Introduction

The Project Area and the southern portion of the Tomales Bay watershed currently support many important biological, physical, and social resources that may be impacted either positively or negatively by alternatives proposed under the Giacomini Wetland Restoration Project. This chapter provides an understanding of both the general environmental setting of the Project Area and a more focused description of those specific resources that could be affected by implementation of the proposed project.

The Affected Environment description is required by NEPA (Section 1502.15) and CEQA regulations (Section 15125) to "succinctly describe" resources or impact areas that could be affected directly or indirectly by project implementation. According to CEQA regulations, this chapter must include a description of the physical environmental conditions in the vicinity of the proposed project, as they exist at the time that the Notice of Intent (NOI) and Notice of Preparation (NOP) are published or at the time environmental analysis is commenced (Section 15125). This environmental setting normally constitutes the baseline physical conditions by which the lead agencies, in this case the Park Service and SLC, determine whether an impact is significant (CEQA, Section 15125).

Knowledge of the regional setting is critical to the assessment of environmental impacts (CEQA, Section 15125). As described in Chapter 1, most of the impact areas or topics were selected through scoping based on the potential for negligible to significant or major impacts either on a temporary, short-term, or long-term basis. While NEPA is only triggered when there is a physical impact on the environment, the Council of Environmental Quality (CEQ) regulations require analysis of social and economic effects in NEPA documents where they might be affected (NPS, Director's Order 12). CEQA does not require analysis of economic or social effects, with the emphasis primarily on physical changes, however, economic or social effects of a project may be used to determine the significance of physical changes caused by the project (CEQA, Section 15131).

Scoping determined that the areas of the environment that could be affected by the proposed project are:

- Land Use,
- Geologic Resources,
- Soil Resources,
- Air Resources,
- Water Resources,
- Vegetation Resources,
- Fish and Wildlife Resources,
- Cultural Resources,
- Public Health and Safety,
- Public Services,
- Visitor and Resident Experience,
- Socioeconomic Resources, and
- Park Management and Operations.

Those impact areas or topics on which the proposed project would have no or only a very negligible effect are described in Chapter 1, but are dismissed from further analysis in this chapter and Chapter 4.

The Affected Environment chapter contains a detailed description or background information on the resource or impact topics. This information provided was gathered from numerous sources, including literature reviews, existing data, and baseline studies conducted as part of the project planning effort within the Project Area. Where applicable, resource or impact topics include a brief discussion of pertinent regulations, laws, ordinances, and policies to create a framework or context in which existing conditions and impacts can be objectively evaluated. Additional information on regulations pertaining to this project appears in Chapters 1 and 6.

Project Setting

Regional and Park Context

The Project Area is located in central California, in western Marin County, approximately 40 miles northwest of the city of San Francisco (Figure 1). It is comprised of federal lands managed by the Seashore, a unit of the national park system, and is within 50 miles of the nine-county San Francisco Bay Area, the fifth largest metropolitan area in the United States. Generally, the more developed regions of the bay area surround the bay itself, with smaller cities, towns, open space and agricultural areas in an outer ring around the urban core. Thirty-three percent (110,822 acres) of the 332,800 acres in Marin County is held as parks, open space and watershed (Marin County Community Development Agency 2004). Fifty-one percent (169,000 acres) is zoned for agricultural use. Developed lands constitute only 11 percent of the county, while 5 percent of the county currently has future development potential (Marin County Community Development Agency 2005).

Roughly 90 percent of the 250,000 residents of Marin County live in the eastern half of the county along State Highway 101.

While eastern Marin is heavily developed along the Highway 101 corridor, western Marin is primarily rural with scattered, small unincorporated towns that serve ranchers and farmers, local residents, and tourists. Roughly 90 percent of the 250,000 residents of Marin County live in the eastern half of the County along the major transportation corridor -- State Highway 101. The Seashore lies on the western perimeter of Marin County, encompassing 71,046 acres beaches, coastal cliffs and headlands, marine terraces, coastal uplands, woodlands, and forests on the Point Reyes Peninsula. The north district of GGNRA adds another approximately 20,000 acres of federally protected lands. Together, these lands account 86 miles of shoreline on both the Pacific Ocean and Tomales Bay.

The Seashore is bounded to the north, west and southwest by the Pacific Ocean and to the east by the residential communities of Inverness, Inverness Park, Point Reyes Station, Olema, and Dogtown. The town of Bolinas is south of the Seashore at the southern tip of the Peninsula. To the east, the Seashore is bounded by Tomales Bay, most of which falls under Park Service ownership and/or oversight. An estimated 11.000 people live in 11 towns and villages in the Tomales Bay watershed (TBWC 2003). The census population figure does not count the many part-time residents who maintain second homes in west Marin.

East of the Seashore and GGNRA, land use is a mix of private residential and agricultural lands, publicly held watershed, and parks and open space. Adjacent to the park are areas managed by Audubon Canyon Ranch, Marin Municipal Water District, Tomales Bay and Samuel P. Taylor State Parks, and Marin County Open Space District lands. Marine boundaries are shared with the Gulf of the Farallones and the Cordell Banks National Marine Sanctuaries and Tomales Bay State Park. Some agricultural parcels have conservation easements deeded to the Marin Agricultural Land Trust, in which the owners have released development rights to protect rural agriculture from development pressures.

Park and Project Area History

The original inhabitants of the Point Reyes area were the Coast Miwok Indians. The Coast Miwok subsisted as hunters and gatherers, relying on the area's plentiful natural resources such as game, birds, fish, shellfish, nuts, fruits, and vegetables for subsistence ((Livingston 1999; Marin County Community Development Agency 2001). Most experts believe that Point Reyes is the site of the first recorded English-Native American contact in North America. Sir Francis Drake may have landed here in 1579 to careen his ship before sailing across the Pacific on a circumnavigation of the globe. He and his crew are believed to have spent five weeks on the coast, repairing his damaged ship and making contact with the Coast Miwok (Kroeber 1953). Sixteen years later in 1595, the first recorded shipwreck on the West Coast occurred when the Spanish galleon San Augustin was wrecked in what is now Drakes Bay. Since then, Point Reyes became a draw from many other sailors/explorers, some of whom lost their ships off the coast. It was Spanish sailor/explorer Sebastian Vizcaino who named this area Point Reyes (Punta de los Reyes) in 1602. In 1793, a Spanish lieutenant traveled through the Olema Valley and, after noting "a wonderment of various settlements along the [Tomales] Bay shore," recommended the Olema-Point Reyes Station area as a fine location for a mission or

establishment (Livingston 1999 *in* Marin County Community Development Agency 2001). While a mission was never established at Point Reyes Station, land grants in the Point Reyes Peninsula and surrounding lands were established during the Mexican period. Point Reyes Station was located within the southwestern corner of the vast Rancho Nicasio land grant, which was granted by the Mexican governor in 1845 to Pablo de la Guerra and Juan Cooper (Livingston 1999 *in* Marin County Community Development Agency 2001). Settlement by Mexicans and, later, Americans displaced the Coast Miwok from their homes and led to drastic reductions in the number of these people through violence and disease (Cook 1976).

Most of the Mexican land grants followed a tumultuous series of ownership changes following the Mexican-American war. The Point Reyes Station portion of the Rancho Nicasio land grant eventually passed to James Black in 1851, who owned these lands for more than a century (Livingston 1999 *in* Marin County Community Development Agency 2001). In 1873, Marin County sheriff James Stocker rented the "rolling hills and level mesa of land" at Point Reyes Station from the Black-Burdell family for establishment of a dairy ranch (Livingston 1999 *in* Marin County Community Development Agency 2001). Vedanta near Bear Valley became the center of various dairies during the late 1800s, with Bear Valley Creek running through the dairy yard. Bear Valley Creek and Olema Marsh areas were a part of historic W Ranch. Fields around Bear Valley and Olema were cleared of brush in the 1860's and heavily grazed. Some fields in Olema and Bear Valleys were used for silage.

In the late 1800s, the Point Reyes region became known throughout California as a premiere dairy and beef cattle ranching region, with its cream and butter products commanding top dollar in San Francisco. As one writer noted, "the product of Point Reyes can be summed up in one word – butter" (Munro-Fraser 1880; Garcia and Associates 2004). Most of the ranches in the Point Reyes area specialized in dairying, cheese and butter production, although some moved into beef cattle ranching and artichoke farming. While people from many countries immigrated to California, the Italian-Swiss and Portuguese immigrants were particular numerous and eventually moved into dairying on the California coastline (Raup 1951). Roads were needed to connect the ranches with outside markets. The original road from Olema, which was the main town at that time, to the Point Reyes Peninsula was later replaced in 1875 with a road that follows the current Bear Valley Road - Sir Francis Drake Boulevard path (Livingston 1994). During the late 1800s-early 1900s, the lower portion of the Bear Valley Creek watershed was leveed by construction of a road berm across the mouth of Bear Valley Creek for Levee Road near its confluence with Lagunitas Creek.

The other industry that boomed in the area during the late 1800s was logging of the Inverness and Bolinas Ridges adjoining Tomales Bay. Until the 1880s, 100-ton steamships navigated Lagunitas Creek -- formerly known as Papermill Creek – on high tides to the old paper mill located near the existing Green Bridge (PWA et al. 1993). In 1874, the North Pacific Coast Railroad constructed tracks through Point Reyes Station, connecting Sausalito to the Russian River area north of Marin County, where timber and butter could be transported to market (Livingston 1999 *in* Marin County Community Development Agency 2001). While logging activities in the Point Reyes area increased exponentially during the late 1800s, removal of trees for lumber was limited in the Bear Valley Creek watershed and restricted largely to that needed by the ranch itself.

Construction of the railroad and growth of the local dairy industry proved the impetus for the birth of the town of Point Reyes Station around 1875 (Livingston 1999 *in* Marin County Community Development Agency 2001). Hotels, saloons, schools, churches, and stores were quickly built to accommodate train passengers and visitors to the town. Even the devastating 1906 San Francisco Earthquake – the epicenter of which was once believed to be Olema, but is now thought by the USGS to be offshore of the Golden Gate Bridge -- did not derail this period of prosperity, with merchants rebuilding stores destroyed in the earthquake with even more grandiose structures (Livingston 1999 *in* Marin County Community Development Agency 2001). The existing Giacomini Dairy Facility property on the Point Reyes Mesa underwent several ownership changes during the late 1800s and early 1900s, including ownership stints by the Burdell and Wilson families (Garcia and Associates 2004). In 1917, the Filippini family established a small 50-cow dairy at the location of the existing Giacomini Ranch Dairy Facility (Livingston 1999 *in* Marin County Community Development Agency 2001).

However, as quickly as the town's fortunes waxed following construction of the railroad and growth of the dairy industry, its fortunes waned following closure of the railroad in 1933 and the onset of the Great Depression (Livingston 1999 *in* Marin County Community Development Agency 2001). At the end of World War II, the Giacomini family assumed ownership of the Filippini Dairy and leveed approximately 550 acres of marshland for use as pastures (Livingston 1999 *in* Marin County Community Development Agency 2001).

Many of the community's original businesses folded in the 1950s, only to be replaced with a slightly different type of commercial enterprise when the Seashore was established in 1962 (Livingston 1999 *in* Marin County Community Development Agency 2001). These new businesses catered to more of a tourist economy and included small shops such as a book store, natural foods store, restaurants, and bakeries.

The Seashore's enabling legislation not only protects coastal and natural resources, but allows for preservation of the pastoral landscape created by more than 100 years of dairying and beef cattle ranching.

Point Reyes had been the object of land protection efforts since the first park feasibility study was authorized in the 1930s. As pressure to develop lands along the Marin coast increased, so did the momentum to protect it. Within the Drakes Estero watershed, large tracts of agricultural lands had been sold to developers and were already being subdivided and developed with approximately 12 houses constructed at Limantour Beach. It was this development pressure that encouraged Congress to push forward with legislation in the early 1960s to protect the coastal resources unique to the Point Reyes peninsula. Although ownership of ranches on the Point Reyes Peninsula transferred to the Park Service, many of the ranch families remained on the land through long-term leases. The Seashore's enabling legislation not only protects coastal and natural resources, but allows for preservation of the pastoral landscape created by more than 100 years of dairying and beef cattle ranching. Almost 10 years later, the GGNRA was established directly adjacent to the Seashore. The eastern portion of the Tomales Bay shoreline and portions of the Olema Valley, including many agricultural operations such as the Giacomini Ranch, were eventually incorporated into the GGNRA when its boundaries were expanded in the 1980s. Since then, a few of these ranchers, including the Martinelli and Giacomini families, have sold their ranches to the Park Service for inclusion in the GGNRA.

Regional and Project Area Climate

The central and southern regions of California are classified as having a Mediterranean climate, generally characterized by wet winters and dry summers. Within these regions of California, however, there is considerable variation in temperature and precipitation, from the extremely hot, dry summers in Death Valley (lowest point in the continental United States) to the foggy, cool summers on California's central coast. The climate along California's central coast is strongly influenced by its marine environment, which tends to moderate temperature extremes through a semi-permanent high-pressure system that is centered over the northeastern Pacific Ocean. Temperatures do not vary much over the year in this region, ranging from the high 50s in the winter to the low 60s in the summer (BAAQMD 2003).

During the winter and spring, the Pacific high-pressure system weakens and moves south, allowing storm systems to move through the region, usually providing copious amounts of precipitation in series of discrete storms. The west Marin coastline receives an average of 38.2 inches of rain annually. This amount is higher than much of the San Francisco Bay area due to the somewhat more elevated terrain along the coast. Most annual rainfall in Marin County occurs from November through March. In the winter, proximity to the ocean keeps the coastal regions relatively warm (BAAQMD 2003). In the summer, the relatively northern location of the strong high-pressure system results in clear skies and hot temperatures further inland and fog and cooler temperatures along the coast. Very little precipitation occurs during the summer months, because storm systems are blocked by the high-pressure system. In the summer months, the marine air is cooled as it passes over the offshore upwelling region and forms a fog layer along the coast (BAAQMD 2003). Beginning in the fall, high pressure forming over the warmer inland areas breaks the summer pattern, introducing warm, dry winds from the northeast and east. The warmest months are September and October, with daily high temperatures averaging approximately 65 to 69 degrees Fahrenheit (BAAQMD 2003).

In the vicinity of the Project Area, average temperatures (°F) during the summer vary from the high 40s to the low-to-middle 70s. During the winter, average temperatures (°F) vary from the mid-to-upper 30s to the upper 50s-low 60s. Approximately 84 percent of the precipitation occurs during November through March, generally in association with storm systems that move through the region. Winter precipitation averages 39.57 inches, slightly higher than the 38.2 inches recorded for west Marin County region. Within the Tomales Bay watershed, approximately 60 percent of the rainfall is lost to evapotranspiration; 6 percent is removed for

use outside the watershed, and the remainder flows into Tomales Bay (Smith and Hollibaugh 1998). Summer precipitation is low, averaging less than 0.2 inches per month because of the Pacific high-pressure system.

In addition to intrannual variability in precipitation, coastal California is subject to extremely wet or extremely dry periods of one or more years driven by long-term climatic trends that affect annual precipitation. El Nino climatic cycles usually produce extremely wet winters, while La Nina ones produce extremely dry winters and can result in drought conditions.

Land Use and Planning

General Land Use and Planning

While conservationists halted large-scale development plans in West Marin in the 1960s, helping to create the National Seashore in the process, the region continues to struggle with land use issues into the new century. Since the 1800s, west Marin has supported dairy and beef cattle ranches and was once identified as one of the leading dairy regions in California. Changing market dynamics have threatened the ranching way of life in this rural enclave of the San Francisco Bay region. A number of family farms have closed in recent decades to the economic pressures of competing with the large-scale agricultural operations in California's Central Valley. In addition, the strong housing market in Marin and elsewhere in the San Francisco Bay area continues to place pressure on undeveloped areas within the county. As with many other rural areas in California, local communities continue to grapple with the issue of improving local economic viability with maintaining rural character and small town environments.

While conservationists halted large-scale development plans in West Marin in the 1960s, helping to create the National Seashore in the process, the region continues to struggle with land use issues into the new century.

Tomales Bay and the Point Reyes region falls within a complex, multi-jurisdictional region, with lands held by a variety of private and public entities, including County, local water districts, state agencies (State Land Commission, state parks, Wildlife Conservation Board, CalTrans), and federal agencies such as the Park Service and the U.S. Coast Guard. Thirty-three percent (110.822 acres) of the 332,800 acres in Marin County is held as parks, open space, and watershed (Marin County Community Development Agency 2005). Fifty-one percent (169,000 acres) is zoned for agricultural use (Marin County Community Development Agency 2005). Developed lands constitute only 11 percent of the county, while 5 percent of the county has future development potential (Marin County Community Development Agency 2005). The complexity is increased by the existence of land use plans and objectives established by non-landowners such as local towns or communities and regulatory agencies such as the California Coastal Commission that oversees implementation of the California Coastal Act through the Local Coastal Program or LCPs.

Several agencies and organizations have established land use plans or guidance for development within the unincorporated portion of Marin County. These land use plans or guidance documents include the Point Reyes Station Community Plan, the Marin County Local Coastal Program Unit II, the Marin Countywide Plan, and the Marin County Zoning Ordinance. On federal park lands, actions are guided by the park's General Management Plan (GMP). The Seashore is currently in the process of revising the GMP for the Seashore and the north district of the GGNRA, which it manages. There are no tribal land use plans within the Project Area or immediate vicinity.

The California Government Code requires each local planning agency, such as the County of Marin, to adopt a comprehensive, long-term general plan for the physical development of the area over which it has jurisdiction. Local planning agencies may elect to prepare community plans, based on public participation and specific local conditions and goals, for individual communities within the general plan boundaries. Future planning decisions can then be based both on the general and the community-specific plan. In the Coastal Zone of California, LCPs supersede all local land use planning and take precedence over all other local policies and zoning. The Project Area falls within the Marin County LCP Unit II.

On federal lands, projects are guided both by the LCP (Marin County Comprehensive Planning Department 1981) – as federal agencies must be consistent with the policies of the Coastal Act – and the GMP. In general, there should agreement between these two plans, although the GMP is, by definition, more limited to scope to just federal parklands and is more general in nature than the LCP (Marin County Comprehensive Planning Department 1981).

Park Management and Zoning

Through a memorandum of agreement between the two national parks, the Seashore manages the 19,265 acres of Bolinas Ridge and portions of Olema Valley and Tomales Bay for GGNRA, including the Giacomini Ranch. The boundaries of the two parks extend on both sides of Tomales Bay, with the Seashore's boundary extending from the Point Reyes Peninsula into subtidal lands on the west side of Tomales Bay and GGNRA's boundary covering the eastern side of Tomales Bay. These incorporated lands include both lands owned by the Park Service, as well as lands that are in private, county, or state ownership. In addition, the Seashore has a 50-year lease on most of Tomales Bay's subtidal lands from SLC to create a more seamless management boundary of the Bay's aquatic resources.

The Seashore and GGNRA currently share a General Management Plan (NPS 1980), which uses three zoning designations to guide park management -- Natural Resource Zone, Historic Resource Zone, and Special Use Zone. The Natural Resource Zone covers pastoral lands, natural landscape areas, sensitive resources, designated wilderness and marine reserves. Historic ranches, the Point Reyes lighthouse, and the lifesaving station are included in the Historic Resource Zone: more information on the Historic Resource Zone can be found under the Cultural Resources section. A third zone called Special Use Zone exists within the boundaries of the Seashore and GGNRA, but these lands are managed by another entity such as Mt. Tamalpais State Park and Audubon Canyon Ranch.

The Natural Resource Zone contains two management zones that are pertinent to the Giacomini project – the Pastoral Landscape Management Zone and Special Protection Zone. Approximately 19,000 acres of the northern Point Reyes Peninsula of the Seashore have been retained in agricultural production within the pastoral zone that supports beef and dairy production. The north district GGNRA in northern Olema Valley contains an additional 10,500 acres leased for cattle grazing. These lands constitute the Pastoral Landscape Management Zone. Pastoral operations presently include six dairies and nine beef cattle ranches. The current GMP indicates that, at a minimum, agricultural buildings and open grasslands will be retained in these areas, and, where feasible, livestock grazing will continue within the limits of carefully monitored range capacities (NPS 1980). This plan acknowledged, however, that future resource management studies could significantly alter the configuration of this zone.

The Special Protection Zone incorporates lands that have received legislative or special administrative recognition of exceptional natural qualities requiring strict protection measures. It includes the Philip Burton Wilderness Area, Gulf of the Farallones National Marine Sanctuary, State of California Marine Reserves, shorelines, and riparian corridors. The boundary for the Farallones National Marine Sanctuary extends into the southern portion of Tomales Bay.

Marin Countywide Plan

California State law requires that all cities and counties prepare and adopt general plans. These plans must be comprehensive, long-range and internally consistent. Every plan must address seven specific topics, or "elements". The County of Marin is currently in the process of updating the Marin Countywide Plan (CWP; Marin County Community Development Agency 2005). The draft EIR was initially released in August 2005 and has been subsequently revised. The purpose of the Plan Update is to set policy guidelines for future conservation and development in the county and to address changed conditions since the last revision of the CWP (Marin County Community Development Agency 1994).

Planning Policies: Point Reyes, including the Project Area, is located in an unincorporated area of the county. The CWP establishes an overall framework and set of goals for countywide development in unincorporated areas. The draft 2005 CWP update also includes implementing program concepts for updating the 2003 Development Code. Included in updated CWP are the seven mandatory General Plan Elements required by the State Planning and Zoning Laws (e.g., Conservation, Land Use, Circulation, Noise, and

Safety), as well as five optional elements that were included in the 1994 CWP (Agriculture, Community Facilities, Parks and Recreation, Trails, and Economic). Many unincorporated communities areas of Marin are guided by community plans that provide specific direction regarding land use, transportation, community facilities, building design, and environmental quality, as well as issues unique to a particular community (CWP 2005). The town of Point Reyes Station has developed the Point Reyes Station Community Plan, which was last revised in 2000 (see description below).

The draft CWP (2005) includes goals, policies, and specific implementation objectives for topics included under each of the required and optional elements. Some of the most pertinent policies or implementation objectives are summarized briefly below.

- Lands of *GGNRA* should be retained in natural state to the greatest extent possible.
- *Protect Open Lands in the Coastal Recreational Corridor* to preserve the rural character, agriculture, and open lands, and protect existing communities and recreational opportunities in the Coastal Corridor.
- *Maintain Village Character in West Marin* through establishment of Community Plans.
- *Restore and Enhance Watersheds*.
- *Promote Natural Stream Channel Function*, including protection and enhancement of fish habitat.
- *Protect Wetlands, Essential Habitat for Special-Status Species, Sensitive Natural Communities, and Important Habitat Wildlife Nursery Areas and Movement Corridors*.
- *Preserve Ecotones* to ensure that "ecotones," or natural transitions between habitat types, are preserved and enhanced because of their importance to wildlife.
- *Limit Access to Wetlands* to avoid or minimize disturbance to wetlands, necessary buffer areas, and associated important wildlife habitat while facilitating public use, enjoyment, and appreciation of bayfront lands.
- *Protect people and property* from risks associated with flooding and inundation.
- *Keep West Marin Rural* by limiting West Marin roads to two lanes, and work with State and federal agencies and local communities to enhance road safety, improve pedestrian, bicycle and transit access through means such as creating an East/West Greenway along the railroad right-of-way.
- *Promote Transportation Alternatives* by working with local, state, and federal governments, businesses, schools, seniors, and environmental groups to encourage use of transit, vanpools, carpools, car sharing, bicycles, and walking for commuting.

Land Use: The Draft 2005 CWP Update retains the "corridor" concept of the 1994 CWP, dividing the County into designated regional units based on specific geographic and environmental characteristics and natural boundaries formed by north/south trending geomorphic ridges. The Project Area falls within the Coastal Corridor. The Coastal Corridor, adjacent to the Pacific Ocean, is designated for federal parklands, recreational uses, agriculture, and the preservation of existing small coastal communities. In addition to the four environmental corridors, there are seven planning areas that define Marin County. One of the planning areas covers both the Coastal and Inland Rural Corridors of West Marin. The West Marin planning area generally consists of open space and agricultural lands and small villages located west of the City Centered Corridor from Fort Cronkite Baker in the south to the Sonoma County line in the north and includes GGNRA, the Seashore, Point Reyes Station, and the Project Area.

Within the West Marin planning area, the Giacomini Ranch is currently designated C-AG1, which is Coastal Agricultural with one unit allowed per 31-60 acres (Figure 18). Olema Marsh is designated C-OS for Coastal Open Space (Figure 18). In general, the Giacomini Ranch is agricultural land that is almost entirely bounded by residential, commercial, and open space lands. The nearest agricultural operations would be the Martinelli Ranch north of the East Pasture, which is operated under lease by GGNRA, and the Genazzi Ranch, which is southwest of the Green Bridge and south of State Route 1. Surrounding lands to the east of the Giacomini Ranch are a mixture of land use designations summarized as follows (Figure 18):

- *C-OS* (Coastal Open Space): Martinelli Ranch parcel of GGNRA; Green Bridge County Park; White House Pool County Park.
- *C-AG3* (Coastal Agricultural with one unit allowed per 1-9 acres): Residential neighborhoods on Point Reyes Mesa; House on west side of Olema Marsh and east of Bear Valley Road.
- *C-MF3* (Coastal Multi-Family with five to 10 units allowed per acre): Residential neighborhood directly north of Giacomini Dairy;
- *C-SF5* (Coastal Single Family with 2-4 units allowed per acre): Residential and commercial neighborhood near and along 3rd and C Streets in Point Reyes Station;
- *C-RS* (Coastal Residential Commercial): Residential and commercial neighborhood near intersection of State Route 1 and Levee Road at Green Bridge;
- *C-SF4* (Coastal Single Family with one to two units allowed per acre): Residential neighborhood on north side of Levee Road.
- *C-SF3* (Coastal Single Family with one unit allowed per 1-5 acres): Residential neighborhood on west side of Sir Francis Drake Boulevard north of Bear Valley Road throughout Inverness Park; the Lucchesi and Kostelic residences; and a portion of the undeveloped West Pasture between the Gradjanski and Lucchesi/Kostelic residences.
- *C-GC* (Coastal General Commercial with Floor to Area Ratio of 0.05 to 0.30): Perry's Deli and adjacent stores and Gradjanski residence in Inverness Park.

Marin County Zoning Ordinance

The County regulates activities by state and local agencies through ordinances, codes, and other measures. The zoning code (Marin County Code Title 22) establishes development regulations that are based on land use designations for different areas established in the CWP. Within each zoning district, specific regulations are established for permitted and conditional land uses and for maximum density and building height.

The Giacomini Ranch lowlands in the East and West Pastures are zoned Coastal Agricultural Production Zone, with 1 housing unit per 60 acres (Figure 19). The portion of Olema Marsh owned by Audubon Canyon Ranch is zoned Open Area, while the portion owned by the Seashore is zoned Agricultural, Residential, Planned (Figure 19). The portion of the dairy facility fronting C Street is zoned Coastal Residential, Agricultural, 10,000-square-foot minimum lot size (Figure 19). The upland area near Mesa Road and the Giacomini Hunt Lodge is zoned Coastal Residential, Agricultural, with 1 housing unit per acre (Figure 19).

Zoning of surrounding lands is a mixture of zoning districts, similar to the land use designations. These are summarized as follows (Figure 19):

- *C-O-A* (Coastal Open Area): Martinelli Ranch parcel of GGNRA; Green Bridge County Park; White House Pool County Park.
- *C-ARP-1* (Coastal Agricultural, Residential, Planned, 1 unit per acre): Residential neighborhood on Point Reyes Mesa;
- *C-RMP-6.5* (Coastal Residential Multiple Planned, 6.5 units per acre): Residential neighborhood directly north of Giacomini Dairy;
- *C-R-A:B-2* (Coastal Residential, Agricultural 10,000 square foot minimum lot size): Residential and commercial neighborhood near and along 3rd and C Streets in Point Reyes Station;

FIGURE 18. COUNTY LAND USE DESIGNATIONS

FIGURE 19. COUNTY ZONIN

- *C-VCR:B-2* (Coastal Village Commercial Residential 10,000 square foot minimum lot size): Residential and commercial neighborhood near intersection of State Route 1 and Levee Road at Green Bridge;
- *C-R-A:B-3* (Coastal Residential, Agricultural 20,000 square foot minimum lot size): Residential neighborhood on north side of Levee Road.
- *C-ARP-5* (Coastal Agricultural, Residential, Planned, 1 unit per 5 acres): House on west side of Olema Marsh and east of Bear Valley Road.
- *C-RSP* (Coastal Residential Single Family Planned): West side of Sir Francis Drake Boulevard north of Bear Valley Road throughout Inverness Park and a portion of the West Pasture between the Gradjanski and Lucchesi/Kostelic residences, including the Lucchesi and Kostelic residences.
- *C-GC* (Coastal Commercial Planned): Perry's Deli and adjacent stores and Gradjanski residence in Inverness Park.

Marin County Local Coast Program Unit II

In 1976, the California Legislature enacted the Coastal Act, which created a mandate for coastal counties to manage the conservation and development of coastal resources through a comprehensive planning and regulatory program called the LCP. The LCP is a planning document that identifies the location, type, densities, and other ground rules for future development in the coastal zone. Each LCP includes a land use plan and its implementing measures. These programs govern decisions that determine the short and long term conservation and use of coastal resources. LCPs are designed to be updated regularly: The Marin County Community Development Agency was planning to update the LCP (Marin County Comprehensive Planning Department 1981) as part of the updated CWP process, but has postponed the LCP update.

Marin County's Local Coastal Program is divided into two units: Unit I and Unit II. Unit II was certified in 1981 and includes the communities of Olema, Point Reyes Station, Inverness, Dillon Beach and Oceana Marin, Marshall, and Tomales. The primary goals of the LCP are to ensure that the local government's land use plans, zoning ordinances, zoning district maps, and implemented actions meet the requirements of -- and implement the provisions and polices of -- the Coastal Act at the local level.

Generally, the Coastal Act requires protection, enhancement, and restoration of environmentally sensitive habitats (including wetlands and riparian habitat); protection and expansion of public access to the shoreline and recreational opportunities and resources; protection of the scenic coastal landscape; and protection of productive agricultural lands. The LCP (Marin County Comprehensive Planning Department 1981) has grouped its policies under four major headings: Public Access and Recreation, Resource Protection (including Natural and Agricultural), Tomales Bay Uses, and Public Services and New Development.

As noted earlier, where there are overlapping policies, the LCP policies supersede those of the County and other organizations in the Coastal Zone. Because the LCP (Marin County Comprehensive Planning Department 1981) is the primary planning document guiding development in the region where the Project Area is located, specific policies that potentially pertain to the proposed project are outlined below:

Resource Protection-Natural Resources

- *Natural Resources on Federal Parklands*: Federal projects involving the modification or alteration of natural resources should be evaluated by the Coastal Commission through the federal consistency review process.
- *Water quality*. The County encourages the Regional Water Quality Control Board, State Department of Health, and other responsible agencies to continue working on identifying sources of pollution in Tomales Bay and to take steps to eliminate them.
- *Stream alterations*. Stream impoundments, diversions, channelizations, or other substantial alterations shall be limited to those for (1) necessary water supply projects, (2) flood control projects where no other feasible method is available, and (3) developments where the primary function is the improvement of fish and wildlife habitat.
- *Stream Buffers*. Buffers to protect streams from the impacts of adjacent uses shall be established for each stream in Unit II. The stream buffer shall include the area covered by riparian vegetation on both

sides of the stream and the area 50 feet landward from the on edge of the riparian vegetation. In no case shall the stream buffer be less than 100 feet in width, on either side of the stream, as measured from the top of the stream banks.

- *Development in Stream Buffers*. No construction, alteration of land forms or vegetation shall be permitted within such riparian protection area. Additionally, the stream buffer will extend a minimum of 50 feet from the outer edge of riparian vegetation, but no less than 100 feet from the banks of a stream.
- *Wetlands*. Wetlands in the Unit II coastal zone shall be preserved and maintained as productive wildlife habitats, recreational open space, and water filtering and storage areas. Allowable resource-dependent activities in wetlands shall include fishing, recreational clamming, hiking, hunting, nature study, bird-watching and boating. No grazing or other agricultural uses shall be permitted in wetlands except in those reclaimed areas presently used for such activities. A buffer strip 100 feet in width, minimum, as measured landward from the edge of the wetland, shall be established along the periphery of all wetlands.
- *Other Environmentally Sensitive Habitats*. Other sensitive habitats include habitats of rare or endangered species and unique plant communities. Development in such areas may only be permitted when it depends upon the resources of the habitat area.

Public Access and Recreation

- *General Policy*: The County of Marin supports and encourages the enhancement of public recreational opportunities and the development of visitor-serving facilities in its coastal zone. Such development must, however, be undertaken in a manner which preserves the unique qualities of Marin's coast and which is consistent with the protection of natural resources and agriculture. Generally, recreational uses shall be of low-intensity such as hiking, camping, and fishing in keeping with character of the existing uses in the coastal zone.
- *Policy on Public Access in Federal Parklands*: Additional coastal access trails and bike paths should be provided where feasible and where consistent with the protection of the parks' natural resources.
- *Bluff-Top Development*: Setbacks from the bluff above the old railroad right-of-way in the Giacomini Ranch's East Pasture shall also be required, consistent with LCP policies on bluff-top development.
- *Bike Paths*: The County supports the concept of a bike/pedestrian trail network in Unit II, connecting the villages and providing access to public parks. Several proposed routes have been discussed by West Marin residents and planning groups, but no final recommendation has been developed. In the absence of such a recommendation, the LCP (Marin County Comprehensive Planning Department 1981) assumes that the most likely location for a bike trail is along Highway 1 and Sir Francis Drake Boulevard. Therefore, to maintain the option for a roadside trail, 10-foot easements will be required for all development projects on either side of these roads. When a final route is agreed upon by the County, community, and concerned agencies and organizations, requirements for roadside easements will be modified to account for the new route.

Public Services and New Development

- *Transportation and Road Capacity*: Sir Francis Drake Boulevard provides a scenic driving experience for coastal visitors and an important access road for local residents. In order to protect its scenic rural character, the road shall be maintained as a two-lane roadway. Sir Francis Drake has adequate capacity to handle increased recreational and local traffic, although traffic patterns do occasionally create hazardous conditions for pedestrians and bicyclists in the areas of Inverness and Inverness Park.
- *Alternative Transportation*: The County strongly encourages the development of alternative modes of transportation, such as bicycle and pedestrian paths that are separated from the road, where possible.
- *Grading*: Any projects involving the movement of earth in excess of 150 cubic yards must adhere to LCP policies concerning minimization of earth movement, construction windows, erosion control and revegetation, and minimization of impervious surfaces.

Point Reyes Station Community Plan

As discussed earlier, the state requires each local planning agency such as the County of Marin to adopt a comprehensive, long-term plan for physical development of the region over which it has jurisdiction. Local planning agencies can decide to create separate community plans for individual communities within the general plan boundaries. In these areas, future planning decisions are based on both the general plan and the community-specific plan. The Point Reyes Station Community Plan was first developed in 1976 to provide guidance on current and foreseeable planning and land use issues based on community goals, objectives, and policies. It was later amended in 1986. Starting in 1999, the plan was revised again and was finalized in 2000. As noted earlier, the LCP takes precedence over all local policies and zoning, so the community plan must be consistent with the LCP (Marin County Comprehensive Planning Department 1981) to be valid (Marin County Community Development Agency 2001).

The plan establishes objectives and policies and programs for supporting or implementing objectives on a number of land use, socioeconomic, agricultural, and natural resource issues.

Natural Resources

- *Support for restoration of the former tidal marshes at the headwaters of Tomales Bay* to natural conditions and protection of the restored wetland in the future through review of development projects or construction activities in consultation with the Park Service and other relevant public agencies and incorporation of either impact avoidance or mitigation measures;
- *Preservation of the physical, ecological, and visual integrity of the bluff area located above the old railroad right-of-way* through the development review process establishment of a 100-foot buffer zone extended eastward from the eastern edge of the railroad grade;
- *Preservation of streams and streamside environments in their natural conditions*, including protection of existing riparian habitat or “buffers” and removal of invasive plant species;
- *Protection and restoration of Tomasini Creek* through allowing the downstream portion to resume its natural slough channel west of Mesa Road, thereby promoting recolonization by steelhead trout; and
- *Protection of Lagunitas Creek, specifically its water quality, coho salmon and steelhead populations, and other aquatic life*.

General Land Use

- *Zoning:* Proposed projects should not conflict with land-use related policies of Marin CWP, including land use designation or zoning standards.
- *Substantial Alteration in Character of Town*: There should not result in substantial alteration of the character or functioning of the community or present or planned future use of an area.
- *Increase in Recreational Demand*: Demand for neighborhood or regional parks or other recreational facilities should not be substantially increased.
- *Increase Density:* Proposed projects should not increase density that would exceed the official population projections for the planning area within which the Project Area is located as set forth in either the CWP or Community Plan.
- *Induce Substantial Growth*: Substantial growth should not be induced in an area either directly or indirectly (e.g., through projects in an undeveloped area or extension of major infrastructure).

Agricultural Land Use

Regulatory and Policy Setting

The federal Farmland Protection Policy Act (FPPA) is intended to minimize the impact Federal programs have on the unnecessary and irreversible conversion of farmland to nonagricultural uses. It assures that -- to the

extent possible -- federal programs are administered to be compatible with state, local units of government, and private programs and policies to protect farmland. Projects are subject to FPPA requirements if they may irreversibly convert farmland (directly or indirectly) to nonagricultural use and are completed by a Federal agency or with assistance from a Federal agency. For the purpose of FPPA, farmland includes prime farmland, unique farmland, and land of statewide or local importance, which is characterized primarily using soil types, as well as management regimes and other factors. Farmland subject to FPPA requirements does not have to be currently used for cropland. It can be forest land, pastureland, cropland, or other land, but not water or urban built-up land.

National Resources Conservation Service (NRCS) uses a land evaluation and site assessment (LESA) system to establish a farmland conversion impact rating score on proposed sites of federally funded and assisted projects. This score is used as an indicator for the project sponsor to consider alternative sites if the potential adverse impacts on the farmland exceed the recommended allowable level. A similar system has been developed for California by the State Department of Conservation, which oversees California's Farmland Monitoring and Mapping Program. This program was established in 1982 to assess the location, quality, and quantity of agricultural lands and conversion of these lands over time. FMMP is a nonregulatory program and provides an analysis of agricultural land use and land use changes throughout California every two years.

The California Land Conservation Act of 1965--commonly referred to as the Williamson Act--enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments which are much lower than normal because they are based upon farming and open space uses as opposed to full market value. Local governments receive an annual subvention of forgone property tax revenues from the state via the Open Space Subvention Act of 1971. The Giacomini Ranch East and West Pastures are under Williamson Act Contracts, as are some of the adjacent ranches such as the Genazzi Ranch to the south and the Martinelli Ranch, now owned by the GGNRA. Olema Marsh is not under the Williamson Act, nor are the parcels at the dairy facility in Point Reyes Station and several commercial and residentially zoned parcels that are currently or formerly owned by the Giacominis near Inverness Park.

Because of the value of agriculture to Marin's economy and its scenic pastoral landscape, the County and Coastal Zone LCP (Marin County Comprehensive Planning Department 1981) have both identified maintenance of agriculture as a high priority.

Marin CWP

- The draft Marin CWP (1994) focused on protection of open space lands in the Coastal Recreational Corridor to preserve the "rural character, agriculture, and open lands
- Encourage agriculture and mariculture in the Coastal Recreational Corridor (CWP 1994).

Marin County Local Coastal Program Unit II

- *General policy*. Marin County intends to protect the existing and future viability of agricultural lands in its coastal zone, in accordance with Sections 30241 and 30242 of the Coastal Act. The County's LCP policies are intended to permanently preserve productive agriculture and lands with the potential for agricultural use, foster agricultural development, and ensure that non-agricultural development does not conflict with the rural character of the County's coastal zone.
- *Agriculture on Federal Parklands*: The continuation of agricultural land uses in the GGNRA and the Seashore is strongly encouraged, where and at a level which is compatible with the protection of natural resources and public recreational use.
- *Agricultural Production Zone*: Only permitted or conditional uses of lands, which includes wildlife refuges, will be allowed in the Agricultural Production Zone (e.g., lands zoned A-60).
- *Conversion of Agricultural Lands*: Projects should not conflict with general policies on agriculture in the Coastal Zone, specifically on agricultural conversions (Article 5. Sections 30241, Sections 30242).

Point Reyes Station Community Plan

- *Williamson Act Contracts*: Lands with agricultural or open space contracts should be preserved, and proposed projects should not cause conflicts with existing Williamson Act contracts.
- *Effect on Agricultural Resources*: Proposed projects should not have impacts to productive agricultural soils or lands with sufficient water resources.
- *Compatibility of Adjacent Land Uses with Agriculture*: Proposed projects should not negatively affect agricultural resources by creating incompatible land uses with adjacent protected lands).
- *Agricultural Viability*: Proposed projects should not affect agricultural operations such as viability of West Marin agriculture by decreasing productivity.

Regional Agricultural Land Uses

Agriculture has been an important part of West Marin culture since the mid 19th century (University of California 2006). In the early 1820s, Marin was settled by the Mexicans or Californnios, whose home base was the San Rafael mission (University of California 2006). The Mexicans raised thousands of longhorn cattle for their hides and tallow (University of California 2006). The cattle ran wild along with herds of native tule elk and were rounded up yearly by Mexican and Miwok vaqueros. After the mission was shut down in 1834, the land and the longhorns were divided up into vast ranchos (University of California 2006).

The Gold Rush of 1849 helped start the dairy industry (University of California 2006). In the 1850s, a San Francisco law firm owned most of the Point Reyes peninsula and established several very successful tenant ranches. They not only produced dairy products, but huge crops of fruit. At that time, most dairy operations were small, 10 to 15 cows, or as many as they could milk by hand (University of California 2006). Before refrigeration, all the milk produced was churned into butter. In 1862, Marin provided a quarter of California's butter (University of California 2006) and was considered one of the state's premiere dairy producers, with products commanding top dollar. Most of the ranches in the Point Reyes area specialized in dairying, cheese and butter production, although some moved into beef cattle ranching and artichoke farming.

Agriculture has been an important part of West Marin culture since the mid 19th century.

Marin continues to support agriculture today, although its preeminence in terms of volume has waned, with the smaller West Marin agricultural operations unable to effectively compete against the extremely large operations in California's Central Valley. Animal operations, particularly dairies, produce generate the majority of agricultural revenue in Marin County (CWP, Marin County Community Development Agency 2005). In general, Marin County agriculture contributes a net surplus of $1.3 million annually to the county's general fund, and property taxes from agriculture generate another $10.3 million annually that are earmarked for other county funds, such as education (Strong Associates 2003). Local animal products include milk, beef, sheep, poultry, and eggs, with oysters, mussels, and clams being produced by the aquaculture industry (Marin County Community Development Agency 2005). Local farms also produce fruits, vegetables, wine grapes, flowers, nursery crops, wool, and hay, honey, and herbs (Marin County Community Development Agency 2005).

While most of the agricultural revenue still comes from animal operations, the number of dairies in Marin County decreased from 200 to 31 between 1950 and 2000, and the number of cattle dropped from 20,000 to 12,000 (Strong Associates 2003). Despite these decreases in ranches and cows, milk production in Marin has increased from 1.95 million pounds in 1964 to 2.25 million pounds in 2000, because of increased milk production per cow and other farming practice improvements (Strong Associates 2003). Reportedly, about 20 percent of the milk sold in the Bay Area comes from Marin dairies (Marin County Community Development Agency 2003). In addition, specialty products such as organic vegetables, grass-fed meats, olive oil, and farmstead cheese now supplement traditional farm income and have helped Marin to maintain an economic foothold in California's increasingly corporate-driven agricultural industry. Marin is considered a leader in organic agriculture, and local producers and support agencies are mounting a concerted effort to certify organic production and promote agricultural product diversification (Marin County Community Development Agency 2005).

As part of the CWP update, Marin County commissioned an agricultural economic analysis of the Marin County agricultural industry with a focus on land use. Dairies and livestock ranches still continue to cover most of the

county's agricultural land in the County, while smaller areas of row crops occupy better soils, often in valley bottoms (Marin County Community Development Agency 2005). In contrast to the findings in 1973 that the largest threat to agricultural lands came from the potential of subdivision into suburban housing, the major issue facing agricultural lands today stems from gentrification or conversion into high value estate development (Strong Associates 2003). This conversion increases the costs of land ownership disproportionately higher than income earned from agricultural operations, thereby creating an economic disincentive for continuing to farm (Strong Associates 2003).

Geologic Resources

Subsidence and uplift along the San Andreas Fault have created a mosaic of topographic landforms that promotes wetland establishment, including steep ravines, depressional "sag" ponds along the fault, broad floodplains, lagoons, and even isolated lakes.

As with other vegetation communities, wetlands are ultimately products of geology. Geology provides the framework under which all other physical and biological forces such as water, sediment, climate, plants, and animals can interact, creating a hydrologically-driven vegetation community with special importance for both humans and wildlife. Nowhere is this more evident than in the Tomales Bay watershed. Tomales Bay and coastal Marin County have both an abundance and diversity of wetland types.

Geology has contributed to this abundance and diversity in a number of ways. Subsidence and uplift along the San Andreas Fault have created a mosaic of topographic landforms that promotes wetland establishment, including steep ravines, depressional "sag" ponds along the fault, broad floodplains, lagoons, and even isolated lakes. This fault-associated topography is juxtaposed against other geologic forces such as coastal erosion processes, which has, over the millennia, created wave-cut platforms. In combination with fault-associated uplift, coastal erosional processes have continually reshaped the northern California coastline and its associated wetlands through processes such as marine terrace building. These geologic forces have also produced a diverse array of hydrologic sources for wetlands, including tidal waters and abundant groundwater seeps and springs that serve as sources or "headwaters" for many of the bay's perennial and seasonal streams and marshes.

Geology even affects the duration of hydrology. Creeks draining off the granite-dominated Inverness Ridge tend to be perennial, while those flowing off Franciscan Complex Bolinas Ridge are seasonal or even ephemeral. The strong interaction between geology and wetlands is particularly visible within the Project Area. This relationship is discussed more in subsequent sections of this Chapter, including Water Resources and Vegetation Resources.

Geologic Resources within the Region and Project Area

The nature of the Project Area has been sharply defined by this region's unique geologic history. The sheer number of fault- and coastal erosion-associated features in this region such as trenches, shutter ridge, fault sag ponds, stream offsets, marine terraces, folded shales, sea stacks, sea caves, and pillow basalt formations has created a wealth of unique geologic resources that draw both amateur and professional geologists to Point Reyes. The San Andreas Fault, responsible for the 1906 Earthquake that devastated San Francisco, runs directly through the Project Area and Tomales Bay. The San Andreas Fault is perhaps the best known fault in California, although there are more than 20-30 other faults in the San Francisco Bay region. "It is the most significant geological feature in the watershed, influencing the geology, topography and overall stability of the area" (TBWC 2003). The San Andreas Fault Zone (SAFZ) forms the active tectonic boundary between the northwestward-moving Pacific plate and the continental North American plate.

Tomales Bay is a relatively shallow estuary that has formed within the long, linear, submerged "rift" valley that has developed along the northwest-trending San Andreas Fault zone. The Bay was formed 15,000 to 5,000 years ago when it was inundated by rising sea levels from thawed ice at the close of the last ice age (Wahrhaftig and Wagner 1972)Through the millennia, tectonic uplift or subsidence associated with plate movement, combined with other influences such as glacial retreat, has shaped the northern California coastline, with oceanic influence alternately retreating or advancing into this fault-controlled valley. At one

point, what is now known as the Pacific Ocean probably extended at least as far as Point Reyes Station and probably even further inland into the Olema Valley.

Interestingly, movement along this major strike-slip fault has apparently displaced lands by as much as several hundred miles. Clark and Brabb (1997) describe similarities between Eocene and Miocene depositional sequences of the Point Reyes Peninsula and the Santa Cruz Peninsula near Monterey, California. These similarities point to displacement of the Point Reyes Peninsula along the fault by as much as 280 miles (Prentice et al. 1991; Niemi and Hall 1996). Evidence suggests that, in the past 25 million years, the Point Reyes Peninsula has been moving northward at a rate of 2 inches per year (Stoffer 2005) San Francisco's 1906 earthquake, however, caused the Peninsula to shift 12-13 inches to the north in a matter of seconds (Shuford and Timossi 1989; Evens 1993). Recent research on the San Andreas Fault has allowed researchers to document the occurrence of 10 additional large-scale land movement events in the past 2,500 years, with a recurrence interval on the order of one major event every 250 years (Zhang et al. 2003).

The movement of the Pacific and Continental Plates has produced striking differences in the geologic nature of the lands on the west and east sides of Tomales Bay.

This movement of the Pacific and Continental Plates has produced striking differences in the geologic nature of the lands on the west and east sides of Tomales Bay. The eastern portion of the Tomales Bay watershed is dominated by the Franciscan formation (U.S. Soil Conservation Service 1985). Bedrock east of the fault (generally east of State Route 1) is the Franciscan Complex that makes up much of California's Coast Range. The Franciscan Complex is believed to be a fossil accretionary wedge of sediment that used to fill the trench of a subduction zone. It is mostly composed of greywacke, sandstone and shale with different grades of metamorphosis. Some parts of the Franciscan Complex are a mélange, including highly metamorphosed, low-grade mudstone, siltstone, and sandstone with occasional inclusions of limestone, chert, serpentinite, eclogite, and amphibolite conglomerate (Galloway 1977).

Between the Bay and the Franciscan Complex hills are low-elevation coastal marine terraces that run along the eastern perimeter of Tomales Bay (Figure 20). The Point Reyes Mesa, which borders the Project Area, to the east is a marine terrace. This prehistoric wave-cut terrace consists of unconsolidated sand, clay, and gravel of marine and non-marine origin (KHE 2006a). These marine- and non-marine materials also underlay the medial or "shutter" ridge that separates the Olema Creek and Bear Valley Creek drainage to the south (KHE 2006a).

West of Tomales Bay on the steeply sloped Inverness Ridge – and within most of the Seashore – granitic rock such as quartz-diorite and granodiorite dominate, forming the backbone of the Point Reyes Peninsula (USSCS 1985; Figure 20). Salinian granite underlies nearly the entire peninsula and is exposed in the areas of Inverness Ridge, Tomales Point, and the Point Reyes Headlands. The granite is unconformably overlain by the Monterey Shale in the southern part of the peninsula which is exposed along the coastline from Drakes Bay south to Bolinas (Konigsmark 1998). Coastal wavecut benches and flooded valleys are the result of sea level fluctuations during the Pleistocene and Quaternary tectonic uplift (Scherer and Grove 2003). The Point Reyes plain, extending from Inverness Ridge west to the headlands is underlain by siltstone and mudstone of the Purisima Formation (Clark and Brabb 1997), which also occurs in the Santa Cruz Mountains.

FIGURE 20. LOCAL GEOLOGY

The Project Area itself is mapped as Quaternary-aged alluvium (KHE 2006a; Figure 20). This alluvium includes stream-borne gravel, sand, silt, and clay, as well as estuarine clay and peat ((Niemi and Hall 1996; Knudsen et al. 1999). Underlying the relatively young Quaternary alluvium that blankets the Project Area is approximately 1000 feet of older interbedded estuarine and alluvial sediments of the Olema Creek Formation (Grove et al. 1995). The closest surface outcrop of this formation is seen within the fault zone approximately 5-miles south of the Project Area. Based on composition and sedimentary structure, the Olema Creek Formation is interpreted to consist of the intermixed fluvial delta and estuary deposits, similar to the modern deposits accumulating on the Lagunitas Creek delta. Packages of fine-grained overbank and back swamp deposits with abundant carbonaceous material are also common (Grove et al. 1995). The alternations between fine- and coarse-grained deposits of this formation reflect the combined influences of subsidence along the San Andreas Fault zone and climatic variations that affect sea level (Grove et al. 1995). Knudsen et al. (1999) report that rapid changes in sediment composition consisting of "mud-over-peat contacts" are commonly associated with an abrupt relative sea-level rise that accompanies earthquake-induced subsidence.

Topographic Resources within the Region and Project Area

Lagunitas Creek Watershed

The topography within the Project Area is controlled by Inverness and Bolinas Ridge and the dominant San Andreas Fault. The Olema Valley, extending from Bolinas Lagoon to Tomales Bay, is representative of this phenomenon. The Olema Valley ranges in width from 1,500 to 7,000 feet and includes a variety of fault-associated topographic features including linear ridges and drainage patterns, parallel stream systems, offset rows of trees and fences, and a series of sag ponds. Most of the watersheds within the Olema Valley have drastically altered and unusual drainage patterns associated with the combination of stream capture and alterations to the topography caused by the strike-slip movement of the San Andreas Fault. Near their headwaters, Olema Creek and Pine Gulch Creek run parallel, but in opposite directions for nearly 2 miles. Near the head of Tomales Bay, Bear Valley Creek drains at an acute angle from Inverness Ridge (likely valley capture) and makes an abrupt turn to the north adjacent to the 1906 fault rupture, running parallel to Olema Creek until they both discharge into the Lagunitas Creek. The 120-foot medial or shutter ridge separates the two creeks (KHE 2006a).

Uplift associated with fault movement has created some relatively steep topography adjacent to the Project Area. Inverness Ridge forms the backbone of the Point Reyes Peninsula, reaching a height of 1,407 feet at Mount Wittenberg. The ridge is characterized by relatively consistent upland elevation with overly steep headwater stream systems. The only interruption in the ridge between Bolinas and Tomales Point is the 400-foot pass at Divide Meadow. Bolinas Ridge to the south of the Project Area in Olema Valley rises to approximately 800 feet in elevation. Sea level rise and retreat has created marine terraces directly east of the Project Area on the Point Reyes Mesa, with elevations ranging from 30 feet at the southern end near the Giacomini Ranch dairy facility to 80- to 100 feet above mean sea level at its northern end near Tomasini Creek (KHE 2006a).

Giacomini Ranch

Prior to 1862, a substantial amount of the Giacomini Ranch was actually open water and intertidal mudflats, with the historic coastal salt marsh concentrated in the eastern portion of the Giacomini Ranch, Olema Marsh, and the mouth of Olema Creek (PWA et al. 1993, Niemi and Hall 1996; Figure 21). This marsh complex represented a significant percentage of the existing salt marsh present at that time in Tomales Bay, with tidal influence at that time believed to extend as far south as Bear Valley during extreme storm tides (Evens 1993). However, during the latter half of the 19th century, sedimentation rates rose dramatically, resulting in rapid deltaic aggradation of coarse alluvium in the southern end of Tomales Bay (Figure 21). This increase in sedimentation probably resulted from an increase in logging and other changes in land use practices (PWA et al. 1993, Niemi and Hall 1996), but was undoubtedly exacerbated by the geologic instability characteristic of this region. It has been estimated that, between 1860 and 1950, approximately 5 vertical feet of sediment deposited within southern Tomales Bay (PWA et al. 1993). Acreage of wetlands within Tomales Bay almost doubled between 1863 and 2001 to 944.2 acres (Parsons et al. 2004), and the Lagunitas Creek delta more than doubled in acreage and length during this period, with the tip of the delta extending approximately

another 2,100 feet beyond its 1863 boundaries by 2001. The greatest sedimentation occurred between 1860 and 1910 (PWA et al. 1993; Figure 21).

Surface rupture in Olema, 1906

The 1906 earthquake may have subsequently "drowned" some of this deltaic aggradation. The surface rupture caused by the 1906 earthquake extended from Bolinas Lagoon to Tomales Bay, with lateral displacement ranging from 14 to 20 feet in the Olema Valley (Gilbert 1908)Levee Road reportedly was offset 20 feet over a zone of faulted ground that was 50 to 60 feet wide. In addition, the roadway embankment within the fault zone reportedly settled as much as 3.5 feet. The surface rupture of the earthquake extended across the Project Area and reportedly was marked by an approximately 50-foot-wide, 18-inch-deep depression in the tidal marshes along the northeast side of the fault (Lawson 1908; Youd and Hoose 1978). Within the Lagunitas Creek delta, sag portions of the trace often appeared as "water lanes:" indeed, the "water lane" depicted as occurring directly north of the Giacomini Ranch in the undiked marsh corresponds almost exactly to the location of an existing, extremely straight tidal marsh channel. During the earthquake, a large portion of the Lagunitas Creek delta "was thrown … into gentle undulations, the difference in height between the swells and hollows being usually less than a foot" (Gilbert 1908). The undulations were not observed along the eastern shore of the bay or in the "the firmer part of the Papermill delta…" (Gilbert 1908). The horizontal shifting of the mud flats occurred over an approximate distance of 1.5 miles along the western margin of the bay, with the observed northern limit near the town of Inverness. Wave action gradually smoothed out the ridges and troughs, but some of the larger troughs remained, ranging in height from 1 to 3 feet or more (Gilbert 1908). This undulation may explain some of the localized losses of salt marsh habitat that were reported within Tomales Bay (Gilbert 1908).

Despite the earthquake, sedimentation and deltaic aggradation continued to be high until at least the 1950s, when construction of several dams and reservoirs began to curtail sediment delivery (Figure 21). These dams include the Peters and Lagunitas Dams, which control about 70 percent of the Lagunitas Creek watershed (PWA et al. 1993). By the early 1940s, rapid sedimentation had converted this marsh from the tidally dominated system depicted in the 1863 map to a fluvial or creek-dominated one, with remnants of the tortuously meandering sloughs once present and characteristic of tidal systems restricted to the eastern perimeter of what would become the East Pasture. The rapid delta formation at Lagunitas Creek encouraged the Giacominis to dike approximately 550 acres of the historic and newly created marsh in 1946 for creation of the Giacomini Ranch. Since diking, topography of the Giacomini Ranch has largely been affected by land-leveling activities, efforts to re-direct flood and creek/drainage flows, and sediment deposited during flooding. Elevation of the levees is highly variable due to maintenance activities and erosion- and cattle-related degradation.

Displacement of Levee Road following 1906 earthquake

FIGURE 21. HISTORIC MAP OF SOUTHERN TOMALES BAY

The topographic map prepared by the (USGS 2003b) indicates that the majority of the active pasturelands are relatively flat, having an average elevation of 4-feet NAVD88 in the East Pasture and 5-feet NAVD88 in the West Pasture (KHE 2006a). The highest ground elevations (up to about 30-feet NAVD88) occur at the Giacomini Dairy facility in the southeast corner of the Ranch (KHE 2006a). The lowest elevations on the map (about 0-feet NAVD88) correspond to bed elevations in interior drainage channels in both the East and West Pastures and portions of Lagunitas Creek between the two pastures (KHE 2006a). In general, the East Pasture is highest along the south margin (11- to 16 feet NAVD88) and slopes down to the average pasture elevation of 4-feet approximately at a distance of approximately one-quarter of the pasture length to the north (KHE 2006a). This sloping surface is part of two similar geomorphic features, one being the face of a natural alluvial fan building out onto the historic marsh plain from the mouth of Lagunitas Creek and the other being a wedge of fine grained sediment splayed onto the East Pasture through a low spot in the levee during repeated flooding (KHE 2006a). The East Pasture is essentially flat over its northern three-quarters (KHE 2006a).

The east half of the West Pasture (located immediately west of the Lagunitas Creek levee) slopes gently and evenly from approximately 8-feet NAVD88 at the south end to 5-feet NAVD near the North Levee (KHE 2006a). Ground surface elevations along the western margin of the West Pasture and along Sir Francis Drake Road range from 14-feet NAVD88 (at the south end) to 21-feet NAVD88 (at the north end; KHE 2006a). Topography is heavily influenced by alluvial fans that have formed at the mouths of several creeks that discharge onto the West Pasture along the base of Inverness Ridge (KHE 2006a). The crest of the West Pasture levee averages about 12 feet NAVD88 in elevation at the south end and 10 feet NAVD88 at its intersection with the north levee (KHE 2006a). The north levee of the West Pasture has an average elevation of approximately 10 feet NAVD88. Along this same span, the East Pasture levee crest is typically about 2 feet lower in elevation than the West Pasture levee (KHE 2006a). Concrete spillways approximately 180-feet long with crest elevations around 7.5-feet NAVD88 occur at the north end of both the East and West Pastures (KHE 2006a). These structures are designed to drain seasonal floodwaters from each pasture.

Topographic information collected by the USGS suggests that, unlike San Francisco Bay marshes, diking in the Project Area has not resulted in extensive subsidence or lowering of elevations within the Giacomini Ranch. In San Francisco Bay, marshes largely developed from organic- or peat-rich clay materials that rapidly compacted once levees were constructed between the 1860s and 1960s. The base elevation of diked marshes in San Francisco Bay is often 7- to 12- feet below that of undiked areas, and subsidence is even greater in the Sacramento Delta, often ranging between 15- to 20-feet.

Conversely, along the outer San Francisco Bay coast, there was a period of rapid marsh formation in the late 1860s and early 1900s in response to increased sedimentation within watershed tributaries. Many of these "young" marshes were largely composed of low-organic coarse alluvial mineral soils that have compacted little, if at all, if and when these marshes were diked (Parsons et al. 2004). Elevations of the adjacent undiked marsh to the north of the Giacomini Ranch range from +3 (low marsh) to +7 feet (high marsh/upland ecotone) NAVD88, with the marsh plain at approximately +5 to +6 feet NAVD88 (USGS 2003b). This information suggests that elevations behind or inside the levees have decreased, at most, 1 foot at the northernmost portions of the Giacomini Ranch and have aggraded within the southernmost portions. Some of the aggradation may result from land leveling and deposition of fill and manure, but the Giacominis also removed the southwestern portion of the East Pasture levee deliberately to preferentially direct flood flows into this portion of the property (KHE 2006a). This dynamic is illustrated in Figure 22, which shows higher elevation areas that would not be subject to tidal flooding even if levees were not present in green: Subtidal and lower intertidal areas exist only in existing creeks, sloughs, and ditches.

Olema Marsh and Lower Bear Valley Creek

A 2004-2005 series of topographic surveys of Olema Marsh and lower Bear Valley Creek also revealed that elevations were higher than originally anticipated, at least in Olema Marsh. The center of Olema Marsh ranged in elevation from approximately +4 - to +8 feet NAVD88 (KHE 2006a). Meanwhile, the elevations of the adjacent Levee Road range from +11- to +13 feet NAVD88, approximately the same elevation as the county's White House Pool park on the north side of Levee Road (KHE 2006a, USGS 2003b). Upstream of Olema Marsh, lower Bear Valley Creek gradient remains flat for 3,000 feet upstream of Olema Marsh and then starts rising gently with a 1 percent grade to the Seashore's maintenance facility area (KHE 2006a).

In 1982, Bear Valley Creek underwent some very dramatic topographic changes as a result of the 1982 flood, a 100-year storm, and clean-up efforts from debris flows after the storm. Prior to the storm, the middle and lower portions of the Bear Valley Creek channel had become deeply incised. During New Year's, 1982, a rainfall total of 11-20 inches was recorded within 24 hours. As a result of these excessive rains and high soil saturation, many of the drainages originating from Inverness Ridge broke loose, resulting in catastrophic debris flows (Ellen et al. 1988). Debris flows originating in the two major tributaries of Bear Valley Creek carried into the mainstem of Bear Valley Creek, choking the former channel, scouring existing road/trail facilities, and turning the colluvial valley bottom into a sandy, braided stream channel with extensive woody debris jams that acted to temporary dam and pond waters within the channel. The lower portion of Bear Valley Creek rapidly went from an incised channel with steep creek banks and no connection to the adjacent floodplain terrace to a swampy marsh that, in some areas, has no defined channel.

Interestingly, the higher-than-anticipated elevations within Olema Marsh do not appear to be related to excessive sedimentation following the 1982 flood or the smaller, but still significant 1998 flood, as was expected (KHE 2006b). The lower section of Bear Valley Creek appears to be comprised entirely of peat derived from tules and cattails that is at least 10 feet deep (KHE 2006a). The flattening of the valley gradient and the berm effect caused by Bear Valley and Levee Roads has contributed to an increase in water residence time and water depth in the lower Bear Valley reaches. Persistent ponding within the creek and marsh encourages build-up of peat within lower Bear Valley Creek and Olema Marsh by precluding oxidation of organic matter, which may be causing marsh surface elevations to increase and contributing to the increase in water depth. Sedimentation that has occurred in Olema Marsh appears to be due more to anthropogenic activities. A large rectangular swath of land within the northern portion of the marsh appears to have been graded and leveled along Levee Road, obliterating some of the remnant slough channel features that were still apparent in 1961 aerial photographs (KHE 2006b).

The central portion of Olema Marsh lies at an elevation between 4- and 6-feet NAVD88 (KHE 2006a). The marsh plain elevation upstream of Bear Valley Road starts at approximately 6-feet (NAVD88) and gradually slopes upward for a distance of 1600-feet to an elevation of approximately 9-feet NAVD88 (KHE 2006a). Moving upstream of this point, the valley bottom steepens, and the creek channel occupies a well-developed channel within a broad floodplain. There are no levees on the south side of Lagunitas Creek between Green Bridge and White House pool to protect Levee Road or existing residences from flooding. As its name implies, Levee Road acts as a levee itself. The crest of Levee road is concave in shape, with roadway high points of 12.5- and 13.2-feet NAVD88 at the east and west ends where it borders Olema Marsh and falling to 11.6-feet midway in between. Similarly, Bear Valley Road is an earthen berm with 60-foot top-width, bisecting a lower portion of Bear Valley Creek and bordering the south- and western margins of Olema Marsh.

Crest elevation of Bear Valley Road range from 15.6- to 14.6-feet NAVD88 and is approximately 7- to 8-feet above the marsh plain surfaces in lower Bear Valley Creek and Olema Marshes.

Geologic Resource Issues - Geologic Hazards

Regulatory and Policy Setting

The devastating impacts of large earthquakes on urban and rural communities and potentially even parks have led to development of various Park Service, state, and local policies and regulations that are aimed at minimizing risks to residents and visitors. Within California, several policies and regulations apply to geologic hazards and geotechnical practice in the San Francisco Bay region. These include the California Alquist-Priolo Earthquake Fault Zoning Act, the Seismic Hazards Mapping Act, the Uniform Building Code, as well as county regulations that address geologic hazards as they relate to grading and construction activities.

While the Park Service is charged to preserve geologic processes "unimpaired," natural geologic processes "can be hazardous to humans and park infrastructure," so park managers must strive to understand future hazards and, once understood, "minimize their potential impact on visitors, staff, and developed areas" (NPS 2001, Section 4.8.1.3). Management policies also direct the Park Service to "try to avoid placing new visitor and other facilities in geologically hazardous areas" (NPS 2001a, Section 4.8.1.3).

FIGURE 22. INTERTIDAL ELEVATIONS

California's Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code Section 2621 et seq.) prohibits the location across the traces of active faults of most types of structures intended for human occupancy and strictly regulates construction in corridors along active faults (earthquake fault zones). The Act is intended to reduce the hazard to life and property from surface fault ruptures during earthquakes. It also defines criteria for identifying active faults and establishes a process of review for building proposals in and adjacent to earthquake fault zones. Under the Alquist-Priolo Act, faults that are characterized as "sufficiently active" and "well-defined" are zoned differently, and construction in these zones is regulated more stringently. A fault is defined as "sufficiently active" if one or more of its segments or strands show evidence of surface displacement during Holocene time (approximately the last 11,000 years). The San Andreas Fault Zone (SAFZ) is the only known on-land "active fault" and only zoned fault within the boundaries of Marin County (Snyder and Smith Associates Inc. and Nichols-Berman 2002). Local agencies are responsible for regulating construction within Alquist-Priolo Zone, including all land divisions and most structures for human occupancy except single family wood-frame and steel-frame dwellings up to two stories that are not part of a development of four or more units (California Geological Survey 2006). Cities and counties cannot approve development unless a geologic investigation is performed by a licensed geologist.

While the Alquist-Priolo Act specifically addresses hazards associated with surface fault rupture, the Seismic Hazards Mapping Act of 1990 (California Public Resource Code Sections 2690-2699.6) specifically focuses on other hazards related to earthquakes such as ground shaking, liquefaction, and seismically induced landslides. Through this Act, the state is charged with identifying and mapping areas at risk of strong ground shaking, liquefaction, landslides, and other corollary hazards. Cities and counties are required to regulate development in mapped seismic hazard zones through requiring appropriate site geologic and soil investigations and mitigation measures as part of permit review. Further support for review of construction within geologically hazardous areas comes from the State of California's minimum standards for structural design and construction are given in the California Building Standards Code (CBSC) (CCR Title 24).

The LCP for Zone II, in which the Project Area is located, states that in Alquist-Priolo Zones, earthquake hazard zones, and areas subject to liquefaction, landslides, bluff erosion, and steep slopes averaging greater than 35 percent, proposed projects will be "required to demonstrate that the area of construction is stable for development, the development will not create a hazard or diminish the stability of the area, the" (Marin Community Comprehensive Planning Department 1981). Furthermore, the Coastal Resources and Management Policies requires that proposed projects in the Coastal Zone must "minimize risks to life and property in areas of high geologic…hazard" (Section 30253). The Point Reyes Station Community Plan (Marin County Community Development Agency 2001) also has developed policies relating to changes in topography that might affect geologic substructures or unstable soil conditions or unique geologic or physical features.

Geologic Hazards within the Project Area

Earthquakes. As described earlier, the Project Area is particularly vulnerable to geologic hazards due to being sited directly on the San Andreas Fault, certainly one of the most famous, if not necessarily the most active, of California's faults.

During the last 160 years, the San Andreas Fault system has produced numerous small-magnitude and a dozen moderate to large (magnitude>6) earthquakes in the San Francisco Bay Area (USGS 2003a) although there have been no extremely large earthquakes on the northern section of the fault since 1906. The Loma Prieta earthquake, the most recent catastrophic event in the Bay region of the SAFZ, occurred in 1989 in the Santa Cruz Mountains approximately 8.7 miles north of Santa Cruz. It caused tremendous damage, including collapse of a portion of the Oakland Bay Bridge. The San Andreas Fault is the only fault within Marin County mapped as being in an Alquist-Priolo Earthquake Hazard Zone, and the boundaries of this "zone" incorporate the Project Area (Figure 23).

The San Andreas Fault is not the only active fault in the Point Reyes area (Figure 23). The Project Area is also located near the offshore Point Reyes fault, which is identified as a Type B seismic source1 by the current

1 The UBC evaluates the risk associated with active faults based on their potential to generate large earthquakes (measured as the moment magnitude for the largest earthquake anticipated on the fault) and their degree of seismic activity (measured as average annual slip rate). Under this system, a *Type A seismic source* is a fault that is capable of producing large-magnitude events (≥ M 7.0) and is highly active (has a

Uniform Building Code (UBC) (International Conference of Building Officials 1997), although it is not zoned by the State of California. The San Gregorio Fault runs in the ocean from Santa Cruz to Point Reyes. The northern extent of the North Hayward fault is located a considerable distance east of the Project Area in the eastern portion of San Francisco Bay. The Rodgers Creek fault, which is the likely northward continuation of the North Hayward fault trend, is located in Sonoma County 25 miles northeast of the Project Area. Both of these faults are zoned by the state and are identified as a Type A seismic source by the UBC (Hart and Bryant 1997; International Conference of Building Officials 1997). Table 3: Faults summarizes current estimates of the maximum earthquake anticipated on the principal active faults in the vicinity of the Project Area.

TABLE 3. MAXIMUM EARTHQUAKE ANTICIPATED ON MAJOR FAULTS IN VICINITY OF POINT REYES NATIONAL SEASHORE

Fault	Estimates of Maximum Earthquake	Estimated Mean Recurrence Interval[b]
San Andreas (northern segment)	7.9[a] 7.45[b]	223 years
Rodgers Creek	7[a] 6.98[b]	205 years
Point Reyes	6.8[a]	Unknown

Sources: [a]International Conference of Building Officials 1997, [b]U.S. Geological Survey Working Group on California Earthquake Probabilities.

Geologists have found that earthquakes do not occur randomly, but rather are clustered, because as strain is released in one area, it may actually increase in another (USGS 2003a). This clustering has led geologists to estimate that the probability of an earthquake of magnitude 6.8 or larger occurring during the next 30 years in the San Francisco Bay region is approximately 62 percent (USGS 2003a). The probabilities of an earthquake with a magnitude greater than 6.7 between 2000 and 2030 are 21 percent for the San Andreas Fault and 32 percent for the Hayward-Rodgers Creek fault (USGS 2003a).

Earthquakes are associated with several major hazards: ground shaking, surface fault or ground rupture, ground failure (e.g., liquefaction, settling, and lurching), landslides, and inundation from tsunamis or tidal waves or waves in enclosed water bodies such as lakes and reservoirs. The potential for a surface fault rupture or ground rupture is limited to areas along the fault or within 250 feet of the fault, which means that the risk of surface fault rupture is extremely high, as the Project Area lies directly over the San Andreas Fault. The risk for tsunami or tidal wave might be considered high, as well. Tsunamis are long period waves that are typically caused by underwater disturbances such as landslides, volcanic eruptions, or seismic events. Areas highly susceptible to tsunamis are low-lying coastal areas such as tidal flats, marshlands, and diked areas that are still at or near sea level. However, the Point Reyes Peninsula and the distance of the Project Area from the mouth of the Bay afford it protection from tsunami-causing events in the open ocean (Anderson Consulting Group 2000; EDAW Inc. 2001).

high average annual slip rate). A *Type B seismic source* is associated with smaller maximum event and/or is less active, but still constitutes a substantial seismic threat (International Conference of Building Officials 1997).

FIGURE 23. EARTHQUAKE HAZARDS

In general, the destructiveness of earthquakes to humans namely, injury, loss of life, and property damage, are influenced by epicenter proximity, earthquake magnitude, a given structure's resistance to earthquakes (e.g., modern structures are constructed so that they flex during earthquakes), and the substrate or geologic materials upon which a structure is built. The Modified Mercalli Intensity Scale is an earthquake shaking intensity scale based on local effects experienced by people, structures, and earth materials based on the damage and havoc created during the 1906 earthquake. Created in 1931, this scale ranges from I, which is an event not felt by people to XII, which are events that cause general panic and total damage. The 1906 earthquake produced ground shaking of Modified Mercalli Intensity VIII to IX in the vicinity of the fault (Wald et al. 1993). Because of its proximity to an active fault, the Project Area has been characterized as occurring in an area with a Mercalli Intensity Shaking Severity Level of X, which are events that are Very Violent (Association of Bay Area Governments (ABAG) 2003). The Earthquake Hazard rating for the Project Area was also the severest one possible (ABAG 2003; Figure 23), classified as regions are near major, active faults that will on average experience stronger earthquake shaking more frequently. This intense shaking can damage even strong, modern buildings.

In addition to proximity, substrate also plays a crucial role in determining the amount of destruction caused by earthquakes. For example, while the 1906 earthquake is often referred to as the San Francisco earthquake, the city of San Francisco does not directly straddle the San Andreas Fault. One of the reasons that the 1906 earthquake was so destructive in San Francisco is that much of the city was built upon imported sand fill that became unstable during plate movement. Loose, saturated materials such as sands can become fluid-like during an earthquake, suddenly losing strength and behaving almost like quicksand. This phenomenon, called liquefaction, typically occurs where groundwater is shallow and the substrate is clean, poorly consolidated, loose sand. Other phenomena include ground lurching or horizontal movement of ground located adjacent to slope faces and lateral spreading, horizontal displacement of soil that occurs in loose, unconfined sedimentary and fill deposits.

Seismic hazard maps have not been issued for the any of the quadrangles in the vicinity of the Project Area (California Geological Survey 2004). However, generalized liquefaction hazard level mapping available characterizes the liquefaction hazard level or susceptibility within the Project Area as being High (ABAG 2003; Figure 24) or Very High (Knudsen et al. 2000). The Project Area occurs within what has been mapped as Quaternary alluvium, which consists of stream-borne gravel, sand, silt, and clay, as well as estuarine clay and peat (Knudsen et al, 1999, Niemi and Hall 1996). The groundwater table beneath the entire Project Area is very shallow, often within 1-4 feet of the ground surface even during the summer (NPS, unpub. data). Bedrock was not encountered within any of the shallow soil borings conducted by KHE (2006a).

At least six liquefaction events have been documented within the Project Area in the past, most of which involved cracks in the ground without other effect, although one instance included lateral spread and ground settlement (Youd and Hoose 1978). Not only is this type of substrate subject to liquefaction, but it tends to amplify the energy of earthquakes. The National Earthquake Hazards Reduction Program (NEHRP) has defined five soil types on the basis of their shear-wave velocity or the velocity at which the rock or soil transmits shear waves. Shaking is stronger where the shear wave velocity is lower. Because the Project Area contains water-saturated mud and artificial fill, it has been mapped as having velocities of less than 200 m/sec, which would provide the strongest amplification of shaking (ABAG 2003).

The seismic hazard conditions present in the Project Area also have implications for the integrity of earthen structures such as levees, which are more prone to failure or breaching when near an earthquake fault or in areas that are rated as having high susceptibility to liquefaction, ground lurching, or settlement. Ground shaking is the primary cause of earthquake damage to human-made structures, including levees.

FIGURE 24. LIQUEFACTION SUSCEPTIBILITY

Landslides. Landslides can be induced by both earthquakes and excessive rainfall. While the Seashore and north district GGNRA lie on one of the more infamous North American faults, the recent physical history of this area appears to have been influenced more by watershed-scale sediment movement precipitated by either anthropogenic disturbance or natural, catastrophic flooding. As discussed earlier, denuding and ground disturbance associated with logging, agriculture, grazing, and other settlement activities appears to have destabilized already unstable hillslopes that subsequently increased the potential for erosion and landslides during moderate to large rainstorms. This sediment then washed down from the upper portions of the watershed into the mouth of Tomales Bay, forming the Lagunitas Creek delta. Since then, natural flood or other catastrophic events such as the 1982 (100-year), 2006 (30-year), and 1998 (10-year) floods and the 1996 Mt. Vision fire has continued to shape Tomales Bay and the Lagunitas Creek subwatershed, particularly the lower Bear Valley Creek and Olema Marsh areas (Anima et al. 1988). Each of these events led to mobilization of enormous amounts of sediment from landslides within the Seashore's watersheds, including the Lagunitas Creek, Olema Creek, and Bear Valley Creek watershed.

The danger from landslides is directly related to the geologic stability of the surrounding landscape. The Franciscan Complex, which runs along the eastern portion of the Tomales Bay watershed, including the Bolinas Ridge, is known for slope instability, thin soils, and high runoff rates. Similarly, the deeper soils on the granite-dominated Inverness Ridge can also be unstable, often leading to massive landslides during large storms that create catastrophic debris and sediment flows. As noted earlier, the Seismic Hazard Zone mapping has not been completed for Marin County (California Geological Survey 2004). However, the USGS (1997)has created a summary distribution map of slides and landflows within the San Francisco Bay region based on historic occurrences of landslides and landflows.

The Project Area itself is mapped as "flatland" and therefore not prone to landslide (USGS 1997). More than 70 percent of the eastern portion of the Tomales Bay watershed, however, is mapped as "Mostly Landslide," with the intervening areas mapped as "Few Landslides" (USGS 1997). The western portion of the watershed -- specifically the eastern portion of the Inverness Ridge draining to Tomales Bay -- is mapped largely as "Few Landslides," with a few pockets or areas representing less than 5 percent of the area characterized as "Mostly Landslide" (USGS 1997). However, anecdotal information from Inverness Ridge residents and local agencies responsible for culvert maintenance suggest that at least the portion of the Ridge adjacent to the Project Area erodes easily, with moderate amounts of sedimentation occurring in most average rainfall years and excessive amounts occurring during wet years.

Geologic Resources and Wetland Functionality

Perhaps, the most critical role that geology plays with regards to wetlands is formation and maintenance. Nowhere is this more evident than in Tomales Bay, which owes it very existence to the San Andreas Fault. However, geology can also influence wetland attributes such as functionality in a number of ways. For example, moderately abundant groundwater in this region provides water sources for municipal and private water supply and recharges surface water in creeks and other water bodies during the summer, which improves habitat quality for wildlife. The headwaters for many of the small drainages on the Inverness Ridge are seeps and springs, in addition to surface run-off, and seeps and springs that emerge at the base of hills serve to increase wetland diversity through increasing hydrologic complexity. From a formation perspective, faults act somewhat as an equalizing agent, with earthquake-induced subsidence counteracting to some degree the inherent tendency of tidal wetlands to evolve toward upland conditions over time due to sediment deposition on marshplains.

Soil Resources

While functions performed by wetlands are considered "hydrologic" or "biological," soils are integral components to almost all of these ecosystem services. Soils bind and transform nutrients and contaminants within floodwaters, which is critical for wetlands' ability to improve water quality. Plants, obviously, need soil to grow, and plants are important to both floodwater retention and water quality improvement through dissipating flood flow energy and allowing sediment, nutrients, and contaminants to drop out of the waters onto the floodplain. Much of the carbon that is exported to source waters such as bays and estuaries does not come directly from plants, but from plant and animal matter that is broken down in the soil into forms of organic matter that can be better assimilated by estuarine and marine organisms. While resident and non-resident wildlife use plants for foraging, protection, nesting, and resting, soil itself is an important wildlife habitat. Benthic and benthic stages of invertebrates burrow in mudflats, while species such as the northwestern pond turtle (*Clemmys marmorata marmorata*) aestivate in dry, sandy upland soils. Without soils – and, more importantly, a functioning soil environment – most wetlands would not be able to perform some of their vital functions.

Soils bind and transform nutrients and contaminants within floodwaters, which is critical for wetlands' ability to improve water quality.

Soil Resources within the Project Area

Soil types mapped within the Giacomini Ranch and Olema Marsh are consistent with this area's unique geologic history. The Marin County Soils Survey provides generalized baseline information on soils within the project area (U.S. Soil Conservation Service (USSCS) 1985). Soils are classified into broad associations comprised of one or two major soil types, from which the name of the association is taken, and several minor soil types.

The northern 60 percent of the Giacomini Ranch and most of the Olema Marsh are comprised of Novato Clay (USSCS 1985; Figure 25). Novato Clay is described as "very deep, very poorly drained soil…in saltwater marshes ...formed in alluvium derived from various kinds of rock" (USSCS 1985). The historic coastal salt marsh in the southeastern corner of the Giacomini Ranch and the portion of Lagunitas Creek along Levee Road is mapped as Blucher Cole complex (USSCS 1985; Figure 25). The Blucher-Cole complex is also formed in alluvium from various kinds of rock, although this mapping unit is typically found in basins and on alluvial fans. Both components of this mapping unit are characterized as very deep soils that are somewhat poorly drained with seasonally high water tables and occasional periods of flooding (USSCS 1985). The southernmost portion of Olema Marsh, as well as the portion of Bear Valley Creek flowing into the Marsh, consists of fluvents, channeled, a hydric soil complex commonly formed in floodplains (USSCS 1985; Figure 25).

Soil borings conducted as part of the proposed project indicate, however, that soil patterns within the Giacomini Ranch and Olema Marsh are much more complex than the soil map would suggest. The historic salt marsh areas in the southern and eastern portions of the East Pasture typically consist of intermixed estuarine clays and peats overlain with a thin (~0.3 –0.5 m) loam or clayey loam layer (KHE 2006a). The very southern portion of the East Pasture has a very thick (2.5 m) accumulation of fluvially derived, interbedded silt and sand (KHE 2006a).

Conversely, sediment in many of the historic subtidal areas in the East Pasture that are directly adjacent to historic and current Lagunitas Creek channels are comprised of loam or silty loam overlain by interbedded silt, clay, and sand (KHE 2006a).

FIGURE 25. SOIL TYPES

Based on an understanding of surrounding geologic materials and the mode of their deposition, the shallow stratigraphy underlying the site includes depositional facies of alluvium (fluvial and alluvial fan deposits) bordering, overlying and/or interfingering with a variety of estuarine (marsh plain) deposits (KHE 2006a). The youngest deposits encountered consist of alluvial silts and fine-grained sands that blanket much of the southwest corner of the East Pasture. These sediments were deposited by floodwaters entering the East Pasture through the low spot in the Lagunitas Creek levee located between White House Pool and the fall summer dam. These sediments were deposited since reclamation of the site in the mid-1940s and overlie preexisting estuarine clays and peats representative of an intertidal high-marsh complex. Estuarine clays and peat deposits underlie the majority of the East Pasture and are capped in other locations by fill material and possibly alluvial fan materials at the historic mouth of Tomasini Creek. Unlike most estuarine deposits, which are high in organic matter, these soils had very low organic content, which, again, may be the reason that this area has not subsided as a result of diking (KHE 2006a).

In the West Pasture, a thin veneer of silty loam rests on a thick sequence of extremely permeable coarse-grained sands and gravels (KHE 2006a). The coarse-grained material probably marks the historic alignment of Lagunitas Creek or reflects near-channel accumulation of bedload and suspended sediment deposited during storm events (KHE 2006a). The texture and depositional relationship of the bulk of these deposits reflect a fluvial- or creek- dominated system displaying course-grained channel bed and bar deposits, fine-grained (silt and clay) overbank or floodplain deposits, and terrestrial organic matter representative of the freshwater marshes on the perimeter of the West Pasture. The northernmost portion of the West Pasture displays estuarine, organic-rich clay and peat, materials reflecting the current tidal and estuarine influence that now dominates this area. Although no soil borings were completed in the higher-elevation alluvial fans on the western perimeter of the West Pasture, site topography and observations of surface materials indicate well developed alluvial fans comprised of angular, coarse-grained sand to fine-grained granitic gravel emanating from the mouths of creeks draining the Inverness Ridge and overtopping and interfingering with fluvial and estuarine deposits (KHE 2006a).

Recent borings in lower Bear Valley Creek show an entirely different soil substrate in this area, with the substrate dominated by very thick beds (8-10 feet) of peat with a thin stratum of fine-grained clays on the surface (KHE 2006a). Thick deposits of shallow peat were also encountered by the County of Marin at the northwest corner of Olema Marsh while completing sediment removal excavations in the Levee Road drainage ditch feeding the western culvert outfall from the marsh (Liz Lewis, County of Marin, *pers. comm*.). Thus, it is inferred that these same shallow peat deposits dominate beneath the intervening Olema Marsh area (KHE 2006a). The historically marshy nature of this low gradient portion of the creek, combined with sustained water ponding in more recent times from damming of the marsh by levees, culverts, and gravel sills, has dramatically reduced breakdown of organic matter. Some creek-borne sand, clay and silt flood plain deposits were encountered with thin interbedded layers of terrestrial vegetation in the most upstream soil boring locations (KHE 2006a).

In summary, shallow soil stratigraphy reflects very well the hydrologic environments depicted in 1862 National Geodetic Survey map, which shows the historic alignment of Lagunitas Creek being through what is now the West Pasture, while the East Pasture, Olema Marsh, and lower Bear Valley Creek appear as estuarine tidal marsh.

Soil Resource Issues - Prime and Unique Farmland Soils

Regulatory and Policy Setting

The federal Farmland Protection Policy Act (FPPA) is intended to minimize the impact federal programs have on the unnecessary and irreversible conversion of farmland to non-agricultural uses. For the purpose of FPPA, farmland includes prime farmland, unique farmland, and land of statewide or local importance, which is characterized primarily using soil types, as well as management regimes and other factors. Farmland subject to FPPA requirements does not have to be currently used for cropland. It can be forest land, pastureland, cropland, or other land, but not water or urban built-up land. California's Farmland Monitoring and Mapping Program was established in 1982 to assess the location, quality, and quantity of agricultural lands and conversion of these lands over time. FMMP is a nonregulatory program and provides an analysis of agricultural land use and land use changes throughout California every two years. Under Public Resources Code Section 21060.1 of CEQA, the FMMP is used to define agricultural land for the purposes of assessing CEQA

environmental impacts to agricultural lands. A more detailed description of land use policies related to agriculture can be found under the Land Use and Planning section. Because the Prime and Unique Farmland Soils designation is still largely a soil-related characterization, the areal extent of Prime and Unique Farmland Soils is discussed under Soil Resources.

Prime and Unique Farmland Soil Resources within the Project Area

The most recent version (2004) of the Important Farmland map of Marin County shows the Giacomini Ranch and Olema Marsh as having several important farmland soil types (California Department of Conservation 2004). The definitions for Prime Farmland, Farmland of Statewide Importance, Unique Farmland, Farmland of Local Importance, and Urban Built-up Land were developed by the U.S. Department of Agriculture (USDA) – Soil Conservation Service (SCS) as part of its nationwide Land Inventory and Monitoring (LIM) system. These LIM definitions have been modified for use in California by the California Department of Conservation, which oversees the Farmland Mapping and Monitoring Project (FMMP). The most significant modification is that Prime Farmland and Farmland of Statewide Importance soil types must be irrigated to qualify as important farmland. Farmland of Local Importance is identified by local advisory committees and varies from county to county, as intended by the LIM. Mapping of Grazing Land as part of an Important Farmland Map is unique to California. The California Department of Conservation has established a minimum mapping unit of 10 acres unless otherwise specified, with units of land smaller than 10 acres incorporated into surrounding map classifications.

Within the Project Area, the southeastern 133.2 acres of the Giacomini Ranch East Pasture was currently mapped as Farmland of Statewide Importance (California Department of Conservation 2004; Figure 26). The entire Giacomini Ranch West Pasture, the northernmost and easternmost portion of the East Pasture, the very westernmost portion of White House Pool County Park, and Olema Marsh are mapped as Grazing Land, totaling 293.2 acres (California Department of Conservation 2004). The remainder (136.4 acres) of the East Pasture and the White House Pool County Park are mapped as Farmland of Local Importance (California Department of Conservation 2004; Figure 26).

Farmland of Statewide Importance is land other than Prime Farmland which has a good combination of physical and chemical characteristics for the production of crops (California Department of Conservation 2006). It must have been used for the production of irrigated crops at some time during the two update cycles prior to the mapping date. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use. Farmland of Statewide Importance must meet all the following criteria: water, soil temperature, acidity-alkalinity, water table, soil sodium content, flooding, erodability, and rock content. Soils in the southeastern portion of the Giacomini Ranch qualified as Farmland of Statewide Importance soils, because the soil type, Blucher-Cole complex, 2 to 5 percent slopes, is one of several designated Farmland of Statewide Importance soil types.

Also, this area is currently irrigated for pasture purposes, which qualifies as “crops” for Prime Farmland and Farmland of Statewide and Local Importance designations, but not the Unique Farmland designation (M. Penberth, California Department of Conservation, *pers. comm*.). Important Farmland maps depict the Project Area as accounting for a moderately high percentage of the Farmland of Statewide Importance soils mapped in Marin County (~30 percent). However, this number is somewhat misleading as Giacomini Ranch only represents 2 percent of the total acreage of Blucher-Cole complex soils mapped in Marin County. A large percentage of the other Blucher-Cole complex soils appear to be mapped as Farmland of Local Importance Soils or Grazing Land probably because, while they are grazed such as East Pasture, they are not irrigated. Most Farmland of Statewide Importance soils are probably irrigated for row crop or sillage, rather than pasture, purposes.

Farmland of Local Importance is either currently producing crops, has the capability of production, or is used for the production of confined livestock (California Department of Conservation 2006). Farmland of Local Importance is land other than Prime Farmland, Farmland of Statewide Importance or Unique Farmland. This land may be important to the local economy due to its productivity or value. It does not include publicly owned lands for which there is an adopted policy preventing agricultural use. Farmland of Local Importance is initially identified by a local advisory committee (LAC) convened in each county by FMMP in cooperation with the USDA-SCS and the county board of supervisors.

FIGURE 26. FARMLAND SOIL TYPE

In Marin County, Farmland of Local Importance is defined as land that is not irrigated, but cultivated or has the potential for cultivation (California Department of Conservation 2006). In the Project Area, Farmland of Local Importance strongly overlaps with areas mapped as Novato Clay, although Local Importance soils are not necessarily linked to a particular soil type. Farmland of Local Importance has been mapped in the northern portions of the East and West Pastures, Olema Marsh, and portions of White House Pool County Park. In 2000, almost all of the areas with Novato Clay soils were designated as Farmland of Local Importance, however, some of these areas in the East and West Pasture have been reclassified in the 2004 map as Grazing Land, probably because of the poor likelihood for crop production given the persistent ponding during winter and spring and high residual soil salinities. This designation, however, has been retained for Olema Marsh and portions of White House Pool park, neither of which has been farmed in recent decades or currently has any realistic potential for farming. Farmland of Local Importance in the Project Area represents less than 0.2 percent of this mapped type in Marin County.

