ESTUARINE ECOLOGY

One of a series of background papers for the Planning Policy Committee Baylands Subcommittee. This paper was prepared by Dr. James Heath,

A REPORT

ON

SANTA CLARA COUNTY WETLANDS

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TABLE OF CONTENTS

RECOMMENDATIONS

IMMEDIATE

LONG-TERM

INTRODUCTION

BASIC ECOLOGY

In dealing with baylands, one should be aware of certain basic ecological operations that exist there. It is these interrelationships that determine, in large measure, the recommendations made not only in this report but in the San Francisco Bay Conservation and Development Commission's report.

Major productivity is derived in marshes. Most of the species of marsh plants are highly productive. However, cordgrass has been shown to be one of the most productive of all wild species with an organic output averaging better than six times the productivity of a wheat field (Pomeroy, 1959).

Few species of animal feed directly on marsh plants. The major contribution of these species is in the production of detritus, the breakdown debris material. This debris, often finely particulate, is transported into mudflat areas and deeper waters where conversion occurs. That is, the material becomes utilized by animals and made into animal tissue.

Thus, marshes and mudflats in combination are essential in providing for productivity in the bay. Loss of either or both is detrimental.

Marshes contribute to the general welfare in other ways. All production is represented by a concomitant release of oxygen. There is also some evidence to suggest that these plants may use and convert carbon monoxide (Dawson, 1966).

Marsh structure and the tidal level at which much of the marsh occurs increase absorptive surface enormously. While a given square meter of mudflat or of open water provides surface for smog absorption and for the stabilization of temperature, marsh plants greatly extend this. A given meter of cordgrass, wet by at least one tide every day, provides not only the mud surface upon which it grows but the additional several meters of wet plant surface as well.

Potentially, a salt marsh provides an evaporative and absorptive surface far in excess of any other formation. The role of such a function in a crowded urban region is obvious.

Mudflats are also productive areas. In addition to the organic materials yielded by the marshes, mudflats have a population of photo-synthetic organisms of their own. Diatoms, minute single-celled plants, occur in enormous numbers. Many species can and do migrate in and out of the mud surface (Palmer and Round, 1967). The development of a gold-brown coat on the mud surface can actually be observed at some times. These enormous numbers of cells not only constitute an

additional source of oxygen but also they provide an important food supply. It should be noted that the appearance of the gold-brown coat on a mudflat is a sign of good condition. Muds in more polluted waters tend to get coatings of blue-green algae.

Snails and various other animals of the mudflats utilize diatoms for food. These, in turn, are fed upon by other animals. This establishes one of the major "food chains" in which the eventual benefactors are the fishes and birds.

Salt ponds or evaporators constitute a highly specialized environment. Studies (Carpelan, 1957) show these to also be quite productive areas. Recent studies on bird use (Anderson, 1970) indicate that all but the highest brines are subject to bird use. In the larger, low-salinity ponds bird use is often quite heavy. Furthermore, the dikes are used by several species for nesting and the shallow ponds are important rest areas in stormy weather.

Salt ponds also offer large water surface areas. They function in the modification of temperature and as absorbers of smog.

Ecological hazards to the baylands are many. The functions mentioned thus far are normal and could continue indefinitely provided one of the hazard factors does not become

excessive. Any one such element could utterly destroy the system.

Even a very brief encounter with a damaging factor can cause a very long term effect. For example, a period of oxygen depletion lasting just a little too long can kill a majority of species. Their death in turn simply adds to the burden; the ecological balance is destroyed. It may be months or even years before some of the species return even if conditions immediately improve. The point is that once a system is disrupted, restoration of a balance may be a long time in coming.

Several things can lead to oxygen depletion. Poisoning by toxic substances such as wasted chrome or zinc compounds can be very extensive. Marine organisms are exceedingly sensitive to those ions and will die in numbers with even a very brief exposure. There are indications that several plants in this county have regularly discharged such substances into sewer lines in recent times. It is to be hoped that as more and more pressure develops for the maintenance of water quality, such events will become a thing of the past.

The addition of organic material, chlorinated or not, adds to the demand for oxygen and can deplete the supply. This means that the total organic load from treatment plants should be considered, not just the percentage of organic (oxidizable) material.

Rich growth of the minute plants of the water system (plankton bloom) can also lead to oxygen depletion. These populations build with great rapidity. When days shorten or some other factors starts to operate, huge numbers may die off. An over-enriched environment greatly increase the likelihood of such an event. This "Lake Erie" effect has been somewhat avoided here in the bay due to circumstances developed far outside of this county.

Turbidity mainly derived from sediments, mainly clays, brought down from the delta, limits light penetration. This limitation also restricts the development of blooms for it is only in the upper meter of water that photosynthesis can be adequate for maintaining the plants. Were the water clearer, this would allow a great deal more growth and would suffice to create disastrous ecological conditions.

ESTHETICS

No one as yet really knows what intensive crowding does to people. However, many agree that relief from the press of humanity is a significant safety valve. Baylands with their vast reaches, persistent breezes, and wild birds calling provide an element that can be a relief for many.

Even aside from the irreparable loss ecologically of

the conversion of baylands to residences with the corresponding increase on pollution, the loss of open space would be a potential disaster. Just as wilderness may not appeal to everyone, so too, open space may not be a necessity for all. But for those who do desire and need it, the retention of the wild shore is imperative. To lose it now would be to ignore in a most callous manner the generations to come.

