was originally located within the headquarters building. As part of the office renovation, the Visitor Center facilities were remodeled into staff offices. A smaller Visitor Contact Station was constructed, separate from the headquarters building, but a more accessible location and within walking distance from the building. Interpretive features were upgraded thanks to funds donated by the San Francisco Bay Wildlife Society. Visitors enjoy interactive displays, a screening room offering a variety of programs for all ages, and larger, more user-friendly exterior signs—all designed to get visitors oriented to the Refuge and out into the habitat to explore for themselves.

Environmental Education Center (EEC)
The EEC located in Alviso provides environmental education programs on the weekdays and public programs on weekends. This facility and its surrounding infrastructure (trails and roads) also require considerable upkeep by maintenance staff.

The Environmental Education Center
USFWS

Other Infrastructure
In addition to building maintenance, a complex infrastructure of roads, parking lots, gates, fences, signs, canals, levees, and water control structures continually require maintenance by

staff to provide suitable habitat for wildlife and provide safe functional areas for Refuge visitors and staff. The Refuge has many miles of roads that were primarily constructed to facilitate access to salt ponds. Most of the main roads are paved or have an aggregate surface. Secondary roads are native surface and are inaccessible when wet. General road maintenance, including grading and mowing, is required to provide safe access through the Refuge. An intricate system of power lines also exists on the Refuge. We allow access by the Pacific Gas and Electric to maintain this infrastructure. Aboveground transmission lines are found primarily along county roads and through ponds. One subsurface line follows the Refuge entrance road and provides service to the Refuge headquarters. In order to maintain the integrity of the Refuge, it is critical to reduce trespass, dumping, and poaching on Refuge lands. It is the intent of the Service to maintain a positive working relationship with neighbors to reduce trespass, vandalism, and theft on adjacent landowner properties. To achieve these goals, the Refuge has fenced, signed, and gated many of the Refuge boundaries. This infrastructure helps to alleviate trespass problems. Annually, most Refuge units will require installation of some new posts due to vandalism or deterioration. Information signs are maintained on the Refuge, but many interpretive signs are old and need to be replaced.

Tide gate: Mallard Slough to Pond A17
Judy Irving © Pelican Media

Other public facilities that require cleaning and repair are parking lots, a fishing pier at headquarters, trails and supporting infrastructure (including signs, kiosks, benches, picnic tables, garbage cans, recycling containers, restrooms), hunting blinds and check stations, and interpretive buildings (such as a hunter's cabin and an outdoor pavilion).

4.11. Safety

The Refuge has an approved Safety Plan and audits are conducted annually. In the event of an emergency, numbers for fire, police, sheriff, or other emergency contacts are readily available.

Law enforcement patrol
©Charles Benton

4.12. Public Uses

More than 750,000 people each year visit the Refuge to hike or bike the trails and to participate in the many activities offered. The majority of visitors are repeat users from the local communities. There are opportunities for visitors to engage in all six of the priority public uses: hunting, fishing, interpretation, environmental education, wildlife observation, and wildlife photography. The Refuge supports these uses through a variety of self-guided and guided opportunities designed to foster an appreciation of Refuge resources, to encourage environmental stewardship, and to inform visitors of the Refuge's purpose. Public use opportunities are depicted by management unit in Figure 18.

To facilitate visitation, the Refuge has two visitor facilities. There is a visitor contact station (VCS) located in Fremont, near the SF Bay NWRC headquarters. It is open Tuesday–Sunday from 10:00 a.m. to 5:00 p.m. The VCS has a staffed information desk, interpretive exhibits, a small bookstore, audio/visual displays, and staff offices. The Refuge also has an environmental education facility (EEC) located at the southern end of San Francisco Bay near the community of Alviso. It is open to the public Saturday and Sunday from 10:00 a.m. to 5:00 p.m. On weekdays, it is open to school field trips by reservation and to the general public as scheduling allows. The EEC houses staff offices, two classrooms, an auditorium, and an enclosed observation tower. On the weekend, the facility is used for public programs. Two positions funded by partners allow the EEC to be open on weekends.

Figure 18. Public Uses by Management Unit

Trails throughout the Refuge also facilitate visitation. The Refuge has over 30 miles of trails in the cities of Fremont, San Jose, East Palo Alto, Mountain View, Menlo Park, Sunnyvale, and Redwood City open during posted Refuge hours (7:00 a.m.–6:00 p.m. in the winter, and 7:00 a.m.–8:00 p.m. in the summer). Trails in Alviso are open from sunrise to sunset. See Appendix H for Refuge Trail Maps. Trails are periodically closed for levee maintenance. All motorized vehicles are prohibited on Refuge trails in order to protect ecologically sensitive areas. Bicycling is permitted on all roads and trails except the LaRiviere Marsh Trail. Dog walking is permitted on the Tidelands, Harrier Spur, and Quarry trails in Fremont. Other allowed recreational uses vary by trail. Information is posted on outdoor kiosks or available from staff.

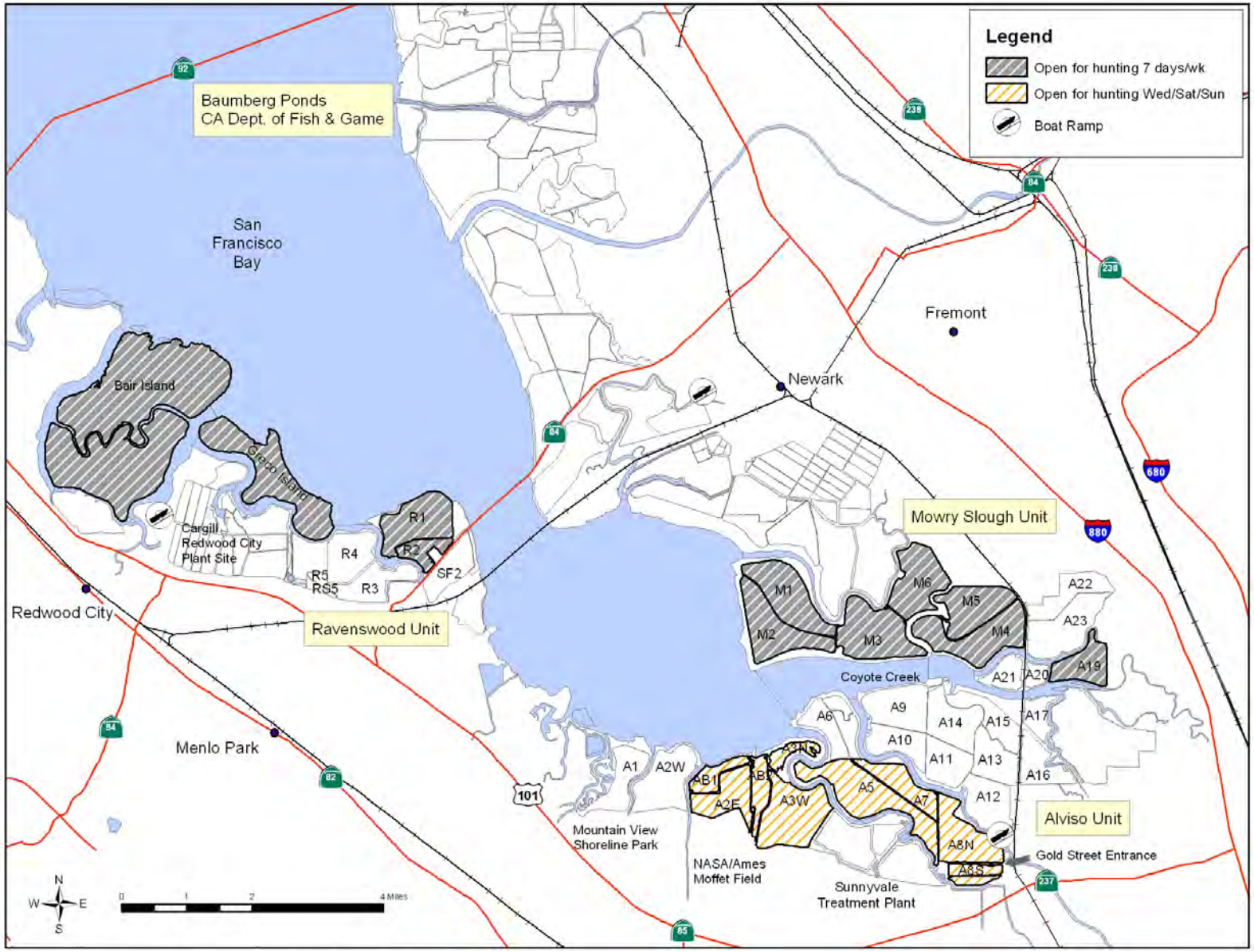
Pedestrian foot bridge at the headquarters
USFWS

All six priority public uses (hunting, fishing, wildlife observation, photography, environmental education, and interpretation) are offered on the Refuge and are described as follows.

4.12.1. Hunting

Waterfowl hunting is a historic recreational activity that occurred prior to the Refuge's establishment and is an activity that continues on the Refuge today. Many species of duck are hunted, but northern shovelers are the dominant species harvested. Outside of the Refuge, opportunities to hunt waterfowl in South San Francisco Bay are limited and this makes the Refuge a valuable resource for area waterfowl hunters. Currently, approximately 7,500 acres of the 30,000 acres on the Refuge are open to waterfowl hunting. This acreage includes managed ponds, tidal areas, and the open bay. The hunt season is set by the CDFG and generally occurs from mid-October to late January. The hunting program is regulated by both the CDFG and the Refuge. Information on hunting regulations can be found at: http://www.dfg.ca.gov/ and http://www.fws.gov/desfbay/Hunt/Hunt_Information.htm. All Refuge hunting areas are boat-access only, except for Ravenswood Ponds R1-R2 and Alviso Ponds A5–A8. Figure 19 identifies areas within the Refuge that are open to hunting.

Figure 19. Refuge Hunt Map



The Refuge has three hunter check-in stations. They are located at Ponds A3W, A2E, and A5. Using data derived from these stations, it is estimated that there are over 3,900 hunter visits annually on all hunting areas within the Refuge (Table 16).

Table 16. Hunt Information for Alviso Area

Year	# Hunters	# Ducks	# Ducks per Hunter	# Geese	# Geese per Hunter	Total Birds	Total Birds per Hunter
2005	1028	2261	2.2	41	.04	2302	2.2
2006	1665	3304	2.0	35	.02	3339	2.0
2007	2464	7231	2.9	88	.04	7319	3.0
2008	1960	2180	1.1	46	.02	2226	1.1
2009	1126	2549	2.3	40	.04	2589	2.3
2010	1789	2557	1.4	24	.01	2581	1.44

In addition to the state determined rules and regulations, the Refuge-specific hunting rules are:

1) Hunting is allowed three days a week (Wednesdays, Saturdays, and Sundays) on the following ponds: AB1, A2E, AB2, A3N, A3W, A5, A7, and A8N. In addition to State Hunting Licenses, hunters of these ponds need a Refuge Special Use Permit. Ponds A1, A2W, A8S, A22, A23, R3, R4, R5, SF-2, and S5 are closed to waterfowl hunting to serve as wildlife sanctuaries, protect endangered species, and reduce conflict with adjacent landowners.

2) Access to Ponds AB1 and A2E is from the Crittenden Lane Trailhead in Mountain View. Access to Ponds A3W is from the Carl Road Trailhead in Sunnyvale. Access to Ponds A3N and AB2 is by boat from the other ponds. Hunting is only allowed from existing hunting blinds for these five ponds. Access to Ponds A5, A7, and A8N is by foot/ bicycle from the Gold Street Gate in Alviso. In these three ponds, hunting is restricted to existing hunting blinds and to walking pond levees.

3) During the two weekends before opening of the hunt season, hunters may bring a boat into Ponds AB1, A2E, AB2, A3N, A3W, A5, A7, and A8N to be used to access the hunting blinds. Hunters are allowed to leave their boat in the ponds during the season and remove them within two weeks following close of the hunt season. The boats will be non-motorized, or use electric or four-stroke gasoline motors.

4) Hunters may maintain an existing blind if they have a valid Refuge Special Use Permit, but the blind will be open for general use on a first-come, first-served basis. We prohibit pit blinds or digging into the levees.

5) Hunters may enter closed areas of the Refuge to retrieve downed birds, provided they leave all weapons in a legal hunting area. The Refuge encourages the use of retriever dogs. They must keep the dog(s) under control at all times. These dogs must be in a vehicle or on a leash until they are on the ponds as a part of the hunt or on the levees (Ponds A5, A7, and A8N only) as a part of the hunt.

6) Hunting dogs are permitted, but handlers must have a hunt license and must be out only during the hunting season.

Other hunting areas do not require a Special Use Permit from the Refuge. These areas include Ravenswood, Bair Island, Mowry Ponds, and the open bay. Hunting in the Ravenswood sub-unit ponds is allowed seven days per week during the hunt season. The Ravenswood ponds are accessible by foot or bicycle and shooting is allowed from the levee only. Hunting in the Mowry Slough Unit and Bair Island Unit is also allowed seven days per week. Access to these ponds is only by boat, and hunting is allowed only from a boat. No specific hunt information is available for these units as there is no check-in point.

