Diked Historic Baylands of San Francisco Bay

Staff Report

Adopted October 21, 1982

San Francisco Bay Conservation and Development Commission

DIKED HISTORIC BAYLANDS

OF

SAN FRANCISCO BAY

STAFF REPORT
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by the
Staff of the San Francisco Bay
Conservation and Development Commission

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Foreward

The BCDC law requires the Commission to make a continuing review of all matters concerning San Francisco Bay. In April, 1979 the Commission began a study of certain diked-off areas that were formerly part of the Bay, but that are undeveloped not filled above five feet above mean sea level (USGS, 1929 datum) and for the most part outside the Commission's permit jurisdiction. The adopted work program for the study directed the staff to: (1) inventory and map the areas; (2) determine their physical and biological characteristics; (3) determine the value and relationship of the areas to the Bay; (4) determine the existing and planned future uses; (5) determine the extent and type of legal controls over these areas; and (6) recommend findings and policies for diked historic baylands.

This report results from that study. It focuses on the values of the areas for Bay-dependent wildlife. It also discusses the existing uses, the likely future pressures to fill and urbanize the areas, the uses that are most suitable for the areas, and the existing local, State and Federal controls over the areas.

The report was prepared by the BCDC staff relying on five technical reports: a biological report prepared by Madrone Associates; a report on restoration and enhancement of diked baylands by Philip Williams and Associates, Harvey and Stanley and Associates, and Madrone Associates; a report on agriculture and one on recreation prepared by the staff; and a powers report prepared by Shute, Mihaly and Weinberger.

The Commission's adopted findings and policies based on this report and maps showing diked historic baylands are available in a separate report entitled, "Diked Historic Baylands of San Francisco Bay, Findings, Policies and Maps" at the Commission office, 30 Van Ness Avenue, Room 2011, San Francisco, California 94102.

Introduction

A. Description of the Study Area

Surrounding the 426-square-mile Bay are more than 80 square miles of diked baylands that, for the most part, are not within the Commission's jurisdiction.[1/] Some still support wetland vegetation, such as pickleweed, because they are flooded or wet for some part of the year. Others support upland vegetation or are cultivated, mostly to grow hay. These 80 square miles (51,156 acres) of baylands comprise 291 sites. They are all located within a band that extends inland from BCDC's jurisdiction to a line that represents the extent of tidal marsh in 1850.[2/]

B. Study Methods

Historic bayland sites within the study area were identified using United States Geologic Survey (USGS) topographic maps; preliminary maps from the Department of Fish and Game report entitled Protection and Restoration of San Francisco Bay Fish and Wildlife Habitat; and aerial photographs. During the summer of 1979, each site was field checked. Inaccessible sites were checked using 1976 aerial photographs. Sites already developed or subject to tidal action were eliminated. New sites discovered during the field work were added into the inventory. All sites were classified by the staff according to broad dominant habitat types. For purposes of the study five categories were established: (1) diked salt marsh; (2) diked freshwater marsh; (3) diked brackish marsh; (4) ponds, lagoons and ditches; and (5) upland/cultivated habitat. After inventory the sites were mapped on 1:24,000 USGS quad sheets. Information on existing and proposed land use, zoning and ownership for each site was obtained from local planning and zoning reports and assessor's records.

Former baylands filled to an elevation higher than five feet above mean sea level (USGS, 1929 Sea Level Datum) were considered to have lost their Bay-related values, and therefore were not studied. Salt ponds and managed wetlands although diked also were not studied because they are already within the Commission's jurisdiction.

Characteristics of Diked Historic Baylands

A. Characteristics Prior to Diking

Before 1850 diked historic baylands were part of the extensive tidal marshes that surrounded the Bay. Inland were vast high marshes and

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1/ Small portions of a few diked bayland sites may be within 100 feet of the line of highest tidal action. The Commission's primary concern within the 100-foot shoreline band is the provision of public access.

2/ Nichols, D. R. and N. A. Wright. 1971. Preliminary Map of Historic Margins of Marshlands, San Francisco Bay, California Basic Data Contribution 9, U. S. Dept. of Housing and Urban Development, and U. S. Department of the Interior, Geological Survey.

uplands that separated the Bay from the oak covered hills. The hundreds of square miles of marshes and uplands were populated by wintering shorebirds and waterfowl that flocked to the Bay estuary for food and rest. Migratory birds took refuge on high marsh and uplands during storms and used dry areas to preen and sun themselves. Resident species such as bear, elk and deer were also abundant.

The large supply of freshwater carried by creeks draining the uplands was one major factor contributing to the abundance and variety of wildlife. Freshwater and tidal water mixed at the mouths of creeks and sloughs. These brackish marsh areas were rich in nutrients and ideal for fish nurseries.

Rainwater also contributed to habitat diversity. It was trapped and ponded at the edge of tidal marshes or in low spots in the marshes. Small freshwater marshes, formed near to or within the tidal marshes, provided a rich and diverse environment for animals and birds. Fresh and brackish water marshes such as these covered over 10,000 acres in the South Bay alone.

B. Present Day Characteristics

Diking and filling after 1800 so diminished Bay marshes that today only a few square miles of tidal marsh and 29 square miles (18,558 acres) of wetlands behind dikes remain. The hundreds of square miles of grasslands that once surrounded the Bay marsh are now covered with urban development except for about 51 square miles (32,598 acres) that are either open space or used for agriculture.

Rainwater is collected from urban areas and piped directly to the Bay. This decrease in freshwater inflow has caused decreased habitat diversity. A more detailed discussion of existing habitat conditions appears in section 2 below.

1. Major Land Uses

Agriculture is the major land use on diked historic baylands today. Most areas are used for the growing of hay and oats for forage or as pasture for dairy cows. All but a few hundred acres of such farming occurs in Napa, Sonoma, Solano and Marin Counties. Forage crops are sold mostly to the dairy farmers of Sonoma County and west Marin County. The remaining land within the study area appears to be vacant and undeveloped. Nevertheless some of these vacant lands serve several important purposes including flood control, waste assimilation and recreation.

About 3,542 acres within the study area are owned by flood control districts. Some of this land is used to retain runoff when heavy storms are co-incident with high tides. The Palo Alto flood basin is a good example.

Baylands are also used for waste assimilation. Sanitation districts own 595 acres of diked historic baylands. Some districts use them to assist in removing pollutants from both storm runoff and partially treated municipal sewage. For example, Mountain View Sanitation District's 20-acre freshwater marsh in Contra Costa County "polishes" the wastewater effluent by removing some of the nutrient load. This wetland also provides wildlife habitat.

Diked baylands are also used for passive and active recreation. Popular activities include hiking, jogging, photography and birdwatching. Users, estimated at over 100,000 per year, include individuals and groups, the young and old, the physically fit and handicapped. A more detailed discussion of recreational uses of baylands will appear in the section on Values.

2. Major Habitat Type

The five habitats within the study areas include: diked salt marsh; diked brackish marsh; diked freshwater marsh; ponds, lagoons and ditches; and cultivated/upland habitat. (Table I shows habitat types by county.) The habitat classifications were chosen by the staff. The biological consultants have further defined these categories in their technical report. While most sites fall into one or the other of the general categories, there are some instances where a site has characteristics of more than one habitat. There are 2,132 acres of mixed habitat within the study area.

For the most part, the type, variety and health of the plants in an area determines the variety and abundance of birds and animals that will be found. Although the abundance and variety of species that used the Bay has decreased since 1850, diked historic baylands still support many species of wildlife that use either the baylands exclusively or use them in conjunction with nearby tidal marshes and Bay waters.

a. Diked Salt Marsh

Of all the diked lands, the 6,159 acres of diked salt marsh in the study area most resemble their tidal counterpart. Historic meanders of former sloughs and surface features remain relatively intact. The dominant vegetation is pickleweed growing in continuous or dispersed stands, depending upon the amount of water available and soil conditions.