In another sense, the baylands are a public trust belonging not just to the immediate owner, not just to the county, but to all men. The area is not like just another hill or just another valley. It is unique. Once destroyed it cannot be recovered or replaced and there is no substitute. Filling is inexpensive; removal of once-filled land with a housing development is improbable at any cost.

One of the truly unique features of the bay is the wildlife. If it were simply a matter of forcing these species elsewhere, the problem of loss of marsh and mudflat would not be so acute. As it is, some species are almost entirely dependent on the marshes and mudflats for their survival; others might survive the loss of these but would be severely reduced in numbers and restricted in occurrence. If the wild cry of the wheeling avocet or the soft talk of the canvasback are to remain for future generations to hear and enjoy then marshes and mudflats must likewise remain.

ESTUARIES

An estuary is a sea-connected body of water with a fresh-water source entering it. A lagoon is a salt-water embayment into which fresh-water flow is low or lacking. South San Francisco Bay is almost a lagoon. Only in a few months during the winter does the salt concentration become reduced enough to be significant. Much of the reduction in salinity that does occur is also due to current flow patterns which bring delta water southward (U.S.G.S., 1970).

In all urbanized areas, enormous pressure has been put on estuaries for these are useless for most commercial purposes as they exist. However, by filling, cheap land is to be had. No major estuary has escaped entirely, and most of those that were subject to less pressure were simply more difficult for access (Newport) or too far from population centers to be worth development (Tomales).

In the southern half of California, only Morro Bay remains with a major portion of the original estuary intact. Mission Bay in San Diego which originally had nearly 1000 acres in mudflat and marsh now has no mudflat and there is a token "wildlife sanctuary" of 85 acres. The estimate for the entire bay is that there remains but 21 acres of marsh. The entire lower portion of Newport Bay of almost 10,000 acres has been

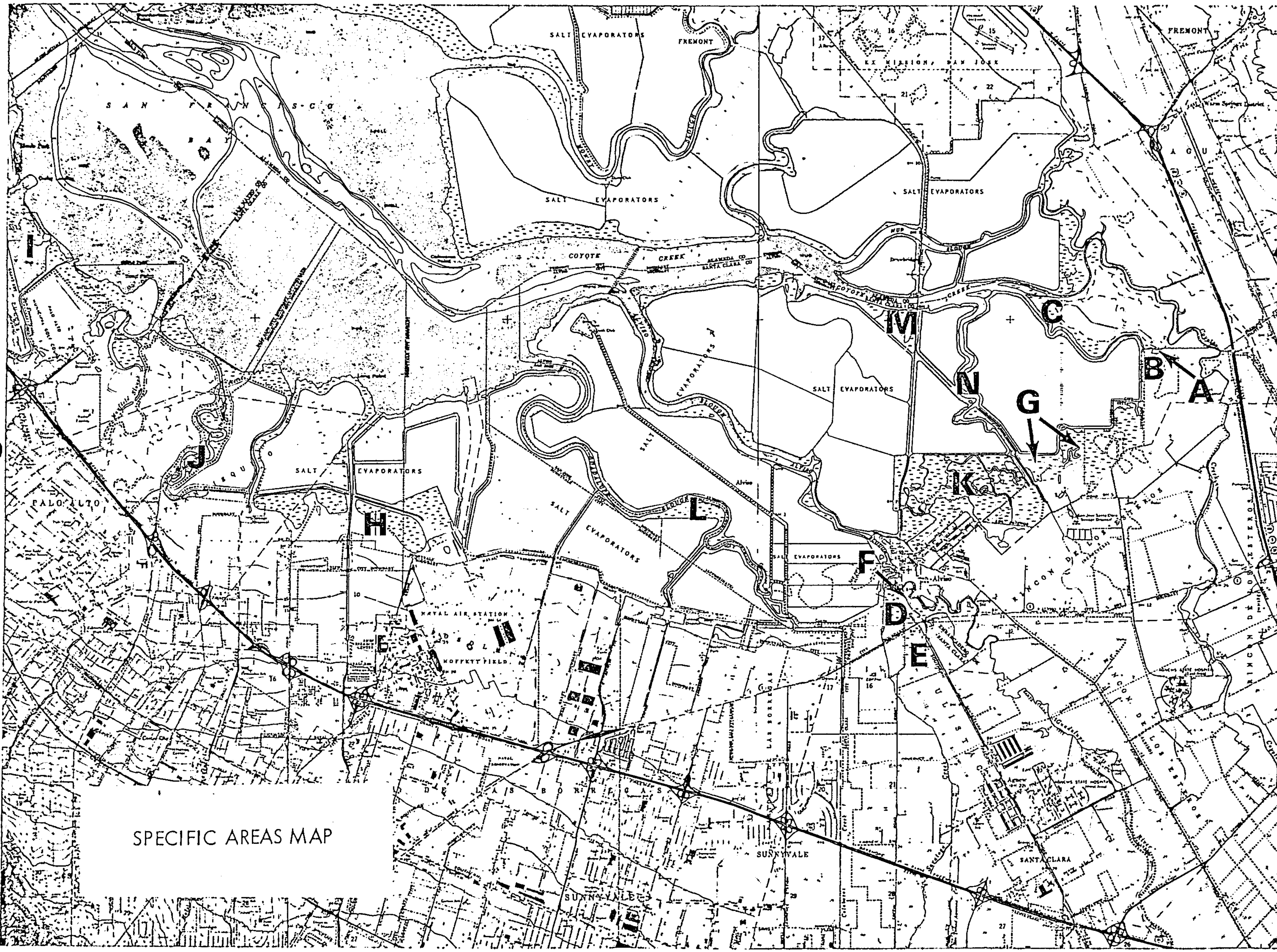
developed. The upper bay has missed development largely because of the high lateral embankments, but there are indications of developments to come. Private individuals and the staff of the Department of Fish and Game have made recent studies which are directed toward the saving of the 650 acres of mudflats and 200 acres of marsh.