Hunter retrieving game
© Aric Crabb

4.12.2. Fishing

Fishing is regulated by the CDFG and information on sport fishing regulations can be found at: http://www.dfg.ca.gov/. Fishing is allowed on the Refuge by boat, from the pier at the Refuge headquarters, the shoreline of the Faber-Laumeister unit, and in Coyote Creek. While there is no public launching facility within the Refuge, public launch ramps are located at Redwood City, Palo Alto Baylands, outside the entrance of the Refuge headquarters in Fremont, and at the Alviso County Park in Alviso. Boating is permitted only on the Bay and its tributaries. It is not permitted in the ponds. Jet skis are prohibited. Though motor boats are allowed, canoes and kayaks are recommended, since motor noise can flush wildlife and waters can be quite shallow in the sloughs and open bay at low tide.

The public fishing pier is located at the end of Marshlands Road and is open year-round. However, birds, particularly the threatened western snowy plover, occasionally nest along Marshlands Road. Between April 1–August 31, when nesting birds are found, Marshlands Road is closed to public vehicle traffic. On weekends when the closure is in effect, public access to the fishing pier is via free shuttle service. As a designated "Public Fishing Pier," no fishing license is needed at this location.

Major fish species caught include rays, leopard sharks, sand sharks, white sturgeon, striped bass, and shiner surfperch. Annual reports estimate that there are about 3,700 fishing visits a year. Anglers conduct both cath-and-release and subsistence fishing. An Environmental Health Hazard Assessment has advised anglers to limit the amount of bay fish that are eaten.

Warning signs at the Dumbarton Fishing Pier and at Coyote Creek Lagoon explain the hazards in Korean, Spanish, Cambodian, Chinese, Vietnamese, and English.

Every year during National Wildlife Refuge Week, the Refuge hosts a special event to introduce the public to fishing. The Refuge supplies bait and tackle and a loaner fishing rod for up to 50 participants. Each participant learns how to use a fishing rod, about the safety and ethics of fishing, and what they can do to protect the San Francisco Bay.

Connections to Pier Fishing Event
USFWS

4.12.3. Wildlife Observation

Wildlife observation is a high public use of the Refuge (see Table 17). Wildlife observation and photography are permitted along all public trails and roads within the Refuge. Guided opportunities that focus on wildlife observation and/or wildlife photography are offered regularly.

Table 17. Estimated Public Use Statistics on the Refuge

Public Use between 2006-20010	2006	2007	2008	2009	2010
# of visitors to Refuge	748,880	913,300	746,000	752,255	775,000
# of participants to special events	1,897	1,267	1,100	1,103	1,835
# of visitors into visitor contact station	22,343	28,570	27,780	26,990	19,360
# of waterfowl hunting visits	3,800	3,500	4,270	3,760	1,459
# of fishing visits	3,700	3,700	3,700	3,700	7,200
# of pedestrian visits	748,880	910,444	743,500	752,255	774,000
# of wildlife observation visits	748,880	910,519	743,600	789,700	812,850
# of wildlife photography visits	1,500	1,500	2,200	2,230	2,200
# of EE program participants	11,797	8,001	10,880	10,894	10,610
# of interpretation program participants	5,826	3,000	6,820	9,735	12,070
# of volunteers	1,128	1,143	908	1,128	911
Volunteer hours	17,613	16,200	16,200	20,217	20,740

In addition to guided activities, the Refuge supports wildlife observation through a variety of self-guided activities. Maps and trail guides are available at interpretive kiosks, which are located near Refuge parking lots and trails, and at the two visitor facilities. An up-to-date bird list is provided free of charge via printed brochure and by internet download. The Refuge also has a variety of items to loan that aid in self-guided wildlife observation. These include: Children's Discovery Packs, Family Birding Packs, adult birding kits, and binoculars. All are available for the public to borrow free of charge.

Boating is also used to facilitate wildlife observation and wildlife photography. While there is no public launching facility within the Refuge, public launch ramps are located at Redwood City, outside the entrance of the Refuge headquarters in Fremont, and at the Alviso County Park in Alviso. Boating is permitted only on the Bay and its tributaries. It is not permitted in the ponds. Jet skis are prohibited. Though motor boats are allowed, canoes and kayaks are recommended, since motor noise can flush wildlife and waters can be quite shallow in the sloughs and open bay at low tide.

Alviso viewing platform
USFWS

Many local organizations and schools use the Refuge trails to conduct field trips for the purpose of wildlife observation and wildlife photography. Three chapters of the Audubon Society conduct their annual Christmas bird counts at the Refuge. Ohlone Audubon covers the Alameda County area. Santa Clara Audubon covers Alviso managed ponds. Sequoia Audubon covers Bair Island.

4.12.4. Environmental Education

One of the reasons the Refuge was established to provide opportunities for "nature study". Because environmental education is part of the Refuge purpose, it is a high priority for the Refuge. To this end, an environmental education center was built in 1979 to facilitate environmental education. The Environmental Education Program serves over 10,000 students annually, providing supporting materials for other educators along with curriculum-based field trips and classroom presentations. Known for developing high quality, innovative instructional models and programmatic materials, the Refuge is a leader in the environmental education field and also provides trainings and resources for other educators in the Service and in the environmental education community.

The majority of field trips and educational programs take place at the headquarters site in Fremont and the EEC in Alviso. Additional programs occur on the Faber-Laumeister Unit of the Refuge in East Palo Alto. School districts and students from all over the Bay Area participate in field trip programs. Several funding partnerships allow us to provide a variety of educational programs. Partners include the City of San Jose, the Santa Clara Valley Urban Runoff Pollution Prevention Program/Watershed Watchers (SCVURPPP), and the San Francisco Bay Wildlife Society.

Some of the many environmental education programs taking place at the Refuge are described as follows.

Wetland Round-up
Wetland Round-up is an educator-led field trip program designed for grades K–6. It is the oldest and largest environmental education program on the Refuge. Conducted both at the EEC and Fremont, this program brings schoolchildren out to the Refuge to learn about tidal marsh, endangered species, native wildlife, and the importance of their habitat.

All activities are correlated to State of California Education Standards. Teachers are required to attend a teacher orientation once every two years. It is recommended that parents also attend training. Parents lead the hands-on activities by using a "Do, Read, Ask" teaching script. The program is offered 3–4 times per week between October and December and March and May. The Salt Marsh Manual, an educators' guide, is provided to teachers to help plan their field trip. The Salt Marsh Manual presents all the activity scripts, pre- and post-visit activities, background information, guidance on planning the field trip, and other resources.

Mud Lab during the Wetland Roundup Program
USFWS

To support this program, the Refuge provides a video lending library for teachers. Very limited bilingual materials are also available in Spanish.

Slow the Flow
This program seeks to inform participants about water pollution and consumption habits as they relate to habitat protection and endangered species conservation. Using grant funding from the City of San Jose, the San Francisco Bay Wildlife Society employs a full-time environmental education specialist and provides a stipend for a part-time Refuge intern. These employees are provided office space at the EEC from which to lead the *Slow the Flow* program. This program connects the *Slow the Flow* messages to visitors and students

through classroom presentations, field trips, interpretive programs, and outreach events (Bird Fest/Spooky Slough). The field trip program covers 5th grade through college, an age group not covered by Wetland Round-up. Volunteers are heavily used as a part of this program, offering significant volunteer opportunities in environmental education and interpretation. This program provides over 5,000 visitor experiences per year.

Botany Bash, Slow the Flow Weekend Interpretive Program
USFWS

Restoration Education
The restoration education program is a service-learning program and focuses on habitat restoration. A restoration education program was developed for Logan High School (Union City, CA) in 2009 through a B-Wet grant. Each year, over 300 students from Logan participate in wetland studies and service learning at the Complex Headquarters in Fremont. The Habitat Heroes Summer Camp program also includes restoration education in Fremont.

In Alviso, local elementary school, middle school, and college students have participated in service learning programs since 2006, and in 2010, a restoration education field trip program was piloted for elementary and college-aged students. This program is still developing, and its audience continues to expand.

The restoration education program in Alviso is supported by a Native Plant Demonstration Garden. The garden is used to teach children and adults about the importance of native plants. The Garden Committee consists of three staff and two volunteers. The goal of the demonstration garden at the EEC is to demonstrate a mature native plant garden that provides wildlife habitat as an example for home gardens. The garden is part of the annual Going Native Garden Tour. In addition, education programs about native plants and gardening with native plants are offered quarterly. Volunteers can assist with planting and weeding the garden throughout the year through our Community Service weekend programs.

A different approach to restoration education has been used on the Faber-Laumeister Unit of the Refuge in East Palo Alto. A summer employment program for local high school students was started in 2010, using Youth Conservation Corps funding, to engage youth in restoration education. In 2010, the Refuge also started providing service learning opportunities for school clubs and after school programs in East Palo Alto and vicinity. This segment of the restoration education program will be expanded in 2011 to include school field trips.

Planting day under Restoration Education Program
USFWS

Summer Camp
The Refuge hosts two free, summer day camps for youth: Marsh-In Summer Day Camp and Habitat Heroes Camp. Together, these camps provide opportunities for children in 1st–12th grade to learn more about the Refuge, ecology, and conservation. The program is tiered so that youth continue to benefit from the experience as they grow.

The Marsh-In Summer Day Camp, established in 1980 and held at the EEC in Alviso, is designed for youth, grades 1–6. For one week, campers participate in hands-on activities such as crafts, games, and nature walks, designed to connect children to nature and to teach about wildlife, plants, habitats, and natural resource conservation at the Refuge. On the last night of camp, campers in grades 4–6 spend the night under the stars at the Refuge.

The Habitat Heroes camp in Fremont began in 2007 and is designed for youth, grades 7–12. Each year through the Habitat Heroes program, a dozen teens develop leadership and team-building skills by participating in trust and problem solving activities. Most of the participants are former Marsh-In Summer Day Camp attendees. Service projects are included throughout the week. In addition, the teens pledge future service to the Refuge and practice their new skills as junior counselors at the Marsh-In Summer Day Camp. Habitat Heroes introduces a new generation of leaders to our Refuge and develops them as dedicated stewards. Many past participants in the Habitat Heroes program continue to volunteer at the Marsh-In Summer Day Camp and also at other Refuge events to provide opportunities for others to learn about conservation and the Refuge.

Habitat Heroes activity
USFWS

Scout Program
Programs tailored to meet badge requirements for the Girl Scouts and Boy Scouts of America are offered at the EEC in Alviso and at Refuge Headquarters in Fremont. Activities are presented intermittently. At the EEC, Webelos, Junior Girl Scout Badge, and Brownie Eco-Explorer patch programs are offered. At the Fremont site, Webelos programs are offered.

Offsite Environmental Education Programs
Library programs are conducted several times a year in San Jose. Staff also participates in fairs, such as Bay Area Environmental Education Resource Fair and Audubon Wildlife Education Day, to share environmental education resources, advertise the Refuge's programs, and advertise intern opportunities.

4.12.5. Interpretation

The Refuge provides an extensive interpretive program that offers guided programs, self-guided opportunities, and special annual events.

Guided Programs
Refuge staff and volunteers offer over 200 guided interpretive programs annually. The majority of programs are given in Fremont and Alviso, though programs are regularly offered at other Refuge and partner sites. These locations include Ravenswood sub-unit, Stevens Creek East Trailhead, the Dumbarton Bridge fishing pier, the ELER (CDFG), Bedwell Bayfront Park (City of Menlo Park), Warm Springs, and the Alviso Marina (Santa Clara County Parks). Schedules and descriptions are published in the Refuge's quarterly newspaper, *Tideline*, and can be viewed by visiting the Refuge's Web site: www.fws.gov/desfbay/. Refuge staff actively promote programs via online Web sites and community calendars. Program flyers are made quarterly and distributed to area libraries for posting.

Programs cover a variety of natural and cultural history topics. A sample of the topics presented includes: birding watching, historical use of local marshlands, wetlands restoration, salt marsh ecology, nature photography, native plants and animals, star gazing, and pollution prevention. Guided programs include walks and hikes, bike tours and van tours, fishing

clinics, planting parties, habitat restoration clean-up events, photography and sketching workshops, festivals, and special events.

Guided Interpretive Tour
USFWS

The Refuge also provides tours for specific program areas such as the SBSPRP, Watershed Watchers, and garden tours. Private interpretive programs are offered by special request. Audubon chapters, scout troops, community groups, senior centers, teachers' associations, and college classes are just a few groups that take advantage of this opportunity.

The interpretive program for the SBSPRP focuses on wetlands restoration and wildlife. Elements of the interpretive program for the SBSPRP include guided public programs, development of interpretive media and displays, and creation of a docent program. Guided public programs are offered at minimum of once per week and have included birding classes, van and bicycle tours, hikes, and talks. Van tours of the SBSPRP allow visitors with lower mobility to get out into the salt pond landscape. Private tours and programs for special groups, such as university classes and media outlets, are also conducted by reservation.

The SCVURPPP provides grant funding for a full-time interpretive specialist and a stipend for a part-time intern to administer the *Watershed Watchers* program at the EEC in Alviso. The program presents a range of interpretive programs. All programs revolve around a common theme: Our Role in Preventing Urban Runoff Pollution. Scout packs and troops, Lyceum groups, after-school childcare centers, universities, and senior centers all participated in tours of the wetlands at the Refuge. Through discussions and activities, participants learned about the Refuge's unique habitats, the diverse life dependent on these habitats, and the protection of wildlife through prevention of urban runoff pollution from storm drains. This program hosts several popular special events at the Refuge including the South Bay Bird Festival, Shark Day, and Spooky Slough. The Refuge relies directly on this funding and staffing to keep the EEC open on Saturdays.