Grazing Land is defined in Government Code §65570(b)(3) as: "...land on which the existing vegetation, whether grown naturally or through management, is suitable for grazing or browsing of livestock" (California Department of Conservation 2006). The minimum mapping unit for Grazing Land is 40 acres. Grazing Land does not include land that is heavily brushed, timbered, excessively steep or rocky lands which restrict the access and movement of livestock. The FMMP convenes a grazing land advisory committee in each project county to help identify grazing lands. The committees consist of members of the local livestock ranching community, livestock ranching organizations, and the U. C. Cooperative Extension livestock advisor. The FMMP works with the president of the local Cattlemen's Association and the U.C. Cooperative Extension livestock advisor in selecting members of these committees. As noted earlier, Grazing Land is a new designation within the Project Area, with most of these lands being Farmland of Statewide or Local Importance that were reclassified. Grazing Land in the Project Area represents less than 0.3 percent of this farmland type in Marin County.

As discussed under Land Use, both the FPPA and CEQA require that projects that might affect prime, unique, and important farmland soil types complete a Land Evaluation and Site Assessment (LESA). LESA establishes a farmland conversion impact rating score that can be used as an indicator to determine the magnitude of adverse impacts on farmland. Results of the LESA are discussed under Land Use and Planning subsection in Chapter 4.

Soil Resource Issues - Sediment Quality and Contamination

One of the most valuable functions that wetlands can contribute to improving the health of a watershed is filtration and/or transformation of nutrients, sediment and contaminants in associated surface and ground water sources. Soluble and sediment-bound nutrients, sediment, bacteria, and contaminants, such as metals, pesticides, and polyalkylated hydrocarbons, can enter wetlands through tidal or freshwater flow. Once they have entered a wetland, sediments and nutrients are deposited onto the floodplain, with nutrients often transformed within the soil or uptaken by plants. Contaminants are often precipitated and bound through sediment reduction processes into insoluble iron or sulfide compounds, dissolved organic compounds, or humic acids (Gambrell 1994; Horne 2000). Natural wetlands are believed to remove as much as 50 percent of ammonium and Total Nitrogen, 20 percent of Total Phosphates, and 30 percent of metals from source waters (Kadlec and Knight 1996).

With the increasing number of wetland restoration projects in San Francisco Bay and the central California coast in the past decade, concerns have been raised among biologists and hydrologists that these stable “sinks” for contaminants could potentially become “sources” of contamination to the environment (Davis et al. 2003). This remobilization could potentially reduce productivity and filtering functions of wetlands, create water quality problems, or reintroduce toxins that may be uptaken by wildlife (Davis et al. 2003).

Wetland restoration can affect reintroduction of nutrients, sediment, and contaminants to the environment in several ways. First, removal of levees in diked marshes could cause sediment erosion through tidal overwash or development of new channels, thereby potentially resuspending sediment and nutrient- and contaminant-laden sediments. Secondly, changes in the hydrologic regime of areas undergoing restoration also can increase the potential for remobilization of nutrients and contaminants. Many contaminants become more soluble under conditions of low pH that sometimes result when reduced sediments become oxidized, such as

when tidal action is introduced to diked areas that were consistently inundated or impounded previously (DeLaune and Smith 1985; Soukup and Portnoy 1986; Gambrell et al. 1991; Peverly and Kopka 1991; Satawathananont et al. 1991; Gambrell 1994; Anisfeld and Benoit 1997). This oxidation can cause a flush of nutrients within overlying waters from breakdown of undecomposed organic matter within formerly anoxic soils (Soukup and Portnoy 1986, Anisfeld and Benoit 1997).

The Tomales Bay watershed is generally considered pristine relative to other large watersheds along the California coast. However, as will be discussed in greater detail under Hydrologic Resources – Water Quality, it is not immune to the negative effects of anthropogenic influences, such as logging, agriculture, leaking septic systems, oil spills, and mercury mining. The absence of large scale industry and the relatively low density of people and cars within the watershed have limited the potential for direct discharge of contaminants such as polychlorinated biphenyls (PCBs) and hydrocarbons, yet there is still the possibility of indirect contamination to Tomales Bay via atmospheric deposition of PCBs and hydrocarbons originating from outside the watershed (Parsons and Allen 2004a). The prevalence of dairy and beef cattle ranching, as well as other forms of agriculture, in this watershed increases the potential for the presence of herbicides and pesticides and other types of pollutants such as bacteria and excessive nutrients relative to more contaminants generally associated with more urban environments such as PCBs (Parsons and Allen 2004a).

Because restoration activities are anticipated to cause some degree of soil disturbance and relocation that might cause any potential nutrients or contaminants present to be released, the Park Service conducted screening-level sediment contaminant and nutrient studies in the Giacomini Ranch and adjacent areas in 2003 and 2005 (Parsons and Allen 2004a, NPS, unpub. data). More information on nutrients and pathogen levels within Project Area waters can be found under the Water Resources – Water Quality discussion.

Regulatory and Policy Setting

From a regulatory perspective, the issue of sediment contamination is tightly linked to water quality. The San Francisco Regional Water Quality Control Board (RWQCB) has established narrative objectives for the amount of suspended sediment in waters, and suspended sediment often is bound to nutrients, pathogens, and contaminants such as mercury. Indeed, the tight link between mercury and sediment transport, deposition, and resuspension has led the RWQCB to be the lead agency evaluating the effect of mercury from the Gambonini Mine on Walker Creek and Tomales Bay under the Clean Water Act, as well as under other state legislation. The Clean Water Act is discussed under Water Resources – Water Quality. The Basin Plan (Regional Water Quality Control Board (RWQCB) 1995a)notes that the suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses. In addition, “controllable water quality factors shall not cause a detrimental increase in the concentrations of toxic pollutants in sediments or aquatic life” (RWQCB 1995a).

The explosion in chemical manufacturing and marketing during the mid 20th century dramatically increased the threat to public health from contamination. During the last 50 years, hundreds of thousands of chemicals have been developed, and the production of synthetic chemicals jumped from 1.3 billion lbs. in 1940 to 320 billion lbs. in 1980 (Orford 1991). Serious public health issues associated with dumping or storage of very hazardous chemicals such as the infamous Love Canal prompted a series of federal pieces of legislation designed to regulate transport and disposal of hazardous waste and require clean-up of toxic areas through the Resource Conservation and Recovery Act (42 U.S.C. 6901 et seq. --1976) and Comprehensive Environmental Response, Compensation, and Liability Act (42 (U.S.C. 9601 et seq. -- 1980), also known as Superfund.

Nutrients

Relative to some other natural vegetation communities, most tidal marshes would be considered nutrient-poor, at least in terms of nitrogen (Mitsch and Gosselink 1993). While the pastures have remained largely wetland in nature despite diking, nutrient concentrations appear to exceed those of natural, undiked marshes, although spot sampling was only conducted once in August 2005 (NPS, unpub. data). Nitrate levels in some of the East Pasture surface soils ranged between 6 – 29 mg/L, while phosphorus ranged between 7-11 mg/L (n=3; NPS, unpub. data). In comparison, nitrate in the undiked marsh north of Giacomini Ranch ranged between 3-6 mg/L, and phosphorous ranged between 5-8 mg/L (n=2; NPS, unpub. data). Interestingly, nitrates in the West Pasture freshwater marsh, which is only infrequently grazed by cattle, ranged as high as

from 29-81 mg/L, while phosphorous concentrations were very low, ranging from 1-3 mg/L (n=2, NPS, unpub. data). Nitrate data for the freshwater marsh may reflect more nitrogen potential of the soil: drying of soils for analysis may have increased organic matter breakdown and nitrification of ammonia to nitrates, which is normally precluded in soils with prolonged waterlogging and anoxia. Not surprisingly, the highest nitrate and phosphorous concentrations were recorded in the East Pasture field used for manure disposal, with concentrations in surface soils of nitrates reaching 134 mg/L and phosphorous, 489 mg/L (NPS, unpub. data). In the manure field, nitrate concentrations dropped by half 6 inches below the soil surface, but phosphorous concentrations remained more variable (NPS, unpub. data).

Metals and Other Contaminants

Many watersheds along the central California coast are naturally high in certain metals such as mercury and nickel due to the presence of mineral deposits and ultramafic rocks. Mercury used to extract gold during the gold rush period in the Sierra Nevada Mountains came from the coastal ranges in California. Later, mercury was mined for other purposes. Between 1964 and 1970, the Gambonini family operated a cinnabar ore or mercury sulfide mine in the Walker Creek watershed, a sub-watershed of Tomales Bay (Whyte and Kirchner 2000; TBWC 2002). Waste from this mine was stored in a tailings pond that breached during extreme storm events in 1982, sending much of this mercury-laden sediment downstream to Tomales Bay. As much as 180 lbs of mercury moved downstream over a period of two months (D. Whyte, RWQCB, pers. comm. in Parsons and Allen 2004a). Whyte and Ganguli (2000) conducted sediment sampling throughout Tomales Bay in the 1990s and determined that mercury concentrations were highest at the mouth of Walker Creek, averaging 10-12 ppm, and decreased in a bell-curve fashion with distance from the mouth. Through sulfur reduction processes in the sediment, this mercury can become methylated and made available to benthic organisms such as oysters and ghost shrimp. These invertebrates, in turn, are consumed by organisms of higher trophic order such as fish and birds.

Studies in Tomales Bay have shown that mercury concentrations in the tissues of sharks, halibut, perch and bat rays from Tomales Bay are slightly higher than those from San Francisco Bay (D. Whyte, RWQCB, pers. comm. in Parsons and Allen 2004a). In addition, mercury levels in liver tissue of ducks from Tomales Bay were two to three times greater than those of ducks from historically contaminated Suisun Bay. Whyte noted that most of the current effects of mercury contamination in Tomales Bay result from resuspension of mercury-laden sediments that were deposited during or slightly after the 1982 storm events. Sediment resuspension of this nature occurs because of scouring and channel migration related to tidal flow (D. Whyte, RWQCB, pers. comm. in Parsons and Allen 2004a).

Results from a study conducted by Long et al. (1990) support the growing awareness that Tomales Bay is not as pristine as previously assumed. The study subjected various benthic invertebrates to survival tests in sediment samples collected from sites in Tomales Bay and San Francisco Bay. Chemical analyses of the Tomales Bay sediment suggested that it was not contaminated, yet the Tomales Bay sediment bioassay samples were categorized with samples from Oakland Inner Harbor as among the most toxic to the test organisms. The same study found that benthos samples collected from Tomales Bay were dominated by relatively hardy polychaetes and molluscs and were nearly devoid of sensitive crustaceans. Based on these finding, the authors concluded that some unknown factor or factors had rendered Tomales Bay sediments “relatively inhospitable” to many benthic organisms.

On the Giacomini Ranch, ranching activities appear to have resulted in comparatively little contamination of soils (Parsons and Allen 2004a). Based on land use and land management practices, the potential for toxic contaminants within the ranch itself would seem to be restricted to decades of hunting with lead shot in portions of the East Pasture and possible spraying of undesirable plants and pests with herbicides or pesticides (Parsons and Allen 2004a). However, the Project Area may be affected by outside sources of contaminants such as mercury from the Gambonini mine and pollutants from nearby landfills. Several RWQCB sampling events between 1999 and 2000 documented the presence of leachates, if not organic compounds and other types of contaminants, in surface waters of Tomasini Creek near Mesa Road one mile downstream from the now closed West Marin Landfill, which at one point took both hazardous and household wastes (D. Elias, Engineering Geologist, RWQCB, *pers. comm*.). Another dump may have once existed just south of the Giacomini Ranch adjacent to Lagunitas Creek and the Green Bridge that served the town of Point Reyes Station during the 1920s -1930s. While perhaps not used for dumping of higher volumes of toxic wastes as would be older landfills in urban and industrial areas, these landfills still represent sources of possible

contamination to the Project Area, particularly these landfills were constructed and largely operated during a period of less stringent regulation regarding liners, distance to groundwater tables, etc.

In the Seashore's study (Parsons and Allen 2004a), the only contaminant that exceeded National Oceanic and Atmospheric Administration's (NOAA's) sediment quality guidelines was nickel, which exceeded NOAA's Effects Range-Median (ERM) at several of the 20 sampling locations. NOAA's ERM is national benchmark that correlates to the concentration at which adverse benthic impacts are found in approximately 50 percent of studies, while Effects-Range Low (ERL) represents a concentration at which adverse impacts were detected in 10 percent of the studies. Nickel and some other metals are naturally high in certain geologic formations, including the Franciscan Formation, which borders the Project Area to the east. Cadmium was also detected at concentrations exceeding the Ambient Sediment Concentration (ASC) standards for San Francisco Bay in Tomasini Creek near Mesa Road, but the level was still substantially lower than NOAA's ERL or ERM standards (Parsons and Allen 2004a).

The two analytes that perhaps were of most concern – methylated mercury and lead – due to watershed mercury contamination and long-term hunting in the Project Area occurred at concentrations well below both published standards and levels observed in San Francisco Bay subtidal and wetland areas (Parsons and Allen 2004a). Reporting limits for selenium and organics laboratory analytical methodologies used were high enough that they precluded comparisons with published standards (Parsons and Allen 2004a). The relatively rural, non-industrialized nature of this watershed suggests, however, the potential for selenium and organics contamination is relatively low, except for those contaminants that disperse through atmospheric deposition, as well as point source and non-point discharge from isolated features such as the West Marin Landfill (Parsons and Allen 2004a).

Soil Resources and Wetland Functionality

As described earlier, soils are integral components of many hydrologic and ecological functions, either directly or indirectly. These functions include water quality improvement, carbon export, and wildlife habitat use and support. The ability of soils to bind or retain contaminants and thereby improve water quality is strongly related to texture (e.g., percentage of clays, silts, sands, and other material), organic matter (e.g., decomposing plant matter), and oxygen. With the exception of deltas, most natural tidal and freshwater marshes have high amounts of fine sediments such as clay and organic matter that, because of their chemical properties, act to strongly bind contaminants. Materials such as sands and gravels are not only more porous or contain more air space between soil particles, but do not possess the same chemical properties that enable nutrients, metals, pathogens, and other contaminants to bind strongly to them. Another important parameter of wetland soils is the lack of oxygen. Sustained inundation or saturation of soils by water causes the soil environment to become reduced or anaerobic, which initiates a complex biogeochemical that helps to lock contaminants into the soils. Once bound to soils, these contaminants are rarely released back into their environment, unless there are drastic changes in wetland conditions such as oxidation of soils due to dewatering. The natural filtering mechanisms of wetland soils have encouraged many municipalities to turn to treatment wetlands to treat or, polish wastewater.

Because of its unique geologic history, soils within the Giacomini Ranch contain less clay and peat material than many other historic marshes. In the East Pasture, very fine, estuarine-derived clays interbedded with peats – very fine decomposed organic matter -- were typically overlain by anywhere from 1.5- to 5 feet of clayey to sandy alluvial material derived from fluvial or creek sources (KHE 2006a). Organic content of the estuarine clays appears relatively low based on laboratory analyses, ranging from 5- to 18- percent (KHE 2006a) compared to 20- to 40 percent in many natural marshes. Soils in the West Pasture consist of an interbedded mixture of layers of gravel, sand, silt, and clay, with the clays again varying in the amount of organic matter content (KHE 2006a). Conversely, Olema Marsh is dominated by peat and fine-grained clays, with substantially lower amounts of fluvial-derived sand, clay, and silt particles (KHE 2006a).

Most of the overlying soils in the Giacomini Ranch undoubtedly date to the massive influx of sedimentation from the upstream watershed that started in the 1860s and still continues to some extent to this day, although the levees have substantially reduced the amount of deposition on the historic floodplains of Lagunitas and Tomasini Creeks. In addition, alluvial material has deposited at the mouths of many of the small creeks and drainages within the Project Area. To a lesser degree, agricultural management has resulted in selective filling of pastures, particularly in the south end of the East Pasture. In contrast, land management

in the Bear Valley Creek watershed appears to have somehow precluded downstream deposition of alluvium – which is also prevalent in this system -- into Olema Marsh, preserving a vegetation-controlled depositional environment. The fine-grained clays occurring with the abundant peat were probably deposited when conditions were estuarine (KHE 2006a)

Air Resources

Air Resource Issues - Air Quality

Regulatory and Policy Setting

Under NPS-77 (Natural Resource Management Guidelines), the Park Service is directed to "seek to perpetuate the best possible air quality in parks because of its critical importance to visitor enjoyment, human health, scenic vistas, and the preservation of natural systems and cultural resources." Parks are urged to "assume an aggressive role in promoting and pursuing measures to safeguard [air quality related values] from the adverse impacts of air pollution." As a federal agency, the Park Service must comply with the Clean Air Act of 1970 (CAA), which underwent several major revisions in 1977 and 1990. Under the CAA, the Seashore is classified as a mandatory Class I area. Title I of the CAA amendments of 1990 defines Class I areas as including all national parks greater than 6,000 acres that were in existence when the CAA was amended in 1977 and identifies these areas as receiving the most stringent protection from air pollution damage. The Park Service is responsible for the protection of parks from ambient air quality impacts, including air quality-related values (AQRVs) such as visibility and the protection of plants, animals, soils, water quality, cultural and historic structures from the effects of contaminants. The northern lands of the GGNRA, including the Project Area, are a federal Class II area.

The CAA charges the Environmental Protection Agency (EPA) with identifying national ambient air quality standards to protect public health and welfare. Standards have been set for seven pollutants: ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), particulate matter less than 10 microns (PM10), very fine particulate matter less than 2.5 microns in diameter (PM2.5), and lead (Pb). A description of these pollutants can be found below and in Table 4. Ozone is produced by the combination of pollutants from many sources, including smokestacks, cars, paints and solvents and is one of the chemicals responsible for formation of smog. Carbon monoxide is a colorless, odorless, poisonous gas that is produced by incomplete burning of carbon-based fuels, including gasoline, oil and wood. Nitrogen dioxide, produced by combustion sources such as cars, power plants, and industrial engines, is a respiratory irritant and a precursor to ozone and, therefore, smog formation. Sulfur dioxide is a gas produced by burning coal, most notably in power plants, and plays an important role in the production of acid rain. Reactive Organic Gas (ROG), a reactive chemical gas composed of hydrocarbons, may contribute to the formation of smog. Particulates are produced by soots, dusts, and smokes and are also a respiratory irritant. If a standard for a particular pollutant is exceeded more than three times in three years in an air basin, it is considered a non-attainment area and is then subject to more stringent planning and pollution control requirements. The San Francisco Bay Area Air Basin, under which the Project Area falls, is a federal non-attainment area for ozone (Table 5).

The federal government has ceded responsibility and authority to establish air quality standards and regulations to states. Section 176 of the Act or the conformity rule requires federal actions to conform to state implementation plans for achieving and maintaining the air quality standards. Federal actions cannot cause or contribute to new violations, increase the frequency or severity of any existing violation, interfere with timely attainment or maintenance of a standard, delay emission reduction milestones, or contradict the State Implementation Plan. Therefore, all Park Service areas are required to comply with state laws on these matters regardless of the type of legal jurisdiction that applies to other activities within the Park Service unit.

TABLE 4. OVERVIEW OF POLLUTANTS OF GREATEST CONCERN IN THE SFBAAB

Pollutant	Sources	Health and Other Concerns
Ozone	Formed by a photochemical reaction in the atmosphere; ozone precursors, including reactive organic gases and oxides of nitrogen (NOx), react in the atmosphere in the presence of sunlight to form ozone. Ozone precursors are emitted by mobile sources such as vehicles, and by stationary combustion equipment.	A severe eye, nose, and throat irritant; increases susceptibility to respiratory infections. An oxidant; can cause substantial damage to synthetic rubber, textiles, and other materials. Produces leaf discoloration and cell damage in plants.
PM10	Results from many kinds of dust- and fume-producing activities, such as demolition, construction, and vehicular traffic; entrained road dust from motor vehicles accounts for approximately two-thirds of the regional PM10 inventory in the project area.	Health concerns focus on particles small enough to be drawn into the lungs when inhaled (PM10). Can increase the risk of chronic respiratory disease with extended exposure.
CO	Motor vehicles are the primary source of CO emissions in most areas. In the urbanized portions of the San Francisco Bay Area, high CO levels primarily develop during the winter near congested intersections, when periods of light winds combine with the formation of ground-level temperature inversions from evening through early morning. In addition, motor vehicles exhibit increased CO emission rates at low air temperatures.	Combines readily with hemoglobin and thus reduces the amount of oxygen transported in the bloodstream. Effects on humans range from slight headaches to nausea to death.

Prior to even initial federal efforts to regulate air quality, the state of California was already establishing air quality standards and necessary controls for mobile vehicle emissions through the state Department of Public Health in the late 1950s. In 1988, the California Clean Air Act was passed. California differs from every other state in that it has retained the authority to develop its own vehicle emissions standards if those standards are at least as stringent as the federal standards under Section 209(b) of the CAA.

The California Air Resources Board (CARB) sets air quality standards for the state targeted at reducing emissions in each of the 35 local air districts. Both CARB and the USEPA have general oversight responsibilities for the purpose of making sure local rules and regulations and stationary source permits issued are consistent towards attainment and maintenance of the California and National Ambient Air Quality Standards (AAQS). To protect public health and welfare, the California Air Resources Board (CARB) has set stricter ambient air quality standards than national standards (Table 5). Under the 1988 California Clean Air Act, air basins were designated as attainment, non-attainment, or unclassified for the state standards. The Bay Area Air Basin, one of the 35 local air districts, is classified as a California non-attainment area for ozone and particulate matter (Table 5). The Bay Area Air Quality Management District (BAAQMD) is the air quality management district for the Project Area and has primary responsibility for control of air pollution. The County of Marin has also established policies regarding air quality in the Marin CWP (Marin County Community Development Agency 2005). The local general plan for the appropriate city or county must be consistent with the Clean Air Plan for this guideline to apply (BAAQMD 1999). The Marin CWP is considered consistent with the Clean Air Plan (Illingworth & Rodkin and Nichols Berman 2002).

TABLE 5. AMBIENT AIR QUALITY STANDARDS & BAY AREA ATTAINMENT STATUS

Pollutant	Averaging Time	California Standards[1]		National Standards[2]	
		Concentration	Attainment Status	Concentration[3]	Attainment Status
Ozone (O_3)	8 Hour	0.070 ppm (137µg/m)	U	0.08 ppm	N
	1 Hour	0.09 ppm (180 µg/m)	N		
Carbon Monoxide (CO)	8 Hour	9.0 ppm (10 mg/m)	A	9 ppm (10 mg/m)	A
	1 Hour	20 ppm (23 mg/m)	A	35 ppm (40 mg/m)	A
Nitrogen Dioxide (NO_2)	Annual Average			0.053 ppm (100 µg/m)	A
	1 Hour	0.25 ppm (470 µg/m)	A		
Sulfur Dioxide (SO2)	Annual Average			0.03 ppm (80 µg/m)	A
	24 Hour	0.04 ppm (105 µg/m)	A	0.14 ppm (365 µg/m)	A
	1 Hour	0.25 ppm (655 µg/m)	A		
Particulate Matter (PM10)	Annual Arithmetic Mean	20 µg/m	N	50 µg/m	A
	24 Hour	50 µg/m	N	150 µg/m	U
Particulate Matter Fine (PM2.5)	Annual Arithmetic Mean	12 µg/m	N	15 µg/m	A
	24 Hour			65 µg/m	A
Sulfates	24 Hour	25 µg/m	A		
Lead (Pb)	Calendar Quarter			1.5 µg/m	A
	30 Day Average	1.5 µg/m	A		
Hydrogen Sulfide	1 Hour	0.03 ppm (42 µg/m)	U		
Vinyl Chloride (chloroethene)	24 Hour	0.010 ppm (26 µg/m)	No information available		
Visibility Reducing particles	8 Hour (1000 to 1800 PST)	(See note 3)	A		
A = Attainment N = Nonattainment U = Unclassified					
mg/m³=milligrams per cubic meter		ppm=parts per million		µg/m³=micrograms per cubic meter	

1. California standards for ozone, carbon monoxide (except Lake Tahoe), sulfur dioxide (1-hour and 24-hour), nitrogen dioxide, suspended particulate matter - PM10, and visibility reducing particles are values that are not to be exceeded. The standards for sulfates, Lake Tahoe carbon monoxide, lead, hydrogen sulfide, and vinyl chloride are not to be equaled or exceeded. If the standard is for a 1-hour, 8-hour or 24-hour average (i.e., all standards except for lead and the PM10 annual standard), some measurements may be excluded. Measurements may be excluded that would occur less than once per year on the average.
2. National standards other than for ozone, particulates and those based on annual averages are not to be exceeded more than once a year. The 1-hour ozone standard is attained if, during the most recent three-year period, the average number of days per year with maximum hourly concentrations above the standard is equal to or less than one. The 8-hour ozone standard is attained when the 3-year average of the 4th highest daily concentrations is 0.08 ppm or less. The 24-hour PM10 standard is attained when the 3-year average of the 99th percentile of monitored concentrations is less than 150 µg/m³. The 24-hour PM2.5 standard is attained when the 3-year average of 98th percentiles is less than 65 µg/m³. Except for the national particulate standards, annual standards are met if the annual average falls below the standard at every site. The national annual particulate standard for PM10 is met if the 3-year average falls below the standard at every site. The annual PM2.5 standard is met if the 3-year average of annual averages spatially-averaged across officially designed clusters of sites falls below the standard.
3. Statewide VRP Standard (except Lake Tahoe Air Basin): Particles in sufficient amount to produce an extinction coefficient of 0.23 per kilometer when the relative humidity is less than 70 percent. This standard is intended to limit the frequency and severity of visibility impairment due to regional haze and is equivalent to a 10-mile nominal visual range.

Air Quality Resources within the Region

A cooperative program, the Interagency Monitoring of Protected Visual Environments (IMPROVE), between the EPA, federal land managers, and state air agencies, was formed to monitor visibility in Class I areas. Data published in a recent IMPROVE report shows that visibility at the Seashore improved during the period of 1996 to 1999 primarily due to a decrease in nitrate particulates, a major component of visibility-blocking material in coastal California. Particulate nitrate is formed from nitrogen oxide and hydrocarbon gases emitted into the atmosphere from fires, diesel engines, and other sources (Malm 2000). Monitoring by the Park Service found no ozone exceedences at the Seashore under either the California or federal standard. Park air resources are rated as having low exposure to ozone, sulfur, and nitrogen emissions and low potential for acidification of surface waters. A recent Park Service report states that "there are no significant air pollution effect concerns in this park [the Seashore] at the present time" (Sullivan et al. 2001).

Some of the greatest threats to air quality within the Seashore and the western portions of Marin County come from outside the region. In 2000, Marin County had a total population of 247,289 (U.S. Census Bureau 2000). As discussed earlier, most of Marin's population lives to the south and east of the Project Area along the county's main transportation corridor, Highway 101. Other populated areas -- including Petaluma in Sonoma County -- are located in a more easterly direction, inland from Point Reyes. Only a small, relatively scattered population lives in the vicinity of the Seashore. Air quality within the coastal portion of rural West Marin can be affected by problems outside the immediate vicinity of the Seashore. In general, the BAAQMD has been unable to attain the ozone (O3) and carbon monoxide (CO; pertinent to urbanized areas only) standards set by the AAQS for the Bay Area. These air quality problems have the potential to affect seemingly unpolluted coastal regions because of wind, air temperature, gradients, and local and regional topography.

Some of the greatest threats to air quality within the Seashore and the western portions of Marin County come from outside the region.

The marine influence that moderates temperatures along the central California coast also affects wind direction and speed. Many areas of the Seashore, particularly along the Drakes Bay, the Lighthouse, and Point Reyes Headlands, are exceptionally windy. Wind speed along the west Marin Coast averages 8- to 10 mph (BAAQMD 2003). During the winter, the predominant regional surface winds flow from the north-northeast (Bell 1958). During spring and summer, stronger north-northwest winds dominate (Bell 1958). These northwesterly winds are primarily caused by the combination of high pressure offshore and the warmer air inland. These winds blow off the ocean and are slowed down, if not intercepted completely, by the complex terrain of the Bolinas Ridge (BAAQMD 2003). During the fall transition, warm easterly winds from the hot, dry inland areas often break through to the coast.

Bolinas Ridge provides a topographic barrier for air pollutants from San Francisco Bay, as since winds play a major role in dispersing pollutants far from respective sources. Air pollution in the region is moderated by strong, westerly winds most of the year. Other sources of pollutants are inversions. When cold air becomes trapped under warm air, the air masses cannot mix, and pollutants begin to accumulate. The frequent occurrence of temperature inversions over the Seashore could concentrate air pollution levels near the ground. Pollutants are more concentrated near the ground during colder weather or after sunset. In general, "the influence of the marine air keeps the pollution levels low" (BAAQMD 2003).

Sensitive receptors refer to land uses that are considered particularly sensitive to decreases in air quality. The designation typically refers to uses such as residences, schools, libraries, hospitals, and other similar facilities where there are large concentrations of children and young people; the elderly; and/or the chronically ill. Because the Project Area is within a relatively rural community, there are not a large number of sensitive receptors located nearby. However, there are small schools, preschools, and a library in the town of Point Reyes Station. In addition, because the Project Area occurs in an area is widely used for recreation, wildlife viewing, agricultural production, and scientific research, and these uses are potentially vulnerable to air quality degradation.

The only air pollutant currently measured in the Point Reyes region is PM2.5 or small particulate aerosols that affect acid deposition and regional haze. Recent data (1999-2001) indicate a daily average concentration of 8.330 ug/m3 or less averaged over three years of data collection, which is well below the state and federal AAQSs of 12 and 15 ug/m3, respectively. As no other ambient air pollutant is measured in this region, air quality data were obtained from other nearby BAAQMD monitoring stations in San Rafael (Marin), Santa Rosa (Sonoma), and Vallejo (Napa). In summary, these stations, which are located in more heavily developed areas, met standards for carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and federal, but not state, standards for ambient particulates smaller than 10 microns (BAAQMD 2003). Santa Rosa exceeded the state's maximum 24-hour average for ozone twice during the three-year period and California's one-hour ozone standard once (BAAQMD 2003b).

Air Resource Issues – Noise and Soundscapes

Background and Regulatory and Policy Setting

While noise often has a negative connotation, one of the intrinsic values of national parks remains the potential for hearing "natural" noises such as crashing waves, running streams, thunder, or singing birds. A combination of noises that is intrinsic to a natural landscape is often characterized as a soundscape. The ability to hear these natural noises in a soundscape is somewhat dependent on the absence of unwanted sound such as urban noise. Unwanted sound can be simply intrusive, destroying either a relaxing experience or the comfort of one's home, or harmful to people's health through hearing impairment or loss.

Unlike more urban parks, the Seashore and north district of GGNRA are located in a rural portion of western Marin County and must contend less with the intrusive influences of urbanization than the southern portions of GGNRA. Regardless of location, however, the Park Service is directed to preserve, to the greatest extent possible, the natural soundscapes of parks and to protect natural soundscapes from degradation due to noise, defined as "undesirable human-caused sound" (NPS 2001, Section 4.9). The natural soundscape is defined as the aggregate of all the natural sounds that occur in parks, absent human-caused sound, together with the physical capacity of transmitting natural sounds (NPS 2001, Section 4.9). The Park Service policy is a more stringent standard than set by the federal Noise Control Act of 1972 or most general plans produced by cities or counties.

The federal Noise Control Act required federal agencies to promote an environment free of the noise that can jeopardize public health or welfare. Sound can be characterized using two parameters: amplitude (loudness) and frequency (tone). The agency tasked with implementing the Noise Control Act, the EPA, established outdoor limits of 55 decibels (dB) and indoor limits of 45 dB averaged throughout a 24-hour period. Decibels refer to the amplitude or peak pressure of the sound wave and are interpreted by humans and wildlife as different degrees of sound loudness. For comparison purposes, an average office has mean noise levels of 60 dB, while close proximity to a jet engine has noise levels as high as 140 dB (Egan 1972; HUD 2004). The noise level of rustling leaves in a forest -- the sound that many visitors come to parks to experience – can be as low as 20 dB (Egan 1972 *in* HUD 2004). Laboratory measurements have correlated a 10 dB increase in amplitude with a perceived doubling of loudness and a 3 dB change in amplitude as the minimum audible difference perceptible to the average person (Federal Highway Administration 1982; EDAW Inc. 2001).

In 1994, the Marin County Noise Element mandated that residences, public spaces, and institutions not be subjected to noise levels above an average of 60 dB over a 24-hour period. Many planning agencies use a 24-hour average of noise intensity, with a 10 dB "penalty" added for nighttime noise (10:00 p.m. to 7:00 a.m.) to account for the greater intrusiveness of loud noises during this time of the day (California Code of Regulations 1988). Marin County is currently in the process of revamping the CWP with the last draft issued in 2005. The County has also developed noise criteria for significance thresholds in its Marin County Environmental Impact Review Guidelines (Marin County Community Development Agency 1994). These criteria generally characterize noise impacts as significant if the project would generate noise that conflicts with countywide or state noise standards; 2) substantially increases noise levels in areas of sensitive receptors; or 3) is not compatible with baseline noise levels.

Noise and Soundscape Resources within the Project Area

Major noise producers in most areas include highway traffic, trains, planes, boats, and industry-related machinery within industrial zones. In rural areas such as west Marin, major producers of undesirable human-caused sound are limited to automobile and truck traffic, jet airplanes, individual businesses, agricultural ranch activities, and individual construction projects. In general, ambient noise levels remain lower in rural areas than in urban areas. In urban areas, ambient noise levels typically range from approximately 60 to 70 dBA, whereas, in rural areas, ambient noise levels range from 40 to 50 dBA. No ambient noise levels are available for the Seashore. However, Marin County assessed noise levels on State Route 1 south of Point Reyes Station in 1987 and 2001, and average ambient noise levels over a 24-hour period climbed from 62 to 65 decibels during those 14 years (Marin County Community Development Agency 2004)). Another ambient noise survey conducted as part of the Affordable Housing project in Point Reyes Station recorded 24-hour average ambient noise levels of 69 dBA at State Route 1 and a newly constructed street near Mesa Road, Williams Street, with maximum and minimum levels of 87 and 43 dBA, respectively. Average ambient noise levels of 66 dBA were measured at Mesa Road and Commodore Webster Drive, with maximum and minimum levels of 87 and 45 dBA, respectively (EDAW Inc. 2001). Traffic on local roads and State Route 1 constituted the dominant noise source during this 2000 survey, which was conducted in the late afternoon (EDAW Inc. 2001).

On its eastern boundary, the Project Area is located directly adjacent to Point Reyes Station, where automobile and truck traffic, agricultural ranch activities, and individual businesses in the town constitute most of the anthropogenic noise sources. On its western boundary, the Project Area is located next to Inverness Park, a small residential community with more limited ranch and business activity than Point Reyes Station. However, Sir Francis Drake Boulevard, the main road for visitors, residents, and park staff traveling to the interior of the Seashore, runs through Inverness Park, and this road generates more than 300,000 vehicle trips per year (NPS 2002). Most of the homes in Inverness Park and all of those in the town of Point Reyes Station proper are located above the Project Area either on Inverness Ridge slope or the top of the Point Reyes Mesa, respectively. There are approximately 20-25 homes that are at the same elevation or just slightly higher than the Project Area in Inverness Park along Sir Francis Drake Boulevard and along Levee Road near Point Reyes Station. The topography of the Project Area has some effect on noise and soundscape resources, with noise generated by or near the roadways and pastures generally carried upwards towards residences on the Inverness Ridge or Point Reyes Mesa.

Water Resources – Hydraulics and Hydrologic Processes

The complex geologic setting of coastal Marin has resulted in an equally complex and diverse hydrologic setting, characterized by tides, creeks with seasonal and perennial water flow, and abundant groundwater that either remains belowground as aquifers or emerges at the ground surface as seeps and springs. The transition from precipitation- and groundwater-derived freshwater at the headwaters to the tidally dominated outer portion of Tomales Bay and the Pacific Ocean beyond superimposes another layer of complexity defined by salinity, with the inner portions of Tomales Bay representing the brackish interface between marine and freshwater influences. The Project Area represents the largest transitional zones between marine and freshwater influences within the watershed.

The movement of water and sediment through the watershed, from Inverness and Bolinas Ridges to Tomales Bay, relies upon a complex interaction between hydrologic, hydraulic, sediment transport, and geomorphic processes, including precipitation, fog drip, run-off; infiltration; evaporation; flooding; connectivity of the stream with the floodplain; sediment transport; surface water interaction with the groundwater table; lateral creek migration, scour and deposition, etc. For the purposes of this document, all of these processes are collectively referred to as “hydrologic processes.”

The purpose of the project is to restore tidal and freshwater hydrologic processes within the Project Area. Being at the head of the Tomales Bay estuary, both tidal and freshwater hydrologic processes are important to the Project Area and are the cornerstone for almost of the other functions provided by wetland ecosystems. These processes not only result in important hydrologic functions such as floodwater retention, groundwater

recharge, and water quality improvement, but are integral to ecological functions (e.g., carbon export and wildlife habitat) and economic services (e.g., recreation and industries such as oyster-growing and fisheries). Realizing the importance of natural hydrologic processes to wetland function, the Park Service and CSLC focused on removing impediments to tides and creeks as the project's primary goal.

Regulatory and Policy Setting

While water quality and impacts to wetlands are highly regulated, hydrologic processes have received less regulatory attention. In recent decades, more local, state, and federal agencies have adopted policies regarding hydrologic processes.

The 2001 National Park Service Management Policies, support practices that "re-establish natural functions and processes in human-disturbed components of natural systems in parks unless otherwise directed by Congress…..Impacts to natural systems resulting from human disturbances include .....changes to hydrologic patterns and sediment transport; the acceleration of erosion and sedimentation; and the disruption of natural processes. The Service will seek to return human-disturbed areas to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated"(NPS 2001a, Section 4.1.5). The 2001 Management Policies also call for parks to "protect, preserve, and restore the natural resources and functions of floodplains (NPS 2001a, Section 4.6.4)," which includes benefits such as floodwater storage.

Marin County also promotes restoration and enhancement of watersheds and natural stream channel function (including protection and enhancement of fish habitat) in its draft update of the Countywide Plan (2005). In the Coastal Zone, the LCP (Marin County Comprehensive Planning Department 1981) also includes policies regarding stream alterations, including protection of stream channels from impoundments, diversions, channelizations, or other substantial alterations, as well as protection of at least 100 feet on either side of creeks as "buffers" to increase wildlife habitat quality and water quality benefits. The Point Reyes Station Community Plan (Marin County Community Planning Department 2000) further supports preservation of streams and streamside environments in their natural conditions, including protection of existing riparian habitat or "buffers" and removal of invasive plant species, and protection of Lagunitas Creek, specifically its water quality, coho salmon and steelhead populations, and other aquatic life in its policies.

Water Resources – Tidal and Freshwater Flows

The Project Area represents a mixture of tidal, freshwater creek or fluvial, and groundwater hydrologic sources (Figure 27). The zone of influence for each of these hydrologic influences shows considerable overlap within the Project Area, making it a very hydrologically dynamic and complex system. A more detailed description of each of these sources follows below.

As described earlier, the functionality of wetlands is integrally tied to the presence of hydrologic sources such as tides, fluvial or creek flow, and groundwater. The importance of hydrology not only relates to it being a source of water for wetlands, but to its properties and the work accomplished by water when it moves either through bi-directional flow of tides or the uni-directional flow of creeks and groundwater.

FIGURE 27. HYDROLOGIC SOURCES

Tidal Surface Water

Tomales Bay. Tides represent a source of energy to estuaries that provides oxygen, sediment movement, and, to some degree, nutrients. Tomales Bay is a 10.8 square-mile shallow, tectonically caused (drowned fault valley) Mediterranean-type coastal estuary (Hollibaugh et al. 1988). Tomales Bay opens at the southern end of Bodega Bay and extends in a southeasterly direction. The bay is approximately 12 miles long and less than one mile wide (RWQCB 2001). The average depth of the bay is less than 20 feet (California Department of Health Services (DHS) 1996; TBWC 2002).

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Tomales Bay is a microtidal estuary, which means that the differences between high and low tide are not as pronounced as in other regions of the world such as Alaska's Bay of Fundy, although mesotidal-type tides occur during extreme spring tides in the winter (Harcourt-Baldwin 2003). Within Tomales Bay, the average annual maximum tidal swing is 8.2 feet, with a difference between mean high and mean low tide of about 3.61 feet (KHE 2006a). Tides in Tomales Bay are mixed semi-diurnal, resulting in a daily tidal regime with two flood or "high water" tides and two neap or "low water" tides of varying height or magnitude (KHE 2006a). Relative to the Pacific Ocean, tides are attenuated somewhat in Tomales Bay, with the height of the high tide being generally 0.6 feet less than that at the Golden Gate (KHE 2006a). Tidal prism -- or the volume of water that is exchanged during the typical half-day tide cycle -- has currently been estimated at 990.4 million cubic feet in Tomales Bay, compared to 1.8 billion cubic feet for south San Francisco Bay (CH2M Hill 1990; Watson et al. 1998) and 70.6 billion cubic feet for the entirety of the San Francisco Bay (Barnard et. al. 2006).

Tomales Bay is a relatively well-studied system for a small estuary. Previous hydrographic studies conducted as part of the Land-Margin Ecosystem Research (LMER) program of Tomales Bay have documented the bay's metabolism, its water composition, the dynamics of its nutrient circulation, and the influence of coastal upwelling (TBWC 2003). One of the first such studies was a 1960 hydrographic survey by Johnson et al. (1961). Additionally, Tomales Bay has been the subject of an intensive study into the biogeochemistry, for example, (Smith et al. 1987; 1989; 1991; 1996) (Hollibaugh et al. 1988; 1991) and hydrologic dynamics (Hearn and Largier 1997; Largier et al. 1997a; 1997b; Harcourt-Baldwin 2003) of estuaries. Cole et al. (1990) studied the hydrographic, biological and nutrient properties of Tomales Bay. Chambers et al. (1995) studied the nitrogen and phosphorus dynamics in fringing tidal marshes of the bay.

Circulation – and, therefore, sediment, nutrient, and contaminant dynamics -- in Tomales Bay are predominantly influenced by the Bay's physical shape, tidal cycles, and watershed run-off (TBWC 2003). Historically, circulation within the bay has been characterized as alternating between a classical estuary (net dilutive or "positive" basin) during wet winter months and a hypersaline estuary (net evaporative or "negative" basin) during dry summer months (Hollibaugh et al. 1988). However, as with many other estuaries, advances in computer modeling such as three-dimensional modeling using detailed bathymetric or bottom topography data has revealed that circulation patterns within Tomales Bay and many estuaries are incredibly complex, both spatially and temporally. Several recently developed 3-D hydrodynamic models of Tomales Bay have shown that different transport mechanisms are important in the outer and inner regions of the Bay (Harcourt-Baldwin 2003, (Gross and Stacey 2003).

Gross and Stacey (2003) have developed a three-dimensional hydrodynamic model of Tomales Bay using the TRIM (Tidal, Residual, and Intertidal Mudflat) program through a contract with the San Francisco RWQCB that will provide information to staff that can be used to establish Total Maximum Daily Load (TMDL) goals for loading of pollutants to Tomales Bay. Harcourt-Baldwin (2003) generated a three-dimensional model using a different program as part of Largier's hydrodynamic research conducted as part of Smith and Hollibaugh's LMER studies referenced above. Tomales Bay is often divided into two or three regions – outer, inner, and sometimes middle bays – that are distinguished by differences in bathymetry and distance from its relatively narrow mouth. Most of these models do not incorporate what might be termed the "inner" inner bay, which would cover the Project Area and the undiked marsh north of the Giacomini Ranch, which is shallower, more vegetated, and driven more by fluvial- or creek processes than the open water portions of Tomales Bay (KHE 2006a; see Project Area discussion below).

In the outer portion of the bay, which is characterized by deep channels and shallow shoals or sandbars and strong tidal currents, tides drive the circulation (Harcourt-Baldwin 2003, Gross and Stacey 2003), although heavy freshwater inflows may temporarily affect circulation patterns (Harcourt-Baldwin 2003). Maximum velocities at the mouth are 6.56 feet/second, but these are reduced over neap tides (Harcourt-Baldwin 2003). These strong tidal currents result in complete vertical mixing of waters such at that stratification of tidal and freshwater flows seldom last longer than a day (Harcourt-Baldwin 2003). These modeling results support earlier research that concluded that water in the northern 3.73 miles of the bay exchanges with nearshore coastal waters on each tidal cycle (Hollibaugh et al. 1988). As distance increases from the mouth, the importance of tidal currents decreases relative to other mechanisms, including differences in density between the less-dense freshwater inflow and the more-dense saltwater tides (Harcourt-Baldwin 2003).

In the middle and inner portions of the bay, which are more uniformly shallow than the outer bay, density-driven flow circulation is the dominant process controlling water movement (Harcourt-Baldwin 2003, Gross and Stacey 2003). During the winter, the classic estuarine circulation pattern of gravitational circulation prevails, with less dense freshwater flowing over more dense seawater. Winter freshwater inflow enters Tomales Bay from two primary sources -- Lagunitas Creek near the Project Area and the head of the bay and Walker Creek near the mouth, generally creating a “lens” or layer of the less-dense freshwater on the surface and more dense seawater on the bottom. Lagunitas Creek accounts for 66 percent of the freshwater inflow to Tomales Bay, while Walker Creek represents approximately 25 percent, with the rest of the freshwater inflow coming from the numerous small tributaries to the Bay (Fischer et al. 1996).

The strength and persistence of the stratification depends on the intensity and duration of the freshwater inflow (Harcourt-Baldwin 2003). The estuary rapidly (< 1 day) returns to initial conditions after small freshwater inflow events (Harcourt-Baldwin 2003). After continuous or high inflow events characteristic of the Mediterranean climate’s wet winters, continuous freshwater inflow sustains stratification of the middle and inner regions (Harcourt-Baldwin 2003). Recent research in other estuarine systems, including San Francisco Bay, has shown that seasonal variability in stratification may also be accompanied by finer scale variation related to depth and tidal cycle, with unstratified conditions developing during spring tides or in shallower areas of channels and bays (Schoellhamer and Burau 1998). Spatial and temporal variability in stratification within Tomales Bay may result not only from factors such as depth and tidal cycle, but differences in freshwater inflow dynamics following storm events.

While Walker Creek and other small drainages flow into Tomales Bay along its entire length, two-thirds of the Bay’s freshwater inflow comes from Lagunitas Creek at the head or southern portion of the bay (Fischer et al. 1996). This large volume of freshwater inflow creates a longitudinal salinity gradient between the southern end or head of the Bay and the northern end or mouth to the Pacific Ocean (Harcourt-Baldwin 2003). This gradient increases flushing or seaward movement of estuarine waters and increases exchange between the middle and outer estuarine regions.

The importance of gravitational circulation within the middle and inner bays decreases during the late spring and summer (Harcourt-Baldwin 2003). As freshwater inflow decreases over the summer, and evaporation increases, estuarine salinity in the middle and inner bays increases, reducing the longitudinal salinity gradient and, consequently, stratification based on difference in density between salt- and fresh waters (Harcourt-Baldwin 2003). The lack of a strong longitudinal salinity gradient within Tomales Bay decreases flushing times from a few days during the winter to approximately 120 days for at least the southern 9 miles of the bay during the summer (Hollibaugh et al. 1988).

In contrast to many other estuaries, however, the density gradient within the estuary does not disappear during the summer, but rather switches from a salinity-driven one to a temperature-driven one (Harcourt-Baldwin 2003). The temperature gradient balances warm temperatures in the middle and possibly inner Bay, which is shallow and more responsive to solar radiation, with upwelling of cold waters in the nearshore Pacific Ocean. Due to strong, persistent offshore winds that churn bottom ocean waters towards the surface during the spring and summer, cold, nutrient-rich water is upwelled along California’s central coast (Smith and Hollibaugh 1998, Harcourt-Baldin 2003). The dense, cold upwelling water moves some distance landwards into the estuary with flood tides as a bottom current due to the fact that cold waters are denser than warm surface waters (Harcourt-Baldwin 2003). Significant subtidal intrusions of cold water have been observed a few times during some summers, with colder waters penetrating halfway into the middle and inner bays (Harcourt-Baldwin 2003). These intrusions may represent key sources of nutrients, particularly organic carbon, during the summer to the estuary (Harcourt-Baldwin 2003). Additionally, this longitudinal

temperature gradient maintains some type of exchange of waters between at least the outer and middle portions of the Bay (Harcourt-Baldwin 2003), which has important implications for summer water quality. Unlike many other shallow estuaries, including portions of San Francisco Bay, the strong spring winds along the coast, which, on average, can reach as high as 35 miles per hour (mph), do not appear to have a substantial effect on circulation within the Bay (i.e., inducing strong vertical mixing or turnover of waters), perhaps because of the sheltering effect of the steep Inverness Ridge along the western perimeter (Tomales Bay Shellfish Technical Advisory Committee (TBSTAC) 2000).

The very innermost portions of Tomales Bay do not appear to be affected by intrusions of upwelling water, and the lack of a strong salinity or temperature gradient with the middle and outer bays can substantially decrease exchange and increase water residence times (Hearn and Largier 1997; Largier et al. 1997). The lack of connection with the ocean and outer bay can result in at least transient periods of hypersaline conditions, such that salinities slightly exceed salinity in the outer Bay or ocean because solar radiation increases evaporation of waters and concentration of existing salts (Hearn and Largier 1997, Largier et al. 1997). However, despite increases in salinity and temperature relative to the middle and outer bays, longitudinal salinity and temperatures are too weak to increase exchange. This weak temperature gradient between inner and outer portions of the Bay disappears during autumn, when solar radiation decreases, and water temperatures cool in the inner Bay (Harcourt-Baldwin 2003).

Occasionally, this autumn cooling, combined with hypersaline conditions, causes yet another circulation pattern to develop for several days that is common in more tropical estuaries, inverse circulation (Harcourt-Baldwin 2003). Inverse circulation results from evaporation concentrating salts in the now cooler surface waters, which then, because of higher density, sink to the bottom and flow oceanward beneath the less dense ocean waters. Hearn and Largier (1997) speculated that the degree of hypersalinity and the duration of inverse circulation, which results in greater exchange between inner and outer portions of the Bay, may have been greater during historic times than now. This change appears to have occurred, because the Bay has become shallower, and because minimum flow requirements within creeks cause reservoir releases of freshwater throughout the summer, decreasing salinities in the inner Bay (Hearn and Largier 1997, Largier et al. 1997).

In addition to changes resulting from sedimentation, circulation patterns within Tomales Bay also have the potential to be affected by sea level rise. In the 1993 feasibility study (PWA et al. 1993), sea level was predicted to rise at a rate somewhere between 1.5 and 5.0 feet over the next 100 years. NOAA reports that, based on review of historic (1854-1999) water level gauge data, sea level has risen at a rate of 0.00328 to 0.0079 feet/year over the last century and that sea levels have risen 0.007 feet/year in San Francisco since 1906 (NOAA 2001) *in* KHE 2006a). Based on 25 years of Point Reyes water level records, NOAA predicts a local sea level rise rate of 0.0082 feet/year in this region (NOAA 2001 *in* KHE 2006a). Based on recent satellite altimetry studies, Cazenave and Narem (2004) report a “very accurate” sea level rise rate of 0.0092 ± 0.0013 feet/year for the 1993-2003 decade. This rate is notably higher than what NOAA’s rate of change based on measured changes in tide gauges over the preceding half century (KHE 2006a). In 2005, the USGS completed a relative coastal vulnerability study that depicted most of Tomales Bay as having low to moderate vulnerability to sea level rise (Pendleton et al. 2005). Most recently, researchers from University of Arizona, the National Center of Atmospheric Research, and other institutions suggest that accelerated melting of the Arctic and Antarctic ice caps and Greenland glaciers could raise sea level by as much as 3 feet by the end of this century and 13 to 20 feet in coming centuries (Overpeck et al. 2006; Velicogna and Wahr 2006).

Ultimately, circulation patterns within estuaries drive not only on the movement and exchange of tidal and freshwater within a system, but the movement and deposition of suspended sediment and associated nutrients and contaminants and even the abundance and diversity of biota such as phytoplankton, zooplankton, invertebrates, and fish. These relationships result from the hydrodynamic effects of circulation patterns such as landward movement of ocean currents, vertical mixing of surface and bottom waters, net upward currents, and salinity structure of waters, particularly low salinity or transitional zones (Kimmerer 2004). Kimmerer (2004) recently summarized decades of research on relationships between suspended sediment and biota and circulation and/or salinity patterns in San Francisco Bay, and another LMER project in the Columbia River Estuary in Oregon has also extensively investigated this estuarine phenomenon. This subject is discussed further under Water Resources – Water Salinity and Estuarine Turbidity Maxima.

Lagunitas Creek. While earlier studies reference the "Inner Bay" of the Tomales Bay watershed, the boundaries for most of these studies or models end well ocean-ward of the Project Area. The Project Area is located in an area of the estuary that would constitute what could be called the "Inner Inner Bay." This "Inner Inner Bay" represents one of the largest estuarine transition zones in Tomales Bay, areas characterized by the dynamic interface both seasonally and interannually between freshwater and saltwater. This portion of the Bay is characterized by even shallower bathymetry than the Inner Bay, prominent gravel and sand bars in creek channels, and large expanses of undiked tidal marsh and intertidal mudflat, some of which is being actively colonized by Pacific cordgrass (*Spartina foliosa*). In actuality, the "Inner Inner Bay" is part of the Lagunitas Creek – and, to a lesser extent, Fish Hatchery Creek – alluvial delta and is, therefore, dominated more by fluvial than tidal processes (KHE 2006a). The portion of Lagunitas Creek in the Project Area bisects the Giacomini Ranch into two "pastures:" East and West (Figures 2, 27).

The importance of fluvial geomorphic processes within the tidally influenced sections of Lagunitas Creek is evident in the series of gravel and sand bars that have formed from the Green Bridge to the open water portions of Tomales Bay in response to episodic flooding. These gravel and sand bars strongly regulate circulation patterns in this reach of Lagunitas Creek. As with any dam, gravel bars or sills in estuaries can impound waters and disrupt tidal circulation patterns through causing tidal truncation or reduction in the extent of drainage during low tides and increasing water residence time. While, from a tidal perspective, these sills limit drainage during low tides and decrease the amount of exposed mudflat available for species such as shorebirds, from a fluvial perspective, these sills create deepwater, almost lagoonal-type pools that are somewhat analogous in function to pools found in creeks in the upper portion of the watershed. Both types of pools provide important permanently flooded habitat for many aquatic species. Retention of water upstream of gravel bars can reduce water quality through decreasing dissolved oxygen concentrations, but tidal exchange during high tides can decrease the potential for stagnant conditions to develop.

There are two major gravel or sand bars within the Project Area that truncate the lower range of tides and control the depth of upstream residual pools: one is located near where the Giacomini Ranch cows cross Lagunitas Creek to reach the West Pasture (cattle crossing), and the other occurs just south or upstream of the Giacomini Ranch north levee. Within this section of creek, the gravel bars appear to function as a series of "dams" that truncate tidal amplitude and preclude upstream waters from draining completely.

TABLE 6. TIDAL DATUMS FOR NOAA TIDE GAUGE, TOMALES BAY AT INVERNESS TIDAL EPOCH: 1960-78

	MLLW Datum (feet)	NAVD88 Datum (feet)
MHHW	5.34	5.83
MHW	4.64	5.13
MTL	2.76	3.25
NGVD29	2.15	2.64
MLW	0.88	1.37
MLLW	0.00	0.49

A comparison of water levels between the nearest NOAA tidal gauging station in Tomales Bay, Inverness Park (Table 6: Datums), and the portion of Lagunitas Creek within the Project Area indicate that, while the stream gradient is relatively flat through the Project Area, the lower range of tidal amplitude becomes progressively more truncated as distance from Tomales Bay increases (KHE 2006a; Figure 28). Figure 28 is a schematic longitudinal profile of channel bed and top of bank elevations, as well as water levels, along Lagunitas Creek through the Project Area from the Green Bridge at the southeastern end of the Project Area to the Ranch's northern levees at the northern end of the Project Area. This graphic shows the weir-type effect that these gravel bars have on water levels, with the base or minimum water levels observed increasing in elevation in a step-wise manner in an upstream direction (KHE 2006a). There is only a very small truncation of high tides or the upper part of the tidal range, with high water levels the portion of Lagunitas Creek within the Project Area relatively similar to those predicted at Inverness (KHE 2006a). This information suggests that MLW and MLLW elevations for the portion of Lagunitas Creek in the Project Area would differ from that of the predicted tides at Inverness, but the other tidal elevations would remain similar (KHE 2006a).

FIGURE 28. TOPOGRAPHY AND BATHYMETRY OF LAGUNITAS CREEK CHANNEL BANKS AND BOTTOM

Typically, at MHW, tidal waters would begin to flood onto marshplains. However, in the reach of Lagunitas Creek within the Project Area, the Giacomini Ranch levees preclude tidal inundation of its historic marshplains. In addition, past deposition of fill in the Green Bridge County Park and White House Pool County Park have also largely eliminated the potential for tidal influence at higher tides in these historic marsh areas. A list of infrastructure and management practices that negatively affect both tidal and fluvial or freshwater hydrologic processes can be found in Table 7. Between Tomales Bay and White House Pool, Lagunitas Creek is wide and relatively uniform in shallowness, although deeper portions of the channel or thalwegs do occur.

The broad and long gravel bar just south of the Giacomini Ranch north levee controls the lowest water level observed between the north levee and the cattle crossing location so that water levels do not drop below approximately 1.9-feet NAVD88, even though portions of the channel are 0-feet NAVD88 (KHE 2006a; Figure 28). As will be discussed in more detail under Water Resources – Water Salinity, circulation patterns within this reach vary seasonally, but, based on long term monitoring data, are typically either well-mixed (fresh in the winter and saline in the late summer-fall) or partially stratified (partial stratification of freshwater at the water surface), although strong stratification occurred very infrequently. The shallowness of this reach, combined potentially with currents and wind, appear to discourage stratification.

Upstream of the cattle crossing location and another prominent gravel bar, the creek becomes noticeably narrower and deeper, functioning almost like what is called a glide with relatively deep water and low velocities. The cattle crossing gravel bar again increases the amount of truncation in the observed low or minimum tidal water levels within Lagunitas Creek at approximately 2.8-feet NAVD88 (KHE 2006a; Figure 28). Circulation patterns within this reach differ noticeably from those downstream. While both upstream and downstream reaches are well-mixed and fresh during winter and spring, the White House Pool reach becomes strongly to at least partially stratified during summer and fall, probably due to the decreasing, but continued, influence of freshwater inflows. The degree of stratification may also be driven by tidal cycle, as other researchers have noted more stratification during neap tides or low tide conditions (Reed and Donovan 1994; Schoellhamer 2001).

Stratification within this reach during summer and fall could result either from reestablishment of gravitational or classic estuarine circulation driven by the opposing forces of tidal currents and freshwater inflows – the pattern in much of the open waters of Tomales Bay – or stratification or resorting of "pooled" waters based simply on vertical differences in density. While the strength of tidal currents decreases at least by tenfold in the "inner" bay relative to the mouth of Tomales Bay (Smith et al. 1971), the presence of longitudinal salinity gradient between the Green Bridge and White House Pool during the summer and fall suggests that gravitational circulation might be occurring despite the shoaling effect on tidal flows caused by the downstream shallow creek channel and gravel bars. Longitudinal salinity gradients, particularly strong gradients, are associated with gravitational circulation patterns (D. Schoellhamer, USGS, *pers. comm*.).

Near the Green Bridge, Lagunitas Creek is primarily a fluvial system. Scour pools within this reach appear to be partially stratified for most of the summer and fall, although strong stratification may occur during higher high tides. Even further upstream, Lagunitas Creek begins to transition into more of a freshwater system influenced by tides such that there is, at least in downstream portions near the Coast Guard wells, a time lag between increases in water levels from tides and the subsequent shift from freshwater (salinities < 0.5 parts per thousand or ppt) to brackish water (salinities ≥ 0.5 and < 2.0 parts per thousand or ppt) conditions (KHE, unpub. data).

Fish Hatchery Creek. Fish Hatchery Creek is the primary tributary within the West Pasture of the Giacomini Ranch (Figure 27). The Giacominis installed a one-way tidegate in the West Pasture north levee near Sir Francis Drake Boulevard, however, at some point, this gate began to malfunction and allow some tidal waters into the pasture (Table 7). Muted tidal flushing in the West Pasture has resulted in reduced tidal prism, with prism currently estimated at 8.1 acre-feet at MHW based on hydrologic modeling (KHE 2006a).

Beyond the Giacomini Ranch, Fish Hatchery Creek continues to run along the western perimeter of Tomales Bay until it reaches the Bay itself. As with Lagunitas Creek, gravel bars within the undiked portion of Fish Hatchery Creek also appear to act as small "weirs," controlling the lower tidal range in the southern sections of the creek (KHE 2006a). Just downstream of the Giacomini Ranch, low tides are controlled at approximately 3.0-feet NAVD88 (KHE 2006a).

TABLE 7. HYDROLOGIC INFRASTRUCTURE AND MANAGEMENT PRACTICES IMPACTING IMPEDIMENT SURFACE FRESHWATER HYDROLOGIC PROCESSES IN THE PROJECT AREA AND UPSTREAM PORTIONS OF THE WATERSHED

Note: For larger creeks, only impediments on mainstem or central portions of creek are listed. Impediments are listed from upstream to downstream. Multiple similar impediments in the same area of watershed are sometimes denoted by total number of impediments in parentheses, for example (2).

Creek	Project Area: Hydrologic Infrastructure/ Management Impediment: Approximate Location	Upper Watershed: Hydrologic Infrastructure/ Management Impediment: Approximate Location
Mainstem Lagunitas Creek	1. *Bridge*: Green Bridge at State Route 1 2. *Levees*: Past Fill Placement on Green Bridge County Park, Levee Road, East Pasture Levee and Creek Bank Fill, Past Fill Placement on White House Pool County Park, West Pasture Levee (5) 3. *Management*: Giacomini Cattle Crossing 4. *Management*: Infrequent Discharge of Ditch Water to Creek 5. *Management*: Levee Maintenance – East Pasture 6. *Management*: Levee Maintenance – West Pasture	1. *Dams*: Lagunitas, Phoenix, Alpine, Kent, Nicasio (5) 2. *Levees*: Sir Francis Drake Blvd and Historic Railroad Grade (2) 3. *Floodplain Development*: Samuel P. Taylor State Park 4. *Levee*: Platform Bridge Road 5. *Bridges*: SFD at Platform and Pt. Reyes-Petaluma Road (2) 6. *Floodplain Development*: Sand Processing Plant 7. *Water Diversion*: Gallagher, Downey Well, and Coast Guard Wells (4) 8. *Water Diversion*: Genazzi Ranch 9. *Management*: Cattle in creek at Genazzi Ranch
Mainstem Bear Valley Creek	1. *Culverts*: Bear Valley Road, Levee Road, Former west outlet – Bear Valley Creek, Silver Hills drainage (4) 2. *Levees*: Bear Valley Road, Olema Marsh parking, Past Fill Placement in north portion of Olema Marsh near Levee Road, Levee Road, Past Fill Placement in White House Pool County Park (5) 3. *Management*: Dredge former west outlet at Bear Valley Creek 4. *Bridge*: Footbridge in White House Pool County Park 5. *Floodplain Development*: WHP park	1. *Levees*: Bear Valley Trail, Bear Valley Road (see Project Area), Limantour Road, Past Fill Placement on west side of creek (4) 2. *Culverts*: Bear Valley Trail, Rift Zone Trail, Vendanta Ranch, Red Barn Road, Visitor Center's Road (5) 3. *Water Diversion*: NMWD right, but no use 4. *Floodplain Development*: Seashore Headquarters Complex 5. *Creek Realignment*: Maintenance Yard 6. *Floodplain Development*: Maintenance Yard 7. *Management*: Dredged below Maintenance Yard
Tomasini Creek	1. *Water Diversions*: at north end near outlet to Tomales Bay 2. *Culvert*: Mesa Road 3. *Levees*: Mesa Road, Tomasini Creek berm, Past Fill Placement on North Side at RR Grade 4. *Bridge*: at Hunt Lodge 5. *Management*: Levee Maintenance 6. *Tidegate/Culvert*: at East Pasture North Levee	1. *Water Diversions* (2) 2. *Culvert*: Road crossing on tributary (3) 3. *Levee*: Ranch Road 4. *Dams*: West Marin Landfill Ponds (2), Livestock ponds (2) 5. *Culvert*: State Route 1 crossing
Fish Hatchery Creek	1. *Culvert*: Sir Francis Drake 2. *Floodplain Development*: Private Residence 3. *Management*: Dredging downstream of SFD 4. *Water Diversion*: Giacomini Ranch 5. *Management*: Maintain Creek Crossing 6. *Tidegate/Culvert*: at West Pasture North Levee 7. *Management*: Cattle in creek	1. *Water Right Diversions* (3) 2. *Culverts*: Vallejo Avenue road crossings of mainstem and tributary (5) 3. *Levee*: Vallejo Avenue 4. *Floodplain Development*: Homes (3) 5. *Bridge*: Driveway crossing of mainstem creek 6. *Floodplain Development*: Commercial and residential development near Sir Francis Drake Boulevard (15) 7.
1906 Drainage	1. *Culvert*: San Francis Drake 2. *Realigned Channel*: Private Residence 3. *Floodplain Development*: Private Residences (2) 4. *Culvert*: into West Pasture 5. *Realigned Channel*: West Pasture 6. *Management*: Dredging downstream of residence 7. *Floodplain Development*: Dredge spoil disposal area 8. *Management*: Cattle in creek	1. *Culvert*: Private Road Crossing 2. *Levee*: Private Road 3. *Floodplain Development*: Private residences (2) 4. *Realigned Channel*: Ditched on north side of Sir Francis Drake

The tidegates on Fish Hatchery Creek in the West Pasture reduce amplitude of both the low and high tides (KHE 2006a). The lowest water levels measured just inside the West Pasture in Fish Hatchery Creek are 3.25 feet NAVD88 (KHE 2006a). This attenuation continues as the stream gradient increases, with the lowest water levels measured on a tributary to Fish Hatchery Creek, the West Pasture Old Slough, at 4.0 feet NAVD88 midway through the West Pasture (KHE 2006a). The tidegates also truncate the upper portion of the tidal range, peaking at approximately 5.25 feet NAVD88 (KHE 2006a). In 2003, the tidegates on Fish Hatchery collapsed and began to erode the levee. During this period, the malfunctioning appeared to allow more even tidal exchange than occurred previously, including into large portions of the West Pasture freshwater marsh (See more detailed discussion under Giacomini Ranch and Water Salinity). After the tidegates were replaced in the fall of 2003, tidal exchange decreased again (KHE 2006a).

Fish Hatchery Creek tidegate

Circulation patterns in Fish Hatchery Creek are largely dictated by its shallow nature. Waters are usually shallow (<25 cm) and well-mixed or weakly stratified, although strong stratification occurs periodically within areas. This periodic stratification results from movement of the "salt wedge," or edge of tidal influence, landward over the season, as the volume of permanent freshwater flows decrease.

The West Pasture Old Slough is a tributary to Fish Hatchery Creek that appears to be a remnant historic tidal slough that has been converted in its upstream reaches into a ditch to channel seasonally high surface run-off from a seep on the Gradjanski property (Figure 27). It connects with Fish Hatchery Creek in the northern portion of the West Pasture, thereby leading to also have a muted tidal regime (Figure 27). The slough is typically well-mixed and strongly brackish to saline (~22.4 to 30 ppt) in the late summer and early fall and either well-mixed or strongly stratified, depending probably on tidal conditions and freshwater inflow, and during the winter, spring, and early summer, when water salinities are fresh to brackish (~0.2 to 21.8 ppt; Parsons, *in prep*.). Salinities are frequently higher in upstream reaches of the slough than in downstream reaches that are closer to the tidegate (Parsons *in prep.*). This pattern in salinities may reflect longer residence time of tidal waters that can extend into this reach, combined with potentially a backwater flooding effect such that lower salinity waters from Fish Hatchery Creek flow back up into the West Pasture Old Slough when seasonal freshwater flows in the slough decrease appreciably (Parsons, *in prep*.).

Tomasini Creek. Tomasini Creek is the primary tributary within the East Pasture of the Giacomini Ranch (Figure 27). As with Fish Hatchery Creek, the tidegate and flashboard dam structure on Tomasini Creek at its outlet to Lagunitas Creek at the north levee has been less than effective in eliminating tidal exchange (Table 7). The gate-dam structure truncates low tides or controls the extent of drainage during low tides to approximately 2.0-feet NAVD88, at least 1- to 2 feet above the deepest portions of the channel (KHE 2006a). However, similar to Lagunitas Creek, there was still substantial tidal exchange over the upper portion of the tidal range, with only minor reduction of the peak flood-tide water levels of less than 0.5-feet (KHE 2006a). Peak high tides within the diked portion of Tomasini Creek reach 7 feet NAVD88 (KHE 2006a). On some of these high tides, waters from Tomasini Creek flood into the East Pasture through a culvert in the Tomasini Creek berm into a borrow ditch that runs along the berm's western side (L. Parsons, NPS, pers. obs.). Monitoring of water levels near the Giacomini Hunt Lodge show tidally driven fluctuations in water level when high tide water levels exceed the base level of 4.5-feet NAVD88 (KHE 2006a).

Based on results of hydraulic and hydrodynamic modeling, the tidegate-dam structure did not appear to be the only feature that is acting to impound water (KHE 2006a). As with Lagunitas and Fish Hatchery Creek, several topographic features within the creek channel appear to be control low or minimum water levels – one between the tidegate and the Giacomini Hunt Lodge and one closer to Mesa Road (KHE 2006a). Close to Mesa Road, an extended debris and sediment jam that is just downstream of the Mesa Road culverts at a point where the creek gradient flattens appears to hydrologically disconnect the lower reach from the upper reach, at least during low flow conditions, thereby limiting water and tidal exchange. Surface water often disappears just below the debris jam during the late summer and fall until the creek reaches the Giacomini Hunt Lodge.

As with Lagunitas and Fish Hatchery Creeks, the creek appears to be well-mixed and largely fresh during the winter and early spring (NPS, unpub. data). Starting in late spring and extending through late fall, most of

the creek remains well-mixed -- or at least partially stratified -- but salinities are more brackish, varying both spatially and temporally along the creek, seemingly in response to tidal cycles and decline in surface and subsurface creek flow (NPS, unpub. data). The downstream end near the tidegate is typically well-mixed and brackish throughout the year. Just upstream, the creek is generally well-mixed or partially stratified, but occasionally becomes strongly stratified (NPS, unpub. data). During some of these periods when this reach is strongly stratified, bottom salinities exceed that of upstream and downstream (bayward) monitoring locations, suggesting that saline waters may be pooling in this section of creek, perhaps in response to an earthen sill or other topographic feature downstream. As with Fish Hatchery Creek, a "salt wedge" appears to move up the creek as freshwater inflows decline during the summer and fall. The advance of the "salt wedge" appears to be blocked by the debris and sediment jam south of Mesa Road, however. While early modeling results suggested that, based on creek gradient, tidal influence could extend as far as Mesa Road (KHE, unpub. data), creek waters near Mesa Road are always fresh and well-mixed (NPS, unpub. data).

Another factor that influences salinity in Tomasini Creek is the presence of perennial groundwater flow from the adjacent Point Reyes Mesa (KHE 2006a). Groundwater seepage may contribute to creek hydrology through run-off from hillside springs, seepage along the base of the Mesa, and subsurface groundwater inflow. Salinities simulated from modeling based on creek flows and attenuated tides, but not groundwater, suggests that the contribution from groundwater to the Tomasini Creek water budget may be considerable (KHE 2006a). Based on modeling, salinities near the Giacomini Hunt Lodge during the summertime with typical low summer flows should range from 20.5 to 25.0 ppt, but actual salinities recorded during monitoring by the Seashore show that salinities range from 15.0 to 18.0 ppt in both surface and bottom waters (KHE 2006a).

Giacomini Ranch. Tidal influence within the West and East Pastures has been significantly minimized through diking and tidegates (Table 7). However, leakiness of the Fish Hatchery Creek tidegate has enabled at least irregular tidal surface overbank flooding of the northern portion of the West Pasture and the northern and central portions of the West Pasture freshwater marsh, as well as depressional features in the central portion of the pasture that appeared to be remnant tidal channels.

West Pasture: Based on water level data collected within the marsh, tidal influence appears to occur in the marsh when tides in the diked area equal or exceed 5.25 feet NAVD88, the maximum tidal range currently permitted by the modified tidegate at the north levee (KHE 2006a). Currently, these tidal events are relatively infrequent and probably only occur when salinities in undiked areas exceed 6.25 to 6.5 feet NAVD88 (KHE 2006a). These extreme high tides occur sporadically throughout the year, but are highest between December and March, when they are often compounded by high volumes of freshwater flow from rainfall. Saltwater entering the freshwater marsh from the north end of the marsh appears to preferentially flow alongside Sir Francis Drake Boulevard before spreading through sheetflow to the central and eastern portions of the marsh, the lowest elevations within the marsh. Because the marsh is a highly vegetated depressional basin, drainage of tidal flows from the marsh does not appear to occur during low tides or even within days as flows recede, but rather to pond for perhaps as long as several months. A more detailed discussion of this occurs in Water Resources –Water Salinity.

East Pasture: The leakiness of the Tomasini Creek tidegate has also created some tidal influence within the diked pasture, albeit more indirectly. On some high tides, waters from Tomasini Creek flood into the East Pasture through a culvert in the Tomasini Creek berm into a borrow ditch that runs along the berm's western side (NPS staff, pers. obs.): these waters often overspill onto the pasture and have created essentially a sparsely vegetated, saline flat that is commonly used during the winter and spring by shorebirds and waterfowl. Some of these waters flow into the pasture's drainage ditch system, which is typically used for storing freshwater for irrigating the pastures during the summer. Otherwise, as with the southern portions of the West Pasture, direct tidal influence may be limited to large storm events that occur during extreme high tides (e.g., 1982 and 2006) that cause overbank flooding of levees into the pastures. Because of the difficulty in estimating waters that enter the East Pasture from Tomasini Creek episodically through this culvert, the very limited tidal prism that does exist currently could not be accurately estimated.

Limited areas of both the East and West Pasture that immediately border Lagunitas Creek also appear to have some very indirect tidal influence through hydraulic connectivity of the pastures' groundwater table with the rise and fall of tides in Lagunitas Creek (See Water Resources – Groundwater for more detailed discussion).

Olema Marsh and Bear Valley Creek. Olema Marsh once represented an integrated tidal marsh complex with the Giacomini Ranch (Figure 21). Tidal influence was believed to extend as far upstream on Bear Valley Creek as the park's administrative headquarters during extreme tide conditions. Construction of the levee

across the mouth of Olema Marsh in 1892 for construction of Sir Francis Drake Boulevard or Levee Road hydrologically disconnected the marsh from the Giacomini Ranch (Table 7). While the flow path of Bear Valley Creek through marsh has not remained constant in the intervening years, currently, the box culvert on the downstream end at Levee Road just before the creek's confluence with Lagunitas Creek acts as a grade control structure that reduces the range of tidal exchange into the marsh (KHE 2006a; Figure 27; Table 7). The culvert invert limits tidal exchange to those exceeding 4.5-feet NAVD88 (KHE 2006a). As with many of the other creeks, the culvert does not appear to attenuate or only minimally attenuates affect the upper portion of the tidal range (KHE 2006a). Prior to the 1998 flood, Bear Valley Creek apparently flowed out of a culvert underneath Levee Road that is on the western perimeter of Olema Marsh near the White House Pool County Park (Figure 27). Currently, this channel is disconnected from the marsh through a build-up of sediment between the marsh and the western culvert, and the culvert now only contains flows from the Silver Hills drainage, which has been redirected into a ditch on the south side of Levee Road. Because sediment deposition within the culvert has raised the elevation of its "bottom," tidal influence in the Silver Hills drainage channel would be limited to some of the highest high tide events, exceeding 6.9 ft NAVD88 (~ 7 ft MLLW; G. Kamman, KHE, pers. comm.).

Fluvial Surface Water or Fresh Water

Lagunitas Creek. The 83.1 square mile Lagunitas Creek watershed is the largest watershed in Tomales Bay (KHE 2006a). Two-thirds of the freshwater inflow to Tomales Bay comes from Lagunitas Creek and its tributaries (Fischer et al. 1996). Its tributaries, Olema Creek, Bear Valley Creek, and Haggerty Gulch, are located, from east to west, respectively, along the southern margin of the Project Area. Lagunitas Creek drains the Coast Range mountains located east and southeast of the Project Area (Figure 20). The watershed is underlain by a variety of Franciscan Complex rocks, mostly greywacke and metavolcanics.

Lagunitas Creek is a perennial system. The stream gradient of the creek within the Project Area is relatively flat. Other than the large bend to the west at the south end of the Project Area, its course is relatively straight and lacks sinuosity, as is common with fluvial-dominated deltaic systems. Considerable debate centers around the reason for the large, almost unnatural 90 degree bend in Lagunitas Creek near White House Pool: it may be due to the alluvial fan present near the Giacomini Ranch dairy or related somehow to the fault. The creek is strongly to moderately entrenched in the Project Area due to presence of the Giacomini Ranch levees and steep creek banks on the south side of Lagunitas Creek along Levee Road. East Pasture levees upstream of the old summer dam location range from 14- to 17-feet NAVD88 in height and drop to as low as 8- 10 feet NAVD88 at their northern end (KHE 2006a). Around White House Pool and the location of the old summer dam, the pastures are graded at levels equivalent to adjacent levees, at about 11- to 12 feet NAVD88 in elevation (KHE 2006a).

Much of the area between Levee Road and Lagunitas Creek was filled since construction of the original embankment for what is now Levee Road and is only slightly lower in elevation than the East Pasture levees (~10-11 feet NAVD88). Levee Road itself ranges from 13- to 15 feet NAVD88 in the residential area. The West Pasture levee ranges from 12-feet at the south end to 10-feet at its northern end (KHE 2006a). Beyond the Giacomini Ranch, Lagunitas Creek has formed natural alluvial levees along its creek bank that are considerably lower in elevation (~ 7.1 feet NAVD88; PWA et al. 1993). Despite these geomorphic constraints, Lagunitas Creek still overtops the levees and creek banks with varying frequency (see Water Resources-Floodplains for more discussion). These flows play an important role in sediment delivery and transport through the Project Area, as well as influencing channel, floodplain, and delta form (KHE 2006a).

While flow may be perennial, Lagunitas and other creeks still have flow patterns characteristic of systems in Mediterranean climates. Creek flow, measured at USGS gauging station near Pt. Reyes Station, averages 357 cubic feet per second (cfs) in February to as low 5.5 cfs in September (USGS 2004). During the severe drought of 1976-77, average monthly summer flow rates dropped to as low as 0.45 cfs (KHE 2006a). Flow is now regulated by the State Water Resources Control Board (SWRCB) through Decision 95-17, which has mandated minimum creek base flow at Samuel P. Taylor State park gage during the summer from storage reservoir releases of 8 cfs during normal rainfall years and 6 cfs during dry years. In November, minimum flow requirements increase to 20 and range between 16 to 25 cfs between November and April 30.

Lagunitas Creek inflow to the Project Area has been significantly altered by historic water development in the basin (KHE 2006a). Approximately 70 percent of the waters from this subwatershed are controlled by dams (PWA et al. 1993). A list of infrastructure and management practices affecting fluvial or freshwater creek processes in Project Area subwatersheds can be found in Table 7. Water development was initiated in the

Lagunitas Creek watershed with the construction of Lake Lagunitas in 1873 (350 acre-feet [AF] of capacity). This was followed by damming to form Phoenix Lake in 1905 (411 AF of capacity). Beginning in 1875, several water companies were created and provided water to the rural communities of Point Reyes Station, Inverness Park, and Olema (SWRCB 1995). Starting in 1955, flow from about 40 percent of the watershed area started entering six water catchment reservoirs (KHE 2006a). Reservoir construction and expansion continued through 1982 with the following facilities:

- ***Alpine Lake*** (1918) with a capacity of 3069 AF;
- ***Alpine Lake*** expansion to 4600 AF in 1924;
- ***Alpine Lake*** expansion to 8900 AF in 1941;
- ***Kent Lake*** (1953) with a capacity of 16,050 AF;
- ***Nicasio Reservoir*** (1960) with a capacity of 22,430 AF; and
- ***Kent Lake*** expansion to 32,900 AF in 1982.

The effect of these dams on hydrogeomorphic processes of Lagunitas Creek has not been specifically studied. However, in arid portions of the country, dams operated for water supply and/or flood control have resulted in a reduction in the frequency and strength of peak instantaneous flows, an increase in the duration of bankfull or ordinary high water flows, and a drastic reduction in summer low flows and gravel/sediment recruitment ((Fenner et al. 1985; Stromberg and Patten 1990; Johnson 1992; 1994; 1998); (Friedman et al. 1998). In additions, dams and levees often reduce the lateral migration rate of meandering systems (Johnson et al. 1971; Bradley and Smith. 1986; Rood and Mahoney 1990; Friedman et al. 1998). Recent studies on Lagunitas Creek have investigated possible problems with a "fining" of the sediment substrate and a reduction in sediment recruitment in the upper reaches downstream of the dams, which may be related to sediment trapping – particularly coarse sediments – by the dams (Stillwater Sciences 2004);. The dams may also be affecting the frequency and intensity of peak flows within the creek ((Stillwater Sciences 2004). As with many other river and creek systems, the effect of damming on the watershed has been compounded by other hydrologic alterations, including past mining of the floodplain terrace for sand (> 2 stream miles upstream from Project Area) and downstream appropriative and riparian water rights stream diversions by property owners.

The Giacominis undertook their own water development for the purpose of irrigating pastures. The following summary is excerpted from a SWRCB water rights hearing report for Lagunitas Creek (1995):

> *"Giacomini…graded and leveled the land, and used water from Lagunitas Creek to leach the salt out of the soil. Giacomini drilled two wells on the southwest portion of the property to obtain water; however, both wells produced water that was too brackish for irrigation. Giacomini then attempted to divert water directly from Lagunitas Creek at the most upstream location adjacent to his property; however, the tidal influence in Lagunitas Creek caused the water to become too salty about May, when the stream flow diminished. Since the mid-1940's, Giacomini has constructed an earthen dam in the creek to prevent saltwater intrusion and to provide freshwater for irrigation."*

The Giacominis diverted water from Lagunitas Creek under claim of a riparian water right (KHE 2006a). An appropriative water right license was also issued by the SWRCB in 1950. The riparian right lays claim to a maximum pumping capacity of 350 cfs year-round. The appropriated right is for 2.67-cfs between May 1 and October 1. In addition to maintaining a freshwater pool for diversion, the Giacomini summer dam ultimately ended up benefiting NMWD by preventing salt water from moving upstream of the Green Bridge during the summer and fall: NMWD constructed groundwater wells for municipal water supply directly upstream of Green Bridge in 1970. The summer dam was historically approximately 100-feet long, 10-feet high, and 60-feet wide at the base. It created a pond that was about 7-feet deep and extended about 1.75-miles upstream, inundating approximately 17 acres (SWRCB 1995). As part of SWRCB Decision 95-17, construction of the dam ended in 1997. The Giacominis now receive irrigation water (approximately 2-cfs during the May 1 through November 1 period) from the NMWD "Downey" well located approximately 0.9-miles upstream of Green Bridge (Table 7). When the Giacomini Ranch is turned over to the Park Service in 2007, irrigation of the pastures will cease, and 2.00 cfs will revert to Park Service management. The remaining 0.67 cfs of the Giacomini's original water right was purchased from the Giacominis by NMWD in the late 1990s.

Olema Creek. Only the mouth of Olema Creek falls within the Project Area, but a short description is provided, because of the creek's size and proximity to the Project Area. It flows directly into Lagunitas Creek just southeast of the Giacomini Ranch old summer dam location. The Olema Creek watershed is an elongated 14.7-square mile drainage basin occupying the San Andreas Fault zone immediately south of the Project Area

(KHE 2006a; Figure 27). Olema Creek is the largest tributary to the Lagunitas Creek subwatershed that is not dammed with the Lagunitas Creek confluence near the upstream boundary of the Project Area. The Olema Creek basin is approximately 9-miles long and 1- to 2-miles wide. Approximately 70 percent of the drainage area consists of runoff from the west flanks of Bolinas Ridge, while the remainder of the watershed occupies the eastern slopes of the Inverness Ridge. Within this basin, the Bolinas Ridge is underlain by Franciscan Complex bedrock, and the Inverness Ridge is composed of fine-grained marine sediments of the Tertiary-aged Monterey Formation (see Figure 20). A mixture of modern/historic alluvial, estuarine, and freshwater marsh deposits blankets the valley floor of this drainage.

Stream gradient of Olema Creek near the Project Area is relatively flat, with the creek following a rather straight – and, in some areas, braided – course. In recent years, the channel has aggraded considerably in its lower sections, causing the creek to jump out of its alignment of the past 80 years, and reestablish a distributary floodplain or network of secondary channels in Stewart Flat in the low-lying floodplains of Olema Creek between the town of Olema and Point Reyes Station. The creek appears to be moving closer toward historic conditions, when moderately sized riparian forests flourished along a somewhat sinuous Olema Creek, as shown in a map of the Berry grant produced in 1854 (Livingston 1995). This depiction is supported by a description by Schofield (1899) of Olema Creek as having banks that are "thickly grown with brush and trees. The last two miles of the creek run through low swampy land, with its banks most of the way heavily lined with willows." Some historical accounts also refer to an "Arroyo Olemus Lake" or Olema Lake, which most likely occurred at Stewart Flat (Niemi and Hall 1996). This "lake" may have been subsequently drained by construction of the Olema Canal, which straightened the section of Olema Creek between Olema and Lagunitas Creek (Niemi and Hall 1996). Currently, Olema Creek is bridged at Levee Road near its confluence with Lagunitas Creek.

The lower two-thirds of the Olema Creek watershed are perennial. The flow is sustained during the summer months principally by the perennial tributaries draining the Inverness Ridge. Tributary streams off the Bolinas Ridge are typically intermittent during the summer months. Streamflows during the winter runoff period, as determined at Olema, typically reflect baseflow conditions of about 5- to 10 cfs, with peak storm flows of several hundred to more than 1,000 cfs (Questa Engineering Corp. 1990). Because of the valley's linear nature, the watershed responds rapidly to rainfall events. Ketcham (1998) indicates that there is an approximate 3-hour lag time on Olema Creek between the onset of significant rainfall events and peak discharge. The estimated mean annual water yield for Olema Creek (at Bear Valley Road) is approximately 20,800 acre-feet (Questa Engineering Corp. 1990). This translates to an average annual flow of just under 29-cfs. However, seasonal flow variability displayed in monitoring data indicates summer baseflow rates ranged 0.1- to 1.0-cfs over dry to near-normal water year types (Questa Engineering Corp. 1990). There is also tidal influence on Olema Creek on the downstream 0.3 miles before it joins with Lagunitas Creek (B. Ketcham, Seashore, *pers. comm*., 2006).

Bear Valley Creek. Similar to Olema Creek, Bear Valley Creek occupies the San Andreas Fault zone valley. Within the fault zone, Bear Valley Creek is separated from Olema Creek by a 120-foot medial ridge composed of marine terrace deposits. Approximately half of the headwaters area of this 4.1-square-mile subwatershed is underlain by Monterey Formation sediments, while the other half lies atop granitic bedrock (KHE 2006a).

Hydrology of this watershed derives not only from surface runoff from the relatively steep upper watershed and more level floodplains in the Olema Valley, but from groundwater originating from the Inverness Ridge. The upper reaches of Bear Valley Creek and its tributaries are single-threaded, moderately entrenched sections that are characterized by a well-defined riparian corridor. These sections are constrained by the steep topography of ravines along Inverness Ridge and the historic ranch roads that are now being used for the Seashore's Bear Valley Trail. The lower portions of Bear Valley Creek consist of single-threaded or multi-threaded channels that are exceptionally shallow. Approximately 2,300 feet upstream of the Bear Valley Road berm, the stream channel becomes indistinct, dissolving into an open water marsh. The stream channel remains indistinct through Olema Marsh until just upstream of Levee Road, where a row of willows and alders marks its course through the Levee Road culverts and County White House Pool park to Lagunitas Creek.

Like the Inverness Ridge tributaries draining the Olema Creek watershed, Bear Valley Creek is a perennial system. No long-term flow monitoring has been completed in the watershed. However, a water supply study completed by the USGS in the mid-1960's does provide some estimates of late-summer creek baseflows or the amount of water in the creek once flooding from rains has ceased (Dale and Rantz 1966). This study indicates that, even though the Bear Valley Creek watershed is just over a quarter of the size of the Olema Creek watershed, summer baseflow rates (measured near Park Headquarters) are of a similar magnitude, ranging from 0.5-cfs during normal rainfall years to 0.25-cfs during dry year-types. The greater yield of Bear

Valley relative to Olema reflects the higher water-bearing properties of the deposits underlying the Inverness Ridge relative to the Franciscan complex material underlying ridges to the east of the San Andreas rift valley (KHE 2006a).

Construction of a road parallel to Bear Valley Creek to connect Point Reyes Peninsula with the town of Olema in the 1800s represented the first of many major infrastructure and management impacts that impacted the subwatershed (Table 7). During the 1800s, Bear Valley Creek was described as having numerous riffles and pools underneath a substantial riparian canopy. This fluvial system eventually flowed into Olema Marsh, which was then a large integrated tidal marsh complex with sinuous tidal sloughs (KHE 2006b). In 1892, a long, culverted berm was constructed across the mouth of Olema Marsh for Sir Francis Drake Boulevard or Levee Road. Following construction of Levee Road in the late 1800s- early 1900s, the creek was dammed by dairy ranchers in the 1920s. NMWD currently has a water right on Bear Valley Creek for diversion of 0.401 cfs between January 1 and December 31, but it is not currently used for water supply (C. DeGabriele, NMWD, *pers. comm*.). Based on a 1942 photo, this area appears marshy and heavily grazed, and there is little riparian vegetation until the creek approaches Olema Marsh. A number of culverted berms were built for Bear Valley Road and the ranch roads in the upper portion of the watershed, all of which affected hydraulic connectivity and sinuousity. The original road from Olema to the Point Reyes Peninsula was eventually replaced with Bear Valley Road and Sir Francis Drake Boulevard. Limantour Road was constructed after World War II. In the 1970s, the Seashore moved a portion of Bear Valley Creek channel for construction of the maintenance facility yard and buildings. By the early 1980s, maintenance dredging for flood control purposes had led to the middle and lower reaches of Bear Valley Creek becoming deeply incised, with the creek bottom roughly 6-8 feet below the floodplain terrace bank at the Seashore's maintenance yard (KHE 2006b).

In 1982, Bear Valley Creek changed dramatically as a result of the New Year's Day floods. Catastrophic debris flows originating from the unstable weathered granite of the Inverness Ridge flowed through tributaries into the mainstem of Bear Valley Creek, choking the former channel, scouring existing road/trail facilities, and turning the colluvial valley bottom into a sandy, braided stream channel with extensive woody debris jams that acted to temporary dam and pond waters within the channel. Storm clean-up resulted in some of the excavated sediment being placed in the floodplain and possibly on the northern edge of Olema Marsh adjacent to Levee Road (Table 7; KHE 2006b). The State Coastal Conservancy provided funding to Audubon Canyon Ranch in the 1980s for an enhancement project, which consisted principally of using drag-lines to create small, unvegetated ponds in Olema Marsh, some of which still persist today. During the 1998 El Nino events, similar small-scale landslides and hillslope failures were observed throughout the Bear Valley Creek watershed. Sediment deposition during the 1998 flood also precipitated a change in channel course for lower Bear Valley Creek from the west to the east side of Olema Marsh. Since 1982, the County of Marin has also diverted one of the larger drainages to Olema Marsh, Silver Hills, to run alongside Levee Road and flow out of the historic outlet on the west side of the marsh.