Since shorebirds need resting and feeding spots on their migration route, the loss of these estuaries is becoming critical. San Francisco Bay is no exception. The fact that so many species overwinter here makes this estuary one of the most critical of all.

THE SANTA CLARA COUNTY BAYLANDS

GENERAL

Two primary impressions are gained almost at once as one investigates the baylands of the county. The first impression is that this is one of the most inaccessible regions of the earth. The only area where one can gain access to really observe marshes and mudflats without trespassing is at Palo Alto. One might add the very limited area of upper Alviso Slough especially where the Mountain View-Alviso Road crosses or some of the fragments seen from Alviso proper, but these are exceedingly limited in quality. All other contacts with the



SPECIFIC AREAS MAP

bay waters must be made past signs warning against trespass. Leslie Salt Company lands are heavily patrolled.

The second impression is one of marsh scarcity. It is true that the shore of practically every dike has a strip of marsh. This is valuable but on an acre basis, trivial. Only a very few marshes remain that are extensive enough to constitute breeding grounds for wildlife.

SPECIFIC AREAS

Two areas are used by harbor seals. Near the mouth of Guadalupe Slough they are frequently seen. Recently they were also seen by a Fish and Game flight near the mouth of Alviso Slough (Bruce Elliot, personal communication).

An unusual aspect of the marsh pattern is that the **Steamboat Slough receiving the San Jose-Santa Clara sewage** outfall is essentially fresh water in its upper reaches with cattails (Typha) and tules (Scirpus) predominating. This fresh-water marsh serves several species of ducks for breeding. However, once chlorination proceeds, it is doubtful that the marsh will survive. It is a guess, but it seems probable that at present flow rates, the sterilizing effect of chlorine will be evident as far as Coyote Slough. It is assumed that dilution at this point will suffice to permit normal marsh growth.