Volunteer providing shorebird information at the South Bay Bird Fest
USFWS

Garden tours of the EEC's habitat gardens and introductions to chemical-free gardening techniques are also conducted. The annual Native Plant Nursery Open House during National Wildlife Refuge Week offers techniques on how to garden with native plants for wildlife.

Self-Guided Programs
The Refuge offers the visitor a range of self-guided opportunities to help them connect with Refuge resources.

Interpretive signs along Refuge trails help facilitate self-guided walks. Over 30 new signs have been created and installed since 2009. They are found along the Tidelands Trail (Fremont), the Marsh View, New Chicago Marsh, Mallard Slough, and Moffet Bay trails (Alviso), and the SF2 Trail (Ravenswood sub-unit). The Tidelands Trail in Fremont is registered as a National Recreation Trail in the National Trails System and is a spur of the San Francisco Bay Trail. Alviso signage is presented in English and Spanish.

New interpretive exhibits at the Visitor Contact Station (2010) and the EEC (2010–11) also provide opportunities for self-guided discovery of Refuge resources. The VCS exhibits introduce the visitor to the SF Bay Complex (including Don Edwards), refuge wildlife, and wetlands restoration efforts. The EEC exhibits shows the visitor five periods of human history along the Bay shoreline.

4.12.6. Special Events

The Refuge also hosts a minimum of six, on-site, special events every year.

Earth Day
The annual Earth Day Clean-Up takes place in the Ravenswood sub-unit in Menlo Park. Staff and volunteers lead participants on the trail picking up trash. Working alongside staff gives participants a unique perspective on management issues and wildlife that they might not otherwise receive.

Endangered Species Day Poster Contest
The Endangered Species Poster Contest has been in existence for 28 years and is co-sponsored by the San Francisco Bay Wildlife Society. The contest is open to schools with grades K–6 in Newark, Union City, Fremont, and East Palo Alto.

South Bay Bird Fest
The South Bay Bird Fest is hosted by the SCVURPPP at the EEC in Alviso to celebrate International Migratory Bird Day. The Santa Clara Valley Audubon Society, SFBBO, and San Francisco Bay Wildlife Society collaborate with the Refuge and SCVURPPP to hold this very popular interpretive event. In 2010, over 300 participants took part in its bird walks, migratory songbird gardening workshops, and live bird show.

Bird Banding Lesson at South Bay Bird Fest
USFWS

Coastal Cleanup
The Refuge hosts a Coastal Cleanup in Fremont each September in coordination with the Alameda County Coast Cleanup Commission. In 2010, well over 150 volunteers participated in the cleanup along Shoreline Trail.

National Wildlife Refuge Week
The Refuge hosts a range of onsite activities and events in celebration of National Wildlife Refuge Week. The Connections to Pier Fishing, Shark Day/Spooky Slough, and a native plant sale are annual offerings. In addition, each year a new event is offered to help encourage participation from returning visitors. Events have ranged from Open Houses to drawing and photography demonstrations to competitive games. The changing events always focus on Refuge objectives, wildlife, natural history, and/or conservation.

Connections to Pier Fishing Event
USFWS

4.12.7. Offsite Public Outreach

Refuge staff and volunteers participate in many off-site events each year for the purpose of outreach to new and nontraditional audience groups. Some recent events were:

- Bay Area Environmental Education Resource Fair
- North Bay Flyway Festival
- Guadalupe River Park Water Fest
- Santa Clara Valley Audubon Wildlife Education Day
- Tri-City Ecology Earth Day Fair
- Alviso Community Center Open House
- Kaiser Health Fair

Refuge booth at the San Jose Health Fair
USFWS

4.12.8. Other Public Outreach

In addition to the activities described above, public outreach is performed through print and electronic media.

Tideline
Foremost among Refuge outreach efforts is the production of a quarterly newsletter, *Tideline*. Approximately 7,000 copies are mailed to Bay Area households, schools, businesses, churches, and libraries while an additional 1,300 people receive the online version. *Sloughs News*, the volunteer newsletter is also published quarterly to inform volunteers of Refuge volunteer needs.

Refuge Web site
The Refuge Web site includes mission statements, the current *Tideline* newsletter, activity schedules, special event announcements, job announcements, volunteer opportunities, environmental education information, and general information about the Refuge such as hours and directions. Past lead articles from *Tideline* are also posted and receive regular hits from people researching a particular plant or species.

Social Networking
Most recently, in 2011, the Complex developed a Facebook page (http://www.facebook.com/pages/San-Francisco-Bay-NWR-Complex/127246590666522) as another outreach tool, posting Refuge management and visitor activities.

Audio Tours
Introduced to the public in July 2009 were two audio tours for locations at headquarters in Fremont and the EEC in Alviso. The tours are comprised of interviews discussing Refuge history, resources, and restoration efforts. They are available for downloading from http://www.yourwetlands.org/audio_tours.htm. This outreach method was developed and produced in partnership with San Francisco Bay Joint Venture.

Television and Video
Recent outreach has included appearances on local cable network television programs and development of audiovisual programs (*The Teddy Project*, *The National Wildlife Refuges of San Francisco Bay and Monterey Bay*).

4.12.9. Non-Wildlife Dependent Recreation

There are many outdoor recreational public uses on the Refuge beyond the supported six priority uses.

Exercise
Refuge trails are heavily used by visitors for the purpose of exercise and/or athletic training. Activities include walking, biking, and jogging. Wildlife observation is incidental to these visits and is not the main purpose of the activity.

A small percentage of Refuge trails are designated Bay Trail or Bay Trail spur. Marshlands Road (Newark) and the Moffett Bay Trail connector (Alviso) provide important commuter biking opportunities that are also well used by both recreational bicyclists and commuters.

Dog-walking
Dog-walking (on leash) is only permitted on the Tidelands, Pumphouse, Quarry, and Harrier Spur Trails, all of which are located at the Refuge headquarters. These are the only trails on the Refuge that allow dogs because Refuge staff and volunteers monitor them. Monitoring includes compliance with regulations. Dogs are permitted only if they are on a six-foot or shorter leash and are under the direct control of the dog walker. The dog walker must pick up and properly dispose of their dog's waste. If issues are identified, dog walking may be prohibited on these trails as well.

Geocaching
Geocaching is an outdoor activity in which the participants use a Global Positioning System (GPS) receiver or other navigational techniques to hide and seek containers (called "geocaches" or "caches") anywhere in the world. Although traditional geocaching is prohibited on Refuge lands, interpretive programs have been designed using this tool. The Refuge has placed coordinates or "caches" in compatible locations with information about the Refuge in order to connect people with nature through current technology. This activity encourages the public to explore various parts of the Refuge in the South and East Bay and learn more about Refuge objectives.

4.13. Volunteer Program

The Refuge receives volunteer support as managed through the Complex-wide volunteer program. Without volunteers, the Refuge would not be able to conduct most of its activities. Volunteers in the form of interns, individuals, groups, court-ordered community service, and corporations help support the visitor services and biology programs, as well as the overall management of the Refuge.

Full-time interns are hired year-round at the Refuge. Interns are filled either through the Student Conservation Association, Inc. (SCA) Conservation Internship program, or through job listings on other organizations' Web sites. Interns are also hired through funding from the Slow the Flow and Watershed Watchers programs. In addition, the Refuge relies on individuals that have developed a strong personal connection to the Refuge, its mission, and objectives. Refuge volunteers include conservation-minded retirees, working adults, and students. Commonly, they become volunteers after having been visitors on one or more occasions. Some of them are Refuge neighbors who have enjoyed many long walks on Refuge trails. Refuge volunteers lead approximately 75 percent of the weekend interpretive programs.

Periodically, area businesses or community groups will approach the Refuge with an offer to organize a work crew for a full or half-day project. On such a large Refuge, help is always needed on larger or more long-term projects such as the removal of invasive species, creek cleanups, or planting native plants. In these situations, the Refuge quickly acquires many hours' worth of improvements from crews that average 10–20 individuals.

The Refuge provides opportunities for individuals to complete court-ordered community service.

Periodically, Scouts may initiate projects, usually with maintenance staff, that both allow the Scout to earn Eagle rank and serve Refuge needs.

4.13.1. Volunteer Activities

Volunteers participate in a wide variety of activities at the Refuge. Year-round, Visitor Services organizes programs that rely primarily on volunteers, particularly those with developed knowledge and skills that help communicate the Refuge's mission. Volunteers staff summer camps, Refuge booths at off-site festivals, on-site events like Earth Day and International Migratory Bird Day, and present interpretive walks and programs.

Both management and operation of the Native Plant Nursery is performed by volunteers. The Nursery grows native plants such as sticky monkeyflower, coast live oak, and coffeeberry that have been used in habitat restoration of Refuge sites.

Native Plant Nursery
USFWS

Volunteers also aid biologists with habitat restoration efforts. Activities include invasive plant removal, replanting of native species, and management of native plant demonstration gardens. Volunteers also support the biology program by participating in biological field surveys.

4.14. Non-Profit Support

San Francisco Bay Wildlife Society
The Refuge relies on support from non-profits. The San Francisco Bay Wildlife Society was established in 1987 to promote the Refuge and is a nonprofit 501(c)(3) cooperating association. It promotes public awareness and appreciation of the San Francisco Bay and funds education and outreach programs at San Francisco Bay NWR Complex. The Wildlife Society publishes *Tideline*, the Refuge's quarterly newspaper, four times per year. The Wildlife Society also raises funds through book sales in the visitor contact station and EEC. Proceeds from the sale of books, posters, and other educational items in the bookstore benefit the Refuge's education programs.

Using grant funding from the City of San Jose and the SCVURPPP, the Wildlife Society is able to employ an environmental education specialist to lead the City's Slow the Flow Program and an interpretive specialist to SCVURPPP's Watershed Watcher's Program. Activities range from sponsoring major events to providing on-going weekend activities and service

opportunities for the public, field trips for school groups, and a variety of programs designed specifically to help Scouts earn badges or patches.

Citizens Committee to Complete the Refuge
The Refuge was established by a group of dedicated individuals with a desire to protect the wetlands around South San Francisco Bay, and their activism continues today. In 1967, the Citizens Committee to Complete the Refuge began as the South San Francisco Baylands Planning, Conservation, and National Wildlife Refuge Committee with the goal of establishing a national wildlife refuge on the San Francisco Bay. In 1972, with Congressman Don Edwards' enthusiasm and support, a bill passed into law to establish the Refuge. The Citizens Committee worked with Congressman Edwards in 1985 to expand the original Refuge boundaries to include additional lands along the edges of the Bay that had the potential to support endangered species habitat and maintain habitat diversity. This campaign was realized in 1988 with the passage of a congressional bill authorizing the Refuge to acquire or accept donations of approximately 20,000 acres of land, double the size of the original refuge boundaries. Today, the Citizens Committee continues to protect the existing Refuge from further development and continues to seek funding and support for acquisition and restoration of lands within the 1990 congressionally approved refuge expansion boundary.

4.15. Existing Partnerships

Partnerships are critical to the success and progress of any refuge. The Refuge has greatly benefited from the support of several entities and individuals. This list of partners is merely a sample of those who contribute funding, personnel, data, and a variety of other resources to the management and conservation of the Refuge.

- Audubon California
- Audubon National
- Alameda County Flood Control & Water Conservation District
- Bay Conservation and Development Commission
- California Coastal Conservancy—South Bay Salt Pond Restoration Project
- California Coastal Conservancy—Invasive *Spartina* Project
- California Conservation Corps
- California Department of Fish and Game
- California Wildlife Conservation Board
- California Wildlife Foundation
- Cargill Salt
- Center for Collaborative Policy
- Citizen's Committee to Complete the Refuge
- City of San Jose
- Ducks Unlimited
- Friends of Redwood City
- NOAA's National Marine Fisheries Service
- Midpeninsula Regional Open Space District
- PRBO Conservation Science (Point Reyes Bird Observatory)
- San Francisco Bay Bird Observatory
- San Francisco Estuary Institute
- San Francisco Bay Joint Venture

- San Francisco Bay Wildlife Society
- San Francisco Regional Water Quality Control Board
- San Francisco State University
- San Jose State University
- Santa Clara Valley Urban Runoff Pollution Prevention Program (Watershed Watchers)
- Santa Clara Valley Water District
- Save the Bay
- Senator Feinstein and staff
- The Bay Institute
- The San Francisco Bay Wildlife Society
- United States Army Corps of Engineers
- United States Geological Survey
- United States Department of Agriculture, Wildlife Services
- Wetland Research Associates
- Individual volunteers

USGS volunteer tracks western sandpipers
Judy Irving © Pelican Media

These entities work cooperatively or separately with the Refuge to pursue funding or in-kind opportunities for various Refuge projects, planning, and permitting efforts, and in some cases, expertise or physical labor and help. Overall, they are vital to the Refuge for their ability to provide expertise, advice, and political support for the Refuge.

5. Refuge Management Direction: Goals, Objectives, and Strategies

5.1. Introduction

One of the most important parts of the CCP process is the development and refinement of the Refuge vision and goals. This section contains the primary goals that will define the management direction of the Refuge for the next 15 years. In addition, as part of the CCP, refuges are expected to develop objectives and strategies that, together, will help achieve the goals. Goals are broad statements of the desired future conditions for refuge resources. Refuge goals may or may not be feasible within the 15-year timeframe of the CCP. Whenever possible, objectives are quantified statements of a standard to be achieved or work to be accomplished. They should be specific, measurable, achievable, results oriented, and time fixed; they should be feasible within the 15-year lifespan of the CCP. Strategies are specific actions, tools, or techniques that contribute toward accomplishing the objectives. In some cases, strategies describe specific projects in enough detail to assess funding and staffing needs.