While Olema Marsh has been heavily impacted by road construction, long-term water level monitoring in Olema Marsh and lower Bear Valley Creek show that conveyance capacity of the Bear Valley Road culverts is still sufficient to pass most streamflows without problems such as backwater flooding (KHE 2006a). Culverts at Bear Valley Road consist of two 6-foot diameter culverts that have a conveyance capacity of 600 cfs (KHE 2006b). However, water levels in Olema Marsh are dramatically higher than the elevation of the downstream 6-foot by 7-foot box culvert at Levee Road, indicating water impoundment and poor hydraulic connectivity between Olema Marsh and downstream Lagunitas Creek (KHE 2006a). The minimum water surface elevation recorded during baseline studies (8.4-feet NAVD88) in Olema Marsh is almost 4-feet higher than the minimum or base water level elevation recorded immediately upstream of the Levee Road culvert (KHE 2006b).

Outflow appears to be limited by several factors (Table 7). As noted earlier, the 1998 storm caused Bear Valley Creek to migrate from a well-defined channel on the western side of the marsh to a more amorphous, ill-defined flow path on its eastern edge, and sedimentation essentially blocked off the western outlet (KHE 2006b). Blockage of the western outlet reduced the available surface area for potential flow conveyance from the marsh from 106 square feet to 42 square feet, which translates into a reduction in conveyance capacity from approximately 630 - 700 cfs to 410 cfs (KHE 2006a). A 5-year flood event produces approximately 490 cfs in Bear Valley Creek (G. Kamman, KHE, *pers. comm*.). In addition, outflow is also severely reduced by an approximately 315-linear-foot earthen berm hardened by heavy vegetation establishment on the east bank of lower Bear Valley Creek just upstream of Levee Road (KHE 2006b). Problems with conveyance of flows at Levee Road have caused backwater flooding that has increased water levels, as well as in lower Bear Valley Creek (KHE 2006a). Based on a comparison of water levels and culvert submergence conditions at Bear Valley Road in 1990 (Evans 1990) and 2005 (KHE 2006b), standing water levels during the summer appear to have increased approximately 6 feet since 1990, which predated the 1998 flood event and migration of the

Bear Valley Creek channel in Olema Marsh (KHE 2006b). Impoundment in Olema Marsh has also resulted in an increase in water surface levels in the Bear Valley Creek marsh directly upstream of Bear Valley Road. Water levels within Olema Marsh (and Bear Valley Creek Marsh) are predicted to continue to increase, which could have a considerable effect on the potential for flooding during storms of Levee and Bear Valley Roads, which are frequently flooded even during smaller storm events.

Tomasini Creek. The Tomasini Creek watershed is over 3.5-miles long, averages 0.75-miles wide, and has an estimated drainage area of 3.3-square miles (KHE 2006a). The upper two-thirds of the watershed consist of Franciscan complex bedrock; the lower third drains lands built on marine terrace deposits that underlie the Point Reyes Mesa (KHE 2006a; Figure 20). Upstream of Mesa Road in property owned by the county as an open space easement, the creek flows down a moderately sloped section of the Tomasini Creek valley in a shallowly entrenched, albeit well-defined channel through a broad riparian zone until it reaches the road, where backwater flooding from undersized culverts and an abrupt change in creek gradient has caused the creek to broaden and become marshy (Table 7). The creek enters the eastern side of the Project Area through a pair of 6-foot diameter circular steel culverts underneath Mesa Road. From there, the stream gradient flattens considerably, encouraging deposition of sediment and debris that has created a blockage that reduces hydraulic connectivity between upstream and downstream reaches.

Tomasini Creek is contained within a leveed channel along the eastern border of the Project Area to its outfall with Lagunitas Creek near Railroad Point or the north levee of the East Pasture (Table 7). This outfall consists of a 22-foot-wide concrete weir containing a line of four 3-foot-diameter circular culverts equipped with one-way tide gates on downstream ends (KHE 2006a). The Tomasini Creek levee was constructed sometime between 1955 and 1960 (KHE 2006a). This levee was constructed to divert Tomasini Creek out of its natural channel alignment, which meandered through the East Pasture. Review of available historic aerial photographs from 1942 and 1943 indicate that, prior to construction of the current levee, the Giacominis may have attempted to redirect Tomasini Creek in a southward direction along the base of the Mesa below the Giacomini Dairy Facility and through the Green Bridge County Park to an outfall point into Lagunitas Creek opposite Olema Creek (KHE 2006a). The historic outlet of Tomasini Creek into the former marsh floodplain is visible in the 1942 photograph as a sizeable alluvial fan (KHE 2006a).

No flow monitoring has been completed on Tomasini Creek. However, flow characteristics (if not totals) for this drainage are likely similar to those on Walker Creek in the northern portion of the Tomales Bay watershed (KHE 2006a). Based on USGS flow records for Walker Creek, winter runoff characteristics in the Tomasini watershed are probably flashy (i.e., very short lag time between rainfall and runoff) and likely similar in magnitude, per unit area, to those in the lower Lagunitas Creek watershed (KHE 2006a). The flashiness of this system is supported by the Giacominis, who attested to the propensity for Tomasini Creek to have high-intensity, short-duration storms that cause significant flooding, particularly in combination with high tides (KHE 2006a). The largest difference between this drainage and others in the Project Area is that summer baseflow rates are much lower per unit area (KHE 2006a). As with Walker Creek, Tomasini Creek does dry down during average and drier years in late fall (NPS, unpub. data), with sustained year-round flows only occurring during wet-year types. However, groundwater springs and seeps within the Point Reyes Mesa terrace deposits may contribute significantly to the creek base flow during summer and fall, maintaining perennial flow and brackish salinities, at least in downstream reaches (See Water Resources – Groundwater).

Similar to other creeks within the watershed, water is extracted from Tomasini Creek through at least three water rights agreements, primarily during the winter for off-creek storage (Table 7). One of these water rights, which covers storage of 12 acre-feet per year between October 1 and April 1, was transferred to the Park Service with purchase of the Martinelli Ranch. In addition, the creek may be negatively affected by the presence of the now-closed West Marin Landfill within its watershed: the landfill is apparently inundated on occasion by overbank flooding during high flows and may therefore potentially decrease downstream water and sediment quality (Table 7). This issue is discussed in greater detail under Soil Resources and Water Resources – Water Salinity and Quality.

Fish Hatchery Creek and Inverness Ridge Drainages. There are four small watersheds draining Inverness Ridge, which enter the Project Area between White House Pool and the North Levee (Figure 27). These drainages include (from south to north): Haggerty Gulch (1.7-square miles); Fish Hatchery Creek (0.9-square miles); the “Creek 2 or 1906 Drainage” (0.2-square miles); and the “Unnamed Tributary” (less than 0.1-square miles; KHE 2006a). Names for the latter two drainages came from a 1917 National Geodetic Survey map (KHE 2006a). All of these drainages are underlain by weathered granite, and each displays

perennial flow and copious winter sediment production. On a per unit area basis, the amount of runoff from each of these small watersheds is similar to that for Bear Valley Creek (KHE 2006a).

All of these drainages are characterized by steep to extremely steep stream gradients as waters flow down ravines on the Inverness Ridge. Within the Project Area, the gradient abruptly flattens, representing active depositional fans. In 1899, Schofield noted that Fish Hatchery Creek was "at first fed by springs and (runs) through cool shady woods,….but on gaining the open valley," it runs through two miles of marshy lowlands. Flows currently enter the Project Area through culverts underneath Sir Francis Drake Boulevard (Table 7). Haggerty Gulch discharges directly into Lagunitas Creek at White House Pool through a 4-foot-diameter circular steel culvert (KHE 2006a; Figure 27), which appears to be at least contributing to some bank erosion and possible undercutting of the Sir Francis Drake Boulevard road base (Land People 2005). All other drainages flow into the West Pasture or private properties on the east side of Sir Francis Drake Boulevard.

Fish Hatchery Creek enters the Project Area on the north side of the Gradjanski property where it flows to the central portion of the West Pasture (Figure 27). The channel near Sir Francis Drake Boulevard has been frequently dredged to remove sediments deposited during storms by the Giacomini family (Table 7). The channel passes through the West Pasture north levee in a pair of recently replaced 3-foot-diameter circular steel culverts equipped with modified tidegates on the downstream side (Table 7). These flap gates are propped open slightly to permit limited two-way exchange between undiked portion of Fish Hatchery Creek and the West Pasture. As with Lagunitas and Tomasini Creeks, water is extracted from Fish Hatchery Creek through at least four water rights agreements, primarily through direct diversions. NMWD has a water right for 0.666 cfs between January 1 and December 1, and the Giacomini family has a water right for 0.5 cfs between April 1 and December 1.

After crossing under Sir Francis Drake Boulevard, the "Creek 2 or 1906 Drainage" channel crosses through the Lucchesi property and discharges into the West Pasture (Figure 27; Table 7). After flowing through a concrete box culvert, the creek makes a roughly 90 degree turn that funnels flow directly into the south end of the West Pasture freshwater marsh. As with Fish Hatchery Creek, the 1906 drainage requires near-annual maintenance to remove accumulated sediment and reduce flood hazards to adjacent properties. The chronic flooding at these properties is driven by channel infilling with granitic alluvium eroded from the Inverness Ridge with subsequent increase in water levels during storm events due to aggradation of the channel bed (KHE 2006a). Flooding impacts are discussed more under Public Health and Safety – Flooding. The 1906 Drainage flows into central southern portion of the marsh, after which it appears that flow largely follows topographic gradients into the depressional basin in the lower-elevation central and eastern portions of the marsh. This depressional basin has formed in response to higher elevations to the west (base of Inverness Ridge), east (West Pasture), and south (1906 Drainage alluvial fan).

The "Unnamed Drainage" has been observed flowing from a culvert in Sir Francis Drake Boulevard into a densely wooded riparian area on the east side of Sir Francis Drake Boulevard and then discharging into a remnant road-side drainage ditch (Figure 27). The water then flows north into Fish Hatchery Creek, just upstream of the north levee culverts. The subtle swale that constitutes this remnant roadside ditch appears to be the dominant water conveyance feature on the west side of the West Pasture freshwater marsh (KHE 2006a).

Another small drainage occurs in the southern portion of the West Pasture (Figure 27). This seasonal creek is also culverted underneath Sir Francis Drake Boulevard and has been ditched to connect with an existing low spot marked by a stand of arroyo willow (*Salix lasiolepis*) near the center of the pasture).

Interior Drainage Ditches and Remnant Slough Features. In the West Pasture, a small drainage appears at the southeastern corner of the Gradjanski property that flows eastward before turning north parallel to Sir Francis Drake Boulevard and eventually connecting with Fish Hatchery Creek near the north levee culvert. As was discussed earlier, this drainage, called the West Pasture Old Slough (Figure 27), appears to be the remnant of a historic tidal slough that has been ditched by the Giacomini family in its most upstream reaches to channel surface run-off from seasonal seeps or springs on the Gradjanski property. The southern portion of the Gradjanski property near this ditch is extremely marshy and appears to be wet for most of the year, although surface flows are only present in the most upstream portion of the slough for one to two months after spring rains end, typically drying up by March or April of each year (Parsons, *in prep*.).

The East Pasture contains a much more elaborate and extensive drainage ditch network to direct surface run-off and deliver and drain irrigation waters applied to the pastures (Figure 27). Historically, water was diverted

from Lagunitas Creek near the upstream end of the East Pasture in the summer after installation of the earthen dam. Currently, the Giacominis are receiving irrigation waters from NMWD's Downey Well, with the waters being piped to the Ranch. Some of the drainage ditches in the East Pasture appear to be former slough channels that have been straightened, with the exception of the northern portion of the largest drainage channel, called the East Pasture Old Slough, which still retains a prominent relict meander. There are two discharge points for drainage ditch waters: a pump-house on the east bank of Lagunitas Creek and three 4-foot-diameter circular steel culverts equipped with one-way tidegates at the northern end of the East Pasture Old Slough. While relatively high salinities in the ponded area adjacent to the tidegates would suggest that these gates are leaky, floodwaters often pond in the northern portion of the East Pasture longer than the West Pasture, which may indicate that these gates and the culvert are not effectively allowing waters to move out.

Irrigation waters are spray-irrigated in a large percentage of the northern portion of the East Pasture, with flood irrigation methods used for the southernmost pastures. Some pastures do not appear to be actively irrigated during the summer, probably because soil salinities are consistently high enough even with irrigation to preclude establishment and maintenance of pasture. In the past, the Giacominis used some of the drainage ditch waters to artificially flood the New Duck Pond and create conditions conducive to use by waterfowl. In addition to irrigation on the East Pasture, the standard dairy practice also includes spray irrigation of liquid waste from the manure ponds. The waste spraying occurs in the summer months within the East Pasture.

Groundwater

Tomales Bay. In addition to tidal and fluvial surface water, the other major hydrologic source to the Project Area is groundwater. According to Oberdorfer et al. (1990), groundwater flow accounts for less than 1 percent of the freshwater in the watershed, but it undeniably influences the hydrology and biology of this and other coastal California watersheds. Within the Tomales Bay watershed, groundwater substantially increases hydrologic complexity within wetland ecosystems by replacing the traditional upland to wetland cross-sectional transition common of most salt marsh systems with a freshwater to saltwater transition. Within many Tomales Bay subwatersheds, salt marshes are fringed with freshwater, brackish marsh, or riparian habitat due to the influence of seeps and springs along most of their perimeter (Parsons et al. 2004). Seeps and springs form the headwaters for many of the small drainages that flow to the Bay (Parsons et al. 2004).

The prevalence of these hydrologic sources within the Point Reyes area relates directly to the geologic complexity of this unstable region, with lateral and vertical movement along the San Andreas Fault fracturing basement rock and enabling underground aquifers to connect with the ground surface. However, certainly in more developed areas, groundwater and seep flow has probably been augmented to some degree by leaking septic systems, as many of the systems within Tomales Bay are antiquated and in need of repair or modernization (TBWC 2002).

East Pasture. Within the East Pasture, groundwater generally flows from south to north on a northwest gradient, largely following the northwest trend of the rift valley that probably imparts a strong parallel groundwater flow pattern similar to other fault-derived flow paths (KHE 2006a). In general, the groundwater gradient mimics the topography of the East Pasture, except in the very northern portion where the flatness of the pasture disconnects the groundwater table from surface topography (KHE 2006a). The lowest portion of the East Pasture is actually in the northeastern corner.

Groundwater was not included in the hydrodynamic model developed by KHE, however, groundwater depths were monitored regularly through shallow groundwater monitoring wells. These data show that a very shallow groundwater table exists throughout most or all of the year (KHE 2006a), with water depths being closer to the surface in the northern, lower elevation portions of the East Pasture. This groundwater table may originate from water-bearing alluvial deposits or layers within the Point Reyes Mesa (KHE 2006a), the adjacent coastal marine terrace formation that consists of non-marine and marine sand, gravel, silt and clay layers (Galloway, 1977; Clark and Brabb, 1997). Past development of small-scale groundwater wells for private use on the Point Reyes Mesa for residents has uncovered several water-bearing layers within this terrace, one of which is at approximately Mean Sea Level or roughly at the same elevation as the northern portion of the East Pasture (G. Ferrando, Point Reyes resident, *pers. comm. in* KHE 2006a). The depth of this groundwater table, as well as the potential for presence of an aquifer beneath the East Pasture, is constrained by the stratigraphy of the East Pasture, which is underlain by deep estuarine clays of low organic content, low permeability, and low groundwater storage capacity that act as aquitards or barriers to groundwater exchange (KHE 2006a).

This factor strongly argues against the possibility of freshwater aquifer of any significant thickness, lateral extent, or storage capacity beneath the East Pasture (KHE 2006a).

Groundwater depths are not always consistent with the topography. The emergent of hillside springs or seep flow from the base of the Point Reyes Mesa contributes another layer of hydrologic complexity (Figure 27). These seeps and springs have promoted establishment of dense riparian scrub and marshy areas on the edges of the Mesa or even on its slopes, which are visible in 1942 photographs of the Project Area. The Giacominis have dredged ditches at the base of the Mesa in many areas to reduce flooding of pastures from groundwater. The source of these seeps and springs is undoubtedly one of the shallower water-bearing alluvial layers that have been documented by groundwater well development in the Point Reyes Mesa terrace. Natural groundwater influences have probably been augmented to some degree by septic systems from the relatively densely populated developments on the top of the Point Reyes Mesa and, in some areas, by non-point source run-off from the town of Point Reyes Station. The relative contribution of septic influences to groundwater cannot be determined, but some limited water testing by the Seashore did detect Methlyene-Blue Active Substances (MBAS) in low concentrations at several locations around the perimeter: MBAS is a constituent of surfactant detergents and a fairly reliable indicator of septic or sewer influence (NPS, unpub. data). Interestingly, much of the West Pasture freshwater marsh appears almost to be completely tidal marsh in 1942, when this area was not diked, which potentially suggests that there has been a substantial increase in localized freshwater flow in this particular area of the West Pasture.

Some of the most evident seeps and springs in the East Pasture and vicinity occur on 1) the riparian habitat and seasonal wetland on eastern perimeter of Green Bridge County Park; 2) seasonally flooded pasture and riparian scrub on the southern slopes of the dairy mesa facility; and 3) seasonally flooded pasture, freshwater marsh ditch, and riparian-marsh scrub on the northern slope of the dairy mesa facility. The most and noticeable area with seeps and hillside springs is the section of the Point Reyes Mesa north of the Giacomini Hunt Lodge and south of Railroad Point. Surface run-off of hillside springs, combined potentially with groundwater emergence at its base, have not only created an extensive riparian scrub or Mesic Coastal Scrub community (see Vegetation Resources) on the face of the "bluff," as it is known, but appears to contribute to some degree to base flow within Tomasini Creek. Most importantly, groundwater inflow may buffer increased salinities within Tomasini Creek, which has become tidal again since failure of the tidegate, and thereby benefit the federally endangered tidewater goby, a brackish water species.

While the groundwater table underlying the Point Reyes Mesa would be considered "fresh," groundwater within the East and West Pastures is saline, with salinities ranging from 2 ppt (brackish) to as high as 40 ppt (hypersaline; NPS, unpub. data). Even the highest elevation area of the East Pasture that appears to be strongly influenced by groundwater from the Mesa had salinities as high as 5-6 ppt, which is brackish (NPS, unpub. data). Research conducted on the groundwater aquifers within the Point Reyes Station area have documented elevated chlorides, an indicator of salinity, in groundwater, even during the winter (Questa Engineering Corp. 2001: Affordable Housing). However, groundwater within the East Pasture displayed an ionic composition more characteristic of marine systems than that of the local aquifers or that would be expected from the presence of cattle and other agricultural practices such as manure spreading (NPS, unpub. data). Salts observed within groundwater, then, appear to be marine salts that were trapped within sediment during deposition prior to diking of the pastures (KHE 2006a). These salts are bound tightly to clay sediments and apparently leach into the groundwater table when it is contact with the clays. As noted earlier, early attempts by the Giacominis to use groundwater from two wells installed at the southeast portion of the East Pasture for irrigation failed due to poor water quality (SWRCB 1995).

As was noted earlier, limited portions of the East Pasture bordering Lagunitas Creek appear to have a hydraulic groundwater connection with the creek that causes shallow groundwater within these portions of the pasture to move up and down to some degree with tidal cycles (KHE 2006a). Although soils in these areas contain very porous coarse alluvium, there does not appear to be movement of water through the soils between undiked and diked areas, but rather that pressure from the tides creates a corresponding hydraulic pressure on the shallow groundwater table within the pasture (KHE 2006a).

West Pasture. Although limited monitoring was conducted in the West Pasture, as with the East Pasture, the general groundwater gradient in the West Pasture appears to run from south to north, again following the general topography and creating higher water levels within the very northern portions of the pasture. This groundwater gradient is overlain by the west to east groundwater gradient established by seeps, springs, and small drainages flowing off or emerging from the base of the Inverness Ridge (Figure 27).

The influence of seeps and springs is more pervasive along the West Pasture perimeter than the East Pasture one, as evidenced by the thin strip of arroyo willows that fringe the pasture along almost its entire length adjacent to Sir Francis Drake Boulevard. Flooding duration varies depending upon location along the perimeter, with some areas saturated to the soil surface for a brief time, while others are wet either permanently or seasonally throughout the winter and spring. There are at least four sizeable areas that are defined by groundwater influence. Two are south of the Gradjanski property and flood for an extended period during the winter and spring. The third occurs between the Gradjanski and Kostelic residences near Fish Hatchery and is flooded or saturated for an extended period. The fourth is the West Pasture freshwater marsh, which floods from groundwater as well as from creeks (1906 Drainage, Unnamed Drainage) and occasionally tidal incursions. As with the creeks, groundwater flow to the marsh appears to be perennial, with much of the flow at least initially routed into an old drainage ditch alongside Sir Francis Drake Boulevard that has not been maintained for some time.

Stormwater Run-Off Sources for Project Area

Another source of hydrology for the Project Area is non-point source discharge run-off from adjacent communities and developments (Figure 27). The Project Area is bordered by two towns and at least three developed areas – Point Reyes Station, Levee Road, and Inverness Park. While some non-point discharge probably occurs from roadside run-off on Sir Francis Drake Boulevard and Levee Road flowing into the West Pasture and Olema Marsh, respectively, larger non-point source discharge occurs from at least three locations in the East Pasture and Tomasini Creek. One shallow ditch conveys run-off from the southern portion of the town through the Green Bridge County Park to a discharge location on Lagunitas Creek just upstream of the Giacomini Ranch. Another ditch conveys run-off from the central and western portions of town to the north-facing portion of the Dairy Mesa facility, where run-off flows down a vegetated swale into the Tomasini Triangle pasture at the eastern edge of the East Pasture. This ditch runs directly next to one of the unvegetated feedlots for young heifers or cattle run by the Giacomini Ranch and probably receives run-off from this lot during storm events. A third ditch parallels Mesa Road in a vacant lot west of the road and eventually joins with Tomasini Creek just after it flows underneath Mesa Road. Flow patterns for these discharges are unknown, but almost all of them are dry by summer, with the possible exception of the one at the Green Bridge County park, which has flow perennially. Groundwater flow from the bottom of the Point Reyes Mesa appears to be channeled into this ditch, as well, possibly explaining the extension of flows beyond the winter and spring rainy season.

Water Resources – Floodplains

As noted earlier, one of the more important hydrologic functions that wetlands and streams play is floodwater retention and dissipation of flood flow energy. This function results from the ability of creeks and bays to be able to move onto their floodplains during periods of high water. Many of these floodplains are vegetated, which helps to slow down flood waters, as well, by a providing a source of “roughness” or resistance. This dissipation of flood flow energy and retention of floodwaters not only benefits humans, but wildlife. This section specifically addresses hydrologic processes related to flooding and access to floodplains within the Project Area. Detailed information on flooding and floodwater retention capabilities of floodplains related to human safety and protection of property is discussed later in this chapter.

One of the more important hydrologic functions that wetlands and streams play is floodwater retention and dissipation of flood flow energy. This function results from the ability of creeks and bays to be able to move onto their floodplains during periods of high water.

For optimal performance of these functions, wetlands and streams should be physically connected to their floodplains and have an intact riparian corridor. The largest creek within the Project Area is Lagunitas Creek, whose floodplains represent almost the entire 550-acre Giacomini Ranch property. As noted earlier, Lagunitas Creek has been subject to a number of hydrologic alterations that could affect flooding. Construction of five dams in the upper watershed has undoubtedly altered flood flow structure. Typically, dams reduce the frequency and duration of instantaneous peak flows, while increasing the duration of bankfull or ordinary high water flows (Fenner et al. 1985, Stromberg and Patten 1990, Johnson 1992, 1994, 1998, Friedman et al. 1998). Within the Lagunitas Creek watershed, the dams are operated specifically for water supply. Except for the mandated flow releases (SWRCB Decision 95-17), the reservoirs are operated to fill, and then spill. In general this means that drainage area during earlier events is limited to the undammed portions of the watershed. Once the reservoirs are full, they pass peak flows through. The effect of the dams on flooding is specifically tied to the timing of the storm event. If the event occurs early in the season, when reservoirs are filling, flooding would be dramatically reduced. If the event occurs after the reservoirs are full, the dams would not change flooding scenarios. In all cases, however, the dams do change the pattern of sediment supply and transport through the watershed. During dry years, the dams reduce the overall level of downstream flooding through increased reservoir retention of flood flows.

In the Project Area, Lagunitas Creek has been disconnected from its floodplains by the 8- to 17-foot levees that have been constructed along its perimeter, which has created a strongly to moderately entrenched creek along this reach and reduces the ability of the creek to connect with its floodplain. During 2-year flood events -- or floods of a magnitude that occur, on average, every 2 years or some recurrence interval greater than that – levees are high enough to preclude the East Pasture from being flooded by Lagunitas Creek. Hydraulic modeling results show that, during 2-year flood events, inundation area totals only 2 acres, and standing water volume totals only 2 acre-feet, most of which comes probably from precipitation and surface run-off (KHE 2006a). Flood recurrence was modeled using extreme flooding conditions, combining both high flood flows and extreme tides (6.0 feet) such as occurred during the 1982 flood (KHE 2006a). In the West Pasture, inundated area (76 acres) and standing water volumes (62 acre-feet) are larger than the East Pasture even under conditions when levees are not overtopped by Lagunitas Creek (<12.5 year flood event), because of surface flows from Fish Hatchery Creek and other small drainages (KHE 2006a). In Olema Marsh, standing inundation volume totals 202 acre-feet during a 2-year event, with most of that water coming from Bear Valley Creek, because poor hydraulic connectivity and the large standing water volume in the marsh greatly reduce the potential of Olema Marsh to provide off-channel floodwater storage for Lagunitas Creek (KHE 2006a).

During 2-year flood events, then, almost all of Lagunitas Creek flood flows remain in the channel, greatly increasing flood stage or the vertical height of flood flows. Hydraulic modeling suggests that, under a 2-year event, peak flood flows in the Project Area could reach as high as 8.2 feet, because of the lack of floodplain storage (KHE 2006a). The cumulative volume of water that could move through the Project Area in Lagunitas Creek under a 2-year event totals approximately 437.8 million cubic feet of water based on hydraulic modeling estimates (KHE 2006a). The lack of floodplain storage not only increases the stage and volume of water in Lagunitas Creek under 2-year events, but exacerbates the erosion potential of flooding, because floodplains dissipate the erosive energy of flood flows. Streamside riparian vegetation can reduce flood flow energy, but 60 to 70 years of levee maintenance has limited the amount of riparian growth, at least along the Giacomini Ranch levees.

Despite levees, overbank flooding does periodically occur (KHE 2006a). Hydraulic modeling indicates that the East Pasture creek bank upstream of White House Pool near the old summer dam location is overtopped by approximately a 3.5-year flood or greater (KHE 2006a). During 5-year flood events, inundated area and standing water volume increases greatly, with acreage increasing from 2 to 249 acres and standing water volume increases from 2 to 611 acre-feet (KHE 2006a). Under successively larger flood flows, inundation area steadily increases, with standing water volume increasing to 2,818 acre-feet in the East Pasture and 450 acre-feet in the West Pasture during a 100-year flood event or flood with a similar magnitude to the 1982 event (KHE 2006a). Comparatively, standing water volume in the 66 acres of Olema Marsh that are inundated during a 100-year flood event averages approximately 544 acre-feet (KHE 2006a). During 100-year events,

flood stage or vertical height of flood flows in Lagunitas Creek is only slightly higher (~ 12.5 feet) than under a 2-year event (8.2 feet), because flood flows are being shunted into the East and West Pastures, thereby relieving flood pressure in the creek itself (KHE 2006a). Based on computer simulations, water levels could reach as high as 13.1 feet in the East Pasture and 9.8 feet in the West Pasture during 100-year flood events (KHE 2006a). From modeling 100-year flows, it is apparent that the West Pasture can absorb only a fraction of the floodwaters that move through the East Pasture (~3.2 percent) and Lagunitas Creek (~1.4 percent; KHE 2006a).

During flood events such as these in which overtopping occurs, water levels within Lagunitas Creek build in vertical height or stage until they exceed the height of the levees, at which point they overtop and flood into the East and West Pastures. Once waters flow into the leveed pastures, the pastures fill rapidly to a maximum standing water volume, where floodwater persists for some time as they slowly drain through the only outlets, which are the concrete spillway and tidegate/culvert (West Pasture only). The southern portions of the East and West Pasture drain quickly, but, during larger storms, floodwaters can remain ponded within the northern portions of the pastures for more than a week, because elevations are lower in these areas than the concrete spillways.

The Levee Road Lagunitas Creek bank floods, on average, during 3-year or greater flood flows (KHE 2006a). While the difference may not seem dramatic, the section of the East Pasture that was modeled is one of the lower elevations areas along the south bank (10-11 feet). Upstream of this location, the levee resumes, and the crest height is 14- to 17-feet, with overbank flood recurrence intervals correspondingly increasing in this area to between 50- and 100-year storm events (KHE 2006a). These results suggest that the height of the Giacomini Ranch East Pasture levee and creek bank effectively places higher flood pressure on Levee Road and the 15- to 20 homes built along the creek's edge (KHE 2006a).

Downstream of White House Pool, flood frequency drops, probably because the creek widens, thereby decreasing stage height or height of flood flows relative to the narrow creek section upstream of White House Pool for floods with the same frequency. While the East Pasture levee downstream of the cattle crossing location is lower in elevation than the one near the old summer dam, flood flows only overtop the levee in this area during a 7-year event (KHE 2006a). The West Pasture levee is also lower in elevation than the East Pasture one, ranging from only 10- to 12-feet high, and, yet, the West Pasture is only flooded by Lagunitas Creek when flood events are quite large (≥12.5-year flood recurrence interval; KHE 2006a).

Lagunitas Creek's floodplains overlap considerably with those of the two other primary tributaries to the pastures – Fish Hatchery and Tomasini Creeks. With the exception of some limited dredging, Fish Hatchery Creek is a very shallow system with relatively intact floodplains. Floodplains are defined by the higher elevation perimeters of the West Pasture along its western and eastern edges. Conversely, Tomasini Creek has been entirely disconnected from its floodplain through construction of a berm. No information is available on how often this creek might overtop its berm, which varies in height near the Giacomini Hunt Lodge from 8 to 12 feet NAVD88, but overtopping events were not observed during 2001-2005. In late 2005-2006, a winter storm-extreme high tide event in January estimated as an approximately 30-year event appears to have breached and overtopped the berms and caused some erosion near the Giacomini Hunt Lodge. According to the Giacominis, the section of levee near the Giacomini Hunt Lodge is the most susceptible to erosion and breaching by Tomasini Creek (KHE 2006a). Currently, Tomasini Creek's active floodplain is restricted to the small floodplain terrace benches on either side of the creek, one of which is the historic railroad grade. Historically, floodplains for this meandering creek probably encompassed a relatively large portion of the East Pasture.

Floodplains for the other creeks and drainages in the West Pasture are relatively small, with the possible exception of the 1906 Drainage, which has a very narrow, confined floodplain through and just downstream of the Lucchesi property until it flows into the West Pasture freshwater marsh. The 1906 Drainage is excavated annually just downstream of the Lucchesi residence for flood minimization purposes.

Floodplains for the lower portion of Bear Valley Creek are defined by Bear Valley Road, which runs along its eastern perimeter, and the elevated floodplain terrace created from deposition of granitic alluvium on its western perimeter. The lower reach of the creek has no defined channel planform or "bed and bank," thereby allowing flood flows to spread across a moderately wide section of the floodplain. Downstream of Bear Valley Road, the creek flows into Olema Marsh, with most of the flows hugging the eastern perimeter. However, the lack of a well defined channel and bank within this section enables the creek to use a large portion of the marsh as a floodplain.

Water Resources - Sediment Transport Dynamics

One of the most important processes for bays and creeks involves movement of sediment from upstream source watersheds to downstream water bodies, such as Tomales Bay or even the Pacific Ocean. This process of moving sediment does not take place instantaneously, but rather over a longer period of time, with large and small-grained material such as gravel, sands, silts, and clays being moved incrementally downstream during different storm events. Through this process, the shape or geomorphology of creek channels is formed. Once sediment finally reaches tidally influenced downstream water bodies, a new type of transport process takes place. Sands from the ocean and river-borne sediments, particularly fines, are continually resuspended by tides and redistributed within estuaries, helping to build sandbars, mudflats, and fringing marshes.

Fluvial or Creek-Dominated Processes

While large flooding events are often accompanied by huge inputs of sediment to downstream water bodies, more frequently occurring flood events, even as frequent as annual or ordinary high water flows, usually move more sediment and have a greater influence on channel shape (Leopold 1994). Reaches of channel tend to go through periods where they either accrete or lose more sediment, however, over time, the aggradation and erosional processes remain in balance in undisturbed natural systems. Should natural catastrophic events change sediment loads, the system will move toward what might be called a new dynamic equilibrium state, ultimately coming to balance sediment inputs and outputs, although the channel may assume a new form or shape.

Anthropogenic disturbances can create discontinuities in the sediment transport process that can tilt the equilibrium scale towards either net aggradation or erosion and radically change the shape or form of the channel. Dams can drastically decrease the amount of sediment or gravel available for downstream recruitment. Areas in which no sediment movement or aggradation is occurring often have what is called “armored” or hardened gravel bars, signifying that material is not depositing or moving downstream. Conversely, areas in which the equilibrium is tilted toward aggradation often have conversion of subtidal or unvegetated intertidal habitats to vegetated ones. One of the most vivid examples of this is the conversion of southern Tomales Bay from a low-energy subtidal and low intertidal system primarily shaped by redistribution of fine-grained clays and silts from Tomales Bay to a fluvial-dominated deltaic system composed of large-grained sands, small gravel, and fines. The massive influx of sediment due to logging and other disturbances associated with development of the upstream watershed tilted the sediment equation from transport to aggradation, with rapid expansion of the intertidal delta into Tomales Bay. It has been estimated that the peak sedimentation period between 1860s and 1910 resulted in deposition of almost 5 vertical feet of sediment (PWA et al. 1993) and 250 -300 acres of new intertidal marsh in very southern portion of Tomales Bay, principally the Giacomini Ranch and area directly north of the Ranch.

During storm events, creeks are moving large or coarse-grained sediment (cobble, gravel, sand, and even boulders), as well as fine sediment (clays, silt, finer sands). Much of the coarse-grained material is deposited within the channels in gravel bars or immediately adjacent to the channel, sometimes forming alluvial or natural levees along the creek channel. Fine sediment typically deposits further from the stream channel through overbank flooding onto floodplains, although changes in channel morphology such as a sudden flattening of the creek gradient or slope, substantial widening of the creek channel, or transition from creek to a large open water body such as a bay can cause fine sediment to deposit within the stream channel itself. Gravel bars are depositional features within creek channels; on floodplains, sediment transport in creeks often manifests as alluvial fans or very large, rounded hills that occur in areas where there are sharp transitions between steep slopes and flat floodplains.

Within many alluvial or classic riverine systems, certain discharge or flow events are believed to perform the most work over the long-term in terms of sediment transport (Wolman and Miller 1960). The dominant discharge is often linked to intermediate streamflow or discharge events, which correspond to “bankfull flow” or flood events that occur every 1- 3 years or very 1.5- 2 years on average. However, there are systems in which the dominant discharge appears to be the largest flood on record such as the Santa Clara River (Stillwater Sciences 2005).

Estuarine Sediment Transport Processes

Within bays and estuaries, sediment is stored within mudflats, sand bars, and shoals or shallows. Storage within estuaries represents a very dynamic process, with frequent remobilization of sediments, particularly fines, from these storage "reservoirs" through resuspension by tides, storms, and wind mixing. These sediments are redistributed to marshplains, mudflats, and channels of the bay or even eventually exported to the ocean. Most of this sediment comes from the surrounding watershed, but sand moved by longshore sediment transport along the Point Reyes coast also moves into the bay to be redistributed by wind-generated waves (PWA 2005). As discussed earlier, construction of dams within the watershed appears to have dramatically reduced watershed sediment contributions to Tomales Bay (Rooney and Smith 1999), increasing the importance of resuspension to sedimentation patterns within Tomales Bay. Construction of dams in the Sacramento-San Joaquin watershed has also dramatically reduced the Central Valley contribution to the San Francisco Bay sediment budget, potentially accounting for large erosional losses in shallow areas in San Pablo and Suisun Bays observed between 1942 and 1990 (Jaffe et al. 1996, 2001 in McKee et al. 2002).

Estuarine circulation patterns largely dictate the pattern of sediment deposition within estuaries, particularly deposition of suspended or fine sediments. As with fluvial sediment transport processes, bathymetry and currents can exert tremendous influence on where suspended is resuspended and where it is deposited. However, estuarine areas are unique in that sediment transport and deposition processes can also be influenced by salinity. Bathymetry, currents, and salinity, either in combination or separately, appear to drive formation of concentrated zones of sediment deposition, which have been referred to as Estuarine Turbidity Maximum (ETM). During recent decades, extensive research has been conducted into this phenomenon, because of its implications for aquatic organism diversity and trapping of sediments, nutrients, and contaminants (Peterson et al. 1975; Arthur and Ball 1979; Kimmerer et al. 1998; Columbia River Estuary Turbidity Maxima (CRETM) 2001). Classically, ETM was linked to the Null Zone observed in transitional regions of estuaries with classic estuarine or gravitational circulation (e.g., strong stratification of fresh and tidal flows) near the landward boundary of tidal influence, which often occurs around 2 ppt (Postma and Kalle 1955; Festa and Hansen 1976; Festa and Hansen 1978); Peterson et al. 1975 *in* Kimmerer 2004). In these zones, sediment resuspended by strong tidal currents moving along the channel bottom and sediments carried by river or creek flow converge and are trapped by the upward moving current created by stratification at the landward extent of tidal influence, greatly increasing water turbidity and eventual sediment deposition on the channel bottom.

In recent years, physical controls other than the Null Zone have been linked to ETM, including abrupt changes in bathymetry or shoaling (Schoellhammer 2001), ebb and flood tidal currents in river mouths (Ganju et al. 2004), and redistribution of dissolved and particulate fractions in intermediate rather than low salinity reaches (Rasheed 1997). In addition to the effect that salinity has on stratification of estuarine waters and longitudinal gradients and currents, salinity can also play a direct role in determining patterns of sediment deposition through flocculation or aggregation of river-borne sediment particles caused by the increased electrostatic charge present at the landward edge of the "salt wedge" (Arthur and Ball 1979).

Sediment Transport Dynamics within Tomales Bay

For the Bay as a whole, the trend towards net aggradation continues, although construction of dams apparently caused deposition rates to drop substantially after the 1950s (TBWC 2002). Comparisons were made between 1861 and 1994 using hydrographic charts with corrections made for changing sea levels (Rooney and Smith 1999). These calculations showed a bay-wide average infilling rate of 0.2 inches/year, which is equivalent to a watershed erosion rate of approximately 80,000 tons per year (Rooney and Smith 1999).

Between 1861 and 1931, sedimentation accumulation rates within Tomales Bay averaged 94 tons per square kilometer per year, increasing to 357 tons per square kilometer per year between 1931 and 1957 and decreasing to 101 tons per square kilometer per year between 1957 and 1994 (Rooney and Smith 1999). These sedimentation patterns contrast somewhat with findings from the PWA et al. (1993) study of southern Tomales Bay and delta expansion, which pointed to the 1861-1931 period as having the highest sedimentation rates. Rooney and Smith (1999) note, however, that sediment yield in the Bay is not necessarily synonymous with erosion and that there can be "decades long delay between maximum level of soil surface disruption and maximum sediment deposition." During these decades, sediment is typically stored in streambeds, gradually moving towards the Bay through episodic resuspension during storms. Another storage reservoir for sediment is stream deltas such as Lagunitas Creek: "A similar delay was found between initial deposition of sediment at

stream deltas and subsequent redistribution other areas of the Bay more geographically remote from deltas" (Rooney and Smith 1999).

While watershed sediment contribution has decreased in the last 50 years, Tomales Bay continues to become shallower through sediment inputs. In addition, colonization – or re-colonization – by native Pacific cordgrass (*Spartina foliosa*) appears to be causing a conversion in some areas of shallow intertidal mudflat to vegetated marsh. The present sedimentation rate in the bay, based on both bathymetric changes since 1957 and sediment yield measurements, has been about 0.04 to 0.08 inches/year (Smith and Hollibaugh 1998).

The dynamics of Null Zones or ETM have not been specifically investigated on a system-wide basis in Tomales Bay, but ETM may exist at the mouth of Lagunitas, Walker, and other tributaries to Tomales Bay that undoubtedly has many of the same benefits for biota documented in San Francisco Bay. The three-dimensional models developed recently for Tomales Bay would be invaluable in evaluating transport and depositional processes such as Null Zones and ETMs throughout the system, particularly as it could strongly bear on the fate of suspended sediment and associated nutrients, pathogens, and contaminants.

Sediment Transport Dynamics within the Project Area

Lagunitas Creek. Construction during the 1950s of the five dams within the Lagunitas Creek watershed, which controls 70 percent of the runoff for this subwatershed, has obviously greatly affected sediment dynamics within this system. MMWD studies conducted in 1979-1980 concluded that total suspended sediment delivery from Lagunitas Creek to the Project Area and vicinity averaged 34,300 tons per water year and 2,140 tons per water year of bedload or coarse sediment as calculated at the Point Reyes stream gage (H. Esmaili and Associates 1980). Annual bedload and suspended sediment transport totals actually decreased at the Point Reyes stream gage relative to the reach immediately upstream at the old Tocaloma Bridge, suggesting that increased channel storage or bank deposition was occurring in what was then – and probably still is now -- an aggrading reach or portion of the stream (H. Esmaili & Associates 1980). Many low-gradient or flatter reaches of creeks in coastal California undergo periods of net deposition during periods of high run-off followed by removal or net erosion during normal run-off conditions (H. Esmaili & Associates 1980). While the subwatershed of its largest tributary, Olema Creek, is less than a fifth the size of Lagunitas, Olema contributed significantly more suspended and bedload sediment to Tomales Bay -- 68,300 tons and 20,800 tons per year, respectively (H. Esmaili & Associates 1980). Higher sediment transport rates for Olema Creek were attributed to possibly climatic change, grazing, or other land use factors (H. Esmaili & Associates 1980), while work conducted in the late 1980s (Questa Engineering 1990) also identified differences in geology and the fact that Olema Creek flows along the active San Andreas Fault Zone.

While sediment transport generally increases with stream discharge or the size of the flood event, some streams have a diminishing rate of increasing suspended sediment transport at higher flows (Leopold 1994, Esmaili & Associates 1980). As noted earlier, more frequently occurring floods known as the "dominant discharge," that occur even as frequently as annually or during ordinary high water flows, usually move more sediment and have a greater influence on channel shape (Leopold 1994). Sediment studies conducted by H. Esmaili & Associates (1980) in 1979-1980 suggested that the rate of sediment transport in the lower sections of Lagunitas Creek just upstream of the Project Area begins to decrease during relatively small flood events (~1-year flood event), but that sediment load continues to increase through at least approximately the 7.5-year flood event and probably greater. Stream rating curves developed for Lagunitas Creek at the Point Reyes gage based on 1979-1980 data suggest that, at least during the early 1980s, a 2-year flood event with flow of 3,515 cfs would move a considerable amount of suspended sediment -- approximately 10,000 tons per day – but substantially less bedload material, only 170 tons per day (H. Esmaili & Associates 1980). None of the suspended material would have been deposited on floodplains because of the levees and/or lack of hydrologic connectivity.

While sediment transport patterns appear to have changed substantially in Olema Creek since the parks purchased portions of the watershed, land use factors affecting sedimentation rates in Lagunitas Creek would not appear to have changed substantially since construction of the dams in the 1950s. Within the Lagunitas Creek watershed, the dams would appear to exert the most control over sedimentation rates and patterns. Because dams tightly regulate some of the smaller flood flow events and their sediment loads, the highest rates of sedimentation in this subwatershed may now come with catastrophic flooding just as is seen currently in the Santa Clara River (PWA et al. 1993, Stillwater Sciences 2005). The 1982 flood caused deposition of 160 acre-feet of sediment on the Lagunitas and Walker Creek alluvial deltas (Anima et al. 1983 *in* PWA et al. 1993). The 1979-1980 study, however, demonstrates that there are still substantial sediment contributions

from unregulated tributaries and their watersheds, even with the dams (H. Esmaili & Associates 1980). Current trends in the upper portions of the Lagunitas Creek watershed have not been formally studied, but several researchers have reported problems with "fining" or excessive deposition of fine sediments such as clays and silts relative to coarse materials such as gravel and cobble; poor sediment recruitment below the dams; and armoring of smaller gravel and fine sediments (Stillwater Sciences 2004).

To determine current trends in sediment transport processes within the Project Area, KHE sampled gravel bars in Lagunitas Creek between the Green Bridge and north of the Giacomini Ranch's north levees (KHE 2006a). As described earlier, there are several prominent gravel bars within the Project Area, including one downstream of the Green Bridge, one near the cattle-crossing location midway through the Project Area, and one just south of the north levees. Results show that grain-size distributions for the Green Bridge and north levee bars are very similar and are dominated by fine-grained gravel (KHE 2006a). The cattle crossing gravel bar is composed of coarse-grained gravel (KHE 2006a). Field observations of the creek between the north levee and Tomales Bay also indicate a relatively coarse-grained, firm bed, grading from fine-grained gravel at the north levee to medium- to coarse-grained sand at the deltaic outfall to Tomales Bay (KHE 2006a). The coarse-grained nature of these surficial bed deposits indicates that Lagunitas Creek possesses a relatively high sediment transport capacity through the Project Area (KHE 2006a).

Conclusions made from grain-size distribution are supported by modeling results that indicate creek flows are sufficient to mobilize and transport coarse-grained materials observed within the Project Area (KHE 2006a) despite flattening of the creek gradient or slope. As might be expected based on channel geomorphology, the narrow, confined reach upstream of White House Pool and downstream of the Green Bridge tends to transport fines, as well as coarse sand and fine gravel, although stream energy is not high enough to convey coarse gravel and cobble (KHE 2006a). Downstream of White House Pool at the cattle-crossing "gravel bar," stream power drops slightly where the creek widens, and there is some loss of transport, but relatively little (KHE 2006a). Transport rates generally increase again downstream of the cattle crossing bar through the north levee (KHE 2006a).

Based on stratigraphy, fine or suspended sediment appear to be deposited within adjacent floodplains when flows are sufficient to crest the levees (KHE 2006a). One of the highest depositional areas in the East Pasture appears to be the southwestern corner opposite White House Pool, where the Giacomins apparently deliberately removed or lowered levees to preferentially direct flooding (KHE 2006a), perhaps because of repeated flooding problems in the past during more frequently occurring flood events (~ 3 to 5 years). The 1942 aerial photograph shot just prior to establishment of the Giacomini Ranch and following an average winter without excessive flood scour or sedimentation clearly shows overbank scour and sediment deposits within the southeast portion of the East Pasture, along Lagunitas Creek, and within the West Pasture, from historic overbank flooding events (KHE 2006a). For overbank flooding events, sediment transport rates are highest just at the point of entry near the south levee of the East Pasture, with flow velocity dropping sharply throughout the remainder of the pasture (KHE 2006a). Modeled flow velocity in the south is high enough to transport coarse sand and fine gravel, which, then, based on modeling results, would be deposited in the southern-most fields, which appears to agree with information from sediment coring and aerial photographs (KHE 2006a). Sediment transport in the northern portion of the East Pasture is hindered by persistent ponding of floodwaters caused by reduced outflow, which is limited by the concrete spillway and culvert capacity. In the West Pasture, flow velocity during highly infrequent overbank flooding events (> 12 years on average) does not appear sufficient to transport sediment through the pasture, with most sediment probably deposited immediately on the floodplain after cresting the levee (KHE 2006a).

While the upstream reach of Lagunitas Creek does have the highest and perhaps most intrusive levee system, from historic maps, it appears that this section of creek was naturally somewhat narrow and confined, at least during recent recorded time. Therefore, the levees may not have changed fluvial sediment transport processes substantially in the reach upstream of White House Pool relative to "natural" conditions. The other potential impediment, Green Bridge, which almost completely spans the active floodplain of the creek, also does not appear to be having a substantial negative impact on transport processes (KHE 2006a), although the presence of the gravel bar directly downstream again may attest to some effect of the bridge on sediment deposition patterns.

Unlike San Francisco Bay, not much is known within Tomales Bay or the Project Area about estuarine sediment transport processes. Within the Project Area, Lagunitas Creek is well-mixed and fresh, usually well below 2 ppt, during the period of highest freshwater flows and contaminant contribution. If the classic Null Zone were to occur during the winter and early spring, it would be at some point in Tomales Bay itself, where channels are deep enough – and tidal currents are strong enough – to create gravitational circulation and

strongly stratified conditions despite the high volume of freshwater flow. Based on longitudinal salinity gradients, gravitational circulation does exist upstream of White House Pool, but only very briefly in the late spring and early to mid-summer, when sediment, nutrient, and contaminant loads are much lower. Typically, ETM are generated through a combination of sediments that are resuspended by strong tidal currents and that are being carried in suspension by river and creek flows. Based on hydraulic modeling results, the strength of tidal currents is not sufficient within the portion of Lagunitas Creek in the Project Area to mobilize even fine sediments except for directly downstream of the cattle crossing gravel bar (KHE 2006a), however, the full complexity of stratified estuarine circulation and associated transport processes may not be captured by a one-dimensional model that is vertically or depth-averaged. ETM may also develop within the Project Area based on other physical forces such as flocculation of creek-borne sediment and organic material induced by increased salinity within waters (Arthur and Ball 1979) or bathymetrically controlled changes in creek circulation and sediment transport patterns due to shoaling at the two gravel bars downstream of White House Pool. While estuarine sediment transport processes have not been as well studied in this watershed as fluvial ones, these processes also have strong implications not only for patterns of sediment deposition in the Project Area, but the potential for the Project Area to improve water quality conditions within southern Tomales Bay by trapping suspended sediment that may be bound to nutrients, bacteria, or other contaminants.

Fish Hatchery Creek. Fluvial transport processes were not specifically modeled, but historical information on past flooding events indicates that flow velocities decrease appreciably once the creek gradient begins to flatten at the base of the Inverness Ridge, creating excessive deposition or debris flow even during relatively mild storm events. During storms, substantial amounts of loose, granitic material from the Inverness Ridge mobilizes and moves down to the valley below, with anecdotal reports suggesting that as much as 10- 12 feet of sediment may have deposited along the base of the Inverness Ridge as a result of extensive debris flows. Over longer periods, these repeated mobilizations of sediment manifest as large alluvial fans on which most of the adjacent homes are constructed. Alluvial fans also occur along the West Pasture perimeter where other Inverness Ridge creeks flow into the West Pasture, including the 1906 drainage. Based on the extent of past excavation, the depositional zone probably extends just downstream of where Fish Hatchery Creek makes a 90 degree turn to flow northward towards the north levee. Tidal current velocities are only high enough near the north levee to move sediment under average and extreme conditions, although extreme tides may be capable of moving silt and fine sand downstream of the levee in the undiked portion of Fish Hatchery Creek (KHE 2006a).

Bear Valley Creek and Olema Marsh. Similar to Lagunitas Creek, the history of Bear Valley Creek is one also marked by discontinuities in the sediment transport, this time, due to infrastructure and creek maintenance activities. As described earlier, Bear Valley Creek has been subjected to a variety of disturbances, including damming; road and berm construction within and across its floodplain; culvert installation; natural and anthropogenic fill in the active floodplain and terraces; channel realignment for construction of the Park Service maintenance facility; and dredging to decrease flooding of the Park Service administrative headquarters. All these disturbances have served to disrupt the sediment transport equilibrium within the creek and Olema Marsh. As was noted earlier, during the 1960s-1970s, the middle section of Bear Valley Creek was incised, meaning that the depth from the top of channel bank to the channel bottom was pretty deep, measuring roughly 6 to 8 feet (KHE 2006b). The incision showed that the channel was out of equilibrium, with sediment loss greatly exceeding sediment gain.

After the 1982 flood, Bear Valley Creek underwent some very dramatic changes as a result of catastrophic debris flows from the Inverness Ridge (USGS 1982). Debris flows originating in the two major tributaries of Bear Valley Creek carried into the mainstem of Bear Valley Creek, choking the former channel and turning the colluvial valley bottom into a sandy, braided stream channel with extensive woody debris jams that acted to temporary dam and pond waters within the channel. In essence, the natural event reshaped Bear Valley Creek, converting at least the middle reach from a net erosional to a net depositional system.

Dynamics of this system are complicated, however. While sedimentation did increase after the 1982 flood, it appears, based on sediment borings conducted by KHE, that much of this sediment is not moving from the middle reach of Bear Valley Creek into the lower and Olema Marsh portions (G. Kamman, KHE, pers. comm.). As discussed earlier, sediment borings in these areas point to increases in elevation being from accumulation of peat or undecomposed organic matter, rather than sediment. Sediment within Bear Valley Creek may be trapped upstream in the reach that has been dredged historically (G. Kamman, KHE, pers. comm.). Modeling results suggest that, if sediments were capable of reaching Olema Marsh, that it would be a depositional environment because of the reduction in flow velocities (KHE 2006a). Under extreme flooding, flow velocities might be high enough for transport of silt and fine sands, but these would drop out of suspension mid-way

through Olema Marsh (KHE 2006a). In the case of both floods and tides, which are limited in extent in Olema Marsh, conveyance of sediment would appear to be highest at the Levee Road culvert, where funneling of flows through a narrow constriction tends to increase stream power and velocity (KHE 2006a).

Hydrologic Processes and Wetland Functionality

Some of the most important functions played by wetlands relate directly to the presence and condition of hydrologic processes, including components linked to hydraulics, geomorphology, and hydrodynamics of fluvial or stream and tidal systems. These functions include dissipation of flood flow energy, retention of floodwaters, water quality improvement, carbon export, and wildlife habitat use and support. Streams that are able to connect with functioning, vegetated floodplains can buffer humans and wildlife from impacts associated with flooding and poor upstream water quality. In addition, these same areas support wildlife not only by providing habitat and food within streams and floodplains, but by exporting food and organisms downstream to larger water bodies. The ability of systems to provide hydrologic functions such as these decreases when streams are leveed or become too deep (incised) and are not able to connect with their floodplains. In addition, development of floodplains for commercial, residential, and, to some extent, agricultural purposes also reduces wetland functionality.

Lagunitas and Tomasini Creeks are leveed, although topographic surveys suggest that they are not incised or that the bottom elevation of channels has not deepened through erosion. As discussed earlier, depending on the exact reach within the Project Area, Lagunitas Creek still connects within its floodplains in the Giacomini Ranch for flood flows that occur, on average, between 3.5 years to 12 years, with flooding in the upstream portions probably exceeding 50 years (KHE 2006a). However, they are not flooded under the most frequently occurring flows, those with a recurrence interval ≤ 2 years, which often correspond to some of the important flows from a geomorphic perspective in terms of channel creation and maintenance, sediment transport, etc. There are no flooding recurrence estimates for Tomasini Creek, but, according to the Giacominis, Tomasini Creek overtops the levee near the Giacomini Hunt Lodge during some of the larger storm events (KHE 2006a). Fish Hatchery Creek has not been leveed within the Giacomini Ranch West Pasture and is well-connected to its floodplains, although the Giacominis occasionally deepen the channel through sediment removal. Rapid aggradation of Bear Valley Creek since the 1982 flood has resulted in reconnection of lower Bear Valley Creek with its floodplains, including in Olema Marsh. Flooding in relation to adjacent private residences and county roads will be discussed in more detail under Public Health and Safety.

Some of the riparian vegetation along the southern portion of Lagunitas Creek adjacent to the Giacomini Ranch – where vegetation would be expected to naturally occur – has been removed and/or precluded from establishing by placement of riprap, although quite a few stands remain, particularly on the lower portions of the bank. In fact, approximately 75 percent of Lagunitas Creek banks with potential to support riparian habitat are vegetated with riparian species despite past levee maintenance efforts. This vegetation increases the ability of this section of creek to dissipate flood flows. Riparian loss along Tomasini and Fish Hatchery Creeks is much more extensive, with approximately 40 percent and 25 percent of the Tomasini and Fish Hatchery creek banks, respectively, supporting riparian vegetation where it would be expected to naturally occur. Historic riparian loss apparently occurred along Bear Valley Creek when it was actively ranched, but, since ranching ceased, riparian vegetation has rapidly recolonized, although increases in water levels within the lower portion of the creek, including the marsh, appear to be drowning some of the mature riparian trees.

Not only do levees keep waters out, thereby decreasing floodwater retention capability, they also keep any waters that do occur such as from precipitation, run-off, or groundwater inside the levees, thereby decreasing the potential for exporting carbon and other food sources to downstream water bodies. Water quality monitoring indicates that dissolved organic carbon within drainage ditches, ditched sloughs, and creeks is relatively high, but this carbon source is unavailable to organisms in Tomales Bay, because waters are trapped within the pastures by the levees (Parsons, *in prep*.). To a lesser extent, export of carbon produced within Olema Marsh is also minimized by the poor hydraulic connectivity between the marsh and Lagunitas Creek (Parsons*, in prep*.).

Loss of floodplain connectivity for more frequent flood flows such as floods occurring every one to two years not only decreases the ability of the Project Area to store floodwaters, but also to improve the quality of downstream waters. Floodwaters carrying nutrients, sediment, pathogens, and other contaminants from upstream portions of the watershed flow onto floodplains, where plants and even topography act to slow down waters and cause these contaminants to drop out of suspension onto the floodplain. Most of these nutrients and contaminants are chemically bound to suspended or fine sediment in flood flows. Once deposited onto

floodplains, nutrients can be uptaken by plants or used by bacteria or retained within sediments for potential release at later periods. Metals and organic contaminants are often effectively "locked" into anaerobic wetlands soils for extended periods of time and only released if wetland conditions drastically change, which is why wetlands are often used for treatment or polishing of wastewater. Changes in stream gradient, stream channel width, or shoals or gravel bars can also encourage deposition of suspended or fine sediment within channels, as well as floodplains. Based on field investigations and hydraulic modeling results, widening of the creek just downstream of White House Pool reduces streamflow velocity – and power – enough to create and maintain the bar composed primarily of coarse gravels at the cattle crossing location, probably during larger flood events. This feature may then influence deposition of slightly finer materials such as coarse sand and fine gravel downstream of the gravel bar during lesser flood events by acting as a shoal.

In addition to overbank flooding or in-channel deposition of suspended sediment during flood events, wetlands and aquatic systems can also trap contaminants through estuarine sediment transport processes such as ETM established by Null Zones or other hydrodynamic or circulation-related forces. The interaction between salt and freshwater in transitional zones such as the Project Area can create zones of high turbidity and potential sediment deposition through development of upward moving water currents or Null Zones or flocculation of sediment and organic material when freshwater encounters saltwater, which has a higher electrostatic charge. These estuarine sediment transport processes combine with fluvial ones to increase the complexity of sediment transport and deposition dynamics within transitional zones. The processes controlling estuarine sediment transport and deposition in Tomales Bay have not been specifically studied, but it is highly probable that ETM occur within the Bay and even the Project Area and that these ETM would have strong implications potentially for water quality improvement and aquatic biota.

Water Resources – Water Salinity and Water Quality

One of the most important functions that wetlands play is the improvement of water quality, which may be that much of the wetland protection regulations relate to water quality. Wetlands improve water quality through trapping of sediments, nutrients, and contaminants, which are either retained or transformed in soils or uptaken by plants. The value of wetlands for water quality improvement has encouraged many municipalities to develop treatment wetlands specifically for at least polishing and refining of treated wastewater.

Water Salinity

Regulatory and Policy Setting

Salinity is typically not a regulated parameter of water "quality," but within certain regions, salinity can be a concern. Discharge of agricultural waters and run-off can increase concentrations of agricultural "salts" (i.e., conductivity or conductance) within downstream water bodies, which can affect aquatic biota. Conversely, increases in duration and volume of freshwater inflow from releases of treated wastewater can change salinity dynamics within estuaries, converting saltwater wetlands to freshwater ones. Large acreages of wetlands within south San Francisco Bay have shifted from being saltwater wetlands to brackish or even freshwater ones because of large volumes of year-round treated wastewater release. The RWQCB has attempted to stop this trend by requiring many sewage treatment plants to store treated or re-use wastewater during the summer to ensure that salinity dynamics of the estuary do not continue to be altered. In the 1995 Basin Plan, the RWQCB states that, "controllable water quality factors shall not increase the total dissolved solids or salinity of waters of the state so as to adversely affect beneficial uses, particularly fish migration and estuarine habitat."

Regional and Tomales Bay Setting

Salinities within Tomales Bay are dictated largely by the degree of tidal and freshwater influence, although other factors can affect salinities and salinity structure such as estuarine geomorphology, current, evaporation, bathymetry, wind, and other hydrodynamic processes. As was described earlier, previous studies and recent three-dimensional hydrodynamic modeling of Tomales Bay showed that different circulation patterns occur in the outer, inner, and even middle portions of the Bay, which greatly affect salinity conditions (Largier et al. 1997a, 1997b; Harcourt-Baldwin 2003; Gross and Stacey 2003). Near the mouth, strong tidal

currents and a channel-shoal structure consistently maintain ocean water salinities, although salinities may briefly be reduced periods of heavy freshwater inflow (Hollibaugh et al. 1988, Harcourt-Baldwin 2003, Gross and Stacey 2003). In contrast, salinities in the middle and inner bays are highly variable, both temporally and spatially. Throughout the year, waters in the middle and inner portions of Tomales Bay vary from well-mixed and nearly fresh after heavy winter runoff to strongly or partially stratified during spring and early summer and potentially even slightly hypersaline in late summer (Hollibaugh et al. 1988, Harcourt-Baldwin 2003, Gross and Stacey 2003) depending on natural variation in summer flows, as well as mandatory and non-mandatory releases from watershed reservoirs. This seasonal variability is accentuated by spatial variability, with numerous large and small creeks and perhaps even groundwater discharge points leading to multiple saltwater-freshwater interfaces along the Bay's perimeter.

These physical interfaces between freshwater and saltwater result in creation of a very dynamic portion of estuarine systems – the transitional zone between saltwater and freshwater. Based on freshwater inflow, the Project Area represents the largest transitional zone within Tomales Bay. Unlike salt marshes in marine-dominated systems, where salinities remain relatively constant throughout and between years, salinities change dramatically both within and between years in these transitional zones in response to seasonal and annual changes in freshwater flow. These seasonal and annual changes in salinity within transitional zones can exert a tremendous influence on ecosystem dynamics by radically altering the diversity and types of organisms present, as well as influencing localized and downstream water quality conditions through sediment deposition and resuspension. Long term changes in freshwater flow related to decadal trends in climate or anthropogenic disturbances such as increases in freshwater flow diversion or increased freshwater flow during the summer can even alter the composition of vegetation communities. One of the largest transitional zones in the San Francisco Bay region is Suisun Bay in the San Francisco Bay – Sacramento Delta estuary.

Salinities within most transitional estuarine zones vary markedly throughout the season, ranging from freshwater conditions (0.2 to 0.5 ppt) in the winter and spring to saline or euhaline (30-40 ppt) conditions in summer. Salinity conditions are not only determined by the volume and duration of freshwater flow, but by circulation patterns driven by physical forces such as tides, density and temperature gradients, wind, bathymetry, and even evaporation. In "classic" estuaries, longitudinal density gradients related to salinity typically result in stratification of waters, often during the spring and/or summer, with freshwater flows creating a lens of less dense freshwater or brackish water on the water surface and tides driving a wedge of denser, saltier water upstream on the channel bottom. During the rainy season, depending on the volume of freshwater flows, tidal influence can be minimized or even eliminated, resulting in a uniformly fresh water column. In the summer and fall, particularly in systems where freshwater flows cease or decrease substantially, water salinity -- and structure of salinity within the water -- can be determined more by the degree of tidal influence, tidal cycle, vertical mixing induced by winds, tidal currents, or bathmetry, and temperature-related evaporation, leading to either salinity-stratified or well-mixed brackish, saline, or even hypersaline conditions that can vary depending on month, tidal cycle, or water depth (Kimmerer 2004, Schoellhamer 2001).

One of the most well-studied components of transitional zones in San Francisco Bay is the Low-Salinity Zone or X2. The LSZ or X2 refers to a hydrologic zone or geographically variable portion of the estuary with salinities of approximately 2 psu (~2 ppt), which has been used in San Francisco Bay as an index of the physical response of estuary to freshwater flow and the effect of freshwater diversions in the Central Valley (Kimmerer 2004). In San Francisco Bay-Sacramento Delta Estuary, investigations into the LSZ and target organism abundance have found significant relationships, at least some of the time, for estuarine-dependent copepods, mysids (*Neomysis mercedis*), bay shrimp (*Crangon franciscorum*), and several fish including longfin smelt (*Spirinchus thaleichthys*), Pacific herring (*Clupea pallasii*), starry flounder (*Platichthys stellatus*), Sacramento splittail (*Pogonichthys macrolepidotus*), American shad (*Alosa sapidissima*), and striped bass (*Morone saxatilis*; Kimmerer 2004). The timescale over which salinity changes can also have a profound effect on estuarine organisms, with gradual changes or stable conditions more beneficial for many species than abrupt changes or fluctuating salinity (Kimmerer 2004). The relationship between salinity and biota is discussed more under Fish and Wildlife Resources. As discussed under Water Resources – Sediment Transport processes, salinity can also affect transport and depositional patterns of suspended sediments through creation of Estuarine Turbidity Maximum (ETM) or zones of increased suspended sediment concentration and deposition to a number of physical processes or properties, including gravitational or classic estuarine circulation, bathmetry, geomorphology, tidal cycles, and flocculation of river-borne sediments and organic material due to increased electrostatic charge of saltwaters (Arthur and Ball 1979, Schoellhamer 2001, Ganju et al. 2004, Kimmerer 2004) .

Lagunitas Creek. The portion of Lagunitas Creek in the Project Area represents a unique component of estuaries – the dynamic interface zone between saltwater and freshwater influences that results in highly variable season and interannual salinity conditions. The Lagunitas Creek delta is one of the largest estuarine transition zones in Tomales Bay and is analogous to the Suisun-lower Sacramento Delta region of San Francisco Bay. Salinity concentrations and structure within Lagunitas Creek appear to be dependent on bathymetry and strongly driven by the natural seasonality of freshwater inflow, corresponding height and range of tides, and deviations from natural intraannual and interannual patterns in freshwater inflow due to reservoir releases (Parsons, *in prep*.).

In the winter (December – April), very uniform freshwater conditions (< 1 ppt) can persist in upstream areas until June, when strong stratification starts to occur with as much as 16 ppt difference in salinities in surface and bottom waters (NPS, unpub. data). Summer freshwater inflow is maintained at minimum levels during both average (8 cfs) and dry (6 cfs) years due to releases from reservoirs mandated by the SWRCB (95-17), which may affect not only overall water salinity, but salinity structure in the Project Area. In the late fall, surface salinities once reached as high as 14 ppt near the Green Bridge, but salinities are typically much lower (< 5 ppt). Salinities decrease appreciably upstream of the Green Bridge during the summer and fall, with conditions often fresh (<0.5 ppt), except during higher high tides when salinities increase after a short time lag to approximately between 1 and 3 ppt (KHE and NPS, unpub. data). Midway through the Project Area, salinity ranged from 0.1 ppt in the winter to 20 ppt in the summer. At the northern end of the Project Area, fresh to slightly brackish conditions (0.1 ppt) are present typically only during the months with rain, with salinities climbing rapidly to 20 to 30 ppt starting in early summer. Results of the hydrodynamic model agreed reasonably well with actual salinities from monitoring data, although the model is a one-dimensional system that averages salinity conditions across depth (KHE 2006a). Within the Project Area, the section of creek upstream of White House Pool is deep enough to become strongly stratified during at least some portion of the year, due, in part, to the water impounding effect of the gravel bar at the cattle-crossing location (Parsons, *in prep*.). Downstream of this gravel bar, the creek widens and becomes shallower, and salinity structure within this reach is usually only partially stratified or even well-mixed (Parsons, *in prep*.).

Some data from 2003 exemplifies this conclusion (NPS, unpub. data, Parsons, *in prep*.). During the rainy season, salinities were uniformly low (0.1 ppt), both within the water column and Project Area. Starting in May, salinities remained low and uniform (0.1 -0.5) in the Project Area, except for the north levee, where salinities increased to approximately 5 ppt. During the June sampling date, salinities increased above freshwater conditions everywhere except at the Green Bridge, but there was only slight stratification within the White House "Pool" (e.g., 0.9 to 1.3 and 2.5 to 2.8). During July, salinities became highly stratified at least within the "Pool," with surface salinities at 3.7 and bottom salinities of 21.6 at White House Pool proper, probably because freshwater inflow, as regulated by reservoir releases, was relatively strong. In August and succeeding fall months, the degree of stratification upstream of White House Pool decreased or even disappeared at times and appeared to become more dependent on an interaction between freshwater flows and tidal cycle. From August through December 2003, the LSZ, represented by bottom salinities of 2 ppt, entirely disappeared from this section of Lagunitas Creek.

The influence of bathymetry on salinity concentration and structure is not only apparent from the stratification within the "Pool," but the fact that, occasionally, higher salinity waters appear to pool between the cattle-crossing location and north levee gravel bars, creating a saltwater "pool" in the midst of the Project Area (Parsons, *in prep.*). In October and November 2003, higher salinity waters ranging around 28 ppt were observed midway through the Project Area, while waters downstream at the north levee ranged from 21 to 24 ppt (NPS, unpub. data). Hydraulic modeling results point to the cattle crossing gravel bar have a significant effect on salinities within the creek: if the gravel bar were not present, maximum salinities within the creek upstream of White House Pool could increase by as much as 35 percent (KHE 2006a).

Salinity and salinity structure is also governed by the pattern of freshwater inflows, particularly during the summer and fall months. In unregulated systems within Mediterranean climate systems, salinities might increase steadily in response to natural hydrologic patterns of steady decreases in freshwater inflow superimposed over small-scale daily variations in evaporation and evapotranspiration. Diurnal variations in flow from evaporation or evapotranspiration associated with vegetation represented as much as 10 percent of the mean stream discharge for the Merced River, with rate dependent on total vegetation cover and ambient temperatures (Lundquist and Cayan 2002). However, in regulated systems such as Lagunitas Creek, salinity structure may also be influenced by daily variation in reservoir releases, as well as pumping or withdrawal rates for NMWD wells and other stream diversions (Parsons, *in prep*.). Randomly selected average daily discharge data from the USGS Point Reyes Station gage shows some interesting small-scale variations in freshwater inflows during the summer of 2001 and 2002 (Figure 29). This gage is far enough upstream that it

is not subject to tidal influence, except during extreme events (G. Kamman, KHE, *pers. comm*.). For example in 2001, stream discharge dropped from 12 cfs to 6.75 cfs within approximately 9 days, followed by a sharp, temporary increase from 7.0 cfs to ~9.4 cfs over the period of one to two days (Figure 29). In summer 2002, stream discharge dropped from 13 cfs to 9.5 cfs over 1 to 2 days, followed later by a sharp increase by approximately 2 cfs over another 1 to 2 days (Figure 29). Whether natural or unnatural, fluctuations in freshwater inflow, particularly sharp ones, as shown in Figure 29, would have substantial effects on salinity patterns, both within stratified and mixed portions of the creek (Parsons, *in prep*.). Modeling results for Lagunitas Creek suggest that changes in stream discharge of 2.0 cfs can result in increases in doubling or 100 percent increases in maximum water salinities (KHE 2006a).

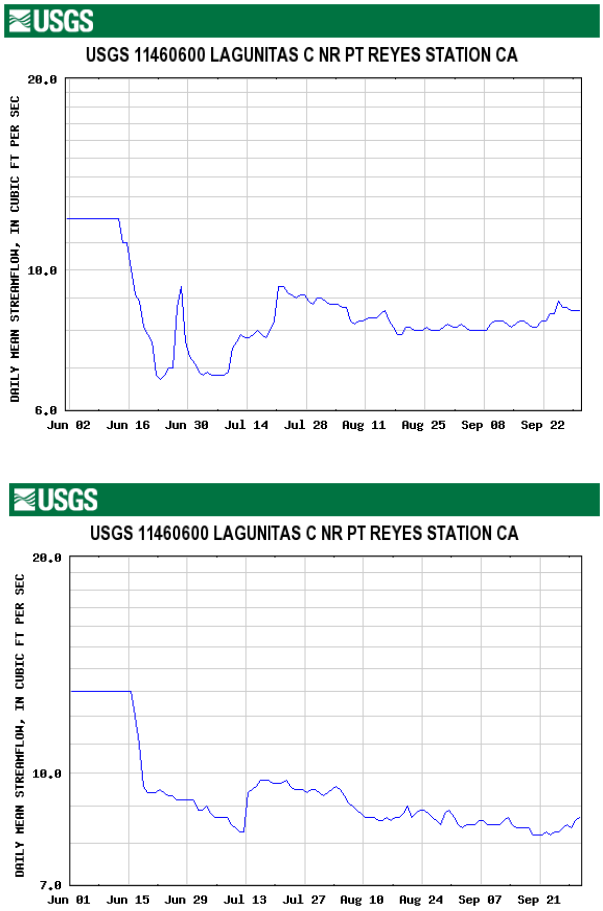

Figure 29. Daily Average Flow, June 1- September 30, 2001 (upper)
Daily Average Flow, June 1 - September 30, 2002 (lower)

Tomasini and Fish Hatchery Creeks. Similarly, as freshwater flow in Fish Hatchery and Tomasini Creeks decreases, salt "wedges" move up the creeks, although the upper portions of at least Tomasini Creek often go dry during the summer and early fall months. Salinity concentrations within Tomasini Creek varied between a maximum of 27-ppt during the summer and 0.1-ppt during the winter (KHE 2006a). The movement of the salt wedge upstream during the summer results in brackish water conditions (~18 – 22 ppt) occurring near the Giacomini Hunt Lodge (KHE 2006a). Perennial fresh water conditions exist at the confluence of Tomasini Creek and Mesa Road. At Fish Hatchery Creek, salinity ranges from perennial fresh waters at the furthest upstream location near Sir Francis Drake Boulevard, progressing toward more saline and seasonally variable waters downstream in the West Pasture (Parsons, *in prep*.). By late summer, freshwater flows have decreased enough to allow the salt wedge to move midway through the West Pasture across from the Lucchesi-Kostelic residence. Salinities of the West Pasture Old Slough tributary are consistently higher than those of Fish Hatchery Creek, probably due to the more seasonal nature of the freshwater inflow. At the West Pasture Old Slough, salinities range from 0.1- to 5 ppt in the winter and 20- to 30 ppt in the summer. During the summer and fall, salinities at the north levee and in the undiked portion of Fish Hatchery Creek are closer to euhaline, ranging from 20 to 30 ppt.

Based on data from 2003, salinity patterns and structure are similar to Lagunitas Creek in that stratification only occurs within certain reaches of Tomasini and Fish Hatchery Creeks during specific seasons, with occurrence dependent on the interaction between freshwater inflow and tides (Parsons, *in prep*.). The water column shows uniform or partially stratified salinities throughout the creeks through June. Strong stratification occurs at deeper sections of the creeks – the central portion of Fish Hatchery and the section of Tomasini south of the Giacomini Hunt Lodge – July and/or August due to the persistence of at least moderate freshwater inflows. Stratification within these deeper sections disappears or is reduced during the early fall in response to decreased freshwater inflow and shallower water depths, resulting in more mixed conditions. Stratification is reestablished in deeper sections during some of the early winter storms, (e.g., 0.4 at the surface and 24.1 at the bottom at Fish Hatchery Creek in November 2003), with conditions turning uniformly fresh once rainfall is persistent.

Giacomini Ranch East Pasture. Areas such as the East Pasture that is not directly influenced by tides and creeks show seasonal patterns and stratification in salinities, as well, although the patterns are somewhat reversed (Parsons, *in prep*.). During the summer and fall 2003-2004, salinities within the drainage ditches and East Pasture Old Slough remain relatively low (~0.2 to 0.8) probably due to pumping of irrigation water into the ditch and slough system. However, during the months of January through March, salinities within the ditch and Old Slough actually increase to between 1.5 to as high as 9.4, with stratification of fresh and

saltwater occurring in some of the relatively deep sections. Irrigation appears to drive down salts during the summer months. Starting in April or May, salinities decrease again and remain low until the following January. The only exception to this is the very northern end of the East Pasture Old Slough, which, despite being cut off from Lagunitas Creek by a dike and one-way flapgate, shows more typical patterns in salinities, with salinities increasing through the summer and fall and dropping during the winter. Areas such as the shallowly flooded vegetated flat near the Point Reyes Mesa and the New Duck Pond are seasonally flooded, with salinities averaging approximately 4 and 1 ppt, respectively. Only the drainage ditch in the Tomasini Triangle at the base of the north-facing Dairy Facility Mesa slope showed consistently fresh- to very low brackish salinities, with salinities never exceeding 0.6 and averaging 0.2 ppt.

As discussed earlier, the source of salts for surface waters within diked portions of the East Pasture appear to result from persistence of residual marine salts deposited when the areas were not diked (KHE 2006a). In addition, the northeastern portion of the East Pasture is being affected by tidal inflows from Tomasini Creek that are being routed through a culvert in the levee into the drainage ditch and shallowly vegetated flat used by waterfowl and shorebirds (Parsons, *in prep*.). Salinity of groundwater was consistently higher throughout the year than that of surface waters, probably due to the limited infiltration of irrigation waters and direct contact with soil horizons containing high concentrations of residual salts. Groundwater salinities were quite variable in the northern and central portions of the East Pasture, ranging from 6 to 40 ppt during the three years of monitoring (NPS, unpub. data). Salinities in the southern portion of the East Pasture, which represents the highest elevations, ranged from only 2- to 5 ppt, probably due to the minimal influence of tides historically at the base of the alluvial fan and the presence of significant groundwater seep and spring flow from the Mesa (NPS, unpub. data). Groundwater salinities in the Tomasini Triangle in the far eastern portion of the East Pasture surprisingly ranged as high as 5- to 9 ppt (NPS, unpub. data). Based on modeling, topography, and historic maps, this area appears to have once been part of an alluvial fan or plain at the mouth of Tomasini Creek and, at least based on current topography, would be above the influence of almost all tides (KHE 2006a). However, data suggests that extreme tides probably once reached this area.

Giacomini Ranch West Pasture and Freshwater Marsh. The West Pasture is not as heavily ditched as the East Pasture, because it is not irrigated. However, it is more heavily influenced by small drainages and groundwater seeps from the Inverness Ridge. These hydrologic sources have generally created a freshwater to saltwater gradient from west to east, as well as from south to north (Parsons, *in prep*.). Northern portions of the West Pasture appear to be saltier due to overbank flooding of limited tidal action through the north levee modified tidegate and groundwater interaction with residual salts in the soil (See East Pasture discussion above). Salinities in the northern portion of the West Pasture along its western perimeter are consistently low due to the strong seasonal to perennial influence of groundwater.

One exception to this salinity gradient occurs within the West Pasture freshwater marsh. Long-term salinities within this marsh prior to 2003 are unknown, but some spot sampling in a few areas associated with amphibian surveys found salinities during the winter that ranged from 0.1 ppt to 0.8 ppt (Fellers and Guscio 2002). Interestingly, while vegetation composition pointed to the marsh largely being “fresh,” salts were detected in the groundwater (NPS, unpub. data). Salinities in shallow groundwater wells within the marsh ranged from 0.3 to 4.4 during late fall 2002 and early 2003 (NPS, unpub. data). This is suggestive of a historic source of salts within the soils, probably to tidal influence prior to diking. Based on the 1862 U.S. Coast Survey map, the West Pasture freshwater marsh was almost completely subtidal or unvegetated intertidal habitat with just a thin fringe of land apparent on the western perimeter. Salts from tidal influence during this period have probably remained in the peaty clay soils despite diking and a conversion from marine or brackish to predominantly freshwater conditions.

In winter 2003, the West Pasture freshwater marsh experienced much higher salinities due to collapse of the culverts at the north levee, which appeared to increase the range of tides allowed into the West Pasture and the freshwater marsh. Based on changes in the vegetation, it appeared that this change in tidal range was dramatically affecting salinities within the marsh (NPS staff, pers. obs.). Monitoring of salinities within the surface waters in July and August 2003 showed that salinities increased to as high as 6 - 35 ppt within this marsh, although groundwater seepage and flow from drainages appear to maintain a freshwater lens of less than 1 ppt at the western perimeter of the marsh or on the water surface (NPS, unpub. data, KHE, unpub. data). Following repair of the tidegate, tidal amplitude within the West Pasture was compressed, limiting the range of tides to between 3.4 and 5.25 ft NAVD88, the latter of which appeared to be the height at which saltwater incursion into the freshwater marsh occurs (KHE 2006a). Tidal events triggering water levels of 5.25 feet NAVD88 appear to only occur when water levels within undiked areas exceeds 6.25 to 6.5 feet NAVD88 (KHE 2006a), which are at the higher end of high tides and relatively infrequent.

Culvert and tidegate repair appears to have reduced the extent and duration of salinity intrusion events in the marsh. However, salinity intrusion events still occur. Based on some continuous water quality monitoring in 2004, salinities in the marsh appear to be highest between December and March, despite increased freshwater flow from rainfall (Parsons, *in prep*.). This counter-intuitive pattern – salinities would typically be expected to be highest during the summer – appears to be related to annual trends in extreme high tides, which are at their highest during this period (>7 feet MLLW). In mid-January 2004, high tides exceeding 6.2 ft MLLW occurred within Tomales Bay, thereby probably triggering a salinity intrusion event. In March 2004, salinities in the marsh ranged from as high as 4.68 to 8.13 ppt, averaging 4.2 and 7.4 ppt, in the deepest and shallowest portions of the marsh, respectively (NPS, unpub. data). Over the next two months, salinities dropped to an average of 2.53 ppt in April 2004 and 1.6 ppt in May 2004, and subsequent monthly spot sampling in the summer showed that salinities remained at these levels throughout the summer (NPS, unpub. data). This water salinity pattern suggests that saltwater intrusion events occur principally in the winter and that the volume of saltwater is high enough to create saline conditions despite very high freshwater inflows from creeks, drainages, and groundwater (Parsons, *in prep*.). In addition, the extended period over which salinities dropped points to long residence time for saltwaters, probably because the highly vegetated and depressional basin structure of the marsh discourages exchange or draining to nearby Fish Hatchery Creek (Parsons, *in prep*.).

Saltwater intrusion events do not necessarily affect the entire West Pasture freshwater marsh. Within the marsh, tidal flows appear to move up the western perimeter of the marsh near Sir Francis Drake Boulevard and then disperse over the marshplain into lowest, deepest portions of the marsh in its center (Parsons, *in prep*.). Based on long-term salinity monitoring, it appears that saltwater intrusion occurs exclusively in the northern and central portions of the marsh, representing approximately two-thirds or 5.3 acres of the marsh. A rise in topographic gradient associated with the base of the Inverness Ridge to the west and the alluvial fan of the 1906 Drainage to the south appears to minimize salinity intrusion in the southern one-third (1.9 acres) of the marsh, particularly in combination with perennial freshwater flows from the 1906 Drainage. Salinities in the 1906 Drainage never exceed 0.1 ppt (NPS, unpub. data).

Water Quality

Perhaps, one of the most important functions that wetlands can provide in Tomales Bay is water quality improvement. While Tomales Bay is often considered a relatively pristine estuary, it is still vulnerable to anthropogenic impacts. As was described under Soil Resources, the Bay is subject to impacts from agricultural activities, leaking septic systems and landfills, past mercury mining, boating and boat facilities, offshore oil spills, and potentially even atmospheric deposition of contaminants from more heavily urbanized watersheds. During the last few decades, poor water quality has forced oyster fisheries to close down several times and, in 1998, was associated with a virus outbreak. In 1994, Tomales Bay was listed as threatened under the state's Shellfish Protection Act. Mercury mining during the late 1960s-1970s eventually resulted in deposition of mercury-contaminated sediment into Tomales Bay. Because of mercury problems, fish consumption advisories were established in 2000 and reissued in 2004 for Bay species such as jacksmelt (*Atherinopsis californiensis*), California halibut (*Paralichthys californicus*), and leopard shark (*Triakis semifasciata*; California EPA Fish Consumption Advisories web page; Advisory No. 400404).

The failure of Tomales Bay to consistently meet water quality standards for designated beneficial uses such as oyster mariculture, public recreation, and wildlife needs prompted the RWQCB to designate it as impaired under Section 303(d) of the Clean Water Act. These water quality problems have galvanized public and private efforts to improve water quality through both source reduction and restoration. The Park Service is actively working with community and local government groups on a number of projects related to water quality, the largest of which is the Giacomini Wetland Restoration Project. The Park Service's commitment to improving watershed health is evidenced by incorporation of a watershed-based restoration goal that encourages project proponents to search for opportunities to improve conditions within the entire Tomales Bay watershed, not just the Project Area. The Park Service believes that reestablishing the hydrologic connection between the Bay and this historic salt marsh could play a vital role in improving water quality not only within the Project Area, but within Tomales Bay by retaining and/or transforming sediment, nutrients, and pathogens in floodwaters. Two-thirds of the Bay's freshwater inflow – and therefore potential sources of pollutants -- comes from the Lagunitas and Olema Creeks, which flow through the Project Area (Fischer et al. 1996).

As with sediment contaminants, excessive inputs of nutrients can convert wetlands from a sink to a source. The Giacomini Ranch has operated since the 1940s, but another dairy existed within a portion of the Giacomini Ranch area prior to that. Agricultural operations such as dairies, in which cattle are highly

concentrated in both pastures and barn facilities, can increase loading of nutrients and potentially pathogens from manure. Because of concerns that restoration could result in at least a temporary increase in nutrient loading into Tomales Bay should the Ranch have very high concentrations of manure in the pastures, the Park Service implemented monthly to quarterly systematic sampling of field parameters, nutrients (nitrate, nitrites, total ammonia, total dissolved phosphates), chlorophyll a/phaeophytin, and pathogen indicators (total and fecal coliform) within the Project Area and selected reference sites in spring 2002. This sampling program would be continued as part of a long-term monitoring program for the proposed project.

Regulatory and Policy Setting

Increasing concern about polluted waters in the 1960s led to a number of federal and state efforts to improve water quality, some of which led to increasing protection for wetlands, which were recognized for their important role in improving water quality.

The most well-known legislation protecting the nation's waters is the Federal Water Pollution Control Act (Clean Water Act) and subsequent amendments of 1977 (33 USC §1251 et seq.). The Clean Water Act provides for the restoration and maintenance of the physical, chemical, and biological integrity of the nation's waters, primarily through three sections – Section 404, Section 401, and Section 303(d). Section 404 (33 U.S.C. 1344) of the Act prohibits the discharge of fill material into navigable waters, tributaries to navigable waters, and special aquatic sites of the United States, including wetlands, except as permitted under separate regulations by the U.S. Army Corps of Engineers (the Corps) and U.S. Environmental Protection Agency. Under Section 401 (33 U.S.C. 1341), states and tribes can review and approve, condition, or deny all Federal permits or licenses that might result in a discharge to state or tribal waters, including wetlands. In California, authority for Section 401 has been delegated to the State Water Resources Control Board (SWRCB), which shares its authority with nine regional boards (see Porter-Cologne Act below).

The Clean Water Act was actually predated by California's Porter-Cologne Water Quality Act of 1969 (California Water Code, Division 7, §13000), the principal California law governing water quality control in California. The Porter-Cologne Act applies broadly to all State waters, including surface waters, wetlands, and ground water; it covers waste discharges to land as well as to surface and groundwater, and applies to both point and non-point sources of pollution. SWRCB is the lead agency for enforcement and provides for establishment of waste discharge requirements for discharge to the state's surface and groundwater resources. SWRCB shares authority for implementation of the Clean Water Act and the Porter-Cologne Act with regional water boards. Each RWQCB governs one of the nine hydrologic regions into which California is divided, adopting regional water quality control plans (basin plans) for their respective regions. Waste discharge requirements for San Francisco Bay are outlined in the *Water Quality Control Plan for the San Francisco Bay Basin* (RWQCB 1995a). Water quality control plans designate beneficial uses of water for specific water bodies, establish narrative or numerical water quality objectives to protect those uses, and provide a program to implement the objectives. For Lagunitas Creek, beneficial uses include contact and non-contact recreation, oyster production, municipal and domestic water supply, agricultural supply, cold freshwater habitat, fish migration, preservation of rare and endangered species, recreation, fish, spawning, and wildlife habitat. For certain water quality objectives such as total and fecal coliform, specific numeric criteria have been developed for different beneficial use types. A list of the most relevant water quality objectives is provided in Table 8. These numeric criteria often specify a maximum or minimum or one-time "not to exceed" concentration or range of values, but also include measures of central tendency such as average or median concentrations (the central or middle value) over specified periods of time.

Should water bodies violate water quality objectives for its beneficial uses, the state is authorized under Section 303(d) of the Clean Water Act to declare these areas as "impaired" or unable to perform designated beneficial uses by specified contaminants. Both Lagunitas Creek and Tomales Bay have been declared impaired under Section 303(d) for excessive sedimentation and high levels of nutrients and pathogens. Tomales Bay has also been listed for mercury. In recent years, the RWQCB has been changing its primary focus from regulating point source discharges only to managing point and non-point source pollutant loads within entire systems or water bodies through setting Total Maximum Daily Load (TMDL) standards. The RWQCB has finalized the Tomales Bay Pathogen Total Maximum Daily Load (TMDL) standard and will be establishing TMDL standards for mercury, sediment, and nutrients over the next five years for Tomales Bay, Lagunitas Creek, and Walker Creek (http://www.waterboards.ca.gov/ sanfranciscobay/tmdlmain.htm). A nutrient TMDL has also been planned, but a schedule for this was not available.

TABLE 8. SELECTED WATER QUALITY OBJECTIVES UNDER THE SAN FRANCISCO BASIN PLAN

BACTERIA[a]	Beneficial Use or Habitat/Location	Fecal Coliform (MPN/100ml)	Total Coliform (MPN/100ml)
Basin Plan	Water Contact Recreation	• Geometric mean<200 • 90th Percentile <400	• Median < 240 No sample > 10,000
	Shellfish Harvesting[b]	• Median < 14 • 90th Percentile <43	• Median < 70 • 90th Percentile <230[c]
	Non-contact Water Recreation[d]	• Mean < 2000 • 90th percentile < 4000	
	Municipal Supply/ Surface[e]	• Geometric mean < 20	• Geometric mean < 100
Tomales Bay Pathogen TMDL *TMDL Load Allocation*	Tomales Bay Lagunitas Creek, Olema Creek, and Walker Creek *Lagunitas Creek at Green Bridge*	• Median < 14 • 90th percentile < 43 • Log mean <200 • 90th Percentile <400 • Log mean < 95	
DISSOLVED OXYGEN	Habitat/Location	Numerical Min. Objective	Numerical Median Objective
	Tidal Waters *Bay* *Delta*	5.0 mg/l Minimum 7.0 mg/L minimum	
	Non-Tidal Waters *Cold* *Warm*	7.0 mg/L minimum 5.0 mg/L minimum	Median D.O. for any three consecutive months not < 80 percent.
PH	Habitat/Location	Acceptable Range	Numerical Change Objectives
	All	6.5-8.5	Controllable water quality factors not cause changes > 0.5 units in ambient pH.
SALINITY	Habitat/Location	Narrative Objective/Numerical Change Objectives	
	All	Controllable water quality factors not increase the total dissolved solids or salinity of waters so as to adversely affect beneficial uses, particularly fish migration and estuarine habitat.	
SEDIMENT	All	• Suspended sediment load and suspended sediment discharge rate not be altered in such a manner to cause nuisance or adversely affect beneficial uses. • Controllable water quality factors not cause a detrimental increase in concentrations of toxic pollutants in sediments or aquatic life.	
TEMPERATURE	Inland Waters – Cold and Warm Habitats	• Natural receiving water temperature not altered unless demonstrated that alteration does not adversely affect uses. • The temperature of any cold or warm freshwater habitat not > 5°F above natural temperature.	
TURBIDITY	All	Waters free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases relatable to waste discharge not > 10 percent in areas where natural turbidity is > 50 NTU.	
UNIONIZED AMMONIA	Habitat/Location	Numerical Objectives	
	All	Annual Median ≤ 0.025	
	Central Bay/Delta	Maximum ≤ 0.16 mg/L	
	Lower Bay	Maximum ≤ 0.4 mg/L	

Notes:
a. Based on a minimum of five consecutive samples equally spaced over a 30-day period.
b. Source: National Shellfish Sanitation Program.
c. Based on a five-tube decimal dilution test or 300 MPN/100 ml when a three-tube decimal dilution test is used.
d. Source: Report of the Committee on Water Quality Criteria, National Technical Advisory Committee, 1968.
e. Source: DOHS recommendation.