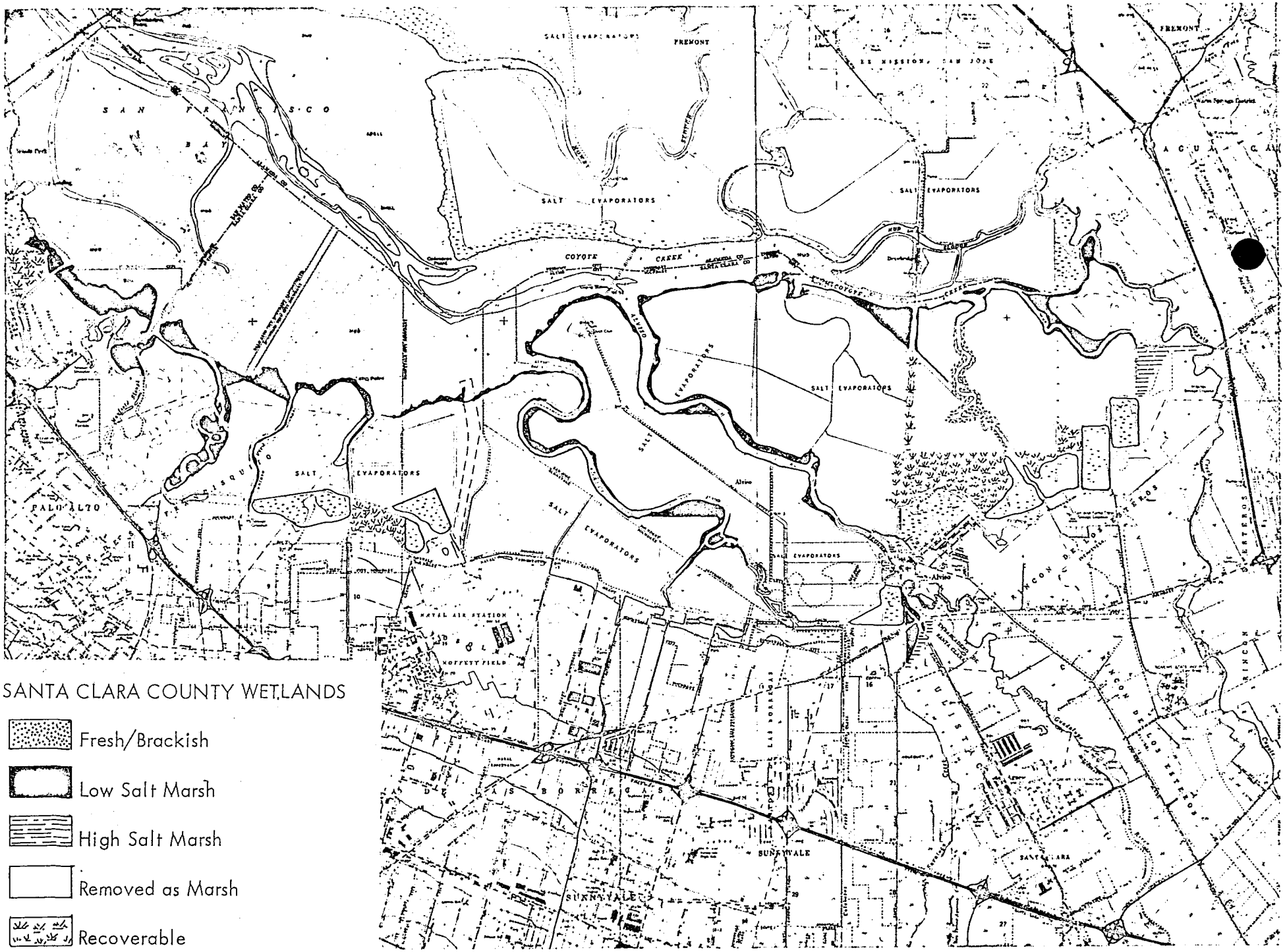
N

Several areas of diking present interesting problems. One of these is Charleston Slough. The upper portions of this basin have been diked off from the bay. The slough, however, is connected by a large pipe which suffices to provide flow into and out of the area. This is enough to keep the marsh in good condition. In fact, at the time of inspection, this was one of the areas of heaviest use by the larger birds such as egrets, great blue herons, and night herons. J

Another area of interest from the standpoint of diking is the New Chicago area. However, due to the many impacts involved, this will be discussed under the consideration of Recommendations **(see page 18)**. K

A small but valuable marsh exists where Dixon Landing Road bends to the right toward the disposal ground. There is a truck wrecking yard at this point. The marsh, to the south, consists of two parts; one is directly a branch of Coyote Slough (south branch) and the other, just south of this, is fed by leaking dikes and a partially plugged conduit. Since it is presently subject to tidal action, it should be subject to BCDC control. Since survey stakes of recent origin appear on some of the dikes, the area will bear watching. A B

The major marshes that are of large enough size for breeding by birds are all cordgrass marshes. These include



SANTA CLARA COUNTY WETLANDS

- Fresh/Brackish
- Low Salt Marsh
- High Salt Marsh
- Removed as Marsh
- Recoverable

the Palo Alto marshes, the lower end of Charleston Slough, the marshes from the dikes bayward in this area and north of the adjacent salt pond, the main curve of Guadalupe Slough near the Sunnyvale oxidation ponds and the triangle at Drawbridge. There are some marshes of smaller size that might be added such as the ones on the upper Coyote Slough near Newby Island.

SALT PONDS

As has been indicated, the salt ponds have been in existence long enough that many species have adapted to their presence. They serve the bird population very well; they provide absorptive surface, and they contribute to the stabilization of temperature. This should not imply that these do not have disadvantages. The acreage of about 8500 means a restriction on tidal flow that is considerable. Were these areas to be opened to tidal flow, the circulation of the south bay would undoubtedly be considerably improved. Also, as noted later, the need for the conversion of some of the salt ponds for sewage oxidation ponds may lead to the point where further use of the ponds for salt production is no longer economical. In this case, pressures for other uses will be great. Ideally, these should be opened to tidal flow and allowed to revert to mudflat and marsh. However, although these were marshes originally, many of the areas have subsided to the point where they would

probably be too deep for the reestablishment of marsh. In such a case, it would seem that the increase in water volume alone would make reopening of the dikes worth while.

EXPLANATION OF RECOMMENDATIONS

IMMEDIATE

1. To expedite the application of the Williamson Act to the bayside lands of the Leslie Salt Company according to their request.

As noted, salt ponds have a high ecological value. If the tax relief is given, then there is an increased probability that there will be no immediate attempt to produce another Redwood Shores in this region. Such a delay will increase the chances for the establishment of a wildlife refuge, for BCDC policy development in more detail, and for better ecological information to become available. As of now, there have been delays in granting Leslie's request. Their case should be abetted.

2. To take such actions as may be necessary to declare the few remaining large marsh areas as permanent marsh. This includes Charleston Slough and the adjacent shoreside marshes, the triangle marsh near Drawbridge, and the marshes along Coyote Creek in the vicinity of Newby Island but particularly the large one due west.

Whether the Board of Supervisors is willing or whether information on the value of these marshes should be filed with BCDC, action should be taken to assure that these few key marshes are preserved. They constitute the major ones suitable for breeding by shorebirds and offering security for those species that become particularly nervous at human presence.

The plan for Charleston Slough (Shoreline Report of County Planning and Recreation Department, 1968) should be reconsidered. Due to the very general nature of the map for the Charleston Slough shoreline development, it is difficult to determine the exact intent and limits for the wildlife preserve. This is particularly true for the lower portion of the slough and for the portion of salt pond number one that is to be used. It would appear that much of what is shown as walkway does, in fact, follow existing dikes. Two dredged inlets are indicated and it is assumed that these represent the points at which the major dike openings are to be created.

From an ecological (wildlife) viewpoint, two factors should be considered. The first is the desirability of some raised ground that is truly supratidal as a well-isolated island to serve as a breeding site for birds and the second is to provide walkways that leave such an area sufficiently distant from human approach that the birds will actually breed there.