Goals, objectives, and strategies may evolve to adapt to changing environmental conditions or needs. Also, staffing and funding are necessary to complete these goals, objectives, and strategies in the stated timeframe.

The following vision statement and five goals of the Refuge provide a context for the management direction.

5.2. Refuge Vision Statement

Don Edwards San Francisco Bay NWR Vision Statement
The Don Edwards San Francisco Bay National Wildlife Refuge was born out of the foresight and perseverance of conservation-minded individuals who recognized the unique landscape of the South San Francisco Bay. As part of the larger San Francisco Estuary, a site of hemispheric importance for shorebirds and waterfowl, the Refuge protects and restores almost 30,000 acres of some of the last remaining tidal marsh, mudflat, open bay, vernal pool, grassland, and upland habitats in the South San Francisco Bay. Within an area of intense urban development, we will strive to restore, acquire, and protect additional lands to create a functioning ecosystem of diverse habitats that will support healthy populations of migratory birds, endangered wildlife, and other native plant and animal species. Through management and restoration of these habitats, we will also aid in the recovery of a number of listed and sensitive species that depend on Refuge lands for their continued existence, including the California clapper rail, salt marsh harvest mouse, vernal pool tadpole shrimp, and Contra Costa goldfield.

To promote the conservation legacy of this Refuge, we will provide wildlife-oriented recreation, environmental education, and interpretation to foster public stewardship, increase appreciation, and encourage community involvement in the conservation of the Estuary.

5.3. Refuge Goals

Goal 1
Protect and contribute to the recovery of endangered, threatened, and other special status species on the Refuge by conservation and management of the habitats on which these species depend.

Goal 2
Conserve, restore, enhance, create, and acquire habitats to support the diversity and abundance of migratory birds and other native flora and fauna that depend on Refuge lands.

Goal 3
Provide the local community and other visitors with compatible wildlife-oriented outdoor recreation opportunities to enjoy, understand, and appreciate the resources of the Refuge.

Goal 4
Through diverse environmental education, interpretation, and outreach opportunities, increase public awareness of the Refuge's purpose and the ecosystem of San Francisco Bay Estuary and promote environmental stewardship and conservation.

Goal 5
Instill community stewardship through volunteerism to support the Refuge's diverse purposes.

5.4. Refuge Goals, Objectives, and Strategies

Endangered, Threatened, and Other Special Status Species
Goal 1
Protect and contribute to the recovery of endangered, threatened, and other special status species on the Refuge by conservation and management of the habitats on which these species depend.

Objective 1.1. Conduct standardized monitoring efforts and research projects in coordination with other regional efforts for salt marsh harvest mouse and California clapper rail within five years. Improve high tide refugia for these species.

Rationale: The California clapper rail and the salt marsh harvest mouse are two of the endangered species for which the Refuge was established. The Draft Tidal Marsh Recovery Plan identifies several actions needed to achieve recovery of the California clapper rail and salt marsh harvest mouse. Actions include evaluating and monitoring existing populations, protecting, managing, and restoring habitat, and conducting research necessary to promote recovery. Refuge management strategies will directly support the actions identified in the Plan. We are also concerned that by allowing the continued use of dog walking near tidal marsh, including high tide refugia, we are opening the door to future use on other Refuge trails and across the Refuge System. To this end, dog walking would be modified to limit dogs to trails primarily in the upland areas only, in order to reduce disturbance to the California clapper rail and the salt marsh harvest mouse.

Strategies
1. Conduct salt marsh harvest mouse surveys within a subset of restored and managed marshes.
2. Revise and implement Refuge monitoring plans and protocols for threatened and endangered species that are consistent with the SBSPRP Adaptive Management Plan and other regional monitoring efforts.
3. Develop and implement standardized monitoring techniques to evaluate ecosystem function and response, species response, and threat response to interim management activities.

4. Investigate California clapper rail response to disturbance including sensitivity to noise and trail use.
5. Expand high marsh and the ecotone/transition zone on the Refuge wherever possible to benefit these species.
6. Identify appropriate habitat for these species in the approved acquisition boundary to prioritize for acquisition or protection.
7. Prohibit dog walking beyond the Tidelands Trail bridge crossings (a reduction of 0.8 miles, or 38 percent). Also, consider shifting the section of trail between the Tidelands Spur Trail and the Harrier Spur Trail slightly inland to expand a buffer between the trail and the adjacent tidal marsh which is at the same elevation. Increase law enforcement and staff/volunteer contact with visitors to ensure compliance. Implement a three to six month monitoring program to ensure compliance.

Objective 1.2. Maintain a 15-year average of one fledged chick per male western snowy plover. Provide appropriate substrate for at least 125 western snowy plover nests annually within five years of implementing the nest site enhancements.

Rationale: The western snowy plover is one of the threatened species for which the Refuge was established. This objective meets goals and objectives identified in the Snowy Plover Recovery Plan including monitoring, management of existing habitat, creation of new habitat, and reducing threats to survival and productivity.

Strategies

1. Conduct nest site enhancement, management actions, and associated monitoring.
2. Evaluate new snowy plover breeding areas as they are discovered/created to determine threats and management needs as data become available.
3. Identify appropriate snowy plover habitat in approved acquisition boundary to prioritize for acquisition or protection.
4. Develop habitat management plan for snowy plover.
5. Support the development of coordinated, standardized sampling methods for annually estimating reproductive success within the San Francisco Bay.
6. Develop methods to monitor western snowy plover survival rates within Recovery Unit 3 (San Francisco Bay).
7. Support and fund studies on western snowy plover habitat use and availability.
8. Identify components of high-quality western snowy plover brood rearing habitat.
9. Develop and maintain updated outreach and interpretive materials on western snowy plovers.

Objective 1.3. Provide appropriate habitat for at least one California least tern colony within the pond complexes to support an average of one fledged chick per nest over a 15-year period, with at least ten nests established annually following habitat creation.

Rationale: The California least tern is one of the endangered species for which the Refuge was established. This objective meets goals and objectives identified in the California Least Tern Recovery Plan including monitoring; identifying potentially suitable nesting sites; preserving and managing nesting habitat; and protecting and managing non-nesting habitat (e.g., foraging areas). No colonies of California least terns currently exist on the Refuge despite potential to provide habitat.

Strategies

1. Identify, preserve, and manage breeding habitat by providing adequate nesting habitat in former, potential, or newly identified breeding areas (including pond and estuarine areas).
2. Create suitable nesting habitat, for example, by capping islands with six to twelve inches of light sand and shell fragments, and maintaining weed free areas.
3. Identify major feeding areas.
4. Support the investigation and implementation of actions needed to increase populations of fish eaten by California least terns in degraded tern feeding areas.
5. Once established, monitor California least tern population to determine status, distribution, and progress of management during the breeding season.

Objective 1.4. Improve ecological function of tidal and managed marsh, especially at La Riviere Marsh, Mayhews Landing, and New Chicago Marsh units in order to enhance tidal marsh habitat.

Rationale: Several units of the Refuge have poor water circulation as a result of levee and berm construction from past uses and the associated lack of tidal channel development during the last century. Decades of water impoundment have led to marsh subsidence and mortality of vegetation. These conditions provide poor quality habitat for wildlife and fish, including threatened, endangered, and other sensitive tidal marsh species (Goals Project 1999). Areas where natural hydrology is compromised also contribute to above average mosquito production and trigger mosquito management by county mosquito abatement districts. Also, the Draft Tidal Marsh Recovery Plan identifies several actions needed to achieve recovery of the California clapper rail and salt marsh harvest mouse. Actions include evaluating and monitoring existing populations; protecting, managing, and restoring habitat; and conducting research necessary to promote recovery. Refuge management strategies will directly support the actions identified in the Plan. According to the San Francisco Bay Area Wetlands Ecosystem Goals Project (1999), only 10 percent of historic wetlands remain. The Goals Project, as well as the Draft Tidal Marsh Recovery Plan, identifies wetland restoration as a critical action toward conserving wildlife and recovering threatened and endangered species. The Southern Pacific Shorebird Conservation Plan (2003) and the North American Waterfowl Management Plan (1998 Update) identify the importance of maintaining, enhancing, and creating wetland habitat for shorebirds and waterfowl. Refuge management strategies will support these objectives. Restoring or acquiring additional tidal habitat will also serve as a buffer for climate change effects. The San Francisco Bay Conservation and Development Commission identifies much of the tidal marsh of the Refuge as under threat from sea-level rise.

Strategies

1. Conduct a hydrological assessment, including ditch connectivity and water hydrology, of each of the sites. For La Riviere Marsh, conduct hydrological assessment to improve northeast corner of the La Riviere site.
2. Work with MADs to assess mosquito numbers in stagnant areas.
3. Develop habitat management plans for Mayhews Landing and Muenster.
4. Update habitat management plans for La Riviere and New Chicago Marshes.

Objective 1.5. Upon Plan approval, implement the mammalian predator management and the avian predator management plans (See Appendix I and J).

Rationale: Invasive (native and non-native species) have become the primary threat to the Refuge System and the Service's wildlife conservation mission. Invasive species have the potential to alter foraging, nesting, and roosting habitat of endangered species and migratory birds that occur on the Refuge. The Service's Biological Integrity, Diversity, and Environmental Health policy (601 FW 3) directs us to prevent the introduction of invasive species, detect and control populations of invasive species, and provide for restoration of native species and habitat conditions in invaded ecosystems that interfere with the Refuge's purposes. Many invasive animal species are predators that threaten native species. The Refuge's proximity to urban environments also highlights the importance of vigilant monitoring of Refuge units. Furthermore, the National Strategy for Management of Invasive Species (April 2003) was developed within the context of the National Invasive Species Management Plan [EO 13112], which functions as the internal guidance document for invasive species management throughout the Refuge System. The Plan identifies four goals:

1) increase the awareness of invasive species issues, both internally and externally;
2) reduce the impacts of invasive species to allow the Refuge System to more effectively meet its fish and wildlife conservation mission and purpose;
3) reduce invasive species impacts on the Refuge System's neighbors and communities; and
4) promote and support the development and use of safe and effective integrated management techniques to deal with invasive species.

Strategies

1. Determine thresholds for predator management actions, appropriate control methods, and potential land management changes, such as:
    - Hazing or removal of individuals
    - Removal of perches within ponds and marshes
    - Control predator access to trash by replacing all of the trash cans within the Refuge to "wildlife proof" trash cans and including informational signage. Manage trash and its removal to minimize attracting predators to endangered species habitat.
    - Work with partners to identify and implement new predator management techniques to protect nests and young.
2. Assess how the predator management program supports the recovery of threatened and endangered species, as well as breeding birds.
3. Develop outreach messages (through press releases, public service announcements) to visitors and neighbors to support predator management (e.g., leave no trace, discourage feeding wildlife).

Objective 1.6. Develop and conduct training annually (or other tools as needed) for staff, partners (e.g., USGS, SFBBO), special use permit holders, volunteers, neighbors, and visitors to reduce trespass and disturbance as well as ensure safety and compliance.

Rationale: As an urban Refuge, there are many disturbances whether from commercial, residential, or management activities. Training and contact with partners and neighbors will contribute to the biological integrity and overall environmental health of the Refuge.

Strategies

1. Biology and visitor services staff will develop protocols and training for staff, law enforcement, partners, permittees, and volunteers to inform the public about how to reduce disturbance to sensitive wildlife habitats.
2. Conduct outreach to reduce trespass and disturbance, including establishing relationships and contacts with neighbors.
3. Conduct annual training for law enforcement, maintenance, other staff, permittees, and volunteers regarding conservation measures to reduce disturbance in and near sensitive wildlife habitats.
4. Increase law enforcement patrols to reduce trespass and disturbance.
5. Provide sensitive wildlife and habitat information and "no entry" signs at launch sites that are adjacent to Refuge lands (e.g., Alviso Marina, Redwood City Marina).

Migratory and Other Native Flora and Fauna

Goal 2

Conserve, restore, enhance, create, and acquire habitats to support the diversity and abundance of migratory birds and other native flora and fauna that depend on the South San Francisco Bay Ecosystem.

Objective 2.1. Within ten years of Plan approval, conduct baseline surveys for population density, presence/absence, and abundance and/or cover of priority native plants, fish, and wildlife to determine species diversity that will inform habitat enhancement actions.

USGS biologists at California gull colony
Judy Irving © Pelican Media

Rationale: Documentation of the occurrence of plants, fish, wildlife, habitats, abiotic components, ecological communities, and invasive species will meet management needs and the directives in the Service's Biological Integrity, Diversity, and Environmental Health policy (601 FW 3). Monitoring changes in biotic and abiotic resources will help management make informed decisions or develop, refine, and evaluate achievement of fish, wildlife, and habitat management objectives. Inventory and monitoring data may also support management of abiotic and biotic resources by other agencies or organizations at broader spatial scales than the Refuge. Development of an Inventory and Monitoring (I&M) Plan will permit prioritization of I&M activities given available resources, relate I&M activities to refuge management goals, document standardized protocols, describe methods for data storage and archiving, and provide templates for summarizing results.