Table Source: RWQCB 1995a

The Park Service Management Policies (2006) support federal and state efforts to either preserve or improve water quality. Parks are required to "determine the quality of park surface and ground water resources and avoid, whenever possible, the pollution of park waters by human activities occurring within and outside of parks" (Section 4.6.3; NPS 2006). Furthermore, parks are mandated to "take all necessary actions to maintain or restore the quality of surface waters and groundwaters consistent with the Clean Water Act and all

other applicable federal, state, and local laws and regulations" (Section 4.6.3; NPS 2006). Marin County regulates activities that substantially degrade surface or groundwater quality through CEQA review, as well as through grading and stormwater permits. It has established several-water related policies, including reduction of pathogen, sediment, and nutrient (WR-2.2), avoidance of erosion and sedimentation (WR-2.3), and protection of watersheds and aquifer recharge (WR-1.1; CWP 2005). The Point Reyes Station Community Plan (Marin County Community Development Agency 2001) identifies protection of Lagunitas Creek, including its water quality, as an objective.

Nutrients and Other Parameters

Tomales Bay. Tomales Bay has been subjected to intensive study on water quality, bay water mixing and nutrient dynamics through the National Science Foundation, Land Margin Ecosystem Research (LMER) program ((Kimmerer et al. 1993; Chambers et al. 1994; Joye and Hollibaugh 1995; Smith et al. 1996; Largier et al. 1997a; Smith and Hollibaugh 1997; Freifelder et al. 1998, and others). This large data set provides an excellent understanding into the complex nutrient cycling found in shallow, Mediterranean-climate estuaries such as Tomales Bay (TBWC 2003).

Nutrient dynamics within Tomales Bay are driven by both oceanic and terrestrial forces. Tomales Bay is considered a heterotrophic estuary in that ecosystem respiration or conversion of organic matter from non-estuarine sources to inorganic nutrients exceeds external supply or internal production of inorganic nutrients by about 10 percent (Smith and Hollibaugh 1998). While most of these converted organic matter is eventually either lost to the atmosphere or recycled internally, dissolved inorganic phosphorous is exported to the ocean and constitutes the primary "product" produced by the Bay that is directly available to external ecosystems (Smith and Hollibaugh 1997).

Organic matter inputs into Tomales Bay come from terrestrial sources (50 percent) and the ocean (50 percent; Smith and Hollibaugh 1998). As might be expected based on the seasonality of terrestrial and oceanic inputs, research has shown that the external supply of organic matter to Tomales Bay varies over seasonal and inter-annual time scales (Chambers 2000; Lewis et al. 2001). Terrestrial sources consist of organic matter, as well as sediment-bound and suspended forms of inorganic nutrients, from the surrounding watershed that flow into the Bay, typically during high rainfall periods. Most of this organic matter and inorganic nutrients enter the Bay through surface flows of its largest tributaries: as described earlier, Lagunitas Creek and its tributaries account for approximately two-thirds of the surface water freshwater inflow to the Bay, while Walker Creek and other small drainages account for the remaining one-third (Fischer et al. 1996). However, during the summer, groundwater discharge into the Bay contributes about as much nutrient load as does streamflow, while, during the winter, it contributes about 20 percent of that of the much higher winter streamflows (Oberdorfer et al. 1990).

Some of the organic matter and inorganic nutrients in surface waters -- and perhaps even groundwater depending on the discharge point -- flow through fringing and deltaic marshes on the perimeter of Tomales Bay before entering Bay waters. A study on two small, at least partially diked deltaic marshes just northeast of the Giacomini Ranch showed that, in some marshes with well-developed channels, short water residence times resulting from channelization of short-duration, high-intensity flows may decouple these systems from the nutrient pathway during the winter, reducing their effectiveness in filtering contaminants (Chambers et al. 1994). However, these same systems act as sources of inorganic nitrogen and phosphorous to the Bay during the summer, probably due to breakdown of organic matter (Chambers et al. 1994).

Oceanic sources come from upwelling or funneling of ocean-derived organic matter in offshore currents. The most intensive upwelling occurs during the summer, in response to strong, often persistent northwesterly winds (Smith and Hollibaugh 1998). Upwelling elevates the concentration of particulate organic matter in the coastal waters, which is then delivered to the bay by tides and particle settling (Smith and Hollibaugh 1998). Direct inorganic nutrient delivery from coastal upwelling in the Pacific Ocean is not of major importance to Tomales Bay, but may be important indirectly by affecting nutrient dynamics or cycling within the bay (Smith and Hollibaugh 1998).

As discussed earlier, tides, temperature, salinity, and freshwater inflow rates affect nutrient circulation patterns in Tomales Bay. During the winter, spring, and early summer, the substantial volume of freshwater inflows to the Bay results in a considerable exchange of organic matter and nutrients between the inner and middle portions of the Bay and the outer Bay and ocean. However, as freshwater flows decrease, circulation mechanisms shift from salinity-driven to temperature-driven gradients, which results in weaker exchange of

waters between at least the middle and portions of the inner Bay and the outer Bay and ocean (Harcourt-Baldwin 2003). This increases water residence time and persistence of nutrients within the Bay from several days during the winter to more than a month in the summer (Smith and Hollibaugh 1998). As noted earlier, water in the northern 3.73 miles of the bay exchanges with nearshore coastal water on each tidal cycle, while water in the southern 8.7 miles of the bay is resident for approximately 120 days during times of low runoff (Hollibaugh et al. 1988).

In the innermost portions of the Bay, absence of a salinity or temperature gradient with the middle and outer portions can effectively eliminate exchange of waters between these regions (Hearn and Largier 1997, Largier et al. 1997a). This phenomenon, which is accompanied by hypersaline conditions, apparently causes a buildup in dissolved inorganic phosphorous, as well as severe depletion of dissolved inorganic nitrogen (Largier et al. 1997a). Understandably, hypersaline systems "are very susceptible to pollution as even small loadings during the hypersaline phase may be recycled and accumulate, rather than being flushed from the system" (Largier et al. 1997a).

Internal sources of energy or organic matter to Tomales Bay also exist in the form of algae. Algae represent important components of the estuarine food web, as well as sensitive indicators of ecosystem health. Dramatic increases in dissolved or sediment-bound nutrients, combined with warm temperatures and stagnant water conditions, stimulates algal growth, sometimes excessive densities of algae called algal blooms. Besides being sometimes unsightly, algal blooms play havoc with ecosystems by causing massive swings in dissolved oxygen content of waters through over-production of oxygen during the day and depletion at night through uptake or even algae die-off. This oxygen depletion can result in a "fish kill" event in which fish and other aquatic organisms die to the lack or sudden decrease in oxygen. Die-offs of algae can also boost nutrient concentrations through recycling of organic matter. In addition, excreted material from large concentrations of consumers such as bivalves, waterfowl, shorebirds, and even mammals such as seals can noticeably affect localized nutrient concentrations, primarily through increases in ammonia (Judah 2000).

Despite water quality problems, Tomales Bay has not been characterized as an eutrophic estuary (Cole 1989; Chambers 2000; Lewis et al. 2001). Studies in 1985-1986 in Tomales Bay indicated that spatial and temporal variations in primary productivity were similar to variations in phytoplankton biomass (Cole 1989). During summer months productivity was highest in the seaward and central regions of the bay and lowest in the shallow landward region (Cole 1989). This lack of sustained high phytoplankton concentrations suggests that the shallowness of the southern region, its shallow photic depths, wind-induced turbidity, and feeding of benthic organisms keeps the populations at a lower level than other parts of the bay (Cole 1989). However, little is known about the phytoplankton dynamics in Tomales Bay and the shifting location of the maximum chlorophyll-a concentrations – variable used to measure phytoplankton – during different sampling periods indicates the dominant processes controlling phytoplankton biomass vary (Cole 1989).

In general, little is known about the nutrient status of Tomales Bay or the primary sources of nutrients to the Bay. A review of the current literature indicates that the nutrient levels in the watershed could be elevated, but the database is not very extensive (TBWC 2002). With so little seasonal data on nutrient loading from the watershed and nutrient levels in Tomales Bay, trends cannot be determined (TBWC 2002). In addition, most of the 12 water quality studies conducted in the watershed and bay have emphasized total and fecal coliform measurements and not nutrient levels (TBWC 2002). The data that is available has suggested that nutrients are a problem for the Bay and subwatersheds, which is why these areas have been listed by the RWQCB as impaired for nutrients. The RWQCB will be preparing a TMDL for nutrients, but it is not scheduled for the near future (http://www.waterboards.ca.gov/sanfranciscobay/tmdlmain.htm).

There are a few long-term or more intensive synoptic programs. CDFG conducted a 10-year sampling program between 1991-2001(Rugg 2000; Rugg 2002). Results from the last two years of this study showed that standards were exceeded for only three measurements (DO levels and un-ionized ammonia) out of 329 in 1998-1999 and only two measurements (DO levels) in 1999-2000 (Rugg 2000, Rugg 2002). Studies conducted in the upstream portions of the Lagunitas Creek by the Park Service found that nutrients, nitrites, and unionized ammonia did not appear to be problematic, at least in the upper portions of the watershed (Ketcham 2001). Nearly all of the samples collected from the larger stream systems and most of the tributary samples were below detection limits (Ketcham 2001). Interestingly, at least one comparison between historical and current conditions suggested that, after more than a century of discontinuities in sedimentation and material export, export of sediment-bound forms of nitrogen and phosphorous from the upper portions of the watershed appears to have reached steady-state conditions (Smith et al. 1996).

As with pathogens, the primary sources of nutrients to the Bay include agricultural operations (e.g. dairies and beef cattle), leaking or poorly constructed septic systems, domesticated animals such as horses, and non-point source run-off from communities. Because of the preeminence within this rural watershed and concentrated number of cattle, dairies have received the most scrutiny. The Chambers et al. (1994) paper correlated "dairy runoff from pasture lands" in the watershed of one of the two study marshes with consistently high dissolved ammonium and phosphate in downstream marsh waters. However, two recent studies that nutrient loading from animal agriculture may not be as high as previously indicated, particularly loading from pastures (Regional Water Quality Control Board (RWQCB) 1995b); Lewis et al. 2001 *in* TBWC 2002).

In addition, even in situations where dairies are contributing nutrients to the system, an overall decrease in agricultural activities within the Tomales Bay watershed may be the reason that export of nitrogen and phosphorous to the Bay has decreased and reached steady-state conditions (Smith et al. 1996). Not only do dairies generate nutrients, but cattle can cause increases in land erosion. Erosion not only impacts downstream water quality through increases in turbidity and associated decreases in water clarity, but many nutrients, contaminants, and pathogens are principally transported in water as bound or sorbed to sediment particles. Estimates of sediment-bound nutrients vary widely, but, in general, phosphorous appears to be transported bound to sediment more than nitrogen, although nitrogen estimates still ranged as high as 51-57 percent in some systems (Meybeck 1984, Haith and Shoemaker 1987; Walling et al. 1997). Most inorganic nitrogen is transported as soluble nitrate, however, where erosion rates and sediment yields are high, the sediment-associated component of the total nitrogen and phosphorous loads will predominate (Walling et al. 1997). For these nutrients, sediment transport processes, primarily suspended sediment processes, largely govern which areas become "sinks." As with nutrients, specific information on turbidity, sediment transport processes, and transport of particulate and dissolved forms of nutrients within Tomales Bay is scarce, as most of the past studies have focused largely on changes to the bay's bathymetry or creek geomorphological processes due to increases – or decreases – in sediment supply.

Giacomini Ranch. Water quality within the Giacomini Ranch has been monitored for four years as part of the planning process. In general, between 2001 and spring 2006, waters within the Giacomini Ranch did not appear to be eutrophic (Parsons and Allen 2004a). With a few exceptions, parameters such as dissolved oxygen, pH, and nitrates only occasionally exceeded water quality objectives in the RWQCB *San Francisco Basin Water Quality Control Plan* or Basin Plan (RWQCB 1995a), which incorporates Tomales Bay as well as San Francisco Bay (Table 8). There were low to moderate concentrations of nutrients and chlorophyll a, even in drainage ditches (ranging from 0.2-1.5 mg/L), with the exception of seasonal pulses (Parsons, *in prep*.). Also, dissolved oxygen and chlorophyll a levels were not characteristic of either highly eutrophic or hypoxic systems, with the exception of some of the drainage ditches and sloughs in the eastern portion of the Project Area (Parsons, *in prep*.).

The RWQCB Basin Plan (1995a) stipulates that, in tidal waters, dissolved oxygen must have a minimum concentration of 5.0 mg/L (approximately 50 percent dissolved oxygen at 15.0 degrees Celsius), and the oxygen concentration for three consecutive months shall not be less than 80 percent of the saturated dissolved oxygen concentration. For non-tidal waters, the dissolved oxygen concentration minimum is 7.0 mg/L for cold water habitat and 5.0 mg/l for warm water habitat. Within some of the ditches and channels in the East Pasture, dissolved oxygen concentrations consistently fell below 5 mg/L within both surface and bottom waters of some ditches and ditched sloughs and were typically even below 2 mg/L (Table 9; Parsons, *in prep*.). The RWQCB objective of 5.0 mg/L was exceeded during 57 percent of the sampling periods in the East Pasture, with oxygen levels below hypoxia (< 2.0 mg/L) and anoxia (<0.5 mg/L) 32 percent and 14 percent of the sampling periods, respectively (Parsons, *in prep*.). The observed hypoxia-anoxia may have been caused by increased oxygen demand from bacteria breaking down organic matter or detritus from vegetation that was disturbed by ditch maintenance (Parsons, *in prep*.). Low dissolved oxygen concentrations also occurred in some of the non-ditched features in the East Pasture, including the East Pasture's New Duck Pond, where a majority of values below 5 mg/L: the New Duck Pond is a shallowly ponded, artificially created feature that was maintained until recently through seasonal flooding of pumped irrigation waters (Parsons, *in prep*.).

Some of the monitoring locations in Olema Marsh and on Tomasini Creek, Fish Hatchery Creek, and smaller drainages in the West Pasture occasionally had concentrations of dissolved oxygen below 5 mg/L (Table 9; Parsons, *in prep*.). RWQCB objectives were exceeded between 21 and 25 percent of the sampling periods in the West Pasture, Tomasini Creek, and Olema Marsh.

Most of these events occurred in the spring or summer, when oxygen concentrations might be affected by a combination of nutrient loading, increased temperature, decreased flow conditions, and, consequently, an increase in primary productivity that could create rapid diel variation in oxygen levels (Parsons, *in prep*.). Some of the lowest dissolved oxygen concentrations for Lagunitas Creek within the Project Area occurred in April 2003, with most having levels just above 5 mg/L ; Parsons, *in prep*.). These comparatively low concentrations may be tied to upstream reservoir releases of poor quality water or nutrient loading from cattle in portions of the creek upstream of the Project Area (KHE 2006a).

TABLE 9. LIST OF FREQUENCY OF EXCEEDANCE OF RWQCB BASIN WATER QUALITY OBJECTIVES DURING SAMPLING PERIODS

Criteria that are not listed can be found in Table 8. Percentage refers to percentage of sampling events in which objective was exceeded by a single sample: it should be noted that some standards are linked to means or medians of a group of samples collected over specific time periods. Areas are WP (Giacomini Ranch West Pasture), EP (Giacomini Ranch East Pasture), OM (Olema Marsh), TOM (Tomasini Creek), and LAG (portion of Lagunitas Creek in Project Area).

	Consistently Exceed (≥75%)	Regularly Exceed (≥50%)	Occasionally Exceed (≥25%)	Infrequently Exceed (>0%)	Never Exceed (0%)
Dissolved Oxygen (>5.0 mg/L)		EP	OM	WP, TOM, LAG	
pH (>6.5 and <8.5)				EP, WP, TOM, OM, LAG	
Nitrates					
USEPA (10 mg/L)				EP, TOM	WP, OM, LAG
AWWA (1 mg/L)		LAG, OM	EP, WP, TOM		
Nitrites					
USEPA (1mg/L)				EP	WP, OM, TOM, LAG
Unionized Ammonia (≤ 0.16 mg/L)				EP, LAG	WP, OM, TOM
Fecal Coliform (Based on Individual Sample Event Values; Means for Monitoring Period are shown in Bold Italic)					
Shellfish Harvesting (<43 mpn/100ml)	All/ ***All***				
Municipal Water Supply (<20 mpn/100ml)	All/ ***All***				
Water Contact Recreation (<200 mpn/100ml)	EP, OM, LAG/ ***All***	WP, TOM			
Non-Contact Water Recreation (<2,000 mpn/100ml)	***All***	EP		WP, LAG, TOM, OM	
TMDL-Lagunitas Creek (<200 mpn/100ml)	EP, OM, LAG/ ***All***	WP, TOM			
TMDL Load Allocation-Lagunitas at Green Bridge (<96 mpn/100ml)	All/ ***All***				

Source: Parsons, *in prep*.

With some exceptions, surface waters within the Giacomini Ranch generally appeared to meet RWQCB Basin Plan (1995a) objectives for pH in surface waters (Table 9; Parsons, *in prep*.). According to the Basin Plan, pH should fall within the range of 6.5 and 8.5. USEPA standards for freshwater stipulate that pH should be within the 6.5 and 9.0. The West Pasture had the highest number of exceedances for pH, with pH exceeding standards during approximately 9 percent of the sampling periods: most of these exceedances came from pH being below 6.5 (Table 9). Several factors control pH within waters of transitional zones, including tidal influence, the chemistry of surface waters and groundwater, seasonal variation in primary productivity, and biogeochemical reactions within underlying soils. In general, waters in the Project Area appear to be largely circumneutral (~7; Parsons *in prep*.). Baseline pH appeared higher in areas that are either tidal or tidally influenced, as tidal waters tend to be more alkaline (~ 7.8), and in upstream portions of creeks that flow off the Inverness Ridge (Fish Hatchery Creek, 1906 Drainage; ~7.8 – 8.1), which may be related to the underlying chemistry that exists from weathering of this granite-dominated geologic formation (Parsons, *in prep*.).

Conversely, baseline pH might be slightly depressed (~5.9 – 6.6) in locations primarily influenced by groundwater (Parsons and Allen 2004a). Water pHs with more basic or alkaline values (>8.5) typically occurred during the spring and summer when primary productivity of algae is highest due to nutrient loading, warm temperatures, and decreased flow conditions (Parsons, *in prep*.). Water pHs with more acidic values (~5.9 - 6.4) were found in drainage ditches and shallow seasonally flooded areas due probably to breakdown of organic matter and production of humic acids or other biogeochemical acid-producing processes (Parsons, *in prep*.). At least one of these shallowly flooded areas in the West Pasture may have largely accounted for the comparatively high number of exceedances of Basin Plan objectives (Parsons, in prep.). Interestingly, while surface waters within Lagunitas Creek within the Project Area had only one exceedance of Basin Plan objectives, some limited sampling on portions of Lagunitas Creek between the Green Bridge and Nicasio Creek revealed that pH levels in deeper portions of some of the pools were considerably reduced, with pHs ranging from 3.9 to 5.2 (KHE, unpub. data).

Nitrates appear to be the most abundant nutrient in the Project Area (Parsons, *in prep*.). Nitrate concentrations between 2001 and spring 2006 were generally low to moderate (between 0.2 and 3 mg/L) and similar in both the Project Area and undiked reference marshes that were sampled (Parsons and Allen 2004a, Parsons, *in prep*.). Nitrates typically occur when ammonia is converted to nitrates under well-oxygenated conditions and have been linked sometimes to the influence of leaking septic on groundwater. Average nitrate concentrations calculated using statistical procedures to estimate values that were below the laboratory detection limits ranged from as high as 9.2 mg/L in East Pasture to as low as 1.03 mg/L in the portion of Lagunitas Creek in the Project Area, with average values for Olema Marsh, Tomasini Creek, and the West Pasture being 1.65 mg/L, 1.46 mg/L, and 1.27 mg/L (Parsons, *in prep*.). Average nitrate concentrations in undiked reference wetlands had a tighter range between 0.93 mg/L and 1.04 mg/L. Mean nitrate concentrations in the East Pasture would appear close to the USEPA human consumption limit of 10 mg/L, but average concentrations in the East Pasture were highly skewed by a few very high values that exceed USEPA objectives, as evident from the much lower median value, 1.89 mg/L (Table 9; Parsons, *in prep*.). While USEPA objectives (established for human consumption) were only exceeded a few times, the higher average concentrations suggest that the Project Area occasionally to regularly exceeds standards recommended for preventing eutrophication in estuaries and maintaining moderate aquatic diversity (1.0 mg/L; (American Water Works Association (AWWA) 1990); Table 9). Winter concentrations were highest, with pulses often observed during October and January rainfall events (Parsons and Allen 2004a). Within the East Pasture, the consistently highest concentrations of nitrate were detected in the drainage ditches and a ditch that receives seep and spring groundwater flow, as well as stormwater run-off from the town of Point Reyes Station and Giacomini Ranch feed lots (Parsons and Allen 2004a). Based on monitoring data, nitrate concentrations in the East Pasture are higher than many other dairies the Seashore (range of means = ~1.8 - 5.27; Ketcham 2001), although this data is limited, and means were calculated using different procedures to estimate values below laboratory detection range.

As might be expected, despite high concentrations in several sampling locations in the Project Area, the highest instantaneous loading rates for nitrates – or total volume of nitrates discharged at a single point in time based on stream discharge and capacity -- came from Lagunitas Creek, with instantaneous loading rates during an April 2006 storm as high as approximately 220 mg per second (mg/s; Parsons, *in prep*.). However, instantaneous loading rates for Lagunitas Creek were typically below 1.0 mg/s. Conversely, the highest instantaneous loading rates recorded during four years of discrete sampling for some of the other creeks, drainages, and seeps totaled only 0.27 mg/s for 1906 Drainage, 0.96 mg/s for Fish Hatchery Creek, 1.29 mg/s for Bear Valley Creek, and 2.22 mg/s for Tomasini Creek (Parsons, *in prep*.). Some of the East Pasture areas still had comparatively nitrate loads, as well as concentrations, with the highest values ranging from 11.1- to 46.47 mg/s for ditches, including one receiving non-point source run-off from the town of Point Reyes Station (Parsons, *in prep*.). However, technically, these areas do not discharge to downstream water bodies because of the levees and tidegates, so there is no active loading, except perhaps during those infrequent periods when the Giacominis have discharged ditch water to Tomales Bay or when floodwaters overflow the levees.

When oxygen in waters is low, an intermediary form of nitrogen, nitrites, can occur that can cause asphyxia in humans and wildlife by binding to hemoglobin and reducing oxygen transport. Nitrites were almost always below the detection limit (Table 9), although they were infrequently detected (4 exceedances) in the East Pasture, with at least one exceedance of USEPA objectives of 1.0 mg/L for human consumption (Parsons, *in prep*.). Based on RWQCB standards, there were four exceedances of nitrite levels considered toxic to aquatic organisms (>0.5 mg/L), with three of these in the East Pasture ditches and one in an undiked marsh (Parsons, *in prep*.).

Overall, ammonia concentrations between 2002 and spring 2006 were generally either non-detect or very low (<1 mg/L) and similar between the Project Area and undiked reference marshes (Parsons and Allen 2004a, Parsons, *in prep*.). The presence of higher concentrations of ammonia, which is often bound to sediment when transported, typically can be traced to the recent or nearby presence of wildlife or livestock or use of ammonia fertilizers, as ammonia is quickly converted to nitrates under well-oxygenated conditions. The well-oxygenated conditions within most of the Project Area appear to be quickly converting ammonia to nitrates, with ammonia concentrations highest in those sampling locations where oxygen levels are consistently low (Parsons, *in prep*.). These locations included the Giacomini Ranch's East Pasture drainage ditches, the drainage ditch receiving groundwater and feedlot-influenced stormwater run-off from Point Reyes Station, and in Lagunitas Creek following a potential discharge of flood waters from the pasture (Parsons and Allen 2004a). Even in these areas, high concentrations typically represented seasonal pulses (Parsons and Allen 2004a). As with nitrates, these seasonal pulses skewed average concentrations to the high end. For example, average ammonia concentrations calculated using statistical procedures to estimate values that were below the laboratory detection limits ranged from 3.1 mg/L in the Giacomini Ranch East Pasture to 0.25 mg/L in the portion of Lagunitas Creek in the Project Area, while median values for those same areas ranged between 0.41 mg/L for the East Pasture and 0.01 mg/L for Lagunitas Creek (Parsons, *in prep*.). Mean and median estimated ammonia concentrations for some of the undiked reference wetlands were as low as 0.1 mg/L and 0.05 mg/L, respectively (Parsons, *in prep*.).

There are no Basin Plan standards for ammonia (RWQCB 1995a), but the RWQCB has established objectives for unionized ammonia. In waters with elevated pH, temperature, and/or salinity, ionized ammonia converts to unionized ammonia, which is toxic to aquatic organisms. Only two sampling locations exceeded the maximum general limit for most estuarine waters of 0.16 mg/L (Table 9; RWQCB 1995a; Parsons, *in prep*.). These maximum exceedances occurred in a Giacomini Ranch East Pasture drainage ditch and in a Lagunitas Creek sample in April 2003 that may have received stormwater flow from the pastures.

As with ammonia, total dissolved phosphate concentrations between 2002 and spring 2006 generally fell below or slightly above the detection limit (<0.0.05–0.20 mg/L), with the exception of the Giacomini Ranch's East Pasture drainage ditches (Parsons, *in prep*.). The presence of phosphates in the surface waters may be directly attributed to human and agricultural activity impacting runoff into water courses within the Giacomini Ranch (KHE 2006a). The Basin Plan objectives focus on the linkage between high concentrations of phosphates and growth and sometimes overgrowth of algae. No specific concentration-based objectives are presented in the Basin Plan (RWQCB 1995a), however, the recommended concentration of phosphorous to prevent algal blooms within estuaries is 0.01 to 0.1 mg/L (NOAA/EPA 1988), which is generally below the detection limit for phosphates in the Seashore's monitoring program.

Measurable concentrations of phosphates were primarily detected in the Giacomini Ranch's East Pasture drainage ditches and ranged from 0.24–6.8 mg/l (KHE 2006a). Concentrations at other locations such as Lagunitas, Fish Hatchery, and Tomasini Creeks were at or below detection limit (0.10 – 0.20 mg/L) for a majority of the monitoring events (KHE 2006a). Mean phosphate concentrations calculated using statistical procedures to estimate values that were below the laboratory detection limits ranged from 2.76 mg/L in the Giacomini Ranch East Pasture to 0.13 mg/L in the portion of Lagunitas Creek in the Project Area, with other mean values estimated as 0.25 mg/L for Olema Marsh and 0.14 mg/L for the Giacomini Ranch West Pasture and Tomasini Creek (Parsons, *in prep*.). Again, mean values were skewed pulses of phosphates, particularly in the East Pasture, which had median concentrations of 1.34 mg/L, with differences between mean and median less dramatic in other portions of the Project Area (median values ~0.08 to 0.24 mg/L; Parsons, *in prep*.). The hypoxia to even anoxia that exists in East Pasture ditches would encourage flux of phosphates from sediments in the ditch. Mean and median estimated phosphate concentrations for undiked reference wetlands range between 0.11 to 0.32 mg/L for average concentrations and 0.08 to 0.133 mg/L for median concentrations (Parsons, *in prep*.). As with nitrates, the highest loading rates for total dissolved phosphates in the Project Area – or the highest volumes of phosphates relative to stream discharge – comes from Lagunitas Creek, with loading reaching as high as 4.2 mg/s in Lagunitas Creek and maximum values for other creek and drainages being no higher than 0.2 mg/s (Parsons, *in prep*.). Loading rates for the East Pasture, which technically does not discharge to downstream water bodies, would have been no higher than 0.85 mg/s (Parsons, *in prep*.).

There are no numerical Basin Plan (RWQCB 1995a) objectives for ambient turbidity conditions. To some degree, measurements of turbidity generally showed a seasonal trend, with the highest values surprisingly in spring, summer, or early fall: turbidity is typically expected to be highest during the winter when sediment is

being actively moved by creeks (Parsons, *in prep*.). The production of suspended particles may be due to events such as upstream dam releases, biological activity, cattle activity, earth-moving and other activities within streams, ditches, and other water bodies (KHE 2006a). Turbidity values in Lagunitas Creek were generally below 50 Nephelometric Turbidity Units (NTU), with the exception of the highest measured turbidity of 266 NTU at the Giacomini Ranch north levee in June 2003 (Parsons, *in prep*.). This measurement may be an anomaly or the result of exchange with downstream Tomales Bay waters during an incoming tide or discharge of pasture waters from an adjacent pump, as values upstream in Lagunitas Creek never exceeded an NTU of 26 on this same date (Parsons, *in prep*.). In Tomasini Creek, turbidity generally ranged between 1 and 40 NTU, with spikes occasionally above 50 NTU occurring during the fall (KHE 2006a). Turbidity values for Fish Hatchery Creek generally fell below 50 NTU, with seasonal spikes over 50 NTU observed during the summer of 2003 and 2004 at downstream locations in the West Pasture (KHE 2006a).

Water temperature is controlled by standards established in a separate document that focuses primarily on elevated temperature water discharges such as cooling waters from power plants, but the Basin Plan does specify that the natural receiving water temperature of inland surface waters shall not be altered unless it can be demonstrated that such alteration in temperature does not adversely affect beneficial uses (RWQCB 1995a). Water temperatures varies seasonally within the Project Area, with warmer predominant during the spring, summer, and early fall, when solar radiation increases and water levels decrease (Parsons, *in prep*.). While all organisms are sensitive to high temperatures, temperature has been identified as limiting factors for certain species, including salmonids. Salmonids use downstream transitional zones of tidal creeks for resting habitat during upstream migration in the winter and for refugia and foraging during outmigration during the spring and summer. During two years of monthly monitoring, temperature in streams known to have supported or that are currently used by salmonids, at least on an intermittent or seasonal basis, ranged from an average of 54.2 degrees Fahrenheit (upper portion of Fish Hatchery Creek in Project Area near Sir Francis Drake Boulevard) to 60.3 degrees Fahrenheit (upper portion of Lagunitas Creek in Project Area between White House Pool and Green Bridge; Parsons, *in prep*.).

Continuous temperature monitoring in upstream portions of Lagunitas Creek during the spring and early summer when salmonid outmigration numbers typically peak showed a steady increase in water temperatures from an average of approximately 56.3 degrees Fahrenheit and range of 48.2 to 64.4 degrees Fahrenheit in April 2003 to an average of approximately 65.3 degrees Fahrenheit and range of 59 to 71.6 degrees Fahrenheit in June 2003 (Parsons, *in prep*.). Water temperatures between monitoring locations both in open water and underneath overhanging riparian trees were almost identical despite the fact that riparian vegetation usually helps to keep water temperature lower due to the effects of shading on solar radiation (Parsons, *in prep*.). During a 24-hour period, temperatures typically varied by as much as approximately 6.3 to 10.5 degrees Fahrenheit (Parsons, *in prep*.). One monitoring location consistently had the both the lowest temperatures and the widest daily variation in temperature: the lowest temperatures were consistently 1.8 to 5.4 degrees Fahrenheit lower than other monitoring locations, although the daily highs were often similar (Parsons, *in prep*.). This monitoring location occurs just downstream of the confluence of Bear Valley Creek and Lagunitas Creek on the south bank underneath overhanging riparian vegetation and may be affected by nighttime cooling of waters within Olema Marsh that subsequently flow into Lagunitas Creek (Parsons, *in prep*.).

Olema Marsh. Water quality monitoring in Olema Marsh was not initiated by the Park Service until August 2004, so the amount of data available from which to draw a conclusion regarding resource conditions in Olema Marsh is more limited. While Bear Valley Creek occurs in a relatively pristine watershed, water quality conditions were only slightly better than Giacomini Ranch (Table 9; Parsons, *in prep*.). Dissolved oxygen concentrations generally averaged around 7.7 mg/L, except for August 2005, when levels dropped as low as 2.6 to 4.17 mg/L (Parsons, *in prep*.). The hypoxic conditions were recorded just upstream of Olema Marsh in lower Bear Valley Creek during the morning, which suggests that supersaturation during the midday and afternoon of the previous day may be resulting in anoxia or oxygen depletion during the night in this sluggish, marshy portion of the creek (Parsons, *in prep*.). Despite this, water pH remained consistently circumneutral during all monitoring events, averaging 7.0 (Parsons, *in prep*). Turbidity levels never exceeded 50 NTU, ranging from 5.13 to 28.8 NTU (Parsons, *in prep*.). Water temperatures in Olema Marsh ranged from as low as 50 degrees Fahrenheit in the winter to as high as 59 to 70 degrees Fahrenheit in the summer, averaging approximately 56.5 degrees Fahrenheit (Parsons, *in prep*.).

Nitrates never exceeded USEPA water quality objectives of 10 mg/L for human consumption, but regularly exceeded levels recommended for preventing eutrophication in estuaries and maintaining moderate aquatic organism diversity (1.0 mg/L), ranging from 0.96 to 2.9 mg/L between August 2004 and April 2006 and

averaging 1.65 mg/L (Table 9; Parsons, *in prep*.). Concentrations flowing into Olema Marsh almost always exceeded those flowing out of the marsh, which suggests an upstream source for this nutrient (Parsons, *in prep*.). Nitrate loading rates at the upstream sampling location ranged from as low as 0.01 to as high as 55.9 mg/s during a 2006 sampling after a large series of storms (Parsons, *in prep*.). During this sampling, nitrate loading rates at the downstream location within Olema Marsh plummeted to as low as 0.14 mg/s (Parsons, *in prep*.). Nitrites were generally not detected (<0.05 mg/L), except for one slightly elevated observation (0.07 mg/L) at the downstream location that did not exceed Basin Plan standards (RWQCB 1995a; Parsons, *in prep*.). Ammonia has not been detected (detection limit < 0.2 mg/L), and total dissolved phosphates generally ranged from non-detectable (<0.2 mg/L) to 0.35 mg/L (Parsons, *in prep*.). No clear upstream-downstream trend was apparent, but often concentrations were higher at the downstream end of the marsh (Parsons, *in prep*.). Slightly elevated concentrations of phosphates observed in Olema Marsh may result either from re-suspension of phosphates in sediments, excretion by aquatic organisms, or influx from some outside source of phosphates such as leaking septic systems (Parsons, *in prep*.).

Fecal Coliform

Tomales Bay. For decades, fecal coliform has been used as an indicator for the presence of pathogenic bacteria that could negatively affect human and wildlife health. Pathogenic bacteria are typically transmitted through human and animal feces, which enter streams and other water bodies either directly through cattle being in creeks or boats discharging sewage or indirectly through leaking septic systems or sewage treatment facilities. Because of the potential impact that bacteria have on shellfish production, research and monitoring for pathogens has been more extensive than that for nutrients. As early as 1967, the Pacific Marine Station and NMWD found that Tomales Bay had fecal coliform levels that were high during the winter runoff periods (Smith et al. 1971 *in* TBWC 2002). Since then, several intensive studies on bacteriological water quality of the Bay and its tributaries have been conducted over the past 28 years, which were summarized in the Staff Report for the pathogen TMDL (Ghodrati and Tuden 2005). These studies include:

- A 1974 shellfish and water quality study by the California Department of Health and Human Services (Sharpe);
- A shoreline and watershed water quality survey carried out in 1976-1977 and 1977-1978 by the RWQCB;
- A sanitary survey conducted by DHS;
- A pilot study conducted by DHS in the winter of 1994–95 to test sampling methods and locations for the 1995–96 study;
- A RWQCB-funded study conducted in 1995–96 by DHS and the RWQCB, under the auspices of the Tomales Bay Shellfish Technical Advisory Committee (TBSTAC); and
- A second RWQCB-funded study conducted in 2001 by the RWQCB and TBSTAC with assistance from the Seashore.

The results of these studies indicate that Tomales Bay and its tributaries have exceeded shellfish and water quality standards over the last three decades (Ghodrati and Tuden 2005). In 1974, DHS designed a study (TBSTAC 2000 *in* Ghodrati and Tuden 2005) to determine the water quality of Tomales Bay and tributary streams during wet weather conditions and relate the results to the bacteriological quality of the shellfish grown in the Bay. Shoreline samples showed elevated total and fecal coliform levels at numerous stations, which were attributed to the possibility of shoreline drainage, tributary streams entering the Bay, and possible failing septic systems. The study concluded that the high coliform counts were due to contribution of wastes by upstream dairies and, in lower Keyes Creek, from raw sewage discharges from the town of Tomales.

The RWQCB conducted a shoreline and tributary sampling survey during the winters of 1976–77 and 1977–78 (TBSTAC 2000 *in* Ghodrati and Tuden 2005), to evaluate the effectiveness of the RWQCB's recent requirements for dairy waste practices. Stream conditions improved for areas in which dairies had come into compliance with the minimum guidelines, although none of the shoreline or stream stations sampled met coliform objectives for water contact and non-contact recreation following periods of rainfall. Stream stations showed decreases in coliform between 1976–77 and 1977–78 following implementation of the minimum guidelines. The report also concluded that sewering of the town of Tomales in June 1977 resulted in decreased levels of coliform in Keyes Creek downstream of developed areas.

In 1980, the Food and Drug Administration (FDA), to determine the degree of pollution and the recovery rate of the Bay during periods of rainfall, conducted a sanitary survey from February 24 through March 12 (TBSTAC 2000 *in* Ghodrati and Tuden 2005). The results of this study showed that the shellfish market

standard for fecal coliform was exceeded in all Bay water quality stations during wet periods. The dry period samples met the standard, with the exception of stations at the head of the Bay and near the mouth of Walker Creek. Seven out of eight shellfish samples exceeded the market standard. Fecal coliform densities in the streams during dry weather were equal to sewage from about 150 to 200 people. During wet weather, fecal coliform densities increased to the equivalent of sewage from 1,500 to 2,000 people or 500 to 700 cows. The highest loadings following rains revealed a bacterial equivalent of 40,000 to 50,000 people or 15,000 to 20,000 cows. The 1980 study concluded that the portions of the Bay most seriously affected by pollution from rainfall and runoff were the head of the Bay (Millerton Point south) and the Walker Creek delta. Rural and livestock sources of nonpoint pollution were considered to be the most likely cause of high fecal coliform densities in the Bay.

The pilot study conducted by DHS in the winter of 1994–95 was a prelude to the study during 1995–96 (TBSTAC 2000 *in* Ghodrati and Tuden 2005). Both of these studies were initiated as a result of Tomales Bay being listed as threatened under the Shellfish Protection Act and the formation of TBSTAC. The data from the pilot study support the theory that the major source of fecal contamination to the Bay is rainfall-related runoff from the tributaries. Two seasonal patterns of fecal coliform densities were observed: 1) sites that showed declining fecal coliform densities throughout the winter, suggesting a nonrenewable source of coliforms, and 2) sites that exhibited high fecal coliform densities throughout the season, suggesting a renewable source.

Following completion of the pilot study, the RWQCB and DHS conducted an intensive RWQCB-funded study of bacteriological and pathogen levels in the water of Tomales Bay and its watershed (TBSTAC 2000 *in* Ghodrati and Tuden 2005). As before, bacterial densities usually exceeded the standards within the first one or two days of each rainfall event, then, typically decreased to acceptable levels by the last day of sampling. Fecal coliform levels in the middle portion of Tomales Bay were generally lower than either the outer- or inner-bay regions, although all Bay stations experienced elevated concentrations of fecal coliforms immediately following rainfall. Consistently high bacterial levels were detected during most of the study at sites within the Walker/Keyes/Chileno Watershed and along the eastern shoreline watershed. Slightly lower concentrations of fecal coliforms were detected throughout the Lagunitas and Olema subwatershed. In contrast, bacterial levels at the western shoreline watershed stations were generally 10 to 100 times lower than those from all other subwatersheds. The highest loadings estimated were within the Walker/Keyes/Chileno and the Lagunitas and Olema subwatersheds. Within the Lagunitas/Olema Watershed, Lagunitas Creek contributed the largest share of the fecal load, followed by Olema Creek. The Bear Valley drainage contributed the lowest loadings for this Subwatershed.

In the winter of 2000–2001, the Water Board, in conjunction with TBSTAC and the Seashore, designed and conducted a study with the purpose of implementing some TBSTAC recommendations from the 1995–96 study. This study looked at both fecal coliform and *E. coli* as indicators for the presence of pathogens through both one-time and repeated measurements throughout three storm events, with repeated *E. coli* sampling used to estimate total loading rates for some of the sampling locations. Throughout the three wet-weather sampling events, the fecal coliform levels for all watershed and Bay station samples significantly exceeded the designated water quality objectives for shellfish harvesting waters and, in most cases, for contact and noncontact water recreation (RWQCB 2001). In general, fecal coliform levels remained high during all rainfall events sampled in all watersheds, typically increasing during the second day of each wet-weather sampling event (RWQCB 2001). Intensive time series sampling conducted on Olema Creek by the Seashore as part of this study showed that bacteria loading as represented by *E. coli* closely tracked stream discharge in terms of the rise and fall in flows, although there was often a two-hour lag in this system between peak stream discharge and peak *E. coli* levels (Ketcham 2001).

Of the inner Bay station samples, the highest fecal coliform levels were consistently detected at the inner Bay Station 1 (located south of the Tomales Bay Oyster Company lease area), which is closest to the inlet of Lagunitas and Olema Creeks (RWQCB 2001). The lower Walker Creek subwatershed contributed the highest one-time and highest overall instantaneous fecal coliform loadings (RWQCB 2001). Lower and upper San Geronimo Creek subwatersheds, which are tributaries to Lagunitas Creek, and lower (7.46×10^{13}) and upper Lagunitas Creek (5.13×10^{13}) ranked as the second and third and fifth and sixth largest contributors, respectively, in terms of instantaneous fecal coliform loading rates (RWQCB 2001). The Keyes Creek and Olema Creek subwatersheds recorded the lowest instantaneous fecal coliform loadings, with Olema Creek estimated at 8.67×10^{12} (RWQCB 2001). While pathogens concentrations are often higher in Olema Creek than Lagunitas Creek, the greater volume of stream discharge in Lagunitas Creek increases the loading potential of Lagunitas Creek relative to Olema (Ketcham 2001). In terms of total loading, Walker Creek again had the highest loading rates per day (3.97×10^{14}), followed by Lagunitas Creek (8.66×10^{13}) and Olema Creek (7.53×10^{13}; RWQCB 2001).

Results of the 2000-2001 study support results from the pilot study, which suggested either the presence of a renewable source or the introduction of new sources of fecal coliform throughout portions of the watershed (RWQCB 2001). As with many other previous studies, the 2000-2001 report speculated that agricultural sources are one of the major contributors of pathogens to Tomales Bay, particularly as the watersheds with the highest concentrations and loadings are primarily agricultural (RWQCB 2001). The RWQCB pointed to runoff from animal pastures (containing manure) and failing onsite sewage disposal systems or as some of the potential new or renewable sources of fecal coliform (RWQCB 2001). In another 2001 study, researchers found that concentration and loading of fecal coliform in creeks near a representative dairy was three times higher than that from a control watershed (Lewis et al. 2001). However, high levels of fecal coliform observed in San Geronimo Creek, which is not heavily agricultural, and Point Reyes Station storm drains indicates that developed areas cannot be discounted as a source (Ketcham 2001).

While most previous studies loosely refer to dairy and beef cattle operations as a primary source of pathogens, the 2001 study by Lewis and colleagues (2001) attempted to better define which portions of agricultural operations might be causing problems. Results appeared to point at dairy facilities rather than pastures – even manured pastures – as the highest potential agricultural contribution to pathogen loading (Lewis et al. 2001). The worst offenders for fecal coliform included manure stockpiles, feed lots, storm drains, and facility runoff, with potential fecal coliform loading from runoff from manure stockpiles and feed lots two to sometimes three orders of magnitude greater than loading from other parts of dairy facilities (Lewis et al. 2001).

Giacomini Ranch. Based on data collected between 2001-early 2006, fecal coliform concentrations were one to eight orders of magnitude greater in the Giacomini Ranch than in undiked wetlands in Tomales Bay and elsewhere (Parsons and Allen 2004a, Parsons, *in prep*.). Fecal coliform concentrations within of all Project Area sampling locations regularly to consistently exceeded TMDL standards proposed for the Lagunitas Creek watershed, with more than 50 to 75 percent of the sampling events having levels higher than 200 mpn/100 ml (Table 9, Parsons, *in prep*.). In 2005, the RWQCB finalized the Tomales Bay Pathogen TMDL, including adoption of fecal coliform concentration limits at the Green Bridge. Results of fecal coliform concentrations show that more than 80 percent of the sampling events did exceed the newly established TMDL concentration at the Green Bridge (95 mpn/100 ml) (Table 9, Parsons, *in prep*.).

In addition to the newly developed TMDL standards currently being finalized by the RWQCB, fecal coliform concentrations also consistently exceeded the Basin Plan standards for shellfish and municipal surface water supply beneficial uses and regularly to consistently exceeded standards for water contact recreation beneficial uses, with the Giacomini Ranch East Pasture and Lagunitas Creek exceeding 200 mpn/100 ml during more than 75 percent of the sampling events (Table 9, Parsons, *in prep*.). The Giacomini Ranch East Pasture also regularly exceeded standards for non-contact water recreation of 2,000 mpn/100 ml during more than 50 percent of the sampling events (Table 9, Parsons, *in prep*.). While both the East and West Pastures are used for dairying, use and land management is much more intensive in the East Pasture than the West Pasture, which is managed more as grazing land than a dairy pasture.

It should be noted that TMDL and Basin Plan standards are based on geometric means or medians for groups of samples collected over a specific sampling period, not single samples, but for the purposes of this document, both the number of objective exceedances by single samples and group means or medians were used to evaluate existing conditions within the Project Area. Most of the Basin Plan objectives focus on geometric means rather than arithmetic or the more traditional mean, because bacteria concentrations are calculated in a logarithmic –based scale that is more appropriately expressed as a geometric mean that divides the number of samples by the product rather than the sum of the values.

Based on concentrations for individual sampling events and mean and 90th percentile values during individual sampling events, the Giacomini Ranch East and West Pastures, Tomasini Creek, and Lagunitas Creek would consistently exceed the TMDL standards for Lagunitas Creek and the load-based allocation for Lagunitas Creek at the Green Bridge (Parsons, *in prep*.). Concentrations during individual sampling events would also consistently exceed Basin Plan bacteria objectives for shellfish and municipal water supply (<43 mpn/100ml), regularly to consistently exceed water contact recreation standards (<200 mpn/100ml), and infrequently to regularly (East Pasture only) exceed objectives for non-contact water recreation (<2,000 mpn/100ml; Table 9). Estimated mean concentrations for all sampling sites during the four-year sampling period would also exceed all Basin Plan objectives for beneficial uses.

As with nutrients, instantaneous loading rates for fecal coliform – or volume of coliforms relative to stream discharge -- remained consistently highest in Lagunitas Creek, although concentrations were almost lower than many other sampling locations. The estimated geometric mean for all sampling events at Lagunitas Creek Green Bridge during the sampling period averaged 14,125 mpn/s, with a median of 5,833 mpn/s (Parsons, *in prep*.). Similar to concentrations, the arithmetic mean for loading rates, which was estimated at 613,763 mpn/s, was skewed by some extremely high values, including a loading rate of approximately 10 million mpn/s during the April 2006 storm, which was a 2.25-year flood event (Parsons, *in prep*.). Some of the highest values for Giacomini Ranch creeks, drainages, and other water features or sources occurred several weeks after a large series of storms in May 2006, with instantaneous loading rates totaling 7,224 mpn/s for the 1906 Drainage, 10,691 mpn/s for Fish Hatchery Creek upstream of the Project Area, 494,371 mpn/s for Tomasini Creek within the Project Area (Parsons, *in prep*.). Estimated geometric mean loading rates during all four years of monitoring for creeks flowing into the Project Area ranged from 28.0 mpn/s for the 1906 Drainage to 202 mpn/s for Tomasini Creek, while portions of the Project Area affected by high concentrations of fecal coliforms in groundwater inflow and/or non-point source run-off had mean instantaneous loading rates ranging from as low as 1.46 mpn/s to as high as 458 mpn/s (Parsons, *in prep*.). Instantaneous loading rates for the East Pasture ranged from 262.3 mpn/s to 1,216.1 mpn/s, but, as was noted earlier, these areas are unable to discharge to downstream water bodies, so loading currently is negligible, with occasional discharges occurring during overbank flooding events and infrequent discharge of ditch water to Lagunitas Creek by the Giacominis (Parsons, *in prep*.).

Olema Marsh. Despite the fact that Olema Marsh is not directly within or below a dairy, fecal coliform concentrations were relatively high in the marsh, which is the downstream reach of Bear Valley Creek prior to its confluence with Lagunitas Creek (Parsons, *in prep*.). Fecal coliform levels consistently exceeded TMDL watershed and load-based standards for Lagunitas Creek and shellfish harvesting, municipal water supply, and water contact recreation beneficial use Basin Plan standards, with more than 75 percent of the sampling events having values greater than 200 mpn/100 ml (Table 9; Parsons, *in prep*.). The non-contact water recreation Basin Plan objective of 2,000 mpn/100ml was only infrequently exceeded (<15 percent of the sampling events; Table 9; Parsons, *in prep*.). For the period between 2004 – early 2006, fecal coliform concentrations averaged 2,403 mpn/100 ml (log mean), with a median of 736 mpn/100 ml and a 90th percentile value of 5,284 mpn/100 ml (Parsons, *in prep*.). These values exceed all TMDL and Basin Plan bacteria standards or objectives (Parsons, *in prep*.).

As noted earlier, TMDL and Basin Plan standards are based on log or geometric means or medians for a group of samples collected over a specific time period. The estimated geometric mean instantaneous loading rates over the two years of sampling ranged from 1,692 mpn/s at the upstream sampling location to 1,241.3 mpn/s at the downstream sampling location, with the highest values of 5.3 million and 24,080 mpn/s, respectively, again being recorded in May 2006, several weeks after a large storm series (Parsons, *in prep*.). These values exceed all but the Non-contact Water Recreation standard of 2,000 mpn established in the Basin Plan (RWQCB 1995a).

Water Salinity and Quality and Wetland Functionality

The Project Area represents one of the largest interfaces between freshwater and saltwater in Tomales Bay. These estuarine transition zones are extremely dynamic areas with large variability in salinity conditions both between seasons and years. One of the unique phenomena often associated with estuarine transition zones is Null Zones or ETM, in which salinity or the interface between freshwater and saltwater can actually affect hydronamic processes and potentially increase trapping of sediments, nutrients, contaminants, and pathogens. These estuarine processes act in concert with fluvial ones in which sediment, nutrients, and contaminants are deposited onto floodplains during overbank flooding of floodwaters to increase the value of these transitional zones to water quality improvement.

Without more intensive monitoring, determining the degree to which Project Area is currently functioning to improve water quality – if at all – is extremely difficult. There appears to be some evidence of downstream reduction in nitrates and coliform during certain periods, although the trend was not consistent. Nitrate and fecal coliform concentrations in Lagunitas Creek almost universally dropped between Green Bridge and the northern levee of the Giacomini Ranch and on Fish Hatchery Creek between Sir Francis Drake Boulevard and the central portions of the West Pasture, but not on Tomasini Creek between Mesa Road and middle of East Pasture (Parsons and Allen 2004a, Parsons, *in prep*.). Tomasini Creek sometimes showed increases in nutrients and fecal coliform between upstream and downstream monitoring locations, suggesting continuing contribution from point and/or non-point sources (Parsons and Allen 2004a, Parsons, *in prep*.). Similar trends

were noted on other monitoring locations on the perimeter, including the drainage ditch in the Tomasini Triangle that receives non-point source run-off from Point Reyes Station and the Giacomini Ranch feedlots, as well as possible septic influences (Parsons, *in prep*.). The fact that nutrients and pathogen concentrations in the Project Area are sometimes lower than other dairy ranches in the watershed suggests that the high percentage of wetlands already present in the Project Area may be playing some role in improving water quality of drainage ditches and creeks within the pastures (Parsons and Allen 2004a).

Vegetation Resources

Vegetation plays a key and prominent role in wetland functionality. Through providing "roughness" or resistance, vegetation slows down and dissipates the energy of flood flows and traps sediment that carries bound nutrients and contaminants. In addition, vegetation and diversity of vegetation communities is integral to wetlands' ability to provide habitat for wildlife species for foraging, breeding, nesting, and refugia or protection. Even when plants die or senesce, they continue to support wildlife through export of carbon to the forest floor, streams, or downstream water bodies or by providing tree snags and large woody debris for nesting, roosting, or protection. The strong association of vegetation and wetlands – particularly as the vegetation is often so distinct -- may be one of the primary reasons why wetlands are often perceived as a vegetation resources despite the strong roles played by geology, hydrology, and soils in these dynamic ecosystems.

Regional Setting

Nearly 18 percent of California's plant species are found in the Seashore.

As with other areas of western Marin County, the Seashore supports a high number of vegetation communities that are diverse in nature. More than 64 vegetation communities or "alliances" have been mapped within the boundaries of the Seashore and the north district of GGNRA, and the parks are known to support more than 900 plant species. In fact, nearly 18 percent of California's plant species are found in the Seashore. In addition, Point Reyes supports 61 plant species that are actually absent from the rest of Marin County (Howell 1970). The Seashore is also a vegetation transition area, between the Pacific Northwest flora, adapted to cold, wet conditions, and the Mediterranean flora, adapted to hot, dry conditions: Approximately 34 plant species reach their southern limit of distribution here, while Point Reyes represents the northern limit of distribution for another 11 (Howell 1970).

This diversity can be attributed in large part to this area's varied geologic history and structure, hydrology, and climate. Bordered by the San Andreas Fault, movement of the Pacific plate relative to the North American Plate has led to the Point Reyes Peninsula having a community and flora composition that is sometimes distinct from that of the Marin County "mainland." Tectonic uplifting along the fault has created an incredibly steep, varied, and unstable topography punctuated by ravines along the backbone of the Point Reyes Peninsula that borders Tomales Bay. Topography on the west side of the Inverness Ridge is more gradual as it descends to Drakes Estero and the Pacific Ocean, with many of the higher elevation upland areas characterized by soft, rolling hills.

The geologic instability of this area has produced a diverse array of hydrologic sources for vegetation communities, including isolated lakes, ponds created within "sags" along the fault, and an abundance of groundwater seeps that often serve as sources or "headwaters" for perennially and seasonally flowing streams. These freshwater influences mix with tidal waters from the Pacific Ocean to create estuarine habitats within sheltered embayments and coastlines along the Peninsula's perimeter. Over geologic time, the Pacific Ocean has alternately encroached upon and retreated from the Marin coastline because of a number of factors, including sea level rise caused by melting of the once extensive glaciers present in North America and land uplift. Not only does this geologic action control the extent of tidal influence in this area, but it has created elevated marine depositional terraces in areas such as the town of Point Reyes Station that are extremely permeable to groundwater seepage. This seepage has created unusual wetland communities that have established on the steep sides of these mesa bluffs.

Superimposed on this geologic matrix are coastal climatic influences that create an extremely mesic or wet environment for vegetation. Unlike more inland areas, the summer season in this Mediterranean climate area

often remains very cool due to extended periods of fog or marine layers. Because of this mesic influence, even upland vegetation communities such as coastal prairie often support plant species that, in inland areas, would be more typical of wetland habitats. Moisture is often concentrated within some of the steep ravines or valleys along the Inverness Ridge, leading to development of highly mesic communities dominated by coast redwood (*Sequoia sempervirens*) and Douglas fir (*Pseudotsuga menziesii*) forests on north-facing slopes with more arid shrublands on the opposing south-facing slopes. Point Reyes marks one of the southernmost boundaries of a Douglas fir forest that once stretched continuously from Sonoma County north to British Columbia (Evens 1993). Arid vegetation communities such as chamise (*Adenostoma fasiculatum*)-dominated chaparral and northern coastal scrub are often isolated in areas that receive substantially less fog and rain. While mesic conditions limit the amount of natural fires that occur, chaparral and Bishop pine (*Pinus muricata*)-dominated woodlands are naturally adapted to these often catastrophic events, quickly establishing almost monotypic stands or patches in drier areas of the coast. Point Reyes is one of few areas in California that retains relict stands of Bishop Pine (Evens 1993). The three largest vegetation community alliances in the Seashore and north district of the GGNRA are coyote brush (~17,500 acres), Douglas fir (~17,400 acres), and California annual grassland mapping unit (~15,000 acres).

Regulatory and Policy Setting

Many native vegetation communities within the United States have been adversely impacted by introduction of non-native plant species, as well as a host of other anthropogenic factors such as commercial, residential, and agricultural development, resource extraction, etc. Vegetation in the Project Area has been subject to human activities for 7,000 - 10,000 years, the period believed to be when this area first became occupied by the Coast Miwok. Although data are not available on the effects of Miwok activities on vegetation, it is assumed that they gathered plants for food and for shelter materials and probably used fire to manipulate growth of certain plant species. Beginning in the mid-nineteenth century and continuing into the present, activities such as land clearing, timbering, cultivation, cropping, road building, commercial development and livestock grazing have markedly affected the vegetation.

These activities have affected all vegetation communities, but the most highly publicized and pervasive threats are perhaps those to wetland and riparian communities: in California, more than 91 percent or 4.6 million acres of wetlands have been lost to development, and losses for the rest of the country are estimated at 50 percent (Dahl 1990). Other communities such as California coastal prairie have received less national attention, but the introduction of non-native annual and perennial grasses of European origin have almost extirpated this unique habitat, which may have once dominated large expanses of California's coastline.

In recognition of these threats, federal and state agencies have moved to protect individual species under federal and state Endangered Species Acts (ESA). The California Department of Fish and Game (CDFG) has designated certain types of vegetation communities as deserving of special consideration as special habitats or Natural Communities, although these designations do not carry the same regulatory implications as federal or state listing for endangered, threatened, or rare plant species. Many special status plant and wildlife species either reside in or use some of these sensitive vegetation communities for all or part of their life cycle. Some of these special habitats such as wetlands and riparian areas are often subject to regulatory oversight under the Clean Water Act (federal) or other state and local legislative mandates such as the Porter-Cologne Act, Streambed Alteration Agreement, and Coastal Zone LCP, because of the important role or functions that these habitats provide to both wildlife and humans.

Beyond regulatory mandates, the Park Service Management Policies (2006) require parks to preserve and restore the natural abundances, diversities, dynamics, and habitats of native plant and animal populations and the communities and ecosystems in which they occur (NPS 2001; Section 4.4.1). The Park Service is also specifically urged to not only avoid impacts to wetlands, riparian vegetation, and threatened endangered species, but to look for opportunities to increase, restore, or reintroduce them when these habitats or species have been threatened or extirpated (NPS 2006; Section 4.4.2.3). In addition to protecting and restoring habitats and species affected by non-native species, parks are also moving towards eradication of invasive species that pose substantial threats to the integrity of native habitats and viability of special status plant species populations. Park Service Management Policies (2006) direct parks to manage and, if possible and prudent, eradicate invasive species that interfere with natural processes and the perpetuation of natural features, native species or habitats (Section 4.4.4.2). In addition, "exotic species will not be allowed to displace native species if displacement can be prevented" (Section 4.4.4).

Vegetation Communities

Some preliminary mapping of vegetation communities within the Project Area occurred as part of the Seashore's Park-wide mapping efforts during the late 1990s. Additional vegetation mapping was performed in 2002-2003 within the Study Area to increase the resolution and scope of these preliminary mapping efforts. This information was used to determine the extent and location of sensitive vegetation communities such as wetland and riparian areas, as well as rare Natural Communities designated by the California Natural Diversity Database (CNDDB).

Vegetation communities within the Giacomini Ranch, Olema Marsh, and adjoining areas (Project Area) were mapped using a combination of classification systems (Parsons and Allen 2004b). The Seashore and GGNRA currently rely on a classification system developed by Todd Keeler-Wolf and John Sawyer (1995). However, the type of vegetation communities encountered within the Project Area were not well represented in the Keeler-Wolf and Sawyer classification system, so a modified Holland (1986) system was employed, as well.

The mapping of more than 80 percent of the Project Area as Active Pasture or Agriculture during initial vegetation mapping efforts conducted by the Seashore and GGNRA suggested that the Project Area was primarily a monotypic, pastoral forb-and herb-dominated vegetation community largely shaped by agricultural activities (Parsons and Allen 2004b). However, ground-based vegetation mapping efforts uncovered an incredible amount of habitat diversity in this highly managed landscape (Parsons and Allen 2004b). There were approximately 27 vegetation communities and 99 plant associations (groupings of dominant plant species) mapped within the Giacomini Ranch and Olema Marsh portions of the Project Area (Figure 30; Parsons and Allen 2004b; Ryan and Parsons, *in prep*.). The acreages of the dominant vegetation communities are shown in Table 6, and the most prevalent of these is described in detail later in this section. Most of these communities are wetland- and riparian-associated communities or ones that are ecotonal or adjacent to wetlands and riparian areas. The area's hydrologic complexity undoubtedly accounts for the wide variety of habitats present (Parsons and Allen 2004b; Ryan and Parsons *in prep.*). In addition to the hydrologic, geologic, and climatic forces discussed earlier, vegetation communities within the Project Area have been shaped extensively by historical and current land management practices.

As Table 10 shows, most of the Giacomini Ranch (~ 40 percent) is comprised of Wet Pasture, which is dominated by grass and clover species (Figure 30, Parsons and Allen 2004b). Pasture areas that have subsided and/or are influenced more by saline groundwater or surface water flows have evolved into Salt Marsh Pasture -- combination of salt marsh and pasture species -- and even Diked Salt Marsh (Parsons and Allen 2004b). The predominance of communities such as Wet Pasture, Salt Marsh Pasture, Ruderal, and Disturbed strongly reflects the agricultural nature of the Project Area, although the diversity even within these highly managed habitat types is apparent in names such as "Wet" Pasture and "Salt Marsh" Pasture (Parsons and Allen 2004b).

Areas along the perimeter of the Giacomini Ranch and Olema Marsh where seeps are present or within slow-moving reaches of freshwater creeks support Forested and Scrub Shrub Riparian, Freshwater Marsh, Vernal Marsh, Wet Meadow, and Moist Meadow vegetation communities (Parsons and Allen 2004b, Ryan and Parsons, *in prep*.; Figure 30).

FIGURE 30. VEGETATION COMMUNITIES

TABLE 10. ACREAGES OF THE MOST DOMINANT VEGETATION COMMUNITIES MAPPED IN THE PROJECT AREA

		Giacomini		Olema Marsh		TOTAL	
		Acres	%	Acres	%	Acres	%
1.	Wet Pasture	209.6	38.1	0	0.0	209.6	34.2
2.	Salt Marsh Pasture	87.5	15.9	0	0.0	87.5	14.3
3.	Ruderal	54.3	9.9	0.2	0.3	54.5	8.9
4.	Open Water	45.5	8.3	5.5	8.7	51.0	8.3
5.	Freshwater Marsh	14.3	2.6	36.3	57.6	50.6	8.3
6.	Forested Riparian	17.2	3.1	13.6	21.6	30.8	5.0
7.	Wet Meadow	22.6	4.1	0.3	0.5	22.9	3.7
8.	Tidal Salt Marsh-Mid	20.6	3.7	0	0.0	20.6	3.4
9.	Diked Brackish Marsh-Low	15.04	2.7	0		15.0	2.5
10.	Diked Brackish Marsh-Mid	14.4	2.6	0	0.0	14.4	2.3
11.	Scrub-Shrub Riparian	11.3	2.1	2.3	3.7	13.6	2.2
12.	Mesic Coastal Scrub	12.4	2.3	0	0.0	12.4	2.0
13.	Diked Brackish Marsh-Mudflat/Panne	12.3	2.2	0	0.0	12.3	2.0
14.	Diked Brackish Marsh-High	9.1	1.7	0	0.0	9.1	1.5

Freshwater Marsh systems are very diverse and are characterized by systems dominated by tall and mid-height emergent plant species, as well as low-growing and floating emergent species. Freshwater Marsh is the dominant community in Olema Marsh and lower Bear Valley Creek, followed by Forested Riparian. Due probably to grazing and other land management activities, the percentage of Scrub Shrub and Forested Riparian in and near the Giacomini Ranch is relatively low compared to Olema Marsh and Bear Valley Creek, totaling only 5.2 percent of that portion of the Project Area. However, the presence of groundwater springs on hillslopes adjoining the Point Reyes Mesa has led to establishment of Mesic Coastal Scrub and Scrub-Shrub Riparian communities east of the East Pasture and Tomasini Creek (Parsons and Allen 2004b).

Brackish marsh vegetation communities are also diverse in general, but Tidal Brackish Marsh habitats often consist of extensive stands of tall emergent plant species along the upper reaches of Lagunitas Creek (Parsons and Allen 2004b). Diked Brackish Marsh and Tidal Salt Marsh communities are comprised of varying mixtures of salt marsh species. Within the Giacomini Ranch, Diked Brackish Marsh occurred in low-lying areas or depressions that were formerly tidal channel sloughs (Parsons and Allen 2004b; Figure 30). Prolonged ponding in diked areas that are tidally influenced either directly or indirectly has either precluded or minimized vegetation establishment, creating Mudflat/Panne communities (Parsons and Allen 2004b). Tidal Salt Marsh-Mid communities -- or salt-adapted vegetation communities that typically occur at middle intertidal elevations in salt marshes that are inundated frequently by tides -- occurred on the outer perimeter of the Giacomini Ranch levees and in the undiked marsh north of the Ranch, while Lagunitas Creek accounted for most of the Open Water habitat (Figure 30).

The number of plant associations within most of the vegetation communities is relatively diverse, ranging from only one to as many as 10 associations or groups of plant species (Parsons and Allen 2004b, Ryan and Parsons, *in prep.*). Plant associations represent groupings of particular plant species that commonly occur together, and a particular vegetation community might be composed of several different distinct plant

associations. A more detailed description of the dominant vegetation communities and their plant associations is provided below.

While not all non-native plant species are invasive and/or are documented to have negative effects on native plant species communities or wildlife habitats, vegetation communities and plant associations dominated by natives are considered to be more "intact" and likely to support to wildlife through providing habitat, food, and other important relationships, some of which may yet to be documented through existing research. The documented or potential importance of vegetation communities and plant associations dominated by native plant species is one of the reasons that some wetland functionality assessment methodologies include native vegetation communities. Many of the dominant plant associations in the Project Area are dominated or co-dominated by non-native species, some of which were introduced as forage species. Others are aggressive ruderal species that invade areas that are highly disturbed. Dominance and co-dominance are loosely based on definitions in the Seashore vegetation mapping methodology, with native communities considered those with relative cover less than 30 percent (Schirokauer and Parravano 2003). Native species are defined using criteria in the California Invasive Plant Council and/or Jepson Manual (1993) regarding the origin of species (e.g., native, non-native, or naturalized). In general, saline environments tend to support less non-native species, because they are incapable of tolerating highly saline conditions. Brackish vegetation communities and plant associations show a higher proportion of non-native species, however, the number is still limited relative to freshwater environments because of the higher salinities. Common non-native brackish marsh species include brass buttons (*Cotula coronpifolia*) and annual beard grass (*Polypogon monspeliensis*). Because of its history of disturbance and management, the Giacomini Ranch is largely dominated by non-native species, with 467 of the 613 acres present in the ranch and Olema Marsh dominated by non-native species (Figure 31). Despite its history of management and disturbance, Olema Marsh is almost completely dominated by native species, although some non-native species occur in the riparian understory (Figure 31).

Freshwater Vegetation Communities

The historical extent of glycophytic or freshwater vegetation communities within the Tomales Bay watershed is unknown (Parsons and Allen 2004b). The numerous perennial freshwater drainages and sources of groundwater flow present in this region strongly suggest that extensive freshwater habitat occurred in this portion of the Tomales Bay watershed historically (Parsons and Allen 2004b). Groundwater, combined with freshwater drainages flowing off the Inverness and Bolinas Ridges, may have led to formation of extensive freshwater habitat in the Olema Valley upstream of tidal influence, particularly prior to European settlement. The interface between fresh and saline influences was probably even more dramatic historically in southern Tomales Bay, fostered by the combination of fluvial input from several major drainages (Lagunitas, Olema), small drainages (Tomasini, Fish Hatchery, etc.), and seep flow from the Inverness Ridge and Point Reyes Mesa (Parsons and Allen 2004b). The 1863 U.S. Coast Survey maps portray the southern end of Tomales Bay as open water and intertidal mudflat with marsh in the southeastern end in what is today the Giacomini Ranch East Pasture, Olema Marsh, and Olema Creek floodplain. Some historical accounts refer to "Arroyo Olemus Lake" or Olema Lake, which most likely occurred along the low-lying floodplains of Olema Creek between the town of Olema and Lagunitas Creek (Niemi and Hall 1996). This "lake" may have been subsequently drained by construction of the Olema Canal, which straightened the section of Olema Creek between Olema and Lagunitas Creek (Niemi and Hall 1996).

However, at least within the Project Area, it is likely that the extent of freshwater habitat was historically lower than it is today (Parsons and Allen 2004b). While Olema Lake was probably freshwater marsh, tidal marsh appears to have extended into Olema Marsh (Parsons and Allen 2004b), with tidal influence during extreme events reaching Park administrative headquarters (Evens 1993). This suggests that Olema Marsh, which Thomas Howell (1970) once described as "perhaps the best freshwater marsh in (Marin) County," is probably an artifact of levee construction during the late 1800s along Sir Francis Drake Boulevard, also known as Levee Road. Bear Valley Creek flows through the Olema Marsh and then empties into Lagunitas Creek through two culverted drainages just upstream of White House Pool. This marsh, considered the most extensive in Marin County, supports the county's largest red alder (*Alnus rubra*)-willow (*Salix* spp.) stand, which grows alongside substantial patches of cattails (*Typha* spp.) and sedges (*Carex* spp., *Scirpus* spp.) (Shuford and Timossi 1989). As Evens (1993) noted, "by restricting tidal influence, man isolated fresh water from salt and created freshwater habitats ... where brackish marsh must have existed before."

FIGURE 31. NATIVE AND NON-NATIVE VEGETATION COMMUNITIES

Within the Giacomini Ranch, an artificially fresh regime has been reinforced, at least within the Project Area, by diking of Lagunitas Creek and minimization of tidal inflow into the pasturelands through one-way tidegates. Freshwater influences have been augmented by spray and flood irrigation in the East Pasture and possible enhancement of groundwater flow from Inverness Ridge and Point Reyes Mesa by septic discharges. The extensive freshwater marsh that exists in the northern portion of the West Pasture today is not even visible in the 1942 aerial photograph taken before the area was diked, suggesting that freshwater marsh conditions have been strongly promoted by the levee and possibly septic influences from houses on the Inverness Ridge.

Wet Pasture in the East Pasture, looking north

Wet Pasture *(Parsons and Allen 2004b)*: A large percentage (38 percent or 210 acres) of the Giacomini Ranch has been mapped as Wet Pasture, particularly the southern and eastern portions of the East Pasture (Table 6; Figure 30; Parsons and Allen 2004b). Wet Pasture is a glycophytic grassland community dominated (> 50 percent) by grasses and herbs that are predominantly facultative or obligate hydrophytes or wetland species.

Freshwater hydrologic sources for this community include bank overflow from small drainages, surface or subsurface movement of groundwater "seep" flow, surface runoff, artificial flooding by spray or flood irrigation, and precipitation.

Clumps of tall emergents such as cattails and bulrush occur amidst a blanket of low-growing species such as hydrocotyle and water parsley in the West Pasture's Freshwater Marsh

Wet Pasture areas are either actively managed as pasture through seeding, irrigation, mowing, leveling, etc., or contain some of the predominant pastoral or forage species such as creeping bent grass (*Agrostis stolonifera*), rough bluegrass (*Poa palustris*), white clover (*Trifolium repens*), and strawberry clover (*Trifolium fragiferum*). Other non-native grass species present included Mediterranean barley (*Hordeum marinum*), perennial ryegrass (*Lolium perenne*), annual ryegrass (*Lolium multiflorum*), and tall fescue (*Festuca arundinacea*). Some native plant species occurred, as well, such as meadow barley (*Hordeum brachyantherum*), water foxtail (*Alopecurus geniculatus*), meadow foxtail (*Alopecurus pratensis*), western mannagrass (*Glyceria occidentalis*), and blue wildrye (*Leymus triticoides*).

Freshwater Marsh *(Parsons and Allen 2004b)*: The minimization of tidal flow through levees and tidegates, combined with strong freshwater influences from drainages, seeps, and irrigation, has encouraged establishment of Freshwater Marsh in some portions of the Project Area. Freshwater Marsh is characterized as freshwater areas dominated by more than 70 percent of persistent sedges, rushes, and other non-clover herbs that are inundated or saturated nearly year-round. Most of the freshwater marshes within the Project Area have developed in slow-moving drainages, drainage ditches, and ponds that have been highly disturbed by cattle or other agricultural activities. The size of this vegetation community is relatively small in the Giacomini Ranch, totaling only 14 acres or 3 percent of this portion of the Project Area. Conversely, this was the dominant community in Olema Marsh and lower Bear Valley Creek, representing 36 acres and 58 percent of this portion of the Project Area.

The large freshwater marsh in the northern portion of the West Pasture is a large (~7.2-acre) seep– and drainage-fed marsh dominated by tall emergent freshwater marsh species such as bulrush (*Scirpus californicus*), cattails (*Typha spp.),* bur-reed (*Sparganium erectum* var. *stoloniferum*), rush (*Scirpus americanus*), as well as low-growing species such as rush (*Juncus balticus* and J. *phaeocephalus*), hydrocotyle, water parsley, creeping bent grass (*Agrostis stolonifera*), western mannagrass, and sedges (*Scirpus pungens* and *S. microcarpus*). The

tall emergent species such as cattails, bulrush, bur-reed, etc., typically occur in dense, almost monotypic clumps that are spatially separated from each other by a dense blanket of low-growing emergent species such as hydrocotyle, water parsley, and sedge (*Scirpus pungens*). Hydrologic conditions are maintained by small perennial drainages that flow onto the gradually sloped surface from the south and west (under Sir Francis Drake Boulevard) and groundwater from the Inverness Ridge, as well as occasional tidal flooding.

The largest freshwater marsh in the Project Area is Olema Marsh (Ryan and Parsons, *in prep*.). Olema Marsh, once described as "perhaps the best freshwater marsh in the county" (Howell 1970), is dominated by tall emergent moncots, such as cattails (*Typha latifolia* and *angustifolia*), bulrush, hardstem bulrush (*Scirpus acutus*), and sedges (*Scirpus microcarpus*), with lesser amounts of low-growing species such as rush, hydrocotyle and water parsley. Lower Bear Valley Creek is also largely freshwater marsh habitat due to its flat gradient, but with a higher percentage cover of floating or low-growing plant species (Ryan and Parsons, *in prep*.). Marsh conditions were once maintained through annual burning of willows by the Bear Valley Country Club (Evens 1993). The freshwater marsh habitat in Olema Marsh and lower Bear Valley Creeks is sustained by perennial creek flow from Bear Valley Creek, as well as seasonal and perennial flow from drainages and groundwater originating from the Inverness Ridge (KHE 2006a). The culverts at Levee and Bear Valley Roads, in addition to remnants of historic fill activities near Levee Road, have largely precluded tidal influence in these once tidal areas and may be negatively impacting riparian habitat along the perimeter through impoundment of waters and steadily increasing water surface levels (KHE 2006b, Ryan and Parsons, *in prep*.).

Wet Meadow *(Parsons and Allen 2004b)*: Wet Meadows support at least 30 percent cover of sedge, rush, or other non-clover herbs, as well as grasses. Typically, dominant sedge and rush species are the short- to medium-sized species, as opposed to cattails, tules, and bulrush. Species include freshwater and/or brackish ones such as spikerush (*Eleocharis macrostachya*), hydrocotyle, rush (*Juncus balticus*, *J. effusus*, and *J. lesueurii*), pennyroyal (*Mentha pulegium*), white clover (*Trifolium repens*), water foxtail, western mannagrass, creeping bent grass (*Agrostis stolonifera*), and perennial ryegrass, as well as occasionally sedge (*Scirpus microcarpus*), monkeyflower (*Mimulus guttatus*), and water cress (*Rorippa nasturtium-aquaticum*). Inundation or saturation with water often extends throughout the spring into at least the early summer. Wet Meadow habitat occurs principally in the West Pasture along the sloped perimeter of the Inverness Ridge where groundwater emerges from the base of the Inverness Ridge and sheetflows across or just below the soil surface. In terms of area, Wet Meadow habitat represents a moderately large proportion of the Project Area (3.5 percent), with area totaling 23 acres.

Scrub-Shrub and Forested Riparian *(Parsons and Allen 2004b)***:** Scrub-shrub and Forested Riparian communities primarily occur along the western boundary of the West Pasture, the southern portion of Lagunitas Creek; Wildlife Conservation Board lands near White House Pool and the Green Bridge; lower Bear Valley Creek; the perimeter of Olema Marsh; and along limited portions of Tomasini and Fish Hatchery Creeks and other small drainages. Most of these riparian communities are hydrologically influenced by headwater or backwater freshwater flooding along creeks and/or tidal flooding in brackish portions of creeks. However, in response to strong groundwater gradients from either the Inverness Ridge or the Point Reyes Mesa, a riparian fringe has established along the western and eastern perimeters of the Giacomini Ranch and the western perimeter of Olema Marsh also receives groundwater flow from either Inverness Ridge or the Point Reyes Mesa.

Within the Project Area, the riparian vegetation communities generally reflected the low stream and valley slope gradient present with red alder and arroyo willow the dominant species. Other species present are box elder, California buckeye (*Aesculus californicus*), eucalyptus (*Eucalyptus globulus*), California bay (*Umbellularia californica*), coast live oak (*Quercus agrifolia*), and shining willow (*Salix lucida* ssp. *lasiandra*). Dominant understory species included California blackberry (*Rubus ursinus*), thimbleberry (*Rubus parviflorus*), stinging nettle (*Urtica dioica*), and horsetail (*Equisetum* spp.). In addition to eucalyptus, a few potential invasive species were also observed such as Himalayan blackberry (*Rubus discolor*), greater periwinkle (*Vinca major*), and Cape ivy (*Delairea odorata*), although the total percent cover of these species was very low, and they were relegated for the most part to the riparian strip along Sir Francis Drake that adjoins the Inverness Park residential area.

Forested Riparian habitat consisting of mature red alder and arroyo willow stands along northern portion of Fish Hatchery Creek adjacent to Sir Francis Drake Boulevard

Grazing has eliminated riparian habitat along most of the drainages within the pastures themselves, although some sapling-sized arroyo willows (*Salix lasiolepis*) and red alders (*Alnus rubra*) are trying to establish at the southern end of Fish Hatchery Creek. In addition to agricultural impacts, riparian habitat along Lagunitas Creek may be affected by upstream hydrologic alterations such as dams, mining, and groundwater withdrawal. By decreasing the magnitude of peak flows, increasing the duration of bankfull or ordinary high water flows, and trapping sediment, dams can alter the dynamics of riparian communities dramatically by decreasing opportunities for recruitment of tree species through flood scour or increasing bank erosion and loss of habitat (Johnson et al. 1976; Bradley and Smith. 1986; Rood and Mahoney 1990; Stromberg et al. 1993; Friedman et al. 1998) . Rising water levels within Olema Marsh – which was once burned annually to eliminate willows for the hunting club (Evens 1993) –currently appear to be causing a dieback of riparian vegetation along the perimeter of the marsh.

Despite elimination of riparian habitat through development, grazing, or agricultural practices, acreage of Scrub-Shrub Riparian habitat (tree canopy <66 feet in height) in the Giacomini Ranch still totaled 11 acres, while that of Forested Riparian habitat (tree canopy > 66 feet in height) totaled 17 acres, representing approximately 2 and 3 percent of this portion of the Project Area, respectively. In Olema Marsh and lower Bear Valley Creek, acreage of Forested Riparian habitat (14 acres) substantially exceeded that of Scrub-Shrub Riparian habitat (2 acres), representing 22 and 4 percent of this portion of the Project Area, respectively.

Brackish Vegetation Communities

While the extent of brackish marsh within the San Francisco Bay Estuary is considerable due to significant natural and anthropogenic freshwater sources such as the Sacramento River and wastewater treatment discharges (Baye et al. 2000), brackish marsh is not as common within central California coast's maritime systems. The central coastal marshes tend to be isolated and few because of the steep modern shoreline with few valleys or wave-sheltered environments (Baye et al. 2000). Those that do exist typically have extensive sandy substrates; relatively small, local inputs of fine sediment and freshwater discharges, and are inundated with water approaching marine salinity (34 ppt) during most of the growing season (Baye et al. 2000).

The historic extent of brackish vegetation communities was probably highest in the southern portions of Tomales Bay, as tidal influence decreased, and freshwater influences from tributaries and groundwater increased (Parsons and Allen 2004b). The combination of significant freshwater fluvial input, as well as groundwater flow along the adjacent ridges and mesas, points to southern Tomales Bay being both historically and currently a sizeable mixing zone characterized by consistently brackish to slightly saline conditions. Brackish marsh species such as bulrush (*Scirpus californicus*), cattails (*Typha* sp.), and alkali bulrush (*Scirpus maritimus*) are visible in 1942 photographs shot immediately before levee construction as patches scattered throughout what is currently the East Pasture, along Tomasini Creek, and near Railroad Point or at the base of the Tomales Bay Trail (PWA et al. 1993). To some degree, this interface "zone" of brackish water habitat probably shifted geographically on an annual basis due to interannual and long-term climatic variability, however, longer term changes in hydrologic regimes, probably on decadal scales, would be required for conversion of vegetation communities (Parsons and Allen 2004b).

In general, brackish marsh habitat within Tomales Bay has been negatively affected by construction of roads, berms, and levees that have eliminated this interface zone and created sharp demarcations between glycophytic and halophytic hydrologic regimes (Evens 1993). To some degree, this brackish hydrologic regime has endured in the Project Area despite diking, minimization of tidal flows, and augmentation of freshwater influences by irrigation, septic, etc., because of failure of the tidal control structures and a strong groundwater

interaction between Lagunitas Creek and the slightly subsided Project Area (Parsons and Allen 2004b). However, a number of factors -- including possibly concentration of salts within brackish waters through evapotranspiration and agricultural-related manipulation of the land and grasses -- has managed to minimize the number and extent of "true" brackish vegetation communities relative to glycophytic and halophytic ones (Parsons and Allen 2004b).

Diked Brackish Marsh *(Parsons and Allen 2004b)*: Diked Brackish Marsh is dominated (>70 percent) by hydrophytic non-clover herbs that are able to tolerate water salinities that average in the brackish or mesohaline range (5-18 ppt). Diked communities are inside of levees or berms and experience typically only muted tidal action, if any. Principal tidal hydrologic sources include muted tidal flow from creeks such as Fish Hatchery and Tomasini that are managed with tidal control structures and, within non-tidal areas, interaction with a saline groundwater table. In addition, these areas are probably also heavily influenced by perennial and seasonal headwaters flooding and seep flow from Inverness Ridge and Point Reyes Mesa, etc. Diked Brackish Marsh often strongly resembles salt marsh communities, but salinities are lower due to the impounded freshwater. Diked Brackish Marsh covers a significant expanse of the very northern portion of the West Pasture, as well as some of the depressional slough traces still evident in this pasture. In the East Pasture, Diked Brackish Marsh is confined to the very northern edges of the East Pasture and around the New Duck Pond, where neither spray or flood irrigation is actively performed. This community is represented by a diverse mix of low-growing, medium-sized, and tall emergent plant species, including freshwater/brackish and saltwater species such as spearscale (*Atriplex triangularis*), pickleweed (*Salicornia virginica*), jaumea (*Jaumea carnosa*), saltgrass (*Distichls spicata*), annual beard grass (*Polypogon monspeliensis*), saltgrass (*Distichlis spicata*), perennial ryegrass (*Lolium perenne*), hydrocotyle (*Hydrocotyle ranunculoides*), bulrush, rush (*Juncus effusus*), bur-reed (*Sparganium erectum var. stoloniferum*), and cattails. Diked Brackish Marsh represents more than 6 percent of the Project Area, totaling approximately 36 acres.

Diked Brackish Marsh along Fish Hatchery Creek in West Pasture

Diked Brackish Marsh (Mudflat/Panne) *(Parsons and Allen 2004b)*: The lowest elevation portion of the East Pasture often floods for a significant period during the winter and spring, which results in sparsely vegetated mudflats that provide habitat for a surprising number of shorebirds and waterfowl during the rainy season. When waters evaporate, a very low-growing, sparse cover of halophytes typically develops in this Mudflat/Panne habitat, consisting of species such as sand-spurrey (*Spergularia rubra*), spearscale, and, to a much lesser extent, saltgrass. This community comprises 1.6 percent (Diked Brackish Marsh-Mudflat/Panne; 11.4 acres).

Tidal Brackish Marsh *(Parsons and Allen 2004b)*: Tidal Brackish Marsh occurs exclusively along sections of Lagunitas Creek where water salinities typically average in the brackish or mesohaline range (5-18 ppt). Tidal Brackish Marsh communities are outside of levees and berms and experience a full range of tidal and freshwater inputs. The extent of this vegetation community remains minimal within the Project Area (<1 percent or 4.8 acres) due to the fact that the Giacomini Ranch levees have infringed upon the intertidal zone where brackish marsh (and Tidal Salt Marsh-Low) would typically develop. The habitat that does exist consists of a thin fringe of either pure or mixed communities of bulrush or alkali bulrush. Occasionally, other species such as Pacific cordgrass (*Spartina foliosa*), pickleweed, or cattails are present, but only in very low numbers.

Tidal Brackish Marsh on Lagunitas Creek

Saltwater Vegetation Communities

Unlike its large neighbor to the south, the Tomales Bay estuary did not appear to have historically the extensive network of fringing salt marshes that were once present in San Francisco Bay (Parsons and Allen 2004b). U.S. Coast Survey maps from the 1860s and 1870s depict small amounts of marsh habitat along the edges of Tomales Bay, with the largest extent in the southern portion of Tomales Bay in what are currently the East Pasture, Olema Marsh, and the Bear Valley and Olema Creek floodplains (Parsons and Allen 2004b). The existing undiked marsh currently north of Giacomini Ranch appeared to be largely unvegetated or sparsely vegetated subtidal and intertidal mudflats (Parsons and Allen 2004b). Walker Creek Marsh, one of Tomales Bay's other large undiked marshes, does not even exist in the Coast Survey maps, with the marsh area shown as subtidal area and intertidal flats (Parsons and Allen 2004b).

The dramatic increase in sedimentation associated with logging and agricultural development (see more detailed discussion under Geologic Resources) had the inadvertent effect of also dramatically increasing deltaic aggradation at the mouths of creeks such as Lagunitas and Walker. Between 1860 and 2000, wetland acreage almost doubled due to this sedimentation (Parsons et al. 2004). Some of this sedimentation resulted in conversion from what appeared to be open estuarine systems with large embayments and little to no marsh habitat into salt marsh estuaries with significant marsh plain and tidal channels (Parsons et al. 2004). Deltaic marsh formed at the mouth of not only Lagunitas Creek, but also Walker Creek, which are the watershed's two largest subwatersheds and potentially the drainages with the highest sedimentation rates (Parsons et al. 2004).

While sedimentation likely increased coastal salt marsh acreage, other changes counteracted this trend, specifically construction of levees for roads and railroad bridges and "reclamation" of wetlands for agricultural purposes. For example, construction of the levee along the southern portion of Sir Francis Drake Boulevard (Levee Road) to a large degree eliminated tidal influence upstream of White House Pool. Many of the marshes on the Bay's eastern shore were impacted to some degree by construction of levees, Highway 1, and the railroad, although some have at least partially breached.

Another significant factor influencing the formation and character of Tomales Bay's salt marshes is its geology, specifically the fact that San Andreas Fault runs directly down the center of the Bay. Following the 1906 earthquake, USGS geologist G.K. Gilbert surveyed conditions in the Olema and Bolinas areas, documenting sags, trenches, landslides, and other features along the fault trace, reporting some localized losses of salt marsh (Gilbert 1908).

Structure of the deltaic marshes that developed as a result of sedimentation does not necessarily follow the classic paradigm for salt marshes, which portrays a subtle elevational gradient from "low marsh" adjacent to creeks, building gradually to a mid-marsh plain that transitions into a "high marsh" zone at the marshes' highest elevations near the upland ecotone. Wetlands at the mouth of Lagunitas and Walker creeks often support only a thin fringe of "low marsh" along the narrow intertidal creek banks that rise sharply to natural alluvial levees and then transition to broad expansive marsh plains that taper to mudflat at their bayward edge. Subtle elevational transitions between marsh plain and Bay are present more in fringing marshes along the western shore of Tomales Bay. But even in these areas, the transitional upland ecotone is often replaced by a freshwater wetland ecotone fostered by extensive groundwater influences along the perimeter of the Bay. Another noteworthy difference was the conspicuous absence in Tomales Bay for many decades of Pacific cordgrass (*Spartina foliosa*; (MacDonald 1974), although abundance of this species has surged dramatically since first being observed in the 1990s, primarily through colonization of the Lagunitas Creek delta mudflats (Parsons and Allen 2004b).

Salt Marsh Pasture *(Parsons and Allen 2004b)*: Muted tidal inflow, as well as the strong, apparent groundwater connectivity between Lagunitas Creek and the Project Area, has led to establishment of several halophytic plant communities within lower elevation portions of the pastures such as Diked Salt Marsh and Salt Marsh Pasture. Salt Marsh Pasture is characterized by a significant presence (at least 20 to 25 percent) of halophytic herbs and forbs in areas with glycophytic grasses, herbs, and pastoral species such as creeping bent grass (*Agrostis stolonifera*) or rough bluegrass (*Poa trivialis*). Halophytes or salt tolerant species include saltgrass (*Distichlis spicata*), alkali heath (*Frankenia salina*), pickleweed (*Salicornia virginica*), spearscale (*Atriplex triangularis*), birdfoot trefoil (*Lotus corniculatus*), etc. Salt Marsh Pasture dominated most of the northern portion of the West Pasture and some of the very northern portions of the East Pasture. In total, it represented a substantial proportion (16 percent) of the Giacomini Ranch portion of the Project Area, with 87.5 acres.

Tidal Salt Marsh – Low, Mid, High, and High Marsh/Upland Ecotone *(Parsons and Allen 2004b)*: Tidal Salt Marsh occurs in the large expanse of undiked deltaic marsh north of the Giacomini Ranch, as well as on central bars/"islands" in Lagunitas Creek, and the fringe marsh along the outboard portion of the Lagunitas Creek levee. These salt marshes are subject to both direct tidal and freshwater influences, including headwaters flooding and high tide events. Tidal Salt Marsh-Mid accounted for approximately 4 percent of the Project Area, totaling approximately 21 acres, most of which occurs on the outboard of levees and in the undiked marsh north of Giacomini Ranch.

Tidal Salt Marsh-Mid and Tidal Salt Marsh-High in undiked marsh north of Giacomini Ranch

Deltaic and fringe marshes typically support a thin fringe of low marsh along the banks of tidal marsh channels and creeks characterized by species such as Pacific cordgrass, alkali bulrush (*Scirpus maritimus*), and pickleweed. The alluvial levees running along larger creeks such as Lagunitas support a "high marsh/upland ecotone" vegetation community with species such high marsh species such as saltgrass, alkali heath, and gumplant (*Grindelia* sp.) mixed with upland species such as red fescue (*Festuca rubra*).

Inland of these alluvial levees lie broad, expansive marsh plains supporting interspersed pockets of very low-growing mid-marsh and high-marsh species assemblages, as well as small, typically unvegetated marsh ponds. Mid- and lower elevation high-marsh zones are dominated by jaumea, saltgrass, seaside arrow-grass (*Trigochlin maritima*), arrow-grass (*Triglochin concinna*), and western marsh rosemary (*Limonium californicum*). During the summer, the presence of purple-flowered western marsh rosemary easily distinguishes lower-elevation high marsh in deltaic marshes. Alluvial fan-tidal ecotones support distinctive local plant assemblages, including uncommon and rare species such as Humboldt Bay owl's-clover (*Castilleja ambigua* ssp. *humboldtiensis*; FSC), Point Reyes bird's beak (*Cordylanthus maritimus* ssp. *palustris*; FSC), and, to a much lesser extent, Marin knotweed (*Polygonum marinense*; FSC; Baye et al. 2000; Parsons 2003). These species are discussed in greater detail later in this section.