There are no data on bird tolerance for this area. Ordinarily, the island should at no point be closer to human approach

than 250 yards. However, if the closest approach is a dead-end observation platform, this might even be reduced to 100 yards, depending upon the island shape and size. We can only assume that persons who come so far will be of a type who will create a minimum of disturbance.

Accordingly, it is suggested that one of the observation platforms be designated for this use and that the other be shifted to extend to the shore in the vicinity of the northwest marsh. Mudflats are important feeding areas for birds, and such a location would permit viewing of the broader reaches of the bay. Additionally, in dredging for fill for an island of a few acres, planning should be carefully done to insure the best location and shape.

The position of the dock on salt pond number one seems isolated from the confluence of several proposed dikewalks. If it were moved to the west at the dike crossing Charleston Slough, visitors would have four routes available to them right at the landing.

There is an assumption inherent in the plan that reflooding of a salt pond will create a wildlife sanctuary. This will, in fact, depend greatly upon actual depths. A good variety of marsh and mudflat will give a greater variety of bird population. That is, there should be permanent water, mudflat and marsh. Only an irregular topography can provide this. Since there seems to be no way of knowing the present topography in the pond, it is suggested that a survey should be made.

Thereafter, plans for the major and minor modifications of the undiked sanctuary could be made.

3. To attempt to establish a legal basis for the protection of most of the lesser marshes of this region.

While the low marshes come under the jurisdiction of the BCDC and can be controlled by that body, less extensive high marshes tend to be looked upon as outside of the bay and beyond BCDC power. Furthermore, there tends to be little or no surveillance of these marshes. This leads to the use of some for the deposit of fill and to the exclusion of flow by dikes or drain closure.

The marsh to the south of Newby Island is a good example of one such high risk marsh. The dikes have been breached by B
erosion to the point where higher tides spill over into the pickleweed marsh and salt meadow. There is also a culvert which seems to be somewhat restricted in flow but does subject the area to tidal fluctuation. At the least, planning maps should show such an area as tidal so that any application for a use or building permit will be noted as being in conflict with present conditions.

A similar marsh condition appears where the Mountain View-Alviso Road crosses the Southern Pacific railroad tracks. At this point, flow from the Alviso Slough passes under the highway and enters the area of about ten acres of marsh. There is dump encroachment occurring on both sides of the highway. D

That to the north is active and destructive. That to the south is presently on higher ground and, if not extended excessively, E
does not endanger the marsh.

Directly south of Alviso Slough, the water access to this marsh area passes through a large conduit. A great deal of wood and other debris blocks this. Not only does this F
constitute a flood control problem, but it restricts flow to the marsh. The wood should be cleared and some screening provided to reduce such blockage.

4. To foster the inclusion of the Alviso Unit into the proposed Federal Wildlife Refuge.

The inclusion of a region into a refuge does not mean the termination of all previous uses, nor does it mean that land use must necessarily change. It simply insures that changes that do occur will favor wildlife and recreational use. In view of the value of the salt ponds for wildlife, this use is considered wholly compatible with the refuge. Furthermore, it is realized that some areas need to remain essentially inaccessible to protect such forms as the harbor seals and some species of nesting birds that are very easily disturbed by human activity. In general, the inclusion of this as wildlife refuge would tend to increase access but with concomitant avoidance of detriment to wildlife.

The Leslie Salt Company at hearings on the refuge has

expressed fear that the presence of people on the dikes will lead to contamination of the salt ponds. This is a strange argument in view of the fact that passage through the pond sequence takes nearly two years. In addition, there is no known pathogenic bacterium that can survive in concentrated brine.

It would seem that the best interests of the County would be served by having this area assigned as a wildlife refuge. Federal law would then exert controls that the County should wish to promulgate itself.

5. To aid in any actions which will permit citizen access to observation and/or fishing sites.

As was noted, access is virtually nil. Vast areas of open space, existing marshes, and good fishing are simply not available. The average citizen should have a chance.

6. The exceedingly rough draft of a park and recreational use for the bayside as prepared for the Supervisors of Santa Clara County (May, 1969) provides a basic plan that offers a great deal. The basic idea is fairly reasonable for providing increased public access. Further detailed planning of the bayside concept should be done in close coordination with the California Department of Fish and Game and the U.S. Bureau of Sport Fisheries and Wildlife. As part of the consideration, the extent of human encroachment should be determined in order to protect the wildlife.

7. To attempt to develop some sort of Santa Clara County Baylands Coordination unit.

Recently, the City of San Jose presented a plan for a railroad spur to the sewage treatment plant. Few, other than the city personnel directly concerned, knew this. Liaison was poor, to say the least. Minor changes could probably have been made in this plan that would have better served the interests of a majority of the people. It was, however, impossible to enter into a discussion at the time of the presentation to the Board of Supervisors.

Similarly, plans for dredging, for dispersal of waste waters and so on appear on the agenda of the BCDC, the Board of Supervisors, or of other agencies without interested parties being informed. Even the investigation by federal personnel into the wildlife refuge potentials seem to have occurred in a vacuum. Whether real coordination can occur is a matter of doubt. However, it does seem that an attempt should be made. If just one person was designated to serve as a resource center, then those concerned could know where to turn to get information on potential actions involving the bay. However it is done, coordination seems to be very much needed.