Strategies

1. Create list of priority species to survey.
2. Work with the regional I&M program to develop a stepdown I&M plan for the Refuge.
3. Develop standardized quantitative and qualitative monitoring protocols to be repeated at intervals, depending on the species.
4. Participate in and support national and regional monitoring efforts (i.e., SF Bay shorebird surveys, mid-winter waterfowl surveys, burrowing owl, harbor seal, etc.). Where possible, conduct habitat enhancements based on survey data collected.
5. Conduct survey and mapping of occupied burrowing owl nesting habitat and pairs on the Refuge; participate in regional burrowing owl surveys. Coordinate with other burrowing owl survey partners (e.g., Santa Clara Valley Audubon Society, City of Mountain View Shoreline Park).
6. Using existing migratory bird maps, mid-winter waterfowl data, and USGS and SFBBO salt pond survey data, identify enhancement actions for high-use migratory bird habitat.
7. Work with partners and cooperators to develop and conduct studies to answer management-related questions.
8. Develop database that incorporates new and historic data, including spatial information (GIS) on core areas and species.
9. Conduct baseline surveys for native mammals, such as bats and rodents, using a variety of techniques (e.g., livetrapping, remotely-triggered photo stations, track identification, and scat identification).
10. Work with partners, such as California Native Plant Society, to create a baseline native plant inventory.
11. Survey/monitor for Suisun thistle, salt marsh bird's beak, soft bird's beak, and California sea-blite distribution and abundance.
12. Conduct surveys using methods such as pitfall, coverboard, and black light to identify reptile, amphibian, and invertebrate species.
13. Participate in regional database (e.g., CNDDB, E Bird, BIOS) to make publicly available.

Objective 2.2. Within two years of Plan approval, complete and implement a weed management and re-vegetation plan on the Refuge.

Rationale: Non-native and invasive species have become the primary threat of the Refuge System and the Service's wildlife conservation mission. As noted in an earlier objective, the Refuge's proximity to urban environments makes it vulnerable to introduced species, highlighting the importance of vigilant monitoring of Refuge units. The National Strategy for Management of Invasive Species (April 2003) has been developed within the context of the National Invasive Species Management Plan [EO 13112], which functions as the internal guidance document for invasive species management throughout the Refuge System. Also, the 2008–2012 National Invasive Species Management Plan (a revision to the 2003 National Strategy for Management of Invasive Species) (NISC 2008) identifies five strategic goals to prevent, control, and minimize invasive species and their impacts. Refuge management strategies will support these goals. The Refuge will also partner with organizations like the Bay Area Early Detection Network (BAEDN) to detect and eradicate new infestations of invasive plants within and adjacent to Refuge boundaries, in order to control new outbreaks before they grow into large and costly environmental threats. One especially difficult invasive plant species in the San Francisco Bay is perennial pepperweed. Perennial pepperweed occurs throughout the Refuge, degrading the quality of habitat needed for wildlife.

Strategies

1. Annually prevent infestations in weed free areas identified during the 2010–2011 baseline inventory (refer to draft weed management plan) by monitoring, mechanical control, cultural control, thermal control, and chemical control.
2. Monitor, map, and identify invasive species and specific populations that may trigger management response in accordance with the weed management plan invasive species/populations prioritization list. (Annually identify invasive species and specific infestations to be controlled.)
3. Use integrated pest management principles to control invasive weed species using mechanical, cultural, thermal, and chemical control treatments. Use early detection, rapid response principles. As feasible, eradicate new species of invasive weeds immediately after their detection, eradicate small outlier populations of high priority weeds, control spread of invasives from travel corridors, contain core infestations at their boundaries, and control/reduce core populations.
4. Expand the use of heretofore rarely used control methods, such as prescribed burning, grazing, and salinization, to reduce invasive weeds.
5. Identify native plant propagation and restoration methods for all major habitat types on the Refuge (if not done in the weed management plan).
6. Annually prioritize weed treatment areas for re-vegetation management, and actively enhance these areas by re-vegetating sites with priority native plant species.
7. Annually propagate native plants from local sources and maintain these plants for re-vegetation projects.
8. Annually monitor and evaluate the efficacy of all control treatments and enhancement/re-vegetation projects, and report the results in the Refuge Complex Weed Database.
9. Coordinate with partners, neighbors, land owners, and weed organizations (BAEDN, Cal-IPC, local weed management areas) to gather and share weed and restoration information, and to develop and implement large scale monitoring, early detection, rapid response, and management plans for weed control and re-vegetation.
10. Contain invasive perennial pepperweed at boundaries (as derived from the 2010–2011baseline inventory), eradicate outlier populations, and reduce cover of the main infestations on the Refuge by 20 percent of the baseline inventory conducted in 2010–2011, within threatened and endangered species habitat (high tide refugia, transition zone, and tidal areas).
11. Eradicate the three existant populations of Algerian Sea Lavendar within Reufge boundaries, and work with neighbors to eradicate populations directly adjacent to the Refuge.
12. Reduce the spread of stinkwort by controlling it along travel corridors, by eradicating 50 percent of outlier populations as identified in the 2010–2011 baseline inventory, and by controlling large infestations.
13. Expand nursery at headquarters and EEC to support revegetation plan.
14. Use staff and volunteers to plant in ecotone/transition zones according to revegetation plan priorities (See Objective 2.2).

Objective 2.3. Over the life of the Plan, reduce the cover of invasive plants on Warm Springs (excluding non-native annual grasses) to less than 30 percent, increase cover of native upland plants and native vernal pool forbs on Warm Springs by 10 percent, and reduce biomass of residual dry matter (RDM) to 1,000–1,200 lbs/acre over each of the Warm Springs subunits in order to improve germination conditions for native plant species and enhance vernal pool hydrologic function (Bartolome et al. 2002; S. Barry, pers. comm.; and BLM 1999).

Rationale: Non-native and invasive species have become the primary threat of the Refuge System and the Service's wildlife conservation mission. Grazing and other land uses at Warm Springs has resulted in a vegetative conversion from perennial native grasses and forbs to non-native grasses. As noted in an earlier objective, the Refuge's proximity to urban environments makes it vulnerable to introduced species, highlighting the importance of vigilant monitoring of Refuge units. The National Strategy for Management of Invasive Species (April 2003) has been developed within the context of the National Invasive Species Management Plan [EO 13112], which functions as the internal guidance document for invasive species management throughout the Refuge System. Also, the 2008–2012 National Invasive Species Management Plan (a revision to the 2003 National Strategy for Management of Invasive Species) (NISC 2008) identifies five strategic goals to prevent, control, and minimize invasive species and their impacts. Refuge management strategies will support these goals. This objective also fits with the actions identified in the Vernal Pool Recovery Plan. Reducing invasive plants and residual dry matter will allow vernal pools to thrive.

1. Develop a habitat management plan for Warm Springs in the next five years.
2. Control invasive weed species using mechanical, manual, and chemical control treatments. As feasible, eradicate new species of noxious weeds immediately after their detection, eradicate small outlier populations of high priority weeds, control spread of invasives from travel corridors, contain core infestations at their boundaries, and control/reduce core populations.
3. Based on the positive results of the grazing program to increase cover of native species (2011 grazing analysis), expand the grazing program into the previously ungrazed pasture on Warm Springs.
4. Begin monitoring of the Pacific Commons area using a newly developed comprehensive monitoring plan that covers the entire Warm Springs sub-unit. Monitor vernal pool, upland, and invasive species throughout Warm Springs and use results to evaluate and adapt the grazing and weed control program.
5. Expand the use of existing methods and investigate new methods for controlling invasive plants and enhancing vernal pool ecosystems, such as prescribed burning, flaming, and salinization. Identify areas for re-vegetation management, and actively enhance these areas by re-vegetating sites with priority native plant species. Purchase grass and native seed mix or collect native seed.
6. Manage the grazing program to rotate cattle among all ten grazing pastures to balance grazing pressure and approach target RDM levels in each pasture.
7. Conduct and encourage research on effects of management on vernal pool species and their habitats.
8. Assess the status of burrowing owls on the Warm Springs sub-unit. Maintain short grass/vegetation height prior to nesting season to facilitate site selection.

Blooming vernal pool
USFWS

Objective 2.4. Within five years of Plan approval, prepare a Habitat Management Plan that investigates options to increase nesting and roosting habitat to benefit shorebirds and waterfowl in the Alviso, Mowry, and Newark Ponds.

Rationale: Migratory birds are Federal Trust Species under the jurisdiction of the Service. One of the Refuge's established purposes is the preservation of natural resources, including the habitat of migratory birds. The Refuge provides wintering, migration, and breeding habitat for waterfowl and shorebirds. The North American Waterfowl Management Plan (USFWS et al. 1986, USFWS et al. 1998), Restoring the Estuary: Implementation Strategy of the San Francisco Bay Joint Venture (Steere and Schaefer 2001), U.S. Shorebird Conservation Plan, and Southern Pacific Shorebird Conservation Plan (Hickey et al. 2003) address population and habitat objectives for healthy waterfowl and shorebird populations. Refuge management strategies will support these objectives. It is important to note that Cargill Salt retains perpetual salt making rights on the Mowry and Newark Ponds; therefore, no change in use will be planned for these areas that would interfere with Cargill's rights per the Declaration of Taking dated June 30, 1977. Any habitat changes must be consistent with the ongoing salt making activities. Specific management actions for some of the Alviso Ponds (non-salt production ponds) under the South Bay Salt Pond Project have not been identified. These ponds may be enhanced for waterfowl and shorebirds during the life of the CCP.

Strategies

1. Manage non-salt production ponds at a variety of water levels and salinities to provide shorebird and waterfowl habitat.
2. In non-salt-producing and salt-producing ponds, identify potential habitat improvements such as the creation of nesting islands using dredge spoil material or vegetation removal and sand placement on existing islands.
3. Increase coordination with partners to implement improvements where possible.

Objective 2.5. Within the life of the Plan, enhance and restore marsh-upland ecotone, especially at Faber-Laumeister, La Riviere Marsh, EEC, Pond A6, Pond A8, and 75 miles of levee by establishing a dominance (>50 percent) of native plants along the levees or transitional uplands of the Refuge.

Rationale: Historic tidal marsh of the Estuary encompassed a gradual transition to uplands and, in many places, included gradual slopes. Today, these "transition" areas, commonly referred to as the marsh-upland ecotone, are dominated by levees with a very steep, narrow transition to uplands. The Refuge tidal marsh ecotones consist only of levees, and they are dominated by non-native plant species. The ecotone is an important functional component of the tidal marsh ecosystem, including provision of the Refuge from predators during extreme high tides. The Goals Project (1999) identifies the importance of restoring the San Francisco Bay marsh-upland ecotone. The Draft Tidal Marsh Recovery Plan also identifies the ecotone as essential to the viability of endangered species populations. The transitional upland areas of the Refuge, though also dominated by non-native plant species, also could provide suitable burrowing owl habitat once restored.

Strategies

1. Determine which native plant species should be included in a general plant palette appropriate for ecotone areas (e.g., levees).
2. Contract or work with partners to propagate plants.
3. Use staff and volunteers to plant in ecotone and transition zones according to re-vegetation plan priorities (See Objective 2.2).
4. Incrementally conduct ecotone enhancement (i.e., weed removal, planting natives) along Faber-Laumeister middle levee through restoration education program.
5. Implement a plan to restore the ecotone of Faber-Laumeister and implement monthly plant maintenance.
6. Identify potential areas to restore to burrowing owl habitat.

Objective 2.6. Within ten years of Plan approval, develop at least 10 new partnerships among Federal, state, and local agencies, organizations, neighbors, businesses, and universities to preserve, restore, and enhance diverse, healthy, and productive ecosystems of the Refuge.

Rationale: Many of the Refuge activities require collaboration with regional partners. Our biology, visitor services, and management programs do not exist without outside expertise or additional funding from partners. With expanded Refuge activities as identified in the CCP, additional partnerships will be necessary to support the CCP actions.

Strategies

1. Continue to work with the Invasive *Spartina* Project to monitor and eradicate invasive *Spartina* on Refuge and adjacent lands.
2. Coordinate with partners, neighbors, landowners, and weed organizations (BAEDN, Cal-IPC, local weed management areas) to gather and share weed and restoration information, and to develop and implement large scale monitoring, early detection, rapid response, and management plans for weed control and re-vegetation.
3. Work with partners in endangered species recovery, including public and private landowners, and appropriate Federal, State, and local agencies.

4. Work with partners to conduct or acquire baseline survey information on fish and other subtidal resource information to develop conservation priorities from survey results.
5. Promote the long-term health of the San Francisco Bay Estuary through ecosystem-based management coordinated with partners (e.g. Invasive *Spartina* Project, San Francisco Bay Joint Venture) around the estuary.
6. Participate and support other ongoing restoration projects on the Refuge and adjacent lands including Bair Island, SBSPRP (including the ISP management).
7. Support the goals of the San Francisco Bay Subtidal Habitat Goals Project by participating in living shoreline projects, designing restoration projects to include subtidal habitat enhancement and restoration where possible, and removal of artificial substrates along the shoreline where possible.
8. Help establish the goals of the Upland Goals Project to support landscape-level upland habitat protection, linkage, and restoration where applicable on Refuge lands.

Objective 2.7. Cooperatively monitor and mitigate for disease outbreaks that affect wildlife, plants, and public health on the Refuge.