A great variety of wildlife including mammals, reptiles and birds inhabit diked salt marshes. Avocet, black-necked stilt, song sparrow, marsh hawk and a few puddle duck species nest in the vegetation which also provides food and/or cover. The high, dry portions of diked salt marshes are important for the survival of the rare and endangered salt marsh harvest mouse. The salt marsh harvest mouse is unique in that it drinks salt water. Its ability to survive on salt water may be a key to studying salt water metabolism in other mammals and provide a valuable research example of how species adapt to natural environmental stresses. Its gradual disappearance as well as reductions in populations of clapper rail and black rail may also be a clue to the health of the Bay environment. The significant reduction in these species indicates that Bay area habitats are experiencing ecological pressures that adversely affect their inhabitants.

The aquatic habitats of diked salt marsh are similar to those occurring within high tidal marsh pools and channels, isolated from tidal flushing except during extreme high tides. The pools and channels have bottoms of soft mud, and throughout much of the year green algae grows in open, sunny areas. In these areas waterboatmen and other insects are generally abundant and small fish are found where standing water is retained year-round.

Table I

Habitat Classification
(Acres)

County	Salt Marsh	Brackish Marsh	Pond Lagoon	Freshwater Marsh	Cultivated/ Upland	Mixed Habitat	County Total
ALAMEDA	2,049	-	2,427	463	1,060	-	5,999
CONTRA COSTA	444	423	937	103	827	62	2,796
MARIN	945	627	336	29	5,579	552	8,068
NAPA	-	169	554	-	2,107	952	3,782
SAN MATEO	220	25	2,143	-	450	91	2,929
SANTA CLARA	1,882	167	814	-	80	193	3,136
SOLANO	320	33	731	-	1,600	-	2,684
SONOMA	299	-	286	-	20,895	282	21,762
Total	6,159	1,444	8,228	595	32,598	2,132	51,156
Percent Total	12%	3%	16%	1%	64%	4%	100%

b. Diked Brackish Marsh

The 1,444 acres of diked brackish marsh in the study area can usually be visually distinguished from diked salt marsh by patches of taller vegetation which commonly grows in a mosaic like pattern. At the lower elevations that are submerged more frequently, tule grows, which provides cover for birds and other wildlife. At higher, drier elevations one finds bulrush. Pickleweed is also found in this zone. Species such as salt grass grow at the highest elevations that are seldom submerged. Ponds are also found in diked brackish marshes and are ideal feeding grounds for waterfowl. Bird's beak, a rare and endangered plant, is found in brackish marshes. Diverse physical characteristics of these sites, including differences in soil salinity, soil permeability and elevation account for the diversity of vegetation. Because of the diversity of vegetation, diked brackish marshes support more diverse wildlife populations than diked salt marshes.

Many brackish tidal marshes in the Bay were diked in the late 19th century and have since been operated as duck clubs. When so managed, the marshes provide optimum habitat for selected species of waterfowl through control of water level and salinity. Such areas are now within the Commission's "managed wetland" jurisdiction whereas other brackish marshes are not.

c. Diked Freshwater Marsh

Although small freshwater marshes were once a common feature around the Bay, only 595 acres of freshwater marshes are in the study area. The areas that do remain are largely dependent on seasonal rainwater and sufficient ponding or high groundwater to sustain vegetation through the dry summer months. The plants colonizing freshwater marshes are mainly cattail, with a few scattered stands of tule, bulrush, and willow.

Freshwater marshes are heavily used by birds and mammals even though many marshes are small and in close proximity to human activities and disturbances. It is common to find nesting black-crowned night heron, or courting and nesting red-winged blackbird, song sparrow, house finch, brown towhee, scrub jay, mourning dove, warbler, swallow, chickadee and goldfinch, as well as large numbers of feeding puddle ducks, shorebirds, and wading birds. Birds that breed in the freshwater marshes include: grebe, heron, bittern, hawk, rail and the salt marsh yellowthroat, a potentially endangered species.

At least two diked former salt marshes in San Francisco Bay are now managed as freshwater marshes for fish and wildlife purposes, providing habitat that is no longer common. They are Coyote Hills Regional Park and the Mountain View Sanitary District marshes. At least 188 species of birds have been observed in the freshwater habitat at Coyote Hills. The marsh and associated ponds contain the largest known nesting site of tri-colored blackbird in the South Bay Area. Snowy egret and great blue heron also use the marsh for feeding and resting. The area provides habitat for many mammals including the muskrat, gray fox, long-tailed weasel, raccoon, striped skunk and beechy ground squirrel. Reptiles are also commonly found. The water supports at least five species of fish and approximately four species of amphibians.

d. Ponds, Ditches, and Lagoons

There are approximately 8,228 acres of ponds and lagoons in the study area. They are important because large numbers of waterfowl and shorebirds rest on their calm water when the Bay is rough or when mudflats are covered by high tides. Many bird species use ponds for feeding. For example, freshwater ponds are used by dabbling ducks. Wastewater oxidation ponds draw phalaropes, small birds resembling gulls that migrate from the Arctic. Numerous perching birds such as blackbirds and swallows feed over ponds on the insects that breed in the waters. Flocks of wading birds feed in the exposed muds of shallow water ponds.

Aquatic conditions in ponds and ditches are extremely variable but in general, poor water circulation degrades water quality, primarily by reducing available oxygen. Most aquatic organisms cannot tolerate substantial reductions in available oxygen. Algae can thrive in ponds even when oxygen is low. Insect larvae or adults are also abundant and certain species of small fish do well in ponds.

There are several types of ponds and lagoons within the study area. Some are part of waste treatment facilities. Some are inactive salt ponds that were taken out of salt production before 1966 and thus not within the Commission's "saltpond" jurisdiction. Plants growing in ponds that were used for concentrating salt are unique because they consist almost exclusively of red photosynthetic bacteria. Some inactive salt ponds have reverted to their former marsh state and now support dispersed stands of pickleweed.

e. Cultivated/Upland Habitat

Lands used for agriculture provide habitat for indigenous birds and mammals and are also used by migratory species. Agricultural land that is dry year-round supports terrestrial species. Lands that are seasonally wet support wintering and migrating waterfowl and some shorebirds. Because of homogeneity of cover during most of the year, cultivated areas generally support a limited number of wildlife species, mostly for nesting and temporary shelter. However, during plowing or when seasonally flooded, fields draw large feeding flocks of certain birds.

In addition the numerous remnants of uncultivated, unfilled, dry upland areas scattered throughout the study area are very important for wildlife. For example, some of these areas act as buffers between developed land and nearby wetlands. Such terrestrial areas have other important functions as well. Upland areas adjacent to freshwater are the preferred nesting habitat of puddle ducks. Windrows on higher ground function as wildlife shelters, perches, and breeding habitat for birds and mammals. Shorebirds occasionally flock to high patches of barren ground near the Bay when forced out of other habitats by high tides. Dikes are used by many species for nesting. For example, least terns and killdeer are attracted to dikes covered with gravelly sand and broken shells.

Values of Diked Historic Baylands

The diked historic baylands are valuable because they provide essential wetland habitat for migratory shorebirds and waterfowl as well as habitat for

resident species. In addition, they provide valuable flood control benefits by retaining urban runoff which during times of high tide could flood adjacent urban areas. They are also valuable for assimilating wastes from both urban runoff and secondarily treated wastewaters. The agricultural and recreational uses also contribute to the economic and social well-being of the Bay Area. Lastly, some diked areas are well suited to enhancement as mitigation projects.

A. Habitat Value

Biologists have two ways to measure the value of habitat: diversity and productivity.