8. To seek control of and partial flow into the New Chicago marsh north of the railroad spur.

This marsh represents what is probably the largest recoverable area of marsh in this county. It was diked off from tidal flow a few years ago. Presently the outfall from the Alviso Sewage Treatment plant provides a water supply that preserves the marsh. On the west side of the railroad, a comparable marsh has no such inflow and has become highly saline and nearly sterile.

The main line of defense against tidal inflow into Alviso lies in dikes bayward of the New Chicago area. To reconstitute the marsh would require the return of some tidal flow. Yet, this must be restricted in order not to break the barrier against flooding at times of heavy rains and high tides. It is suggested that at the roadway crossing the railroad near Drawbridge a single culvert could be inserted. It should be of a calculated diameter to insure tidal flow but to restrict enough to prevent overflow with high tides. The railroad spur could serve as an inner limiting dike.

The present dumping of fill by the county should be curtailed and with the completion of the present terrace, should cease. It might well continue in back of the rail spur for this seems to be an area destined for industrial development.

There should be provision for unidirectional flow under the rail spur fill so that rainwater and any street drains into the area would drain seaward only. It would seem most logical to redirect the outflow from the oxidation pond directly to the north of the rail spur and into the marsh.

9. To assert every influence to have water releases from the proposed Peripheral Canal absolutely assured.

The recent study of the Geological Survey (McCulloch

et al, 1970; Conomonas et al, 1970) indicates the great dependence of the south bay on the delta outflow. Furthermore, as reported at the Symposium on Estuaries at the Pacific Division of the American Association for the Advancement of Science meetings in June, the turbidity of the water in all of the bay is in great measure due to clays brought down in the Sacramento River. If these are to be routed past the delta by the canal, the waters of the bay may be expected to clear up considerably. This is no blessing. Our waters are already well fertilized. With turbidity gone, there would be a considerable extension of the depth at which photosynthesis could occur and consequently the development of the same conditions that produced the trouble in Lake Erie. Thus, a minimal turbidity is needed; Sacramento River water is needed; the Peripheral Canal must not have preemptive rights in the event of a drought year. No one knows that the minimum should be, but it seems safe to say that releases of five million acre feet would be an absolute minimum. The figure should probably be twice that.

LONG-TERM RECOMMENDATIONS

1. To seek to prevent further encroachment, legal and illegal, on the marshes.

In the long run, it would seem that some system of surveillance is needed to watch critical points of the baylands.

It may well be that some areas of present fill are legal and were established prior to BCDC regulation. However, there is some evidence that even with these, the limitations placed on the use permit have not been observed. Fortunately, there is not much access to the best marshes so that these, at present, are not under pressure from indiscriminate entry. However, at Newby Island, on the Standish Ranch property, on the New Chicago marsh, by Electro-Western Industries, and at the Hoxie dumping ground the opportunities for abuse abound.

2. To prepare for and seek aid in the reconstitution of such lands as hold the potential of becoming quality marshland.

New Chicago is a case where urgency seems evident. There are other areas, however, that could be returned to useful and productive marsh. These are shown on the map. One marsh between the dumps, the treatment plant sludge ponds, the salt ponds, and Grey Goose Slough is losing out to the dumping. It is also being equipped with a tide gate. If this gate were prevented from complete closure, the marsh could easily be retained. It would require a cost analysis, perhaps, but this should at least be considered. Since the dumping must eventually come to an end, the question of values becomes one of when to turn off. This may be mostly an economic decision. G

The area just southeast of Stevens Creek near Moffett

Field also holds potential. If, as rumored, NASA holds this, then it is probable that nothing can be done. Again, however, this should be investigated and if the property belongs to NASA, they should be reminded of their public announcements of concern with the environment. H

The last area is one of mixed jurisdiction. It is the so-called Faber Tract just north of San Francisquito Creek at Palo Alto. This is under Santa Clara County control even though it is geographically in San Mateo County. According to the BCDC permit, the area was to be opened to tidal flow. The dike has not been breached. I have complained to BCDC of this violation. The county should act to preserve this potential marsh and wildlife breeding ground. I

3. To prepare a marina plan and to designate the suitable and unsuitable areas for this use. The plan should also designate the maximum numbers of slips allowable to keep the numbers of boats in balance with the restricted passage of the sloughs.

Marinas mean access to open water and promulgate beneficial use of the bay. However, the limited passage of the sloughs suggests that an upper limit should be put on the number of boats likely to use any one passage. Alviso Slough is a case in point. A marina that could handle another hundred boats could easily be incorporated in this area. The congestion on the slough would be almost a disaster.

In view of the wildlife associated with Guadalupe Slough, it would seem that minimal development here should be an objective. A possible exception might be a marina near the mouth.

If the shoreline park plan is implemented even in part so that it becomes possible to drive to the bayside, pressure will become very great for mooring space for boats in that region. If such marinas were developed with entrances close to the mouth of the slough and with space being dredged from a salt pond for the marina space, minimal damage would be likely. Access to the shore front (probably by foot or bicycle) could be via the dike around the marina thus obviating the need for a bridge or ferry service.

The county would seem to have the right to modify the requirements under the Williamson Act so that, should Leslie Salt be willing to accept such a development, the penalties would accrue only to the acreages concerned.

4. To prepare a contingency plan in case a) Leslie Salt ceases production and b) the San Jose-Santa Clara sewage treatment plant fails to meet current or future objectives or objections.