Rationale: The Refuge is bound by the Bay and urban lands that can have an effect on its natural and trust resources as well as human health. Wildlife and plant disease outbreaks have occurred intermittently on the Refuge and are not well understood. Due to the vast acreage of the Refuge, a cooperative approach with other partners is necessary to quickly respond to any disease introductions to prevent further spread.

Strategies

1. Work with others to monitor and mitigate effects of disease (botulism, cholera, sudden oak death, West Nile Virus, etc.) on wildlife and plant health.
2. Continue to protect wildlife while ensuring public health through coordination with mosquito abatement districts.
3. Implement a mosquito management plan.

Objective 2.8. Reduce the carbon footprint of the Refuge operations by 30 percent of 2012 baseline numbers by 2027.

Rationale: This objective meets with the Service's Climate Change policy, which recommends reducing Refuge staff carbon footprint to offset climate change impacts. The Refuge could also serve as a leader in the community to encourage neighbors to reduce their own carbon footprints.

Strategies

1. Contract work to measure/assess carbon inventory.
2. Reduce the carbon footprint of our facilities, vehicles, and workforce in support of the Service's Climate Change Strategic Plan.
3. Investigate and, if feasible, incorporate solar, wind, and other renewable sources to reduce energy costs.
4. Support and facilitate management-oriented research on climate change impacts to wildlife and habitat.

Objective 2.9. Within five years, investigate and respond to current and future climate change impacts to Refuge properties and resources.

Rationale: Climate change is already affecting wildlife throughout the State (Parmesan and Galbraith 2004), and its effects will continue to increase. Wetlands are especially sensitive to climate change. Nicholls et al. (1999) estimated that 22 percent of wetland loss will be due to inundation, primarily through sea-level rise and other human factors. Historical records show that sea level in the San Francisco Estuary has risen 18–20 centimeters (7 inches) during the past 150 years. The 2006 California Climate Action Team Report projects that mean sea level will rise 4–33 inches by the year 2100 (CEPA 2006). Pacific Institute's 2009 report estimates a rise of 1.0–1.4 meters by 2100 (Heberger et al. 2009). Much of the Refuge is located below sea level, placing it at greater risk of inundations. This objective also helps to achieve Statewide Conservation Action I in the California Wildlife Action Plan (CDFG 2005). Collecting data on physical and biological changes will help determine how such natural resources on the Refuge are shifting in light of climate change.

Strategies

1. Coordinate with the Service's California Landscape Conservation Cooperative, the Service's regional I&M program, Bay Area Ecosystems Climate Change Consortium, and others to address near-term and long-term climate change and sea-level rise impacts as they relate to the Refuge.
2. Assess and prioritize sea-level rise impacts on refuge properties and resources that the Refuge will try to address.
3. Investigate methods for mitigating sea-level rise such as raising levees and increasing sedimentation.
4. Identify and implement best practices to begin mitigation of climate change impacts, especially those Refuge lands at risk of sea-level rise.
5. Investigate and prioritize for acquisition, lands within the approved acquisition boundary that have feasible opportunities to address sea-level rise impacts for marsh migration and other effects from climate change.
6. Obtain funding to support additional climate change modeling of future trends for refuge habitats.
7. Use existing USGS/PRBO Conservation Science models to help inform management decisions.

Objective 2.10. Actively work with partners and willing sellers to acquire remaining lands within the approved acquisition boundary of the Refuge.

Rationale: Some lands within the approved acquisition boundary have already been converted to urban developments, while other lands are owned or managed by other public agencies or conservation organizations with goals similar to the Refuge. Therefore, we will focus on the remaining lands within the approved acquisition boundary that have not yet been protected and have good potential to provide habitat or be restored for threatened and endangered species, and other Refuge purposes. The Refuge is particularly interested in acquiring unprotected high marsh, ecotonal, and upland habitats that will benefit migratory birds that are Refuge trust species. The Refuge is also interested in acquiring those lands within the approved acquisition boundary that can address climate change effects (see Objective 2.9). The Refuge is committed to

acquiring these lands from willing sellers as identified in the 1990 Final Environmental Assessment of Potential Additions to the San Francisco Bay National Wildlife Refuge.

Strategies

1. Using the 1990 EA as a reference, investigate remaining lands within the approved acquisition boundary with the potential to meet the Refuge's purposes.
2. Express to these landowners our interest in acquiring these prioritized lands, particularly willing sellers.
3. Work with partners to acquire funding and support for acquisitions.
4. Acquire or protect currently unprotected high marsh, ecotonal, and upland habitats by working with adjacent landowners, NGOs, and other Federal and State agencies.
5. Identify and acquire areas with the potential to be restored to burrowing owl habitat.
6. Investigate and prioritize for acquisition, adjacent upland areas within the approved acquisition boundary for marsh migration and other effects from climate change. (Objective 2.9, Strategy 5)

Public Uses

Goal 3

Provide the local community and other visitors with compatible wildlife-oriented outdoor recreation opportunities to enjoy, understand, and appreciate the resources of the Refuge.

Objective 3.1. In five years, develop a visitor services plan that provides and promotes high quality, safe public opportunities such as wildlife observation, wildlife photography, hunting, fishing, and other compatible recreational programs for up to 1 million visits per year.

Rationale: The Refuge is surrounded by several million people, and population is expected to increase over the next 15 years. We expect that visitation of the Refuge will increase as well (currently about 750,000 annually), and intend to construct additional infrastructure to accommodate this, such as wildlife viewing facilities and fishing access. Wildlife observation, photography, hunting, and fishing are identified in the 1997 Improvement Act as four of six priority public uses on refuges. Hunting and fishing are existing uses, occurring prior to the Refuge's establishment, and they are not likely to conflict with the other purposes of the Refuge. Fishing is an existing use of the Refuge and will be expanded to provide additional shoreline opportunities, while hunting (waterfowl) will continue on certain ponds and the open bay. These uses are provided when deemed compatible with wildlife and habitat.

Also, the Refuge is located in a highly urbanized area near other growing public access opportunities (e.g. the San Francisco Bay Trail, SFBAWT, and CDFG lands) that will require coordination with these and other partners to create a consistent network of recreational options. Refuge public use opportunities are expected to support the San Francisco Bay Trail and SFBAWT Plan goals of providing access around the entire Bay. This objective also supports the California Wildlife Action Plan (CDFG 2007), which calls for state and Federal governments to give greater priority to wildlife and natural resources conservation education through both formal and nonformal educational means.

Strategies

1. Outreach to cultural groups, organized community groups.
2. Ensure that public access opportunities at the Refuge are maintained or expanded, especially in light of restoration and enhancement activities (e.g., install water bars along Tidelands Trail to slow erosion).
3. Assess trail use, particularly on Refuge/Bay Trails, and develop additional management and monitoring guidelines. Consider step-down planning for trail uses.
4. Investigate, and if feasible, construct additional wildlife viewing facilities at different areas of the Refuge.
5. Investigate, and if feasible, use remote cameras near closed, sensitive wildlife areas to increase wildlife observation opportunities.
6. Install a raised boardwalk extending the entire length of the interior levee of the Faber-Laumeister site.
7. Develop and/or update non-personal materials such as brochures and wayside exhibits for hunting and fishing programs in order to provide current information and to convey Refuge messages.
8. Conduct interpretation using compatible, outdoor recreation-based activities (e.g., bicycling, yoga).
9. Improve fishing facilities at Coyote Creek Lagoon and Faber-Laumeister with a small fishing platform.
10. Assess shoreline fishing to Alviso Slough (near Pond A9) and implement if feasible.
11. Develop a nature exploration area at headquarters to promote the Children in Nature initiative and NWRS Vision.
12. Update fishing pier at Marshlands Road, including renovating the fish cleaning station.
13. With input from the local hunting community, design, construct and maintain at least one universally-accessible photography blind.
14. Explore the feasibility of a bus stop at the Fremont headquarter entrance with local transit authorities.
15. Update EEC facility to provide visitor contact or information services on the weekends (at a minimum).
16. Increase number of meetings to solicit hunter feedback. Develop an interactive hunt Web site for hunt permits, interactive hunt maps, relevant links to other hunt information, and a collection of hunt data; track hunt use over a 5-year period once major tidal restoration breaches are completed to determine use.
17. Create a volunteer program from hunt community to assist with upkeep of hunt blinds and other hunt infrastructure.
18. Refuge staff and law enforcement officer will work cooperatively with local law enforcement officers and CDFG wardens to enforce CFR and Refuge-specific regulations to provide a quality experience for all visitors.

Objective 3.2. Within the life of the Plan, construct a Visitor Center Complex (including auditorium, resource library, staff offices, EE facilities) at Refuge headquarters in Fremont with a capacity of up to 200,000 visits per year. Build to Silver LEED certification or better and incorporate into the environmental education and interpretive programs to promote conservation practices.

Boardwalk at the EEC
Genie Moore

Rationale: The Refuge once had a large visitor center complete with auditorium for programs. Due to increased staff, this space was converted to office and auditorium for office use. While a smaller contact station was constructed, it does not provide sufficient space for interpretive and environmental education needs. Furthermore, visitors have expressed interest in having a larger visitor center similar to the previous facilities. This objective also meets with the Service-wide inititative to earn LEED certification of Silver or higher, while also meeting with the Executive Order 13514 to establish an integrated strategy towards sustainability in the federal government and to make reductions of greenhouse gases a priority of federal agencies.

Strategies

1. Assess area near Pavilion or other sites for feasibility.
2. Obtain funding to design and construct the visitor center.

Objective 3.3. Within five years of Plan approval, research, and if feasible, promote a wildlife compatible, water-based, wildlife observation program at Alviso Slough, Newark Slough, and Bair Island.

Rationale: Through this objective we will facilitate wildlife observation and photography opportunities using a different mode of transportation. Wildlife observation and photography are identified in the 1997 Improvement Act as two of six priority public uses on refuges. This objective also meets with the regional SFBAWT Plan goals to provide non-motorized boat access around the Bay. Ongoing restoration efforts may reduce numbers of terrestrial trail miles; promoting water-based recreation would help the Refuge maintain public access opportunities.

Strategies

1. Research the feasibility of adding staff or docent-led, water-based programs such as canoe/kayak tours to the visitor services program.
2. Identify potential canoe and kayak launch or destination (per the SFBAWT) site on the Refuge (e.g., Dumbarton Bridge/fishing pier).
3. Pursue grant funding through the Coastal Conservancy and the Department of Boating and Waterways to supplement site construction costs.
4. Install signage such as “No Wake”, to reduce boating impacts along Newark Slough and other appropriate Refuge locations.

Objective 3.4. Within five years of Plan approval, develop and implement a public outreach program to promote responsible, water-based recreation in order to decrease wildlife disturbance.

Rationale: Increased water-based recreation opportunities will require sufficient outreach to reduce wildlife disturbance. The Refuge is accessible by many boat launches outside of the Refuge and with the increased promotion of water-based recreation around the Bay through the SFBAWT Plan, it will be important to make contact with that user group in order to reduce the increased potential for wildlife disturbance and habitat degradation.

Strategies

1. Identify established and future locations of water-based access to the Refuge and their owners and/or managers.
2. Develop outreach materials to promote wildlife disturbance reduction messages within the water-based recreation user group.
3. Establish partnerships with site owners/managers, as identified in strategy 1, as well as relevant partner agencies and water-based recreation organizations with the purpose of promoting wildlife disturbance reduction messages and the distribution of prepared outreach materials.
4. Through partnerships with local site owners/managers, as identified in strategy 1, promote the development of water-based recreation that minimizes wildlife disturbance and includes wildlife disturbance reduction components to the infrastructure (e.g. design of launch sites, inclusion of exhibits, and usage of signs).

Learning to canoe with Save the Bay
Judy Irving © Pelican Media

Objective 3.5. Within two years of Plan approval, research the feasibility of implementing a wildlife photo permit system.

Rationale: This objective will promote photography, identified in the 1997 Improvement Act as one of six priority public use on refuges. Hunt blinds on the Refuge can provide a dual purpose, serving both hunters and photographers. A permit system will allow photographers access to locations not normally offered to the public.

Strategies

1. Research other NWR photography permit systems.
2. Assess and identify potential blind sites and/or photography areas, such as at Ponds A2E, A3W, and Ravenswood ponds.
3. Develop photographer guidelines, maps, and other relevant material.
4. Explore Federal requirements of creating a fee-based program, including potential use of the Duck Stamp.
5. Form partnerships with local wildlife photography groups/organizations to facilitate the development and implementation of potential system.

Environmental Education, Interpretation, and Outreach

Goal 4

Through diverse environmental education, interpretation, and outreach opportunities, increase public awareness of the Refuge's purpose and the ecosystem of San Francisco Bay Estuary and promote environmental stewardship and conservation.

Objective 4.1. Develop and implement a unified message for the public within the first two years of the CCP. Incorporate the unified message into environmental education, interpretation, outreach, and recreation throughout the life of the CCP.

Rationale: This objective was developed to ensure that a unified message is presented to the public consistently across all visitor services, outreach, and public affairs aspects of the Refuge. This objective also supports the California Wildlife Action Plan (CDFG 2007), which calls for state and Federal governments to give greater priority to wildlife and natural resources conservation education.