1. Diversity

Diversity means how many types of plants and animals are present in a particular area. Diversity is considered to be a measure of the health of the environment. Diversity in nature is often also what makes it interesting. Natural areas that have mountains, streams, and different types of vegetation, flowers, and many birds and animals are the most interesting and scenic. Some people consider the Bay marshes to be monotonous and boring; there is nothing spectacular about them. This is true if one compares their present appearance and diversity to that of the past. At one time there were herds of Tule elk and many grizzly bear using the Bay margin. Sea otter were abundant and fed on the clams in the Bay. The willows that lined creeks that fed into the Bay and cattails growing in freshwater marshes provided visual diversity.

Man reduced the diversity of both the appearance of the estuary and wildlife resources found there not by his presence or hunting alone but by his works. He diverted freshwater, cut trees, channelized streams and put pollutants into the Bay. When man's works overwhelm the natural capacities, habitat is destroyed and the birds and animals die out or leave.

There are a variety of birds and animals using the baylands today, including deer, fox, raccoon, duck, egret and hawk. They can only remain so long as the variety of habitats -- fresh, brackish, and saline wetlands; agriculture; and weedy uplands -- with all their varying types of vegetation, remain. The variety of species could be increased if the habitat diversity were improved through enhancement.

2. Productivity

Productivity of a particular habitat means both the amount of plant food and nutrients that are produced and that are made available to the ecosystem via the food web. Plants found in a healthy marsh usually make available substantial amounts of food and nutrients for use within the site and for transport elsewhere.

Tidal marshes are highly productive because the dominant plant, pickleweed, grows very densely. The number of plants per acre is much greater and much more productive in comparison with wheat and other grains used by man.

Some of the nutrients that are beneficial and available to the system consist of decaying plant material. Tidal action removes a large

percentage of dead plant matter (detritus) to the Bay that is consumed by small Bay dwelling organisms. These are in turn eaten by larger species, such as fish, that are in turn eaten by larger animals or man. The productivity of the Bay system thus depends upon the productivity of its tidal marshes and, to some extent, on the diked wetlands which provide a similar type of habitat.

Diked historic baylands are not always as productive as their tidal counterparts for two reasons. The plants that grow in a diked salt marsh do not grow as densely as in an established tidal marsh. Secondly, a large amount of the plant material does not leave the area. However, plant matter is eaten by consumers such as insects, worms and snails that live in the baylands. These are in turn eaten by stilt, avocet and gull which come to the baylands to feed. When these birds return to the Bay, the nutrients they consumed are released into the Bay system.

When man diked more than 200 square miles of the 313 square miles of tidal marshes that formerly surrounded the Bay, he dramatically decreased the ability of the Bay to support large numbers of organisms because their food (energy) source was cut off. The productivity of the Bay ecosystem was thus considerably decreased.

A reduction in the acreage of wetlands within the diked historic baylands will reduce the productivity of the total Bay ecosystem because these remnants of the Bay still support valuable plants such as pickleweed. Food produced by the plants and exported still contributes to the health of the Bay ecosystem. More importantly, the remaining diked historic baylands are a valuable future resource. If enhanced, such as by being returned to tidal action, they can increase the overall productivity of the Bay.

The diked historic baylands are valuable to the ecosystem for two additional reasons. They add to the total amount of habitat available in the whole region. Some provide specific habitats that are critical to some specific species.

3. Extent of Habitat

The extent of habitat means the area or amount of suitable land or water available within the region. It determines the numbers of each kind of species that can survive in the Bay region. A decrease in amount of habitat of a particular type is often the reason that a certain species becomes rare and endangered. For example, the decrease in supply of nesting habitat for the condor and the least tern reduces their numbers. If a sufficient loss occurs, a species may become extinct.

Indigenous, non-migratory species are particularly dependent upon habitat supply. The salt marsh harvest mouse can only survive as long as it has an adequate supply of high, dry salt marsh.

Supply of habitat in the Bay is particularly important for migratory shorebirds and waterfowl. The large expanses of diked agricultural lands and diked brackish marshes of the Contra Costa shore of Suisun Bay provide these species, on a smaller scale, with the habitat formerly supplied by the large tidal marshes that used to exist near Alviso and in Napa County.

Small remnants of open land can also be important. Some smaller parcels serve as "wildlife oases" within urban areas. Animals tolerant of human activities can use these habitat islands. Skunk and raccoon are examples.

4. Specific Functions of Particular Habitats

Some habitat is valued because of a specific function it may serve. Terrestrial areas within the diked historic baylands serve three particularly important functions. First they act as a buffer between the Bay and development. Secondly, they provide corridors for wildlife movements. Thirdly, they serve as transition zones.

Diked historic baylands serve as buffers between the Bay tidal marshes and development. Shy marsh species are particularly sensitive to human disturbances and need these buffer zones.

Some diked historic baylands function as corridors connecting disparate undeveloped areas along the Bay shoreline. Some resident wild animals, similar to migrating birds, must move between different types of habitat as part of their life cycle, during various seasons of the year, or as part of their daily activities. Connections between habitats are critical for these migrations.

Transition zones are called "edge habitat" by ecologists because they are areas where two different habitats meet or combine. The zone supports a diveristy of plants and animals. Within the diked historic baylands for example, birds normally found in tidal flats and marshes come to the high ground transition zone when tides are high. In addition, species usually found in uplands may come to diked historic baylands on occasion for supplementary food. The diked baylands that serve as transition zones are increasingly important because they are replacing productive wildlands around the estuary that are rapidly disappearing.

Finally, it is important to remember that all things within a natural system are interrelated. An action that affects one species within the system sets off a chain reaction throughout the system. One man-induced change within the Bay system provides an example. Near the outfalls of some waste treatment plants, as well as at locations in the South Bay, particular organisms that can thrive in the discharged water are beginning to colonize. This undoubtedly affects the type of organisms that will start coming to the area to feed. Reaction to those changes will affect an even larger area. Similarly, filling diked historic wetlands will certainly influence the numbers of migratory species that come to the Bay. Mammals and birds that we now find around the estuary will likely be fewer. Such changes may also set off a chain reaction that will affect a larger area. In many cases, it is impossible to accurately predict the eventual outcome.

In addition to the habitat value, diked historic baylands have other attributes that are important.

B. Flood Control

The urbanization of upstream watersheds and the diking and filling of tidal marshes has increased flooding in the Bay Area. Urbanization causes

an increase in runoff from impervious surfaces, such as parking lots, roads, and roofs, that prevent absorption of the rain into the soil. Urbanization also results in the collection of runoff in storm sewers that convey the runoff more rapidly and efficiently. Thus, these changes associated with urbanization increase the total amount of water that reaches the flood plain and shortens the period of time in which water reaches the flood plain. When the downstream receiving areas--the Bay marshes--are filled or diked, water has less area over which to disperse and must go directly into the Bay. If high volumes of water reach the downstream areas at the same time that the tides are high, there is no place for the water to go. Waters that were once dispersed over the high tidal marshes then back up in stream channels and flood adjacent urban areas.

Thus, the remaining diked, unfilled historic baylands are particularly valuable for flood control because they retain stormwater during coincident heavy runoff and high winter tides. However, the reputed value of a tidal marsh to function as a sponge, literally absorbing flood waters, is generally falacious because soils subject to regular inundation are already saturated. Diked former baylands may function as partial sponges, however, since they are "drier" on the surface than a tidal marsh, but this does little to alter their net capacity.

The most practical way to view the flood control function of diked historic baylands is to regard them as basins with capacity available to hold runoff from surrounding uplands following rains. They also act as a reservior to hold a part of the tidal volume of the Bay that occasionally exceeds the capacity of the active tidal plain. In the absence of such "overflow" lands, the combination of the Bay's tidal flux and subsidence of many upland areas will inevitably lead to large and expensive new levees to protect the developed shoreline.