It should be self-evident that if Leslie ceases its operation, the prospect for the salt ponds will change at once.

The pressure will undoubtedly be for development of the ponds by fill and conversion to residential and commercial use. Are current laws able to contain this? Does the planning area have significant jurisdiction? Should some areas be sacrificed if others are offered in exchange? Such questions should be asked and answers prepared, for it seems certain the day will eventually come when the issue is real.

The treatment plant is another kind of case. As population builds, more solids will need to be treated. Chlorination is not a very suitable answer, for it only delays oxygen demand; it does not satisfy it. If the organic load becomes excessive--and it approaches unsatisfactory levels now--then other solutions will be sought. Sunnyvale has used the great expanse of a converted salt pond for oxidation. Although it is said that chrome salts have poisoned the system a number of times, the basic idea is a good one. San Jose may well attempt to solve the problem here in the same way. While modification of a pond to give linear flow rather than random flow may be required, the use of such a system holds a great potential. It may seal the fate of the salt production, however. At any rate, there should be an analysis to govern the development should this plan be proposed.

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APPENDIX A

MAJOR MARSHES, LAGOONS AND ESTUARIES OF CALIFORNIA

(Data From Calif. Fish and Game Coastal Wetland Inventory, 1969-70. See also Sunset, 1970)

AREA	WATER	MUDFLAT	MARSH
NORTH COAST			
ESTUARIES:			
Humboldt Bay	4,500	5,000	500
Eel River	2,300	500	1,050
LAGOONS:			
Big Lagoon	900		570
Stone Lagoon	350		170
CENTRAL COAST			
ESTUARIES:			
Bodega Bay	840	45	50
Tomales Bay	5,950	2,900	440
Drakes Bay	1,290	580	200
Bolinas Bay	370	720	150
San Francisco Bay	258,000	41,600	32,000
Salt Ponds	49,920		
Morro Bay	650	1,400	575
LAGOONS:			
Russian River	200		100
Pescadero Marsh	75		50
Watsonville Slough	30		48

AREA	WATER	MUDFLAT	MARSH
SOUTH COAST			
ESTUARIES:			
El Estero	15	35	150
Mugu	250	500	1,420
Bolsa Chica	1,000	1,000	3,000
Newport Bay	9,000	10	20
Upper Newport	500	650	200
Mission Bay	1,700		21
San Diego Bay	11,723	800	300
Salt Ponds	1,272		
LAGOONS:			
Santa Ynez River	50		110
Goleta Slough			260
Buena Vista	175		25
Aqua Hedionda	250		90
Bataquitos			475
San Elijo	100		160

SANTA CIARA COUNTY BAYLANDS AREAS, (Estimated)

High Marsh	20 acres
Fresh-Water Marsh	40 acres
Salicornia	250 acres
Cord Grass	800 acres
Salt Pond	8,320 acres
Mudflats	3,000 acres

SAN FRANCISCO BAY

Estimates vary but in general the original bay surface is considered to be about 750 square miles. Present area is usually given as 450 square miles. (Salt ponds are credited at about 50,000 acres.) However, the present National Estuarine Study (Vol. 5, Part 1, page 82) gives the following:

AREAS OF ESTUARIES

	Total Area	Basic Area of Important Habitat	Area of Basic Habitat Lost by Dredging and Filling	% Loss Habitat
California	552,100	381,900	225,800	67.0
N.Y. (next in %)	376,600	132,500	19,800	15.0
N. Car. (most area)	2,206,600	793,700	8,000	1.0

And on Page 83, the 1957 figures for San Francisco Bay are as follows:

Residential & Commercial	6,080
Recreation	41,856
Industrial	7,488
Transportation	11,200
Dumps and Vacant lands	4,480
Agriculture	36,096
Salt Ponds	38,464
Military and Reserved	9,728
	155,392

APPENDIX B

Bird use of baylands is often considered in only general terms. In the past, the Audubon Society Christmas Bird Census was one of the few statistical analyses made. Recently Boliman, Thelin and Forester did an intensive survey of the bird population. A partial report on their work has been accepted for publication by the California Fish and Game Bulletin. The summary of the article follows:

> The primary objective of this study was to observe and count the number of various bird species using San Francisco Bay.
>
> The number of birds sighted exceeded 3.5 million annually. Of the 11 classifications of birds, shorebirds and ducks predominated.
>
> The Bay environs is an important feeding and resting area for migratory birds, as evidenced by the large number of these species sighted in the months of November, December, and January. Waterfowl sightings in the month of December exceeded 500,000 in 1964 and approximately 200,000 in December of 1965.
>
> Bird densities were highest on tidal flats and saltponds. There were indications that the marsh areas had a very low bird density which is not necessarily accurate. Dense vegetation in marsh areas restricted observation while saltponds and tidal flats had little vegetation. Each habitat provides the conditions necessary for birdlife and, therefore, cannot be assessed independently of the others. In the total environment, the marsh habitat is just as important as the mudflat areas.
>
> A continuation of past and present trends in the removal and destruction of wildlife habitats in San Francisco Bay can but reduce bird populations and may accelerate the

> extinction of certain species. When demands for improvement of environmental quality are increasing, the present and future value to society of having a thriving bird population so accessible and located in the heart of a megalopolis should not be summarily dismissed as of little consequence. This study, conducted as a result of patient effort by many interested in maintaining the birdlife of the Bay, is but one phase of the overall measurement of the value of this resource.