Other

The Project Area also includes a number of other habitats not directly classifiable by specific hydrologic regimes. Many of these are upland communities and/or represent a minor component within the Project Area.

Coastal Mesic Scrub on Point Reyes Mesa Bluff

Mesic Coastal Scrub *(Parsons and Allen 2004b)*: Even some of the limited coastal scrub habitat present in the Project Area incorporates a mesic or moist component, with perennial or seasonal seep flow on the Point Reyes Mesa creating a unique vegetation community characterized by both arroyo willow (*Salix lasiolepis*) and coyote brush (*Baccharis pilularis*). In general, this community is dominated by a dense canopy of low shrubs or trees, but with scattered grassy or ruderal openings. Willow grows in combination with coyote brush, poison hemlock (*Conium maculatum*), poison oak (*Toxicodendron diversilobum*), and even coast live oak (*Quercus agrifolia*). Natural seep influences may be augmented to some degree by septic systems from residential areas on Point Reyes Mesa. Groundwater influences appear

to extend beyond the slope to Tomasini Creek, which has been bermed to contain flow along the base of Point Reyes Mesa. Acreage of Mesic Coastal Scrub was relatively high because it spans the face of the Point Reyes Mesa, totaling 12.4 acres or 2 percent of the Project Area.

Ruderal (*Parsons and Allen 2004b*): Ruderal communities represented a significant portion of the Project Area. Ruderal included areas supporting a mixture of herbs and forbs with often no clear or consistent dominance pattern. Most of the levees and berms within the Project Area, as well as the alluvial floodplain of Fish Hatchery Creek in the West Pasture, were mapped as Ruderal. A large proportion of the species within these polygons was non-native, but a significant amount of blue wildrye was also observed growing on the levees. Hydrologic input to these communities consists of very infrequent overbank flooding and precipitation. Acreage totaled 54.5 acres or approximately 9 percent of the Project Area.

Vegetation Communities of Special Significance – Wetlands and Riparian Areas

While wetlands are included as vegetation resources, wetlands really represent a complex integration of geologic, hydrologic, and biological processes. Wetlands are probably often described as vegetation communities, probably because the unique vegetation that typically occurs in wetlands is the perhaps the most enduring and easily identifiable characteristic of these complex systems. However, it is the integration of these geologic, hydrologic, and biological processes that enables wetlands to provide the diverse number of hydrologic, ecological, and socioeconomic functions and "services" to wildlife and humans that they do. Some of the functions and services that wetlands provide – and that the proposed project is trying to restore – include water quality improvement, floodwater retention, and habitat for resident and non-resident wildlife. While other "vegetation communities" such as forests and grasslands obviously have intrinsic value, in terms of the number and degree of functions and services, wetlands and riparian habitats arguably offer the greatest benefit to the biological and social environment.

The beauty of California's relatively rugged coastline has encouraged extensive residential, commercial, and agricultural development, dramatically reducing acreage of coastal wetlands, particularly in southern and central California. Estimates for coastal wetland loss are as high as 95 percent. Despite these losses, California supports the most extensive coastal wetlands of any west coast state except Alaska (NOAA 1990). Total wetland acreage has been estimated at 3,800 acres for the outer central California coast stretching from Cape Mendocino in the north to Point Conception in the south, excluding San Francisco Bay (Dennis and Marcus 1984). Recent estimates of wetland acreage within Tomales Bay totaled 944.2 acres (Parsons et al. 2004), with Giacomini Ranch and Olema Marsh combined accounting for approximately 613 acres. Together, the Project Area wetlands represent approximately 16 percent of the remaining wetlands present along the outer central California coast.

The beauty of California's relatively rugged coastline has encouraged extensive residential, commercial, and agricultural development, dramatically reducing acreage of coastal wetlands, particularly in southern and central California.

Regulatory and Policy Setting

The increasing awareness of the value and importance of wetland and riparian functions for both people and wildlife may represent one of the primary reasons that impacts to wetlands and their watersheds have become more closely regulated in recent decades. The U.S. Army Corps of Engineers (Corps) oversees Section 404 of the federal Clean Water Act and Section 10 of the federal Rivers and Harbors Act, both of which serve to ensure that impacts to navigable waters and special aquatic sites such as wetlands are minimized. In addition, wetlands are also regulated under other federal statutes, including Section 401 of the Clean Water Act and the federal Coastal Act, both of which are administered by state agencies – RWQCB and California Coastal Commission (CCC), respectively.

The Park Service also scrutinizes projects with the potential to impact wetlands in order to comply with an Executive Order that decrees that federal agencies should "…avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct and indirect

support of new construction in wetlands wherever there is a practicable alternative..." In compliance with this Executive Order, the Park Service adopted a policy of "no net loss of wetlands," with a longer term goal of net gain Service-wide. Implementation of this policy meant that, for new development or new activities, the Park Service pledged to avoid adverse wetland impacts to the extent practicable; minimize impacts that could not be avoided, and compensate for remaining unavoidable adverse impacts through restoration of degraded wetlands at a 1:1 ratio. Unlike Section 404 of the Clean Water Act, adverse impacts under Executive Order 11990 are not interpreted strictly as discharge of dredged or fill material, but encompass a much broader range of actions, including groundwater withdrawals, water diversions, nutrient enrichment, livestock grazing, pumping, flooding, and impounding.

These regulations and policies have seemingly increased the amount of confusion regarding how wetlands are defined. The confusion stems from the fact that jurisdiction or the amount and type of wetlands regulated under these statutes can vary between administrative agencies. While the RWQCB relies largely upon the Corps and its 1987 methodology to determine Section 401 jurisdiction, the CCC has taken a broader, more expansive interpretation of wetlands, and so has the Park Service. The net result is that there could be substantially more CCC- and Park Service- regulated wetlands than Corps-regulated wetlands within the same Project Area.

Riparian zones often fall into one of these regulatory "gray" zones. Riparian zones can be defined as "wetlands" by the Corps if they remain wet enough to support hydrophytic or "water-loving" plant species and have soils that show indications of prolonged ponding or saturation. Typically, juvenile or young riparian stands often qualify as Corps' "wetlands" and then transition to non-jurisdictional wetlands as the elevation becomes higher through sediment deposition, and older plants become more capable of surviving through tapping into groundwater tables rather than relying on surface inundation or saturation. The CCC, however, might continue to classify them as wetlands based exclusively on the predominance of hydrophytic or water-loving plant species. Ultimately, these disparities in regulatory interpretation really reflect differences in the jurisdiction of these various state and federal agencies, not differences in the biological or ecological definition of wetlands.

Within the Project Area, the disparity between these jurisdictional boundaries was not substantial, probably due to the fact that, despite diking and its appearance as largely a grassy pasture, most of the Giacomini Ranch has remained "wetland" from a regulatory perspective. Generally, only the highest or most topographically elevated portions of the Ranch would be considered "upland," and, occasionally, even some of those areas were delineated as wetland due to the influence of seeps. For the purposes of complying with different federal, state, and local regulations and policies governing actions in wetlands, three wetland delineations using different delineation protocols were performed to determine areas subject to the jurisdiction or oversight of the Corps, RWQCB, CCC, CDFG, Park Service, and County and local agencies and organizations. The results of these delineations are described below.

Hydrogeomorphic Classification

Within the wetland regulatory and management community, there has been a strong push in recent years to classify wetlands not only according to vegetation type and structure such as freshwater marsh or salt marsh, but on hydrogeomorphology. Naturally, regional variations exist in the specific types of hydrogeomorphic features present, but most wetlands share some basic hydrologic and geomorphic attributes that enable them to be classified, on at least a basic level, by a methodology developed by Brinson (1993). The Project Area incorporates at least five different hydrogeomorphic classes of wetlands, including Estuarine Fringe; Slope Wetlands; Groundwater Slope Wetlands; Riverine Wetlands; and Organic Soil Flats. Because of the hydrologic complexity within the Project Area, a considerable amount of overlap occurs between these geomorphic classes.

Estuarine Fringe Wetlands are comprised of tidal wetlands in the undiked marsh north of the Giacomini Ranch, as well as the narrow fringe of undiked marsh on the outboard of the Giacomini Ranch levees and some of the islands or topographically elevated "central bars" in the middle of Lagunitas Creek. The entire Project Area could be classified as Riverine Wetlands, which include floodplains and riparian areas along rivers, creeks, and streams, although a large portion of the Riverine Wetlands for Lagunitas Creek and Tomasini Creek have been eliminated or minimized through levees that greatly reduce the amount of overbank flooding. Only Fish Hatchery Creek, Bear Valley Creek, and some of the small drainages flowing off the Inverness Ridge are hydrologically connected with their floodplains, although hydrologic functioning of these creeks has also been negatively impacted by culverts, road levees, ditching, and frequent dredging.

With levees reducing the amount of overbank flooding, most of the Giacomini Ranch could be classified as functioning more as Slope Wetlands, with surface runoff and precipitation generally sheetflowing from the higher-elevation southern portions of the two pastures towards the lower-elevation northern portions, where waters drain out either through one-way or modified one-way tidegates or over concrete spillways. Some of the surface run-off derives from groundwater that emerges at the base of the Inverness Ridge or Point Reyes Mesa and flows into the two pastures. This abundant groundwater creates groundwater slope wetlands or, as they have been referred to in other areas of the country, "seepage toeslope" wetlands on the perimeter of both the West and East Pastures. In the West Pasture, the western perimeter is at a higher elevation than most of the rest of the pasture, encouraging sheetflow of this emergent groundwater into the center of the pasture, except where there are depressional basins such as in the extensive freshwater marsh along Sir Francis Drake Boulevard. The Point Reyes Mesa appears to support both seepage toeslope wetlands, as well as localized areas of hillside seepage slope wetlands, which manifest themselves as extensive arroyo willow forests or Mesic Coastal Scrub on the face of the Point Reyes Mesa bluff. In the East Pasture, the influence of these seeps creates more localized seepage toeslope features, because the perimeter elevation is flatter and more consistent with elevations in the center of the pasture.

Corps Jurisdiction

The Corps regulates several types of activities in waters of the United States, which includes navigable waters, tributaries to navigable waters, special aquatic sites (e.g., wetlands), and areas that are "adjacent" to navigable waters. These waters are regulated under Section 404 of the Clean Water Act (40 CFR Section 328.3) or Section 10 of the Rivers and Harbors Act (33 U.S.C. 403). A wetland delineation was performed by the Seashore and verified by the Corps in 2005 (Parsons 2005). A description of delineated wetlands is provided below, and acreages are provided in Table 11 (Parsons 2005). Based on this delineation, 536.6 acres of wetlands and waters subject to Section 404 jurisdiction under the Clean Water Act exist in the Project Area, with 249.3 of those acres also subject to Section 10 jurisdiction under the Rivers and Harbors Act (Figure 32; Parsons 2005)

***Section 404 Jurisdictional Waters* (Parsons 2005).** Within the Project Area, jurisdictional tidal features were defined as wetlands and waters that fell below the High Tide Line (HTL), which was calculated as 8.06 ft NAVD88 (Figure 32). Jurisdictional tidal waters present in the Delineation Study Area consisted of unvegetated (<5 percent vegetation cover) areas below the High Tide Line (HTL) in Lagunitas Creek and the downstream portions of Tomasini, Fish Hatchery, Bear Valley, and Olema Creeks. Jurisdictional non-tidal waters consisted of unvegetated areas below the Ordinary High Water (OHW) elevation. Non-Tidal Waters were mapped in small portions of Fish Hatchery Creek, Tomasini Creek, 1906 drainage, and a small drainage near White House Pool. Potential jurisdictional Section 404 "adjacent" waters consisted of one small portion of a historic slough in the Giacomini Ranch East Pasture that has been hydrologically disconnected from Tomales Bay by the Lagunitas Creek levee.

***Section 404 Jurisdictional Wetlands* (Parsons 2005).** Jurisdictional tidal wetlands were comprised of vegetated areas (>5 percent vegetation cover) below the HTL (Figure 32). Within the Project Area, tidal wetlands included the undiked marsh plain north of the Giacomini Ranch, fringing marsh along Lagunitas Creek, and fringing marsh along the downstream portions of Tomasini Creek and the Silver Hills drainage outlet. It also included diked portions of Fish Hatchery Creek in the northern portion of the West Pasture that are flooded during high tides. Jurisdictional Non-Tidal Wetlands consisted of vegetated areas (vegetation cover > 5 percent) below the OHW. Within the Project Area, Non-Tidal Wetlands included vegetated, upstream portions of Fish Hatchery Creek, the Old Slough in the Giacomini Ranch West Pasture, and Tomasini Creek. It also included most of Silver Hills drainage channel that flows parallel to Levee Road and is then culverted to flow through the White House Pool County Park. By far, the largest portion of Non-Tidal Wetlands occurred in Olema Marsh, which largely falls below OHW and is heavily vegetated.

FIGURE 32. CORPS JURISDICTIONAL WETLANDS AND WATERS

Jurisdictional Section 404 "adjacent" wetlands represented most of the jurisdictional features delineated in the Project Area. "Adjacent" wetlands consisted of vegetated areas directly adjacent to Tidal and Non-Tidal Waters and Wetlands that could be considered connected either through hydrology (e.g., groundwater movement) or ecologically (e.g., movement of organisms). Specifically, these jurisdictional features included most of the wetlands in the Giacomini Ranch pasturelands and selected areas in Olema Creek and in County Park lands near White House Pool and the Green Bridge/dairy facility area.

***Section 10 Jurisdictional Waters* (Parsons 2005).** Jurisdictional Section 10 waters consisted of navigable waters either presently or historically subject to tidal influence that fall below Mean High Water (MHW; Table 11; Figure 32). In the Project Area, jurisdictional Section 10 waters included Lagunitas, Tomasini, Fish Hatchery, Bear Valley, and Olema Creeks. In addition, it included portions of the Giacomini Ranch, Olema Marsh, and Olema Creek floodplains that were historically subtidal or intertidal and therefore below MHW before being diked or culverted/bridged.

TABLE 11. ACREAGES OF JURISDICTIONAL SECTION 404 WETLANDS AND WATERS AND SECTION 10 WATERS

	Section 404 Waters			Section 404 Wetlands			Section 10
	Tidal	Non-Tidal	Adjacent	Tidal	Non-Tidal	Adjacent	Waters
Project Area	43.88	0.36	1.93	54.99	49.85	385.63	249.28

Source: Parsons 2005

CCC Jurisdiction

Within California, the CCC administers the state program (California Coastal Act) for implementation of the federal Coastal Zone Management Act (CZMA). Any action by a federal agency such as the NPS requires a federal consistency determination by the CCC as required by CZMA. The CCC reviews all proposed wetland development projects within the California Coastal Zone. The Project Area falls within the Coastal Zone.

In the Coastal Zone, the CCC, with assistance from CDFG, is responsible for determining the presence and size of wetlands subject to regulation under the California Coastal Act (1976). The CCC has adopted the CDFG wetland definition and classification system, which is a modified version of the Cowardin classification system (Cowardin et al. 1979) in which an area needs only to meet one of the three parameters (hydrophytic vegetation, hydric soils or wetland hydrology) to qualify as a wetland (Radovich 1993). The Cowardin classification system is also the basis for the National Wetland Inventory (NWI) maps of wetlands and waters prepared by the USFWS for the entire United States. Because NWI is prepared from high-altitude aerial photography, mapped wetlands are typically those that are readily discernible in aerial photographs, such as perennially ponded marshes, stock ponds, lakes, and forested riparian areas along streams and drainages. It is less likely to incorporate seasonal or saturated wetlands that pond only seasonally or are primarily saturated through the growing season and support a low-growing emergent vegetation cover that is indistinct in aerial photographs from adjacent grasslands (e.g., wet meadows, flats, seeps, etc.)

Because hydrophytic vegetation is prevalent within the Seashore and coastal Marin County, the CCC wetland delineation was conducted as part of the vegetation mapping and Cowardin wetland classification effort that create and classified polygons with similar vegetation communities or plant associations (Parsons 2005). For this reason, areas that supported hydrophytic vegetation, but did not necessarily appear to have wetland hydrology, are incorporated into the CCC wetlands map, but are absent from the map of wetlands potentially subject to jurisdiction by the Corps (Parsons 2005) or management and oversight by the Park Service.

This delineation method yielded vastly different results than both the 1991 NWI map and Corps map. The 1991 NWI map identified only 17 wetland and aquatic habitat types in the Project Area, while approximately 225 different classifications of aquatic habitat were mapped by the Seashore (Parsons 2005). Based on the delineation, approximately 90 percent or 673.1 acres of the total Project Area qualified as a wetland potentially subject to CCC oversight (Figure 33; Parsons 2005). The Giacomini Ranch, adjacent undiked marsh, and County of Marin park areas near White House Pool and the Green Bridge account for 593.4 acres, with Olema Marsh and the downstream portion of Bear Valley Creek (79.7 acres) comprise the remainder.

Because the CCC takes a broader interpretation of wetlands relative to its regulatory oversight, acreages of wetlands potentially subject to CCC jurisdiction are greater than that subject to Corps' jurisdiction. A substantial amount of these "drier" areas that did not qualify as Corps jurisdictional wetlands were riparian areas designated as wetland under the USFWS's new Riparian System code (see below for more detail). Table 12 presents an abbreviated list of the type and acreages of wetlands delineated within the Project Area that would appear to be potentially subject to oversight by the CCC. Below is a brief description of the Cowardin system and classes that were mapped within the Project Area.

***System/Subsytems* (Parsons 2005).** Because of its location at a major freshwater-estuarine confluence, the Project Area is a combination of palustrine (freshwater) and estuarine (saltwater) wetlands and Riparian non-wetlands. Estuarine Systems are those in which salinities during the period of average annual low flow exceeds 0.5 ppt (Cowardin et al. 1979). Areas mapped as Estuarine included not only undiked, tidal areas such as Lagunitas Creek and the undiked marsh north of Giacomini Ranch and Lagunitas Creek, but even some areas inside dikes such as the Giacomini Ranch West and East Pastures, Tomasini and Fish Hatchery Creeks, and Olema Marsh. Acreage of Estuarine Systems within the Project Area totaled 332.94 acres, with almost all of that area occurring in the Giacomini Ranch and adjacent areas (332.89 acres; Table 12). Estuarine influence in these areas results either from tidal surface flow muted to some degree either naturally or by improperly functioning tidegates (Olema Marsh; Fish Hatchery Creek/northern portion of Giacomini Ranch West Pasture; Tomasini Creek) or from indirect tidal interaction with the saline groundwater table. The elevated salinities observed in the diked pastures' groundwater tables probably derive from residual marine salts deposited in underlying estuarine sediments when these areas were open to tidal flushing (KHE 2006a). Most of the mapped Estuarine areas consisted of the Intertidal Subsystem (2), but the Subtidal Subsystem (1) did occur in Lagunitas Creek, the northern portions of Fish Hatchery and Tomasini Creeks, and some diked portions of old sloughs in the Giacomini Ranch.

Because of the extensive tidal influence at the northern end of the Project Area, Palustrine Systems dominate the southern end, particularly Olema Marsh, Bear Valley Creek, and the southern end of the Giacomini pastures. In the northern end of the Project Area, Palustrine areas are relegated to the fringes of the Giacomini Ranch on higher gradient sections of creeks such as Tomasini and Fish Hatchery and small drainages and higher elevation areas adjacent to seeps flowing off the Inverness Ridge or Point Reyes Mesa. Acreage of Palustrine Systems within the Project Area totaled 366.6 acres, with 300.9 of those acres occurring in the Giacomini Ranch (Table 12). Often a sharp juxtaposition exists between Palustrine and Estuarine wetlands, as evidenced by the West Pasture freshwater marsh or Palustrine Emergent marsh polygon (e.g., PEM1Eb) adjacent to Sir Francis Drake Boulevard that is bordered by an Estuarine Emergent (E2EM1R) Diked Tidal Salt Marsh polygon with summer groundwater salinities as high as 50 ppt. There are no Palustrine Subsystems.

Some areas on the upland perimeter of the Project Area were mapped as the NWI's new Riparian (Rp) System category. Riparian (Rp) Systems support Scrub Shrub or Forested Class hydrophytic vegetation, but lack wetland hydrology. Acreage of Riparian Systems within the Project Area totaled 55.1 acres, with 37.9 of those acres occurring in the Giacomini Ranch (Table 12). Most areas within the Project Area that qualified as Riparian (Rp) are Intermittently (J) or Temporarily Flooded (A) in which flooding occurs only at peak storm flow discharge or for several days following peak discharge or flooding occurs only an episodic basis (i.e., recurrence interval > 2 years). These Riparian Systems are dominated by deeply rooted riparian tree and shrub species -- many of which are considered hydrophytic at least in their seedling and juvenile stages -- that typically rely on groundwater tables that are greater than 12 inches from the soil surface. All of the Riparian System areas were mapped as Lotic (1) or flowing water Subsystems, because they occurred at the periphery of freshwater streams, creeks, drainages, or actively flowing seeps.

FIGURE 33. WETLANDS POTENTIALLY SUBJECT TO CCC OVERSIGHT

TABLE 12. ACREAGES OF COWARDIN SYSTEMS AND CLASSES IN THE GIACOMINI WETLAND RESTORATION PROJECT DELINEATION STUDY AREA

Wetland Code	Classification	Giacomini Ranch & SLC and County Park Lands (Acres)	Olema Marsh and Bear Valley Creek (Acres)	Delineation Study Area Total (Acres)
SYSTEM				
E	Estuarine	332.89	0.05	332.94
P	Palustrine	300.87	65.72	366.59
Rp	Riparian	37.92	17.21	55.13
CLASS				
UB	Unconsolidated Bottom	52.49	5.60	58.09
AB	Aquatic Bed	9.86	4.03	13.89
EM	Emergent	523.61	36.07	559.68
SS	Scrub Shrub	30.62	5.25	35.87
FO	Forested	54.51	32.04	86.55

Class/Subclass. Most of the Project Area is dominated by low-growing Emergent (EM), Persistent (1) plant species such as pastoral, salt marsh, and ruderal forbs and herbs. Acreage of Emergent Class within the Project Area totaled 559.7 acres, 523.6 acres of which occur in the Giacomini Ranch and adjacent areas (Table 12). Areas with taller vegetation (Scrub Shrub or Forested) tended to occur outside the Giacomini Ranch or on its perimeter due the lack of grazing and/or higher quantities of freshwater from seeps and drainages and creeks. Acreage of Scrub Shrub Class in the Project Area totaled 35.9 acres, with 30.6 of those acres occurring on the perimeter of the Giacomini Ranch or adjacent areas (Table 12). As with Aquatic Bed, the areal extent of the Scrub Shrub class was relatively low within all regions of the Project Area. Acreage of the Forested Class totaled 86.6 acres, with 54.5 acres occurring on the perimeter of the Giacomini Ranch and adjacent areas (Table 12). The Forested Class was the dominant class in the portion of Bear Valley Creek (20.6 acres) within the Project Area and the second highest class in the White House Pool and Green Bridge County Park (54.5) and Olema Marsh (11.4 acres) areas (Table 12). Unconsolidated Bottom subclasses within the Project Area consisted largely of Cobble-Gravel (1), Sand (2), Mud (3), and Organic (4). Mineral soils (Subclasses 1-3) dominated most of the Project Area, but a combination of Organic and Mud sediments occurred in some of the unvegetated portions of Olema Marsh.

Park Service Oversight

Director's Order #77-1 established Park Service policies, requirements, and standards for implementing Executive Order 11990, which directs federal agencies to avoid long- and short-term impacts to wetlands. The Park Service uses the Cowardin classification system (Cowardin et al. 1979) as the basis for creating a Park Service standard for defining, classifying, and inventorying wetlands that might be subject to adverse impacts and Park Service oversight.

Park Service lands within the Delineation Study Area generally include the Giacomini Ranch and portions of Bear Valley Creek upstream of Bear Valley Road and the southern 14.0 acres of Olema Marsh. Wetlands potentially subject to management and oversight by the Park Service were delineated using the Cowardin wetland delineation definition developed by the USFWS (Parsons 2005). This definition relies on the presence of two of three criteria – wetland hydrology and hydrophytic vegetation or hydric soils – to classify areas as wetlands. Because of the similarity of this approach to that of the Corps, the Seashore proposed to delineate these wetlands by modifying, if necessary, the boundary line proposed for potential Corps' jurisdiction to incorporate areas that met two, but not necessarily all three, criteria (Parsons 2005).

After reviewing information collected during the delineation, there did not appear to be any areas that would require expansion of the Corps' potential jurisdictional boundary (Parsons 2005). There were some areas that technically only met two of the criteria, but most of these areas qualified as Corps' wetlands, as well, because wetland hydrology and hydrophytic vegetation were present, and the absence of hydric soil indicators could be explained by the fact that soils were fill, recently disturbed, or alluvial and therefore less likely to display obvious hydric soil indicators. Therefore, wetlands potentially subject to management and oversight by the Park Service in the Project Area total 446.4 acres.

CDFG

CDFG has historically had a more limited jurisdiction than the Corps, focusing specifically on lakes, major tidal sloughs, rivers, and streams, where streams are defined as "....a body of water that flows at least periodically or intermittently through a bed or channel having banks...." Jurisdiction is typically defined as the bed of the drainage and the bank up to the top of significant cut. CDFG jurisdiction over riparian habitat is discussed in the next section.

CDFG jurisdiction in the Project Area would include only non-federal lands, specifically portions of Lagunitas Creek owned by the State Lands Commission, Wildlife Conservation Board, or privately owned; Fish Hatchery Creek directly upstream and downstream of the Giacomini Ranch; 1906 Drainage directly upstream of the Giacomini Ranch; the northern portion of Bear Valley Creek and Olema Marsh, and the portion of Tomasini Creek upstream of Mesa Road (Figure 34). CDFG jurisdiction on Lagunitas Creek is somewhat complicated, because, in the southern portion, it would extend to top of bank on the southern bank of the creek, where lands are privately owned or owned by the Wildlife Conservation Board. On the northern bank, which is the Park Service-owned Giacomini Ranch, it would extend to the Ordinary Low Water mark, which is the ownership boundary for State Lands Commission. From White House Pool, CDFG would have jurisdiction over Lagunitas Creek below the OLW mark, because both banks of the creek are owned by the Park Service. CDFG jurisdiction on private lands is not shown. Acreage of potential CDFG jurisdiction over streams, rivers, lakes, and major sloughs in the Project Area totals 73.6 acres (Figure 34).

Riparian Buffers and Protection Ordinances

While riparian areas are often protected through federal regulations and policies as "wetlands," riparian areas have received some special protection of their own through state and local regulations and ordinances.

- ***CDFG***. In addition to streams, rivers, and lakes, CDFG also typically includes adjacent riparian areas within its jurisdiction. Jurisdiction is typically defined as extending to the outer limits of riparian vegetation where it occurs beyond the bank cut. CDFG jurisdiction in the Project Area would include only non-federal lands, specifically portions of Lagunitas Creek owned by the State Lands Commission, Wildlife Conservation Board, or privately owned; Fish Hatchery Creek directly upstream and downstream of the Giacomini Ranch; 1906 Drainage directly upstream of the Giacomini Ranch; the northern portion of Bear Valley Creek and Olema Marsh, and the portion of Tomasini Creek upstream of Mesa Road (Table 13; Figure 34). Acreage of potential CDFG jurisdiction over riparian habitat in the Project Area totals 24.7 acres (Figure 34).

- ***Coastal Zone***. Marin County has enacted a Streamside Conservation Area (Marin County Code, Title 22, Section 22.56-G(3), however, within the Coastal Zone, the SCA is defined by the Local Coastal Plan. Buffers in the Coastal Zone are defined to include all riparian vegetation on both sides of the stream AND the area 50 feet landward from the edge of the riparian vegetation (Marin County Comprehensive Planning Department 1981). In no case shall the stream buffer be less than 100 feet in width, from either side of the stream, as measured from the top of the stream bank. No development or vegetation removal is permitted within this buffer unless no alternative sites are feasible. LCP jurisdiction would include both federal and non-federal lands and would therefore incorporate riparian vegetation or "zones" on Lagunitas Creek, Fish Hatchery Creek, 1906 Drainage, Bear Valley Creek, Tomasini Creek, and several other small drainages feeding into the Giacomini Ranch, Lagunitas Creek, and Olema Marsh (Table 13; Figure 34). Acreage of potential LCP jurisdiction over riparian habitat in the Project Area totals 84.9 acres (Figure 34).

FIGURE 34. RIPARIAN AND BUFFER HABITAT

Other Buffers and Protection Ordinances

Local policies have established protection ordinances for other types of buffers.

- ***Point Reyes Mesa Bluff***: In addition, the LCP (Marin County Comprehensive Planning Department 1981) and the Point Reyes Station Community Plan (Marin County Community Development Agency 2001) have developed some specific protection objectives regarding the Point Reyes Mesa bluff, including, as was stated in the Community Plan (Marin County Community Development Agency 2001), "preservation of the physical, ecological, and visual integrity of the bluff area located above the old railroad right-of-way through the development review process establishment of a 100-foot buffer zone extended eastward from the eastern edge of the railroad grade." Based on the LCP and Community Plan, approximately 17.0 acres at the base of the Point Reyes Mesa Bluff extending from Mesa Road to Railroad Point or the terminus of the Tomales Bay Trail would be subject to oversight under the LCP and Point Reyes Station Community Plan in the Project Area (Table 13; Figure 34). In many areas, the Bluff would also qualify as Corps and CCC jurisdictional wetland and/or riparian habitat subject to oversight by CDFG and the LCP.

- ***Upland Buffer- Wetlands: Coastal Zone***. The Local Coastal Plan has developed policies for protecting upland areas on the perimeter of wetlands. An upland buffer for wetlands at least 100 feet in width minimum has been established on the periphery of wetlands in the Coastal Zone. No development or vegetation removal is permitted within this buffer unless it complies with LCP policies. LCP jurisdiction would include both federal and non-federal lands and would therefore incorporate upland areas in the Project Area in and on the perimeter of the Giacomini Ranch and Olema Marsh. Acreage of potential LCP jurisdiction over upland habitat in the Project Area totals 81.9 acres (Table 13).

TABLE 13. ACREAGE OF RIPARIAN, BLUFF, AND OTHER HABITAT POTENTIALLY SUBJECT TO REGULATION OR OVERSIGHT

	CDFG – Riparian	*LCP – Riparian Buffer*	*LCP and Community Plan – Bluff Buffer*	*LCP – Upland Buffer*
Habitat potentially subject to jurisdiction or oversight	*24.7 acres*	*84.9 acres*	*17.0 acres*	*81.9 acres*

Wetland and Riparian Condition and Functionality

In order to achieve protection of these ecosystems, the Park Service has been directed to "conduct or obtain parkwide wetland inventories to help ensure proper planning with respect to the management and protection of wetland resources" (NPS 2006, Section 4.6.5).

Beginning in 2000, the Seashore initiated an enhanced wetlands mapping project. During the first two phases of the project, more than 911 acres within 230 wetlands polygons or areas were inventoried and mapped. In 2003, the Seashore began a third phase of the wetlands mapping project that focused on the 140,094-acre Tomales Bay watershed. As one of the larger landowners within the Tomales Bay watershed, the Park Service felt that it could contribute to improving water quality within Tomales Bay by identifying potential pollutant sources on its lands and targeting degraded wetlands for restoration (Parsons et al. 2004). In order to evaluate the condition of existing wetlands and how well they are currently functioning, the Seashore recognized that it needed to expand its mapping efforts to incorporate a condition and functional assessment of wetlands. A number of different methodologies exist for assessing wetland condition and/or functions, but, ultimately, the Seashore created a hybrid assessment methodology that incorporated components from several methodologies, including the recently developed California Rapid Assessment Methodology (CRAM; (Collins et al. 2003; 2004). This assessment methodology uses indicators or metrics of wetland condition or functionality based on observable impairments or disturbances to hydrologic processes, hydrologic functions, landscape connectivity, soils, vegetation communities, and ecological functions such as wildlife habitat, as well

as qualitatively ranking the number and intensity of potential "stressors" to wetlands such as grazing, contamination, etc. (Parsons et al. 2004).

As part of this functional assessment, more than 1,500 acres and 717 polygons of wetlands were mapped within the western portion of Tomales Bay and Olema Valley (Parsons et al. 2004). Using a semi-quantitative evaluation of scores for both functionality and stressors, sites were ranked as being either high or medium priority for more detailed future evaluation of condition and functionality and possible future restoration. A large percentage of the sites or Functional Units that were considered either high or medium priority for restoration occurred in specific areas of the watershed, including the Waldo Giacomini Ranch in the southern portion of Tomales Bay and the Bear Valley Creek subwatershed (Parsons et al. 2004). In fact, of the six high priority restoration "sites" or drainage areas identified in the Tomales Bay-Olema Valley watershed, three of them were on the Giacomini Ranch, specifically the eastern portions of the East Pasture-Tomasini Creek, the leveed portion of Lagunitas Creek, and the diked northern portions of the East and West Pasture (Parsons et al. 2004).

While functional assessment is still to some degree in its infancy as a tool for characterizing the condition and functionality of wetlands, the Seashore believes that this approach could be very promising in terms of the type of information that it can provide for the resource managers (Parsons et al. 2004). Incorporation of condition and functional assessment could substantially increase the value of the wetland inventory efforts that the Seashore has been conducting since 2000. In addition, this approach will provide a framework for either selection or justification of additional areas selected for source reduction and restoration efforts.

Vegetation Communities of Special Significance – CNDDB Natural Communities

In addition to special status plants, the California Natural Diversity Database (CNDDB) also tracks occurrences of rare and significant vegetation communities that have been imperiled by commercial and residential development, invasion by non-native species, etc. (CDFG 2005). These special habitats or Natural Communities have been described using a vegetation classification system initially developed by Holland (1986) specifically to create a uniform system for classifying communities in which sensitive plant and animal species are found for the CNDDB. CDFG is in the process of transitioning its classification of Natural Communities from the Holland (1986) system to one developed by Sawyer and Keeler-Wolf (1995). Natural Communities are the cornerstone of CDFG's broad-based ecosystem approach to planning for the protection and perpetuation of biological diversity, termed Natural Communities Conservation Planning Program or Habitat Conservation Plans (CDFG 2006). The NCCP began in 1991 with large-scale planning efforts for more than 6,000 square miles of coastal sage scrub habitat that supports the California gnatcatcher and approximately 100 potentially threatened and endangered species (CDFG 2006).

Two special habitats or Natural Communities have potential to occur within the vicinity of the Project Area: Coastal and Valley Freshwater Marsh and Northern Coastal Salt Marsh (CDFG 2005). Coastal Freshwater Marshes are permanently flooded freshwater wetlands with deep, peaty soils dominated by perennial, emergent monocots approximately 4-5 m tall such as rush (*Scirpus* spp.) and cattails (*Typha* spp.; Holland 1986). It has been documented from a 34-acre marsh west of Drakes Beach (NDDB 2005). Northern Coastal Salt Marsh is characterized by salt-tolerant halophytes that form moderate to dense cover approximately 1 m tall and is usually separated into "zones" based on tidal elevation – low marsh, mid marsh, and high marsh (Holland 1986). Northern Coastal Salt Marsh is documented from the head of Tomales Bay (CDFG 2005).

Of the vegetation communities mapped within the Project Area, at least four potentially qualify as a CNDDB special habitat or Natural Community: Tidal Salt Marsh-Low, Tidal Salt Marsh-Mid, Tidal Salt Marsh-High, and High Marsh/Upland Ecotone. These communities appear to match the Northern Coastal Salt Marsh habitat described by Holland (1986) and subsequently identified as a special habitat. As noted earlier, Northern Coastal Salt Marsh has already been documented at the head of Tomales Bay. While information on the exact location of this occurrence was not available, it is likely that the CNDDB record refers to the undiked marsh north of the Giacomini Ranch and possibly at the base of the Tomales Bay trailhead. However, this occurrence should be expanded to include the fringe on the outboard portion of the Lagunitas Creek and Giacomini Ranch levees, as well, particularly the northern portions of the levee where the "shelf" is widest.

Most of the freshwater marshes mapped within the Giacomini Ranch do not appear to qualify as a CNDDB special habitat, even the somewhat floristically unique Freshwater Marsh in the West Pasture. According to Holland

(1986), Coastal and Valley Freshwater Marshes are characterized by being permanently flooded by freshwater rather than brackish or alkaline waters or waters having variable salinity regimes. Probably because of the historical tidal incursion through the malfunctioning one-way tidegate on Fish Hatchery Creek, this marsh appears to have a highly variable salinity regime, with salinities increasing during the summer and dropping during the winter and spring when seep flows are probably highest. The high spatial (and temporal) variation in salinity within this portion of the West Pasture is reflected in the fact that the "Freshwater Marsh" lies directly adjacent to an area dominated by halophytic species such as pickleweed and saltgrass. For this reason, this marsh would probably not qualify as a CNDDB special habitat.

Conversely, Olema Marsh might qualify as a CNDDB special habitat, as it is permanently flooded with freshwater, with saline incursions limited to the "mouth" of the marsh where Bear Valley Creek flows underneath Levee Road. In addition, it has deep, peaty soils dominated by tall emergent, perennial monocots. In his taxonomic treatment of Marin flora, Howell (1970) characterized Olema Marsh as "perhaps the best freshwater marsh area in the county." However, as pointed out earlier, based on 1862 maps, Olema Marsh appeared to be part of a large tidal marsh complex historically and was probably converted from a brackish to a freshwater marsh by construction of Levee and, later, Bear Valley Roads (Parsons and Allen 2004b). Ironically, then, this hallmark freshwater marsh feature is probably an artifact of anthropogenic disturbance. Even after roads were constructed, Olema Marsh apparently has continued to change both hydrologically and floristically, with increasing water levels within the marsh in recent decades drowning out some of the perimeter riparian vegetation. Ultimately, the fact that Olema Marsh is probably not a natural freshwater system might argue against its inclusion as a CNDDB Natural Community.

Special Status Plant Species

Regulatory and Policy Setting

Numerous species of plants have undergone local, state, or national declines, which have raised concerns about their possible extinction if they are not protected. Special status plant species include those that are legally protected under the federal and California Endangered Species Acts (ESA) or other regulations and those that are considered rare by the scientific community or the Seashore. Special status species can include:

- plants that are listed or proposed for listing as threatened or endangered under the federal ESA (50 CFR 17.11 for animals; various notices in the Federal Register [FR] for proposed species) and/or the California ESA (Fish and Game Code §2050 *et seq.*; 14 CCR §670.1 *et seq.*);
- plants that are candidates for possible future listing as threatened or endangered under the federal ESA (61 FR 7506 February 28, 1996);
- plants that are designated as "species of concern" (former category 2 candidates for listing) by the U.S. Fish and Wildlife Service (USFWS) or "species of special concern" by the California Department of Fish and Game (CDFG);
- plants that meet the definition of rare or endangered under the California Environmental Quality Act (CEQA) (14 CCR §15380), which includes species not found on state or federal endangered species lists;
- plants listed under the California Native Plant Protection Act (Fish and Game Code §1900 et seq.);
- plant species that occur on California Native Plant Society (CNPS) lists; and
- plant species that the Seashore deems locally rare or of special concern, even though they are not officially listed.

The federal ESA of 1973, as amended, requires federal agencies to consult with the USFWS before taking actions that (1) could jeopardize the continued existence of any federally listed plant or animal species (e.g., listed as threatened or endangered) or species proposed for listing, or (2) could result in the destruction or adverse modification of critical or proposed critical habitat. The USFWS has provided the Seashore a list of special status species that have potential to occur in the Seashore, north district of the GGNRA, and Marin County. A list of these species is provided in Appendix A.

The Council of Environmental Quality Regulations for Implementing the National Environmental Policy Act (Section 1508.27) also requires considering if an action may violate federal, state, or local laws or requirements imposed for the protection of the environment. As with special habitats or Natural Communities, CDFG has created a CNDDB of known or reported occurrences of threatened, endangered, rare, or CNPS-listed

species within California. Information from the CNDDB on special status plant species within quadrangles in the Seashore and north district of the GGNRA is incorporated into Appendix A, although not all known occurrences within the Seashore and the GGNRA have been reported to the CNDDB historically.

Beyond regulatory mandates to avoid or minimize impacts to special status species, the Park Service Management Policies (2006) encourage parks to strive to recover all federally listed threatened, endangered, or candidate species within park boundaries and to restore their critical habitats. The Park Service also will inventory, monitor, and manage all state and locally species in a manner similar to that of federally listed ones (Section 4.4.2.1.; NPS 2006). Park managers should ensure that park operations do not adversely impact endangered, threatened, candidate, or sensitive species and their critical habitats either within or outside the park and must consider federally and state-listed species and other special-status species in all plans and NEPA documents (NPS-77 Natural Resource Management Guidelines).

Special Status Plant Species Resources within the Project Area

A list of 92 special status plant species with potential to occur in the Project Area is provided in Appendix A**.** This table was prepared using information from the USFWS (2005), CNDDB (2005), and the CNPS Rare Plant Inventory (2005). It also contains information on regulatory status, habitat, and flowering period derived from the CNDDB (2005) and CNPS Rare Plant Inventory (2005). The plant species listed in Appendix A occur in a variety of habitats present in Marin County, including freshwater marshes, coastal salt marsh, coastal prairie, coastal dunes, coastal scrub, riparian scrub, chaparral, valley and foothill grassland, serpentine areas, broadleaf upland forest, and closed-cone and coniferous forest (NDDB 2005). Approximately 30 of the special status species with potential to occur in the Study Area are found in wetland features such as coastal salt marsh, brackish marsh, freshwater marsh, bogs and fens, vernal pools, and seasonal wetlands.

Of the 92 plant species with potential to occur in the Project Area and vicinity, there appeared to be at least the general type of habitat for 61 of those (Parsons 2003). However, the number of species with real potential to occur in the Project Area is probably lower (Parsons 2003). Some of the 92 plant species -- Delta mudwort (*Limosella subulata*; CNPS List 2), Mason's lilaeopsis (*Lilaeopsis masonii*; FSC; SR; CNPS List 1B), and Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*; FSC; CNPS List 1B) -- that were recorded as occurring in Marin County appear to have resulted from erroneous identifications, as they have never been observed outside the Sacramento Delta or San Francisco Bay areas (Parsons 2003). Secondly, some of the habitats identified as occurring within the Project Area are very disturbed (e.g., many of the areas mapped as freshwater marsh or seasonal wetlands) and therefore marginal in terms of potential for rare plants (Parsons 2003). Third, some of the terms in the CNDDB such as "freshwater marsh" cover wide variations in this general type of habitat, with most of these species tending to occur in a very specific type of that general habitat (e.g., Sonoma alopecurus; Parsons 2003).

Focused surveys documented the presence of six special status species in the Project Area (Parsons 2003; NPS, *unpub. data*; Figure 35). Three are former Federal Species of Concern that have been designed as Species of Regional Concern by the Sacramento USFWS office: Point Reyes bird's-beak (*Cordylanthus maritimus* ssp. *palustris*; former FSC; FSRC; CNPS List 1B), Humboldt Bay owl's-clover (*Castilleja ambigua* ssp. *humboldtiensis*; former FSC; FSRC; CNPS List 1B), and Marin knotweed (*Polygonum marinense*; former FSC; FSRC; CNPS List 3). In addition to these three species there are two other Species of Regional Concern: Pacific cordgrass (*Spartina foliosa*) and salt marsh owl's-clover (*Castilleja ambigua* ssp. *ambigua*). Lastly, Lyngbye's sedge (*Carex lyngbyei*), a CNPS List 2 species, has also been observed.

Two species, Humboldt Bay owl's-clover and Lyngbye's sedge, have been recorded within the Giacomini Ranch (Parsons 2003, NPS, *unpub. data*). Point Reyes bird's-beak was observed exclusively in diked and undiked marsh habitats north of the Project Area. A very small patch of another salt marsh species, Marin knotweed also occurred in the undiked marsh north of the Giacomini Ranch, but some distance away from the Giacomini Ranch. Surveys in Olema Marsh did not uncover any rare plant species (Ryan and Parsons, *in prep*.), and the potential habitat for most of the freshwater marsh species is poor. Acreage of habitat for special status species that are directly in the Project Area is listed below in Table 14.

FIGURE 35. SPECIAL STATUS PLANT OCCURRENCES

TABLE 14. ACREAGE OF SPECIAL STATUS PLANT SPECIES DIRECTLY IN THE PROJECT AREA

Common Name	Scientific Name	Acres
Point Reyes bird's-beak	*Cordylanthus maritimus* ssp. *palustris*	0.4
Humboldt Bay owl's-clover	*Castilleja ambigua* ssp. *humboldtiensis*	16.2
Pacific cordgrass	*Spartina foliosa*	0.9
Lyngbye's sedge	*Carex lyngbyei*	0.1

Point Reyes bird's-beak *(Parsons 2003)*: Point Reyes bird's-beak is a hemiparasitic annual herb that grows in the mid- to high marsh areas of coastal salt marshes. Marin County represents the southern end of the existing range for this species, which stretches into Oregon (CNPS 2005). It once occurred in Alameda, Santa Clara, and San Mateo counties, but the historical populations are believed to have been extirpated (CNPS 2005).

Point Reyes bird's-beak

In Marin County, Point Reyes bird's-beak occurs both in coastal salt marshes along the coast and in marshes on the margin of San Francisco Bay. Point Reyes bird's-beak has been documented in several locations within the Seashore and the north district of the GGNRA, principally in Drakes Estero, Limantour Marsh, and in marshes within Tomales Bay. Habitat for this species tends to encompass lower elevation high marshes. The preference for areas with sandy substrates and low-growing vegetation reflects the strong relationship between bird's-beak distribution and abundance and natural disturbance events such as wrack or alluvial material deposition or vegetation dieback that create openings suitable for recruitment and establishment (USFWS *in prep*.).

Humbolt Bay Owl's Clover

Throughout its range, this species has experienced a dramatic decrease in numbers due to impacts such as development, foot traffic, non-native plants, and altered hydrology (CNPS 2005). Within the Seashore and the north district of the GGNRA, the main threats to this species appear to be trampling and grazing by tule elk and cattle (PORE; P. Baye, *pers. comm*.). In the Project Area, there were four populations and/or groups of plants in the Pocket Marsh near Bivalve Channel, at the end of the Tomales Bay Trailhead, and in the undiked marsh directly north of the Giacomini Ranch. Most of these populations numbered several hundred to less than a thousand individuals (Figure 35).

Humboldt Bay owl's-clover **(Parsons 2003).** This species is another hemiparasitic member of the Scrophulariaceae family that also grows in intertidal salt marshes, although its flowering time and microhabitat differ slightly from that of Point Reyes bird's-beak. This annual is listed as occurring in Humboldt and Marin counties (CNPS 2005). Within the Seashore and north district of GGNRA, it occurs commonly in intertidal salt marshes along Drakes and Limantour Esteros and in the southern portion of Tomales Bay.

There has been some speculation that some of the populations in the Seashore and Tomales Bay might be taxonomically distinct from their northern, Humboldt County counterparts (P. Baye, *pers. comm*.). The Tomales Bay form is distributed in lower elevation and slightly wetter portions of marshes than plants in Humboldt County and has succulent, glabrous leaves and stems with white-tipped, truncate flower bracts (Parsons 2003, P. Baye, *pers. comm*.). In Tomales Bay, owl's-clover often co-occurs in the same intertidal zone (mid-marsh) with Point Reyes bird's-beak (USFWS *in prep*.), although it establishes at slightly lower elevations (Parsons 2003).

Threats to this species include loss of salt marsh habitat due to diking and filling for agriculture and urbanization (USFWS *in prep*.). Within the Seashore and GGNRA lands, severe cattle trampling and grazing pose a significant threat to populations of both subspecies (P. Baye, *pers. comm*.). Some of the largest remaining populations of this species, particularly of the Tomales Bay form, occur in the southern portion of Tomales Bay within the Project Area. There were six occurrences or "populations" within the Project Area that were located at the end of the Tomales Bay Trailhead, along the eastern and western undiked marsh fringes of Lagunitas Creek, and in the undiked marsh north of Giacomini Ranch (Parsons 2003). Occurrences numbered from just a few individuals to more than 10,000 plants in some years (Parsons 2003; Figure 35).

Marin knotweed *(Parsons 2003)*: This annual herb is found principally in Marin, Napa, and Sonoma counties (CNPS 2005). Few occurrences have been documented (CNPS 2005). Hickman (1993) noted that the taxonomic status of the species is uncertain and that it may either be related to *Polygonum aviculare* or may actually be *Polygonum robertii*, a non-native species from the Mediterranean. Populations of this species found within the Seashore have typically been small and spatially dispersed (M. Coppoletta, Seashore, *pers. comm*.). It is possible that the extent of Marin knotweed within the Seashore and the north district of the GGNRA has been underestimated due to the difficulty of seeing this non-descript plant (Parsons 2003). Only one occurrence of this species has been documented within the Project Area. One individual was observed growing on the undiked marsh deltaic island directly north of Bivalve Channel (Parsons 2003; Figure 35). The primary threat to this species has been characterized as salt marsh development (CNPS 2005).

Pacific cordgrass just north of the Giacomini Ranch

Pacific cordgrass. Pacific cordgrass (*Spartina foliosa*; FSRC) is a member of the grass or Poaceae family that colonizes the low intertidal zones between Mean Sea Level (MSL) and Mean High Water (MHW) in saline portions of estuaries. It often grows along the edge of tidal creeks and on tidal mudflats. Its tall height often contrasts sharply with the low-growing plants of the "mid-marsh" portion of tidal marshes. This particular perennial grass is endemic to central and southern California coastal salt marshes and is found as far south as Baja (Thompson 2001). Its northerly endemic range is Sonoma County (Strong and Daehler 1995), but it can be found in the far north of California, where it has been introduced into Del Norte County. This species occur in several areas within the Seashore, north district of GGNRA, and Tomales Bay.

Interestingly, prior to 1990, Pacific cordgrass had not been sighted in Tomales Bay during at least recent times, although it grew in Drake's and Limantour Esteros. In 1974, MacDonald and Barbour documented the "conspicuous absence" of Pacific cordgrass in Tomales Bay despite its extensive presence in San Francisco Bay and other central California estuaries (PWA et al. 1993). There has been some speculation that historic populations of this species may have been lost during the 1906 earthquake, when some portions of Tomales Bay sharply subsided (Peter Baye, *pers. comm*.). Baseline surveys conducted as part of the feasibility study for the proposed project found "several colonizing patches" of Pacific cordgrass at the mouth of Lagunitas Creek in late 1991 (PWA et al. 1993). Since then, numbers of this species have jumped exponentially, particularly at the seaward edge of the Lagunitas Creek delta, where numerous very distinctive, circular patches of cordgrass have colonized the expansive mudflats. Numbers also appear to be increasing substantially within the undiked portions of the Project Area, primarily along tidally influenced creeks such as Lagunitas Creek and tidal creeks in the undiked marsh north of Giacomini Ranch (Figure 35).

Unlike many other salt marsh species that have primarily been negatively impacted by development, the principal threat to Pacific cordgrass is the introduction of the non-native Atlantic cordgrass (*Spartina alterniflora*) to San Francisco Bay in the 1970s as part of a project (Ayres et al. 1999). Atlantic cordgrass, which is native to the Atlantic and Gulf coasts of the United States, immediately became an aggressive competitor with Pacific cordgrass, displacing the native species through both shading and growing over a broader tidal range. The severity of the threat increased when managers and scientists realized that Atlantic cordgrass was also hybridizing with the native species, making it much more difficult to recognize the non-native species in the field. Through genetic testing, scientists have been able to determine that most of the new occurrences of Atlantic cordgrass in San Francisco Bay are primarily hybrids (Invasive Spartina Project

2004). Based on recent surveys, Atlantic cordgrass hybrids have spread throughout the south and central portions of San Francisco Bay, but have yet to invade northern San Francisco Bay (Ayres et al. 1999). The Seashore has documented both Atlantic cordgrass and hybrids in Drake's Estero, but ISP has not yet found these species in Tomales Bay despite several years of survey. More detailed information on invasive *Spartina* species can be found later in this section.

Salt marsh owl's-clover *(Parsons 2003)*: This species (*Castilleja ambigua* ssp. *ambigua*) has distinct ecotypes that grow in salt marshes, as well as coastal grasslands (USFWS *in prep*.). While this species is not formally listed by the USFWS, CDFG, or CNPS, the rarity of the salt marsh ecotype within the San Francisco Bay region could eventually lead to salt marsh owl's clover being considered a species of regional significance. As with *Castilleja ambigua* ssp. *humboldtiensis* (former FSC; CNPS List 1B), this species grows in intertidal salt marshes, although its flowering time and microhabitat differ slightly. Within salt marshes, subspecies *ambigua* tends to establish at higher elevations near Mean High Higher Water (MHHW) that are often ecotonal to grasslands and is distinguished from subspecies *humboldtiensis* by its hairy stems and leaves. Once described as "common along the borders of salt marshes" in the late 19th century (Greene 1894; USFWS *in prep.*), salt marsh owl's clover is nearly extirpated in the San Francisco Bay estuary, with only one large modern population in Contra Costa County and potentially a few others in San Pablo Baylands remaining (USFWS *in prep*.). There are a few, usually small, salt-tolerant populations of this species along central California coastal marshes outside San Francisco Bay, including at Rodeo Lagoon, Marin Headlands, Pine Gulch Creek in Bolinas Lagoon, Limantour Marsh, and Tomales Bay Trailhead marsh (USFWS *in prep*.). Within the Seashore and GGNRA lands, severe cattle trampling and grazing pose a significant threat to populations of both subspecies (P. Baye, *pers comm*.).

Lyngbye's sedge. Lyngbye's sedge (*Carex lyngbyei*), a member of the sedge or Cyperaceae family, is a perennial herb that is native to California and is also found elsewhere in North America and beyond (CalFlora 2006). It is included by the CNPS on its List 2, which contains species that are rare, threatened, or endangered in California, but common elsewhere (CNPS 2005). Marin County is the southern extent of its range in California, which extends north into Del Norte and Humboldt Counties and into Oregon. Within Marin County, it has been documented in the Inverness and Bolinas USGS quadrangles (CNPS 2005), although the Seashore has no documentation of its presence within park boundaries (NPS, unpub. data). Howell (1970) described it as occurring in the "Salicornia (pickleweed) belt of the salt marsh along Tomales Bay near Inverness," which is the southernmost known California station. USFWS noted that this species "almost always occurs under natural conditions in wetlands" (USFWS *in* Calflora 2006). Within the Project Area, Lyngbye's sedge was observed in a moderately sized patch on a Tidal Marsh "shelf" on the outboard side of the East Pasture levee and a small patch with a few individuals in the undiked marsh just north of the Giacomini Ranch's West Pasture (Figure 35).

Threats from Non-Native and Invasive Plant Species

As was evident in the description of Pacific cordgrass, the presence of invasive or non-native species can pose a real threat to the viability and integrity of native or natural vegetation communities. These species can not only displace individual native species, thereby increasing the potential for their extinction, but change entire landscapes, such as the apparent large-scale conversion in California from perennial bunchgrass-dominated to non-native annual-dominated grasslands over the last few centuries that has supposedly now given the state its golden hued hills. In addition, invasive and non-native species can alter the physical and biological processes of ecosystems in ways that are sometimes hard to discern, but that have tremendous impacts on food web and population viability dynamics.

Within the Project Area, the presence of invasive non-native plant species was documented through vegetation mapping, although the specific location and areal extent of occurrences of specific "problem" species were not necessarily mapped unless the occurrence was relatively large (e.g., stands of eucalyptus; Parsons and Allen 2004b). Invasive species were defined as those ranked by the California Invasive Plant Council (CalIPC) or by the Seashore as a significant threat to native ecosystems of California and/or the parks. CalIPC relies on a categorical system of ranking the seriousness posed by invasive species, with "High" comprising the most invasive ones and the list, "Limited," the least invasive. CalIPC just recently revised its list and ranking system since the last version was introduced in 1999.

The Seashore also manages a comprehensive weed removal program that has targeted a number of this CalIPC species, but that has focused on some very high priority species that include pampas grass (*Cortaderia* spp.), French broom (*Genista monspessulana*), Scotch broom (*Cytisus scoparius*), cape ivy (*Delairea odorata*),

eucalyptus (*Eucalyptus* spp.), European dune grass (*Ammophila arenaria*), and iceplant (various species). The Park Service is directed to manage and eradicate invasive plant and animal species that "interfere with natural processes and the perpetuation of natural features, native species, or natural habitats…" (NPS 2006; Section 4.4.4.2).

Approximately 49 CalIPC invasive species occurred in the Project Area (Parsons and Allen 2004b). Although the number of species is relatively high, the number of occurrences and/or areal extent of most of these plants remained comparatively low (Table 15; Parsons and Allen 2004b). Of the 49 species, nine were on the "High" List, which includes the most invasive and widespread invasive species. The most common "High" threat species in the Project Area were fennel (*Foeniculum vulgare*) and Himalayan blackberry (*Rubus discolor*), with Himalayan blackberry acreage in the Project Area totaling 9.36 acres (Table 15). Himalayan blackberry represented a common riparian understory or shrub species, although California blackberry (*Rubus ursinus*) appeared to have a higher percent cover (Parsons and Allen 2004b). Fennel primarily establishes in Ruderal and Disturbed habitats along levees, berms, and other areas. Only two (2) patches of pampas grass (*Cortaderia jubata*) have been observed in the Project Area, with acreage totaling less then 0.01 acres (Table 15). Some efforts at eradicating at one of these patches have already been undertaken under the Seashore's Exotic Management Plan. Cape ivy (*Delairea odorata*) and English ivy (*Hedera helix*) occurred in the riparian habitat adjacent to Sir Francis Drake Boulevard in scattered patches totaling less than 0.4 and 1.8 acres, respectively (Table 15), but, due to these species' invasiveness, their presence represents a threat, because of the proposed project's objective of increasing riparian habitat.

TABLE 15. ACREAGE OF THE DOMINANT INVASIVE NON-NATIVE PLANT SPECIES

Common Name	Scientific Name	Acres
Himalayan blackberry	*Rubus discolor*	9.36
Fennel	*Foeniculum vulgare*	2.77
English ivy	*Hedera helix*	1.79
Poison hemlock	*Conium maculatum*	0.41
Cape ivy	*Delairea odorata*	0.40
Periwinkle	*Vinca major*	0.30
	Phalaris aquatica	0.25
Pampas grass	*Cortaderia jubata*	0.01

Twenty-six (26) species on CalIPC's "Moderate" invasives list have been documented in the Project Area, including both regional and widespread invasives (Parsons and Allen 2004b). Of these 26 species, six were very common in the Project Area: bull thistle (*Cirsium vulgare*), poison hemlock (*Conium maculatum*), tall fescue (*Festuca arundinacea*), common velvet grass (*Holcus lanatus*), Italian ryegrass (*Lolium multiflorum*), and pennyroyal (*Mentha pulegium*). Most of these species preferentially established in disturbed areas such as levees or near barns, roads, etc. Densities of Italian thistle and bull thistle typically remained low in polygons in which they occurred, but poison hemlock and tall fescue were often found in dense clumps on levees and within pastures, respectively. Pennyroyal, an obligate hydrophyte or wetland species, was relatively common (88 polygons) in some of the freshwater wetland vegetation communities such as Wet Pasture and Freshwater Marsh. Other Moderate Invasiveness species such as greater periwinkle (*Vinca major*) are less common and restricted to riparian areas, but it, as with Cape ivy, represents a threat to riparian restoration efforts.

Riparian understory dominated by Cape Ivy

Interestingly, common velvet grass, which is strongly threatening the integrity of the parks' coastal grasslands through rapid colonization of coastal prairies and dairy cattle ranches, was not as common as other grasses within the Project Area, nor was Italian ryegrass, which is found in overwhelming numbers in many San Francisco Bay region counties such as Sonoma (Parsons 2005). Conversely, some of the grasses on the Limited Invasiveness list were extremely common, including creeping bent (*Agrostis stolonifera*) and annual beardgrass (*Polypogon monspeliensis*).

Some species that were not on the CalIPC list, but are of great concern to the Seashore, north district of GGNRA, and others are eucalyptus (*Eucalyptus* sp.), giant reed (*Arundo donax*), perennial pepperweed (*Lepidium latifolium*), and Atlantic cordgrass (*Spartina alterniflora*) and its hybrids with the native cordgrass, Pacific cordgrass (*Spartina foliosa*). Giant reed (*Arundo donax*) does not currently grow in the Project Area, but there are two currently non-spreading occurrences upstream of the Project Area on Olema Creek and

tributaries to Lagunitas Creek (Brannon Ketcham, Seashore, *pers comm*.). Eucalyptus was primarily found growing in large stands along Point Reyes Mesa on private lands.

As was described under Special Status Species section, the native cordgrass species, Pacific cordgrass, has been designated a Species of Regional Concern due to the fact that non-native, invasive Atlantic cordgrass hybrids have been rapidly displacing it in San Francisco Bay. The 2004 Invasive Spartina Project (ISP) found that the distribution of introduced *Spartina* species throughout the San Francisco Estuary had not changed significantly since the 2001 Bay-wide inventory survey, with most of the hybridized plants remaining in the southern and central portions of San Francisco Bay (ISP 2004). However, the population had spread to 734 net acres, up 52 percent from the 2001 estimate of 482 net acres (ISP 2004). In addition, dense-flowered cordgrass (*Spartina densiflora*) hybrids have also been found in several eastern Marin County marshes (ISP 2004). Atlantic cordgrass and hybrids have also been discovered in Drake's Estero, and the Seashore has been vigorously treating them through tarping to try and eliminate this threat to outer coast populations of Pacific cordgrass. ISP has been conducting surveys in Tomales Bay for Atlantic cordgrass and hybrids during recent years and has yet to discover any, although at least two occurrences of dense-flowered cordgrass have been recorded historically within the Bay.

The other strong threat to salt marsh vegetation communities comes from perennial pepperweed, which has severely invaded many of the high marsh and upland ecotonal areas and levees within San Francisco Bay marshes. In some areas in the northern and southern reaches of the San Francisco Bay Estuary, pepperweed grows in dense stands over extensive areas (May 1995). While this species is capable of establishing in almost any environment, its advance appears primarily confined to wetland (May 1995). Pepperweed is an excellent competitor, growing early in the season, producing a large seed set as well as spreading by rhizomes, able to colonize bare mineral soil, and possibly allelopathic (J. Collins, SFEI, pers. comm.; Corliss 1993; Trumbo 1994). The most recent sighting of this species occurred in 2005 in Walker Creek marsh, where Seashore staff observed and attempted to remove several small patches growing on the alluvial levee and an in-channel island. However, pepperweed has apparently also been observed in the past in the Bivalve Channel just north of the Giacomini Ranch (P. Baye, *pers. comm*.).

In general, while the Project Area supports hundreds of non-native species as do many other "wild" and managed areas in California, there are very few invasive species of concern, and these, at least currently, have limited distribution. The invasive species of most concern are cape ivy, pampas grass, English ivy, and, perhaps, greater periwinkle, all of which are associated with or can grow in riparian habitat.

Vegetation Resources and Wetland Functionality

As described in the beginning of this section, vegetation plays a key and prominent role in wetland functionality, particularly for floodwater retention, dissipation of flood flow energy, water quality improvement, and wildlife use and habitat. The effectiveness of vegetation within the Giacomini Ranch in slowing and dissipating the energy of flood flows and improving water quality has not been quantitatively evaluated. However, the predominance of the rather monotypic, low-growing Wet Pasture vegetation community within the pastures, along with relatively sparse amount of riparian vegetation cover along creek banks, would suggest that the ability of vegetation to reduce flood flows has been decreased potentially relative to natural systems. In addition, microtopographic variability within the pastures has been substantially reduced through land-leveling activities, which would also decrease the ability of these areas to dissipate flood flows once floodwaters overtop levees.

The relationship between vegetation and wildlife habitat will be discussed in the Fish and Wildlife Section, but grazing and mowing of vegetation, along with diking, has also minimized the ability of vegetation communities within the Giacomini Ranch and, to some extent, Olema Marsh to contribute to carbon export to Tomales Bay. Through intensive study during the 1980s and 1990s, researchers participating in the LMER program concluded that Tomales Bay is a heterotrophic estuary that receives most of the organic matter used or broken down by organisms from outside sources such as the surrounding watershed lands and fringing marshes (Chambers et al. 1994). Historic tidal marshes such as Giacomini Ranch and Olema Marsh may have played a key role historically in helping to support the food web within this estuary. Interestingly, dredging of drainage ditches to remove aquatic vegetation does appear to have elevated dissolved organic carbon levels in waters relative to undiked marshes, probably because of accelerated breakdown of decaying organic matter and vegetation (Parsons, *in prep*.). However, this carbon cannot be exported to Tomales Bay because of diking and installation of one-way tidegates. Furthermore, the lack of hydrologic connectivity in both the Giacomini Ranch and Olema Marsh, along with removal or suppression of riparian establishment in the

Giacomini Ranch, has also minimized the ability of the Project Area to contribute large woody debris to surrounding waterways for use by aquatic organisms.

Fish and Wildlife Resources

One of the most important functions associated with wetlands and riparian areas is the habitat that they provide for wildlife species. Some wildlife species use creeks, wetlands, and riparian habitat for a portion of their life cycles such as breeding or spawning, foraging, refugia, or as a migration corridor. Others are resident species that spend their entire lives within these systems. Adjacent uplands not only support wildlife typically considered upland species, but are also important to wetland- and riparian-associated species for refugia during high tides or high freshwater storm flows, foraging, movement between sites, etc. Most of the Project Area supports wetland and riparian vegetation, as well as some upland, communities that provide important habitat for common and special status wildlife species. The value of the Project Area to fish and wildlife is integrally tied, of course, to the overall value and importance of the Point Reyes region and Tomales Bay watershed.

Some wildlife species use creeks, wetlands, and riparian habitat for a portion of their life cycles such as breeding or spawning, foraging, refugia, or as a migration corridor. Others are resident species that spend their entire lives within these systems.

Fish and Wildlife Resources Setting

The incredible geologic, hydrologic, and floristic diversity within the Point Reyes region has led to a tremendous diversity in the wildlife that use or visit this area. The juxtaposition between the marine environment of the Pacific Ocean and the terrestrial environment of the rugged Marin coastline, combined with the sheltered estuarine environment of Tomales Bay and other embayments, translates into an amazing breadth of habitat types or ecological niches for animals. It is largely because of this habitat diversity that Point Reyes has become world-renowned for its importance to marine, estuarine, and terrestrial wildlife species.

Point Reyes falls within the UNESCO-designated Golden Gate Biosphere Reserve, a partnership of 13 protected areas in the larger San Francisco Bay region. Largely because of its importance to wildlife, Tomales Bay has been designated as a Wetland of International Importance by the Ramsar Convention and is one of only 22 sites in the United States with this designation. Tomales Bay is also one of 16 "wetlands" that qualifies for inclusion as a wetland of regional importance under the Western Hemisphere Shorebird Reserve Network because of its large number of wintering and migrating shorebirds, which number more than 20,000 (Kelly 2001). Within the coastal waters directly offshore of Marin County, there are four of California's 34 Areas of Special Biological Significance (ASBS) and two of only 11 national marine sanctuaries in the United States. In some ways, this recognition of the value of Point Reyes and Tomales Bay to wildlife reflects the larger importance of California, which has been recognized as only one of two Biodiversity Hotspots within the continental United States by Conservation International. The entire San Francisco Bay area was characterized as one of the highest, if not the highest, ranked regions in terms of being a Hot Spot of Species Rarity and Richness by NatureServe (2000).

This biodiversity is evident in the number of species that use this area or call it home. The Point Reyes region supports 28 species of reptiles and amphibians, 65 species of mammals, and breeding habitat for 130 species of birds. As many as 32 of these are listed as federally endangered or threatened. Nearly 490 bird species -- representing 45 percent of the avian fauna documented in the United States -- have been sighted on land and over near shore waters at Point Reyes. The Point Reyes area has more varieties of birds than 20 other individual states (J. Kelly, ACR, *pers. comm*.). Point Reyes, Tomales Bay, and other open water areas on the Marin coast are important stops for migratory species on the Pacific flyway and provides important alternate habitat for birds using San Francisco Bay, the largest estuary in California. Some of what draws overwintering and migrant bird species, as well as resident wildlife, are the richness and diversity of aquatic life within the waters of the Pacific Ocean and Tomales Bay. Tomales Bay represents the second largest Pacific herring spawning estuary in California and supports one of the largest remaining coho salmon (*Oncorhyncous kisutch*) populations along the central California coast. These resources attract several hundred seals and sea lions every winter that come here to pup. Point Reyes is one of only four mainland breeding areas worldwide for

northern elephant seals (*Mirounga angustirostris*) and provides haul-out and pupping areas for 20 percent of the mainland California population of harbor seals (*Phoca vitulina*).

Regulatory and Policy Setting

Many wildlife species within the United States have been adversely impacted by increasing urbanization, resource extraction, contamination from pesticides, metals, and other pollutants, and introduction of non-native wildlife species. A number of regulations and policies have attempted to protect wildlife from these negative impacts, with most of these focused either on preservation of key or critical habitat or protection and recovery of the species itself. Some of the habitat protection is accomplished directly through the establishment of Critical Habitat under the federal Endangered Species Act (ESA) or Essential Fish Habitat or California's Lake and Streambed Alteration Agreement (Section 1600; see Vegetation Resources) and LCP Zone II's policies on Environmentally Sensitive Habitats. Marin's draft CWP (2005) is proposing to establish policies for protection of essential habitat for special status species, wildlife nursery areas, movement corridors, and ecotones, because of their importance to wildlife. CCC policy focuses on maintenance, enhancement and, where feasible, restoration of marine resources, particularly areas and species of special biological significance (Article 4, Section 30230). In other cases, habitat protection largely comes indirectly from other legislation aimed at protecting wetlands and riparian habitat for water quality and other purposes under Sections 404 and 401 of the Clean Water Act and under the Streamside Conservation Areas and upland buffer areas around wetlands policies under the LCP for Zone II.

In addition to habitat, federal and state agencies have moved to protect individual species under federal and state ESA. The federal ESA protects threatened and endangered species from unauthorized "take", and directs federal agencies 1) to ensure that their actions do not jeopardize the continued existence of listed species or result in the destruction or adverse modification of Critical Habitat and 2) to utilize their authorities by carrying out programs for conservation. Section 7 of the act defines federal agency responsibilities for consultation with the U.S. Fish and Wildlife Service (USFWS) for most mammal, bird, and fish species or with the National Marine Fisheries Service for anadromous or ocean-going fish. Once a species has been listed under the federal ESA as threatened or endangered, the USFWS is required to identify and protect Critical Habitat. Even bird species that are not necessarily protected under federal or state ESA receive some protection under the Migratory Bird Treaty Act of 1918 (16 U.S.C. §703-712). The Migratory Bird Treaty Act protects almost all migratory wild birds and their parts (including eggs, nests, and feathers) and makes it unlawful to take, possess, buy, sell, purchase, or barter any migratory bird or to cause a "taking," which is defined as disturbance that causes nest abandonment and/or loss of reproductive effort (e.g., killing or abandonment of eggs or young). Policies in the Point Reyes Station Community Plan (Marin County Community Development Agency 2001) specifically identify "protection of Lagunitas Creek, specifically its water quality, coho salmon and steelhead populations, and other aquatic life."

Beyond regulatory mandates, the Park Service Management Policies (2006) require parks to preserve and restore the natural abundances, diversities, dynamics, and habitats of native animal populations and the communities and ecosystems in which they occur (NPS 2006; Section 4.4.1). The Park Service is also specifically urged to not only avoid impacts to threatened or endangered species, but to look for opportunities to increase, restore, or reintroduce them when these habitats or species have been threatened or extirpated (NPS 2006; Section 4.4).

Fish and Wildlife Habitats

While vegetation communities are often strongly correlated with fish and wildlife habitats, particularly in terrestrial zones, groupings of plant species in and of themselves cannot fully define habitats that are of value to animal species. This is particularly true in marine and estuarine environments where many of the important habitats are "plant-less" or primarily water- and substrate-based such as pools and riffles in streams, intertidal mudflats in estuaries, and sandy beaches. Even in vegetated areas, variation in plant species composition or assemblages may be meaningless to wildlife that focus more on the architecture or diversity of plant or canopy (foliage) heights or the size and number of vegetation "patches." Some species, of course, have developed strong linkages with particular plant species such as the Myrtle's silverspot butterfly (*Speyeria zerene myrtleae)* and its caterpillars, which exclusively feed on members of the violet family. The number of truly dependent relationships between animals and particular plant species is relatively small, however, which might suggest that wildlife are largely not dependent on native plant species as long as non-native species perform similar ecological roles.

Managers and scientists continue to debate the importance of native versus non-native species to wildlife, particularly as some wildlife species now frequently use non-native species for breeding, nesting, or foraging. Non-native plant species can subtly alter the dynamics of vegetation communities and habitats in such a way as to make them less valuable to wildlife. Invasion into riparian habitat by the low-growing herb greater periwinkle (*Vinca major*) dramatically suppresses establishment of shrubs that provide important habitat for certain riparian avifauna. In addition, establishment of taller riparian invasives such as giant reed (*Arundo donax*) and salt cedar (*Tamarisk* sp.) seem to be associated with decreases in insect populations, and these decreases can negatively affect insectivorous riparian birds (CNPS Policy on Invasive Plant Species (2006).

Ultimately, while terrestrial wildlife habitats are often strongly associated with vegetation, the value of particular habitats for wildlife is often driven by numerous landscape-level and site-level factors such as lack of fragmentation or gaps in habitat "corridors;" habitat or "patch" diversity; the amount of edge habitat relative to interior habitat; canopy closure of trees; hydrology; soils or substrate; and the amount of light penetration in waters, etc. Below is a description of fish and wildlife habitats in Tomales Bay and the Project Area.

Tomales Bay

The diversity of wildlife species using Tomales Bay directly relates to the diversity of habitats present. This diversity is enhanced by the juxtaposition between marine and freshwater influences. Unlike the mouth of Elkhorn Slough in Monterey Bay, which deepens abruptly into a large submarine canyon directly offshore, the Pacific Ocean in Point Reyes and surrounding areas is relatively shallow due to the presence of the Continental Shelf that juts out at least one-quarter mile offshore, creating a light-infused, relatively warm marine environment that supports large kelp and seagrass forests, as well as rocky reefs and sandy bottom habitats. As with other areas along the California coast, strong northeasterly winds produce along this shelf an upwelling effect or turnover of deeper waters that are rich in nutrients and, therefore, very attractive to many aquatic organisms (Smith and Hollibaugh 1998). As the shelf steepens inland, marine subtidal habitats transition into rocky and sandy intertidal zones that are exposed for some period during low tides and are subject to wave action. The westward portion of the Point Reyes Peninsula is largely dominated by expansive sandy beaches that abruptly convert to rocky shoreline on the eastern-facing slopes of Tomales Point adjacent to Tomales Bay.

This shallowing trend continues as the Pacific Ocean moves into Tomales Bay. With a large source of fine sediments coming from its upper watershed, the muddy bottom of Tomales Bay provides a sharp contrast to the sandier and rockier habitats of the Pacific Ocean. Deposition and resuspension of both fine sediment and sands within the Bay has created substantial variation in bathymetry or the topography of the Bay's bottom from the outer to the inner portions, offering both shallow and deeper water habitats, with some subtidal areas being as deep as 56 feet. Some of the shallow waters that are protected from fast currents support large eelgrass (*Zostera marina*) forests. As of the late 1980s, Tomales Bay had approximately 37 eelgrass beds covering approximately 969 acres, predominantly in the northern or outermost portion of the estuary (Spratt 1989).

During low tides, shallow intertidal areas become exposed mudflat or tidal flats. As was described under Hydrologic Resources, the amount of intertidal mudflat in Tomales Bay has probably increased since the early to mid 1800s, because of the high amount of sedimentation once the watershed became more heavily developed. However, some of these mudflats are being converted to vegetated tidal marsh by colonization of Pacific cordgrass, which was once apparently absent from the Bay (MacDonald and Barbour 1974), but has increased exponentially in cover since the early 1990s. Low marsh areas dominated by Pacific cordgrass have not only colonized mudflats or tidal flats, but started fringing estuarine sloughs and creeks within tidal marshes. These low marsh areas either subtly grade or sharply transition into the mid-, high, and even upland ecotone habitats of salt marshes. As with intertidal mudflats, the acreage of intertidal wetlands in Tomales Bay has almost doubled between 1862 and the present because of the substantial increase in sedimentation.

Movement of the Pacific and Continental Plates along the San Andreas Fault has created topographic relief that enhances habitat diversity. Within the Bay itself, upland islands have emerged along the fault. The moderate – to steep topographic relief of the Inverness Ridge and the coastal marine terraces on the east side of Tomales Bay have created very different habitats within close proximity to the Bay, including mixed broadleaf

evergreen and conifer forest on the west and rolling grasslands and occasional stands or forests of oak (*Quercus* sp.) on the east.

The diversity of niches and habitats for wildlife in Tomales Bay can be defined not only vertically by topography, but horizontally by salinity. The broad transition from freshwater to brackish environments within the estuary and from brackish to marine environments within the ocean increases the potential for species richness and diversity. Salinity can create ecological niches not only within vegetated areas, but within the water column itself. Many species are restricted by physiological tolerance to specific salinity regimes. Other species seem to thrive under specific salinity regimes, even migrating to some extent with specific salinity gradients as it changes throughout the year in response to freshwater inflow, tides, and evapotranspiration. As was described under Water Resources – Water Salinity, the Low Salinity Zone or X2, which generally approximates 2 psu or ppt, is often correlated with the presence of particular taxa and species, including certain species of copepod, mysid shrimp, and fish (Kimmerer 2004).

The salinity gradient even promotes diversity in vegetated habitats by creating freshwater, brackish, and salt marsh communities. While most systems show this type of diversity only in a longitudinal gradient, the presence of groundwater seeps and springs along the base of many of the ravines and valleys in this watershed has added a latitudinal component, as well, often creating a perimeter of freshwater or brackish marsh or riparian habitat around the perimeter of tidal marshes, thereby increasing habitat diversity.

Project Area

Considering the high diversity of vegetation and aquatic communities mapped in the Project Area, it is not surprising that the Project Area has a high diversity of fish and wildlife habitats. The Project Area is located in one of the largest estuarine transition zones or interface areas between saltwater and freshwater in Tomales Bay. Wetland and aquatic habitats include open bay, estuarine sloughs and creeks, tidal flats, tidal marsh, brackish and freshwater marsh, riparian thickets, and flooded pastures and meadows (Avocet Research Associates (ARA) 2002). Terrestrial or upland habitats in the immediate vicinity include mixed broadleaf evergreen forest, conifer forest, coastal scrub, coastal grassland, and remnant coastal prairie, as well as certain drier portions of the pastures within the Giacomini Ranch (ARA 2002). Using the vegetation map developed by the Seashore in 2002-2003 (Parsons and Allen 2004b), existing wildlife habitat conditions have been characterized in the Project Area using a combination of canopy architecture or elevation zone (i.e., general height of dominant plant species or intertidal elevation “zone”), hydrologic regime (e.g., seasonally flooded, permanently flooded, intertidal, etc.), and management regime (i.e., highly managed, lightly managed, ruderal, unmanaged; Figure 36).

The value of these habitats for wildlife relates primarily to the diversity and/or rarity of species using these habitats or the abundance of individuals of particular species (J. Evens, ARA *pers. comm*.). High value wildlife habitats support an abundance of different types of wildlife species (e.g., birds, mammals, invertebrates, fish, etc.) or high numbers of a particular type of wildlife group or guild (i.e., areas supporting large numbers of shorebirds or shorebird species) and/or provide important breeding, nesting, or adult habitat for endangered or threatened species that is critical to their continued viability or recovery. Some of the high value habitats in the Project Area include Tidal Salt Marsh, Seasonally Flooded-Ponded Muted and Non-Tidal Brackish Marsh, Forested and Scrub-Shrub Riparian Habitat, Freshwater Marsh, and Mesic Coastal Scrub, A list of characteristic species assemblages and acreages of high value wildlife habitats in the Project Area can be found in Table 16. Listed below are detailed descriptions of wildlife habitats that occur in the Project Area.

FIGURE 36. WILDLIFE HABITAT

Giacomini Ranch – West Pasture. In general, habitat diversity within the West Pasture remains highest on its western perimeter due to a number of potentially interrelated factors, including increased topographic and hydrologic complexity combined with less active agricultural management (Figure 36). On the western side of the Project Area, mixed broadleaf evergreen forest and conifer forest or Woodlands dominate the steep and rugged sides of the Inverness Ridge. These forests stretch from the top of the Ridge, whose highest point is Mt. Wittenberg, to its very base near Inverness Park and Inverness. Because of groundwater seeps and the prevalence of many small freshwater drainages flowing off the Ridge through steep ravines, riparian thickets of either Forested or Scrub-Shrub Riparian vegetation communities have established all along the toe of the Ridge, with the width of the corridor strongly influenced by amount of groundwater and freshwater flow and land management practices such as riparian removal, grazing, or replacement with horticultural species. Moving eastward, the fringing riparian thicket borders a variety of habitats, including Muted Tidal Brackish Marsh dominated by pickleweed (*Salicornia virginica*), Freshwater Marsh, and seasonally or temporarily flooded Meadows and Pasture-Grasslands. These diverse habitats transition primarily into temporarily flooded or saturated Meadows and Pasture-Grasslands, most of which are managed by some mowing during the summer. These meadows and pastures abruptly end on the eastern side of the West Pasture with Ruderal levees that have been primarily colonized by short and medium-sized weedy species such as non-native grasses, poison hemlock (*Conium maculatum*), and fennel (*Foeniculum vulgare*), as well as patches of some native species such as blue wildrye (*Leymus triticoides*).

The largest permanent Freshwater Marsh in the West Pasture occurs in the northwestern end of the West Pasture. The 7.2-acre West Pasture freshwater marsh supports a tremendous diversity of microhabitat types, with small to large patches of medium- and tall emergent species such as rush (*Scirpus microcarpus*), cattails, bur-reed, bulrush, and rush (*Scirpus americanus*) interspersed throughout a matrix of low-growing and floating emergents such as water parsley and hydrocotyle. Approximately 1.8 acres of Seasonally Flooded-Ponded Pasture-Grasslands south of Inverness Park along Sir Francis Drake Boulevard, which flood for an extended period during the spring into early summer, have less habitat diversity, with cover dominated by low-growing and floating emergent plant species exclusively.

Coho Salmon

TABLE 16. ACREAGE OF HIGH VALUE WILDLIFE HABITATS IN THE GIACOMINI RANCH AND OLEMA MARSH PORTIONS OF THE PROJECT AREA

Note: Table includes group, order, or class of organisms and representative species using these habitats. Numbers include portion of Lagunitas Creek in Project Area and part of undiked marsh north of the Giacomini Ranch. Boldface names indicate special status species.

High Value Wildlife Habitat	Group/Order/Class (time period/activity)	Representative Species	
Tidal Waters-Channel/ Subtidal and Intertidal TOTAL: 40.3	Mammals	**Southwestern river otter**	Harbor Seal
	Birds/Waterfowl	Greater scaup	Lesser scaup
	Birds/Waterbirds	Belted kingfisher Common loon	**California brown pelican** **California clapper rail**
	Birds/ Shorebirds	Greater yellowlegs Spotted sandpiper Dunlin	Dowitcher Willet
	Birds/Raptors	Osprey	
	Fish	Topsmelt Bay pipefish English sole Threespine stickleback Arrow goby Prickly sculpin	Staghorn sculpin **Steelhead** **Coho salmon** **Chinook salmon** **Tidewater goby**
	Invertebrates/Reptiles	Mysid shrimp	Northwestern pond turtle
Non-Tidal Waters-Channel and Pond with No Connectivity to Tidal Waters TOTAL: 3.0	Birds/Waterfowl	Mallard Gadwall	Wood duck Bufflehead
	Birds/ Waterbirds	Belted kingfisher Eared grebe Black phoebe Virginia rail	Sora Great egret Great blue heron Black-crowned night-heron
	Amphibians	**California red-legged frog** Bullfrog	Pacific tree frog
	Reptiles	**Northwestern pond turtle**	
	Fish	Threespine stickleback Arrow goby	Mosquitofish Longjaw mudsucker
Muted Tidal and Non-Tidal Waters-Channel with Connectivity to Tidal Waters TOTAL: 2.2	Birds/Waterfowl	Mallard Gadwall	Green-winged Teal
	Birds/ Waterbirds	Belted kingfisher Greater Yellowlegs Willet	**Green-backed heron** Great egret Great Blue heron
	Amphibians	**California red-legged frog**	
	Reptiles	**Northwestern pond turtle**	
	Fish	**Steelhead salmon** **Coho salmon** **Chinook salmon** **Tidewater goby**	Threespine stickleback Arrow goby Longjaw mudsucker Mosquitofish
Tidal Salt Marsh TOTAL: 29.6	Mammals	California vole	Shrews
	Birds/ Waterbirds	**California black rail** (Mid and High Marsh)	**Great egret**
	Birds/ Shorebirds (roosting)	Greater yellowlegs Godwits	Willets
	Birds/ Passerines	**Saltmarsh common yellowthroat**	Song sparrow
	Birds/ Raptors	**Short-eared owl** Northern harrier	White-tailed kite **Peregrine falcon**
	Fish (high tides)		
	Invertebrates	Gastropods Crustaceans	Amphipods (decomposers)
Tidal Brackish Marsh TOTAL: 4.8	Birds/ Waterbirds	Virginia rails	**California black rail**
	Birds/ Passerines	**Saltmarsh common yellowthroat**	Song sparrows Marsh wren
Muted Tidal Brackish Marsh-Mid and Tall TOTAL: 6.1	Birds/ Passerines	Saltmarsh common yellowthroat Marsh wren Song sparrow	Red-winged blackbird Savannah sparrow
	Birds/ Waterbirds	Virginia rail Sora	American coot Snowy egret

TABLE 16. ACREAGE OF HIGH VALUE WILDLIFE HABITATS IN THE GIACOMINI RANCH AND OLEMA MARSH PORTIONS OF THE PROJECT AREA

Note: Table includes group, order, or class of organisms and representative species using these habitats. Numbers include portion of Lagunitas Creek in Project Area and part of undiked marsh north of the Giacomini Ranch. Boldface names indicate special status species.

High Value Wildlife Habitat	Group/Order/Class (time period/activity)	Representative Species	
	Birds/ Shorebirds	Greater yellowlegs	Lesser yellowlegs
Muted Tidal Brackish Marsh – Mudflat/ Panne TOTAL: 13.2	Birds/ Shorebirds	Dunlin Dowitcher spp. Greater yellowlegs	Wilson's snipe Willet Killdeer
	Birds/ Waterfowl	Gadwall American Wigeon	Green-winged Teal
	Invertebrates		
Freshwater Marsh TOTAL: 52.8	Birds/ Waterfowl	Mallard Cinnamon teal Canada goose	Pied-billed grebe Ruddy duck Gadwall
	Birds/ Waterbirds	**California black rail** Virginia rail	Sora American bittern
	Birds/ Passerines	**Saltmarsh common yellowthroat** Red-winged blackbird	Marsh wren Song sparrow
	Amphibians	**California red-legged frog** Pacific tree frog	Bullfrog
	Reptiles	**Northwestern pond turtle**	
	Fish	Threespine stickleback	
Forested and Scrub Shrub Riparian TOTAL: 45.4	Mammals	**Southwestern river otter** **Dusk-footed woodrat**	black-tailed deer
	Birds/ Passerines	**Saltmarsh common yellowthroat** Warbling vireo Wilson's warbler	Swainson's Thrush Bewick's wren Purple finch
	Amphibians	**California red-legged frog**	**Pacific tree frog**
Mesic Coastal Scrub TOTAL: 12.4	Birds/ Passerines (resident and non-resident)	**Saltmarsh common yellowthroat** **Swainson's thrush**	Warbling vireo Wilson's warbler
Tidal Salt Marsh- High/ Upland Ecotone; Uplands TOTAL: 3.6	Mammals	Voles (refugia)	Shrews (refugia)
	Birds/ Waterbirds	**California black rail** (refugia)	**California clapper rail** (refugia)
	Birds/ Passerines	**Saltmarsh common yellowthroat** Savannah sparrow	Song sparrow Wrentit
Seasonally Flooded-Ponded Pasture-Grassland TOTAL: 1.8	Birds/ Waterfowl	Wood duck American wigeon Green-winged teal	Gadwall Common merganser
	Birds/ Waterbirds	Great egret	Great blue heron
	Amphibians	**California red-legged frog**	

Open Water habitat within the West Pasture is restricted primarily to relatively scattered unvegetated sections of creeks and isolated depressional features, some of which may be relicts of when the West Pasture was tidal. Because most of the creeks are relatively low gradient, Low or Tall Freshwater Marsh has established in most of the creek channels. Some intertidal mudflat occurs on the perimeter of creek channels during low tides, particularly on the northern end of Fish Hatchery Creek, but perennial creek flow, combined with the tidegate system, preclude Fish Hatchery Creek and other drainages from becoming fully intertidal.

Olema Marsh and Lower Bear Valley Creek. A similar gradient in habitats occurs at Olema Marsh and lower Bear Valley Creek (Figure 36). Conifer and mixed broadleaf evergreen forests or Woodland on the Inverness Ridge extend to the toe of the ridge, where a riparian thicket of largely Forested Riparian habitat has established due to groundwater and freshwater flow from several small drainages. This riparian thicket transitions downslope into the largest Freshwater Marsh in the Project Area, the Olema Marsh, approximately 39 acres in size. Ponding of water in this marsh is promoted by poor hydraulic connectivity of the marsh with

Lagunitas Creek (See Hydrologic Resources for more detailed discussion). Increasing water levels within recent decades appears to be killing some riparian trees closest to the marsh, leaving some dead trees as snags. Most of the marsh is dominated by tall emergents such as cattails, bulrush, rush (*Scirpus acutus*), although there are some Freshwater Marsh-Low areas dominated by floating or low-growing emergents such as water parsley. An earlier enhancement project during the 1980s that was undertaken by one of the property owners, Audubon Canyon Ranch, attempted to increase the amount of Open Water-Pond habitat through excavation, however, most of the created Open Water has slowly been recolonized by vegetation. A few willows have colonized spoil piles or berms left by excavation, creating some canopy diversity within the marsh. As with the West Pasture, the marsh also sharply transitions to upland on its eastern perimeter, but, rather than levee, the marsh is bordered by the natural shutter ridge that divides the Bear Valley and Olema Creek watersheds. The shutter ridge supports primarily a low-growing cover of native and weedy grasses and herbs within unmanaged or ruderal Pasture-Grassland habitat.

Because of the abrupt change in creek gradient within this portion of Bear Valley, the lower portion of Bear Valley Creek located directly upstream of Olema Marsh has also turned into a sizeable Freshwater Marsh with no defined channel. Several floodplain terraces of varying elevation on the western perimeter of the creek have expanded the diversity of riparian habitat types within this reach of the creek, creating riparian stands or Forested Riparian dominated by coast live oak and California bay, as well as by alder and several species of willow.

Giacomini Ranch – East Pasture. The habitat gradient within the East Pasture of the Giacomini Ranch differs slightly from that of the West Pasture and Olema Marsh (Figure 36). The East Pasture borders the town of Point Reyes Station, which is situated on Point Reyes Mesa, an elevated coastal marine terrace. Most of the Mesa has been developed, with the exception of GGNRA's Martinelli Ranch at the northern end of the East Pasture, which has retained a somewhat rolling hill topography dominated by Pasture-Grassland somewhat reminiscent of the coastal prairies that once covered a significant percentage of California's central coastline. The moderately steep slopes of the Mesa support either Coastal Scrub or Mesic Coastal Scrub vegetation communities. Groundwater springs and seep flow on portions of the Mesa have led to establishment of an unusually wet habitat for hillsides dominated by thickets of arroyo willow and coyote brush. One of the largest Mesic Coastal Scrub areas (~12.4 acres) occurs adjacent to Tomasini Creek on what is called the Point Reyes Mesa Bluff midway between the Giacomini Hunt Lodge and the Tomasini Creek tidegate. Coastal Scrub and Mesic Coastal Scrub habitats typically extend to the toe of the Mesa, where they transition either into highly or lightly managed Pasture-Grassland or creeks and ditches.