Flood control use can also restore some of the ecological values of wetlands. For example, tidal action could be introduced by tide gates from April to October to induce growth of marsh plants. Prolonged winter rainstorms that produce large volumes of runoff that must be retained within the basins do not damage wetland plants because salt marsh vegetation is dormant during winter months. Furthermore, use of runoff to enhance a marsh is beneficial in helping to diversify habitat because it creates a range of brackish water conditions at the salt marsh edge.

C. Waste Treatment

Pollutants are removed by wetlands in several ways. Sediment is physically removed as a result of settling, trapping, and filtering by vegetation. Micro-organisms in the wetland environment also utilize and transform chemical compounds. Lastly, some wetland plants absorb and utilize or store pollutants. Common pollutants that would otherwise enter the Bay include heavy metals and suspended solids.

Two waste assimilation projects are located within diked baylands, one in Palo Alto and one in Martinez. In Palo Alto, the Association of Bay Area Governments is monitoring the effectiveness of wetland vegetation in removing pollutants from urban runoff. The Mountain View Sanitary District in Martinez is monitoring the use of marsh plants to assimilate pollutants from treated wastewater. Although no definitive information is available, it

appears that nutrients are absorbed by marsh plants and that levels of phosphorus, nitrogen, heavy metals, and suspended solids are reduced when urban runoff flows through diked baylands. The baylands may thus be valuable in reducing pollution in San Francisco Bay.

D. Agriculture

Even though the habitat value of diked agricultural lands is less than that of diked wetlands and tidal marshes, retention of these areas in existing uses is important. Agricultural areas provide greater habitat value than developed areas in the Bay Area and also help to buffer urbanized areas from diked wetlands and tidal marsh. In addition agricultural lands are important to the Bay Area economy because they provide jobs and low cost feed for dairy cattle.

Dairy farms of the North Bay provide about 50 percent of the milk and milk products that are consumed in the Bay Area. Forage for these dairies is grown almost entirely on diked historic baylands and sold to local dairies. Because feed costs are one of the largest expenses incurred by dairy farmers and because transportation costs make imported feed more expensive, use of locally grown feed is important to keeping costs down and the dairies in business.

The ratio of hay-oat farmers to dairies is critical. Each is dependent upon the other. A reduction in the number of dairies would mean hay-oat farmers would not have a market for their product. Likewise a reduction in acreage of forage crops would require more feed to be imported. Higher costs for dairymen would result and could force some dairies to go out of business. This would be highly undesirable as most dairy farms and most hay farms are family enterprises and the farms themselves provide valuable open space. In addition, the dairy industry employs skilled and non-skilled workers on farms and in creameries and factories that manufacture milk products.

If farming is discontinued on the diked baylands, they would most likely be developed. The habitat and buffer values would then be lost.

E. Recreation/Open Space

All of the diked historic baylands serve as open space. The open space function is especially evident in the North Bay where hundreds of acres of agricultural land can be seen from the major highways.

Some of the baylands are used for passive recreation. Most activities occur along the dikes and at visitor centers at the nine designated recreation areas in the baylands. The South Bay in particular offers opportunities for nature study. Hiking, photography, and birdwatching occur on diked baylands in Palo Alto, at the San Francisco Bay National Wildlife Refuge in Alviso and Newark, and at the Coyote Hills Regional Park in Fremont. Many different types of groups including schools, scouts, Audubon Society and handicapped take advantage of the opportunities to view wildlife and study the Bay environment.

Active recreation, such as jogging, hiking and riding, is very popular along the trails that surround the baylands. This is because baylands

are so near urban areas that people can use them in much the same way as their neighborhood park. Although there is no accurate count of all who use the baylands for recreation, the number is estimated to be over 100,000 per year.

Relationship of Diked Baylands to San Francisco Bay

For the most part, diked historic baylands are no longer physically connected to the Bay. However, they are still closely related to the Bay in that changes that occur in them can affect San Francisco Bay.

First, a reduction in the acreage of diked baylands will reduce both the supply and diversity of wildlife. The variety of habitats behind dikes -- salt, brackish, and freshwater marsh; ponds; lagoons; and uplands — is a determinate of the diversity of wildlife that use the entire estuary. Migratory waterfowl and shorebirds rely not only on the open Bay and tidal marshes for feeding and resting but also on the protected diked baylands for refuge from storms. If the diked areas were filled and thus no longer available, many migratory species would go elsehere or not survive.

The supply and diversity of wildlife in the Bay region will also decrease if breeding grounds are diminished. The first to be lost will be the rare and endangered species such as the least tern and salt marsh harvest mouse. Others severely affected will be species whose migratory corridors are severed by intervening development.

Second, as noted earlier, diked historic baylands play an important role in flood control. Prior to diking these marshes were natural flood retention areas. High tides and runoff collected in the marshes until the tide subsided. Diking and filling of marshes has increased the incidence of flooding and in many areas large amounts of fill were placed to construct levees to keep high tides out of developed areas.

Diked historic baylands still retain flood water. Further filling of diked areas reduces the number of potential sites for flood control. Higher and wider flood control levees may be required in-lieu of non-structural methods. Such structures have already been proposed for the South Bay. Levees are costly to build and maintain and the public would likely bear most of these high costs.

Third, diked historic baylands can trap pollutants from urban runoff or assimilate waste. The pollutants and waste would otherwise flow directly into the Bay, degrading water quality.

Some potential uses of diked baylands are illustrated in Appendix A.

Possible Future Uses

A. Uses Proposed by Local Jurisdictions

According to most local plans, many diked historic baylands will not be preserved but are designated for development that requires fill. Maps 1 and 2 show the future uses for the 51,156 acres of diked historic baylands as taken from these plans. Table II shows future land use by county.

About 14,936 acres are designated for commercial, residential and industrial uses. Development will preclude protection of habitat value because all the above uses will require fill.

TABLE II

Proposed Land Use*
(Acres)

County	Agriculture	Urban Development	Open Space/ Park	County Total
ALAMEDA	147	2,666	3,186	5,999
CONTRA COSTA	0	2,589	207	2,796
MARIN	2,709	3,924	1,435	8,068
NAPA	3,176	606	0	3,782
SAN MATEO	0	2,848	81	2,929
SANTA CLARA	0	942	2,194	3,136
SOLANO	1,663	975	46	2,684
SONOMA	21,013	386	363	21,762
Total	28,708	14,936	7,512	51,156
Percent Total	56%	29%	15%	100%

*From County General Plan Designations through 1980.

About 7,512 acres are designated for future recreation and open space in local general plans. However, the majority of local jurisdictions use these designations to hold land for future planning purposes or as urban reserves. It is therefore likely that many wetlands and agricultural lands in this category will be held until they can be converted to other uses, most likely ones that require fill. Exceptions include the 4,137 acres that are owned by sanitary districts and flood control districts which may keep their land unfilled and undeveloped. Wetlands in the Cities of Hayward and Menlo Park, the Town of Corte Madera, and Santa Clara County will also remain unfilled because local plans, zoning and policy are directed to that end.

About 28,708 acres are designated for agriculture. It is difficult to predict how much of this land will actually be used for agriculture in the future. However, recent trends, location, availability of services, and ownership provide a clue as to their destiny. Agricultural land has been disappearing at a rate of 23,000 acres per year in the Bay Area according to a report prepared by the People for Open Space. Almost 75 percent of the land use change occurs as a result of urbanization. Sonoma, Marin, Napa and Solano Counties have all lost agricultural lands at a steady rate over the last several years.

Most agricultural land is near urban centers. The agricultural lands of Marin and Sonoma are within a 30 minute commute from San Francisco. Agricultural areas in Napa and Solano counties are within a 20 minute drive from Vallejo. The demand for residential units within commuting distance of urban areas creates pressure for conversion of agricultural land.

Extension of service district boundaries or of services themselves often precedes conversion to urban uses. For example, municipal services are available adjacent to large agricultural parcels in western Sonoma and Marin Counties. Services need only cross the Napa River to be available for residential uses in eastern Sonoma County.