Strategies

1. Define three main themes to be presented and incorporated into the Visitor Services Plan (see Objective 3.1). Present in a variety of other venues (e.g., fairs, meetings, conferences, with public and partner groups).
2. The thematic message needs to support the following resource management objectives: migratory birds, endangered species, importance of wetland habitats, climate change/reducing carbon footprint, and habitat restoration.
3. Develop and implement various ways to convey the theme, i.e. verbally, visually, and other media in field trips, interpretive programs, and outreach events.
4. Train staff and partners to distribute messages (e.g. informal visitor contacts, meetings, phone conversation, etc.)

Objective 4.2 Improve educator training and pilot new environmental education (place-based, service-learning, and habitat restoration) resources for use by educators and other partners in the first five years after the CCP is approved.

Rationale: Environmental education is identified in the 1997 Improvement Act as a priority public use that can be allowed when compatible with other Refuge purposes. The Refuge has provided environmental education opportunities for several decades as it is one of its founding purposes. The Refuge relies on other educators to integrate and reinforce the environmental education concepts that are presented on field trips (Wetland Round-Up, Slow the Flow, and Restoration Education programs) into their classrooms and daily activities, improving retention

among students and encouraging participation in conservation in their everyday lives. To prepare teachers, parent volunteers, and other educators to support our environmental education programs, Refuge staff provide training and materials. As part of its environmental education programs, educator guides and additional resources have been developed over the years to help teachers create curricular connections to State education standards, and continue student learning and appreciation beyond their visit to the Refuge. Furthermore, the educator guides and other related materials have become known and relied upon as an important asset for many environmental education providers, and the activities and information provided therein are used significantly beyond the boundaries of the Refuge. This objective will enhance opportunities and resources to support teachers and parents so they can maximize the field trip experience for students. By piloting additional activities and resources, the Refuge has the opportunity to set new standards in environmental education by formally developing and integrating accessible information to Spanish language speakers, and restoration education elements into the educator guides and other related materials.

Strategies

1. Revise educator guides and other related material for the Wetland Round-Up, Slow the Flow, and Restoration Education field trip programs.
2. Translate materials into Spanish and offer programs in Spanish.
3. Develop teacher and student resources for environmental education programs focused on habitat restoration.
4. Develop and enhance teacher and parent training materials for all environmental education programs.
5. Train partners to host Wetland Roundup Field Trip programs for other groups (e.g., Girl Scouts, Marine Science Institute).

Marsh-In Summer Day Camp
USFWS

Objective 4.3. Within five years of Plan approval, develop and expand environmental education programs for neighboring communities that focus on habitat restoration for former salt ponds, restored wetlands habitats, and uplands.

Rationale: As an urban Refuge surrounded by more than several million people, we would like to build community support for conservation by involving our neighbors in restoration projects occurring on the Refuge.

Strategies

1. Expand Science Night program to other schools.
2. Redesign four Discovery Packs with self-guided activities at headquarters and EEC.
3. Offer enrichment activities throughout the year for Habitat Heroes.
4. Research Mayhews unit as a restoration education site with local schools and implement where feasible. Environmental education programs could include field trips, science nights, and service learning projects, etc.
5. Explore and develop, where possible, environmental education programs focused on habitat restoration with local schools at all Refuge sites (e.g., Warm Springs, Alviso, Fremont, East Palo Alto).
6. Expand the audience for environmental education programs focused on habitat restoration to include six high schools and four colleges (e.g., Mission College, UC Santa Cruz, Logan High School, Menlo-Atherton High School).
7. Develop environmental education curriculum in Spanish that addresses the Refuge's resource management objectives and issues, compatibility issues, and ecoregion concerns.
8. Develop environmental education programs for non-school based audiences (e.g. adults, youth groups, scouts, afterschool programs, etc.).
9. Develop and present careers in conservation programs for outreach events and programs.
10. Offer programs to 5th grade through college levels.

Objective 4.4. Provide watershed study and water conservation program for Alviso Unit area.

Rationale: Environmental education is identified in the 1997 Improvement Act as a priority public use that can be allowed when compatible with other Refuge purposes. Watershed and water conservation education help to support the Refuge by teaching the local community about their everyday impacts to the water quality of the wetlands on the Refuge.

Strategies

1. Offer programs to 5th grade through college levels.
2. Increase capacity for joint water pollution control plant/EEC tour programs.
3. Collaborate with and incorporate additional partner organizations that will contribute to outreach activities and the Refuge mission.

Objective 4.5. Update the Environmental Education Center building and grounds to Silver LEED certification or better by 2027. Use the Environmental Education Center as an example in environmental education and interpretive programs to promote conservation practices.

Rationale: The EEC requires expansion and update to reflect the themes that are promoted in the environmental education program. Moreover, current space cannot accommodate the current interest in both the environmental education program and public uses requested by the local community. Updating the EEC will also represent the messages we convey in our visitor services programs and outreach efforts. This objective also meets with the Service-wide inititative to earn LEED certification of Silver or higher, while also meeting with the Executive Order 13514 to establish an integrated strategy towards sustainability in the federal government and to make reductions of greenhouse gases a priority of federal agencies.

Strategies

1. Research and incorporate solar, recycled water, recycled materials, wind energy, and other green building elements into the buildings and grounds where appropriate.
2. Develop interpretive materials (e.g. Web site, panels) and programs that present green/LEED features as conservation measures that can be replicated.
3. Incorporate green building design elements into environmental education curriculum as teaching tools.
4. Using the facility to teach about climate change.

Objective 4.6. Within five years of Plan approval, expand interpretation at the Warm Springs sub-unit, including increasing tours over the next five years from two per year to one each week during the vernal pool flowering season.

Rationale: Interpretation is identified in the 1997 Improvement Act as a priority public use that can be allowed when compatible with other Refuge purposes. The Warm Springs sub-unit of the Refuge has been growing in popularity as one of the rare Bay Area locations to learn about and enjoy vernal pool grasslands.

Strategies

1. Recruit volunteers and increase staff to conduct tours.
2. Provide annual training to tour guides.
3. Outreach to Warm Springs Trail users through signage (on trail and Cushing bridge) and non-personal materials such as mailings, email, and Web sites.

Vernal pool tour at Warm Springs
USFWS

Objective 4.7. Expand interpretation program through additional programs and events including two new interpretive programs, ten special events, and nine outreach events a year through either staff or docents to ensure the Refuge incorporates a wide range of appropriate topics and addresses a diversity of audiences.

Rationale: Interpretation is identified in the 1997 Improvement Act as a priority public use that can be allowed when compatible with other Refuge purposes.

Strategies

1. Identify topics/themes that have not been covered.
2. Annually review programs and update programs.
3. Develop audio tour and improve MP3 self-guided tour offerings, explore cell phone audio tour program.
4. Develop additional geocache and earth cache sites.
5. Host ten special events and nine outreach events annually.

Objective 4.8. Update old or outdated interpretive materials such as information sheets and interpretive panels based on the themes developed in the Visitor Services Plan within 5 years and then review or update as needed.

Rationale: Much of the signage on the Refuge is in poor condition or is outdated, requiring update and replacement.

Strategies

1. Identify and prioritize materials that need to be replaced.
2. Consider using respective languages of the community on signage.

Replacing boundary signage
USFWS

Objective 4.9. All staff will include a public outreach component for major Refuge and partner activities.

Rationale: As an urbanized Refuge, our activities are extremely visible to the public. Visitors are often curious or concerned about activities they see happening on the Refuge, especially in closed areas. The Refuge plans to improve outreach of Refuge and partner activities to improve public relations.

Strategies

1. Use outreach tools such as press releases, staff/volunteer/permittee notification, public service announcements, temporary signage, Web site updates, Facebook, and temporary exhibits.
2. Train staff, volunteers, partners, and permittees on how to make contact with visitors and the type of message to convey.

Volunteers

Goal 5

Instill community stewardship through volunteerism to support the Refuge's diverse purposes.

Objective 5.1. Within the life of the Plan, increase volunteers and volunteer hours by 60 percent of 2012 baseline to support the continuing and new operational needs of the Refuge programs.

Rationale: Our biology, visitor services, and management programs do not exist without the support of volunteers, including our volunteer interns. With expanded Refuge activities as identified in the CCP, expanding the volunteer program will be necessary to support the CCP actions.

Strategies

1. Complete program needs assessment for volunteers and create new, as well as revise existing, position descriptions for volunteers and interns.
2. Create a volunteer Web site and explore other social networking methods (e.g., Facebook) to announce new volunteer opportunities and update regularly.
3. Update orientation materials for all volunteers to inform them about the Service, the Refuge System, and refuges in the Complex.
4. Establish a quality training program that will allow volunteers to conduct biological, environmental education, and interpretation activities; conduct these trainings as needed.
5. Recruit volunteers through a variety of community groups (e.g., professional organizations, boy scouts, girl scouts, cultural organizations, Audubon, Sierra Club), local businesses, and local neighborhoods.
6. Recruit interns from local universities, community colleges, and environmental/conservation-oriented university programs throughout the country.
7. Provide professional enrichment opportunities for all volunteers such as conferences, workshops, and formal presentations.
8. Construct additional housing for volunteers and seasonal staff.

Objective 5.2. Expand public stewardship projects for each of the following areas: headquarters, Warm Springs, Alviso-managed ponds, Moffett Bay Trail, Ravenswood, Bair Island, Faber-Laumeister, and others as appropriate within the life of the CCP.

Rationale: Identifying stewardship projects are another method to sustain support of specific Refuge sites through self-directed individual and group volunteers.

Strategies

1. Recruit volunteers from areas near sites identified in the objective to conduct stewardship projects (e.g., weed management, plant propagation, monitoring, public safety, trail maintenance, trash removal).
2. Recruit and train volunteer leaders to manage stewardship projects.

Objective 5.3. Develop one volunteer program (i.e., activity or event) every five years that outreaches to different segments of the Bay Area community.

Rationale: Increase long-term community interest in the Refuge goals through developing community support and leaders who may, in turn, advocate for related environmental ecosystem needs.

Strategies

1. Increase efforts to recruit youth (e.g., through local ecological/science organizations in high schools and colleges) to sponsor volunteer events on the Refuge.
2. Recruit volunteers through Federal and State programs geared toward retraining people making career changes.
3. Train Refuge volunteers to be volunteer leaders in order to lead self-directed volunteer projects.

6. Plan Implementation

6.1. Implementation

During the next 15 years, the objectives and strategies presented in this CCP will be implemented; the CCP will serve as the primary reference document for all Refuge planning, operations, and management until it is formally revised at the end of the 15-year period. The Service will implement this CCP with assistance from existing and new partner agencies and organizations and from the public.

CCPs provide long-term guidance for management decisions and set forth goals, objectives, and strategies needed to accomplish Refuge purposes and identify the Service's best estimate of future needs. These plans detail program planning levels that may exceed current budget allocations and, as such, are primarily for Service strategic planning and program prioritization purposes. Plans do not guarantee a commitment of resources.

Activities required to accomplish the management strategies discussed in this CCP are referred to as projects. Every effort will be made to implement these projects by the deadlines established here. However, the timing of implementation of the management activities proposed in this document is contingent upon a variety of factors, which are listed in further detail in the following text.

- Funding and Personnel
- Step-Down Management Plans
- Appropriate Uses and Compatibility Determinations
- Compliance Requirement
- Monitoring and Evaluation
- Partnerships and Opportunities
- Adaptive Management
- Plan Amendment and Revision

6.2. Funding and Personnel

To implement the proposed action and achieve the objectives and goals of this CCP, the Service will need additional funding. Fund or staffing for specific projects will be requested through the Refuge Operating Needs System (RONS). RONS projects are proposed new Refuge projects that do not represent replacement of existing equipment or facilities. The projects proposed in this CCP will be added to the RONS list during the life of this CCP. Some CCP funding needs may be recorded in the Service Asset Maintenance Management System (SAMMS) for the Refuge System. Maintenance projects include repair and replacement of existing buildings and facilities and removal of unneeded infrastructure. The estimated startup cost to implement management and projects in the CCP is $6,703,500, with annual costs of $774,700 for full implementation (based on 2011 dollars). Staff costs (both existing and additional staff needed to implement the CCP) total $1,777,600 annually. However, costs must be incrementally increased for inflation and increased activities such as new research studies and non-native control methods.

The Refuge has a total of 12 permanent staff: refuge manager, two wildlife refuge specialists (one part-time), two maintenance workers, two wildlife biologists, three environmental education specialist (two part-time), interpretive park ranger, and an outdoor recreation planner (part-

time). The Refuge also has one term full-time biologist. The Refuge receives law enforcement, administrative, other biological, and other visitor services support from the Complex staff. Current staffing costs for the Refuge are estimated at $863,600 for these positions. Salaries constitute a significant cost of implementing the CCP. Funding for 15.5 additional staff is needed to implement the objectives and strategies of the CCP. An additional $934,000 (based on 2011 salary costs) per year is needed to fund the additional staff positions; this figure does not include salary increases over time. Table 18 describes the staffing needs for the Refuge for each project proposed by this CCP; Table 19 describes the budget proposal needed to implement the CCP. The needs and costs shown in Table 18 and Table 19 are best estimates and may not entirely reflect the costs of managing the Refuge.