Many of the ditches and ditched sloughs within the East Pasture support Freshwater Marsh-Low habitat, although there are some stands of tall emergents – primarily cattails and bulrush – in some areas. The Giacominis have maintained some Non-Tidal Open Water-Channel habitats through frequent dredging of ditches and ditched sloughs to remove vegetation for water conveyance purposes. Muted Tidal Open Water-Intertidal habitat is largely precluded, even in Tomasini Creek, by levees, culverts, and tidegates that do not allow ditches or creeks to fully drain.

Several other freshwater and brackish marsh features occur in the East Pasture. The Old and New Duck Ponds are artificial depressional features that were constructed by the Giacominis for duck hunting. While both the East and West Pastures would appear to be relatively flat, both pastures slope downward towards the north, with the lowest elevations being in the northeastern corner opposite the large Mesic Coastal Scrub thicket on the Point Reyes Mesa Bluff. These low elevations, combined with episodic influxes of saltwater during high tides from a culvert on Tomasini Creek, have converted what was once probably a pasture into approximately 13.2 acres of seasonally flooded-ponded Muted Tidal Brackish Marsh-MudFlat/Panne habitat that floods extensively during winter and early spring. Following drawdown, salt-tolerant plant species stunted from prolonged inundation establish, although cover remains sparse. Muted Tidal Brackish Marsh with mid-sized emergent species such as alkali bulrush (*Scirpus maritimus*) has colonized deeper portions of a ditch immediately adjacent to the Tomasini Creek berm. Smaller marshes flooded for a shorter period during the winter occur in some of the ponds created by the Giacominis for duck hunting. The Old Duck Pond supports Freshwater Marsh habitat, while the New Duck Pond has developed into approximately 2 acres of Non-Tidal Open Water-Pond and Non-Tidal Brackish Marsh dominated by mid-sized emergent species such as spikerush (*Eleocharis macrostachya*) and alkali bulrush, probably because of the higher amount of residual salts in the soil.

Lagunitas Creek. Outboard of both the East and West Pastures, the levees are fringed by either Tidal Salt Marsh, Tidal Brackish Marsh, and, in the southern portion, Riparian Scrub-Shrub composed primarily of arroyo willow and Himalayan blackberry (*Rubus discolor*; Figure 36). The Tidal Salt Marsh and Tidal Brackish Marsh

often occur as elevated "shelves" or as a fringe along the creek, which is Tidal Open Water- Channel habitat (Figure 36). Within the Project Area, Lagunitas Creek provides primarily two types of Open Water habitat. Downstream of White House Pool, the creek is shallow, and, during low tides, expansive flats composed of fine muds and coarse gravel and sands become exposed, creating Tidal Open Water-Channel/Intertidal habitat, although the deepest portions of the creek remain Tidal Open Water-Channel/Subtidal habitat. Upstream of White House Pool, the cattle crossing gravel bar has created a different mix of aquatic habitats through extensive ponding of creek waters. This long, flatwater pool extends to just south of the Green Bridge and is much deeper, remaining largely subtidal, except for the very edges of the creek, which become exposed during very low tides. Some distance upstream of the Green Bridge, the creek becomes more shallow again -- albeit more freshwater in nature than the section downstream of White House Pool -- and converts into more of a riffle, run, and pool structure characteristic of fluvial systems, although anthropogenic and cattle disturbance has probably impacted condition of these aquatic habitats to some degree.

North of the Giacomini Ranch, Lagunitas Creek continues to widen as it flows toward Tomales Bay. On its western and eastern perimeter, the creek is bordered by undiked Tidal Salt Marsh. The transition between creek and marshplain is abrupt, with sediment deposition during storms creating relatively high alluvial or natural levees along the creek perimeter. These Tidal Salt Marsh-High/Upland Ecotone habitats subtly grade into the Mid- and High- Tidal Salt Marsh, which extend for some distance northwards towards Tomales Bay. Low elevation Tidal Salt Marsh or Tidal Salt Marsh-Low is restricted to fringes along tidal creeks within the Tidal Salt Marsh, although expansive patches have colonized intertidal mudflats at the very northern edge of the Lagunitas Creek delta. Fringing marsh along the perimeter of Tomales Bay between Inverness Park and Inverness shows a slightly different habitat structure, with Tidal Open Water-Channel/ Subtidal and Intertidal habitats of Fish Hatchery Creek and the Bay transitioning from low elevation Tidal Salt Marsh through Mid- to High Tidal Salt Marsh before abruptly converting to Tidal Salt Marsh-High/Upland Ecotone, Freshwater Marsh, or Riparian Forest or Scrub-Shrub habitat at the toe of the Inverness Ridge.

Fish and Wildlife Habitats of Special Significance

While all habitats are important, some habitats are considered particularly important, because they are considered key to saving the threatened and endangered species that use them. These habitats have received special protection or attention through federal and state regulations or local ordinances. A number of these habitats and the regulatory mechanisms in place for protecting them have been discussed earlier under Vegetation Resources. These include:

- ***Wetlands***. Because of their critical role in improving water quality for both humans and wildlife, waters and special aquatic sites such as wetlands are protected through Section 404 and Section 401 of the Clean Water Act and California's Porter-Cologne Act. Wetlands are also protected through California's Coastal Act and CDFG's Streambed Alteration Agreement. Wetlands are protected under the California Coastal Act for the benefit of "marine organisms" and "human health," and CDFG manages lakes, rivers, and streambeds for the protection of fish, wildlife, and native plant resources. For more information on acreage of wetlands, see Vegetation Resources.

- ***Riparian Areas***. In addition to protection of riparian habitat that qualifies as "wetland" according to federal and state regulatory agencies, riparian habitat is also protected by other state and local regulations and policies. CDFG regulates activities river- and streamside riparian habitat through Streambed Alteration Agreements, and the County of Marin has established a Streamside Conservation Area or stream setback that is superseded in the California Coastal Commission's Coastal Zone by specific policies under the Local Coastal Plan (LCP) that protects riparian habitat. In certain areas, specific riparian habitat is protected: the Point Reyes Station Community Plan has identified preservation of the riparian habitat on the Point Reyes Mesa bluff as a specific objective.

- ***CNDDB Special Habitats or Natural Communities***. CDFG has designated certain habitats or Natural Communities as deserving of protection, although they are afforded less protection than special status species. This designation invokes a broad-based ecosystem approach to planning for the protection and perpetuation of biological diversity or multiple special status species. In the Project Area, two special habitats have been identified as potentially occurring – Coastal and Valley Freshwater Marsh and Northern Coastal Salt Marsh. Northern Coastal Salt Marsh would include the undiked marsh to the north of the Giacomini Ranch, as well as the fringe marsh adjacent to Sir Francis Drake Boulevard extending from the Ranch to Inverness. There are two areas that may potentially

qualify as Coastal Freshwater Marsh – the West Pasture freshwater marsh and Olema Marsh – but neither would appear to completely meet the qualifications.

Critical Habitat

When the federal government lists a species as endangered or threatened, it is also supposed to identify that species' critical habitat. Critical Habitat includes those areas that are important for the species' survival or recovery and that need special management. While a designated critical habitat area is not intended to include the entire potential habitat of the species, it can include habitat that is not currently occupied by the species. The federal government does not consider economic impacts when it "lists" a species, but it does consider economics when deciding what areas should be designated as critical habitat. The agency is required to use the best available scientific information in making a decision about critical habitat. Only about 12 percent of listed species have a designated critical habitat area.

The Project Area incorporates Critical Habitat area for the federally endangered central California coast coho salmon (*Oncorhynchus kisutch*) and threatened central California coast steelhead (*Oncorhynchus mykiss*). Initially, it used to include Critical Habitat for the California red-legged frog (*Rana aurora draytonii*), but boundaries were adjusted during a recent reproposal of the Critical Habitat listing for this species, and the Marin Units 1 and 2 are currently located some distance east and west of the Project Area, respectively. Marin Unit 2 includes the Drakes Estero and Limantour Estero watersheds on the western portion of the Point Reyes Peninsula, and the boundary line is at least 1 mile or more from the Project Area. Marin Unit 1 appears to include principally the Walker and Chileno valleys northeast of Point Reyes Station. Critical Habitat has been designated for three other species that occur in the Project Area, but those listings are either for different “evolutionary significant units” of the same species (chinook salmon) in other states or different populations within the same state (San Diego and Orange county populations of tidewater goby; *Eucyclogobius newberryi*; FE).

Central California Coast Coho Salmon Critical Habitat. Critical Habitat for the federally endangered central California coast coho salmon population is designated to include all river reaches accessible to listed coho salmon from Punta Gorda in northern California south to the San Lorenzo River in central California, including Mill Valley (Arroyo Corte Madera Del Presidio) and Corte Madera Creeks, tributaries to San Francisco Bay. Excluded are areas above specific dams or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 4,152 square miles in California. The following counties lie partially or wholly within these basins: Lake, Marin, Mendocino, San Mateo, Santa Clara, Santa Cruz, and Sonoma.

Central Coast Steelhead Salmon Critical Habitat. Critical Habitat for the federally threatened central coast steelhead salmon population is designated to include all river reaches and estuarine areas accessible to listed steelhead in coastal river basins from the Russian River to Aptos Creek, California (inclusive), and the drainages of San Francisco and San Pablo Bays. Also included are all waters of San Pablo Bay westward of the Carquinez Bridge and all waters of San Francisco Bay from San Pablo Bay to the Golden Gate Bridge. Excluded is the Sacramento-San Joaquin River Basin of the California Central Valley as well as areas above specific dams or long-standing, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). In Tomales and Drakes Bays, Critical Habitat does not include areas upstream of Peters Dam, Seeger Dam, and Soulejule Dam.

Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act is the governing authority for all fishery management activities that occur in federal waters within the United States 200 nautical mile limit, or Exclusive Economic Zone (EEZ). Originally passed and signed into law in 1976, the Magnuson Act, as it was then called, established the U.S. 200 nautical mile limit and by implication legitimized a 200 nautical mile EEZ for all other maritime nations. One of the potentially applicable components of this act to non-oceanic activities is that it requirement conservation and enhancement of Essential Fish Habitat (EFH). Both marine and freshwater EFH designations can be made. Defined by Congress as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity," the designation and conservation of Essential Fish Habitat seeks to minimize adverse effects on habitat caused by fishing and non-fishing activities. Non-fishing activities that can affect EFH include dredging and filling. The EFH descriptions and

identifications for the Pacific's FMPs were approved on: September 27, 2000, for west coast salmon fisheries. The regulated EFH species in Tomales Bay is coho salmon, which occurs in Lagunitas Creek. Freshwater EFH includes Tomales Bay to the upper portions of its watershed, while the entire outer coastline of Point Reyes has been designated marine EFH.

General Fish and Wildlife Use

Regional and Tomales Bay Setting

As described earlier, the incredible diversity of wildlife attracted to this region by its diversity and complexity of habitats has gained Point Reyes and Tomales Bay international recognition. The Continental Shelf present offshore hosts not only hundreds of resident organisms, but numerous migratory and transient visitors who come to feast on its resources and breed and rear young in its relatively sheltered environs. Coastal upwelling or turnover of nutrients from deeper marine waters due to strong winds dramatically boosts primary productivity within nearshore waters (Smith and Hollibaugh 1998). The California coast is one of just five major coastal upwelling regions in the world, and while coastal upwelling areas make up only one-tenth of a percent of the ocean's surface area, they account for 95 percent of the global marine biomass and more than 21 percent of the world's fisheries landings (MBARI 2002). Hundreds of invertebrate species take advantage of bountiful resources in submerged rocky and sandy habitats. Plentiful invertebrates and large kelp forests sustain thriving fisheries, including commercial species such as rockfish and Pacific herring. Marine seabirds come seasonally in large numbers to the outer coast and Farallones to breed and nest. In addition, every winter, more than 30 percent of the world's cetacean mammals swim by the coast of Point Reyes, as whales move annually from calving grounds in Baja California to the artic water. Harbor seals and northern elephant seals also come in winter to haul-out and pup, taking advantage of the benign environment and rich food resources.

Many of these marine species find additional foraging, protection, and even nursery habitat in the shallows of Tomales Bay. The Park Service recently initiated a project with several local partners to document the biodiversity of Tomales Bay. By fall 2004, the Tomales Bay Biodiversity Inventory (TBBI) had documented more than 2,000 species in the intertidal and subtidal portions of the Bay, including 28 species of Protozoa, 9 species of Fungi, 262 species of Mollusks, 270 species of Arthopods, 252 species of Annelid Worms, and 419 species of Chordates, which includes mammals and more than 40 species of fish (TBWC 2002; Seashore 2005). The incredible diversity in submerged, intertidal, and upland habitats attracts species that move in and out of the estuary, as well as estuarine species that spend their entire lives within its boundaries. During summer and early fall, many marine fish species, as well as skates, rays, and sharks, move into the Bay to forage on populations of estuarine organisms, many of which are peaking in abundance during this period (TBWC 2002). Non-resident fish species that use Tomales Bay include coho salmon, steelhead, sardines, ling cod (*Ophiodon elongatus*), Pacific herring, northern anchovy (*Engraulis mordax*), and marine surfperch species such as walleye surfperch (*Hyperprosopon argenteum*; Bratovich and Kelley 1995, TBA 1995 *in* TBWC 2002; Pettigrew 2004). Sandier portions of the Bay draw bottom-dwelling fish such as California halibut (Evens 1993). Even marine mammals such as harbor seals and sea lions (*Eumetopias jubatus*) venture into the estuary to feed on herring and other marine species. Harbor seals often haul out and rest on tidal sand bars and sandy beaches within the outer Bay such as Hog Island and Tom's Point, using some areas for pupping (Allen and King 1992). Sea lions feed in the Bay during December and January when the herring and salmon are running (ARA 2002).

The food web within Tomales Bay is also supported by primary producers such as phytoplankton (Spratt 1989), as well as eelgrass. The large eelgrass beds in Tomales Bay provide foraging and nursery habitat, as well as refugia or protection from predators for many species of invertebrates, fish, birds, and mammals (TBWC 2002). Many invertebrates, fish, and even some waterfowl forage in or on eelgrass, including juvenile Dungeness crab (*Cancer magister*), some flatfish species, and bat rays. Pacific herring, which often number as many as 50 million during spawning periods, uses eelgrass and algae such as *Gracilaria* for its eggs (Moore and Mello 1995)*in* TBWC 2002), and least terns (*Sterna antillarum*) and other species such as loons (Gaviiformes); grebes (Podicipediformes), and cormorants (*Phalacrocorax auritus*; CSC) forage on these and other small fish (Palmer 1962) *in* TBWC 2002). Many waterbird species such as surf scoters (*Melanitta perspicillata*), bufflehead (*Bucephala albeola*), scaup, goldeneyes, and black brant (*Branta bernicla*) consume herring roe or eggs (Hardwick 1973; Bayer 1980; Briggs et al. 1987; TBWC 2002) or, in the case of brant, eelgrass itself (Goals Project 1999).

Along with its larger neighbor to the east, Tomales Bay is an important stop on the Pacific Flyway for migratory and overwintering waterfowl and shorebirds. Thirteen years of surveys have recorded approximately 163 waterfowl and shorebird species within the Bay, with 122 of those occurring regularly or at least occasionally (Kelly 2003). During the fall and winter, the Bay supports on average approximately 25,000 waterfowl, tens of thousands of gulls, and 20,000 shorebirds, with the latter statistic earning it a designation as one of 16 Wetlands of Regional Importance by the Western Hemisphere Shorebird Reserve Network (Kelly and Tappen 1998; Kelly 2001). During spring, Marin hosts as many as 150 species of breeding birds, most of which are on the coast (ARA 2002). Tomales Bay cannot compete with San Francisco Bay in terms of sheer numbers, but Tomales Bay supports higher densities of many species (J. Kelly, ACR, pers. comm.) and accounts for a large proportion of many species' statewide population numbers. Tomales Bay represents roughly 30.8, 12.3, and 6.4 percent of the state's total population of black brant, bufflehead, and scoters, respectively (Kelly and Tappen 1998). Tomales Bay is one of only three sites along the Pacific Flyway that support more than 100 red knots (*Calidris canutus*) during spring migration (C. Hickey, PRBO, *pers. comm*.). Ten of the 17 Partners-in-Flight Riparian Focal Species breed in the Point Reyes region (C. Hickey, PRBO, *pers. comm*.), and it may support one-third of the total population of neotropical migrant species such as saltmarsh common yellowthroat (*Geothlypis trichas* var. *sinuosa*; former FSC, CSC; ARA 2002). Many species move from Tomales Bay to San Francisco Bay or vice versa during migration, including dunlin (*Calidris alpina*; (Warnock et al. 1995) and canvasback (*Aythya valisineria*), greater scaup (*Aythya marila*), and surf scoter (Takekawa et al. *in press*). A large factor in the avian diversity found in Point Reyes comes from rare or extremely rare species, which account for 50 percent of total species observed (Evens 1993).

Tidal Salt Marsh is occasionally used by wading birds and long-legged shorebirds for roosting or foraging, but more commonly by rails such as California clapper rails (*Rallus longirostris obsoletus*; FE, SE), California black rail (*Laterallus jamaicensis coturniculus*; ST), Virginia rails (*Rallus limicola*), and sora (*Porzana carolina*) that remain within intertidal marshes and small channels, where they forage on invertebrates in the mud. Many songbirds are incidental or occasional visitors to Tidal Salt Marsh, including the saltmarsh common yellowthroat. Southwestern river otters (*Lontra canadensis sonorae*; CSC) forage along tidal creeks on macroinvertebrates, building burrows in adjacent Upland Ecotone or riparian habitat. Resident estuarine fish in Tomales Bay include threespine stickleback (*Gasterosteus aculeatus aculeatus*), arrow goby (*Clevelandia ios*), Pacific staghorn sculpin (*Leptocottus armatus*), shiner surfperch (*Cymatogaster aggregata*), bay pipefish (*Syngnathus leptorhynchus*), and non-native species such as yellowfin goby (*Acanthogobius flavimanus*; TBWC 2002, (Pettigrew 2004), with composition sometimes dependent on tidal cycle. Some fish move up onto marshplains during extreme high tides to forage on benthic and epibenthic invertebrates. Northern harriers (*Circus cyaneus*; CSC), White-tailed kites (*Elanus caerulus*), and osprey (*Pandion haliaetus*; CSC) hunt rails and other species in Tidal Salt Marshes, including rodents living in drier portions of wetlands and ecotones.

During extreme high tides or storm events, many avian and mammal species such as rails, rodents, and otters find refuge in uplands bordering the estuary. The steep slopes of the Inverness Ridge, as well as the lower-elevation coastal marine terraces on the east, not only offer refugia and foraging habitat during extreme events, but, of course, habitat for a diversity of terrestrial invertebrates, amphibians, reptiles, birds, and mammals. Some of the most important, unique, or charismatic of these species include the northern spotted owl (*Strix occidentalis caurina*; FT), Point Reyes mountain beaver (*Aplodontia rufa phaea*; former FSC), tule elk (*Cervus elaphus nannodes*), bobcat (*Felis rufus*), and mountain lion (*Puma concolor*).

Habitat diversity within estuaries occurs not only through vertical variability in topography or bathymetry, but through horizontal or longitudinal variability in salinity. Shifts in salinity regime are linked to shifts in wildlife species assemblages and changes in the diversity and type of species, although some species seem to move with ease between regimes. Because of physiological tolerances, many species are restricted to specific salinity regimes, such as the California freshwater shrimp (*Syncaris pacifica*), California red-legged frog, tidewater goby, and northwestern pond turtle. For other species, salinity tolerance shifts between life stages. Marine species such as coho salmon, steelhead, and other anadromous fish use freshwater environments in the upper portions of watersheds for spawning and rearing of young, with the young eventually moving back out to sea. Salmon use brackish areas only as transitional habitat for foraging, resting, or refugia during upstream or downstream migration or during the process of converting from freshwater to saltwater. Other marine species such as California halibut, flounder, and Pacific herring use brackish environments within the estuary as nurseries for young, which return to the sea as adults.

One of the most productive habitats within many estuaries is the estuarine transition zone. Within open water areas of estuaries such as San Francisco Bay, certain invertebrates and fish occur preferentially in the Low Salinity Zone (LSZ) or X2, where salinity approximates 2 psu or ppt (discussed under Water Resources –

Water Quality). Significant relationships between X2 and abundance have been found, at least some of the time, for estuarine-dependent copepods, mysids, bay shrimp (*Crangon franciscorum*), and several fish including Pacific herring and starry flounder (Kimmerer 2004). Within Tomales Bay, the Lagunitas and Walker Creek deltas probably represent the largest estuarine transition zones. Conversely, some invertebrate species appear to prefer hypersaline conditions, which occur during the late summer in the innermost portions of Tomales Bay. Discrete populations of closely related species of the copepod genus *Acartia* have apparently been observed in portions of Tomales Bay during hypersaline periods (Kimmerer 1993). Even estuarine circulation patterns can affect species diversity or viability, with the strength of gravitational or classic estuarine circulation linked in San Francisco Bay to successful recruitment for Bay shrimp and starry flounder and movement of mysid, longfin smelt, and striped bass (Kimmerer 2004).

Fish and Wildlife Species Resources Within the Project Area

While moderate to intensive development and management of the Giacomini Ranch and Olema Marsh may have caused wildlife resources to decline relative to historic conditions, the Project Area nonetheless supports a diverse array of animal species, a large proportion of which are special status because their populations are considered at risk (ARA 2002). During the course of baseline wildlife surveys, at least six reptiles, four amphibian, 32 fish, and 194 bird species were observed in the Project Area. Of the 194 bird species, 49 percent were year-round residents, a pattern that mirrors the region in general (ARA 2002). More specific information on special status species is provided below, and a list summarizing some of the species present can be found in Table 17. While many species are resident to the Project Area or vicinity, numerous others are transients, including even some marine species, that primarily use Tomales Bay, but occasionally frequent the Project Area as a supplement to the more extensive habitats in the Bay itself such as Tidal Open Water-Channel Subtidal and Intertidal habitats (ARA 2002). Sea lions have even been known to occasionally wander as far south as the Project Area (ARA 2002).

Many of the species observed in the Project Area rely upon the complex mosaic of wildlife habitats present. For example, 75 percent of the avian species observed during winter surveys were not restricted to just one habitat, but were utilizing a combination of riparian, marsh, and open water habitats (ARA 2002). The most rare species such as salt marsh common yellowthroat, California black rail, sora, and yellow rail (*Coturnicops noveboracensis*), often moved between Tidal Salt Marsh, Freshwater Marsh, Forested and Scrub Shrub Riparian, and shallowly flooded- ponded Pasture-Grasslands (ARA 2002). This habitat interdependence extended to species other than avian ones. While California red-legged frog breeds and rears in the West Pasture freshwater marsh, during the summer, most frogs may have moved into riparian areas and forested hillsides to the west or possibly into the pastures (Fellers and Guscio 2002; G. Fellers, USGS, *pers. comm*.).

In general, most of this habitat diversity occurs on the perimeter or “edge” of the Giacomini Ranch and, to some extent, Olema Marsh. Within the Giacomini Ranch, the perimeter or edge represents not only the dynamic interface between groundwater, freshwater, and, to some extent, saltwater, but is also less heavily managed for agricultural purposes. In addition, it offers proximity of some very different types of habitat such as coniferous forest or Woodland and Coastal Scrub to the Project Area also act to promote the diversity of wildlife species observed (ARA 2002).

Giacomini Ranch – East Pasture. While both diked pastures are grazed by cattle, the East Pasture differs from the West in that it is more heavily managed through grazing, mowing, ditch dredging, irrigation, and manure spreading and is almost completely disconnected from tidal influence, both of which affect the potential to support wildlife. Diking, perhaps not surprisingly, seemingly impacts aquatic communities more than others. Most of the drainage ditches and diked tidal sloughs within West and East Pastures had very low numbers and diversity of benthic, epibenthic, and macro- invertebrates (NPS, unpub. data). Permanent impoundment of waters does not allow ditches and creeks to become oxygenated through regular exposure, so the muds are very anoxic and support few species, including one species of gastropod (snails) and non-native crayfish, the latter of which may have been introduced by the Giacominis. Numbers and diversity of fish also remained low within Giacomini Ranch waterways, a large percentage of which are hydrologically disconnected from both upstream and downstream water bodies (NPS, unpub. data). Three-spine stickleback and mosquitofish (*Gambusia affinis*), along with, in lesser numbers, goby larvae and longjaw mudsucker (*Gillichthys mirabilis*), were the only fish observed in the drainage ditches and ditched sloughs in the East Pasture, with threespine stickleback representing the principal species observed in Tidal, Muted Tidal, and Non-Tidal waters within the Project Area (NPS, unpub. data, ARA 2002). The lack of hydrologic connectivity, combined with frequent hypoxia or low oxygen conditions potentially caused by ditch dredging, minimizes the number of species that can establish and live in these habitats.

Despite low numbers of invertebrates and fish, ditched waterways provided aquatic and basking habitat for northwestern pond turtles, which were seen "regularly" in the East Pasture (Fellers and Guscio 2002). A few adult California red-legged frogs occurred in the East Pasture, although they were not believed to be breeding adults, and no juveniles were observed (Fellers and Guscio 2002).

Bullfrogs (*Rana catesbeiana*), believed to be one of the primary predators of red-legged frog, have been observed in Tomasini Creek and some East Pasture ditches (Fellers and Guscio 2002). Pastures provide habitat for small rodents such as voles (*Microtus*), gophers (*Thomomys*), and shrews (*Sorex*; ARA 2002). Southwestern river otters (*Lontra canadensis sonorae*; CSC) occasionally swim in drainage ditches near Lagunitas Creek, and, infrequently, red fox (*Vulpes vulpes*) use some of the discarded irrigation pipes in the Pastures, as well as visit the Dairy Facility (L. Parsons, *pers. obs*., J. Evens, *pers. obs*.). Black-tailed deer (*Odocoileus hemionus columbianus*) also move down regularly from the Point Reyes Mesa Bluff to graze in pastures.

Avian use of the pastures in the East Pasture was seasonally variable. The northern portion of the pasture themselves frequently hosted roosting Canada geese (*Branta canadensis*), great blue herons (*Ardea herodias*; S4), great egrets (*Ardea alba*; S4), and, occasionally, waterfowl species such as mallards (*Anas platyrhynchos*). Virginia rails and sora established territories in 2001-2002 in one of the ditched sloughs (ARA 2002). In general, ditches supported a low diversity of species that include occasional use by mallards, gadwall (*Anas strepera*), lesser scaup (*Aythya affinis*), eared grebe (*Podiceps nigricollis*), black phoebe (*Sayornis nigricans*), and even belted kingfisher (*Ceryle alcyon*; ARA 2002). Raptors hunt over the East and West Pastures, probably searching for small mammals and unwary birds. However, in general, managed pastures "are relatively depauperate in terms of supporting breeding birds in general and special status species in particular" (ARA 2002). Savannah sparrows (*Passerculus sandwichensis*) did attempt to nest in some of the managed pastures, however, some of the fields were mowed during the height of nesting effort, thus excluding perhaps a third of their population (ARA 2002). The only avian species using managed pastures as its primary habitat was grasshopper sparrow (*Ammodramus savannarum*; former FSC, S2), but it arrived late and did not breed (ARA 2002). Large flocks of migratory swallows sometimes forage low over pastures and marshes, especially early and late in the day (ARA 2002).

Several areas in the East Pasture supported at least seasonally higher avian densities. Waterfowl species such as mallards often use drainage ditches and ditched sloughs in low numbers. Buffleheads regularly use some of the old Duck Ponds created by the Giacominis (ARA 2002). The greatest waterfowl and shorebird use in the East Pastures occurs in what is known as the shallow shorebird area in the northeast corner of the East Pasture, a unique habitat within the Project Area. This Muted Tidal Brackish Marsh-Flat / Panne floods from December through April – although in years with early rainfall, it can be early as October -- with surface runoff, precipitation, and tidal waters that flow into the East Pasture from a culvert in the levee of the Tomasini Creek berm, creating brackish water conditions. Many waterfowl species, especially dabbling ducks such as gadwall, wigeon, and teal, are attracted to this area in the winter (ARA 2002). Shorebirds also gather here in rather high numbers to roost and forage when adjacent tidal flats are inundated at high tide (ARA 2002). Some of the most common shorebird species included dunlin, dowitcher species (*Limnodromus sp*.), greater yellowlegs (*Tringa melanoleuca*), common snipe (*Gallinago gallinago*), willet, and killdeer (J. Kelly, ACR, *pers. comm*.).

TABLE 17. PRESENCE OF GENERAL WILDLIFE GROUPS, CLASS, OR ORDERS AND REPRESENTATIVE TAXA AND/OR SPECIES WITHIN SPECIFIC UNITS OF THE PROJECT AREA

Note: E: East Pasture; TC: Tomasini Creek; W: West Pasture; L: Lagunitas Creek; and O: Olema Marsh

General Groups, Class, or Orders	Representative Taxa or Species	EP	TC	WP	LC	OM
FISH						
Native Estuarine Fish-Resident	threespine stickleback, arrow goby, longjaw mudsucker, staghorn sculpin, prickly sculpin, **Tidewater goby, Tomales roach**	√	√ **TG**	√ **TG**	√ **TR**	√
Non-Resident Native Fish	Salmonids		√	√	√	**?**
	Starry flounder, topsmelt				√	
Non-Native Fish-Resident	Mosquitofish	√		√		
	yellowfin goby				√	
INVERTEBRATES						
Epibenthic Invertebrates	Gammarid amphipods		√	√	√	
Pelagic Invertebrates - Native	Mysid shrimp		√		√	
Pelagic Invertebrates – Non-native	Korean shrimp		√	√	√	
Benthic Invertebrates - Bivalves			√		√	
Macroinvertebrates - Native	Western shorecrab					
Macroinvertebrates – Non-Native	Green crab		√		√	
	crayfish	√		√		
AMPHIBIANS AND REPTILES						
Amphibians - Native	**California red-legged frog**	√	√	√		√
	Pacific tree frog	√	√	√	√	√
Amphibians – Non-Native	Bullfrog	√	√			√
Reptiles	**Northwestern pond turtle**	√	√	√	√	√
BIRDS						
Diving Ducks	Greater and lesser scaup, canvasback, buffleheads, ruddy	√			√	√
Dabbling Ducks	Mallards, gadwall, wigeon, teal, northern shoveler, wood ducks	√	√	√	√	√
Waterbirds	Cormorant, Virginia rails, sora, eared grebe, belted kingfisher, **California black rail, California clapper rail**			√ **BR**	√ **BR CR**	
Colonial Nesting Waterbirds	Herons, egrets,	√		√		
Shorebirds – Deep Probers	Dowitcher, greater yellowlegs, common snipe, willet	√		√		
Shorebirds – Shallow Probers	Dunlin, spotted sandpiper	√		√	√	
Passerines – Riparian/ Neotropical migrants	Swainson's thrush, warbling vireo, Wilson's warbler	√	√	√	√	√
Passerines –Riparian/ Resident	**Saltmarsh common yellowthroat**, Bewick's wren	√	√ **YT**	√ **YT**	√	√ **YT**
Passerines - Marsh	Marsh wren, red-winged blackbird, **Saltmarsh common yellowthroat**	√		√	√	√
Passerines - Grassland	Savannah sparrow, grasshopper sparrow, Western Meadowlark	√		√		
Raptors	Osprey, **American peregrine falcon**, White-tailed kite	√		√	√	?
Non-Native Birds	Turkeys, European starlings	√		√		
MAMMALS						
Small ground-dwelling mammals	Voles, gophers, shrews	√	√	√	√	
Bats		√	√	√	√	√
	Southwestern river otter	√	√	√	√	?
	Red fox	√		√		
	Black-tailed deer	√	√	√		

Giacomini Ranch – Tomasini Creek. A greater diversity and number of wildlife occurred in creeks and portions of pastures that had at least muted tidal influence. Tomasini Creek's malfunctioning tidegate allows the full upper range of high tides, but attenuates low tides, creating permanent Muted Tidal Open Water-Channel/Subtidal habitat rather than the Muted Tidal Open Water-Channel/Intertidal habitat that would probably exist were the tidegate removed.

Perhaps, the largest benefit of increasing tidal influence and hydrologic connectivity comes from the associated increase in aquatic organisms. Benthic invertebrates still occurred only in low densities, probably

because the tidegates and associated structures act to impound waters even during low tides, decreasing Muted Tidal Open Water-Channel/Intertidal habitat and increasing soil anoxia (NPS, unpub. data). The number of epibenthic organisms increased slightly, with Tomasini Creek supporting the non-native brackish water shrimp (*Palaemon macrodactylus*) and native mysid shrimp (*Neomysis mercedis*), an important prey item for salmon (Bratovich and Kelley 1988), along with smaller epibenthic invertebrates such as amphipods, isopods, and insects. The invasive non-native crustacean, green crab (*Carcinus maenas*), may also occur in Tomasini Creek.

Muted tidal influence also increased fish species diversity slightly compared to the East Pasture. Fish in Tomasini Creek included staghorn sculpin (*Gymnocanthus tricuspis*) and prickly sculpin (*Cottus asper*), as well as threespine stickleback and longjaw mudsucker. Starting in 2002, the federally endangered species, tidewater goby, has been observed annually in relatively low numbers in a section of Tomasini Creek from the Giacomini Hunt Lodge to the midpoint of the Point Reyes Mesa bluff. In addition, federally endangered juvenile central coast coho salmon and *Oncorhynchus mykiss* juveniles -- assumed for regulatory purposes to be steelhead -- were found in small numbers in June 2005 in Tomasini Creek (NPS, unpub. data). One steelhead was also observed in 2004 (D. Fong, GGNRA, *pers. comm*.). Any historic runs of steelhead or coho salmon in Tomasini Creek may have been negatively affected by repeated diversions of Tomasini Creek through different parts of the East Pasture (see Water Resources), leveeing of the creek, dredging, and installation one-way tidegates. Furthermore, summer rearing habitat for salmon and steelhead juveniles in upper portions of the watershed may be limited by draw-down of Tomasini Creek in the late summer and early fall during average and dry rainfall years and water quality impacts from operation of the now-closed West Marin Landfill. The increased diversity of aquatic organisms also draws other species, as well, including common North American raccoons (*Procyon lotor*) and southwestern river otter (J. Evens, ARA, *pers. comm*.).

While the western leveed portion of Tomasini Creek does not support much riparian vegetation, the eastern bank has a well-developed riparian corridor that transitions into the expansive and unique Mesic Coastal Scrub habitat that extends across the face of the Point Reyes Mesa bluff. The combination of riparian and coastal scrub habitats attracted about 4 percent of the breeding birds observed in the Project Area during spring, including species such as Swainson's thrush (*Catharus ustulatus oedicus*, CSC), Bewick's wren (*Thryomanes bewickii*; CSC), Wilson's warbler (*Wilsonia pusilla*), Warbling vireo (*Vireo gilvus*), and Allen's hummingbird (*Selasphorous sasin*, CSC; ARA 2002). Winter use of these habitats was slightly higher, with almost 10 percent of the birds observed during winter occurring here (ARA 2002). Saltmarsh common yellowthroat occurred upstream near the Giacomini Hunt Lodge and north of Mesa Road (ARA 2002). Greater yellowlegs and dabbling ducks sometimes use the creek itself (J. Evens, ARA, *pers. comm*.).

Giacomini Ranch –Fish Hatchery Creek and West Pasture. As with Tomasini Creek, muted tidal influence and better hydrologic connectivity with upstream portions of Fish Hatchery Creek watershed appear to increase wildlife diversity in the West Pasture relative to the East, even though it is diked. In addition, pastures in the West Pasture are not as highly managed as the East Pasture, with only annual mowing, occasional creek dredging, and creek flow regulation via tidegates occurring. Grazing pressure is also reduced relative to the East Pasture. As with Tomasini Creek, tidegates do not allow waters to fully drain, thereby retaining largely Muted Tidal Open Water-Channel/Subtidal habitats within creeks and ditched sloughs, although there are some fringes of Muted Tidal Open Water-Channel/Intertidal habitat on the creek perimeter.

Fish assemblages within the West Pasture were very similar to the East, with threespine stickleback and mosquitofish the most common species, although sculpin and arrow goby were also present (NPS, unpub. data, ARA 2002). The number of epibenthic organisms also increased slightly, primarily through occurrence of smaller invertebrates such as amphipods, isopods, and insects. While water quality conditions are generally better in West Pasture drainageways than in the East, fish kills of highly tolerant species such as threespine stickleback occurred occasionally in the West Pasture freshwater marsh, perhaps because elevated primary productivity during the day causes oxygen depletion at night. *Oncorhynchus mykiss* juveniles, assumed for regulatory purposes to be steelhead, were observed in very low numbers (one individual) in Fish Hatchery Creek in both 2001 and 2005 (NPS, unpub. data; ARA 2002). Historic accounts depict a thriving steelhead run on this creek, with a very rough estimate of 10,000 "young" (< 3 inches) in 1899 (Schofield 1899) *in* ARA 2002). Interestingly, despite its name, this subwatershed probably has never supported a "fish hatchery" operation (B. Ketcham, Seashore, *pers. comm*.). In addition, in late 2005, Seashore biologists found five individuals of what has been preliminarily identified as tidewater goby in the West Pasture Old Slough, a tributary to Fish Hatchery Creek.

Northwestern pond turtle appears to occur in lower numbers in the more saline West Pasture than in the East, with only one reported sighting in 2001-2002 (Fellers and Guscio 2002). Conversely, the West Pasture

supports the largest population of breeding adult and juvenile California red-legged frogs in the Giacomini Ranch, with frogs primarily utilizing the West Pasture freshwater marsh habitat and adjacent portions of Fish Hatchery Creek (Fellers and Guscio 2002). In 2001-2002, adult frogs totaled as high as 21 (Fellers and Guscio 2002). In 2003, the already malfunctioning tidegate on Fish Hatchery Creek collapsed, increasing the amount of tidal flow. This increase in tidal flow expanded the degree of salinity intrusion into the marsh and appeared to cause a decrease in frog use (G. Fellers, USGS, pers. comm.). While tidal influence was reduced after tidegate repair in fall 2003, salinity intrusion still appears to be occurring. Since 2003, numbers of frogs have not been as high, although 12 adults and one egg mass were found in January 2006 (G. Fellers and P. Kleeman, unpub. data). Predation pressure on this population may come primarily from native predators such as black-crowned night heron (*Nyctiorax nyctiorax*) rather than bullfrogs, which were detected for only the first time in this marsh in 2006 (Fellers and Guscio 2002; P. Kleeman, USGS, *pers. comm*.). A more detailed discussion of the California red-legged frog occurs later in this section.

Southwestern river otter regularly use the levee near the Fish Hatchery Creek tidegate, apparently foraging on crustaceans such as the invasive, non-native green crab. Several otter burrows have been built in the Forested Riparian habitat adjacent to Sir Francis Drake Boulevard at the West Pasture north levee (ARA 2002). Black-tailed deer occasionally graze in the West Pasture Freshwater Marsh, and non-native wild turkeys (*Meleagris gallopavo*) have commonly been observed using Meadows and Pasture-Grassland in the West Pasture, as well.

As with the East Pasture, herons, egrets, and Canada geese occasionally roost in seasonally flooded-ponded or temporarily flooded Meadows and Pasture-Grassland, and waterfowl sporadically use Fish Hatchery Creek and the West Pasture Old Slough. Marsh wrens *(Cistothorus palustris)* frequent stands of cattails and bulrush in Fish Hatchery and the West Pasture Old Slough. Virginia rails established territories along Fish Hatchery Creek, however, sections of creek with shorter vegetation tended to support primarily song sparrows (*Melospiza melodia*; ARA 2002; J. Evens, ARA, *pers. comm*.). American goldfinch (*Carduelis tristis*) and house sparrow (*Passer domesticus*) flocks occasionally use large patches of tall weeds on the levees such as poison hemlock (*Conium maculatum*). However, the habitat with the highest value to breeding birds was the West Pasture Freshwater Marsh-Forested Riparian association in the northwestern corner of the property (ARA 2002). Saltmarsh common yellowthroat, Virginia rail, song sparrow, marsh wren, blackbird (*Euphagus cyanocephalus)*, and other marsh-riparian associates commonly occur in the marsh and the riparian corridor adjacent to Sir Francis Drake Boulevard. Use of the Freshwater Marsh-Forested Riparian was also high during the autumn and winter, with 40 to 50 percent of all species observed during autumn occurring in riparian-marsh or riparian-ruderal field associations in the northwestern and southwestern corners of the Project Area, respectively (ARA 2002). In addition to these "permanent habitats," waterfowl often congregate in large numbers in the southern portion of the West Pasture in seasonally flooded-ponded Meadows and Pastures that receive significant freshwater inflow from groundwater and small drainages flowing off the Inverness Ridge.

Olema Marsh. While the value of Olema Marsh to avian wildlife is well-documented (Evens and Stallcup 1991, 1992, 1993, 1994; Stallcup and Kelly 2004, 2005), information on the other animals that use this system is not as complete. The marsh provides extensive refugia opportunities from both animal and human "predators," complicating efforts to understand the wildlife community. California red-legged frogs breed in the marsh, but total numbers of this population are not known due to the difficulties of accurately surveying this population (G. Fellers, USGS, pers. comm.). The marsh also supports Northwestern pond turtle, Pacific treefrogs (*Pseudacris regilla*), and bullfrogs, but, again, numbers of the latter, a potential red-legged frog predator, cannot be determined (G. Fellers, USGS, *pers. comm*.). Southwestern river otter used to occur in the marsh, but have not been seen recently, perhaps because impounded conditions in the marsh do not create a sufficient creek gradient to allow passage, at least via water, for otter: otter will move over land, as well as through water, to access areas (J. Evens, ARA, *pers. comm*.). This same issue may account for why no coho salmon, steelhead, tidewater goby, or California freshwater shrimp have been found in Olema Marsh either (Fong 2003; D. Fong, GGNRA, *pers. comm*.; NPS, unpub. data), although this marsh may have served as habitat for all of these historically.

Smolt trapping by the Seashore upstream of Olema Marsh in 1999 captured 21 steelhead – five of which were classified as pre-smolts (Ketcham *in prep.*). Fish species such as stickleback and sculpin were observed in very low numbers in the northern portion of the marsh during 2005, as well as in higher numbers near park headquarters in spring 1999 (NPS, unpub. data). Historically, salmon are believed to have used this watershed, which is one of the reasons that a hunting and fishing club was established during the 1800s. Initially, the fishing and hunting clubs allowed members to fish coho salmon and steelhead trout, but as numbers decreased from overfishing, many clubs began stocking thousands of fish that were not native to this region such as eastern brook trout and Quinnat salmon (Mason 1983). Despite this and other dramatic

changes due to agricultural and ranch development, there continued to be reports of 8-14 inch trout in some of the deep pools near the Park's administrative headquarters up until 1982 (B. Ketcham, Seashore, *pers. comm*.). Following 1982, the structure of the creek changed dramatically, with many of the deep pools favored by trout and salmonid species eliminated (B. Ketcham, Seashore, *pers. comm*.). Coho salmon have not been observed, at least in recent times, in the Bear Valley Creek watershed (B. Ketcham, Seashore, *pers. comm*.).

Olema Marsh was at least once considered "one of the most diverse habitats for breeding, wintering, and migrating birds in the Point Reyes area" (Evens 1993). Because of the value of Olema Marsh to birds, breeding bird censuses were conducted between 1984 and 1994 and again in 2004 (Evens and Stallcup 1991; 1992; 1993; 1994; Stallcup and Kelly 2004). During the earlier monitoring, a prolonged drought encouraged conversion of some of the marsh to willow-dominated riparian habitat, and this shift, along with drier conditions in the marsh itself, appear to cause declines from pre-drought numbers of some of the most common breeding birds such as marsh wren, Virginia rail, song sparrow, and salt marsh common yellowthroat, with declines ranging from 36 percent (song sparrow, yellowthroat) to as high as 77 percent (marsh wrens; Evens and Stallcup 1992). Concurrently, numbers of red-winged blackbirds (*Agelaius phoeniceus)* increased by approximately 31 percent, as well as increase in other riparian associates such as black-crowned night heron (*Nycticorax nycticorax*; formerly FSC, S3) and green-backed heron (*Butorides striatus*; Evens and Stallcup 1991, 1992). Between 1984 and the early 1990s, vast flocks of blackbirds often roosted in the marsh at night, and red-winged blackbirds bred actively (Evens and Stallcup 1991). Drought conditions also appeared to attract increased numbers of waterfowl to the marsh, possibly because of lower water levels elsewhere (Evens and Stallcup 1992). In 1993, the drought ended, and populations of many of the previously common bird species rebounded, including marsh wrens, song sparrows, Virginia rails, and saltmarsh common yellowthroat (Evens and Stallcup 1993, 1994). The increase in riparian vegetation continued to attract riparian associates, the three most common being warbling vireo, Swainson's thrush (*Catharus ustulatus*), and Wilson's warbler (Evens and Stallcup 1994).

Between 1991 and 1994, total number of species ranged from 77-81 during the winter and 44-49 species during the spring (Evens and Stallcup 1991, 1992, 1993, 1994). In 2004, this species richness trend reversed, with the number of species totaling 74 in spring and 65 in winter (Stallcup and Kelly 2004). As before, red-winged blackbird, marsh wren, and song sparrow represented generally the most abundant species in autumn, winter, and spring, along with saltmarsh common yellowthroat, which had at least 12 nesting territories during spring 2004 (Stallcup and Kelly 2004; 2005). California black rails were not detected, but relatively high numbers of Virginia rails occurred in all survey periods, and sora frequented the marsh in fall (Stallcup and Kelly 2004, 2005). The expansion of riparian habitat on the west side of the marsh where the Bear Valley Creek flowed prior to 1998 continues to attract an increasing number of riparian associates. As might be expected, the number of waterfowl species using the marsh typically peaks in winter, although many continue to visit throughout the spring. Common waterfowl species included mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), wood duck (*Aix sponsa*), green-winged teal (*Anas crecca*), cinnamon teal (*Anas cyanoptera*), northern shoveler (*Anas clypeata*), and ring-necked duck (*Aythya collaris*; Stallcup and Kelly 2004, 2005).

Lagunitas Creek. For Lagunitas Creek, as with other California creeks, the story of its fisheries and other resources is strongly interwoven with the history of the watershed and its development since the 1800s. Anecdotal stories told of this area by Spanish explorers and later by European Americans paint a bucolic picture of abundant natural resources, particularly fish and game. Lagunitas, or Papermill Creek as it was once known, reportedly supported a substantial run of steelhead in the late 1800s, estimated at more than 200,000 "young" (<3 inches; Schofield 1899 *in* ARA 2002). Historic coho outmigration to the sea once numbered as many as 3,000 to 5,000 fish annually (Smith 1986).

While watershed development and excessive sedimentation between 1860 and 1950 undoubtedly affected salmonids, as well as other aquatic species, construction of levees and a seasonal gravel dam for impoundment of fresh stream water for pasture irrigation probably ranked as two of the largest impacts to remaining fisheries (ARA 2002). Levee construction precluded fish and other organisms' access to the interior of the former tidal marsh, while the gravel dam largely cut off upstream access and dramatically altered salinity dynamics. These major hydrologic impacts were closely followed in the 1950s with construction of a series of dams for reservoirs in the upper portions of the watershed, substantially reducing sediment loads in the creek (PWA et al. 1993). The temporary gravel dam installed by the Giacominis, known as the old summer dam, impounded waters for almost 1 mile upstream to a point well upstream of the Green Bridge and State Route 1 (KHE 2006a). The long residence time of waters behind the dam resulted in unnaturally warm water temperatures uncharacteristic of natural California coastal systems and essentially eliminated the brackish zone that would naturally move up and down the creek, creating instead a sharp demarcation

between salt waters downstream and fresh waters upstream (ARA 2002). This warm, fresh- water impoundment attracted numerous non-native fish species that probably outcompeted and/or foraged upon any native fish species and invertebrates capable of tolerating conditions within the "pool." Seven of the 23 fish species caught in a 1983 survey were non-native species, including largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and black crappie (*Pomoxis nigromaculatus*), that prey on native fish (Bratovich et al. 1984 *in* ARA 2002).

These geomorphic and hydrologic alterations may have initiated a steady decline in population of species such as tidewater goby in Lagunitas Creek (ARA 2002). Within a decade after levees and dams were constructed, tidewater goby, a small annual fish that is adapted to brackish waters and that historically had been recorded within the Lagunitas Creek watershed, was seemingly extirpated from Lagunitas, as well as within all of Tomales Bay. The last sighting in Lagunitas Creek was in 1953 (Swift et al. 1989). One researcher (Wang 1982)*in* ARA 2002) concluded that the absence of tidewater goby in Lagunitas Creek was due to high summer salinities and the inability of the species to migrate upstream due to the gravel dam. Another reason for its decline may relate to the exponential increase in non-native fish with impoundment of warm, fresh waters behind the gravel dam, as non-native fish have been strongly implicated in the species' overall decline (Moyle 1976) *in* ARA 2002). This impoundment probably also negatively affected salmonids, who are sensitive to high water temperatures and predation by non-native species, as well as to obstacles that would limit either the upstream (winter) or downstream (spring, early summer) migration.

In 1997, the Giacominis stopped constructing the gravel dam by the SWRCB, which also mandated minimum instream flow requirements to ensure flow for fisheries. During the summer, freshwater flow rates at Samuel P. Taylor must equal at least 8 cfs, except during documented drought conditions, when they can drop to 6 cfs. During the winter, starting in November, freshwater flow must equal at least 20 cfs. Two years later, a San Francisco State University graduate student conducted some intensive monitoring during the summer and discovered a sharp decline in the number of non-native fish, with the only species present being yellowfin goby and American shad (*Alosa sapidissima*), neither of which is considered a warm water fish (Pearson 2000, ARA 2002). During 105 seining events between June and August 1999, Pearson (2000) recorded approximately 3,300 individuals and 17 species (ARA 2002). Marine fish species such as Pacific herring, topsmelt, surf smelt (*Hypomesus pretiosus*), and shiner perch (*Cymatogaster aggregata*) represented 89 percent of the total catch (Pearson 2000). Other marine species included northern anchovy, bay pipefish, prickly sculpin, and starry flounder (Pearson 2000). Resident estuarine fish species consisted of threespine stickleback, yellowfin and cheekspot (*Ilypnus gilberti*) goby, and staghorn sculpin (Pearson 2000). As with Bratovich et al. (1984), Pearson (2000) also reported capturing Tomales roach (*Lavinia symmetricus* ssp. 2; CSC) -- although in higher numbers than previously caught.

Based on surveys in 2002 and 2005, fish assemblages appear to differ seasonally, which is probably related to a number of factors, including freshwater inflow rates, salinity, and migration of species within Tomales Bay. Estuarine assemblages comprised of threespine stickleback, arrow goby, sculpin, and occasionally bay pipefish appear to dominate most reaches of the creek in the Project Area during low tide or water periods during spring, early summer, and late fall, when freshwater flows are highest. During high tides in these seasons, large schools of topsmelt move in, along with starry flounder (NPS, unpub. data). Starting in mid-summer through early fall, fish assemblages appear to shift to a more marine-dominated one. In August 2002 surveys, a few shiner surfperch were caught in addition to large numbers of topsmelt (ARA 2002). During 1999, the transition was even more dramatic, with surf smelt, bay pipefish, shiner surfperch, prickly sculpin, Pacific staghorn sculpin, and starry flounder only caught during the summer (Pearson 2000).

While coho and steelhead salmon do not spawn in the Project Area, they do migrate through this area when adults move to spawning grounds upstream during the winter and when juveniles move to Tomales Bay and eventually the Pacific Ocean in spring and summer. Adults and juveniles will use transitional zones of estuaries for foraging and refugia from predators, with some steelhead often spending up to a year in estuaries (Smith 1987). Pearson (2000) recorded coho salmon during spring and early summer sampling within the Project Area, while steelhead occurred during the entire monitoring period from April through August 1999. In June 2005, moderate numbers of juvenile steelhead and coho salmon were found upstream of White House Pool in fresh- to brackish sections of the creek, possibly utilizing some of the refugia provided by dense thicket of willows overhanging into creek waters (NPS, unpub. data). During this same period, large numbers of mysid shrimp -- one of the primary prey items for salmon whose numbers have dropped precipitously within the San Francisco Bay estuary -- were found in creek waters downstream of salmon occurrences and in other undiked marshes (NPS, unpub. data). These dense willows also provide potential habitat for California freshwater shrimp, but surveys in 2001 (Fong 2003) failed to find this species within the Project Area.

In March 2002, smolts of another salmon species, chinook (*Oncorhynchus tshawytscha*; FT), were found in the Project Area (ARA 2002). Chinook spawn in Lagunitas Creek and one of its tributaries, San Geronimo Creek, in lower numbers than coho or steelhead salmon (MMWD 2005). The largest runs of chinook salmon typically occur in the Sacramento-San Joaquin River system and large coastal streams from the Russian River north (ARA 2002). However, Marin Municipal Water District has consistently documented Chinook salmon during its 10 years of monitoring, with 2005 being one of the most successful years to date with 105 estimated chinook salmon (MMWD 2005). It is possible that chinook may have always spawned in small numbers in the Lagunitas Creek watershed: chinook fry were planted in Marin County streams in the late 1800s (ARA 2002). In addition to steelhead, coho, and chinook, there have been anecdotal reports of other anadromous species within this section or upstream sections of Lagunitas and Olema Creeks, including chum salmon (*Oncorhynchus keta*), white sturgeon (*Acipenser transmontanus*) and Pacific lamprey (*Lampetra tridentata*; FSC), as well as possibly green sturgeon (*Acipenser medirostris*; FT; ARA 2002, MMWD 2005). White sturgeon is not listed in California and does not spawn in Lagunitas Creek, but occasionally forages in Tomales Bay (ARA 2002). Green sturgeon, which was recently listed, is known to occur in Tomales Bay and "may also forage in Lagunitas Creek" (ARA 2002).

While removal of the summer dam and establishment of mandatory instream flow requirements has probably improved conditions for fisheries and aquatic organisms within Lagunitas Creek, the watershed and its resources are still affected by hydrologic alterations such as upstream dams. As described earlier, these dams greatly alter hydrogeomorphic processes, which can significantly impact resident and non-resident biota. Dams trap sediment that could be used downstream for spawning by salmon and alter geomorphic and sediment transport processes that could impact channel and stream structure and, consequently, habitat availability for salmon. In addition, dams change the structure of freshwater flows, typically decreasing the frequency and duration of instantaneous peak flows and increasing the duration of bankfull or ordinary high water flows, which are more erosive and damaging to habitat and possibly to stream biota, as well. As was mentioned earlier, research on the upper watershed of Lagunitas Creek has pointed to a possible "fining" or increase in the amount of fine sediment in the channel substrate, depletion in sediment recruitment directly downstream of the dams, and increase in the intensity and frequency of peak flows, all of which can affect habitat for aquatic organisms, including salmon (Stillwater Sciences 2004); B. Ketcham, Seashore, *pers. comm.*).

Reservoirs can have a dramatic impact on summer flows, as well. Salinity structure in downstream water bodies can be altered by drastically reducing freshwater inflow, prolonging the period and volume of freshwater inflow relative to natural conditions, or causing unnatural fluctuations -- particularly sharp fluctuations -- in freshwater inflow rates. Many organisms are extremely sensitive to changes in salinity, particularly abrupt changes, as they may not be physiologically tolerant of either increases or decreases in salt content of waters. Highly motile species can move in response to fluctuating salinity, although there may be a transitional period in which aquatic diversity is very low as species re-adjust to changed conditions. However, benthic organisms cannot respond as rapidly. High variation in salinity results in low benthic abundance and diversity (Kimmerer 2004), which is consistent with the general pattern of estuarine diversity, in which relatively few species can withstand the fluctuations between freshwater and brackish water (Remane 1971 *in* Kimmerer 2004). Even under stable salinity regimes, however, benthic species diversity is consistently lowest in low-salinity water (Markmann 1986; Nichols and M.M. Pamatmat 1988; Hymanson et al. 1994; Kimmerer 2004).

Lagunitas Creek's fish and invertebrate resources draw both birds and mammals to the Project Area. The open waters of Lagunitas Creek account for approximately 8 percent of all bird species using the Project Area during the winter and approximately one-third of all species during the autumn (ARA 2002). Most of these species are large waterbirds, including some special status ones such as American white pelican (*Pelecanus erythrorhynchos*; CSC), cormorant, heron, snowy and great egret, osprey, and belted kingfisher (ARA 2002). Only the kingfisher breeds on site (ARA 2002). During autumn, young green-backed herons (*Butorides virescens*) frequent the shoreline of Lagunitas Creek, where willows overhang (ARA 2002). Waterfowl using subtidal portions of Lagunitas Creek included canvasback, greater scaup, lesser scaup, common goldeneye (*Bucephala clangula*), bufflehead, wood duck (*Aix sponsa*), common merganser (*Mergus merganser*), and American coot (*Fulica americana*; ARA 2002). Shorebirds such as greater yellowlegs and spotted sandpiper (*Actitis macularia*) foraged on intertidal mudflats or creek edges at low tides (ARA 2002).

One of the habitat associations that drew some of the highest amount of breeding and autumn bird activity was the Forested and Scrub Shrub Riparian and ruderal Pasture-Grassland association in the Green Bridge

County Park (ARA 2002). Yellow warbler (*Dendroica petechia brewsteri*, CSC) breeds in this and near Inverness Park and is a common fall migrant through riparian corridor (ARA 2002).

As noted before, the southwestern river otter, whose numbers had once dwindled precipitously, low, appeared to have rebounded, at least within the southern portion of Tomales Bay. In addition to the burrow and signs of otter presence near the West Pasture's north levee, otter burrows have also observed near White House Pool (ARA 2002). Reputedly, even Pacific harbor seals (*Phoca vitulina richardsi*) have wandered on occasion up into the estuarine reaches of Lagunitas Creek, although none have been observed since baseline studies were initiated in 2001.

Special Status Fish and Wildlife Species

As of 2005, 63 special status taxa -- two invertebrates; seven fish, one amphibian, one reptile, 50 birds, and two mammal species -- either currently or historically occurred in the Project Area (ARA 2002, Stallcup and Kelly 2004, 2005). Of those 63, at least five federally endangered and two federally threatened have historically or recently been found in the Project Area – four bird species, two fish species, and one amphibian species. A list of special status species with potential to occur in the Project Area can be found in Appendix B.

California red-legged frog

The four federally endangered species observed during baseline studies or documented historically included the tidewater goby, central coast coho salmon, California clapper rail, California brown pelican (*Pelecanus occidentalis californicus*), and Least Bell's vireo (*Vireo bellii pusillus*; FE; SE). The California brown pelican irregularly visits the Project Area in small numbers, typically foraging along Lagunitas Creek shoreline (ARA 2002). As of 2003, the California clapper rail had occurred in four of the last six winters in the undiked tidal marsh north of the West Pasture, however, it has not been sighted since (ARA 2002, J. Evens, ARA, *pers. comm*.). The tidewater goby had not been sighted since 1953, when it was found in Tomasini Creek in 2002 (Fong 2003). Lagunitas Creek supports one of the largest remaining central coast coho salmon populations, and this species migrates through the Project Area during winter, spring, and early summer. One federally endangered species, California freshwater shrimp, was potentially documented as occurring in Lagunitas Creek within the Project Area in summer 1999 (Pearson 2000), but identification was never confirmed, and historic and recent surveys have only found the species on the section of Lagunitas Creek some distance upstream of the Project Area in more freshwater habitats near Shafter Bridge and on lower sections of Olema Creek (Fong 2003).

Federally threatened species in the Project Area include the California red-legged frog and central coast steelhead salmon. Some of the largest remaining populations of the federally threatened California red-legged frog (*Rana aurora draytonii*) occur on the Point Reyes peninsula and adjacent areas. This species was first found in the Giacomini Ranch during the Feasibility Study (PWA et al. 1993). Since 2001, surveys have documented small to moderate breeding populations in the freshwater marsh and Fish Hatchery Creek in the West Pasture (Fellers and Guscio 2002; G. Fellers and P. Kleeman, unpub. data). In addition, the frog occurs in the Olema Marsh (G. Fellers, *pers. comm*.). As with coho, Point Reyes and the Lagunitas Creek watershed represent another important stronghold for steelhead, which has been listed as threatened within the central coast ESU (Evolutionarily Significant Unit). Another federally threatened species, chinook salmon, is also present in the Project Area: this anadromous species spawns in the Lagunitas and San Geronimo Creek watersheds, although in much lower numbers than coho or chinook (MMWD 2005).

Two federally delisted species have been observed, the Aleutian Canada goose (*Branta canadensis leucopareia*) and the American peregrine falcon (*Falco peregrinus anatum*) – the latter is still designated a state-endangered species. The American peregrine falcon regularly forages over the Giacomini Ranch and adjacent undiked marshes, while the Aleutian Canada goose occasionally roosts in the northern portion of the West Pasture (ARA 2002). Green sturgeon, which has been reportedly several times in Lagunitas Creek during recent years, was recently listed as federally threatened, at least for populations spawning in the Sacramento River. Previously, the USFWS had designated federal Species of Concern (FSC), many of which were potential candidates for listing. This designation has been eliminated, but the regional office of USFWS in Sacramento has developed its own list of species of concern, designated in this report as SacFWSSC. The Project Area has supported or currently supports 16 of these species.

State-listed endangered and threatened species totaled at least six, many of which were also federally listed. State-endangered species included American peregrine falcon (FD), California brown pelican (FE), California clapper rail (FE), and Least Bell's vireo. Least Bell's vireo occasionally visit riparian corridor along the southern portion of Lagunitas Creek, but they do not nest here (ARA 2002). State-threatened species consisted of California black rail, bank swallow (*Riparia riparia),* and sandhill crane (*Grus canadensis tabida*). Potential breeding California black rail has been consistently present in undiked marsh north of Giacomini Ranch and, during surveys, in freshwater marsh in West Pasture (ARA 2002). Sandhill crane is a very rare visitor to the flooded pastures in the Giacomini Ranch, and bank swallows also represent rare transients to the Giacomini Ranch, especially in fall (ARA 2002). An additional 20 resident and non-resident taxa are on California's list of Special Concern Species, including the southwestern river otter, osprey, double-crested cormorant, American white pelican, northern harrier, yellow rail, and saltmarsh common yellowthroat (ARA 2002).

CDFG has initiated a process to determine and set conservation priorities for native birds by revising the initial California Bird Species of Special Concern (BSSC) document (Remsen 1978), which subjectively described declining or vulnerable species (PRBO Conservation Science 2006). The revision process, coupled with other recent efforts to develop and implement conservation strategies, led to expansion of the Bird Species of Special Concern concept to include ranking of special concern taxa for conservation priority using objective criteria. Also, the original BSSC list included only full species but the current draft list includes full species, subspecies, and identified populations. The Project Area supports approximately 21 BSSC species. The state has also developed rarity rankings, which is preceded by the letter "S," for wildlife, with rankings ranging from presumed extinct (SX) to secure, common and widespread (S5). Ten of the species have rarity rankings.

Listed below are more detailed descriptions of federally and state listed species that are either resident or commonly occurring in the Project Area.

Tidewater Goby (FE)

The tidewater goby is a small fish that occurs along the coast of California in coastal lagoons and the uppermost brackish areas of larger bays and estuaries (Swift 2003), including several lagoons and estuaries along the Marin-Sonoma coast. Until 2002, this species had not been sighted in the Tomales Bay watershed since 1953, when it was last documented in Lagunitas Creek. In 2002, fisheries surveys found tidewater goby in a leveed section of Tomasini Creek, a downstream tributary to Lagunitas Creek and southern Tomales Bay that runs along the eastern perimeter of the Giacomini Ranch. Since then, it has possibly been also found in a diked slough in the West Pasture in late 2005: the identification is still being confirmed (NPS, unpub. data).

Until 2002, the tidewater goby had not been sighted in the Tomales Bay watershed since 1953, when it was last documented in Lagunitas Creek.

The tidewater goby was listed as endangered in 1994 throughout its entire range. Critical habitat for this species was designated in 2000 and includes 10 coastal stream segments in Orange and San Diego Counties in southern California (65 FR 69693). The most important elements of coastal lagoons and estuary systems for support of goby are a natural hydrological regime, which results in sufficient streamflow, areas of shallow water as well as deep pockets of permanent water, sand and silt substrate, a variety of aquatic and emergent vegetation, and a diversity of prey species; and an environment free from exotic fishes (USFWS).

Tidewater gobies are mostly annual, but some fish may live into a second year (Swift 2003). Because gobies are small and not necessarily good swimmers compared to species such as salmon, their ability to disperse when conditions change or become adverse is poor, with recolonization occurring only if another population exists within about 6.2 miles or less (Swift 2003). Not surprisingly, recent genetic studies show that gene flow is restricted or lacking between groups of populations (Dawson et al. 2001; 2002). Because of this lack of gene flow, considerable genetic variation exists among populations in San Francisco Bay counties, including Marin (Barlow et al. 2001). Recent genetic analyses performed by Jacobs and Earl (Jacobs and Earl 2005) suggest that the Tomasini Creek population may be most closely related to those at three northern coastal marshes -- Estero de San Antonio, Estero Americano, and Salmon Creek – but that the Tomasini Creek population does appear to be genetically distinct and to have differentiated many hundreds, if not thousands, of years ago. Its life history also has implications for the stability of existing populations, with even relatively

persistent and large populations such as Rodeo Lagoon having sharp interannual fluctuations in numbers from seven gobies to 100 gobies per square meter within the span of a few years (D. Fong, GGNRA, unpub. data).

As noted earlier, tidewater goby establish either in the brackish reaches of coastal creeks or in permanently or seasonally impounded coastal lagoons with a sufficient freshwater inflow to create brackish conditions. According to the USFWS, goby prefers salinities of 12 ppt, but a wide range of salinities can be tolerated, with reproduction occurring in fresh water (<0.5 ppt) up to at least 25 ppt (Swift 2003). The species may even be able to survive for a few weeks in hypersaline conditions (45 ppt; Swift 2003). Within these systems, fish tend to prefer areas without strong flood scour. Within systems, fish will move up and down the creek with seasonal movement of the brackish water zone.

Some of the largest threats to tidewater goby populations include hydrologic alterations and non-native and native predators (Swift 2003). Artificial structures that constrict or eliminate the interface zone between tidal and freshwater reaches either impact or even eliminate tidewater gobies (Swift 2003). Non-native or introduced aquatic organisms can also negatively affect goby populations. Some of the documented freshwater and brackish water predators on goby include largemouth bass, green sunfish (*Lepomis cyanellus*), striped bass (*Morone saxatilis*), yellowfin goby, and shimofuri goby (*Tridentiger bifasciatus*; Swift 2003). Crayfish may disrupt nesting sites while digging for the eggs in the sand (Swift 2003). The native rainbow trout or steelhead, starry flounder, Pacific staghorn sculpin, and prickly sculpin have also been documented to feed on tidewater gobies in the lower Santa Ynez River and elsewhere (Swift 2003).

Within the Project Area, the species occurs in a section of Tomasini Creek that has been bermed to run against the base of Point Reyes Mesa until it drains into Tomales Bay. The creek supports both open water and vegetated sections. Most of the creek bottom is muddy or a combination of clay and silt (G. Kamman, KHE, *pers. comm*.). The flashboard dam and culvert structure is malfunctioning and allows modified two-way flow, such that the creek is influenced by the full upper range of high tides, but does not drain completely during low tides. This maintains permanent ponding or subtidal conditions within the creek, which may have become intertidal mudflat during low tides if it had been allowed to drain completely. The tidegate, along with natural "bar" features within the creek itself, may have created a "mini-lagoon" that benefits the goby, despite the fact that the substrate and flow conditions are probably not optimal. In addition, as noted earlier, it has also been possibly found in a diked slough in the West Pasture. This slough is not a fluvial or creek system such as Tomasini Creek, but rather appears to drain freshwater surface run-off from a seasonally flowing seep present on the Gradjanski property, as well as surface run-off from overbank flooding of the pasture by Fish Hatchery Creek. It receives tidal influence from Fish Hatchery Creek, which has muted tidal flows with lower amplitude than Tomasini Creek. As with Tomasini, substrate conditions are suboptimal, with the surface substrate being muddy or a combination of clay and silt. Acreage of existing tidewater goby habitat in the Giacomini Ranch totals 6.1 acres.

As with all of the creeks in the Project Area, Tomasini Creek becomes largely fresh to low brackish during the winter and early spring and well-mixed or partially stratified in the summer and fall, with advance of the "salt wedge" upstream starting in spring when freshwater flows begin to drop. By late fall, salinities near the Giacomini Hunt Lodge typically range between 15- to 23 ppt (NPS, unpub. data). While brackish conditions are maintained to some degree by Tomasini Creek, lower water salinities are sustained even during late summer and early fall when surface flows in the creek often dry up (NPS, unpub. data). Groundwater spring and seep flow from the Point Reyes Mesa appear to reduce salinities within the creek even when surface flows in Tomasini Creek cease, although some subsurface flow may persist. The strong influence of groundwater is attested by the large stand of willows that grows on the steep bluff of the Point Reyes Mesa directly to the west of the creek, as well as by hydrodynamic modeling results (KHE 2006a). Because of the seasonal nature of freshwater influence, salinities in the diked slough in the West Pasture, the West Pasture Old Slough, are typically higher than in Fish Hatchery Creek, although scouring flood flows during the winter are minimal to non-existent. Circulation patterns in this slough vary from well-mixed and brackish to saline (22.4 to 30 ppt) in the late summer and early fall to strongly stratified at times and fresh to brackish (0.2 to 24.7 ppt) in the winter through early summer. The hydrology of these areas is discussed in more detail under Water Resources.

In 2002, 12 tidewater gobies were caught in March (ARA 2002). Numbers remained fairly low in subsequent sampling conducted between 2002 and 2005, with 20 gobies caught in 2003, 22 in 2004, and six in 2005 (NPS, unpub. data). Five gobies identified as tidewater goby were found in the West Pasture Old Slough in November 2005 (NPS, unpub. data). In addition to goby, fish sampling revealed low to moderate numbers of some of the native predators of goby, including prickly sculpin, staghorn sculpin, and *Oncorhynchus mykiss* (steelhead or rainbow trout). Numerous crayfish have been observed in East Pasture drainage ditches, which

are separated from Tomasini Creek by the levee, and starry flounder occur in Lagunitas Creek directly downstream of the creek's mouth. Another potential predator could be bullfrog, which has been observed or heard in the creek in areas where the fish has frequently been caught.

In 2006, tidewater goby were also found in non-tidal portions of the East Pasture. During the December 2005 storm, these fish may have been washed into the East Pasture Old Slough from Tomasini Creek when the Tomasini Creek levee breached, or they may have entered the slough from the bay. During the storm, the entire northern portion of the East Pasture was flooded and connected through elevated surface waters with Lagunitas Creek and Tomales Bay. Tidewater goby have been found outside the mouth of Tomasini Creek. Lastly, these fish may have entered the East Pasture Old Slough Pond through the one-way tidegates if the tidegates were malfunctioning and allowing water in as well as out. During surveys, dead marine fish species were discovered in the pond, suggesting that gobies probably entered from the Lagunitas Creek side of the pond. The pond is bermed off from the rest of the East Pasture Old Slough, because the Giacominis once reputedly used this area for hunting. This pond consistently has brackish water salinities, probably because the tidegates leak. As with Tomasini Creek and the West Pasture Old Slough, substrate conditions are suboptimal, with the surface substrate being muddy or a combination of clay and silt.

California red-legged frog (FT)

The California red-legged frog is the largest native frog in the western United States (USFWS). It is one of two subspecies of the red-legged frog found on the Pacific coast; the other is the northern red-legged frog (*Rana aurora aurora*; USFWS). The California red-legged frog once ranged across much of California, including portions of the Sierra Nevada Mountain Range, where it is believed to be the title character of Mark Twain's famed short story, "The Celebrated Jumping Frog of Calaveras County" (USFWS). In 1865, when the story was written, red-legged frogs were the largest frogs in the state; bullfrogs were not introduced to California until 1896 (USFWS). The name of this species derives from its belly and hind legs, which are often red or salmon pink in adults (USFWS).

The California red-legged frog was federally listed as a threatened species in 1996. , 1996. It has been completely extirpated from the floor of the Central Valley (Fisher and Shaffer 1996) and is nearly gone in both the Sierra Nevada foothills and in the southern quarter of its range (Fellers and Guscio 2002). In a few parts of the central Coast Range, there are still large, vigorous populations, some of which probably rival what was present 200 years ago (Fellers and Guscio 2002). Several robust populations still exist in the San Francisco Bay area (especially Alameda and Contra Costa Counties) and in the coastal drainages from San Mateo County (just south of San Francisco) south to Santa Barbara County (Fellers and Guscio 2002).

Some of the largest remaining populations in California are at Point Reyes National Seashore (Marin County) where there are more than 120 breeding sites with a total adult population of several thousand frogs (Fellers and Guscio 2002). Most of the breeding sites are artificial stock ponds constructed on lands that have been grazed by cattle for 150 years (Fellers and Guscio 2002). Interannual variability in numbers for some of the most stable populations such as Cemetery Pond in Olema Valley totals less than 25 percent (G. Fellers and P. Kleeman, USGS, *pers. comm*.). Within some of these ponds or impounded estuaries, both adult and juvenile frogs have been found in areas that are moderately saline (B. Ketcham, Seashore, *pers. comm*.). Critical Habitat for this species was recently reproposed in November 2005 and includes two proposed Critical Habitat Units in Marin County, one which encompasses the entire Drakes Estero watershed and one which appears to incorporate the Chileno and Walker Creek valleys some distance northeast of the Project Area (USFWS 2005). The Project Area is currently included in neither proposed Critical Habitat Unit (USFWS 2005).

This species is threatened within its remaining range by a wide variety of human activities including urban encroachment, construction of reservoirs and water diversion, contaminants, agriculture, and livestock grazing (USFWS 2000). While bullfrogs have frequently been called a threat, or even a primary cause of the declines, there is almost no direct evidence that this is the case (Fellers and Guscio 2002), and it is at least as likely that non-native fish (e.g., striped bass, green sunfish, catfish, mosquitofish) play a significant role in the decline of native ranid frogs (Hayes and Jennings 1986).

Red-legged frogs require aquatic habitat for breeding, but also use a variety of other habitat types, including riparian and grasslands and other upland areas (USFWS; G. Fellers, USGS, *pers. comm*.). Adults often utilize dense, shrubby or emergent vegetation closely associated with deep-water pools that pond for at least six months (~ December through June) with fringes of cattails and dense stands of overhanging vegetation such as willows as breeding and rearing habitat (USFWS). During the summer months, frogs will often move out of

breeding habitat into adjacent riparian areas (Fellers and Guscio 2002). Salinity can influence suitability of habitat for red-legged frogs (Fellers and Guscio 2002). Published tolerance criteria indicate that larvae and adults can tolerate salinity levels as high as 7.0 ppt, while eggs require salinities of less than 4.5 ppt (Jennings and Hayes 1989). However, anecdotal information from the Seashore and other areas along the coast suggest that frog populations, including egg masses and tadpoles, can persist in areas with higher average salinities, possibly because frogs are using pockets or lens of freshwater in otherwise saline environments.

Historical records of red-legged frogs suggest that red-legged frogs have been present in the vicinity of the Giacomini Ranch since 1922 (Fellers and Guscio 2002). The species was first observed on the Giacomini Ranch during baseline wildlife surveys conducted during 1993 (PWA et al. 1993). A few individuals were observed in a drainage ditch in the East Pasture (PWA et al. 1993). Surveys conducted in the fall, winter, and spring of 2001-2002 showed that, while a few frogs were found in most areas, the main concentration was in the freshwater marsh in the West Pasture adjacent to Fish Hatchery Creek and, to a lesser extent, in Fish Hatchery Creek itself (Fellers and Guscio 2002). Acreage of the West Pasture freshwater marsh totaled 7.2 acres, all of which is potential red-legged frog breeding habitat. Another approximately 1.0 acre of breeding habitat occurs in portions of Fish Hatchery Creek. In 2001-2002, 21 adult frogs were detected in the freshwater marsh, and 18 adult frogs, in Fish Hatchery Creek (Fellers and Guscio 2002; Table 18). Based on the number of egg masses observed, Fellers and Guscio (2002) estimated the total number of adult frogs during that season in the West Pasture at 90-100 individuals In the East Pasture, adult red-legged frogs were sparsely distributed and unlikely to breed (Fellers and Guscio 2002). A total of six sightings occurred in the East Pasture, and no eggs or tadpoles were observed (Fellers and Guscio 2002). During the summer, frogs moved out of the freshwater marsh, possibly into the riparian corridor along Sir Francis Drake Boulevard or across the street (Fellers and Guscio 2002), although it is possible that the frogs are also using the extensive pastures within the Giacomini Ranch (G. Fellers, USGS, pers. comm.).

The following winter, culverts on Fish Hatchery Creek at the north levee collapsed, allowing more tidal inflow into the West Pasture and the freshwater marsh. The culverts were repaired in fall 2003, reducing tidal inflow, but only a few adults and no egg masses or tadpoles were observed in the West Pasture freshwater marsh and Fish Hatchery Creek during the 2003-2004 season (G. Fellers, USGS, *pers. comm*.). Since then, frog numbers have increased slightly, but not to 2001-2002 levels (Table 18). In 2004-2005, approximately 10 adult red legged frogs were detected, but no egg masses were observed (G. Fellers and P. Kleeman, USGS, unpub. data). In January 2006, a survey following the second largest recorded storm in history found 12 adult frogs and 15 egg masses (G. Fellers and P. Kleeman, USGS, *pers. comm*.).

As was discussed under Water Resources, salinity intrusion into the West Pasture currently appears to be controlled by extreme high tide events and long residence time during winter months, not by evapotranspiration during the summer months, as might be expected. Extreme high tides in Tomales Bay exceeding approximately 6.2 ft NAVD88 cause water levels within the muted tidal West Pasture to increase to 5.25 ft NAVD88, the uppermost part of the tidal range in the pasture, which then allows tidal waters to overbank flood and flow into the central and lowest elevations portions of the freshwater marsh. The southern half of the marsh does not appear to be affected by salinity intrusion, perhaps because of high perennial freshwater inflow from the 1906 Drainage and because elevations are higher. Interestingly, despite the availability of suitable habitat in the southern portion of the marsh, most of the frogs detected are in the central portion of the marsh (P. Kleeman, USGS, *pers. comm*.), which suggests either that breeding attempts ultimately may not be successful or that the frogs are somehow find pockets or lens of freshwater that enable egg masses and tadpoles to persist successfully. Bullfrogs and bullfrog tadpoles were observed in certain portions of the East Pasture, but not in the West Pasture until 2006, when at least one bullfrog was heard calling in the West Pasture freshwater marsh (P. Kleeman, USGS, *pers. comm*.). In the West Pasture, black-crowned night herons might be one of the potential red-legged frog predators (Fellers and Guscio 2002).

Red-legged frog adults and tadpoles also occur in what is believed to be low to moderate numbers at Olema Marsh, particularly along its western perimeter where there are sizeable small drainage and seep influences (G. Fellers, USGS, *pers. comm*.). However, the exact size of this population is unknown (G. Fellers, USGS, *pers. comm*.). There are significant numbers of bullfrogs (G. Fellers, USGS, *pers. comm*.). Acreage of breeding red-legged frog habitat totaled 39.8 acres, which represents the entire marshy portion of Olema Marsh. The adjacent riparian area provides potential over-summering habitat for red-legged frog, but the grasslands to the east along the shutter ridge may be too dry.

TABLE 18. CALIFORNIA RED-LEGGED FROG BREEDING IN WEST PASTURE FRESHWATER MARSH AND ADJACENT FISH HATCHERY CREEK

Year	Adults	Egg masses	Minimum adults present
2001-2002	18	45	90
2002-2003	No night or egg mass surveys during breeding season		
2003-2004	4	-	4
2004-2005	10	-	10
2005-2006	12	15	30

Central California coast coho salmon (FE), central California steelhead (FT), and coastal California chinook salmon (FT)

Central California coast Coho, Central California coastal steelhead, and southern Oregon/California coastal chinook salmon occur in several creeks on the Point Reyes peninsula and in the Lagunitas Creek watershed that drains portions of the Seashore and GGNRA, as well as MMWD, state park, and private lands. Chinook salmon have been documented primarily in the Lagunitas Creek-San Geronimo Creek watersheds (MMWD 2005).

Central California coast coho salmon was first listed as a threatened species in 1996, although it was reclassified in August 2005 as endangered. Its ESU includes all naturally spawned populations of coho salmon from Punta Gorda in northern California south to and including the San Lorenzo River in central California, as well as populations in tributaries to San Francisco Bay. Critical habitat for this species was designated in 1999 and includes all river reaches accessible to listed coho salmon from Punta Gorda in northern California south to the San Lorenzo River in central California. Designated critical habitat for coho in the Seashore includes all accessible estuarine and stream areas in the coastal watersheds of Marin County except areas above longstanding, naturally impassable barriers or above Peters Dam on the mainstem of Lagunitas Creek and Seeger Dam on Nicasio Creek (NOAA-Fisheries 1996).

Steelhead was listed as a threatened species in 1997. The steelhead ESU includes all naturally spawned populations of steelhead (and their progeny) in California streams from the Russian River to Aptos Creek, and drainages of San Francisco and San Pablo. Critical Habitat for the federally threatened central coast steelhead salmon population went into effect in January 2006 and is designated to include all river reaches and estuarine areas accessible to listed steelhead in coastal river basins from the Russian River to Aptos Creek, California (inclusive), and the drainages of San Francisco and San Pablo Bays. In Tomales and Drakes Bays, Critical Habitat does not include areas upstream of Peters Dam, Seeger Dam, and Soulajule Dam.

California coastal chinook salmon was initially listed in 1999 as federally threatened and was redesignated in August 2005. Critical habitat for this species also became effective in January 2006 and includes many watersheds on the northern California coastline extending down to the Russian River watershed, but not as far south as Tomales Bay. Chinook salmon that spawn in the Tomales Bay watershed are believed to be strays from the Russian River population (B. Ketcham, Seashore, pers. comm.), although chinook fry have historically been planted in the Lagunitas Creek watershed, as well (ARA 2002).

Coho, steelhead, and chinook salmon are anadromous fish species. Anadromous species spend a portion of their life cycle in marine waters and a portion, specifically spawning and rearing, in fresh waters. There are differences between steelhead, coho, and chinook salmon life cycles. While virtually all coho in western Marin County watersheds have an 18-month freshwater life cycle, steelhead juveniles may migrate to the ocean after 18 months or extend freshwater residence for up to three years. Most coho return to spawn after 18 months, but steelhead may spend several years in the ocean before returning to spawn. Additionally, steelhead may make several spawning migrations while all coho spawn once and die. Most juvenile chinook along the California coast migrate out to sea within the first year of their life (i.e. "ocean-type" chinook) and spend three years in the open ocean (Nielsen Monterey Marine Sanctuary website). Some chinook, however, spend more than one year in freshwater bays or estuaries before moving into the ocean environment (Healey 1991) *in* (Nielsen) website).

Coho salmon and steelhead use the upper portions of coastal creek watersheds for spawning and rearing. Coho salmon tend to prefer relatively low-gradient systems with larger watersheds. Chinook salmon will spawn in either mainstem portions of rivers and creeks or tributaries.
All species spawn in gravelly portions of streams where particle-size distribution enables eggs that are laid to remain adequately oxygenated. From anywhere from one to three years later, the juveniles migrate downstream into the lower estuarine areas where they remain for a period of time, foraging and adjusting to the saltwater before migrating into the open ocean. Spawning adults also spend some time in downstream or estuarine reaches of creeks, while they wait for the appropriate flow conditions in associated tributaries.

Lagunitas Creek watershed, including Olema Creek, was believed to support 10 percent of the remaining coho population.

Most historic information on salmonid numbers in the Tomales Bay watershed is anecdotal. These historic accounts suggest that salmonids were abundant in the Tomales Bay watershed before extensive alteration by dam construction, logging, and stream channelization and that runs were sizeable enough to support a fishery in the bay at the end of the 1800's. Local residents recounted stories of "salmon runs" and "excellent trout fishing" along Lagunitas and Olema Creeks, which actually may refer to young steelhead, often indistinguishable from rainbow trout during the three-year period they typically spend in fresh water. Interviews with long time residents and fisheries managers suggest that coho and steelhead in the Point Reyes area have been declining since the turn of the 20th century, with significant declines occurring as late as the mid-1950's. At the time listing was being considered for coho, steelhead, and chinook salmon, the Lagunitas Creek watershed, including Olema Creek, was believed to support 10 percent of the remaining coho population (Brown et al. 1994; NOAA-Fisheries 1996).

For most drainages, only data on coho salmon abundance have been gathered. Watershed monitoring efforts have documented a general trend in increased juvenile coho salmon in Lagunitas Creek and other Tomales Bay and coastal Marin drainages, although there have been years with fewer fish such as 1998-2000 and 2002-2003 (Seashore*, in prep.*; MMWD 2006). In Lagunitas Creek, juvenile coho numbers have ranged between approximately 4,500 in 2004 and 8,500 in 2005 since 2001, with numbers generally increasing (MMWD 2006). Juvenile surveys for 11 years have resulted in estimates of 4,818 ± 2,850(SD) per year and 27,091 ± 7,169 (SD) for steelhead (MMWD 2006). In Olema Creek, one of the largest tributaries to Lagunitas Creek, juvenile coho numbers have ranged between approximately 3 fish per square meter in 1998-1999 and approximately 50 fish per square meter in 2001-2002 (Seashore, *in prep.*). Spawner surveys for 10 years have resulted in estimates of 251 ± 117 (SD) coho redds per year in the Lagunitas Creek watershed (MMWD 2005). Coho spawning on the mainstem takes place largely in Samuel P. Taylor State Park, upstream of Seashore- and GGNRA-administered lands (Trihey & Associates 1994; 1996; 1997). Coho numbers appear to be strongly affected by changed ocean productivity patterns associated with the Pacific Decadal Oscillation, which shifted from the Alaska Current to the California Current in the late 1990s (Seashore, *in prep.*).

The presence of anadromous species such as steelhead and coho salmon in the southern portion of Tomales Bay is typically restricted to adults that are migrating into the upper watersheds for spawning and outmigrating smolts. Most of these species are moving through Lagunitas Creek on their way up or out of the upper portions of the Lagunitas and Olema watersheds. The Project Area, then, provides primarily transitional habitat for salmonids currently that are either migrating upstream to spawn or outmigrating to the estuary and, eventually, the ocean. Many salmonids in other systems use estuaries for rearing for an extended period before migrating to sea (Reimers 1973; Simenstad et al. 1982)and estuarine marsh channels are used by some salmonids as nursery habitats (Levy and Northcote 1982; Simenstad et al. 1982). Research conducted by fisheries scientists in the Skagit delta and elsewhere shows that estuarine habitat is extremely important in the life cycle of wild chinook salmon (Aitkin 1998), although its importance for coho salmon appears to be more geographically and temporally variable(Magnusson and Hilborn 2003; Miller and Sadro 2003). In some northern and central California systems that close annually due to decreased freshwater flow and migrating sandbars, fall runs of chinook salmon are literally forced to rear in estuaries during the summer until fall rains reopen the mouth (Busby and Barnhart 1995).

Whether for a few days or a few months, most anadromous fish use the heavily vegetated side channels and blind (dead-end) sloughs of a healthy estuary to escape predators and acclimate to salt water (Simenstad et al. 1982). When estuaries are leveed, juveniles are forced into main channels where water is deep, currents are strong, food is scarce, and predators can easily find them. Use of marshes in Tomales Bay has not been as well studied, and construction of levees and tidegates within the Project Area preclude use of the Giacomini Ranch East Pasture and may restrict the amount of use in muted tidal areas. A list of the infrastructure and

management practices that negatively affect both the opportunity for salmonid passage and rearing/refugia and capacity to support salmonids, even if opportunity exists, can be found in Table 7 under Water Resources. Dams, culverts, tidegates, and flashboard dam structures eliminate or restrict the opportunity for salmonids to move upstream to spawning areas, while levees, floodplain development, channel excavation, and channelization activities restrict opportunity for development of off-channel refugia such as secondary channels that can be used by fish during spawning or outmigration in both upstream and downstream reaches. Even if opportunity exists, the capacity of these systems to support salmonids can be negatively affected by trapping of sediment by dams, water diversions, pollutant discharges to creeks, increases in turbidity associated with channel excavation, and other factors that affect the potential for salmon to thrive. One measure that has been developed to assess the potential for an estuarine system to provide refugia and foraging opportunities for salmon is total aquatic edge or the linear perimeter of creek provided by a wetland. Currently, approximately 14.9 miles of aquatic edge would appear to be available to salmonids for foraging, refugia, and other uses in the Project Area.

The presence of the red-legged frog restricted the ability to conduct electrofishing surveys for federally endangered and threatened salmonids during baseline wildlife surveys, but O*ncorhynchus mykiss* juveniles – presumed to be steelhead -- have been observed on Fish Hatchery Creek and Tomasini Creek on several occasions (ARA 2002, NPS, unpub. data). Both Fish Hatchery and Tomasini Creeks reputedly had historic runs of steelhead. Populations of coho salmon are unlikely to have occurred in at least Fish Hatchery Creek, because of the small size of the watershed and the high stream gradient (B. Ketcham, Seashore, *pers comm*.). The lower portion of the watershed that falls within the Giacomini Ranch does not provide appropriate spawning habitat conditions (i.e., no riffle/pool complexes with appropriately sized gravel in riffles, etc.).

A few coho juveniles were found in Tomasini Creek in summer 2005 (NPS, unpub. data), although long-term sustainability of any spawning population is uncertain due to the sharp drawdown of water in the creek that occurs most summers. Information on anadromous species runs in Bear Valley Creek is also poor, but smolt trapping by the Seashore upstream of Olema Marsh in 1999 netted 21 steelhead – five of which were classified as pre-smolts (Ketcham, *in prep.*). Coho salmon have not been observed, at least in recent times, in the Bear Valley Creek watershed (B. Ketcham, Seashore, *pers. comm*.).

In addition to these smaller tributaries, steelhead and coho juveniles also occurred in the mainstem of Lagunitas Creek during summer surveys in 1999 and 2005 (Pearson 2000); NPS, unpub. data): these are probably juveniles and smolts that are outmigrating to Tomales Bay and the Pacific Ocean. Chinook salmon have not been documented in the Project Area, although they must migrate through the Project Area on their way to spawn in the upper reaches of Lagunitas Creek and San Geronimo Creek.

California black rail (ST)

The California black rail is listed as threatened under the California ESA. Black rails primarily use tidal salt marsh habitat, but they are also observed in freshwater marsh (Grinnell and Miller 1944; Manolis 1978; Evens and Page 1986; Evens et al. 1991; Aigner et al. 1995).

The species' range is currently confined to the northern San Francisco Bay Estuary, with small, isolated populations along the outer coast in Tomales Bay, Bolinas Lagoon, Morro Bay, and Bodega Bay (Manolis 1978, Evens et al. 1991); in the Sacramento Valley and foothills (Aigner et al. 1995); and in the Colorado River basin (Evens et al. 1991). However, these locations outside the San Francisco Bay are believed to support less than 10 percent of the total population, and, because of fragmentation and small sizes of these populations, they are susceptible to stochastic extinctions (Evens et al. 1991).

Former breeding populations in Central and South San Francisco Bay and the coastal marshes of southern California are apparently extirpated (ARA 2002). The historic and ongoing pressures of agriculture, salt production, and urbanization has reduced tidal marshlands of San Francisco Bay by an estimated 85 percent (Goals Project 1999), and there has been a concomitant reduction in Black Rail populations supported by that habitat (Evens et al. 1991). Early in the 20th century, black rails were apparently very common in the tidal marshes of Tomales Bay near Point Reyes Station (Grinnell and Miller 1944). This population suffered habitat loss and undoubtedly a great reduction in numbers following diking and draining of these marshlands in the mid-1940s with the development of the Giacomini Ranch (ARA 2002).