About 3,054 acres are owned by banks, trusts and real estate companies and many of these are leased on a short term basis to farmers. Such institutions usually do not hold lands indefinitely for agricultural purposes. The lands will therefore most likely be converted to urban uses. The Commission staff has received within recent months several environmental impact reports (EIR's) for residential development on agricultural lands controlled by similar types of owners in Marin and Sonoma Counties. An EIR for conversion of 1,600 acres to residential development is being prepared for a parcel across the Napa River from Vallejo.

About half of the lands that are presently in agricultural use are under the Williamson Act contracts. This does not guarantee that the land will remain in agricultural use in perpetuity. A farmer may cancel his contract at any time and may sell his land nine years after cancellation.

Forage crops do not have a high yield per acre and even minor shifts in economic conditions can affect the profitability of a farming operation. Many farmers in the North Bay are already operating at or near the margin. If the market for hay declines or prices drop, farmers may decide to discontinue farming. This has occured in Marin County where 1,000 acres of land will be taken out of Williamson Act contract in 1983.

Although, many local jurisdictions are concerned about conversion of agriculture lands, most do not have strong preservation ordinances. Therefore, a strong State law whose purpose is agricultural preservation may be the best way to ensure preservation of agricultural lands.

B. Uses Compatible with Wetland Values

There are several land uses that may well be compatible and perhaps even complementary to wetland conservation, including flood control, waste assimilation, mitigation, recreation, and limited types of commercial recreation.

Land retained as wetland can provide economic benefits to a land owner if it is utilized for recreational purposes, sold for mitigation, or used for development that is compatible with wildlife use.

Land retained as wetland can also be of benefit to the region. The diked lands are a resource that can be utilized to increase the fish and wildlife values in the Bay. If some baylands are returned to tidal action, the Bay's productivity will also increase. Enhancing lands as fresh or brackish water marshes increases the supply of these habitats and thus increases the diversity of the Bay system. The particular types of new habitat that could be most beneficial to the Bay include: habitats in short supply, such as brackish and freshwater marshes; habitats for rare and endangered species; habitats that have a variety of vegetation zones from tidal marsh to upland transition zones; and tidal habitats.

The City of Palo Alto, the Alameda Flood Control District and the Marin County Flood Control District utilize diked baylands to retain flood waters. Incidentally, the freshwater enhances habitat. Many South Bay jurisdictions, especially San Jose and Alviso, need additional flood control. The utilization of retention basins as an alternative to levee or other construction projects may be cost effective as well as beneficial to fish and wildlife resources by providing needed brackish and freshwater habitat in the South Bay.

Waste assimilation projects can provide similar benefits. Diked baylands can be used to remove nutrients from secondarily treated water and also create fresh or brackish water wetlands. The baylands can also be used as emergency holding basins to protect against pollution of the Bay in the case of accidental releases of untreated wastewater.

Many wetlands behind dikes are suitable for recreation uses and need only minimal improvements to be profitable recreation areas. Duck hunting and fishing are popular recreational activities and diked historic baylands provide exceptional opportunities for these sports. Many baylands in the South Bay were leased for hunting and fishing within the past 20 years. Most are not now used mainly because the number of waterfowl have decreased.

With the exception of the Suisun Marsh, landowners have not managed or maximized the recreational potential of their lands. Water management could increase the number of waterfowl. Recreational use can occur both during the hunting season and all year for fishing. Charleston Slough in the City of Mountain View was leased until recently to a sportsman's club for hunting as well as fishing.

Small portions of some commercial recreation facilities such as restaurants can be placed on upland areas or on piles over wetland areas with minimal disturbance to the habitat. Opportunities for people to see wildlife can be provided by such facilities, especially if adjacent wetland areas are enhanced to attract more wildlife to the project areas.

Diked historic baylands are suitable mitigation sites for projects that require fill in the Bay or in wetlands. In the past, the Commission, as well as local jurisdictions and the Corps of Engineers, has required restoration or enhancement of diked wetlands as a permit condition for projects for which fill in the Bay was found to be necessary. There are a number of proposals for fill for ports, airports, and water-related industries where mitigation may be appropriate. Groups such as the Audubon Society, Trust for Public Lands, and the Nature Conservancy, as well as private developers, have recently expressed an interest in buying diked baylands for mitigation.

C. Restoration and Enhancement

Many bayland sites are ideally suited for restoration or enhancement. Some are close to tidal waters, some support wetland vegetation and some already have interior dikes that would prevent inland properties from flooding. About 1,000 acres of well suited diked baylands have already been restored to tidal action or enhanced. Several hundred acres more are required to be restored or enhanced due to conditions in BCDC permits.

Until recently very little technical information was available about marsh restoration and enhancement. No agency had developed criteria for selecting sites for marsh restoration nor developed engineering criteria for construction projects. In some cases baylands sites with highly productive habitats were proposed as mitigation sites, which may lead to a loss in habitat values. In addition some mitigation projects were built without proper construction standards so that the success of the project was not always assured.

Recognizing the need for technical advice on how to resolve these problems, the staff asked the consulting firms of Madrone Associates, Philip Williams and Associates, and Harvey and Stanley and Associates, all of whom had experience in the marsh restoration field, to prepare guidelines for marsh restoration and enhancement as part of their reports on diked historic baylands because many baylands are suitable for restoration. Their recommendations can be found in the technical report entitled, "Guidelines for Restoration and Enhancement of Diked Historic Baylands."

D. Hazards of Converting to Urban Uses

Diked historic baylands are difficult and expensive to convert to high density urban uses because former marshlands are underlain by young bay muds. These muds, deposited less than 10,000 years ago, are unconsolidated and in certain localized areas contain porous, water saturated, fine grained sand. Bay muds have a high potential for damage when they contain these liquifiable sands that can cause ground failure during earthquakes. Because Bay muds amplify seismic waves they can contribute significantly to damage and loss of life from ground shaking during earthquakes.

In addition, many diked historic baylands lie within the 100 year flood plain and are frequently flooded during the winter.

Bay muds of the North Bay are mainly of the Reyes soil type. These soils are prone to severe expansion and contraction caused when soils get saturated with water in winter and then dry out during the summer. Damage to building foundations from settlement of structures is quite common.

The U. S. Geological Survey in a 1979 report stated urban developments placed on bay muds have a high potential for personal property damage and for flooding. Unless stringent building requirements are placed on the developer it is likely that buyers and the public will bear heavy costs to repair, maintain and replace structures damaged by flooding, settling and earthquakes.

Existing Controls

A. Federal Controls

The United States Army Corps of Engineers is the agency with the most comprehensive regulatory authority over diked wetlands. The authority of most State agencies is limited to the influence they wield with the Corps. Cities and counties have extensive power through their planning and regulatory processes but a survey of their activities indicates that minimal attention has been directed to the values of diked wetlands. Furthermore, most local governments have not enacted ordinances to protect wetland values.

Jurisdiction is vested in the Corps through two major federal statutes, Sections 9 and 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Federal Water Pollution Control Act as amended in 1972 and 1977, now called the Clean Water Act. Under the 1899 Act, the Corps exercises jurisdiction over wetlands that have been separated from the Bay by a dike or other obstruction so long as the wetland lies below the plane of what was historically the level of mean high tide. Under section 404 of the Clean Water Act, the Corps exercises jurisdiction in a broader manner to include most wetlands regardless of whether they are above or below the level of mean high water because the courts have emphasized that the functional purpose of the Clean Water Act is to avoid and control water pollution no matter where the source is located. However, to be a wetland for the purposes of Section 404, an area must support vegetation typical of areas periodically inundated by water. Also, most agricultural activities that do not result in runoff or other direct discharge into the Bay are not subject to a Corps permit requirement under section 404.