Staff opening tide inlet at Pond SF-2
USFWS

Table 18. Staffing Plan and Needs

Current Staffing Level	***Estimated Unit Costs (includes benefits)***	***Quantity***	***Costs***
Refuge Manager GS-0485-13	$130,000	1.0	$130,000
Wildlife Refuge Specialist GS-0485-11	$91,000	1.0	$91,000
Wildlife Refuge Specialist GS-0485-11	$91,000	0.6	$54,600
Maintenance Worker WG-4749-8	$75,000	1.0	$75,000
Maintenance Worker WG-4749-6/7/8	$65,000	1.0	$65,000
Wildlife Biologist GS-0486-11	$91,000	1.0	$91,000
Wildlife Biologist GS-0486-9/11	$76,000	1.0	$76,000
Environmental Education Specialist GS-1701-11	$91,000	1.0	$91,000
Environmental Education Specialist GS-1701-9	$76,000	0.5	$38,000
Instructional Systems Specialist GS-1750-9	$76,000	0.5	$38,000
Interpretive Park Ranger GS-0025-7/9	$62,000	1.0	$62,000
Outdoor Recreation Planner GS-0023-9	$76,000	0.5	$38,000
Total Existing Staff Cost:		**10.1**	**$863,600**
Staffing Additions	***Estimated Unit Costs (includes benefits and start-up costs)***	***Quantity***	***Costs***
Botanist GS-430-7/9	$64,500	1.0	$64,500
Wildlife Biologist GS-486-5/7/9	$52,000	1.0	$52,000
Wildlife Biologist GS-486-7/9/11	$64,500	1.0	$64,500
Wildlife Refuge Specialist GS-485-5/7	$52,000	1.0	$52,000
Wildlife Refuge Specialist GS-485-7/9	$64,500	1.0	$64,500
Biological Science Technician GS-404-4/5 (seasonal)	$46,500	4.0 (half-time)	$93,000
Interpretive Park Ranger GS-0025-9	$79,000	1.0	$79,000
Visitor Services Information Assistant GS-0025-4/5	$46,500	2.0	$93,000
Bilingual Environmental Education Specialist GS-1701-9	$79,000	1.0	$79,000
Environmental Education Specialist GS-1701-9*	$79,000	1.0	$79,000
Law Enforcement Officer GS-0025-7/9	$64,500	1.0	$64,500
Information Technology Specialist GS-2210-5/7	$52,000	0.5	$26,000
Maintenance Worker WG-4749-6/7/8	$65,000	1.0	$65,000
Administrative Support Assistant GS-0303-6/7	$58,000	1.0	$58,000
Total Additional Staff Cost		**15.5**	**$934,000**
TOTAL STAFF COST:		**25.6**	**$1,777,600**

Table 19. Budget Proposal for Don Edwards San Francisco Bay NWR Comprehensive Conservation Plan

Project Description	***Operational Cost for Startup***	***Average Annual Cost***
Conduct baseline wildlife surveys and additional endangered species surveys [Obj. 1.1, 2.1]	$120,000	$100,000
Boat (for surveys and management efforts) [Obj. 1.1, 2.1]	$10,000	
2 trucks for surveys and weed management [Obj. 1.1, 2.1, 2.2]	$30,000	

Create and maintain nesting islands (esp., western snowy plover and California least tern) [Obj. 1.2, 1.3]		$100,000
Snowy plover brochures [Obj. 1.2]	$5,000	$1,000
Hydrological modeling for La Riviere, Mayhews, New Chicago Marsh [Obj. 1.4]	$240,000	
Predator management outreach materials (signage, brochures) [Obj. 1.5]	$50,000	$3,000
Additional predator management costs [Obj. 1.5]	$150,000	$140,000
Signage, outreach materials at launch sites to reduce disturbance [Obj. 3.4]	$30,000	$3,000
Weed management (mechanical, cultural, thermal, and chemical controls) [Obj. 2.2]	$10,000	$125,000
Marsh-upland ecotone enhancements (Faber, La Riviere, EEC, A6, and A8) [Obj. 2.5]	$300,000	$20,000
Convert vehicle fleet to more fuel efficient technologies [Obj. 2.8]		$20,000
Energy efficient improvements to infrastructure (e.g., solar, wind, water) [Obj. 2.8]		$30,000
Assess climate change impacts and adapt planning accordingly [Obj. 2.9]		$100,000
Improve Tidelands Trail by installing water bars [Obj. 3.1]	$20,000	
Raised boardwalk extending the entire length of the interior levee of the Faber-Laumeister site [Obj. 3.1]	$400,000	
Bus stop near the headquarter entrance [Obj. 3.1]	$50,000	
Construct wildlife viewing facilities [Obj. 3.1]		$100,000
Webcam near closed and/or sensitive areas [Obj. 3.1]	$50,000	
Canoe and kayak sites on the Refuge (near Dumbarton Bridge, etc.), interpretive/informational signage [Obj. 3.3]	$20,000	$1,000
Universally-accessible photography blind [Obj. 3.1]	$2,000	
Contract to design interactive hunt Web page [Obj. 3.1]	$10,000	
Brochures and wayside exhibits for hunting [Obj. 3.1]	$6,000	$750
Update fishing pier including renovate fish cleaning stations [Obj. 3.1]	$200,000	
Small fishing platform at Coyote Creek Lagoon and Faber-Laumeister [Obj. 3.1]	$600,000	
Fishing access at Alviso Slough near A9	$35,000	$1,000
Brochures and wayside exhibits for fishing (Coyote Creek, Faber, Alviso Slough, fishing pier) [Obj. 3.1]	$20,000	$750
Construct a Visitor Center Complex (including auditorium, resource library, staff offices, EE facilities) at Refuge headquarters [Obj. 3.2]	$7,000,000	
New interpretive programs [Obj. 4.7]		$200
10 special events [Obj. 4.7]		$1,000
2 new audio tours (contract out) [Obj. 4.7]	$2,000	

Update old or outdated interpretive materials-information sheets and interpretive panels [Obj. 4.8]		$2,000
Update the EEC building and grounds to Silver LEED certification or better [Obj. 4.5]	$3,500,000	
Climate change/LEED curriculum [Obj. 4.5]	$10,000	$500
Develop new teacher and student resources [Obj. 4.2]	$5,000	$1,000
New training materials for educator to lead field trips, (include electronic materials, DVDs, and Web-based materials) [Obj. 4.2]	$5,000	$1,000
Additional Science Nights [Obj. 4.3]	$1,000	$500
Additional Restoration Education program sites [Obj. 4.3]	$10,000	$3,000
Watershed study and water conservation education program* [Obj. 4.4]	$10,000	$5,000
Contract for Spanish translation [Obj. 4.2]	$15,000	$1,000
Additional Habitat Heroes programs [Obj. 4.3]		$300
4 discovery packs [Obj. 4.3]	$500	$300
Nature exploration area at HQ [Obj. 3.1]	$85,000	$2,000
Expand greenhouse at HQ and EEC [Obj. 2.2]	$20,000	$10,000
Summer Camp [Obj. 4.3]		$900
Construct volunteer/intern/seasonal staff house [Obj. 2.2, 5.1]	$80,000	
Vehicle for visitor services program [Goal 4 and 5]	$15,000	
Volunteer training materials [Obj. 5.1]	$1,000	$500
TOTAL	**$17,117,500**	**$774,700**

6.3. Step-down Management Plan

Some objectives in the Plan require more detailed planning than the CCP process is designed to provide. For these projects, the Service will refer to step-down management plans and other plans to provide additional details necessary to implement objectives and strategies in the CCP. Some of these plans include NEPA documentation. A number of step-down plans will be developed or updated, including:

- Fire Management Plan (last updated 2004)
- Habitat Management Plan
- Weed Management Plan
- Visitor Services Plan
- Fishing Plan
- Hunting Plan

6.4. Appropriate Use and Compatibility Determinations

Federal law and policy provide the direction and planning framework to protect the Refuge System from inappropriate, incompatible, or harmful human activities and to ensure that Americans can enjoy Refuge System lands and waters. The 1997 Improvement Act is the key legislation on managing appropriate public uses and compatibility.

Before activities or uses are allowed on a refuge, uses must be found to be appropriate and then compatible through a written appropriate use and compatibility determination. An *appropriate use* is defined as a proposed or existing use on a refuge that meets at least one of the following four conditions: 1) use is a wildlife-dependent recreational use; 2) use contributes to fulfilling the Refuge purposes, Refuge System mission, or goals or objectives of the Refuge; 3) use involves the take of fish and/or wildlife under State regulations; or 4) use has been found appropriate in prior determinations (603 FW 1 of the Service Manual). A *compatible use* is defined as a proposed or existing wildlife-dependent recreational use or any other use of a refuge that, based on sound professional judgment, will not materially interfere with or detract from the fulfillment of the Refuge System mission or the purposes of the Refuge. *Sound professional judgment* is defined as a decision that is consistent with the principles of the Service's management and administration, available science and resources, and adherence to the requirements of the 1997 Improvement Act and other applicable laws. Wildlife-dependent recreational uses may be authorized on a refuge when they are compatible and not inconsistent with public safety.

Appropriate use determinations are included in Appendix N for livestock grazing, recreational boating, research and monitoring, and mosquito management.

Compatibility determinations are included in Appendix C for research and monitoring, livestock grazing, mosquito management, wildlife observation and photography, environmental education and interpretation, waterfowl hunting, recreational boating, and recreational fishing.

6.5. Compliance Requirements

This CCP was developed to comply with all Federal laws, executive orders, and legislative acts. Some activities (particularly those that involve a major revision to an existing step-down management plan or preparing a new plan) would need to comply with additional laws and/or regulations besides NEPA and the Improvement Act.

The Refuge System has established laws that guide the identification and evaluation of accidentally discovered archaeological resources. Any discovered resources will be handled in accordance with regulations that include the Native American Graves Protection and Repatriation Act, National Historic Preservation Act (NHPA), Antiquities Act of 1906, Archaeological Resource Protection Act of 1979, and Historic Sites Act of 1935.

6.6. Monitoring and Evaluation

The CCP is designed to be effective for a 15-year period. The Plan will be reviewed and revised as required to ensure that established goals and objectives are still applicable and that the CCP is implemented as scheduled. The monitoring program will focus on issues involving habitat management programs, wildlife and plant inventory, other monitoring and management activities, visitor service activities, and environmental education programs. Monitoring and evaluation will use the adaptive management process. This process includes setting goals and objectives, applying management tools and strategies, and subsequently conducting monitoring and analysis to measure achievement of objectives and refine management techniques.

Collection of baseline data on wildlife populations will continue. This data will be used to update existing species lists, wildlife habitat requirements, and seasonal use patterns. Migratory and resident birds, raptors, and species of management concern will be the focus of monitoring efforts.

Where information gaps exist, a concerted effort will be made to obtain information. With new information, goals and objectives may need modification. Public involvement will be encouraged during the evaluation process.

Monitoring of public use programs will involve the continued collection of visitor use statistics. Monitoring will be done to evaluate the effects of visitor service on Refuge habitat, wildlife populations, and visitor experience.

6.7. Partnership Opportunities

Partnerships are critical to the achievement of Refuge objectives and strategies. The Refuge has partnered with governmental agencies, non-governmental organizations, and individuals to conduct wildlife monitoring, habitat restoration, facility maintenance, environmental education, and interpretation activities. These partners play an important role in helping the Service achieve its mission and the Refuge's goals. The Service will continue to rely on these and other partners in the future to help implement this CCP and to provide input for future CCP updates. In addition, the Service will continue to explore other potential avenues for partnerships and assistance in the monitoring and restoration of the Refuge.

Forster's tern chick at USGS banding site
Judy Irving © Pelican Media

6.8. Adaptive Management

Adaptive management is the process of implementing policy decisions as scientifically driven experiments that test predictions and assumptions about management plans, and using the resulting information to improve the plans. Adaptive management provides the framework within which biological measures and public use can be evaluated by comparing the results of management to results expected from objectives. Management direction is periodically evaluated within a system that applies several options, monitors the objectives, and adapts original strategies to reach desired objectives. Habitat, wildlife, and visitor service management techniques and specific objectives would be regularly evaluated as results of a monitoring program and other new technology and information become available. These periodic evaluations would be used over time to adapt management objectives and strategies to better achieve management goals. Such a system embraces uncertainty and provides new information for future decision making while allowing resource use. The management scenario proposed in this CCP provides for ongoing adaptive management of the Refuge. The CCP may be amended as necessary at any time in keeping with the adaptive management strategy. For example, actions

considered in the other CCP alternatives may be implemented given changing environmental conditions or funding sources. Any major changes to the CCP may require additional NEPA documentation and public involvement processes.

6.9. Plan Amendment and Revision

The CCP is intended to evolve as the Refuge changes, and the 1997 Improvement Act specifically requires that CCPs be formally revised and updated at least every 15 years. The formal revision process would follow the same steps as the CCP creation process. In the meantime, the Service would be reviewing and updating this CCP periodically based on the results of the adaptive management program. While preparing annual work plans and updating the Refuge database, the Refuge staff will also review the CCP. It may also be reviewed during routine inspections or programmatic evaluations. Results of any or all of these reviews may indicate a need to modify the Plan. The goals described in this CCP would not change until they are re-evaluated as part of the formal CCP revision process. However, the objectives and strategies may be revised to better address changing circumstances or to take advantage of increased knowledge of the resources on the Refuge. It is the intent of the Service to have this CCP apply to any new lands that may be acquired. If changes are needed, the Refuge manager will determine the appropriate public involvement and associated NEPA documentation.

The intent of the CCP is for progress and/or achievement of Refuge objectives during the lifetime of this Plan. Management activities would be phased in over time, and implementation is contingent upon and subject to results of monitoring and evaluation, funding through Congressional appropriations and other sources, and staffing.