As of 1994, the undiked marsh north of the Giacomini Ranch appeared to support a breeding population of at least seven pairs of California black rails (Evens and Page 1986; Evens and Nur 2002). Breeding individuals have also been detected in intermittent years at Olema and Bear Valley Marshes, immediately south of the Giacomini Ranch (ARA 2002). During baseline surveys, black rails were detected in the Giacomini Ranch and in Olema Marsh (ARA 2002). Territorial black rails were calling on territories in May-June 2002 and were assumed breeding in the West Pasture freshwater marsh (ARA 2002). Small numbers (1-2 individuals) also occurred within the Project Area in brackish and freshwater marsh (ARA 2002). There is no recent information since 2001-2002 on the number of breeding pairs, although it is possible that numbers have decreased (J. Evens, ARA, *pers. comm.).* Isolated satellite populations such as Tomales Bay would be expected to have high variability – perhaps as much as 50 percent variance – in annual numbers of rails (J. Evens, ARA, pers. comm.). Some of these populations may function as meta-populations such that a local sub-population may go extinct some years, only to be re-colonized in subsequent years by strays from San Francisco Bay (J. Evens, ARA, *pers. comm*.). The high rate of predation that occurs in the Tomales Bay population likely exacerbates the meta-population effect.

Within the San Francisco Bay region, black rails tend to occur in larger undiked marshes associated with larger rivers and in some bayshore parcels, particularly those associated with the mouths of rivers of creeks (Evens et al. 1989). A single pair of rails can occupy and breed in marshes as small as 1.2 acres, however their ability to persist and to sustain a population would be reduced in such a small area and would be dependent on contiguity to other habitat (J. Evens, ARA, *pers. comm*.). A significant positive relationship exists between marsh size and both presence and density of rails (J. Evens, ARA, *pers. comm*.). In a large, productive marsh, black rail territories may be small, i.e. < 1.2 acres. There is no information on breeding territory size for black rails in Tomales Bay, but a recent San Francisco Bay-wide study assessed average territory size for a number of marshes (Herzog et al. 2004) . Mean number of breeding birds in San Francisco Bay marshes averages 0.11 individuals per acre, although variation in the mean number of breeding birds per hectare in marshes was fairly high, ranging from 0.02 to 0.26 individuals per acre (Herzog et al. 2004).

Unlike clapper rails, black rails both forage and nest in the mid- to high marsh plain, well above the low marsh and intertidal mudflats favored by clapper rails. Relationships between black rail presence and habitat variables in San Francisco Bay include vegetation height, presence of alkali heath (an indicator of high elevation marsh habitat), and absence of amphipods (indicators of lower elevation marsh). The condition of transitional vegetation along the upland edge adjacent to marshes is also a factor in habitat suitability for rails (Evens and Page 1986). Other variables that help explain the patchy distribution of black rails in tidal marshes of the San Francisco Bay region are patch size, patch distribution (contiguity), patch configuration (linear vs. broad), predator populations, hydrological cycles, and fluctuations in water level (Evens et al. 1989; Evens et al. 1991; Flores and Eddleman 1993). During higher high tides, black rails move to higher elevations in marshes or adjacent upland areas to escape floodwaters, because rails are poor fliers and unable to fly long distances. To minimize predation pressure, high tide refugia habitat needs to be above the higher high tide water levels and well-vegetated with at least medium-sized plants to provide cover from predators that use high tides as an opportunity to prey on rails (J. Evens, ARA, *pers. comm*.). Black rail habitat in the Project Area and adjacent undiked marsh to the north of the Giacomini Ranch currently totals 120 acres, with approximately 39 acres of refugia habitat, some of which is the Giacomini Ranch levees. Within the immediate Project Area, black rail habitat totals approximately 59.3 acres with 32.4 acres of high tide refugia. While the levees are well above most of the higher high tides, they are often poorly vegetated due to trampling from cattle and people and are subject to disturbance pressures from people seeking to view the rails who may inadvertently flush them into the open where they are vulnerable to predation.

California clapper rail (FE, SE)

The California clapper rail is one of the largest rails (family Rallidae), measuring 13-19 inches from bill to tail (USFWS). The California clapper rail was designated as Endangered throughout its entire range in 1970 (35 FR 16047). A joint Salt Marsh Harvest Mouse and California Clapper Rail Recovery Plan was published in 1984, and both species will be included in the Tidal Marsh Ecosystem Recovery Plan, currently under review (USFWS). No Critical Habitat has been designated for this species. The California clapper rail is also designated as Endangered by the state, along with two other subspecies (*levipes* and *yumanensis*) that do not occur locally (CDFG 2005).

Although once more widely distributed along the California coast, present distribution is restricted almost exclusively to the emergent salt and brackish tidal marshes of San Francisco Bay and the Suisun Delta (ARA 2002). Recent records from coastal estuaries outside of San Francisco Bay are sporadic and represent

presumed dispersants or vagrants (ARA 2002). The constriction of the clapper rail's range appears to have resulted from numerous factors, including diking or development of habitat, freshwater habitat conversion, habitat fragmentation, lack of high-tide refugia, mercury accumulation in eggs, and increase in predators such as the non-native red fox and Norway rat (*Rattus norvegicus;* USFWS).

Throughout their distribution, California clapper rails occur within a range of salt and brackish marshes. Clapper rails have rarely been recorded in non-tidal marsh areas (USFWS). In south and central San Francisco Bay and along the perimeter of San Pablo Bay, rails typically inhabit salt marshes dominated by pickleweed and Pacific cordgrass (USFWS). In the north Bay (Petaluma Marsh, Napa-Sonoma marshes, Suisun Marsh), clapper rails also live in tidal brackish marshes which vary significantly in vegetation structure and composition (USFWS). Use of brackish marshes by clapper rails is largely restricted to major sloughs and rivers of San Pablo Bay and Suisun Marsh, and along Coyote Creek in south San Francisco Bay (USFWS). As with black rails, marsh size is positively correlated with the presence and density of clapper rails: research has shown that approximately 250-acre marshes are needed to support optimal densities, but smaller marshes (~2.5 – 5 acre minimum) will support clapper rails, especially when adjacent to larger marshes (J. Evens, ARA, *pers. comm*.). Clapper rails tend to prefer marshes with an intricate, dendritic slough network composed of very small or fourth order creek channels (ARA 2002). Low marsh areas with sparse vegetation, mudflats, and tidal sloughs are important foraging areas for rails (ARA 2002). Higher marsh areas with dense vegetation are used for nesting and high-tide refugia (Albertson and Evens 2000).

In the early 1900s, when tidal marshes were more extensive, clapper rails were reported as occurring in Tomales Bay (Grinnell and Miller 1944). In 1980, one bird was heard in the portion of the East Pasture adjacent to Tomasini Creek (J. Evens, unpub. field notes). Since then, the species has been largely absent, although individuals were sighted for years in the undiked marsh north of the Giacomini Ranch during fall and winter between 1995 and 2001 (J. Evens, R. Stallcup, unpub. field notes). There are no recent breeding records, however. Except for the "intermittent presence of wandering or wintering birds," the population of clapper rails in Tomales Bay appears to be extirpated (ARA 2002), despite the fact that the northern portion of the Project Area and the adjacent undiked marsh offer at least 116.8 acres of foraging and nesting habitat, in addition to the 39 acres of high tide refugia.

California freshwater shrimp (FE)

The California freshwater shrimp was listed by the USFWS as endangered (55 FR 43884) in 1988. This species is the only extant member of the genus (Fong 2003).

The shrimp is found in low elevation (<116 m), low-gradient (generally <1 percent slope) perennial freshwater streams where banks are structurally diverse with undercut banks, exposed roots, overhanging woody debris, or overhanging vegetation (Fong 2003). As its name would suggest, California freshwater shrimp is believed to occur only in freshwater conditions (<0.5 ppt) within streams in the watershed, although it may be able to temporarily tolerate increases in salinity of up 16 to 17 ppt (USFWS 1998).

The shrimp is endemic to 17 coastal streams in Marin, Sonoma, and Napa counties north of San Francisco Bay, California (Fong 2003). Within the Seashore and GGNRA, the shrimp is found exclusively within the Lagunitas Creek watershed. It has also been found in Walker Creek in Tomales Bay (Serpa 1992). The shrimp was first observed and collected in Lagunitas Creek in 1877 (Hedgpeth 1975). The current, known range of the shrimp within Lagunitas Creek extends from Shafter Bridge in Samuel P. Taylor Park to roughly 1 mile below the confluence with Nicasio Creek (Hedgpeth 1975; Serpa 1991). Near the Project Area, the shrimp has been found in lower Olema Creek (Fong 1999).

As part of baseline surveys for the proposed project, habitats were surveyed using a qualitative ranking system developed by Serpa (1996) to evaluate habitat suitability of streams for shrimp. This system evaluates features known to be important to shrimp such as water depth, presence or absence of undercut banks, etc (Fong 2003). All surveyed habitats within the project area were generally rated as either "fair" or "poor" sites for shrimp, and no California freshwater shrimp were captured during surveys in September 2001 (Fong 2003). Many of the required habitat components were either absent or not available on a consistent basis (Fong 2003). The presence of the introduced mosquitofish in the ditches and creeks in the Giacomini Ranch pastures likely precludes the presence of freshwater shrimp.

In Lagunitas Creek itself, operation of the gravel summer dam for more than 50 years would seemingly have increased the amount of habitat for shrimp, as dam impounded freshwater for more than 1 mile upstream of

the Green Bridge. However, the warm temperatures within the "pool" attracted a significant number of non-native fish (Bratovich and Kelley 1988) that may have preyed upon freshwater shrimp, thereby decreasing the quality of the habitat (Pearson 2000).

Two years after the dam was permanently removed, Pearson (2000) reported finding three individuals of California freshwater shrimp during surveys between April and August 1999 in "freshwater" conditions, with two individuals found near the location of the old summer dam underneath overhanging riparian trees. However, it is unclear from the report whether identification of these individuals was positively confirmed, and not much information was included in the report as to exactly when the individuals were caught. Fong (2003) and subsequent surveys (NPS, unpub. data) have repeatedly found non-native brackish water or Korean shrimp (*Palaeomon macrodactylus*) in Lagunitas Creek upstream of White House Pool near the old summer dam location.

Threats to existing populations of freshwater shrimp include "introduced fish, deterioration and loss of habitat resulting from water diversion, impoundments, livestock and dairy activities, agricultural activities and developments, flood control activities, gravel mining, timber harvesting, migration barriers, and water pollution" (USFWS 1998). All of these threats have historically occurred along Lagunitas and Olema Creeks.

California brown pelican (FE)

California brown pelican was listed as federally Endangered in 1970. It commonly occurs on local estuaries and nearshore waters as a non-breeding visitor, particularly during summer and fall, with several hundred individuals sometimes present in Tomales Bay (ARA 2002). Winter numbers in Tomales Bay are lower, ranging as high as 56 (Kelly and Tappen 1998). It irregularly visits the Project Area in low numbers, most commonly in the fall when it forages on the shoreline of Lagunitas Creek near its mouth (ARA 2002).

Least bell's vireo (FE, SE)

The Least Bell's vireo was once widespread throughout California, but its numbers have declined precipitously. It inhabits riparian woodlands with tall trees and shorter thick shrubs. In 1980, the state of California listed this species as endangered, and in 1986, the USFWS followed suit. At one point, the vireo was known to breed from interior northern California near Red Bluff in Tehama County south through the Sacramento and San Joaquin valleys and Sierra Nevada foothills and in the coastal ranges from Santa Clara County south to the approximate vicinity of San Fernando in Baja California. Currently, its breeding range is in Southern California, with large populations in Riverside and San Diego counties and smaller populations in Santa Barbara, Ventura, and San Diego counties and in northern Baja California. In early 1994, USFWS designated about 38,000 acres at 10 localities in portions of six counties in Southern California as "critical habitat." The vireo is threatened by loss and degradation of its habitat through human and human-induced activities and by nest parasitism of the brown-headed cowbird (*Molothus ater*). Adverse impacts to vireo habitat result from clearing and other impacts to riparian habitat. This species occurs as an extremely rare vagrant in riparian corridor along southern end of Lagunitas Creek (ARA 2002).

Green sturgeon (FT)

In April 2005, the National Marine Fisheries Service, which oversees recovery of marine and anadramous fish under ESA, listed the southern San Francisco-Sacramento River population of green sturgeon as federally threatened. The northern population, which extends from the Klamath River to the Columbia River estuary, was not included.

Sturgeon is the largest and possibly the oldest fish found in freshwater (ARA 2002). Green sturgeon can reach 7.5 feet in length and weigh up to 350 pounds (ARA 2002). This large anadromous fish ranges from Alaska to Mexico in marine waters and feeds in estuaries and bays from San Francisco Bay to British Columbia (ARA 2002). It spawns in fresh water in the mainstem of large rivers, with the only remaining spawning populations being in the Sacramento and Klamath River basins in California and possibly in the Rogue River in Oregon (ARA 2002). Sturgeons in general are highly vulnerable to habitat alteration such as damming, diversion, and pollution and activities such as over-fishing because of their specialized habitat requirements, the long time it takes them to reach breeding maturity, and their sporadic reproductive success (ARA 2002).

Green sturgeon is recorded from Tomales Bay (Blunt 1980; TBA 1995) and may enter Lagunitas Creek to forage, as do white sturgeon (ARA 2002).

American peregrine falcon (SE, FD)

One of the most widely distributed of warm-blooded terrestrial vertebrates, the peregrine falcon occurs in an amazing diversity of habitats all over the world, which lends credence to its name, which means "wanderer" (White et al. 2002). The peregrine was a cause célèbre of the environmental awakening of the 1970s (White et al. 2002). Although it was thought to be a globally declining and endangered species, numbers were later found to be greater than originally thought, although it was greatly harmed by the widespread use of persistent chemicals such as DDT that lowered reproduction and survival rates (White et al. 2002). By 1970, the peregrine was federally protected in the United States, and peregrines have since made a strong recovery (White et al. 2002).

During the past 20 years, the peregrine falcon population in San Francisco Bay has increased ten-fold, with 10-20 birds in the estuary (SFEP 2004). While the population is increasing, success of reproduction efforts is questionable (SFEP 2004). One factor that has increased this species' popularity is its propensity to nest in very urbanized areas. San Francisco Bay Area has seen the appearance of urban peregrines on a small scale, with birds nesting on or frequenting the Bay Bridge, buildings in downtown San Francisco, and the Golden Gate Bridge (Bell 1994). In Tomales Bay, the peregrine falcon may potentially breed in the Seashore. It has been regularly observed foraging over the Giacomini Ranch and the undiked marsh to the north (ARA 2002).

Sandhill crane (ST)

The sandhill crane is one of only 15 species of cranes in the world and is one of just two crane species native to North America. They are also the oldest living species of bird, with fossils dating back over 6 million years (Save the Bay 2005). One subspecies of crane that spends the winter in California's Central Valley is the greater sandhill crane (Save the Bay 2005). At approximately five feet tall, the greater sandhill crane is one of the tallest birds in the world (Save the Bay 2005). Listed by state as threatened, the survival of the greater sandhill crane is imperiled by habitat loss and degradation (Save the Bay 2005). Within Tomales Bay, sandhill cranes are very rare visitors to wet pastures on the Giacomini Ranch (ARA 2002).

Bank swallow (ST)

The Bank Swallow is one of the most widely ranging of all the species in the swallow family. It is migratory, breeding in western North America on around to eastern Eurasia, while in the winter, it moves south into Central and South America or into Africa and Central Asia. As its name night suggest, the bank swallow is a colonial nesting bird which normally nests along river "banks," but due to human encroachment, they have altered their nest site selection to utilize quarry slag piles and, in San Francisco, sand bluffs in close proximity to freshwater marsh areas.

The species has been listed as threatened by the state because of habitat loss in the Central Valley (Murphy 2006). Once widespread on the coast, this species is now limited to two confirmed colonies, one of which is a single site in the exposed bluffs of the Merced Formation at Fort Funston facing the ocean (Murphy 2006). In Tomales Bay, this species is a rare transient over the Giacomini Ranch, especially in the fall (ARA 2002).

Threats from Non-Native and Invasive Wildlife Species

Non-native and invasive wildlife species can completely alter ecosystem dynamics and the value of aquatic system to native species, as Tomales Bay's neighbor to the east, San Francisco Bay, has demonstrated over the past several decades.

The San Francisco Estuary can now be recognized as the most invaded aquatic ecosystem in North America (Cohen and Carlton 1995). It has 212 introduced species, 69 percent of these are invertebrates, 15 percent are fish and other vertebrates, 12 percent are vascular plants, and 4 percent are protests (Cohen and Carlton 1995). In the period since 1850, the San Francisco Bay and Delta region has been invaded by an average of one new species every 36 weeks, increasing in 1970 to one new species every 24 weeks (Cohen and Carlton 1995). In the state as a whole, nearly half of all freshwater species are introduced (TBWC 2002).

In addition to extirpating native species such as the Sacramento perch from some portions of its range, invasive species are also completely altering the bottom portion of the San Francisco Bay food chain (Cohen

and Carlton 1995). Phytoplankton populations in the northern reaches of the Estuary may now be continuously and permanently controlled by introduced clams, with the Asian clam (*Potamocorbula*) filtering the entire water column over the channels more than once per day and over the shallows almost 13 times per day (Cohen and Carlton 1995). In addition to phytoplankton, the Asian clam also consumes bacterioplankton, phytoplankton, and zooplankton (copepods), and so may substantially reduce copepod populations both directly and indirectly (loss of food source). The dramatic decline in copepod population, in turn, could cause collapse in the native copepod-eating mysid shrimp (*Neomysis*), which are one of the major food stocks for salmon and other fisheries (Cohen and Carlton 1995).

Many consider the implications of this large-scale aquatic invasion of San Francisco frightening for Tomales Bay. Currents from Golden Gate can reach some of the estuaries and lagoons along the northern California coast, which is how some surmise that Atlantic cordgrass and its hybrids, non-native competitors with the native Pacific cordgrass, reached Drakes Estero watershed. In addition, ballast water, the primary factor for introduction of many aquatic organisms to San Francisco Bay, can be discharged off the Marin Coast, thereby increasing the potential for introduction of these same species to Tomales Bay. The Tomales Bay All-Taxa Biological Inventory has already documented the presence of at least 28 non-natives among the 2,015 aquatic species recorded during the last three years (Seashore 2005). At least five are deemed to be a serious threat to ecosystem health and native species (Seashore 2005). Other species have spread "overland" through transportation of timber, hay, and fur or were even introduced by humans for food or recreation such as the bullfrog and warmwater fish, respectively (TBWC 2002). Some of the non-native species in the Tomales Bay watershed include the Virginia opossum (*Didelphis virginiana*), the bullfrog, the red fox, Norway rat, black rat (*Rattus rattus*), house mouse (*Mus musculus*), two species, and several fish and bird species (TBWC 2002).

Within the Project Area, several non-native and invasive species have been documented, with perhaps the ones of highest concerns being the green crab (undiked marsh north of Giacomini Ranch), bullfrog (East Pasture, Tomasini Creek, Olema Marsh), and the red fox (Giacomini Ranch-East Pasture and dairy facility). Other non-native species of concern include the yellowfin goby (Lagunitas Creek), turkeys (West Pasture), brackish water or Korean shrimp (Lagunitas and Tomasini Creeks), mosquitofish (Giacomini Ranch East and West Pastures), and crayfish (Giacomini Ranch East and West Pastures). There are also several native species in the Project Area or vicinity whose presence and/or abundance is sometimes considered detrimental, including brown-headed cowbird, a nest parasite found occasionally in Olema Marsh that disturbs the nests of other birds, and common ravens (*Corvus corax*) and American crows (*Corvus brachyrhynchos*), which prey on young of endangered and threatened bird species.

Green crab

One of the aquatic invasive species of most concern is the green crab, which is also present in San Francisco Bay. The green crab is native to the Atlantic coasts of Europe and northern Africa, where it inhabits rocky shores, sand flats, and tidal marshes (ARA 2002). The green crab arrived in San Francisco Bay in 1989-1990 and has since spread as far north as Washington and as far south as Morro Bay (ARA 2002).

The green crab is a food and habitat generalist, capable of eating an extraordinarily wide variety of animals and plants, including bivalve mollusks, polychaetes, and small crustaceans. Indeed, it is its status as a dietary generalist that poses perhaps the greatest threats to native species and their ecosystems. At the turn of the century, this species basically wiped out the soft clam industry of Maine and the surrounding waterways (van Heertum 2002). In California, it has been estimated to cause the loss of as much as 50 percent of Manila clam stocks and substantial decreases in other crab populations (van Heertum 2002). In Bodega Harbor, records show a significant reduction in clam and native shore crab in abundance since the arrival of the green crabs in 1993 (Grosholz et al. 2000). Beside its threat as a predator and potential disruptor of the native food chain, green crab may carry a parasite, the acanthocephalan worm, which can infect local shorebirds (CDFG 2001)*in* ARA 2002).

The green crab arrived in Tomales Bay in 1995-1996. In a study done at one shellfish operation in Tomales Bay, the Manila clam (*Tapes philippinarum*) harvest showed a 40 percent drop after the arrival of green crabs (Biocontrol News and Information 1999; Grosholz and Olin 2000). Numbers were apparently high early on, but declined during some of the El Nino years in 1999-2000. In 2005, green crab numbers in one wetland area in Tomales Bay, Tomasini Estuary near Tomasini Point north of the Giacomini Ranch, were estimated as approximately 8,5000 individuals, with a density of 0.007 to 0.02 crabs per square foot (Pettigrew 2005). These densities are similar to Bodega Bay, which reportedly has densities of 0.15 crabs per square meter, but an order of magnitude lower than densities in European and Atlantic coast estuaries, which has led some

(Yamada 2001) to speculate that competition and environmental factors may be limiting expansion in Pacific coast estuaries (Pettigrew 2005). In the Project Area, the green crab has been sighted primarily in the undiked marsh north of Giacomini Ranch's West Pasture.

Bullfrog

Native to the eastern United States, the bullfrog was introduced to California several times early this century (Storer 1922; Morey 1990). It is now widespread and common in the state (Bury and Luckenbach 1976). The bullfrog is the largest frog in California (Morey 1990), and it may compete with or consume the other amphibians with which it co-exists.

Highly aquatic, bullfrogs are found in quiet waters of ponds, lakes, reservoirs, irrigation ditches, streams, marshes, and other permanent water (Stebbins 1954; Morey 1990). Wright and Wright (1949; Morey 1990) listed shoreline cover and shallow water as important habitats for adults and tadpoles, respectively. Permanent water is often required for the completion of larval development. In California, breeding and egg-laying occur from March to July (Stebbins 1972 *in* Morey 1990). Tadpoles require at least six months to transform, and individuals in many populations overwinter as tadpoles and transform during their second year (Treanor and Nicola 1972) *in* Morey 1990).

Adults are opportunistic feeders taking both aquatic and terrestrial prey items. Invertebrates are the primary food of bullfrogs ((Frost 1935; Korschgen and Moyle 1955; Cohen and Howard 1958; Taylor and Michael 1971; Morey 1990), but vertebrate prey such as fish, salamanders, frogs (including bullfrogs) and tadpoles, spadefoot toads, snakes, turtles, birds, and mice are also taken. Moyle (1973) *in* Morey 1990) suggested that bullfrogs are responsible for the elimination of the red-legged frog from the floor of the Central Valley and adjacent Sierra foothills, and for reduction in the range of the yellow-legged frogs. Supporting evidence for this is sparse (Morey 1990), but bullfrogs are believed to have played some role in the decline of California red-legged frogs and other native amphibians.

Red fox

The red fox is widely distributed in lowlands in central and southern California (Johnson 1990). Introduced populations inhabit Sacramento and San Joaquin valleys and scattered coastal and inland locations from Sonoma County south to Monterey County, and east to Stanislaus County, as well as in Ventura, Los Angeles, and Orange counties (Johnson 1990). The red fox hunts small and medium-sized mammals, ground squirrels, gophers, mice, marmots, woodrats, pikas, and rabbits, but it is its affinity for hunting federally and state endangered ground-nesting species such as California clapper rail and California black rail that have raised concerns about its increasing numbers within the San Francisco Bay region and other coastal areas with rail populations (San Francisco Bay Estuary Goals Project 1999). The impact of this species on rails and other ground-nesting species is increased, because most of the remaining marshes are leveed or near levees, which the red fox readily use to access rails, and the red fox can swim, unlike its native counterpart (Goals Project 1999).

Fish and Wildlife Resources and Wetland Functionality

One of the most important or certainly most publicized functions for wetlands is to provide breeding, nesting, foraging, and refugia habitat for wildlife, as well as to support wildlife species in distant locations through export of carbon and potential food sources. Tomales Bay is tremendously important to estuarine and marine species. Despite diking and other agricultural activities, the Project Area is also currently important to wildlife, particularly avian species, although it also provides support for amphibian and fish species currently, as well. Much of the existing value of the Project Area to wildlife probably results from the fact that it is already wetland, although the diversity of wetland and upland habitats within the Project Area and immediate vicinity also appears to play a crucial role in increasing species diversity. Its value may be enhanced, as well, by the fact that the Project Area falls within one of the largest estuarine transition zones in Tomales Bay, a dynamic and often biotically diverse interface between saltwater and freshwater environments.

Most of the species detected in or around the Giacomini Ranch occurred on the perimeter of the Ranch itself, where there is more habitat diversity.

From a broad perspective, most of the species detected in or around the Giacomini Ranch occurred on the perimeter of the Ranch itself, where there is more habitat diversity. This habitat diversity comes primarily from the juxtaposition between not only freshwater and saltwater environments created by abundant groundwater and fluvial sources at the edge of an estuary, but between the wetland and upland environments that have been created by uplift along the San Andreas Fault and other geological processes. However, this habitat diversity also appears to stem in part from the fact that many of the Ranch's "edges" are not as highly managed for agriculture. Some of the most frequented wildlife areas on the Ranch are the West Pasture freshwater marsh, the ruderal or unmanaged field in the northern portion of the West Pasture, the riparian corridor and seep-fed meadows along Sir Francis Drake Boulevard, the riparian scrub habitat at the Green Bridge County Park and on the Point Reyes Mesa, and the shallow shorebird habitat that has developed in one of the East Pasture's ruderal fields (ARA 2002).

More than 300 acres of the 550 acres of pastures and lowland areas in the Giacomini Ranch East Pasture are actively managed though irrigation, mowing, manure spreading, grazing, and other activities. Wildlife surveys found few species actively using these managed pastures, and the few species that did were sometimes prevented from successfully because of agricultural activities (ARA 2002). The primary species using the Giacomini Ranch East Pasture were roosting waterfowl or waterbirds and occasionally deer, red fox, sparrows, swallows, and small mammals such as voles and gophers (ARA 2002). Within these monotypic pastures, drainage ditches and ditched sloughs did increase habitat diversity -- and thereby species diversity -- somewhat, attracting northwestern pond turtle and depauperate fish and invertebrate communities in addition to the occasional southwestern river otter, waterbird and waterfowl, and California red-legged frog. While non-native species are present in the ditches such as mosquitofish, the ditches and pastures do not appear to be heavily managed through use of herbicides or pesticides, which may increase diversity relative to other very highly managed wetlands.

Olema Marsh is not as highly managed as the Giacomini Ranch, which has probably increased its relative value to wildlife. Olema Marsh offers some of the same habitat diversity as Giacomini Ranch, because the marsh borders the Inverness Ridge, which contributes upland habitat, as well as groundwater and fluvial influences that sustain both the marsh and a broad riparian zone. The overall importance of this marsh to wildlife is difficult to gauge, because of the complexities involved in comprehensively surveying it. Certainly, its value to particular types of birds has been well-documented, and it does support California red-legged frog, but use by fish and invertebrates, some of which are also special status species, is uncertain. Based on historic maps, this area might have once attracted special status fish and invertebrates such as tidewater goby, coho salmon, and perhaps in freshwater portions or in very wet years, California freshwater shrimp, but these species have not been sighted in the marsh or upstream watershed. The status and future of steelhead in this system still remains questionable due to problems with the Levee Road and Bear Valley Road culverts, as well as potentially the lack of a defined flow path through the marsh (KHE 2006b).

On a larger scale, hydrologic disconnection of both the Giacomini Ranch and Olema Marsh from Lagunitas Creek has substantially decreased the potential of these areas to support or improve conditions for marine and estuarine species in other areas of Tomales Bay. The low numbers and diversity of fish and invertebrate species that do occur within the Project Area are largely unavailable to aquatic organisms within the Bay, thereby decreasing the Project Area's overall value to wildlife. Obviously, some waterbirds and raptors, as well as southwestern river otter, do forage in the Giacomini Ranch but the contribution to the larger food web within the Bay has been minimized by levees, culverts, and other hydrologic alterations. The lack of hydrologic connectivity between creek and floodplain also limits the ability of these wetlands to export carbon and to improve water quality, both of which can affect Tomales Bay wildlife. Poor water quality not only impacts the oyster industry, but it may negatively affect both diving ducks and fish-eating waterbirds, which forage on benthic invertebrates susceptible to contamination in sediment (diving ducks) or require high visibility to sight prey (waterbirds; Kelly and Tappen 1998). In addition, excessive amounts of sediment in flood flows can literally "smother" populations of benthic invertebrates that act as food source for shorebirds, which may account for several years of sharp mid-winter declines observed in certain shorebird species numbers in Tomales Bay following very large storm events (Kelly 2001).

Cultural Resources

While public awareness of the importance of wetlands appears to be a relatively recent phenomena, this awareness really reflects more of a reacquaintance with the functions, values, and "services" provided by wetlands – values and functions that were recognized for hundreds to thousands of years prior to European settlement. The bountiful resources of the Pacific Ocean and sheltered bays encouraged settlement by Native American tribes that relied on open water areas and wetlands for fish, game, shellfish, and other food resources. Many of these same peoples actually created and/or managed wetland features for specific functions and services. The Omiomi Coastal Miwok appeared to have developed large tidal marsh ponds near Novato in Marin County for waterfowl hunting, and the Yrgin Ohlone managed salt pannes in Hayward in east San Francisco Bay for salt harvesting (Goals Project 1999). These same resources were highly prized by English and Spanish explorers and later by settlers who moved into the San Francisco Bay and Point Reyes regions.

Background and Regulatory and Policy Setting

The Seashore's history of Native American settlement, European exploration, and eventual colonization by Spaniards and Americans left it a legacy of important archeological and historic resources. A more detailed summary description of the history of the Project Area can be found at the beginning of this chapter.

Since the early 1900s, a number of laws and policies have been enacted to protect cultural resources such as these for the enjoyment of future generations of park visitors. The Antiquities Act of 1906 (16 USC §432) mandated protection of historic or prehistoric remains "or any antiquity" on federal lands, including historic monuments and ruins. It was superseded by the Archeological Resources Protection Act of 1979 (16 USC §470aa et seq.) as an alternative federal tool for prosecution of antiquities violations on public lands. In addition to protecting resources, the Archeological Resources Protection Act regulates excavation and collection on public and Indian lands and requires notification of Indian tribes that may consider a site of religious or cultural importance prior to issuing a permit. The importance of consulting with Native American tribes was bolstered by passage of the American Indian Religious Freedom Act (42 USC §1996), which stresses that religious concerns should be accommodated or addressed under NEPA or other appropriate statutes. The Archeological Resources Protection Act was amended in 1988 to require the development of plans for surveying public lands for archeological resources and systems for reporting incidents of suspected violations.

The National Historic Preservation Act of 1966, as amended (16 USC §470 et seq.) requires agencies to take into account the effects of their actions on properties listed in or eligible for listing in the National Register of Historic Places. The Advisory Council on Historic Preservation has developed implementing regulations (36 CFR 800), which allow agencies to develop agreements for consideration of these historic properties. The Park Service, in consultation with the Advisory Council, the California State Historic Preservation Officer (SHPO), Native American tribes, and the public, has developed a Programmatic Agreement for operations and maintenance activities on historic structures. This 1995 Programmatic Agreement provides a process for compliance with the National Historic Preservation Act and includes stipulations for identification, evaluation, treatment, and mitigation of adverse effects for actions affecting historic properties.

In addition to federal and state laws governing protection of cultural resources, Executive Order 11593 instructs all federal agencies to support the preservation of cultural properties. It directs them to identify and nominate cultural properties under their jurisdiction to the National Register of Historic Places and to "exercise caution… to assure that any federally owned property that might qualify for nomination is not inadvertently transferred, sold, demolished, or substantially altered." The Park Service incorporated direction from law and federal policy into development of the Cultural Resources Management Guidelines (NPS 1998a), which recognizes five types of cultural resources: archeological resources, historic structures, ethnographic resources, cultural landscapes, and museum objects.

In California, authority for NHPA has been transferred to California's Office of Historic Preservation. The Office of Historic Preservation also is responsible for oversight of California Pubic Resources Codes Section 21083.2-21084.1, which requires state and local agencies to evaluate impacts of proposed projects to archaeological and historic structure resources. Federal and federally-sponsored programs and projects are reviewed pursuant to Sections 106 and 110 of the NHPA. Section 106 of the NHPA requires federal agencies to consider the effects of proposed federal undertakings on historic properties. NHPA requires federal agencies

to initiate consultation with the State Historic Preservation Officer (SHPO) as part of the Section 106 review process. The State Office of Historic Preservation maintains the California Register of Historic Places. The California Register includes resources listed in or formally determined eligible for listing in the National Register of Historic Places, as well as some California State Landmarks and Points of Historical Interest. Properties of local significance that have been designated under a local preservation ordinance (local landmarks or landmark districts) or that have been identified in a local historical resources inventory may be eligible for listing in the California Register and are presumed to be significant resources for purposes of CEQA unless a preponderance of evidence indicates otherwise (PRC Section 5024.1, 14 CCR § 4850).

Tribal Lands

The recently completed Point Reyes National Seashore Cultural Affiliation report (Emberson et. al. 1999) examining Native American affiliation at Point Reyes concluded that the Federated Coast Miwok people have a clear, exclusive affiliation with the lands managed by the Seashore extending back more than 2,000 years. The Federated Coast Miwok are politically recognized by the federal government as the Federated Indians of Graton Rancheria. A FIGR representative was present for most of the archeological survey conducted in the Project Area.

Archeological Resources

Park Setting

Archeological resources are “the remains of past human activity and records documenting the scientific analysis of these remains” (NPS 1998). These include artifacts, ecofacts, and features. Over 100 Native American archeological sites exist within the Seashore, primarily on the coastal lowlands. These known prehistoric sites are primarily shell middens, voluminous deposits of rich organic soil with a relatively high content of local shell, created by human habitation of the site. The Seashore also has approximately 90 historic terrestrial archeological sites. These sites typically reflect historic occupation and use of the peninsula, first by homesteaders and dairy ranch communities, and later by government lighthouse and lifesaving personnel and private radio telecommunication companies. They include discrete trash pits containing old bottles, tins, broken tools and crockery, buried corduroy roads, ruined ranch sites, and radio communication facilities. Almost 90 percent of the Seashore’s lands have not yet been surveyed for archeological resources.

Archeological Resources within the Project Area

No archaeological resources or human remains were identified during surveys conducted in 2002 by the Anthropological Studies Center at Sonoma State University (Newland 2003).

Cultural Landscapes and Features

Park Setting

Cultural landscapes “are settings we have created in the natural world” (NPS 1998). In 1998, the Seashore started developing a cultural landscape inventory database. To date, the database has identified 12 historic cultural landscapes, with the dairy and cattle ranches on the Point Reyes Peninsula comprising the single largest landscape (Seashore 2001). The smallest is located at the 19th century lime kilns located in the Olema Valley (Seashore 2001). Landscapes can range in scale from historic sites to substantial districts (Seashore 2001). They may express a high level of design, as seen in the two former RCA / Marconi Wireless Stations on Point Reyes and Bolinas, or, conversely, they may be landscapes that have arisen from need or desire over time, rather than arising from measured designs (Seashore 2001). The ranches along Lagunitas Creek and the Olema Valley fall in this category (Seashore 2001).

In total, the Seashore manages 39 cultural landscapes: 23 are within the boundaries of the Seashore, and 16 are within the North District of the GGNRA. The landscape and landscape features primarily reflect the maritime, ranching, communications, and military history of the park. Two of these landscapes are considered historic districts. The Point Reyes Ranches Historic District is the largest and encompasses over 22,000 acres on the Point Reyes Peninsula with the oldest dairy operations (1857-1939) known as the “alphabet ranches.”

The Seashore has rehabilitated the NHRP-listed Pierce Point Ranch in this district. Home Ranch is listed as a landscape feature integral to the Point Reyes Ranches Historic District Cultural Landscape. Home Ranch is one of the oldest and best preserved ranches on the Point Reyes Peninsula (Livingston 1994). The Olema Valley Ranches Historic District, including the Lagunitas Creek ranches, is a smaller, but comparable district with a broader range of architectural styles and site development influenced by a higher diversity of ownership and lack of standardization (Seashore 2001).

Several other landscape features have national significance. The 1927 Point Reyes Lifesaving Station is a National Historic Landmark, and the Marconi/RCA Wireless Stations sites are in the process of being nominated as a multiple property National Historic Landmark. The Point Reyes Light Station, which was built in 1870, is listed on the NRHP. The Olema Lime Kilns are listed as a California State Historical Landmark and also as a National Register of Historic Places property.

Cultural Landscapes and Features within the Project Area

The Project Area is not located in the Seashore's two historic ranching districts (Garcia and Associates 2004), although the Martinelli Ranch, which is owned by GGNRA and directly northeast of the Giacomini Ranch, is included in the Historic Resource Zone. Surveys of the Giacomini Ranch in 2002 identified two previously unrecorded cultural landscape features: a portion of the North Pacific Coast Railroad grade (ASC-69/01-01) and a historic-period levee system and dam (ASC-69/01-02; Newland 2003). The dam was a temporary gravel dam that the Giacominis installed each summer to provide freshwater for irrigation purposes. The Giacominis stopped summer dam installation in 1998 prior to selling the property to the Park Service. While the original levee system was constructed more than 50 years ago, the degree of alteration to this system due to repairs and reinforcement (e.g., rip-rapping) will probably reduce its value as a historic resource (Mark Rudo, Park Service, *pers. comm.*). The study determined that neither resource was eligible for listing on the National Register of Historic Places (Newland 2003). In 2004, four additional landscape features were recorded by Garcia and Associates (2004): two manure lagoons and two corrals in the main complex. The corrals are not on Park Service property. None of these features was considered eligible for National Register of Historic Places listing (Garcia and Associates 2004).

Historic Structures

Park Setting

Historic structures are "material assemblies that extend the limits of human capacity" and comprise such diverse objects as "buildings, bridges, vehicles, monuments, vessels, fences, and canals" (NPS 1998). More than 300 historic structures are found on land managed by the Seashore. The structures range from simple timber-framed barns to the cast-iron Point Reyes Lighthouse to the concrete Mission Revival Marconi transmitting station. Historic structures are found throughout most of the park, except for the Wilderness Area, and mark the built history of the Seashore. Approximately two-thirds of the Seashore's listed structures are ranch structures managed under leases and permits. The remaining structures reflect the park's maritime and radio communication history.

Four sites are listed in the National Register, including the Point Reyes Lifeboat Station, a National Historic Landmark. Three additional properties have been determined to be eligible for the National Register of Historic Places, and several additional properties are in review. Within the Seashore, 297 historic structures are on the List of Classified Structures, the Park Service inventory of historic and prehistoric structures.

Historic Structure Resources within the Project Area

Historic structure surveys were conducted in 2004 to evaluate the historic buildings, structures, and landscape features at the Giacomini Dairy Facility and a separate residence on Sir Francis Drake Boulevard in Inverness Park (Garcia and Associates 2004). The study determined that the Giacomini Ranch was much younger than many of the other Olema Valley and Point Reyes dairies that operated in the 19th century and that many of the buildings had been highly modified (Garcia and Associates 2004). Neither the Dairy Facility structures nor the Inverness Park residence appeared to meet any of the criteria for listing in the National Register of Historic Places (Garcia and Associates 2004).

Public Health and Safety

In addition to hydrologic and ecological functions, wetlands also provide social services, several of which directly relate to public health and safety. Wetlands reduce impacts from floods by providing floodwater storage and decreasing the destructive energy of flood flows. While the public has become more knowledgeable about the functions and services that wetlands offer, wetlands still labor to some degree with age-old misconceptions of wetlands as swamps filled with mosquitos, dank water, and other nuisances and dangers. Unfortunately, this view has resurfaced with growing concern about the spread of West Nile Virus and other mosquito-borne diseases and the potential impact on public health. These concerns need to be balanced with a better and more scientific understanding of the diseases, their vectors, mode of transmission, and the relationship of wetlands and other habitats to disease vectors.

Flooding and Public Safety

Regulatory and Policy Setting

Flooding has historically had severe safety and economic impacts on both urban and rural communities and even parks. Federal and local regulations have been promulgated to reduce both the exposure of communities and parks to damaging flooding and the funds required to rebuild communities and parks following such major floods (Clearwater Hydrology and Nichols-Berman 2002). Until the early to mid-1980s, the flood control and reduction strategies that were typically applied in Marin and other Bay Area counties often had detrimental impacts on aquatic, riparian and wetland habitats (Clearwater Hydrology and Nichols-Berman 2002). Growth in the understanding of the linkage between hydraulic and fluvial geomorphological processes caused a re-evaluation of some of the commonly applied flood control techniques, such as use of concrete channel lining, channel straightening and the elimination of functional floodplain areas (Clearwater Hydrology and Nichols-Berman 2002). The current and evolving regulatory environment affecting flood control activities reflects this changed understanding of flood dynamics and the role of wetlands and riparian areas in regulating floods.

Flooding has historically had severe safety and economic impacts on both urban and rural communities and even parks.

The National Flood Insurance Act of 1968 and the Flood Disaster Prevention Act of 1973 established the National Flood Insurance Program (NFIP) which is administered by the Federal Emergency Management Agency (FEMA; Clearwater Hydrology and Nichols Berman 2002). The NFIP provides insurance coverage to property owners within flood hazard areas that are delineated on published Flood Insurance Rate Maps (FIRMs) for both the 100-year and 500-year flood events (Clearwater Hydrology and Nichols-Berman 2002). In order to quality for the program, candidate municipalities and unincorporated county areas must adopt local floodplain development policies and enforce flood control measures for new construction and redevelopment projects within their jurisdictions (Clearwater Hydrology and Nichols-Berman 2002).

FEMA prepares Flood Insurance Studies and associated FIRM maps to assist communities in local land use planning and flood control decision-making (Clearwater Hydrology and Nichols-Berman 2002). The County of Marin entered into the NFIP in 1982, the date the original FIRM maps were published for the incorporated area (Clearwater Hydrology and Nichols-Berman 2002). Based on the CWP, the Project Area falls within the 100-year flood hazard zone (Clearwater Hydrology and Nichols-Berman 2002). The extent of the 500-year flood hazard zone was not delineated in the Point Reyes area (Clearwater Hydrology and Nichols-Berman 2002).

The Park Service specifically addresses flooding in its 2006 Management Policies. Parks are directed to "minimize potentially hazardous conditions associated with flooding" (NPS 2006; Section 4.6.4). Furthermore, parks should "avoid direct and indirect support of floodplain development and actions that could … increase flood risk" (NPS 2006, Section 4.6.4). When development must occur within a floodplain, non-structural measures should be used to reduce hazards to human life and property, while minimizing impacts to the natural resources of floodplains (NPS 2006; Section 4.6.4). Development must also be consistent with the standards and criteria of the NFIP (NPS 2006; Section 4.6.4).

Background and Regional Flooding Patterns and History

Two forms of flooding occur in Marin County: 1) tidal flooding and 2) watershed flooding (Clearwater Hydrology and Nichols-Berman 2002). Tidal flooding develops when high tides exceed either the top of bank elevation of tidal sloughs and channels, or the crest of bay levees. Watershed flooding occurs in response to severe runoff-inducing rainfall over the tributary watershed of one of the region's stream channels. Major watershed floods are typically generated by rainstorms of 3-4 days duration that include nested periods of high intensity rainfall. Such rainstorms occur primarily during the wet winter season, which normally extends from November through March. When watershed flooding occurs in conjunction with high bay tides in coastal areas of Marin County, the extent and/or depth of overbank flooding or levee overtopping can increase due to an upward adjustment in the flood water surface profile. The potential for tides to affect flooding patterns in coastal areas could increase in the future due to sea level rise, which would increase base elevation ranges for Mean Sea Level (MSL) and Mean Higher High Water (MHHW) and increase the risk of flooding to homes, roads, and other infrastructure that are at or slight above sea level elevations.

Watershed flooding can result from two different and extreme rainfall patterns (Brown 1988). One pattern is a series of regional storms that saturate soils by persistent rainfall over a period of several weeks. The other pattern is a localized storm of high precipitation intensity during which rainfall lasts for a few hours to a few days and may or may not fall on presaturated ground. Both patterns may cause severe flooding. Localized storms often concentrate on the Pacific coastline and release continuous, very intense rains lasting for several hours to a maximum of four days (Brown 1988). As of the mid-1980s, five of the severest localized storms in the San Francisco Bay region occurred in November 1950, October 1962, January-February 1963, January 1967, and January 1982 (Brown 1988). Some of these extreme precipitation events were influenced to some degree by the El Nino climatic phenomenon (Clearwater Hydrology and Nichols-Berman 2002). Typically, the associated weather is much wetter, and storms and tides are more intense than during non- El Nino periods (Clearwater Hydrology and Nichols-Berman 2002).

As rainfall intensity increases, surface run-off from upland areas flows into nearby drainages and creeks. During a storm, waters will continue to rise until they reach a point at which the stage or height of floodwaters in the channel are at their highest, which is called peak flow. From this point, flood flows typically decrease. This flood flow pattern or flood hydrograph often resembles a flood wave that propagates down the creek channel, ultimately dissipating in some larger body of water (Dunne and Leopold 1978). The height or stage of this flood wave depends, in part, on the amount of reservoir capacity within the system (Dunne and Leopold 1978). In addition to man-made water storage structures, "reservoirs" include the channel itself, the "active" floodplain that is subject to flooding during bankfull or ordinary high water flows, and floodplain terraces that include the flood-prone area (~50-year flood events) and more planning-driven concepts such as the 100-year and 500-year floodplains. In low gradient or topographically "flat" systems, floodplain terraces often consist of large flats or plains adjacent to the riparian corridor or, in tidal marsh systems, marsh plains. Floodplains are discussed more under Water Resources – Hydraulics and Hydrologic Processes.

Because of differences in the length of streams, size of watershed, and run-off rates, the peaks of flood waves can be offset somewhat, with peak flooding in adjacent fluvial or creek systems occurring at different times. Differences in peak flow timing and water pressure can sometimes create a phenomenon called backwater flooding in which rising flood flows from a river or creek actually back up into the channel of another connecting creek or tributary, particularly if there is large "reservoir" capacity through extensive floodplains near the tributary's mouth. During very large storm events, floodwaters from the Russian River in Sonoma County actually flow upstream into one of its largest tributaries, the Laguna de Santa Rosa, which has extensive floodplains that are estimated, at times, to provide more floodwater storage than Lake Sonoma and Lake Mendocino combined (City of Sebastopol 2005).

Development of floodplains and even efforts to "control" floods through flood control channels can sometimes exacerbate the degree and damage from flooding. Watershed flooding is commonly associated with the development of formerly active floodplains and an increase in the peak rates of watershed runoff (Clearwater Hydrology and Nichols-Berman 2002). Peak flow rates increase due to increases in impervious surface coverage and the construction of storm drain systems, which reduce the time of concentration for runoff (Clearwater Hydrology and Nichols-Berman 2002). When peak flow rates increase substantially, and the altered flow regime is not accommodated using channel modifications, stormwater detention or diversion, and/or stream conservation zones, episodic flooding can ensue (Clearwater Hydrology and Nichols-Berman 2002).

Watershed flooding can precipitate other factors that can dramatically increase the risk and damage from flooding such as complete or partial failures of dams and reservoirs. MMWD currently operates five reservoirs in the Lagunitas Creek watershed. Dam failures are extremely rare due to the stringent design and permitting requirements for dam construction and operation (Clearwater Hydrology and Nichols-Berman 2002). However, in the active tectonic environment of the San Francisco Bay Area, the risk of a dam failure during a major earthquake remains a possibility (Clearwater Hydrology and Nichols-Berman 2002).

Damage-inducing flooding has occurred infrequently in the County, primarily in the lower lying alluvial valleys and former marsh plains in eastern Marin that border the San Francisco Bay (Clearwater Hydrology and Nichols-Berman 2002). Because flooding has only been quantified in modern times, comparing the relative degree of flooding between different major flooding events is difficult, particularly as flooding is often evaluated in terms of subjective factors such as number of people affected, property losses, and reports on areal extent of observed inundation (Brown 1988). The most severe winter in terms of precipitation was probably that of 1861-1862 during which regional storms produced massive flooding throughout the San Francisco Bay region (Waananen et al. 1977; Brown 1988). Frequent, major storm-producing precipitation occurred between 1879 and 1915, a period that was followed by 22 years of less damaging or non-damaging precipitation seasons with one exception (Brown 1988). Between 1937 and 1982, damaging storms recurred on average on an interval of once every 3 years, with the 1955 storm considered to be generally the largest of the 20th century (Brown 1988; FEMA 1997). In 1982, much of Marin County was hit by a severe storm whose intensity was increased by a series of high tides.

Project Area Flooding Patterns and History

As the Project Area is situated in an alluvial valley at the confluence of at least three moderate to large-size creeks and a number of smaller drainages, it is perhaps not surprising that the entire Project Area has been mapped within the FEMA-designated 100-year flood hazard zone (Clearwater Hydrology and Nichols-Berman 2002). The history of the Project Area has been one that has marked by a number of catastrophic floods that have caused extensive to homes, ranches, and roads, as well as substantially changed the physical environment. Within the Project Area, flooding is directly influenced by both tidal and watershed processes, with flooding from creeks often exacerbated by extreme tide conditions.

The largest recorded flood in the Project Area and vicinity was the 1982 storm, which is considered to be a rainfall event with a 100-year recurrence interval. Within the San Francisco Bay region in general, the storm dropped as much as half of the mean annual precipitation within a period of about 32 hours, triggering 18,000 slides, damaging 100 homes, and killing 14 people (Ellen et al. 1988). In Olema and Inverness, 24-hour rainfall totaled 11-20 inches. Flood- and tidal waters completely inundated the Project Area and surrounding low-lying lands, including many of the homes along Levee Road and large sections of the road itself. Damage was intensified by numerous catastrophic landslides along the Inverness Ridge, with the resulting debris flow exacerbating flooding by blocking stream channels and drainage ways and causing localized flooding of Sir Francis Drake Boulevard (Ellen et al. 1988). Huge amounts of sediment were excavated from Bear Valley Creek and other drainages. As described under Hydrologic Resources, the flood also had major effects on hydrologic and geomorphic processes of local creeks, including Bear Valley Creek.

North bank of Giacomini Ranch East Pasture levee during 1982 Storm, a 100-Year Flood Event (Photo: Tom Quinn)

The Giacomini Ranch levees were completely submerged in the high water of this flood. Levees failed in several locations, including along the right bank (East Pasture) between the former summer dam and a few hundred feet downstream of the Green Bridge; opposite the White House Pool County Park; almost the entire length of the West Pasture bordering the creek; and numerous locations along the East Pasture between

White House Pool and the North Levee (KHE 2006a). As with many other floods that severely affected coastal areas, damage was exacerbated by the fact that the flood coincided with a series of higher high tides.

Following the flood, the Giacominis successfully petitioned for the Corps to armor the right bank of Lagunitas Creek with rip rap for several hundred feet upstream of the former summer dam. In addition, the Giacominis replaced the former creek-side levee to its current, set-back location by importing 200- to 300 cubic yards of local landslide material (KHE 2006a). The rebuilt section of levee became higher in elevation than lands on the south side of Lagunitas Creek, which effectively increased flooding potential of homes along Levee Road (KHE 2006a). In response to flood damage from the 1982 event, Marin County formed Flood Control Zone 10, which covers the Inverness Ridge, to collect taxes and clean and restore local creek channels (Clearwater Hydrology and Nichols-Berman 2002).

In 1998, another flooding event occurred, which was estimated as having a 10-year recurrence interval. Again, the entire alluvial valley and floodplains of Lagunitas and Olema Creeks were underwater. Residents along Levee Road and the east side of Sir Francis Drake Boulevard reported substantial flooding, although flooding for many homes on Levee Road was reduced by not only the decreased severity of flooding relative to the 1982 storm, but by the fact that many of the homes had been raised to decrease flood frequency.

This storm was also accompanied by some major hydrologic and geomorphic changes in the Project Area, including an apparent shift in the channel course of Bear Valley Creek from the west to the east side of Olema Marsh, possibly in response to excessive sediment deposition on the west side of the marsh from Inverness Ridge erosion. This sediment deposition resulted in blockage of the western culvert near the White House Pool County Park parking lot and redirection of Bear Valley Creek flow and other Olema Marsh waters to the other remaining culvert in the northeastern corner of Olema Marsh (KHE 2006b). Blockage of the western outlet reduced the available surface area for potential flow conveyance from the marsh from 106 square feet to 42 square feet, which translates into a reduction in conveyance capacity from approximately 630 – 700 cfs to 410 cfs (KHE 2006a). A 5-year flood event produces approximately 490 cfs in Bear Valley Creek (G. Kamman, KHE, *pers. comm*.). The reduction in outflow is compounded by two other factors, as well: the eastern culvert is installed at a higher elevation than the western culvert, and a 315-linear-foot earthen berm that is hardened by heavy vegetation establishment near the eastern outlet acts as a funnel, further limiting drainage (KHE 2006b). These hydrologic impediments appear to be causing a steady increase in standing water levels within Olema Marsh, with water levels possibly increasing as much as 6 feet since 1990 (Evans 1990, KHE 2006b). These increasing water levels exacerbate the potential for flooding of Levee Road and Bear Valley Road, which already flood frequently during storms.

On December 30-31, 2005, intense rainfall and extreme high tides again produced another major flooding event in the Project Area and other portions of the San Francisco Bay region. The magnitude of this flood on Lagunitas Creek at the USGS Point Reyes Station gage has been roughly estimated as an approximately 30-year flood (Greg Kamman, KHE, *pers. comm*.). The Giacomini Ranch flooded completely, with flooding exacerbated by damage to the Giacomini Ranch East Pasture levee a short distance downstream of Green Bridge and near the former summer dam site. Residents along Levee Road noted an appreciable drop in creek water levels when the levees breached (J. Langdon, Levee Road resident, *pers. comm*.). Flooding was again compounded by extreme high tides, which backed up residual floodwaters and caused additional flooding in the Project Area and upstream areas on Lagunitas, Olema, and Bear Valley Creeks. Properties and/or homes on Levee Road and the east side of Sir Francis Drake Boulevard flooded, with the latter apparently due to blockage of stream channels from debris flows off the Inverness Ridge.

While major flooding events remain the most memorable in terms of extent of inundation and damage, hydraulic modeling conducted as part of the proposed projects suggests that the Project Area and vicinity floods frequently, even during lesser storm events. Model simulation results indicate that the southern creek bank of Lagunitas Creek on which approximately 15 to 20 Levee Road homes are constructed generally starts to become overtopped by flood flows during storms with a 3-year recurrence interval (KHE 2006a). Based on hydraulic modeling, properties on the eastern portion of Levee Road would not be completely flooded until flows exceed a 5-year storm event, whereas homes on the western portion of Levee Road, White House Pool park, and Levee Road near White House Pool park would be completely flooded during a 5-year or even smaller storm event (Table 19). These areas are flooded despite the fact that water surface elevations generally drop as flood flows move downstream past the western Levee Road homes towards White House Pool, because, at least during higher flood flows, flood pressure is being partially relieved by overtopping of the Giacomini Ranch levee (Table 19).

Based on hydraulic modeling estimates, flood flows overtop the portion of the Giacomini Ranch East Pasture levee near the old summer dam during 3.5-year storm events or during storms with slightly higher water levels than a 3-year event (KHE 2006a). Upstream of this and near where the levees were repaired after the 1982 flood event, the minimum flood flows capable of overtopping the East Pasture levee increases substantially, with modeling suggesting that 100-year flood events would be required (KHE 2006a). Downstream of White House Pool, the West Pastures levees overtop during flood events with a 12-year recurrence interval or greater while the East Pasture levee is overtopped by a 7-year flood or greater (KHE 2006a).

Water levels in the West Pasture simulated by hydraulic modeling in the West Pasture indicate that the three primary residences on the east side of Sir Francis Drake Boulevard are not impacted by rising waters from Lagunitas Creek during any of the simulated flood events (5-, 10, 50-, 100-year), except for potentially the 500-year storm event (Table 19; KHE 2006a). The eastern edge of the Gradjanski property -- which is already an existing freshwater marsh – probably floods under 50-year flood events in Lagunitas Creek, while the eastern edge of the Lucchesi and Kostelic residences would flood only during 100-year flood events (Table 19; KHE 2006a). With the exception of the lowest elevation home, all structures would appear to remain 3- to 4-feet above the 500-year flood water level from Lagunitas Creek: the lowest elevation home would be within 1 foot of the 500-year flood water level. These homes and properties are protected from flooding by Lagunitas Creek not by the levees, which are actually much lower in elevation than the homes, but by the fact that they were constructed on alluvial fans created by some of the numerous Inverness Creek drainages that flow into the West Pasture (KHE 2006a). In addition, based on hydraulic modeling simulations, Lagunitas Creek does not appear to create a backwater effect on upper reaches of either Fish Hatchery Creek or the 1906 Drainage that would increase flood risk (KHE 2006a).

The continued flooding of the homes and properties adjacent to Sir Francis Drake Boulevard in Inverness Park that has been documented even under relatively minor storm events is due to these homes' proximity to the Fish Hatchery Creek and 1906 Drainages that flow off the Inverness Ridge (KHE 2006a). During storms, the Inverness Ridge is prone to landsliding due to its weathered granite bedrock composition (KHE 2006a). In addition to large volumes of sediment, these tributaries frequently produce and carry large woody debris (KHE 2006a). Cumulatively, the sediment and debris commonly clogs the culverts passing beneath Sir Francis Drake Boulevard, causing water, sediment and debris to overtop the road and flow towards the houses (KHE 2006a). Material that passes through the culverts or over the road also falls out of suspension on the downhill side of the roadway due to the rapid change in slope and stream energy (KHE 2006a). This material accumulates and fills drainages, causing further overtopping of creek banks and flooding of surrounding areas (KHE 2006a).

Flood hydrographs or patterns for Lagunitas Creek and its tributaries in the Project Area, Olema and Bear Valley Creeks, show that peak flows appear to be offset, such that the peak of the flood wave from Bear Valley Creek arrives at the confluence before that of Olema Creek and Lagunitas Creek. Based on review of available historical flood flow records, the Olema Creek peak is estimated to lag 2 hours behind the Bear Valley peak, while peak flows on Lagunitas Creek lag 6 hours and 4 hours behind the Bear Valley and Olema Creek peaks, respectively (KHE 2006a). However, backwater flooding at the mouth of Bear Valley Creek primarily occurs during 2-year+ flood events not due to backup of waters from Lagunitas Creek, but due to reduced conveyance capacity through the Levee Road culvert connecting Olema Marsh to Lagunitas Creek (KHE 2006a).

Flood estimates for the 2- through 500-year floods for the Project Area and vicinity are presented in Table 20 (KHE 2006a). A couple of methods were employed to derive these estimates, including: 1) a standard flood frequency analysis of the USGS flow data at their Point Reyes Station gauge (USGS 1982) and 2) applying an area adjustment factor to FEMA unit runoff estimates (FEMA 1997). For comparison, peak flow estimates for the recent 1982, 1998, and 2005 floods are also presented on Table 20. A flood frequency curve generated from the data indicates that the 1998, 1982, and 2005 events approximate floods having a 10-, 100-, and 30-year recurrence interval, respectively.

TABLE 19. ESTIMATED FREQUENCY OF FLOODING BY LAGUNITAS CREEK UNDER EXISTING CONDITIONS FOR PROPERTIES AND ROADS ADJACENT TO THE PROJECT AREA

Note: Estimates are based on vertical flood elevations generated by computer hydraulic modeling (KHE 2006a) and elevation information from topographic survey performed by the USGS (2003b) and are for flooding by Lagunitas Creek only.

Location	Vertical Flood Elevation**	Extent of Potential Flooding Based on Hydraulic Model (KHE 2006a) and Topography (USGS 2003b).
Levee Road Homes East		
2-Year Event	~ < 12	No potential for flooding from Lagunitas Creek.
5-Year Event	~ <15.3	Flooding. Creekside edges of properties potentially flooded.
10-Year Event	~ <16.9	Flooding. Properties and Levee Road flooded except for southeastern corner of Levee Road near State Route 1.
50 – 500 Year Events	~19.1 – 21.4	Flooding. Potential for properties and roads to be flooded completely.
Levee Road Homes West		
2-Year Event	~11.4 – 11.6	Flooding. Potential for some flooding in northern portion of properties 500 to 1,000 feet east of Olema Creek.
5-Year Event	~ <15.0	Flooding. Potential for properties to be flooded up to Levee Road and for flooding of Levee Road west of Olema Creek.
10 – 500 Year Events	~16.1 – 20.8	Flooding. Potential for properties and Levee Road to be completely flooded.
Levee Road WHP Park		
2-Year Event	~ 10.1 – 11.0	Flooding. Potential for WHP Park to be flooded extensively with minimal flooding of Levee Road.
5- to 500 Year Events	~ 12.9 – 18.1	Flooding. Potential for almost all of park and Levee Road from Olema Creek to Bear Valley Road to be flooded.
WHP at Sir Francis Drake		
2- to 10- Year Events	~9.8 – 13.1	No potential for flooding from Lagunitas Creek.
50 – 500 Year Events	~14.1 – 15.0	Small potential for flooding from Lagunitas Creek during 500-year flood event.
Sir Francis Drake Homes East		
2- to 5-Year Events	~6.25 to 7	No potential for flooding from Lagunitas Creek.
10-Year Event	<7.8	No potential for flooding from Lagunitas Creek. Pasture just east of Gradjanski property flooded.
50-Year Event	<8.8	Flooding. Very eastern edge of Gradjanski property flooded by Lagunitas Creek. No potential for flooding of home.
100-Year Event	<10.1	Flooding. Larger portion of eastern edge of Gradjanski property and eastern edge of Lucchesi/Kostelic properties flooded by Lagunitas Creek. No potential for flooding of homes.
500-Year Event	~ 11.8 – 13.0	Flooding. Eastern half of private properties flooded by Lagunitas Creek. Flooding close (~ 1 foot) to lowest elevation home. Flooding 3- to 4 feet below elevation of other two homes.

TABLE 20. FLOOD DISCHARGE ESTIMATES FOR VARIOUS RETURN INTERVALS

	FEMA (1997) 107.3 mi²	USGS 81.6 mi²	KHE[1] 81.6 mi²	FEMA/NPS 14.6 mi²	FEMA[3] 15.2 mi²	KHE 15.2 mi²
Year/Flood Return Period	Lagunitas Creek at Olema Ck. (107.3 mi²) (cfs)	Lagunitas Creek at Pt. Reyes (81.6 mi²) (cfs)	Lagunitas Creek at Pt. Reyes (81.6 mi²) (cfs)	Olema Creek At Bear Valley Rd. (14.6 mi²) (cfs)	Olema Creek At Lagunitas Creek (15.2 mi²) (cfs)	Olema Creek At Lagunitas Creek (15.2 mi²) (cfs)
Reported Discharge						
1982	n/a	22,100	n/a	n/a	n/a	4117
1998	n/a	12,200	n/a	2503[2]	2,599	n/a
2005	n/a	17,700	n/a	n/a	n/a	4117
Predicted Discharge						
2-yr	n/a	n/a	3515	n/a	n/a	1193
5-yr	n/a	n/a	8,051	n/a	n/a	2152
10-yr	14,700	n/a	11,597	3,590	3,728	2815
50-yr	25,000	n/a	19,830	5,150	5,348	4624
100-yr	28,050	n/a	23,268	5,720	5,939	n/a
500-yr	34,840	n/a	30,799	6,810	7,071	n/a

Notes: 1) Flow estimates from flood frequency analysis (KHE 2006a).
2) From B. Ketcham, Seashore, *pers. comm*. 2003.
3) FEMA 1997 estimates increased by ratio of drainage areas (15.2 mi²/14.6 mi²).

Table Source: KHE 2006a

Disease and Public Health

Background and Regulatory and Policy Setting

Public diseases can be transmitted through a variety of ways, including person-to-person, as well as animal-to-person, contact. Some diseases are transmitted through direct contact such as biting of an insect such as a tick or a mosquito. Others are transmitted indirectly such as transmission of the Hantavirus through respiration or breathing in of air containing virus-laden particulate from fecal matter generated by mice or exposure to air contaminated by birds carrying the avian flu. Some of the most problematic vectors of disease are those that are extremely common, difficult to avoid, and/or difficult to detect such as ticks, mosquitoes, and mice. Each of these vectors shows affinity for particular types of habitats or conditions, although ticks, which are primarily an "upland" problem, can be occasionally found in upland ecotone or high marsh areas bordering marshes that are flooded more infrequently.

Because of mosquitoes' affinity for water, wetlands are typically considered breeding grounds for these insects, although any land that has stagnant or standing water such as old tires, septic systems, abandoned pools, clogged roof gutters, and rice fields or other agricultural operations poses a risk for supporting mosquitoes. Mosquitoes are dipteran insects with aquatic immature stages and an aerial adult stage (Kwasny et al. 2004). Depending upon seasonal and environmental factors, it generally takes three to 12 days for a mosquito to complete its life cycle from developed egg to early adult stage (Kwasny et al. 2004). Mosquitoes are sometimes separated into two groups: floodwater mosquitoes and standing water mosquitoes (Kwasny et al. 2004). Floodwater mosquitoes have eggs that can withstand dry summer conditions in soil, leaf litter, or at the bases of plants until seasonal summer or fall flooding triggers eggs to hatch, pupate, and emerge as adults (Kwasny et al. 2004). This type of mosquito commonly occurs in managed seasonal wetlands such as those in San Francisco Bay and the Central Valley (Kwasny et al. 2004). Standing water mosquitoes lay their eggs in water or on emergent vegetation in water (Kwasny et al. 2004).

Both floodwater and standing water mosquitoes require water for some portion of their life cycle. Typically, mosquitoes need stagnant, still, or "standing" water that is not subject to high flow velocities or dynamic circulation patterns such as strong wind fetch or daily tidal flushing to breed and complete their growth cycle. Wave action across larger bodies of water physically retards mosquito production by inhibiting egg laying and

decreasing larval survival (Jones & Stokes Associates 1995). In addition to water residence time, success of mosquitoes' breeding efforts is affected by water quality such that higher temperatures and higher organic content tend to produce greater number of mosquitoes (Collins and Resh 1989). Also, the pattern of flooding may affect mosquito numbers, with gradual increases or decreases in water levels more conducive to breeding than stable or rapidly fluctuating water levels (Jones & Stokes Associates 1995). Many mosquito species attach their eggs to emergent vegetation, which increases the attractiveness of stagnant waters with some emergent vegetation cover such as drainage ditches in diked areas. Emergent vegetation also decreases the ability of natural predators to prey upon mosquitoes.

Mosquitoes affect public health not only by causing localized allergic reactions on skin when mosquitoes bite people, but through transmitting diseases to humans and other birds and mammals. One of the first diseases linked to mosquitoes was malaria, an ancient disease that originated in Africa and that has killed millions during the past couple of centuries (AMCA 2005). Malaria incidences decreased in the mid 20th century when use of pesticides began to control populations of the genus responsible for transmission of the disease, Anopheles (AMCA 2005). Other diseases associated with mosquitoes are dog heartworm, encephalitis, yellow fever, and, most recently, West Nile Virus.

West Nile Virus is an "arbovirus" or arthropod-borne virus that is primarily transmitted by mosquitoes. Its reservoir host is birds, which means that birds can carry the virus and transmit to mosquitoes that bite them unlike people, horses, and most other mammals that act only as incidental or "dead-end" hosts (CDC 2004). Unlike malaria and dengue fever, which are carried by only one type or genus of mosquito, several genera – a total of 44 species -- can carry West Nile. These mosquitoes bite birds carrying the virus and then transmit it to humans and other animals such as horses. As with many diseases, the virus causes either no symptoms or a mild illness with flu-like symptoms in most individuals, but, in relatively rare cases, particularly with immuno-compromised individuals and the elderly, West Nile can progress to encephalitis, inflammation of the brain, or neurodegenerative disease. The virus was first detected in the United States in 1999 in New York City (DHS 2006). Since then, it has spread to 44 states, including California, where it was first identified in 2002 (DHS 2006). In 2005, West Nile Virus activity in birds was found in 54 of California's 58 counties (DHS 2006). As of the end of 2005, 927 human infections from 40 counties had been reported to date, and there were 18 fatalities in California, all of which were in the Central Valley or southern California (DHS 2006). In Marin County, there have been no reported human cases, although 14 dead birds have tested positive for the virus (DHS 2006).

Mosquitoes, as well as birds, can also be tested for the virus. DHS presented detailed data for Alameda and Contra Costa counties in east San Francisco Bay. Within these counties, five species of *Culex* mosquitoes tested positive for West Nile in 2005, two of which appeared to have the highest rates of being infected: southern house mosquito (*Culex quinquefasciatus*) and the Western encephalitis mosquito (*Culex tarsalis*), the latter of which is also the carrier for Western Equine Encephalitis. None of the mosquitoes tested to date in Marin County have tested positive for West Nile, but the county has seven mosquito species present that have tested positive elsewhere in California or the United States, including mosquitoes in the genera *Culex*, *Ochlerotatus*, and *Anopheles* (District, unpub. data). The two species that appear to pose the highest threats based on rates of infection are the northern house mosquito (*Culex pipiens*) and potentially the Western encephalitis mosquito (Marin and Sonoma County Mosquito and Vector Control District 2005). Marin has grouped the northern house mosquito with the southern house mosquito (District, unpub. data), probably because they represent subspecies that occur in different climatic regions, but which can hybridize where they occur together.

The rates of infection within particular mosquito species does not directly correspond to rates of disease transmission, because certain mosquitoes have higher affinities for biting humans than others or do not migrate far from larval habitat. *Culex pipiens* is the most common pest species in urban and suburban setting and, therefore, according to the District, represents the most immediate threat to humans in towns and cities of Marin and Sonoma Counties. This species typically bites birds, but certain urban "strains" appear to prefer mammals, including humans (Savage and Miller 1995). *Culex tarsalis* (the "encephalitis mosquito") may be another important local vector. *Culex tarsalis* primarily bites birds, but will bite humans, livestock, and other mammals if the opportunity presents itself (Kwasny et al. 2004). This switching of host species, combined with the ability of this species to travel long distances, makes it a potent vector of arboviruses, and laboratory data suggests that this species may become the primary vector of West Nile in California (Kwasny et al. 2004).

California law requires that, if a problem source of mosquito production exists in waters or lands that have been artificially altered from natural conditions, the party responsible for those conditions is liable for the cost

of abatement (California Heath and Safety Code 2000 *et seq*.). Enforcement of this law is the responsibility of local mosquito abatement districts, which are the governmental organizations responsible for controlling specific disease vectors within their jurisdiction. As their name implies, mosquito abatement districts are primarily responsible for controlling mosquitoes as pest species and disease vectors.

Because of concerns regarding West Nile, the western portion of Marin County was annexed into the District in 2005. Through annexation, which required 50 percent approval from West Marin residents, the district expanded its jurisdiction to add 42,000 parcels, 7,000 of which were in Marin County. The annexation drew strong protests from some members of the West Marin community over fears that the District would use chemical pesticides for mosquito control. Specifically, concerns were expressed about use of methoprenes and pyrethins, both of which have been linked in the literature to toxicity in aquatic organisms, including salmon and frogs. Community representatives have been working with the District to test non-toxic approaches to mosquito control that include education and limited use of larvicides that kill mosquitoes during the larvae stage of development. These larvicides contain a naturally occurring bacterium (*Bacillus thuringiensis israelensis*) that is common in soils. A one-year Memorandum of Understanding (MOU) with community groups signed by the District in 2006 limits pesticide use to these larvicides except during public health emergencies (District, unpub. data).

Jurisdiction of mosquito abatement districts extends over private, county, and state lands, but not federal lands. Federal agencies are responsible for vector control on federal lands. The Park Service has established management policies regarding management of pests, with control of native pests such as mosquitoes only advocated if these pests pose a "significant threat to human safety" as determined by the U.S. Public Health Service, which includes the CDC (NPS 2001). The Park Service requires each park unit to establish an Integrated Pest Management Program (IPM) to reduce risks from pests to the public, park resources, and the environment (NPS 2001). While the District does not have jurisdiction over the GGNRA and Seashore lands, the parks allowed the District to trap mosquitoes on Park Service lands for identification purposes in 2005.

Mosquito Species and Habitats in the Project Area and Vicinity

Three days of mosquito trapping in June 2005 in the Project Area and other parts of the Seashore found eight species of mosquitoes, and six of these either also or exclusively occurred on the Giacomini Ranch (District, unpub. data). Mosquitoes on the Giacomini Ranch included the Western encephalitis mosquito, tule mosquito (*Culex erythrothorax*), banded foul water mosquito (*Culex stigmatosoma), Culiseta particeps, Culiseta inornata, and Ochlerotatus dorsalis* (District, unpub. data). Based on this limited sample size, the most common species appeared to be the Western encephalitis mosquito, tule mosquito, *Culiseta particeps, and Culiseta inornata*. At least one occurrence of the northern house mosquito was documented in the Olema Valley, but not on the Giacomini Ranch (District, unpub. data). However, results of the sampling could be skewed by the season chosen for sampling (early summer), with certain species potentially not active, or not as active, during this time of year. Park Service staff observations point to mid- to late summer, particularly August, as the peak periods of mosquito abundance.

Of the mosquito species identified on the Giacomini Ranch, three of these have tested positive in California for West Nile: the Western encephalitis mosquito, tule mosquito, and banded foul water mosquito (District, unpub. data). As noted earlier, the Western encephalitis and northern house mosquitoes have been identified by the District as posing the highest risk of West Nile Virus transmission. The Western encephalitis mosquito is a standing water species that lay its eggs in water, and adults can emerge continuously throughout the summer and fall in areas that have been flooded for an extended period of time, usually for more than 2- to 3 weeks. These seasonally to semipermanently flooded areas include rice fields, poorly drained pastures, semi-permanent and permanently flooded wetlands, sewer treatment plants, and dairy farms (Kwasny et al. 2004). The tule mosquito is another standing water mosquito that deposits its eggs among thick vegetation on the edges or margins of lakes and inland ponds and is one of the few mosquitoes that feeds actively during the day (Kwasny et al. 2004). The banded foul water mosquito is so named because of its association with polluted waters: it typically lives for two to three weeks, but females can live up to several months in cooler climates (Napa County Mosquito Abatement District 2004).

On the Giacomini Ranch, District trapping efforts focused on those areas that are seasonally wet for long periods of year (District, unpub. data). As described under Vegetation Resources, the Giacomini Ranch has remained largely wetland despite being diked more than 60 years ago. Flooding from creeks, run-off, groundwater, and, to a certain degree, tides, creates areas with a wide range in the amount of inundation or saturation, lasting from just a few days to throughout the year. Most of these areas are extensively

vegetated, with the exception of irrigation drainage ditches and ditched sloughs that have been dredged to remove vegetation. While levees were obviously constructed to exclude flooding from Lagunitas Creek and Tomasini Creek into the pastures, based on hydrologic modeling, they also act to impound waters within the pastures, particularly in the northern portion of the pastures, thereby prolonging the duration of inundation and saturation (KHE, unpub. data). Construction of extensive ditch systems to drain pastures and/or convey irrigation waters also creates stagnant standing water areas that often become vegetated, if not consistently dredged. While currently allowing muted tidal flow due to modifications or malfunctioning, one-way tidegates installed on Fish Hatchery and Tomasini Creeks do not allow waters within these creeks to fully drain during low tides, which creates stagnant or backwater conditions. The overall numbers and seasonal patterns in abundance of mosquitoes have also probably been affected by seasonal irrigation within the East Pasture. Most of the southern portion of the East Pasture is flood irrigated for several months during the summer, often create standing water for several weeks, while fields in the northern portion are typically spray-irrigated. Near the dairy facility, the Giacominis also maintain several waste ponds, where mosquitoes have apparently been documented in the past.

While no quantitative sampling has been performed, based on Park Service staff observations, mosquito numbers typically appear to be much lower in the undiked marsh than in the northern portion of the West Pasture, although mosquitoes are still present. Because many of the species typically rest during the day, only biting when disturbed or when hosts are present nearby, this suggests that most of the mosquitoes encountered in the undiked marsh are residents, although some may fly over from nearby diked areas..

Fish surveys on the Giacomini Ranch have documented non-native mosquitofish in both the East and West Pasture creeks, drainage ditches, and ditched sloughs (NPS, unpub. data). The Giacominis most likely introduced these species at some point to control mosquito populations. This fish species has been observed only in very low numbers in the immediate vicinity outside the Ranch (NPS, unpub. data). Mosquitofish are considered to be relatively tolerant of the harsh aquatic conditions that exist in some of the Project Area's waters. Many of the drainage ditches and ditched sloughs have very low to no oxygen, even during the day, and high levels of nutrients and pathogen indicators such as fecal coliform (see Water Resources – Water Quality). These hypoxic and even anoxic conditions create poor habitat for other types of native mosquito predators such as native fish and other insects that might help control mosquito populations.

Limited mosquito trapping has been conducted at or near Olema Marsh (District, unpub. data). The most recent sampling in October 2005 found five species of mosquitoes, with the tule mosquito (*Culex erythrothorax*) by far the most prevalent (District, unpub. data). Other species observed included the banded foul water mosquito (*Culex stigmatosoma*), northern house mosquito (*Culex pipiens), Culiseta particeps, and Culiseta inornata* – many of the same species that occur at the Giacomini Ranch (District, unpub. data). Again, at least three of these species – northern house mosquito, tule mosquito, and banded foul water mosquito – are ones that have tested positive for West Nile Virus in California. The water drainage problems in Olema Marsh that have resulted in longer water residence times and stagnant water conditions increase the potential for mosquito breeding within this large freshwater marsh habitat.

Public Services

Municipal Water Supply

Regional and Project Area Setting

Marin County is served by five water districts. These water districts obtain water supplies from local surface water reservoirs, groundwater, and through agreements for imported water with out-of-county agencies such as the Sonoma County Water Agency. The districts are responsible for providing water to residents and seeking new sources of water when projections indicate a potential long-term deficit in supply. The Project Area is located within the North Marin Water District (NMWD) West Marin Service Territory. NMWD also services Novato in eastern Marin County, however, there is no direct connection of water supply between the two service territories. Freshwater flow on Lagunitas Creek, which flows through the Project Area, is largely controlled, however, by five dams operated by the Marin Municipal Water District (MMWD), which services most of the rest of eastern Marin County. Water supply for the community of Inverness, northwest of the Project Area, is provided by a smaller district, the Inverness Public Utilities District.

Within the West Marin area, NMWD services the towns of Point Reyes Station, Olema, Bear Valley, Inverness Park, and Paradise Ranch Estates. NMWD has 775 active accounts in the West Marin service area, which equates to about 1,769 people using NMWD's estimate of 2.28 people per account (D. McIntyre, NMWD, *pers. comm*.). Currently, the West Marin service area water demand totals approximately 316 acre-feet per year (afy). The projected future demand is 480 afy. NMWD is currently working on a long-range water system plan to identify required facility replacement and improvements needed to properly serve existing and future customers in the West Marin service areas.

NMWD currently obtains its water supply for the West Marin service area from two wells located adjacent to Lagunitas Creek on the U.S. Coast Guard (USCG) property in Point Reyes Station (Figure 37). These wells were installed in 1970. Prior to installation of the wells, NMWD had conducted a study of potential groundwater sources for a potential development project on the east shore of Tomales Bay and concluded that the only aquifers capable of yielding significant amounts of water were in alluvial deposits along stream channels (NMWD 1967).

The Coast Guard wells are located approximately 50-feet from the edge of Lagunitas Creek with perforations starting 5-feet below the surface of the creek (SWRCB 1995). The wells are 60-feet deep and extend to bedrock, which is located about 50 feet below the surface of the stream (SWRCB 1995). Recent investigations into stratigraphy of this general area associated with Point Reyes Affordable Housing Project show that soils consist of alluvial deposits (fluvial or creek material), terrace deposits (marine material), and bedrock, which is shale, sandstone, and claystone and believed to be part of the Millerton Formation (Questa Engineering Corp. 2000). The alluvial deposits generally consist of gravelly loams at the surface with interbedded layers of gravelly sands and clays of varying thickness and density (Questa Engineering Corp. 2000). The wells are located in alluvial deposits of unconsolidated sand, silt, and gravel at the lower end of Lagunitas Creek, with the depth of alluvium restricted by the depth to bedrock (SWRCB 1995). A NMWD description of soils encountered during construction of the well indicates the upper 15-feet of alluvial deposits at the Coast Guard wells consist of brown sandy loam (KHE 2006a). Blue sandy clay occurred between 15- and 30-feet below ground surface (bgs), followed by blue sandy clay with some gravel from 30- to 35-feet bgs (KHE 2006a). Five feet of "washed" gravel was encountered from 40- to 50-feet bgs, followed by 10-feet (50- to 60-feet bgs) of brown cemented gravel and clay (KHE 2006a). Bedrock occurred below 60-feet (KHE 2006a).

Capacity of the Coast Guard wells is approximately 807 to 968 afy, which equals approximately 500 to 600 gallons per minute (gpm). The water is pumped from the wells to the Point Reyes Water Treatment Plant, where it is treated before being piped to end users. Treatment typically involves removal of iron and manganese using potassium permanganate and green sand filtration, followed by disinfection with chlorine. Once treated, the water can be stored before it is distributed. The Point Reyes area has three water storage tanks with a total storage capacity of 500,000 gallons. From this facility, water is distributed to Olema, Bear Valley, and Inverness Park in the West Marin Service area: distribution pipelines are discussed further below.

NMWD has two other active wells that it has developed –the Downey Well and the Gallagher Well. The Downey and Gallagher wells are located at varying distances upstream of the Coast Guard wells on Lagunitas Creek (Figure 37). The Downey Well is no longer used for municipal water supply, although approximately 2 cfs of water is pumped from this well during the summer to the Giacomini Ranch for irrigation purposes as part of NMWD's agreement with the Giacomini family. The Gallagher Ranch well is used for emergency purposes and is not currently connected to the West Marin distribution system, although NMWD is contemplating further development of this well in the future to meet existing demand and offset seasonal quality problems with the Coast Guard wells.

FIGURE 37. LOCATIONS OF NMWD WELLS AND PIPELINES

Regulatory and Policy Setting

Federal and state regulations and policies protect both the supply and quality of drinking water for the public. The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources, which include rivers, lakes, reservoirs, springs, and ground water wells. SDWA authorizes the USEPA to set national health-based primary standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. Within California, the authority for implementation of the SDWA has been delegated to the California Department of Health Services (DHS). The California Safe Drinking Water Act (CA SDWA) was passed to build on and strengthen the federal SDWA. The CA SDWA authorizes DHS to protect the public from contaminants in drinking water by establishing maximum contaminants levels (MCLs) that are at least as stringent as those developed by the U.S. EPA, as required by the federal SDWA. In addition to primary standards, DHS has also set secondary drinking water standards and MCLs for analytes or contaminants of lesser concern that affect the taste, odor, or appearance of drinking water such as chlorides.

Protection of drinking water supplies also occurs through the Porter-Cologne Act. Water quality control plans designate beneficial uses of water for specific water bodies, establish water quality objectives to protect those uses, and provide a program to implement the objectives: one of those beneficial uses is municipal and domestic water supply. For Lagunitas Creek, SWRCB has designated municipal and domestic water supply as a beneficial use, as well as contact and non-contact recreation, agricultural supply, cold freshwater habitat, fish migration, preservation of rare and endangered species, recreation, fish, spawning, and wildlife habitat. A more complete description of this law can be found under Water Resources – Water Quality. Marin County also regulates activities that substantially degrade or deplete groundwater resources, interfere with groundwater recharge, or substantially degrade surface or groundwater quality through CEQA review.

Municipal Water Supply Issues – Water Distribution

NMWD supplies water to its customers using a network of pipelines, which are either buried belowground or suspended below bridges. There are no water collection, treatment, or storage facilities within the Project Area, but some of distribution pipeline systems are present. Approximately 185,000 gallons of water is piped via an 8-inch asbestos cement, steel, PVC, or iron pipeline system to Levee Road, Inverness Park, and Bear Valley service areas through a pipeline that runs from Point Reyes Station on the north side of State Route 1 and Levee Road to the Sir Francis Drake Boulevard/Bear Valley Road intersection. The pipeline is suspended underneath the Green Bridge and the Olema Creek Bridge on Levee Road, but is buried below ground at both the current eastern outlet and former western outlet of Bear Valley Creek near Olema Marsh (NMWD, unpub. data). The pipeline is buried directly adjacent to the road at the current eastern outlet of Bear Valley Creek, but, at the former western outlet (and current outlet for the Silver Hills drainage), the pipeline route has been diverted slightly such that the pipe is located approximately 100 feet from Levee Road. The current depth of the underground pipeline along Levee Road is unknown, particularly in creek areas where there is potential for changes in surface grade elevations due to sedimentation or erosion, but most buried pipelines are installed so that the top of the pipe is approximately 3 feet below existing grade (C. Chandrasekera, NMWD, *pers. comm*.). From the intersection with Bear Valley Road, a 6-inch pipeline runs to Inverness Park along the western side of Sir Francis Drake Boulevard in Inverness Park (NMWD, unpub. data). Another pipeline runs on the western side of Bear Valley Road to Fox Drive with connections to other pipelines servicing the Silver Hills community and the Bear Valley storage tanks (NMWD, unpub. data). The Bear Valley Road pipeline does not cross Bear Valley Creek.

Municipal Water Supply Issues – Salinity Intrusion

In 1976, NMWD started having problems with salinity intrusion into the Coast Guard wells. Water districts are required by law to provide safe drinking water for customers. The 1995 Basin Plan (RWQCB 1995a) specifies that “controllable water quality factors shall not increase the total dissolved solids or salinity of waters of the state so as to adversely affect beneficial uses, particularly fish migration and estuarine habitat.” In addition, the California Department of Health Services (DHS) sets chloride levels in potable water as a secondary drinking water standard (NMWD 1997). Chloride is a conservative ion, meaning that it does not change forms or bind readily to soils, and is therefore considered a good indicator of water salinity. Chlorides occur in

waters derived from both marine and terrestrial sources such as surface waters (fluvial or creek, run-off, etc.) and groundwater, with mineral content of terrestrial sources determined by weathering of rocks native to the area. Primarily for aesthetic reasons, DHS has set the recommended maximum contaminant level (MCL) for chloride at 250 mg/L (NMWD 1997). The upper MCL is 500 mg/L (NMWD 1997). A chloride concentration of 250 mg/L is considered the taste threshold for most people, however, often people can taste levels as low as 100 mg/L (NMWD 1997). In addition to aesthetic concerns, elevated salinities can pose problems for people with sodium issues and are often accompanied by increases in manganese that result in discoloration of treated water effluent (NMWD 1997). NMWD has established 100 mg/L as its taste and odor threshold (NMWD 1997).

Salinity intrusion is a common concern for water districts located in coastal watersheds that rely on groundwater for supplies. Typically, this type of salinity intrusion problem results from overpumping of "fresh" aquifers for municipal and agricultural water supplies, which allows intrusion of underlying marine-dominated saline "groundwater" from bays or oceans to move landward. Based on groundwater gradient data collected to date, there is no evidence that this phenomenon is occurring in the Lagunitas Creek watershed (Questa Engineering Corp. 2001). Despite considerable study, the exact cause of salinity intrusion in the Coast Guard Wells is still uncertain, but mechanisms governing salinity intrusion are likely to be complex and involve a combination of many factors. Starting in the early 1990s, when the Park Service began discussions with the Giacominis regarding purchase of the Giacomini Ranch, a number of studies have been conducted to evaluate salinity intrusion dynamics at the Coast Guard wells, including studies by Philip Williams and Associates (1996a; 1996b), NMWD and Soldati Engineering (NMWD 1997), and Kamman Hydrology & Engineering, Inc. (KHE 2006a) as part of baseline studies for the proposed project.

Salinity intrusion into the Coast Guard wells first occurred in 1976-1977 coinciding with an extreme two-year drought event (NMWD 1997). In the 1970s, the Giacomini family was still installing the gravel summer dam each summer downstream on Lagunitas Creek for the purposes of drawing irrigation water to increase pasture forage (See Water Resources for more detailed description). The summer dam was located approximately 2,500 feet downstream of the Green Bridge and 5,700 feet downstream of the Coast Guard wells (NMWD 1997). In addition to providing irrigation waters for Giacomini, the summer dam had the additional benefit of being "an effective barrier to prevent saltwater from flowing upstream in the groundwater basin during high tide cycles and contaminating the District's Coast Guard wells" (NMWD 1997). The dam created a pond that was about 7-feet deep and extended about 1.75-miles upstream, inundating approximately 17-acres (SWRCB 1995). Giacomini typically installed the dam in May or June, with removal occurring in November or December, often by large creek flows associated with rainfall events (NMWD 1997).

In 1976, when the gravel dam was removed on January 18, 1976, chloride levels within the wells rose from 29 mg/L to 106 mg/L in 10 days, peaking at 230 mg/L on February 10, and did not dip below 100 mg/L until March 1977 (NMWD 1997). Creek flow had been below 4 cfs for several months and, during the month of January, consistently fell below 3 cfs, dropping as low 1.6 cfs during this period (USGS Point Reyes gage). The day following removal of the dam, predicted tides at Inverness peaked at 6. 1 feet MLLW, with salinity intrusion occurring approximately 8 days after the last high tide exceeding 5.5 feet MLLW. The following winter, the dam was removed on January 4, 1977, and chlorides within the well rose to 198 mg/L, approximately 10 days after the end of the last higher high tide series. From 1976 through 1997, salinity intrusion events as determined by chloride levels exceeding 100 mg/L occurred in six separate events: January-February 1976, January - May 1977, December 1977, December 1980-January 1981, January-February 1981, and December 1986 (NMWD 1997). Based on monthly and weekly data collected by NMWD, well chloride concentrations remained far below 100 mg/L between 1987 and 1997 (NMWD, unpub. data *in* KHE 2006a).

Based on qualitative analysis of the data, NMWD was not able to find a strong correlation between high tides and salinity intrusion events, perhaps because of the "noise" generated by so many other factors such as pumping rates, dam operation, etc. However, through an analysis of patterns in the data, NMWD concluded that, during this period, salinity intrusion events appeared to occur when several factors coincided, specifically 1) the dam was down, 2) Lagunitas Creek flows were lower than 5 cfs for several weeks, and 3) tides as predicted for Inverness exceeded 6.4 ft MLLW (NMWD 1997). Other findings included that infrequent high chloride levels recorded in the creek typically occurred one to two weeks before elevated chlorides were detected in the well and that, once salinity intrusion occurred, chloride levels would remain elevated (>100 mg/L) from three weeks to as long as 16 weeks (NMWD 1997). Earlier, PWA concluded that the Coast Guard wells could operate without saltwater affecting the wells for flows above 6 cfs, although the occasional spring tide would push the salinity front upstream above the wells at high tide (PWA 1996b). PWA also noted the

"considerable time lag" of one week between occurrence of high chlorides in the creek and high chlorides in the well (PWA 1996b).

Between 1970 and 1997, when the summer dam was installed annually, salinity intrusion appeared to only occur in the winter or season of higher high tides -- typically December through February with tides exceeding 6.0 feet MLLW -- when the dam was down, but streamflows were low (<5-6 cfs), either because the rainy season had not started yet or because of drought (1976-1977). The one salinity intrusion that occurred when the dam was installed took place during the drought when the dam was put in after the winter high tide series, thereby probably trapping saline waters that could be diluted by the minimal streamflow present (NMWD 1997).

In the 1990s, several events occurred that caused NMWD to become concerned about the long-term future of the Coast Guard wells in terms of providing potable water to West Marin customers. The State Water Resources Control Board (SWRCB) was reevaluating the advisability of continuing to issue permits to the Giacominis for annual installation of the gravel summer dam because of concerns regarding impacts to beneficial uses within Lagunitas Creek such as water quality and support of wildlife, particularly to coho salmon and steelhead. In 1995, the SWRCB issued a decision to not issue the Giacominis a permit for installation of the gravel summer dam, effective in 1997. The SWRCB also mandated minimum in-stream flow requirements of 8 cfs during average- and wet-year summers and 6 cfs during dry-year summers as measured at the Samuel P. Taylor USGS gage, with instream flow requirements rising to 20 cfs required in November.