A permit from the Corps for most work in wetlands is required by both federal statutes. The Corps determines whether or not to issue a permit for a given project under Sections 9 and 10 based on its own criteria contained in regulations promulgated under the 1899 Act. The regulations promulgated under section 404 of the Clean Water Act are issued by the Environmental Protection Agency but administered by the Corps. The Corps must follow the requirements of both sets of regulations.

Under the 1899 Act, the District Engineer must subject the proposed project to a "public interest review" having two aspects. The first includes a review of such factors as economics, aesthetics, general environmental concerns, historical values, fish and wildlife values, flood damage prevention, water quality, etc. Quite obviously this evaluation allows for

considerable discretion on the part of the Corps. The second component of the review is more restrictive and requires that the proposed project be "water dependent" and that no feasible alternative sites are available.

The EPA regulations under section 404 administered by the Corps establish a related test, but they employ a significant presumption that has the effect of making those regulations stronger than the Corps regulations. Specifically, if a project is proposed in a wetland and does not require access or proximity to the wetland to fulfill its basic purpose, practicable alternatives that do not involve use of the wetland site are presumed to be available. This provision is probably the most significant of the entire body of regulations administered by the Corps. The effect of the presumption is to place the burden upon applicants to make what would normally be a difficult showing that other sites are not available. This burden must be satisfied before a project may be approved in a wetland.

The Corps is also required to consult with interested federal and state agencies. This requirement is significant because it is one of the primary means by which California agencies have influence over activities proposed in diked wetlands. In fact, the Corps consults with the California Department of Fish and Game on all applications affecting wetlands and gives its recommendations great weight.

The federal Coastal Zone Management Act is also involved. Corps regulations provide that no permit will be issued to a non-federal applicant until the appropriate state agency has certified that the activity complies with the approved Coastal Zone Management Program. The section 404 regulations provide that if an approved Coastal Zone Management Program has identified and evaluated practical alternatives, these alternatives shall be considered by the Corps as part of the consideration of alternatives. Thus, to the extent a Coastal Zone Management Program deals with possible alternative locations for projects that might be proposed in a wetland, the Corps would utilize that information in determining whether that project could, in fact, be placed on an alternative site.

Other federal statutes and policies are also applicable in diked wetlands. The National Environmental Policy Act provides for the Environmental Impact Statement process on all major federal actions. Also Executive Order No. 11990 imposes the requirement that a project in a wetland may not be approved unless there is "no practicable alternative."

The discussion above summarizes the protections that are presently in place. Within the past year members of Congress have drafted amendments to the Clean Water Act and the Rivers and Harbors Act that are intended to limit the extent of the Corps jurisdiction and speed up the permit process. None of this legislation is being pursued currently.

In addition, the Presidential Task Force on Regulatory Relief within the Office of Management and Budget received recommendations from Assistant Secretary of the Army, William Gianelli, for administrative and legislative changes to section 404 of the Clean Water Act. The changes would reduce the Corps permit jurisdiction to areas that are "inundated," thus eliminating jurisdiction behind dikes. The Task Force did not respond to Secretary Gianelli's proposals, and the staff does not anticipate any response or changes in the near future.

B. State Controls

Numerous State laws and policies also bear on development in diked baylands. However, none of them give any State agency the degree of authority that is vested in the Corps of Engineers. For example, the State Water Resources Control Board and the Regional Water Quality Control Board exercise water quality review pursuant to the Clean Water Act and the Porter-Cologne Water Quality Control Act. Specifically, the Regional Board administers waste discharge requirements under the water pollution provisions of California law. The basic thrust of the water quality controls under these statutes is over discharges that impair water quality of biologically sensitive areas, including wetlands. The Department of Fish and Game has several responsibilities which may affect projects in diked historic baylands. These include streambed alteration agreements and native plant protection. However, the most significant involvement of the Department of Fish and Game is through comments on Corps permit applications, pursuant to the Fish and Wildlife Coordination Act. The Department reviews project applications and proposals in accordance with its responsibility for protection of fish and wildlife resources and habitat. The Department's general policy has been to oppose wetland development unless a project is dependent upon a waterfront site, no less damaging alternatives exist, and loss of existing or potential fish and wildlife habitat is offset by restoration of an area of comparable size and value.

There are several other state laws and legal doctrines that bear peripherally on diked historic baylands. They are the California Environmental Quality Act, the Resource Agency Basic Wetlands Protection Policy, the Keene-Nejedly California Wetlands Preservation Act which authorizes the Departments of Parks and Recreation and Fish and Game to conduct a study to identify wetlands that should be acquired or protected, and the public trust doctrine, pursuant to which the State has retained an interest in tidelands that have been patented into private ownership.

C. Local Governmental Controls

Finally, cities and counties also have a role in the regulatory process. There are 32 Bay Area cities and counties with identified diked historic bayland sites. Four have adopted some form of protection -- mainly overlay zoning districts -- that are specific to wetlands or marsh. They are the Town of Corte Madera, Santa Clara County, and the Cities of Hayward and Menlo Park. It is reasonable to assume that wetlands within these jurisdictions will remain in a their existing natural state. Approximately ten other jurisdictions have adopted plans and ordinances that designate wetlands as open space, flood plain, or conservation zones. However, the policies and ordinances do not specifically provide wetland protection, so it is questionable whether they will remain as wetlands or be converted to other uses that require fill. Some 17 or 18 cities and counties do not have provisions that would prevent wetlands from being filled or otherwise greatly altered.

Seven jurisdictions have diked historic baylands used for agriculture. Some have large lot zoning, and some general plan policies

propose retaining agricultural uses. However, agricultural lands in these jurisdictions are being converted to other uses every year.

Mosquito Abatement Districts, known as Vector Control Districts, are single- or multi-city or county districts formed under state law to control the growth of mosquitoes, flies, and other insects. They have an interest in baylands because among the powers they possess are the power to construct and to maintain dikes, canals, and ditches needed to eliminate breeding areas and the power to abate as a public nuisance breeding places for mosquitoes, flies, or other insects created by any use of land or artificial change in the natural condition of the land. (California Health and Safety Code Section 2200 through 2426).

Conclusion

The diked historic baylands surrounding San Francisco Bay have retained many of the values associated with tidal marshes. Although most of these baylands do not have a direct hydraulic connection with the Bay, they all contribute to the Bay ecosystem and to the surrounding urban areas. Diked historic baylands have diverse functions and values. They are of biological importance because they provide major wildlife habitat and contribute nutrients to the Bay ecosystem through export. The wide variety of water regimes and vegetation, even though modified within the diked areas, contributes greatly to the habitat extent and diversity of the Bay. Diked lands act as a buffer between urban uses and the remaining natural tidelands and serve as protected corridors for wildlife movement in and out of the wetland areas. They also serve as nesting, denning, or breeding areas for some wildlife species, including some rare and endangered species.

Diked historic baylands perform other important functions to residents of San Francisco Bay Area, such as retaining storm runoff and flood waters, maintaining water quality by assimilating wastes (i.e., removing pollutants from runoff and wastewater) and buffering land areas from storms and erosion.

A reduction in the supply of diked historic baylands will have a direct effect on San Francisco Bay because the supply and diversity of wetlands will decrease. Flood hazards will increase and construction of flood control levees will require new Bay fill. Pollutants that could be removed by marshlands may enter the Bay.

Of the 51,156 acres of diked historic baylands, 14,936 are designated for urban uses according to local plans and will be filled for residential, commercial or industrial use. About 7,512 acres are designated for recreation and open space, but they most likely will be converted to other uses. About 28,708 acres are designated for agricultural use. Without strong new State protection to ensure preservation, agricultural lands will be lost because of their proximity to transportation corridors and services, because most are not under Williamson Act contracts, and because farmers are now operating at or near the profit margin.

Diked historic baylands are difficult and expensive to convert to high density urban uses because former marshlands are underlain by young bay muds. These muds, deposited less than 10,000 years ago, are unconsolidated and in certain localized areas contain porous, water saturated, fine gained sand. Bay muds have a high potential for damage when they contain these liquifiable

sands that can cause ground failure during earthquakes. Because Bay muds amplify seismic waves they can contribute significantly to damage and loss of life from ground shaking during earthquakes.

Diked historic baylands that are retained as wetlands can be compatible with several uses, including flood control, waste assimilation, recreation, and limited commercial recreation. Diked historic baylands that are retained as wetlands provide a significant regional benefit because they provide critical habitat for migratory species.

Presently the only agency with permit authority over the 18,558 acres of wetlands within the study area is the Corps of Engineers. No federal, state, or local agency has enacted strong legislation that would prevent the conversion of agricultural uses that are on the 32,598 acres of diked baylands within the study area.

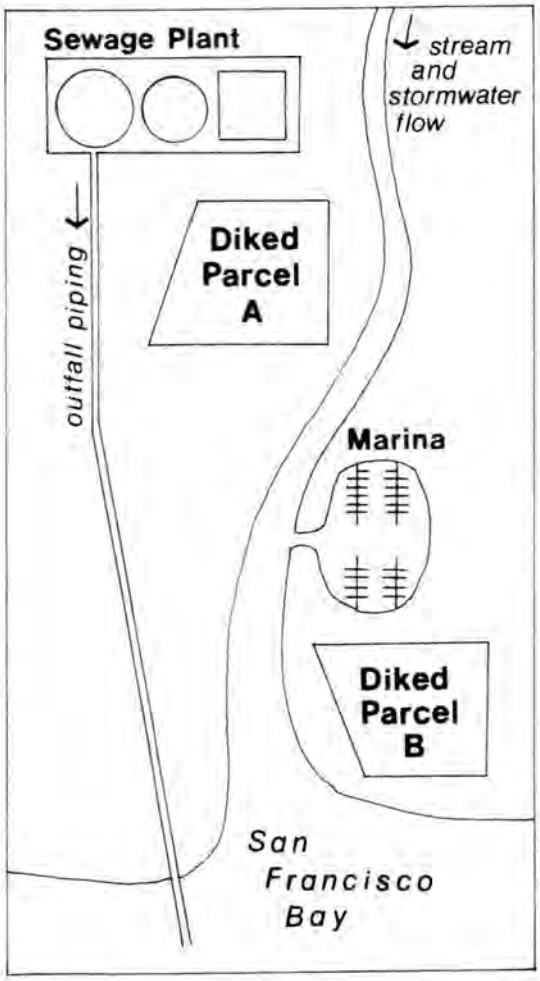
Appendix A

Selected Development Compatible with Diked Historic Baylands

by

Kent Dedrick
State Lands Commission

1. Present Configuration

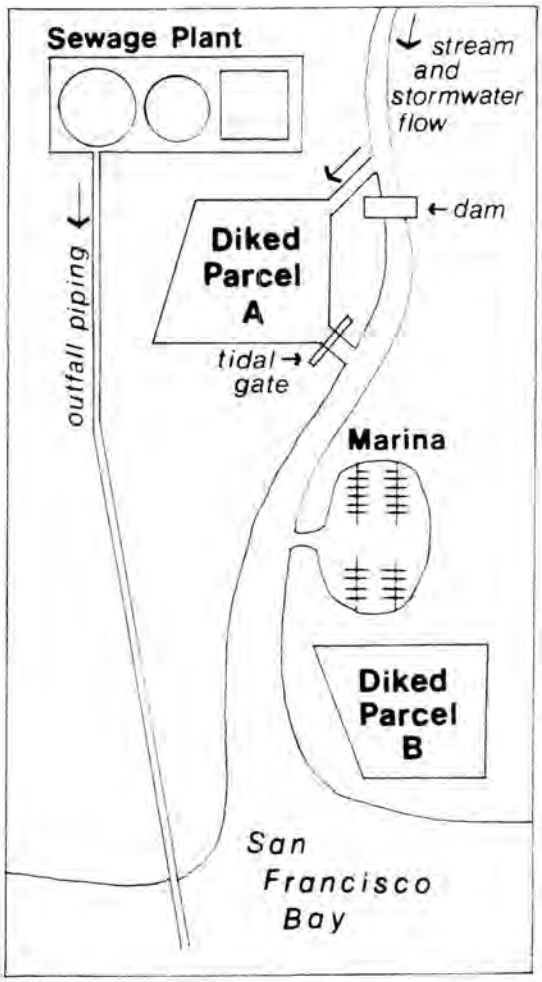


In its natural state, much of San Francisco Bay was ringed by a wide fringe of tidal marshlands which were heavily cut up by hundreds of miles of tidal creeks and sloughs. Freshwater streams draining relatively small watersheds either flowed into the marshlands, or into one of the tidal sloughs. During the rainy season, stream flows often dominated the hydraulic regime, but during the dry portion of the year daily high and low tides provided a continuing scouring force that prevented the accumulation of sediments originating from both Bay and upland sources.

Today, nearly all of these former marshlands have been diked or filled, and used for a variety of purposes such as agriculture, hunting preserves, solar evaporation for salt production, transportation, and land development. Many formerly navigable sloughs have become shallow mudflats and some have become salt meadows. Former small historic port areas are now as much as four miles from waters of sufficient depth to accommodate navigation.

Flood control channels and marinas occupy the beds of some of the former sloughs, and many of these sloughs have also served as receiving waters for sewage treatment plant effluents. In any case, it is often necessary to dredge these channels so that they can continue to serve the requirements of navigation and/or flood control. Providing for dredge spoil disposal sites thus remains a necessity.

2. Flood Basin, Seasonal Wetland



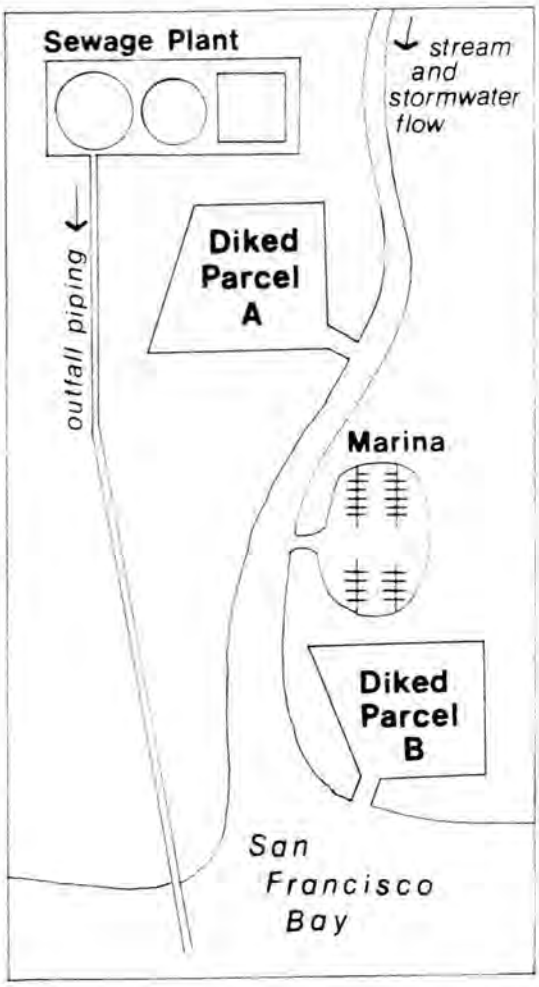
During times of heavy rains when streams entering the Bay are at flood level stage, high Bay tides can lead to overtopping of protective levees at lowland portions of the stream. For example, at Palo Alto and San Mateo, this flood potential has been eliminated through construction of reservoirs to accept the flood waters and then discharge them when the tide is low. In Diagram 2, Diked Parcel A is shown in a flood basin configuration.

The flood waters create a seasonal wetland area which can serve as waterfowl habitat during the rainy months. The water in the flood basin must be maintained at a level that is sufficiently low to provide capacity to accommodate storms later in the season.