Concurrently, the Park Service began actively discussing with the Giacomini family purchase of 550 acres of the Giacomini Ranch for wetlands restoration. Specifically, NMWD was worried that wetland restoration through removal of levees would move the saltwater-freshwater interface upstream closer to the wells (NMWD 1997). While the feasibility study conducted in 1993 only fleetingly referred to the salinity intrusion issue (PWA et al. 1993), the Park Service subsequently contracted with PWA to evaluate in greater detail the potential for the restoration project to increase salinity intrusion into the Coast Guard wells. A number of technical memoranda were prepared in April and May 1996 (PWA 1996a, 1996b).

Concerned about the loss of the gravel dam and the potential for the ranch to be restored to tidal wetlands, NMWD contracted with Soldati Engineering to analyze all of the water quality and other data collected to date to assess the potential for future salinity intrusion events and identify ways to provide adequate, good quality water to the West Marin area given the coming changes. The NMWD study (1997) recommended implementation of off-tide pumping practices. Under this practice, NMWD stops pumping for a six hour period (three hours before to three hours after) peak tides, when the predicted tide at Inverness is greater than 5.9 feet. Based on NMWD data, with implementation of the off-tide pumping practices, there have been a few periods since 1997 in which the salinity intrusion threshold of 100 mg/L either came very close to being exceeded (>90 mg/L; August 2001, October 2002 June 2003) or was exceeded (>100 mg/L; November – January 2003; July – September 2004; NMWD, unpub. data). There were no salinity intrusion events in 2005.

As part of the Point Reyes Affordable Housing Project, Questa Engineering Corp. performed a hydrogeologic investigation for the area located west of the USCG property in the town of Point Reyes Station on Mesa Road (Questa Engineering Corp. 2000). Because of concerns related to the impact of proposed leach fields on the Coast Guard wells and municipal water supply, Questa (2000) performed a detailed groundwater investigation and analysis. Questa (2000) determined that the housing project largely occurred outside the Zone of Contribution or recharge area to the Coast Guard wells. Groundwater gradients generally followed topographic gradient with waters flowing from the coastal marine terrace uplands into the adjacent Lagunitas Creek aquifer in which the Coast Guard wells are constructed (Questa Engineering Corp. 2000). However, while groundwater generally followed topographic gradients, to the east and southeast of the housing project, "there is a distinct turning of the groundwater contours towards the east that reflects the draw-down influence of the NMWD water wells" (Questa Engineering Corp. 2000). Questa (2000) concluded that the area where this shift in groundwater gradient direction occurred represented the apparent Zone of Contribution or recharge area for the Coast Guard wells, which appears to be oriented along the axis of Lagunitas Creek (Questa Engineering Corp. 2001). Questa noted in its report that, while the Coast Guard wells are "recharged largely by the streamflow/underflow of Lagunitas Creek," lateral inflow from the adjacent hills appears to play a role, as well, although probably "to a lesser degree."

As part of its investigation, Questa collected water samples from monitoring wells for analysis in December 1999, January 2000, and March 2000. Despite the fact that it was winter, chloride concentrations in groundwater sampled during this period still ranged from 48 to 138 mg/L, compared to 18 to 35 mg/L for well

and creek water samples collected by NMWD during all of 1999 (Questa Engineering Corp. 2000). Water quality testing results indicate that elevated late-season chloride concentrations in groundwater are reduced significantly through the winter wet season, likely due to increased surface water recharge (KHE 2006a). In its response to comments on the draft EIR, Questa postulated that "tidal effects in Lagunitas Creek in the vicinity of the NMWD wells are more likely to have a stabilizing influence on groundwater levels during drought conditions" by maintaining the existing groundwater gradient and, thereby, the existing groundwater travel time from the eastern boundary of the housing project to the wells, estimated to be on the order of 2 to 3 years (Questa Engineering Corp. 2001).

As part of hydrologic analyses and modeling contracted for under the proposed project, KHE evaluated prior research into salinity intrusion events, as well as data collected by both NMWD and the Seashore. NMWD data included discrete water quality data (weekly and quarterly samples that include chloride and other ions), pumping rates, stream flow, predicted tides at Inverness, well completion reports, and miscellaneous correspondence (KHE 2006a). The Seashore and KHE also collected additional topographic information upstream of the Green Bridge to improve hydrodynamic model calibration, discrete water samples and salinity sampling during high tides, and continuous water level and salinity data for portions of September and October 2005. NMWD also collected additional discrete sample data during a high tide series in October 2005. Representatives from KHE and the Seashore met with NMWD representatives several times to coordinate monitoring efforts and discuss available data and preliminary findings. One of the factors that improved data analysis capabilities relative to the 1997 efforts was the availability of continuous water quality data (continuous quasi-conductivity data), which is collected at the treatment plant by NMWD. This data provided a finer level of detail on fluctuations in salinity at the treatment plant in relation to stream discharge, pumping, and tides. Both monitoring and modeling investigations focused on the reach or section of Lagunitas Creek adjacent to the NMWD Coast Guard wells, which previous studies had pointed to as the area where infiltration was probably occurring.

Continuous and discrete monitoring data collected by KHE and the Seashore during the low-flow period in September-October 2005 indicate that tidally-driven water level changes occur in Lagunitas Creek adjacent to the Coast Guard wells when predicted tides at Inverness exceed approximately 3.7 feet MLLW (KHE 2006a). However, tides did not increase water salinity from base levels of approximately 0.1 ppt until water levels in the creek reached approximately 5.1 feet and predicted tides at Inverness had risen to approximately 4.8 to 5.0 feet MLLW (KHE 2006a). The maximum salinity observed in this period occurred when predicted tides reached 5.73 feet at Inverness and was 1.5 ppt, with 1 ppt of seawater containing approximately 560 mg/L of chloride (KHE 2006a). Salinities quickly returned to baseline concentrations once tide levels dropped, suggesting that creek flows – which averaged 9.0 cfs during the monitoring period – quickly flushed salts out of this portion of the creek (KHE 2006a). In addition, no strong stratification occurred within this "pool," meaning that there was no meaningful difference in salinity between surface and bottom waters (KHE 2006a).

Because salinity intrusion has been believed historically to be related to surface flows or shallow subsurface flow governed by surface flows, the KHE model did not include groundwater. Data analysis and hydrodynamic modeling of surface water flows by KHE (2006a) focused primarily on conditions in the reach of Lagunitas Creek adjacent to the Coast Guard wells since 1997, after the old summer dam was discontinued. As flows during the monitoring period exceeded average and dry-year minimum flow requirements, KHE used the monitoring data to calibrate the hydrodynamic model and investigated maximum summertime salinities under both average-year (8 cfs) and dry-year (6 cfs) flows (KHE 2006a). Simulation results suggested that the highest salinities under average-year flows would be approximately 1.6 ppt and would exceed 1.5 ppt only 1 percent of the time. Under average-year summer flow and high tide conditions, simulated average salt concentrations would reach 700 mg/L in a 330-foot reach or section of Lagunitas Creek during a tide series where water levels exceed 5.5 feet MLLW and peak at over 6 feet MLLW (KHE 2006a). With a 2 cfs drop in streamflow to 6 cfs, maximum salinities would increase to approximately 3.2 ppt and would exceed 3.0 ppt less than 1 percent of the time (KHE 2006a). Under dry-year summer flow and higher high tide conditions, simulated average salt concentrations would climb to 1,692 mg/L in the 330-foot section of Lagunitas Creek adjacent to the Coast Guard wells (KHE 2006a). Because the model is incorporating extreme boundary conditions (freshwater to saltwater), the model sometimes overestimated and sometimes underestimated salinities relative to observed salinities, but differences between simulated and observed on the higher high tides modeled never differed more than by 0.3 ppt, which is well within generally accepted industry standards for hydraulic modeling (KHE 2006a).

Based on review and analysis of monitoring data and modeling results, KHE (2006) concluded that the process of chloride delivery to the wells is more complicated than simply intrusion of saltwater during high tides and low-flow events, and other mechanisms may be contributing or even account for delivery and sources of salt

to the wells. Important observations, trends, and conclusions from the KHE study (2006a) and other studies are:

- Analysis of the long-term monitoring data from NMWD and data collected by KHE and the Park Service suggest that patterns in salinity observed since 1997 represent two superimposed – and possibly interconnected – trends.

- A large-scale, quasi-seasonal trend sometimes resembling a left-skewed bell curve in which salinity generally (but not always) increases abruptly in summer each year after streamflows drop below 9–10 cfs – often around July -- and continues to either steadily or incrementally increase through the summer to the fall or early winter when it peaks and then gradually tapers off through late winter and spring. The decrease in salinities appears to steadily taper off regardless of increases in stream discharge associated with reservoir releases or fall storm events. In some years, the bell curve pattern is not as strong, and/or salinities do not peak until as late as November.

- Superimposed on top of this large-scale, quasi-seasonal trend are a number of temporary (< 1 week in duration) spikes or increases in salinity that may contribute to the incremental increase in chlorides observed in the quasi-seasonal trend. These spikes as measured by the continuous quasi-conductivity or "Virtual Salinity" data collected by NMWD at its treatment plant show the following relationships:

  1) Occur only in periods of low flows less than 9–10 cfs;
  2) Typically occur in periods of maximum well-pumping rates (summer-time pumping rates);
  3) Occur only when spring tides exceed 5.5 - to 5.7 feet MLLW (even though higher salinity waters reach the vicinity of the Coast Guard wells when predicted tides at Inverness are as low as 4.8 to 5.0 feet MLLW).
  4) Consistently occur approximately 5- 10 days after a 5.5 to 5.7 feet MLLW spring or high tide event, typically during a neap or low tide event;
  5) Manifest as a single peak regardless of the number of days of high tide events the previous week;
  6) May potentially be connected with the large-scale, quasi-seasonal trend such that base-level chloride concentrations may rise in an incremental or stair-step fashion after each "spike" event;

- Boring logs for the Coast Guard wells indicate a 15-foot thick clay layer occupies the intervening area between the creek bed and the deeper water-bearing gravels in which the wells are screened (KHE 2006a). If this clay layer is laterally continuous, it would retard significant exchange of water and salts between creek and well intake (KHE 2006a). Questa (2000) provided some support for this finding, as it found that, in some areas, including within the estimated recharge area to the Coast Guard wells, the groundwater table appears to be confined or under pressure, presumably from an aquitard or stratum within the soils that confines water below.

- The similarity in seasonal chloride concentrations between the coastal marine terrace aquifer (Questa Engineering Corp. 2000) and Coast Guard wells (NMWD, unpub. data), coupled with the documented creekward gradient of terrace groundwater and observed shifting of the groundwater gradient near the wells due to drawdown by the wells (Questa Engineering Corp. 2000), suggest that the terrace aquifer may be at least one contributing source of chloride to the Coast Guard wells.

Based on the available information, KHE (2006a) has developed some preliminary conclusions regarding the possible scenario for salinity intrusion into the NMWD groundwater wells (KHE 2006a). Ultimately, salinity intrusion appears to be controlled by a combination of factors, including tidal height, streamflow discharge, pumping rates, and possible influence from the adjacent terrace groundwater aquifer. Based on virtual salinity or conductivity data, predicted tides at Inverness of approximately 5.5 to 5.7 feet MLLW appear to the threshold at which salinity "spikes' begin to occur, with tides exceeding 5.5 to 5.7 feet MLLW producing an almost linear response in virtual salinity levels such that the sharpness of the salinity "spike" appears strongly correlated with tidal height. Salinity intrusion events during which NMWD experience chlorides exceeding 100 mg/L appear to correlate with exceeding 5.9 to 6.0 feet MLLW (NMWD 1997, NMWD, unpub. data). The assumption in previous studies has been that the point of infiltration occurs at the Coast Guard wells. However, a number of factors, including the impervious stratigraphy where the Coast Guard wells are drilled; the discrepancy between when tidal influence occurs at the Coast Guard well (~4.8 to 5.0 feet) and the

threshold at which virtual salinity begins to rise (~5.5 to 5.7 feet); and the long lag time between high tides and actual intrusion into the wells (~5 to 7 days), point to the point of infiltration being upstream of the section or reach of Lagunitas Creek adjacent to the Coast Guard wells. The triggers of salinity intrusion are described based on tidal water level elevation. It should be noted that potential effects of sea level rise would result in general increases in tidal elevations, subjecting the areas within the description area to greater tidal influence.

The exact point or points upstream of the Coast Guard wells where saltwater infiltrates the alluvial aquifer is unknown, but it is possible that at least one of the locations at which infiltration currently occurs is at the Downey Well. The Downey Well, drilled in December 1977 in the streambed gravel bar, is shallow, with bedrock occurring only 25 feet below ground surface. The well was taken out of service in 1982, because of continual maintenance problems and problems with the quality of well from the well (e.g., highly turbid; NMWD 1997). Since construction, Lagunitas Creek has migrated and "captured" the well, such that the well is now in the center of the creek (NMWD 1997). The well was operated infrequently between 1993 and 1997 for additional irrigation waters for Giacomini, but since 1997 and discontinuation of the gravel summer dam, it has been used every summer to provide the Giacominis with irrigation water (NMWD 1997). As elevated chloride concentrations first occurred prior to drilling of the Downey Well, it is possible that there are other infiltration points, as well, where localized stratigraphy of the streambed allows or allowed infiltration of tidally influenced waters into the alluvial aquifer. Based on the fact that salinity intrusion prior to 1997 was associated with tides exceeding 6.4 feet MLLW (NMWD 1997), this infiltration point would probably also be upstream of the Coast Guard wells.

Hydraulic modeling information suggests that the Downey Wells should become exposed to tidal influence when predicted tides at Inverness reach 5.7 feet MLLW, which corresponds approximately to the tidal range (5.5 feet – 5.7 feet MLLW) at which spikes in virtual salinity or conductivity first become apparent at the Coast Guard wells (G. Kamman, KHE, *pers. comm*.). Pumping of the well during the summer may exacerbate salinity intrusion by increasing capture of tidally influenced waters into the alluvial aquifer. The role of pumping may account for the difference in lag time between high tides and salinity between summer and winter: during the early winter, when pumping rates are down, lag times appear to lengthen from 5 to 7 days to 10 days. From this potential infiltration point, located approximately 3,400 feet upstream of the Coast Guard wells tidally influenced waters would have to flow horizontally through the interbedded layers of alluvial gravels and fines to reach the Coast Guard wells and treatment plant. The exact amount of time that it would take waters from the Downey Well to reach the Coast Guard Wells would depend on horizontal conductivity rates of the alluvial aquifer soils, but 5- to 10 days appears reasonable based on the stratigraphy that is presumed to exist between these well locations (KHE 2006a).

During periods when stream discharge is below 10 cfs and pumping rates are elevated, spring tides move some distance upstream on Lagunitas Creek from the Coast Guard wells before they infiltrate into the alluvial aquifer. Once tidally influenced waters reach the Coast Guard wells, elevated summer-time pumping rates may increase horizontal hydraulic conductivity rates and promote capture of these waters by the Coast Guard wells. The contribution of pumping can be seen from the fact that, during periods when pumping rates drop during the summer and tides exceed 6.0 feet MLLW, the sharpness of the salinity spikes is reduced. The temporary tidally influenced "spikes" in salinity typically dissipate in less than a week. However, even after dissipating, they may potentially contribute to the incremental or stair-step pattern in salinity increases that appears to occur seasonally in chloride concentrations, at least during most years.

As freshwater flows increase and the frequency of spring tides decrease in the fall, chloride concentrations in the alluvial aquifer still tend to taper off very gradually, which may result in part from the fact that decreased pumping rates for both the Downey and Coast Guard Wells during the fall are reducing infiltration capacity and/or conductivity rates and thereby increasing the amount of time needed to "recharge" the alluvial aquifer with fresh water from the stream. Through the winter and spring, salts in the alluvial aquifer are steadily diluted with freshwater from increased stream discharge, except perhaps in periods or years where rainfall is very low.

By late spring of average and wet years, salinities have dropped to "baseline" conditions, which are probably determined by chloride concentrations in the adjacent terrace groundwater aquifer. Even in winter, chloride concentrations in groundwater sampled near the wells still ranged from 48 to 138 mg/L (Questa Engineering Corp. 2000). During dry years, the significant reduction in streamflow, particularly during past years when the SWRCB had not mandated minimum instream flow rates, may have increased the influence of this terrace groundwater aquifer on alluvial aquifer and may have exacerbated the problems with extremely low streamflow during the spring or high tide series that caused several salinity intrusion events during the 1976-

1978 period. Even during average or wet years, the terrace groundwater aquifer may contribute to the incremental increase in chloride levels over the summer and fall. However, it is safe to assume that generally, the system involves both surface water-recharge of alluvial aquifers, perhaps at defined infiltration points or locations upstream of the Coast Guard wells, as well as some degree of lateral inflow from the terrace groundwater aquifer.

Traffic and Transportation

The sharp juxtaposition between parkland and rural communities has significantly increased the potential for transportation problems along West Marin's largely narrow, two-lane road system, particularly considering its proximity to the highly urbanized San Francisco Bay watershed. In general, Marin County is progressive in terms of encouraging alternative transportation, but even alternative transportation sometimes comes with economic or environmental "costs" that makes implementation a delicate balancing act between competing social and ecological issues. This is nowhere more evident than in West Marin, where community members have sought for decades ways of improving safe and energy-efficient alternative transportation for both residents and visitors, but have had efforts stymied by the fact that most potential routes would cause impacts to the very natural resources that have drawn most of these people to live or visit here. These issues are complicated further by the fact that seemingly similar objectives such as increasing bicycle and/or pedestrian access are motivated by different and often conflicting goals such as transportation versus nature experiences that may ultimately lead to different types of solutions. Within this document, the issue of pedestrian and bicycle "transportation" is addressed under Traffic and Transportation, while trails and other types of public access for both visitors and local residents are addressed under Visitor and Resident Experience. Resolution of these complex environmental and social issues will require a delicate balance to be struck between competing concerns, values, and resources.

Regulatory and Policy Setting

Within Marin County, policies on transportation largely focus on reducing congestion, while encouraging alternative modes for transportation, including use of mass transit and bicycle and pedestrian access.

On a state level, Propositions 111 and 116 passed by voters in 1990 triggered state legislation requiring urban counties to establish a Congestion Management Agency (CMA) to create, update, and administer a Congestion Management Plan (CMP) for the county. The purpose is to establish Levels of Service (LOS) for designated freeways, state highways, and local arterials and to maintain those standards by increasing capacity or managing travel demand on those roads. The CMA annually monitors service levels on freeways, state highways, and routes of regional significance as part of the annual update. State Route 1 from SFD to PRS is part of the designated roadway network. Under CEQA, the County also evaluates changes in traffic conditions, with projects creating changes dropping the Level of Service (see description below) below Level D considered a "significant" impact.

Within the Coastal Zone, which incorporates the Project Area, the LCP (Marin County Comprehensive Planning Department 1981) specifically identifies Sir Francis Drake Boulevard as providing a scenic driving experience for coastal visitors and an important access road for local residents. The LCP (Marin County Comprehensive Planning Department 1981) notes that, "in order to protect its scenic rural character, the road shall be maintained as a two-lane roadway." The LCP (Marin County Comprehensive Planning Department 1981) concluded that "Sir Francis Drake has adequate capacity to handle increased recreational and local traffic, although traffic patterns do occasionally create hazardous conditions for pedestrians and bicyclists in the areas of Inverness and Inverness Park." In addition, the LCP (Marin County Comprehensive Planning Department 1981) identified the need to expand public trails and bike paths both on federal and non-federal lands, but also stresses the need to ensure that they are compatible with the protection of natural resources and "the unique qualities of Marin's coast." Specifically, the concept of a bike/pedestrian trail network that would connect the villages and provide access to public parks was supported (Marin County Comprehensive Planning Department 1981). This issue is discussed further under Visitor and Resident Experience.

The Point Reyes Station Community Plan (Marin County Community Development Agency 2001) focused on the lack of off-street parking as a concern, given the steady increase in numbers of visitors and area residents. All new structures and uses are required to provide off-street parking scaled to the level of use (Marin County Community Development Agency 2001). The Community Plan (2000) also supports efforts to reduce congestion through alternative transportation, including efforts to identify appropriate locations for

paths that could be used for both bicycle commuting and recreation, including investigations into the feasibility of using the abandoned railroad right-of-way.

Transportation Patterns and Traffic Issues in the Project Area and Vicinity

In general, existing and projected future transportation issues are defined, at least for roads and intersections, using Level of Service (LOS) criteria. Separate criteria are established for roads, signalized intersections, and stop sign-controlled intersections. LOS for intersections is typically based on the amount of delay measured in seconds between when a vehicle reaches an intersection, including a queue, and when it passes through the intersection. LOS for roadways uses a Volume-to-Capacity ratio based on conditions of free flow and the amount of restriction on maintaining speed limits or safe speeds for roadway conditions within designated areas. Criteria applicable to the Project Area are shown in 21A and 21B.

The Project Area only has two road segments within its boundary – a portion of a regional roadway, Sir Francis Drake Boulevard or Levee Road, and a portion of Bear Valley Road. Otherwise, most of the roads occur at the perimeter or in the vicinity of the Project Area and include a variety of state, regional, and local roadways. Existing conditions for these roads, as well as for parking, mass transit, and other transportation modes, is discussed in more detail below.

While LOS is often provided only for current conditions, projections can be made into the future based on anticipated increases in population or visitation to an area. The Seashore contracted with BRW and Lee Engineering (1998) to provide an evaluation of existing and projected future conditions on Park Service, state, and county roads. To assess future conditions, BRW and Lee Engineering (1998) analyzed trends in the San Francisco Bay region population growth and trends in visitation and conclude that visitation would increase 1 percent annually from 1998-2010. Based on this conclusion, traffic count data for local, regional, and state roadways were factored by a growth rate of 1.0 percent per year to evaluate impacts of increases of this magnitude on LOS within the general Point Reyes area (BRW and Lee Engineering 1998).

However, since 1998, park visitation has not increased 1 percent annually. Visitation reached a peak of 2,579,949 in 1992 (NPS, unpub. data). In 1998, visitation totaled 2,477,409 (NPS, unpub. data). In 2004, visitation actually had dropped to 1,960,055, a drop of 21 percent (NPS, unpub. data). Visitation rose slightly in 2005 to 1,988,585 (NPS, unpub. data). However, BRW and Lee Engineering had projected that visitation would total 2,750,000 in 2005 based on a 1 percent annual increase, a difference of 28 percent or 761,415 annual visitors relative to actual numbers of visitors in 2005. By 2010, annual visitation was projected to climb to 2,890,000 (BRW and Lee Engineering 1998). If visitation increased annually from 2005 by 1 percent, it would reach 2,090,023, approximately 28 percent lower or 799,977 fewer visitors than originally projected .

TABLE 21A. STOP SIGN-CONTROLLED INTERSECTION LOS DESIGNATIONS

LOS	Vehicle Delay (seconds)	Description
A	<10	Little or no delay.
B	>10 – 20	Short traffic delay.
C	>20 – 35	Average traffic delay.
D	>35 – 55	Long traffic delay.
E	>55 – 80	Very long traffic delays.
F	>80	Excessive traffic delays.

Source: Highway Capacity Manual Third Edition

TABLE 21B. ROADWAY LOS DESIGNATIONS

LOS	Volume to Capacity (V/C) Ratio		Description
	Freeways	Arterials	
A	0.00 – 0.35	0.00 – 0.60	Conditions of free flow. Speed is controlled by driver's desires, speed limits or physical roadway conditions, not other vehicles.
B	0.36 – 0.54	0.61 – 0.70	Conditions of stable flow. Operating speeds beginning to be restricted, but little or no restrictions on maneuverability.
C	0.55 – 0.77	0.71 – 0.80	Conditions of stable flow. Speeds and maneuverability somewhat restricted. Occasional back-ups behind left-turning vehicles at intersections.
D	0.78 – 0.93	0.81 – 0.90	Conditions approach unstable flow. Tolerable speeds can be maintained but temporary restrictions may cause extensive delays. Speeds may decline to as low as 40 percent of free flow speeds. Little freedom to maneuver, comfort and convenience low.
E	0.94 – 1.00	0.91 – 1.00	Unstable flow with stoppages of momentary duration. Average travel speeds decline to one-third the free flow speeds or lower, and traffic volumes approach capacity. Maneuverability severely limited.
F	>1.00	>1.00	Forced flow conditions. Stopages for long periods, and low operating speeds (stop-and-go). Traffic volumes essentially at capacity over the entire hour

Source: 2003 Performance Measures Monitoring Report Highway Capacity Manual Third Edition

State Highways. State Route 1 is the only major regional highway located in the vicinity of the Project Area. State Route 1 is one of the most scenic roadways in the state, offering panoramic and often breath-taking views of California's frequently rugged and remote coastline. The scenic beauty of this roadway makes it a favorite of television commercial producers. The winding and heavily traveled highway hugs the outer coastline of California from southern California to the Lost Coast just north of Fort Bragg. Within Marin County, State Route 1 separates from Highway 101, the main highway in eastern Marin County, just north of the Golden Gate Bridge, heading westward from Mill Valley to the outer coast, where it again begins its winding route up the coast. In the vicinity of the Project Area, State Route 1 goes through the small town of Olema before it enters Point Reyes Station, where it temporarily turns into A Street (see Local Roadways below). Once north of Point Reyes Station, State Route 1 begins to curve westward to follow the eastern boundary of Tomales Bay towards Marshall and Bodega Bay.

Between Olema and Point Reyes Station, it is a two-lane, north-south trending roadway with average annual daily traffic volume of 6, 100 vehicles south and 2,300 vehicles north of Pt Reyes Petaluma Road (DKS Associates 2001 *in* EDAW 2001). The CMA regularly evaluates LOS on the portion of State Route 1 between Sir Francis Drake Boulevard in Olema and Point Reyes Station (DKS Associates 2001 *in* EDAW 2001). A 2000 CMA survey characterized this portion of State Route 1 as Level B LOS in both directions, northbound and southbound, during the afternoon peak hour (DKS Associates *in* EDAW 2001; Tables 21A and 21B). North of Point Reyes Station, LOS drops to Level C for both morning and afternoon peak hours. The design capacity of State Route 1 and some of the other roadways in the area is approximately 34,000 vehicles per day: as of 1996, vehicle trips on State Route 1 amounted to approximately 20 percent of capacity, ranging from 6,100 to 6,800 vehicles per day (Marin County Community Development Agency 2001). No change in LOS is anticipated between 1998 and 2010, even given a projected – and possibly not realistic – increase in Point Reyes area visitation of 1 percent per year (BRW and Lee Engineering 1998).

Regional Roadways. Sir Francis Drake Boulevard, including Levee Road, which is technically the southernmost portion of Sir Francis Drake, is the only regional roadway located in the vicinity of the Project Area. As was noted earlier, it was specifically referred to in the LCP (Marin County Comprehensive Planning Department 1981) as providing both a scenic driving experience, as well as being an important access road for residents living on the Point Reyes Peninsula.

Sir Francis Drake Boulevard, which originates in eastern Marin County, runs primarily as a two-lane road once east of the town of Fairfax through the towns of Woodacre, Forest Knolls, Lagunitas, and Tocaloma before stopping at State Route 1 in the town of Olema. From Olema, the road picks up again at Levee Road near the

Green Bridge in Point Reyes Station. Traffic traveling south on Levee Road is controlled using a stop sign, but there is no stop sign for vehicles on State Route 1. Levee Road moves through a small residential area as it curves westward and crosses the northern end of Olema Marsh. The road then curves northward to follow the western edge of Tomales Bay as it becomes the main and only road for residents of Inverness Park, Inverness, other private developments on the Inverness Ridge, ranches within the Point Reyes headlands, and visitors to the Seashore and State and County Parks such as Tomales Bay State Park and Chicken Ranch Beach. Seashore visitors use this road to access Drake's Estero, Tomales Point, Abbott's Lagoon, the Lighthouse, Chimney Rock, and many other beaches along the Point Reyes Headlands.

A LOS Analysis was performed on the portions of Sir Francis Drake Boulevard just east of the town of Olema and west of the intersection with Pierce Point Road rated this portion of the regional roadway generally as Level D during both morning and peak hours (BRW and Lee Engineering 1998). However, the portion near Pierce Point Road had slightly better traffic conditions during morning peak hours (Level C; BRW and Lee Engineering 1998). LOS was not anticipated to change greatly between 1998 and 2010 in either location, even given the projected – and possibly not realistic – increase in Point Reyes area visitation of 1 percent per year (BRW and Lee Engineering 1998).

Collectors and Local Roadways. A Street corresponds to the in-town portion of State Route 1 within the town of Point Reyes Station and is the main downtown street in Point Reyes. Within town, State Route 1 is a two-lane road with a posted speed limit of 25 mph. Mesa Road is a local roadway that runs along the eastern portion of Point Reyes Station and the main roadway serving the Point Reyes Mesa residential development. It has several curves and corners. A portion runs along the Giacomini Ranch property in the vicinity of Tomasini Creek, which flows underneath Mesa Road, and the small dirt road that leads to the Giacomini Hunt Lodge. From Mesa Road, several smaller roads – some of which are considered private – provide access for residents who live on the Point Reyes Mesa directly adjacent to the northern portion of the Giacomini Ranch East Pasture. Mesa Road eventually curves eastward and ends at State Route 1 on the northeastern boundary of Point Reyes Station. A stop sign at the intersection with State Route 1 controls crossing of the state highway, which does not have a signal or stop sign.

In the town of Point Reyes Station, B and C Streets parallel A Street to the west and are less heavily traveled than A, serving primarily residences and commercial businesses and public services such as the Sheriff's substation and Fire Station. C Street runs along the eastern perimeter of the Giacomini Ranch Dairy Facility. B Street has a stop sign at its T-intersection with State Route 1, but there is no stop sign for cross-traffic on State Route 1. There are three other stop-sign controlled intersections on B Street. There are no stop signs on C Street.

At the eastern end of town, another local arterial road, Point Reyes-Petaluma Road, serves as an important connection between Point Reyes and towns such as Nicasio, Novato, and Petaluma.

A more direct connection between the portion of Sir Francis Drake Boulevard that ends in Olema and the portion near Inverness Park is Bear Valley Road, which starts in Olema and runs north-south until it dead-ends into Sir Francis Drake Boulevard. The intersection has a stop sign for vehicles traveling north on Bear Valley Road, but there is no stop sign for cross-traffic on Sir Francis Drake Boulevard. Most of this road runs through undeveloped areas such as pasture, with the exception of the Park's administrative headquarters and Bear Valley Visitor Center and a relatively small residential development at the northern end of the road near the intersection with Sir Francis Drake Boulevard. Visitors to the park use Bear Valley Road to access the Bear Valley Visitor's Center, Bear Valley Trail and associated trails and remote camping areas, as well as Limantour Road, a Seashore-maintained road that crosses over the Inverness Ridge to Limantour Beach. This road also provides access to a youth hostel and to several Seashore-owned residences in the vicinity of the youth hostel and the Limantour Beach area. Limantour Road has a stop sign at its intersection with Bear Valley Road, but there is no stop sign for cross-traffic on Bear Valley Road.

Within the town of Inverness Park, several small roads connect residences with homes constructed on the slopes of the Inverness Ridge, including Drakes View Drive and others.

At the northern end of Sir Francis Drake Boulevard, Pierce Point Road connects visitors, park employees, and rancher residents with the Tomales Point area, including Abbott's Lagoon, McClure Beach, Tomales Bay State Park. Some of the quarries proposed for restoration with use of excavated sediment from the Project Area would be accessed from Pierce Point Road.

LOS information for A Street is discussed under State Highways. Point Reyes-Petaluma Road was rated as Level C during both morning and afternoon peak hours (BRW and Lee Engineering 1998). The LOS analysis for Bear Valley Road characterized it as Level D under both morning and afternoon peak hours and under existing and projected future growth conditions (BRW and Lee Engineering 1998). Pierce Point Road had a lower LOS south of Tomales Bay State Park (LOS C) than north of the park, where LOS increased to Level B, at least in the morning (BRW and Lee Engineering 1998). Another local arterial road, Point Reyes-Petaluma Road, was rated as Level C during both morning and afternoon peak hours (BRW and Lee Engineering 1998).

Intersections. None of the intersections within the vicinity of the Project Area are signalized. There are approximately 12 intersections within the vicinity of the Project Area that are stop sign-controlled. The majority (10) are T-intersection stop signs or single stop-sign intersections in which cross-traffic is allowed to flow freely. Two intersections in the town of Point Reyes Station are either four-way stop sign-controlled or two-way stop sign-controlled at a four-way intersection with cross-traffic allowed to flow freely. Again, as explained earlier, at intersections, LOS is defined as the average total delay in seconds per vehicle from the time a vehicle stops at the end of the queue until the vehicle departs from the stop line, including the time from the back to the front of the queue. Some typical LOS for intersections without signals in the vicinity of the Project Area are given below ((DKS Associates 2001; EDAW Inc. 2001)).

- *State Route 1 and Sir Francis Drake Boulevard/Levee Road*: Morning Peak Hour (Level A); Afternoon Peak Hour (Level B); Weekend Mid-Day Peak Hour (Level B).
- *State Route 1 and Mesa Road near Green Bridge*: Morning Peak Hour (Level B); Afternoon Peak Hour (Level B); Weekend Mid-Day Peak Hour (Level B).
- *State Route 1 and Mesa Road near Greenbridge Gas*: Morning Peak Hour (Level A); Afternoon Peak Hour (Level A); Weekend Mid-Day Peak Hour (Level A).

Emergency Vehicle Access. The Marin County Fire Department is located at 201 B Street. Average response time for the fire department is 5 minutes (DKS Associates 2001 *in* EDAW 2001). Emergency vehicles currently have access to the Project Area from C Street and the Dairy Mesa facility and Sir Francis Drake Boulevard near the town of Inverness Park. Emergency vehicles currently experience little or no delay in accessing the Project Area during the morning, evening, and weekend peak hours, because of immediate proximity and/or high levels of service at the relevant intersections. Emergency access to the interior of the Project Area is somewhat limited. Compacted earthen roads would allow some degree of access, unless roads are flooded or extremely wet to most of the East Pasture. However, there are no existing ranch roads in the West Pasture, although a dirt track does allow 4 wheel-drive (4-WD) vehicles to enter the West Pasture near the Gradjanski residence and cross Fish Hatchery Creek at a creek crossing. In addition, there is a gate at the southern end of the West Pasture that allows 4-WD access at the southern end. Access at the northern end is largely foot access via the north levee.

Parking. BRW and Lee Engineering (1998) did not analyze parking capacity in the Project Area and immediate vicinity. However, parking capacity was qualitatively assessed for existing and future parking needs in other areas of the Seashore by rating parking capacity from very high to very low (BRW and Lee Engineering 1998). Parking lots with very high capacity were those in which occupancy does not exceed 90 percent of capacity during weekdays and weekends regardless of season, while areas with very low parking capacity are more than 90 percent full during most weekdays and weekends regardless of season (BRW and Lee Engineering 1998).

On-street parking in downtown Point Reyes Station has historically been a subject of community concern. On-street parking represents a large share of the downtown parking facilities. Approximately 40 percent of the homes on the west side of Point Reyes Station do not have driveways, carports, or garages, necessitating on-street parking. As visitation to Point Reyes Station increases, competition for on-street parking spaces will increase and cause additional impacts to residents and merchants in town. The Point Reyes Station Community Plan (Marin County Community Development Agency 2001) identified localized parking congestion in the downtown area as a major concern. Furthermore, on-street parking has also been identified as an impediment to improving the traffic capacity of downtown streets. According to the LCP (Marin County Comprehensive Planning Department 1981), “parking restrictions and limits on recreational vehicle travel could also substantially improve capacity. On some streets, cars park “nose-in,” which increases capacity relative to parallel parking, but decreases overall traffic capacity.

Public use of informal social paths or trails on the Giacomini Ranch levees have resulted apparently in periodic parking problems periodically both in the vicinity of Third and C Streets in Point Reyes Station and along Sir Francis Drake Boulevard. There are no designated formal or informal parking areas for the Giacomini Ranch

East Pasture and Green Bridge County Park trail network. Most people park alongside homes on 3rd and C Street in Point Reyes Station or walk to the trail from other parts of town. Because there are no designated formal or informal parking areas, street parking is often at a premium on most weekends in the town of Point Reyes Station, with people parking along C Street or Third Street. This increases parking and traffic congestion, noise, and trash for residents on Third Street. Parking along C Street typically occurs along the side fences of residences, business, or public service operations, as no homes actually front C Street. Parking on Third Street occurs in front of homes. While use of this trail is not heavy relative to formal Park Service trails such as Bear Valley Trail and appears to be mainly used by local residents, nearby homeowners state that the trail is attracting increasing numbers of people from other communities looking for opportunities to walk their dogs. Because of overflow problems from Point Reyes Station, it is likely that the worst problems occur on weekends when visitors need to park further from downtown because of the limited number of parking areas near A Street. They end up vying for parking with the limited number of people using the informal social path during that time. Because parking occupancy probably exceeds 90 percent on most weekends, particularly during the high season, parking capacity for this particular area might be rated between low and medium.

Two formal parking lots serve existing trails in the Project Area and vicinity. There is a parking lot at the trailhead for Tomales Bay Trail with approximately 14 parking spaces that generally has, based on the BRW and Lee Engineering criteria, very high parking capacity and another parking lot at White House Pool County Park with approximately 43 parking spaces that might be rated as having medium to high capacity.

Parking for the informal social path on the Giacomini Ranch north levee consists of one or more roadside pull-outs that can comfortably fit approximately 23 vehicles. Because this path is not as heavily used, parking and pull-outs into traffic along Sir Francis Drake Boulevard are typically not problematic, and parking capacity might be rated as very high. However, between December and February, many birdwatchers flock to “Waldo’s Dike” to observe California black rails in the undiked marsh north of Giacomini Ranch and use the levee for access. Parking during peak visitation periods such as weekends can become chaotic, with pull-outs full and vehicles parking haphazardly along Sir Francis Drake Boulevard where there is no road shoulder. With vehicles often in the actual roadway, this parking pattern impacts road safety and decreases vehicle conveyance and LOS. Use by birdwatchers, some of whom come from all over the state to view rails, is limited to extreme high tide events, which, during December, January, and February, occurs usually for four days each month. The worst parking problems comes when one or more of those days coincide with the weekend, and, because of these problems, parking capacity would probably receive an overall rating of medium capacity, in which occupancy does not exceed 90 percent except during weekdays and weekends in holiday and high season periods.

Public Transportation. Golden Gate Transit provides daily bus service within Marin, Sonoma, San Francisco, and Contra Costa counties. During the week (Monday through Friday, the West Marin Stagecoach provides service between San Anselmo, Point Reyes Station, Inverness Park, and Inverness. The West Marin Stagecoach started in 2002 as a two-year demonstration service created by Marin County that focused on increasing access for seniors, youths, and others to medical, civic, educational, work, and shopping sites throughout Marin. At least initially, the Stage was funded by the Marin County Transit District, the County of Marin, and the Federal Transit Administration. Money from the sales-tax hike (Measure A) passed last November 2004 apparently ensured the future of the West Marin Stagecoach.

During the week, the Stage’s 12-passenger buses have four east- and west-bound runs each day, with the last eastbound run leaving at approximately 5 p.m. from Point Reyes. There are at least three formal stops in the vicinity of the Project Area at the Dance Palace in Point Reyes Station, downtown Point Reyes Station, and Inverness Park. Published travel time from Point Reyes Station to San Anselmo is approximately 54 minutes. The Stage also has the capability of carrying two bikes on outside bike racks. Golden Gate Transit used to provide one route on the weekends that served Point Reyes Station (Route 65), but it no longer runs.

Alternative Transportation. Pedestrian activity is generally light within the vicinity of the Project Area. As noted earlier, use of the informal social paths and other trails in the vicinity is discussed more fully under Visitor Experience. Pedestrian traffic in the western portion of Point Reyes Station is very light and limited to residents, users of the informal social path, and, on weekends, visitors parking on the outskirts of town. Residents occasionally walk or casually bicycle on the shoulder of Sir Francis Drake Boulevard and Levee Road, but use is limited, probably due to concerns about safety due to the narrowness of the shoulder in some areas. Many of those walking or casually bicycling are linking to the White House Pool County Park at the intersection of Levee, Sir Francis Drake, and Bear Valley Roads, which has a weather-dependent dirt trail that runs along the south side of Lagunitas Creek (see Visitor Experience). In addition to casual bicyclists, long-

distance road cyclists also frequent the Point Reyes Station and Inverness Park areas, particularly on weekends. While casual bicyclists will often ride on the dirt shoulder, road cyclists typically hug the paved edge of the roadways, which are all two-lane and narrow to moderately wide. None of the highways or roadways discussed has formal bike lanes.

For several decades, residents of southern Tomales Bay have discussed the possibility and effects of creating a pedestrian and bicycle trail that would link the western portion of Tomales Bay near Inverness to Point Reyes Station and potentially even further north along State Route 1. The first formal attempt to address this issue was the West Marin Pathways Study, completed in 1988 by Brian Wittenkeller and Associates for West Marin Paths, a local non-profit group, and Marin County. This document incorporated a detailed conceptual plan and cost estimate for a bicycle and pedestrian pathway system around the south end of Tomales Bay, including several alignments adjacent to or crossing over into the Giacomini Ranch. The concept plan was very comprehensive and ambitious (LandPeople 2005). It included recommendations for bike lanes and/or paved multi-use paths along much of the route, including many routes that were on the then-private Giacomini property (LandPeople 2005). It did not include a detailed evaluation of environmental, construction, and maintenance constraints, and requirements (LandPeople 2005). The West Marin Pathways Study was never adopted, although two small components were reportedly constructed by either the County or others – a cantilevered pedestrian causeway at White House Pool and a bridge across the eastern Bear Valley Creek outlet in White House Pool County Park. According to local residents who participated in the process, this was because of the high (for the time) estimated implementation cost and concern over environmental and adjacent landowner impacts. The estimated cost for the pathway improvements was approximately $2.75 million for design, construction, and construction contingencies, plus $1.5 million for land acquisition (LandPeople 2005).

A more recent pertinent document that was adopted by the County is the June 2001 *Marin County Unincorporated Area Bicycle and Pedestrian Master Plan*, prepared by Alta Transportation Consulting for the Marin County Department of Public Works (LandPeople 2005). This document contains analysis; goals, objectives and policies; a proposed system and improvements plan; and specific projects (LandPeople 2005). Among the projects is a recommended series of improvements in the Point Reyes and Inverness Area, including a potential bike/pedestrian path from the Point Reyes Station to Inverness (LandPeople 2005). The Plan refers to the 1988 West Marin Pathways Study. The Plan also recommends the use of railroad right-of-way, where feasible, to complete the recommended routes (LandPeople 2005). The Plan does not go into detail on the precise location or configuration of these bicycle routes, but does include bikeway standards that imply the routes would be either paved Class I separated multi-use path at least 8' wide, or paved bike lanes 4 to 5' wide on the road shoulder (LandPeople 2005). The draft Marin CWP also shows a proposed trail along Levee Road and Sir Francis Drake Boulevard the entire distance to Inverness, but the map does not specify the type of trail (LandPeople 2005).

Visitor and Resident Experience – Public Access Resources

National parks are valued for the recreational and aesthetic resources they provide to the public, both visitors and adjacent residents. Park visitors expect national parks to provide beauty, a sense of quiet, and opportunities for hiking, bird-watching, and other recreational pursuits. Perhaps, some of the most valued natural resources within parks in terms of sheer visitor numbers are "wetland" ones such as rivers, lakes, oceans, waterfalls, and even geysers. While earlier sections have focused on utilitarian ecological and social functions of wetlands such as water quality improvement or floodwater retention, wetlands undeniably provide other important social services, one of which is recreation. Wetlands offer opportunities for hiking, birdwatching, fishing, kayaking and canoeing, boating, and swimming. In addition, wetlands can provide breathtaking vistas or viewsheds. These recreational benefits are one of the reasons that the public has come to increasingly value wetlands.

As discussed under Traffic and Transportation, increasing emphasis on alternative transportation means such as walking and bicycling has added another dimension to public access traditionally encountered in parks, which focuses on providing visitors with a natural experience. For exercise or to improve the environment, an increasing number of people are looking to use trails and paths for transportation purposes. While, overall, the objective appears to be the same, bicycle and/or pedestrian public access, differences in the goals of these user groups – transportation versus nature experience – can result in very different solutions that may

not be mutually satisfactory. For the purposes of this document, bicycle and pedestrian issues related primarily to transportation are covered under Traffic and Transportation, while this section focuses primarily on public access for natural and recreational purposes.

Regional and Park Setting

As a region, the San Francisco Bay area has actively sought opportunities for providing public access to both its residents and visitors. Agencies such as the Bay Conservation and Development Commission have taken a very proactive role in increasing access along the edge of San Francisco Bay, project by project. Perhaps, the most ambitious regional effort is the San Francisco Bay Trail, a planned recreational corridor that, when completed, encircle the San Francisco Bay region with a continuous 400-mile network of bicycling and hiking trails, of which 240 miles have been completed.

Some of the largest tracts of undeveloped land within the county are its national parks, including the Seashore and north district of GGNRA.

With more than 50 percent of its lands in public ownership or conservation easement, Marin County is one of the leaders in the San Francisco Bay region in terms of providing access to both residents and visitors. Some of the largest tracts of undeveloped land within the county are its national parks, including the Seashore and north district of GGNRA. While many parks primarily serve visitors who come from outside the park's region, the majority of the 2.5 million visitors who come to the Seashore each year live in the San Francisco Bay area. In 2002, more than 700,000 visitors visited the three Seashore visitor centers, and more than 70,000 visitors had extended contacts with park interpretative staff through ranger-led programs. The main visitor is at Bear Valley near the park's administrative headquarters, which serves 350,000 people annually. The nearby trail, the Bear Valley Trail, is the most heavily used trail, with 70 percent of visitor centers users believed to use the trail (J. Dell'Osso, Seashore, *pers. comm*.).

The Seashore provides backcountry campgrounds, numerous beaches, and 147 miles of hiking trails. Activities include hiking, water sports, horseback riding, fishing, camping, wildlife viewing, and other interpretive opportunities. Hiking is primarily a day-use activity. There are approximately 50 trails throughout the Seashore, and they are found in a range of habitat types, ranging from wooded mountains to sandy beaches. Overnight stays are possible in four backcountry campgrounds, the Stewart Horse Camp, the Point Reyes Hostel, a private campground, and local hotels and inns. Visitors bring horses daily to ride on designated trails, and hundreds rent horses every week from commercial stables.

Though Stinson Beach and Bolinas attract more surfers, North Beach is known as a challenging surfing area. Nature study and wildlife viewing are important activities at Point Reyes. Visitors make special trips to the Seashore to see migrating whales, shorebirds, breeding elephant seals, tule elk, and spring wildflowers. Information received from visitor surveys conducted by Sonoma State University (NPS 1997; 1998b) found that most park visitors spend 2-6 hours at the Seashore in a variety of activities dependent upon the season, ranging from whale watching and kayaking to hiking and bird watching.

The attractiveness of the Point Reyes area to visitors and residents is enhanced by the fact that the western portion of Marin County remains largely undeveloped, even those portions not owned by the Park Service. The pastoral setting of the largely agricultural community draws many visitors, who enjoy both viewing the working farms and purchasing some of the locally produced products in stores within local towns. The beauty of the area has also led to an active artist community that caters to visitors. Tomales Bay itself – portions of which fall within the Seashore and GGNRA boundaries – attracts people interested in the thriving oyster industry and abundant water-based recreational opportunities such as boating, kayaking, and swimming. The "open space" opportunities offered by the Seashore and GGNRA have been greatly enhanced through creation of numerous other open space areas and parks in western Marin County by local and state agencies, including Marin Municipal Water District lands, County Open Space lands, Mt. Tamalpais State Park, Tomales Bay State Park, and several small County Parks at White House Pool, Green Bridge, and Chicken Ranch Beach.

Regulatory and Policy Setting

The Park Service 2006 Management Policies emphasizes that "providing opportunities for appropriate public enjoyment is an important part of the Service's mission" (NPS 2006, Section 8.1). In fact, public education

and enjoyment could be considered an integral component of the wetland restoration process. "When practicable, the Service will not simply protect, but will seek to enhance, natural wetland values by using them for educational, recreational, scientific, and similar purposes that do not disrupt wetland functions" (NPS 2006, Section 4.6.5). In 2003, the Seashore published a report that evaluates in detail the condition and maintenance and upgrade needs of existing trails (Seashore 2003). The Trail Inventory and Condition Assessment with Recommendations report (2003) also discusses the need and potential for new trails, including the potential for trails in or adjacent to the newly purchased Giacomini Ranch (Seashore 2003). It notes that one of the tasks will be to determine "appropriate levels of public access for interpretive and educational uses…….Because the bulk of the property will be devoted to marsh restoration, it appears unlikely that major through-trail routes will be feasible (with the possible exception of a portion of the Tomales Bay west shore trail as described in the Marin Countywide Trails Plan)" (Seashore 2003).

Marin County also actively supports enhancement of public access and recreation. Within the Coastal Zone, the LCP (Marin County Comprehensive Planning Department 1981) encourages enhancement of public recreational opportunities and the development of visitor-serving facilities in its coastal zone, as long as it "preserves the unique qualities of Marin's coast and … is consistent with the protection of natural resources and agriculture." Generally, low-intensity recreational uses such as hiking, camping, and fishing are favored over high-intensity uses (Marin County Comprehensive Planning Department 1981). The LCP (Marin County Comprehensive Planning Department 1981) also directs federal parks to provide additional coastal access trails and bike paths "where feasible and where consistent with the protection of the parks' natural resources." Specifically, the LCP (Marin County Comprehensive Planning Department 1981) expressed support for the East/West Greenway along the railroad-right-of-way and the concept of bike and pedestrian trail network in the West Marin area, with potentially the most likely area being State Route 1 and Sir Francis Drake Boulevard. The Community Plan (2000) also supports efforts to identify appropriate locations for paths that could be used for both bicycle commuting and recreation, including investigations into the feasibility of using the abandoned railroad right-of-way.

However, while facilitating public use, enjoyment, and appreciation of bayfront lands, projects should "avoid or minimize disturbance to wetlands, necessary buffer areas, and associated important wildlife habitat" (Marin County Comprehensive Planning Department 1981). Both the LCP (Marin County Comprehensive Planning Department 1981) and the Point Reyes Station Community Plan (Marin County Community Development Agency 2001) have established policies against development of the Point Reyes Mesa bluff area above the railroad-right-of-way in the Giacomini Ranch East Pasture through setbacks.

In 2001, the County of Marin issued the *Marin County Unincorporated Area Bicycle and Pedestrian Master Plan.* This document contains analysis; goals, objectives and policies; a proposed system and improvements plan; and specific projects (LandPeople 2005). Among the projects is a recommended series of improvements in the Point Reyes and Inverness Area, including a potential bike/pedestrian path from the Point Reyes Station to Inverness (LandPeople 2005). The Plan also recommends the use of railroad right-of-way, where feasible, to complete the recommended routes (LandPeople 2005). The draft Marin CWP also shows a proposed trail along Levee Road and Sir Francis Drake Boulevard the entire distance to Inverness, but the map does not specify the type of trail (LandPeople 2005).

Both the Architectural Barriers Act of 1968 (PL90-480) and the Americans with Disabilities Act (ADA) of 1990 (PL 101-336) help to ensure that buildings and other facilities meet set standards to make them accessible to all visitors, including those with disabilities. The Park Service complies with ADA standards and follows the stricter of either the Americans with Disabilities Act Accessibility Guidelines (ADAAG; 36 CFR part 1191) developed in 1991 or the Uniform Federal Accessibility Standards (UFAS) established in 1984. Standards for outdoor recreational facilities are often guided by recommendations from a report issued in September 1999 by a Regulatory Negotiation Committee convened by the Architectural and Transportation Barriers Compliance Board (Access Board) to help guide development of guidelines for facilities such as trails, boating and fishing facilities, parks, and sports facilities. Based on these guidance documents, the Park Service requires that walks or paths that connect to accessible features need to be made accessible and that key features in the park need to be made accessible. However, paths need to be kept consistent with preserving the natural and cultural resources of the park, if the same experience can be provided on some portion of the alignment or a different trail. California has also developed handicap access standards through California Building Code, Title 24 regulations, although the Title 24 standards are intended for urban facilities and not necessarily rural and park-type trails.

Public Access Opportunities within the Project Area and Vicinity

Background

For comparison purposes, semi-quantitative ranking systems were developed as part of this document for characterizing visitation and the number of public access structures, facilities, and uses.

The number of structures, facilities, and uses within a 0.5-mile radius of trailheads or destination areas (e.g., Drake's Beach) is ranked as low, moderate, and high based on a relative comparison with the number of structures, facilities, and uses present in other areas of the Seashore and north district of the GGNRA. Structure, facilities, and uses include not only constructed buildings and facilities (e.g., visitor centers, bathrooms, bridges, stairs), but amenities such as telephones and water fountains and attractions or permitted uses such as birdwatching, fishing, horseback riding, backpacking trailhead, and connections to other trails, etc.. The Seashore's Roads and Trails Division was consulted on the number of facilities, structures, and uses for other trailheads or destination points in the Seashore and north district of the GGNRA. Because this system is intended to be only a semi-quantitative tool for assessing effects of the proposed project, each facility, structure, and attraction or use was simply counted as one, regardless of the size of facility or relative degree of "draw" that certain facilities structures, and attractions or uses might have. Facility, structure, and use ranking consisted of low (between 1 and 5 structures, facilities, and uses), medium (between 6 and 10), and high (> 10). The Bear Valley Visitor Center area ranked as having the highest number of structures, faculties, and uses with approximately 25.

Although formal data on use of these structures and facilities do not exist, for the purposes of this document, use of facilities, structures, and uses semi-quantitatively estimated as very low (average of < 50 people per day), low (average of ≥ 50 and <125 visitors per day), medium (average of ≥125 and <450 people per day), and high (average of ≥450 people per day). These criteria were developed based on a relative comparison of daily numbers of people using other structures, facilities, and uses in the Seashore and north district of the GGNRA. Information used to develop criteria on public access, structures, and facilities and/or visitation came from analysis of aerial imagery, consultation with the Seashore's Roads and Trails division, published information, and data from the Interpretative and Law Enforcement Divisions. Data from the Interpretative Division includes estimated number of visitors based on road traffic counts and multipliers for average number of people per car.

Public Access Resources

Because the Giacomini Ranch has been privately owned until recently, the only formal trails within the Project Area are those on lands owned by the Seashore and GGNRA and lands managed by the County of Marin Parks and Open Space District (Figure 38). However, several informal trails have been developed along portions of the Giacomini Ranch's levees. The Project Area and immediate vicinity currently incorporates approximately five (5) formal or informal trails or trail segments. A description of these formal and informal trails is provided below.

The number of structures, facilities, and uses of formal and informal trails in the Project Area ranged from low (between 1 and 5) to medium (between 6 and 10), with White House Pool County Park and the Giacomini Ranch West Pasture characterized as medium. All of the existing trails in the Project Area would be characterized as having very low visitation (average of <50 people per day) relative to trails such as Bear Valley, including Tomales Bay Trail, Olema Marsh Trail, Giacomini Ranch West Pasture, Giacomini Ranch East Pasture, White House Pool County Park, and Green Bridge County Park (E. Hulme, superintendent, Marin County Open Space and Park District, *pers. comm*.).

To the north of the Giacomini Ranch, Tomales Bay Trail, which is on GGNRA lands that are leased by the Martinelli family for beef cattle grazing, starts at a moderate-sized parking lot on State Route 1 on the eastern side of Tomales Bay and winds approximately 1.37 miles on a fire road trail through grassy hills to a vista point that overlooks the southern portion of the Bay (Figure 38). This designated hiking and biking spur trail ends at the base of Railroad Point, just north of where Tomasini Creek flows out into Tomales Bay. Visitor amenities are minimal along this trail and restricted to maintenance of the fire road and signage at the start of the trail, so public access structures, facilities, and uses would be characterized as low. The trail is not ADA accessible. Use of this trail would be estimated as very low compared to heavily used trails such as Bear Valley, although there are no formal use estimates.

South of Giacomini Ranch, the County has leased two areas from the state of California Wildlife Conservation Board that are maintained as parks. The largest of these is the County's White House Pool park located at the intersection of Sir Francis Drake Boulevard and Bear Valley Road (Figure 38).

An approximately 0.4-mile unpaved dirt path starts on the northern side of Levee Road near the northeastern corner of Olema Marsh and winds through dense riparian habitat and open ruderal grassland areas adjacent to Lagunitas Creek before it ends at White House Pool. Two small wooden bridges cross the former and current outlets for Bear Valley Creek. A large paved parking lot (discussed below) occurs at the western end of the park and provides some access for water-based recreation such as kayaking. With the exception of the parking lot, visitor amenities are relatively simple and restricted to a portable toilet and small benches that have been placed along the creek. However, because of the accessibility to people with bikes, horses, boats, and dogs, the number of structures, facilities and uses of this trail ultimately ranked as high. Use of this trail is very low relative to the Bear Valley Trail with annual visitation of this and the Green Bridge County Park trails estimated at 7,000 people (E. Hulme, superintendent, Marin County Open Space and Park District, *pers. comm*.) and includes primarily people walking dogs, bicyclists, and birdwatchers. The County does limited maintenance on the trail annually. The trail is not ADA accessible.

The eastern end of the White House Pool County Park trail is directly opposite the Olema Marsh trail, which runs approximately 0.36 mile along the eastern edge of Olema Marsh through grassland directly adjacent to the shutter ridge created by the San Andreas Fault (Figure 38). Use of this trail would be characterized as very low compared to heavily used trails such as Bear Valley, despite the fact that it offers a moderate or medium number of attractions and features (facility, structure, and uses between 6 and 10). Most visitors come to this area for birdwatching and access it from the southern end, which includes an access road and a small unpaved parking lot. This trail has the potential to link the White House Pool County Park trail with the Limantour Trail that parallels Bear Valley Creek and thereby potentially connect with the Bear Valley Trail near the Bear Valley Visitor's Center. Use of this trail linkage would currently require crossing of several busy roads that do not have pedestrian crosswalks. The trail is not ADA accessible.

Between the Green Bridge and Giacomini Ranch dairy facility is a small, approximately 10-acre parcel dominated by seasonal wetland/grassland and riparian scrub-shrub (Figure 38). Several dirt paths totaling approximately 0.5 miles criss-cross the park, with the main entrance and exit points being the Giacomini Ranch driveway at 3rd and C Streets in Point Reyes Station and the southeastern side of the Green Bridge. Amenities are extremely minimal in this park, with structures, facilities, and uses ranked as low (between 1 and 5). The trail is not ADA accessible. While visitor use of this trail system would be characterized as very low compared to Bear Valley Trail, a fair number of people use this system, largely because it connects to one of the informal paths that has been created on the Giacomini Ranch's southern levee. The County does limited maintenance on the trail annually.

For many years, the public has accessed the Giacomini property along an approximately 0.46-mile informal dirt path on the elevated creek bank and levee (Figure 38). This spur trail ends at approximately the location of the Giacomini's old summer dam and largely has views of Lagunitas Creek, some patches of riparian habitat, the Giacomini Ranch's East Pasture, and the White House Pool County Park. Use of this trail would be characterized as very low compared to heavily used trails such as Bear Valley, although there are no formal use estimates. Most of the users are members of the local community who walk their dogs, bird watch, or even do some painting, most of whom access the trail from 3rd and C Street in Point Reyes Station. Because of its informal nature, there are no visitor amenities, and there is no connection with the White House Pool County Park. Facilities, structures, and uses would be characterized as low (between 1 and 5). It is unclear whether the Giacominis maintain this area or whether it is maintained through use, but there is no formal maintenance. The trail is not ADA accessible.

FIGURE 38. EXISTING CONDITIONS - PUBLIC ACCESS

The other informal trail in the Project Area is at the northwestern corner of the Giacomini Ranch along the top of the levee at the northern end of the West Pasture (northwestern levee; Figure 38). It can be accessed from a small pull-out area on the east shoulder of Sir Francis Drake Boulevard north of Drake's View Drive. This approximately 0.3-mile dirt spur trail leads from Sir Francis Drake Boulevard to the northeastern corner of the West Pasture at Lagunitas Creek. This trail does not receive as much use as the informal path near Point Reyes Station, however, there are occasional hikers and dog walkers, as well as hunters who access State Lands Commission areas north of the Giacomini Ranch via this levee. Other than parking, amenities are minimal, but structures, facilities, and uses ranked as medium (between 6 and 10), because of the viewing, birdwatching, and other features available. The trail is not ADA accessible. The trail generally receives few or very low number of visitors. Highest visitation for this trail occurs in the winter, when literally hundreds of birders from San Francisco Bay and other areas crowd onto the levees to view California black rails that move from the adjacent undiked marsh during extreme high tides in December, January, and February into higher elevations areas such as the levees. During the weekends, more than 50 vehicles are often parked haphazardly some distance along the narrow shoulder of Sir Francis Drake Boulevard. Because of the potential disturbance to these special status species, in 2005, the Seashore requested that birdwatchers restrict trail use to the western end of the trail to decrease proximity to rails seeking high-tide refuge.

Parking issues are addressed under Transportation, but, because parking affects visitor and resident experience in terms of ease accessing trails, information from the Transportation section is summarized here. Two formal parking lots serve trails in the Project Area and vicinity. There is a parking lot with 14 parking spaces at the trailhead for Tomales Bay Trail that generally has high capacity (i.e., occupancy does not exceed 90 percent of capacity during weekday and weekend regardless of season) and another parking lot with approximately 43 parking spaces at White House Pool County Park that has medium capacity (i.e., occupancy does not exceed 90 percent of capacity during weekdays and most weekends except for some holiday and high season period weekends). Approximately 23 informal parking areas exist for the Giacomini Ranch West Pasture in pullout areas along the side of Sir Francis Drake Boulevard, although parking often overflows onto the street during the winter high tide periods. There are no designated formal or informal parking areas for the Giacomini Ranch East Pasture and Green Bridge County Park trail network, with most people parking alongside homes on 3rd and C Street in Point Reyes Station or walking to the trail from other parts of town. Parking can be difficult on busy weekends and weekdays.

Visitor and Resident Experience – Visual Resources and Viewsheds

Background and Regulatory and Policy Setting

The Park Service Organic Act of 1916 states that the Park Service "…shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations…by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the **scenery** and the natural and historic objects and the wildlife therein…" Park Service Management Policies (2006) describe the "park resources and values" that are subject to the Park Service no-impairment standard (NPS 2006; Section 1.4.6). Included among these are a park's "scenery, scenic features, natural visibility, both in daytime and at night, and natural landscapes." Park Service management policies characterize scenic views as highly valued characteristics of the natural resources, processes, systems, and values found in national parks. Scenery is not limited to features, but relates to light and shadows, as well. Parks are directed to "…preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human-caused light" (NPS 2006, Section 4.10).

Viewsheds are often experienced from automobiles, which has resulted in designation of scenic highways in California.

Viewsheds are often experienced from automobiles, which has resulted in designation of scenic highways in California. The entire segment of State Route 1 in Marin County is an eligible state scenic highway under the Caltrans Scenic Highway Program. The *Guidelines for the Official Designation of Scenic Highways* (Caltrans 1996) states that the scenic corridors (defined as the area of land generally adjacent to and visible from the

highway) of officially designated state scenic highways are subject to protection, including regulation of land use, site planning, advertising, earthmoving, landscaping, and design and appearance of structures and equipment. Within the Coastal Zone, which incorporates the Project Area, the LCP (Marin County Comprehensive Planning Department 1981) specifically identifies Sir Francis Drake Boulevard as providing a scenic driving experience for coastal visitors and an important access road for local residents. The LCP (Marin County Comprehensive Planning Department 1981) notes that, "in order to protect its scenic rural character, the road shall be maintained as a two-lane roadway."

The LCP for Zone II (Marin County Comprehensive Planning Department 1981) refers to visual resource protection policies in the Coastal Act that address the importance of protection of views to scenic resources from public roads, beaches, trails, and vista points. The *Marin Countywide Plan* (draft Countywide Plan 2005) mandates that visual and aesthetic resources, especially scenic vistas, shall be protected by review of planned projects and removal of inconsistent existing elements. The County has developed two policies to protect visual and aesthetic resources. The Viewshed Protection policy protects visual access to the bay front and scenic vistas of water and distinct shorelines through its land use and development review procedures. The View Corridor and Enhancement Policy urges that existing built elements, such as overhead utilities, which detract from the shoreline and marsh landscape, should be eliminated or blended into the environment.

Visual Resources and Viewsheds in the Project Area and Immediate Vicinity

Background

The analysis of viewshed or visual resources was guided by two widely-accepted protocols used for evaluating visual impacts of proposed projects: the Federal Highway Administration (FHWA) technical document *Visual Impact Assessment for Highway Projects* (Federal Highway Administration 1983) and the US Forest Service (USFS) *Landscape Aesthetics: A Handbook for Scenery Management* (USDA 1995). These protocols, together with guidance from Park Service Management Policies (2001) on protecting dark night sky resources, form the basis of an objective methodology used to establish the visual characteristics and quality of landscapes and to assess impacts on scenic vistas and scenic resources.

The analysis was based on the premise that people value most highly the more scenic landscapes, that natural or natural-appearing landscapes are generally the most valued, and that people also value cultural enclaves of structures (fences, historic structures) as sub-dominant visual themes nested within larger natural-appearing landscapes (USDA 1995). While this is generally true, in Marin County, pastoral landscapes, as well as natural landscapes, are valued, as well, with the county and the public making efforts to retain an agricultural way of life in west Marin and the scenic values this way of life provides. Pastoral landscapes include predominantly agricultural lands with grazing by livestock, however, other forms of agricultural also have scenic value to people such as vineyards. In addition to composition and structures, other valued characteristics of landscape include diversity of form, line, color, and texture; long sweeping vistas; and natural lightscapes (FHWA 1983, NPS 2001).

Eight viewpoints and view corridors were chosen to represent the visual resources of the Project Area for this analysis (Figure 39). These views were chosen subjectively as those locations from which most visitors would visually experience the Project Area. They were also chosen to represent the range of views of the Project Area which are available from within the site and from the surrounding community. For each of these views, the present landscape character was described according to principles defined in FHWA (1983) and USDA (1995) and incorporated natural lightscape characteristics, as required by Park Service Management Policies. Baseline conditions were then compared to projected changes to the views under all project alternatives. In the analysis, potential changes to the following landscape elements were evaluated:

FIGURE 39. VIEWSHED ANALYSIS LOCATIONS

- *Integrity:*

  Scenic integrity is defined in *Landscape Aesthetics: A Handbook for Scenery Management* (USDA 1995) as:

- *The degree of direct human-caused deviation in the landscape by management such as earth moving, road construction, or resource extraction:* This element is evaluated by measuring the degree of alteration in line, form, color, and texture from the natural or natural-appearing landscape character, or from the established landscape character accepted over time by the general public. This is done by measuring changes in scale, intensity, and pattern against the attributes of that landscape character.

  Views with high scenic integrity also have a sense of wholeness or intactness, with no discordant elements.

- *Diversity:*

  Diversity in landscape is characterized by variety in form, line, color, and texture components visible in a landscape view. Diversity is also characterized by high variety in these components within the foreground view (up to 0.25 miles from the observer), mid-ground view (between 0.25 and 1 mile from the observer), and background view (more than 1 mile from the observer) of the view; and also variety between these views. In general, mid-ground views are subjected to the most visual scrutiny by observers.

- *Prospect:*

  Scenic values increase as the terrain allows longer views. Prospect describes the length of view from the viewpoint or view corridor.

- *Natural Lightscapes:*

  Scenic values are highest in landscapes dominated by natural lighting regimes. After sundown these landscapes are lit predominantly by star- and moonlight. In scenes with natural lightscapes light pollution from nearby communities and distant metropolises is minimized.

Visual Resources in Project Area – General Description

In addition to active recreational opportunities such hiking, biking, walking dogs, horseback riding, and kayaking, visitors and residents of local communities can experience the beauty of national parks and undeveloped areas through viewsheds or opportunities to view aesthetically pleasing vistas within the watershed, whether that be the waters of Tomales Bay, grazing cows in a field, or a herd of tule elk on Tomales Point.

The major visual resource landforms in the Project Area and immediate vicinity are the rift zone valley along the San Andreas Fault (valley bottom), the Point Reyes Mesa coastal marine terrace bordering the Giacomini Ranch to the east (terrace), the granitic-dominated Inverness Ridge on the west (ridge), and the grassy shutter ridge hills that separate Bear Valley Creek from Olema Creek (hills). For the purposes of evaluating existing viewshed resources, visual quality was assessed at nine viewpoints in the Project Area and immediate vicinity. Viewsheds in the Project Area include both low-elevation viewpoints along roads and trails, as well as higher elevation ones on the Point Reyes Mesa and Inverness Ridge, which include many rural residential developments. Because of the steepness of the Inverness Ridge and even Point Reyes Mesa, background visual resources, which include features more than 3 miles from the viewpoint, are often not visible, except in certain directions (e.g., north along the rift zone valley) or from elevated viewpoints on the Inverness Ridge or Point Reyes Mesa.

Viewshed resources are experienced somewhat differently by visitors and residents even at the same viewpoint depending whether they are stationary or moving. As the LCP noted, Sir Francis Drake, which closely follows the edge of Tomales Bay, offers numerous viewsheds or viewpoints, although the experience probably differs slightly depending on whether visitors and residents are driving, bicycling, walking, or standing still. Motorists can catch glimpses of the southern and northern portions of Olema Marsh on Bear Valley Road and Levee Road, respectively, and of the western portion of the Giacomini Ranch along portions of

Sir Francis Drake Boulevard. Viewing opportunities along Sir Francis Drake Boulevard primarily consist of pastures and, when present, grazing cattle: the levee obscures views of Lagunitas Creek. Groundwater and small creeks along the base of the Inverness Ridge have promoted growth of stands of riparian scrub-shrub and forest (see Vegetation Resources) that obscure portions of the pasture from vehicular, pedestrian, and cyclist passers-by on Sir Francis Drake Boulevard. The viewshed of some of the residents of Inverness Park is also minimized by the riparian habitat, primarily those along Sir Francis Drake Boulevard. Most of the residents, however, live on the hillside, above the treeline. Viewpoints near Olema Marsh from Bear Valley and Levee Roads, most often seen from a moving car, primarily offer views of marshlands, riparian forest, grassy hills along the shutter ridge, and the forested Inverness Ridge. Most of the residential development on the Inverness Ridge in the Silver Hills is remarkably hidden from view by the tall conifers that dominate much of the ridge.

Some viewpoints can only be accessed on foot. The elevated vista point near the end of Tomales Bay Trail offers spectacular views of southern Tomales Bay, Lagunitas Creek, undiked marshlands, the forested Inverness Ridge, and, depending on the exact viewpoint, some views of the heavily vegetated Point Reyes Mesa bluff. The lower elevation White House Pool County Park trail and the two Giacomini Ranch informal paths offer more constrained views of Lagunitas Creek, pastoral areas with cows, riparian habitat, the forested Inverness Ridge, the heavily vegetated Point Reyes Mesa bluff, and/or undiked marshlands. Visual quality of these areas is negatively affected to some degree by unsightly infrastructure or encroachments associated with agricultural development such as levees, riprap, pipelines, power poles, and deteriorating barns, although the dairy cows and pasturelands themselves, which remain green almost all year long, can be perceived as a benefit to visual quality as they provide highly valued pastoral scenery.

On the eastern side of the Giacomini Ranch, viewshed opportunities are constrained by natural topography and land use and ownership, as most of the East Pasture's perimeter is privately owned or leased by the Giacominis from the Park Service. As with Inverness Park, residents of Point Reyes Station live on an elevated mesa or terrace that maintains a viewshed despite the fact that willows are present and have even expanded in areal extent. The elevation of the terrace in this area allows panoramic views of southern Tomales Bay and the entire Giacomini Ranch, similar to that offered by the Tomales Bay Trail. Several isolated stands of very tall eucalyptus growing on the Point Reyes Mesa slope on private lands probably do block views of Tomales Bay in some areas. Views from the town of Point Reyes Station are reduced to some degree by the presence of the dairy facility buildings and barns, some of which are quite tall. Views from town primarily consist of pastures, grazing cattle, and the heavily forested Inverness Ridge. Growth and expansion of willow along the eastern edge of the Green Bridge County Park has apparently negatively affected views for some of the residents near 3rd and C Streets in Point Reyes Station, whose homes are on a lower portion of the mesa than those to the north.

Visual Resources in Project Area – Specific Descriptions from Viewpoints

Sir Francis Drake Boulevard, Inverness Park: Along Sir Francis Drake Boulevard bordering the West Pasture the **foreground** view is dominated by tall (average = 20 foot) riparian trees such as willow and alder sustained by groundwater that seeps from the toe of the Inverness Ridge and sheetflows across the West Pasture. Between these clumped stands of riparian trees, travelers may observe longer views across the West Pasture. In the **mid-ground,** these views are dominated by short, grazed annual grasses that are green in the winter and golden-yellow in summer on the flat pasture and that are broken occasionally by sparse stands of open-leaved willow trees growing in linear ditches and old slough channels. Behind the pasture, the rise of the West Pasture levee is visible, and beyond that the rough, green vegetation on the slopes of the Point Reyes Mesa. At the northernmost reach of this view corridor, the longer views are obstructed by the tall (~9 foot), green stalks of cattails in the freshwater marsh bordering Sir Francis Drake Boulevard. At several locations along the roadway, views of the Project Area are interrupted by small homesteads consisting of single-story wood frame houses and out buildings, vehicles and farm equipment, fencing, and small ranch operations. From many vantage points along the road, the bright silver form of the loafing barn is visible in the far distance beyond the Lagunitas Creek levees. At the far southern reach of this view corridor, the scene is dominated by the broad blue/brown band of Lagunitas Creek and its abundant green riparian vegetation, rounding a 90-degree bend at White House Pool. At night, the lightscape from this view corridor is dominated by lighting from the town of Inverness Park, residences bordering the Project Area, and a horizontal band of sparse dim lights from the visually-distant Point Reyes Mesa residences.

Inverness Ridge above Inverness Park: From residential roads on Inverness Ridge above Inverness Park, observers, including residents, can obtain an expansive view of the Project Area. The **foreground** of these

views is typically dominated by conifer forest trees lining the roadways. **Mid-ground** views consist of tree tops and roofs of single-family homes. The **background** views, however, are dominated by the East and West Pastures within the Project Area. One of the primary elements of this view is the blue undulating form of Lagunitas Creek winding north through the Project Area, bordered by thin, bright green bands of tall wetland vegetation. The levees bounding the creek are visible at this vantage, distinguished from the lower marsh plain by their brighter gold color in summer, breaking the pastures into geometric forms. Black and white cows graze and rest in the pastures. The vegetation in pastures in late summer is variegated gold and dull green, broken by linear bands of darker green riparian vegetation persisting in ditches and old slough channels. During the winter, when the pastures are more uniformly green, the islands of riparian vegetation are distinguished primarily by their height and apparent roughness. Beyond the pastures, to the east, the roofs and rough, dark green vegetation of the Point Reyes Mesa forms a contrasting horizontal band of color and texture. The view to the south affords vistas of the East Pasture, including grazing cows, green irrigated grasslands, and streaks of brown fencing and silver-colored irrigation piping. Behind the East Pasture observers can see the silvery geometric form of the loafing barn in the East Pasture and the brown, unvegetated fenced cattle lots, and the structures of Point Reyes Station behind them. Looking to the north, observers can note the linear feature of the West Pasture north levee bounding the end of the West Pasture and marking the transition from pasture to the Natural Landscape characterized by green undiked salt marsh and blue Tomales Bay to the north. The forested Inverness Ridge to the west, and grassy rounded hills to the east, slope down to meet the marsh and the bay. At night, the lightscape approximates natural lighting, broken only by the sparse dim line of visually-distant lights from Point Reyes Mesa residences~~,~~ and from cars moving along Sir Francis Drake Boulevard.

West Pasture North Levee: The immediate **foreground** is dominated by the highly-artificial structure of the 20-foot tall weather station and the wire fence surrounding this equipment. Looking south from the eastern tip of the levee, into the Project Area, the foreground of the view is scored by the broad dark blue line of Lagunitas Creek bounded within its levees. The levees themselves are set back from the creek by a 10-foot band of low-texture herbaceous vegetation~~,~~ and rise about 8 feet above the marsh plain. The levees are dominated by a Ruderal Landscape characterized by a texturally-complex annual exotic herbaceous plants, mostly gold-colored by late summer. Behind the levee, looking toward the East and West Pastures, the **mid-ground** view is of short-grazed annual grasses, gold-colored in summer and broken up in places by green patches of taller perennial shrubs along linear features such as ditches and old slough channels. The West Pasture is bordered to the west by the tall green cattails of the freshwater marsh. Behind the freshwater marsh, in the **background** of the view, automobiles on Sir Francis Drake Boulevard are occasionally seen and heard, and houses on the lower elevations of the dark-green forested Inverness Ridge are visible. Looking toward the East Pasture, a dominant feature of the mid-ground view is the 10-foot tall highly-geometric form of the Tomasini Creek tide gate controlling the outflow of Tomasini Creek water into Lagunitas Creek and the levees that preclude views of the East Pasture. Further down the East Pasture levee, to the south, the small, wooden, pitch-roofed pumphouse for the East Pasture irrigation system is visible, as are the wooden power poles delivering electricity to the pumps. These, combined with the levees, disrupt the integrity and unity of the Pastoral Landscape. In the background, residences on the Point Reyes Mesa, which are about 30- to 50 feet above the level of the marsh plain, are visible between and behind tall green stands of eucalyptus trees. The silvery, geometric form of the loafing barn, in the far southern end of the Project Area is partially visible in the distance. After sundown, this view is highly characteristic of a rural lightscape: sparsely distributed residential lights on the slopes of the Inverness ridge, headlights of cars moving along Sir Francis Drake Boulevard, and the dim visually-distant lights of Point Reyes Station and the Point Reyes Mesa are the only intrusions into the natural darkness.

White House Pool County Park: This view corridor along the single-lane dirt trail paralleling Lagunitas Creek, accessed from the White House Pool County Park parking area, is dominated in the **foreground** by the broad blue channel of the creek and its associated bright-green riparian vegetation. In the **mid-ground** view, the southern portion of the East Pasture levee rises up about three feet above the level of the marsh plain, visually separating the creek from the southern portion of the East Pasture. The levee is dominated by tall, rough, flowering weedy vegetation, intermittently broken by low hedges of dark green blackberry bushes and tall solitary stands of round-profiled gray-green willow trees. A post-and-wire fence runs along the top of the levee, contributing to the pastoral quality of the view. Behind the levee, elevated silver~~y~~ irrigation piping is clearly visible, somewhat disrupting the integrity and unity of the Pastoral Landscape characterized otherwise by green pasturelands dotted sparsely with black and white cows. The expanse of green fields in the East Pasture in the **background** is broken up by levees, ditches, roads, wooden power line supports, and fences running parallel and perpendicular to each other. Looking to the east, viewers can observe the strongly-pitched roof and metallic siding of the large loafing barn and its skirt of unvegetated brown cattle yards. To the northeast, the rough, dark green undifferentiated vegetation of the Point Reyes Mesa is punctuated with

glimpses of private residences and stands of tall linear eucalyptus trees. Behind the Point Reyes Mesa, the smooth grassy rounded form of Black Mountain dominates the horizon, sloping northward down to other grassy, rounded ridges and the green-and-golden bluffs of Millerton Point. To the northwest, observers can view the heavily forested Inverness Ridge paralleling the Project Area northward, with occasional outcroppings of single family houses on lower slopes. The northwest prospect includes views of residential development and power lines following Sir Francis Drake Boulevard to the north. After sundown, the lightscape at this location is altered only by the thin band of lights of the residences on the Point Reyes Mesa~~,~~ and the dim collection of lights from the residences on the slopes and toe of the Inverness Ridge.

Point Reyes Station C Street: From C Street looking westward towards the Project Area, the immediate **foreground** of the view is largely dominated by ranching activities associated with the Giacomini Dairy. At the northmost portion of this view corridor, views of the dairy operations, including the loafing barn and wood-frame houses and out buildings, are obscured by a 25-foot-tall stand of rough-textured, dark green Monterey Cypress trees. At the southern reach of this view corridor, pale wooden fences and rough-churned expanses of the dairy's enclosed cattle yards front C Street. Beyond the cattle yards, the scene encompasses several tall, rounded peaks of stores of materials, including manure and sawdust, and the open, dark interior of the aluminum-sided loafing barn. Looking to the south, viewers can observe rough, dark green. shrubby vegetation on the southern portion of the East Pasture levee and the linear feature of the levee itself confining Lagunitas Creek to its broad blue channel. Beyond the operations yards in the **mid-ground** vista, viewers can observe the green short-grazed irrigated fields or Pastoral Landscape of the East Pasture. These fields are predominantly smooth-textured, but are broken by occasional patches of taller, rough-textured dark green vegetation, with black and white cows dotting the pasture. Wooden power poles elevate linear stretches of wire across the pasture, somewhat disrupting the integrity and unity of the Pastoral Landcape. Beyond the pasture in the **background** view, the rise of the levee stretching north along Lagunitas Creek is visible, backed by coniferous forest and the housing development at the toe and lower slopes of the Inverness Ridge. Occasional traffic on Sir Francis Drake Boulevard is visible. The lightscape at this location is altered from natural conditions~~,~~ and is dominated by the nearby lights of Point Reyes Station~~,~~ and the dim sprinkling of lights from the residences on the Inverness Ridge.

Hunt Lodge East Pasture: The **foreground** in front of the Hunt Lodge is dominated by the rough, dark-green cattails choking the channel of Tomasini Creek running northward parallel to the East Pasture. The long, red, wood-sided Hunt Lodge itself forms a prominent part of the view here, surrounded by boxy green hedges and tall Monterey Pine and eucalyptus trees. Beyond Tomasini Creek, the levee visually and topographically separates the channel from the flat green plane of the East Pasture grasslands. The levee, which rises about 3- to 5 feet above the pasture, is topped by a Ruderal Landscape characterized by rough, patchy blanket of tall multi-colored weedy vegetation. The East Pasture beyond the levee, in the **mid-ground** of the view, is segmented into geometric forms by broad roads, post-and-wire fences, and silvery elevated irrigation piping. This piping, the Tomasini Creek levee, and infrastructure such as wooden power poles and electrical lines, fences, and the pitched-roof wooden pumphouse somewhat detract from the integrity and unity of visual resources in the Pastoral Landscape that is otherwise dominated by black and white cows in the fields. Beyond the pasture, the horizontal rise of the Lagunitas Creek levee is visible in the background, backdropped by the rough dark-green evergreen vegetation of the Inverness Ridge. In the background of this view, the Natural Landscapes of Inverness Ridge and the rounded grassy hills to the east converge to meet the undiked salt marsh and the bay. To the south, the dark green rough-vegetated slopes of the Point Reyes Mesa rise up above the Project Area, topped with a sparse settlement of residences and tall stands of eucalyptus trees. Beyond the Mesa to the south, the metallic aluminum siding of the loafing barn is highly visible at the south end of the East Pasture, ringed by fences and the barren grounds of cattle yards. The natural lightscape at this site is marred only by the dim residential lights from the Inverness Ridge.

Tomales Bay Trail: The vista from the Tomales Bay Trail encompasses nearly the entire Project Area. The predominant feature of the **mid-ground** view of the Project Area is the long, dark blue sweep of the Lagunitas Creek channel, running from the far southern reach of the site northward towards the bright blue basin of Tomales Bay. Looking to the south, the silvery pitched roof of the loafing barn protrudes a tiny bit into the irrigated green fields of the East Pasture, which are segmented and somewhat disrupted by linear fences, roads, ditches, and power poles. To the east of the pumphouse, the shallow channels of remnant slough features are visible, along with linear artificial-looking ditch features, bounded by the dark green slopes of the Point Reyes Mesa. The artificially constrained path of Tomasini Creek, leveed to run alongside the Point Reyes Mesa until it reaches the tidegate at its mouth to Lagunitas Creek, is also highly visible. Looking to the west beyond Lagunitas Creek, the rise of the roughly-vegetated levee, dominated by a Ruderal Landscape, visually separates the West Pasture from the rest of the Project Area. In the **background** view, the Ridge is the dominant feature of the west vista, paralleling the smooth fields of the Project Area~~,~~ and running north to

meet Tomales Bay. From this vantage, occasional traffic is seen and heard on Sir Francis Drake Boulevard, and the houses dotting the hillside are unobtrusive.

Olema Marsh Bear Valley Road: The **foreground** of the view along Bear Valley Road is dominated by tall (~15 foot), dark green riparian forest vegetation, such as willow and alder trees. Between stands, observers can look west into Olema Marsh. Immediately visible from the road are bright green patches of mid-height wetland vegetation (~2 foot tall), such as bulrush and fern, backdropped by taller (~9 foot) cattail and patches of open water. In the **mid-ground** view the land slopes up to the grassy, golden Shutter Ridge, dominated by a somewhat Natural Landscape of ruderal and native grasses and forbs. Wooden power poles are visible in the far distance. To the north, the mid-ground view is dominated by a row of dark green willow trees bounding the marsh, and beyond that, the green Bolinas Ridge and golden rounded Black Mountain comprise the **background** view.

Socioeconomic Resources

The Seashore is one of the 30 most visited parks in the National Park system. It is a destination park for national and international visitors, as well as a regularly visited resource for the 5 million residents of the nine counties that comprise the greater San Francisco Bay Area. Visitation to the park is approximately 2.5 million annually and is unusually consistent year-round, averaging roughly 200,000 visitors monthly.

Marin County has a $500 million annual tourist industry. It is estimated that the Seashore contributes over $150 million to the regional economy visitor expenditures on dining, fuel, gifts, groceries, and lodging (NPS 2002). According to a visitor survey conducted by Sonoma State University (NPS 1997), 74 percent of the visitors to the park are traveling to the Seashore as their main destination; 50 percent of park visitors are staying between 2-6 hours in the park, with 30 percent staying overnight; and 40 percent of visitation comes from Marin, Sonoma, and San Francisco Counties, with 16.5 percent coming from outside of California.

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The Seashore received 2.35 million visitors in 2000, accounting for 930 travel party days and nights in the area. An average visitor party spends $94 per party per night in the local area ($109 if locals excluded). Total visitor spending was $87 million in 2000 or $80 million excluding local visitors. This spending of visitors from outside the local region generates $69 million in sales by local tourism businesses, yielding $25.6 million in direct income and supporting 1,100 jobs. Each dollar of tourism spending yields another $0.63 in sales through the circulation of spending within the local economy. Including these secondary effects, the total economic impact of the park on the local economy is $113 million in sales, $42 million in wages and salaries, and 1,800 jobs (Michigan State University 2001).

Park Operations and Management Resources

Background

To fulfill its mission, the Park Service receives funding from both the federal appropriations process and other federal revenue sources. The Park Service requests direct Congressional funding and reports on the other federal revenue sources through an annual budget document submitted to Congress entitled “Budget Justifications,” or more popularly called, the “Green Book.” Like most federal agencies, the Park Service relies on federal appropriations to fund its core activities, although there is increasing use of alternative revenue sources such as fees and even private grants and mitigation monies to fund specific projects. In addition to base funding, certain parks receive monies from fees generated through park admissions, and parks can also apply for one-time funding through certain appropriation programs that cover cyclic maintenance, construction, etc. For example, the park recently received approximately $1.6 million in this one-time funding for cyclic maintenance on historic structures and other natural resources projects. As part of the San Francisco Bay Network, the Seashore benefits from monitoring information gathered as part of the $800,000 Inventory and Monitoring (I&M) Network. The park will also receive about $625,000 in fee revenues for other

maintenance projects and operation of the whale shuttle system and campground reservation system. In addition, the park receives approximately $1,000,000 in FirePro and Wildland Interface funding for hazardous fuel reduction and fire prevention activities.

Because of the limited amount of base funding available to support the 389 park units, the Park Service directs its units to consider the effects of proposed projects on base funding, including any increases in operations and maintenance expenses.

Park Operation and Management Resources

For FY2006, the Seashore has about 75 permanent staff, 10 term employees, and 25-30 temporary staff working on a variety of projects and programs, including Natural Resources, Cultural Resources, Science, Maintenance, Roads and Trails, Fire, Law Enforcement, and the Pacific Coast Learning Center. During the peak summer months, the park staff increases to about 150 staff members, including Youth Conservation Corps enrollees who provide assistance in a number of ways to Point Reyes National Seashore. This work force is supplemented by 20,000 hours of Volunteers-in-Parks service, three Student Conservation Assistants, and AmeriCorps.

The Seashore maintains the necessary infrastructure to support an annual park visitation of 2.25 million people, provide offices, support structures and limited housing for the permanent and seasonal park staff. The Seashore also administers approximately 19,000 acres of the north district of GGNRA. More than half of the Seashore -- the 32,373-acre Philip Burton Wilderness Area -- must be managed in conformance with the 1964 Wilderness Act, NPS Management Policies (NPS 2001a, Chapter 6), and the Director's Order and Reference Manual 41 for Wilderness Preservation and Management. The Wilderness Act requires that, except as necessary to meet the minimum requirements for the administration of a wilderness area, "there shall be no temporary roads, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, or no other form of mechanical transport, and no structure or installation" within the wilderness (16 U.S.C. 1131 et seq., Section 4 (c)).

Permanent park structures outside the Wilderness Area include:

- 3 visitor centers
- 2 environmental education centers
- 30 restroom complexes
- 4 backcountry campgrounds
- 17 water systems
- 147 miles of trails
- Over 100 miles of roads
- Over 100 public and administrative structures, and
- 27 sewage treatment systems

The Seashore also manages and protects park cultural resources including:

- 297 historic structures
- 127 recorded archaeological sites
- 11 identified cultural landscapes
- 498,000 museum objects

Financial resources available to achieve the park's annual goals include a base-operating budget of approximately $5.6 million. In addition, the park receives supplemental support for fire operations, cyclic maintenance, special natural resource projects, and repair and rehabilitation of structures.

Apart from the Park Service program, there are numerous commercial leases within the Seashore operating businesses, farms, ranches, and an aquaculture production. Leases include:

- 6 dairies
- 9 beef cattle ranches
- Silage production on approximately 1,000 acres of land,
- Oyster production in Drakes Estero, and
- Water supply to Bolinas Community

Project Operation and Management Resources

Planning and other activities conducted for the proposed project to date have been almost exclusively funded out of non-Park Service monies. The wetland restoration component has received funding from a Caltrans mitigation, SS Cape Mohican oil spill settlement funds and at least two private grant sources (Gordon and Betty Moore Foundation, National Fish and Wildlife Foundation). This funding has covered expenses of from one to two term FTE employees and occasional seasonal hires involved in planning and overseeing the proposed project. Since acquisition of the property, annual expenditures for the project, including personnel, monitoring, some property maintenance, and contracting for baseline studies including hydraulic and hydrodynamic modeling, ranged from $132,026 to $277,833 annually through September 2005. Personnel costs incorporated most of the environmental compliance activities for the proposed project, including scoping, alternative workshops, and preparation of this document, as well as a substantial amount of the vegetation and wetland-related baseline studies. The Seashore is currently applying for funding from at least three more private grant sources. It is anticipated that private funding would entirely pay for any further planning needs (i.e., permitting) and implementation or construction of the proposed project.

The proposed project has received some federal funds and support. Federal monies used for the proposed project came from $1.55 million in Congressional appropriations used to purchase the Giacomini Ranch and two competitive grant programs (Conservation Challenge Initiative and Park Service-USGS). Permanent base-funded Seashore staff has assisted with administration of the project, such as contracting, payroll, benefits administration, personnel, and maintenance associated with immediate operations and maintenance needs. On an annual basis, it is estimated that, on average, permanent, base-funded staff contribute less than 25 FTE days each year to the proposed project.

The Giacomini Ranch currently has no park facilities. Maintenance is not performed by Park staff currently on an annual basis, as most of the maintenance with the exception of the 2003 West Pasture levee repair and sediment removal from the 1906 Drainage downstream of the Lucchesi residence has been conducted by the Giacominis as part of their on-going operation of the ranch under a Reservation of Use agreement until spring 2007. However, immediate operations and maintenance needs such as repair of the Fish Hatchery Creek culvert and tidegate in 2003 and annual sedimentation removal from the 1906 Drainage due to flooding of adjacent private residences have been overseen by park maintenance personnel. Because the Giacominis continue to operate the Giacomini Ranch, existing informal social paths are not currently maintained by the Seashore.