After the end of the rainy season, Bay waters from Belmont Slough are allowed to flow into the San Mateo Slough flood basin ("Mariner's Lagoon") which then serves as a recreational waterway. Salt water flow must be sufficient to prevent stagnation; outflow water is pumped into the Bay. At Palo Alto, small amounts of salt water are permitted to enter the flood basin during the dry season to provide irrigation for brackish water flora. However, most Bay flora and fauna have difficulty in adapting to abrupt salinity changes; a point that is often ignored in design of flood basins.

The configuration in the diagram can be expected to lead to sedimentation from stream water flows in Diked Parcel A, and further sedimentation from the Bay itself in the entire area bayward of the dam. Maintenance dredging can be expected both for the marina and its navigation channel to the Bay.

3. Tidal Reservoirs and Marshland



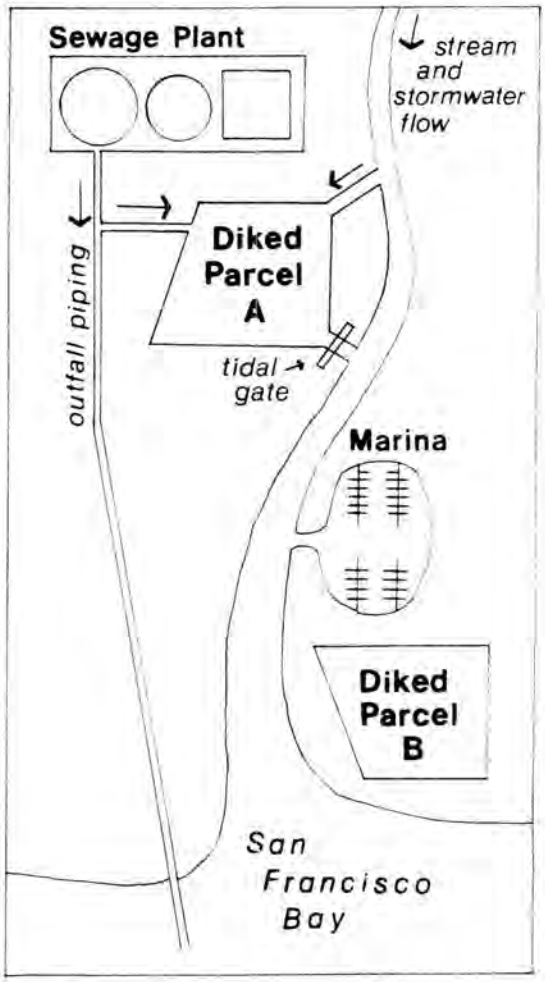
In Diagram 3, both Parcels A and B are shown open to the tides of the slough and San Francisco Bay. In this configuration, these parcels will alternately fill and drain with each change of the tide. As a result, the current of water in the slough channel shown will be considerably stronger than that expected under the conditions of Diagram 1 ("Present Configuration"). In general, the increased currents can be expected to assist both in scouring the downstream portions of the slough and in reducing the need for maintenance dredging.

This principle has been known in Europe for well over a century, and was the subject of a paper by Henry Mitchell, former Chief in Physical Hydrography of the U. S. Coast Survey in 1869. Mitchell summarized his results in his "General Rule -- a river having a bar at its mouth will be injured as a pathway for navigation if the tidal influx is reduced by encroachments upon its basins."

At Palo Alto, reduction in the need for maintenance dredging is helpful both for flood control needs and for navigation by vessels berthed at the marina, as seen in the diagram. In addition, the increased Bay water surface thus created in the diked parcels leads to increased oxygenation of Bay waters, and provides additional habitat for fish, shellfish and waterfowl.

The negative factors that must be considered are, first, that the options for establishing a flood control basin as in Diagram 2 ("Flood Basin, Seasonal Wetland") are reduced, and second, increased currents in the slough may lead to additional sedimentation in the marina area. Such factors must be studied in assessing any overall plan for dike breaching.

4. Brackish Water Marsh



A number of different possibilities are available for establishing brackish water marshlands from existing diked parcels. In Diagram 4, freshwater is shown introduced both from a stream and from a sewage treatment plant. Some salt water can be introduced to maintain the desired degree of salinity in the parcel. Other possible variations are to construct levees across Diked Parcel A that incorporate water control structures to provide gradations in salinity between the freshwater inflow and Bay waters of the slough.

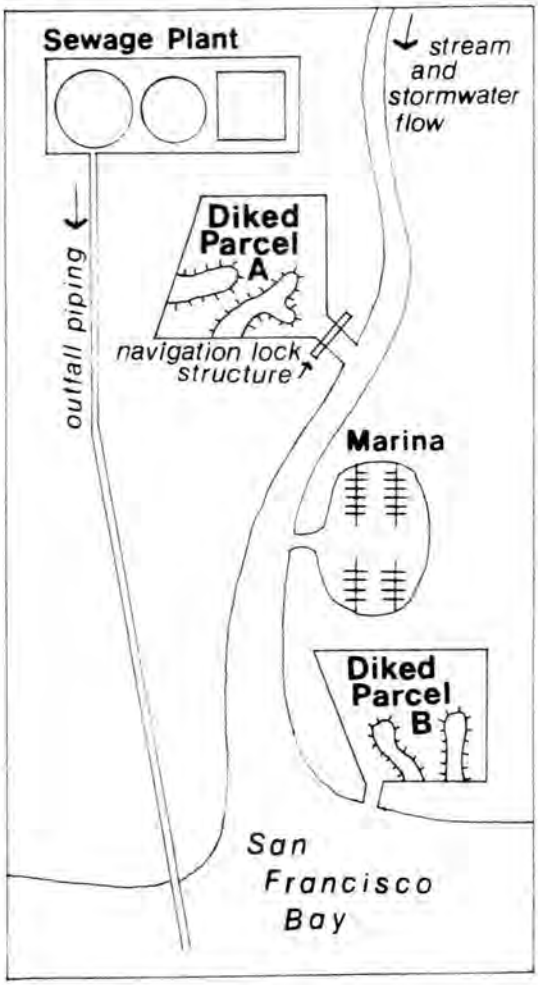
In this configuration, Diked Parcel A can also serve as a flood control basin, and as an emergency reservoir for sewage effluent in the event of a breakdown in the sewage treatment plant.

However, this configuration does not provide the possibilities for increasing the tidal prism in the slough noted in the case of Diagram 3 ("Tidal Reservoirs and Marshland"). Maintenance dredging will therefore continue to be necessary in the interests of flood control and navigation.

Many waterfowl prefer brackish water habitat over salt water marshlands. Because of this, considerable interest has developed to increase the acreage of fresh to brackish water habitat in the San Francisco Bay Area.

5. Residential Lagoons

Many residential lagoon projects have been constructed in the San Francisco Bay Area and in other parts of the nation others are being proposed. In some cases, yacht moorings are available at the residence sites, while in others, external marinas serve the area.



The large tidal range in San Francisco Bay between high and low tides has resulted in a variety of project design approaches. In some designs this large range in tide heights has been regarded as a factor to be avoided on aesthetic grounds; in these cases, water flow control structures have been built to limit the tidal range within the lagoon area. This practice can lead to problems with water quality and excessive aquatic vegetation. Limiting the tidal range means that less Bay water is available for flushing. Furthermore, residential use of garden fertilizers washed into the lagoon by runoff waters adds to the nutrient level in the lagoon. These factors can combine to produce heavy infestations of widgeon grass and other undesirable aquatic plants that can be controlled only through expensive countermeasures.

In one case, a controlled level lagoon has been fitted with a navigation lock to permit large yachts to be berthed inside. This configuration is shown in Diagram 5, but is should be noted that maintenance dredging remains necessary for the yachts to make convenient passage to and from the Bay itself.