There have also been hypotheses as to the relationship of saltponds to bird use. Anderson studied the use of saltponds of various salinities for a year. His paper also has been accepted for publication by the Department of Fish and Game.

In the conclusions he states:

> Many species of birds were observed using the salt ponds. Those birds making the heaviest use of the ponds were shorebirds, ducks, grebes and Bonaparte's gulls.
>
> Dabbling ducks, coots and fish eating birds exhibited a marked preference for Pond 1, which had the lowest average salinity. Diving ducks, grebes, phalaropes and Bonaparte's gulls disclosed a high degree of salinity tolerance and predilection for food items existing in ponds of high salinity. Shorebirds used ponds that were shallow enough for wading irrespective of salinity.

Additionally, a table (Table 3) from his paper suggests the intensity of use of the saltponds by various groups of birds.

TABLE 3

PERCENT OF BIRDS UTILIZING THE SALT PONDS

Birds	Pond 1	Pond 3	Pond 4	Pond 5	Pond 6	Total Sightings
Grebes	1	8	25	54	12	30,440
Herons	61	19	9	7	4	626
Dabbling ducks	69	13	11	3	4	92,387
Diving ducks	26	36	11	14	13	77,785
Coots	70	19	6	1	4	6,570
Shorebirds	10	8	8	60	14	122,433
Phalaropes	6	23	31	32	8	43,255
Bonaparte gull	4	12	44	24	16	17,281
Terns	30	2	35	32	1	3,427

APPENDIX C

The following pages are facsimiles taken from Volume 5 of the National Estuary Study.

Bio-physical Characteristics and Use Conflicts of San Francisco Bay, California

San Francisco Bay, with its complex of subsystems, is a unique estuarine area. In 1850 the total area of the San Francisco Bay complex was about 700 square miles. By 1958 filling and diking reduced the area to about 435 miles and in 1968 the area was estimated at 400 square miles. There were about 300 square miles of marshlands in 1850; they now total about 75 square miles. About 70 square miles of the Bay is mud flat. Tide stages range from a low of about 2 feet to a high of 9 feet. While central portions of the Bay are relatively deep, it has extensive shoal areas with much of it shallower than 12 feet at mean low water.

Climate of the San Francisco Bay area is the Mediterranean type with warm to hot summers and moist, mild winters. The Sacramento-San Joaquin River delta, Napa and Santa Clara Valleys have hot, dry summers, with summer high temperatures approaching 100 degrees daily. However, at coastal areas exposed to oceanic influences, summer temperatures are reduced, and winter temperatures moderated. At San Francisco, the average daily temperature during January is about 50 degrees, while in July it is about 59 degrees. Maximum recorded is 101 degrees, and minimum is 27 degrees. Annual rainfall is about 20 inches. At Antioch, in the Sacramento-San Joaquin River delta, about 35 miles east of San Francisco, the average daily temperature for January is about 47 degrees, while in July it is about 77 degrees. Maximum is 114 degrees, and minimum is 14 degrees, with a 12-inch annual rainfall.

The Bay's major fresh-water sources are the Sacramento and San Joaquin River systems that drain California's Central Valley. It also receives fresh water from small tributary streams flowing into San Pablo Bay and San Francisco Bay. Fresh-water inflow, as a result of rain storms, occurs primarily during the period November through March. Snow melt from the Sierra Nevada occurs through June.

Tidal circulation is as varied as the various current patterns in the Bay. It is best in North Bay, in part as a result of the inflow from the Sacramento and San Joaquin Rivers, and is poorest in South Bay partly because of lack of major inflow.

Because of the topography of the Bay floor and the variations in the shoreline, the tides flow faster at some points than at others. The tidal crest in North Bay moves with speeds quite different from those in South Bay. Toward the end of the flood tide in North Bay, the tide has already begun to ebb in South Bay. Similarly, toward the end of the ebb tide in North Bay the tide will have started to rise in South Bay, and North Bay waters will flow directly into South Bay.

In general, San Francisco Bay proper is usually well mixed. San Pablo and Suisun Bay vary from well mixed during late summer-fall months to partly mixed during the winter, spring, and early summer months. During periods of extreme freshets or heavy snow melt runoff, Suisun Bay will approach fresh-water conditions throughout with this condition extending into the eastern portion of San Pablo Bay. Mixing in South Bay depends heavily on strong winds. During late summer water quality problems usually occur in South Bay; much of which can be attributed to stagnation brought on by conditions discussed above.

The shore of San Francisco Bay is dissected by many embayments and rocky headlands. Marshlands are located adjacent to tributary streams in San Pablo Bay, Suisun Bay, and South Bay. While extensive tideflats consisting of mud and fine sand border the above mentioned subsystems.

Recent census figures indicate that about 5 million people live in the Bay area. The San Francisco Bay complex has been highly modified by man's activities. Channel modifications, diking, filling, port facilities, and industrial complexes have altered most of the Bay bottom and shoreline. Residential and industrial complexes surround the Bay and contribute both industrial and domestic waste to the system. Agricultural waste from the Central Valley add considerable amount of nutrients to the system. The East Bay from Pittsburg south to Hayward is highly industrialized. In the West Bay the industrial complex spreads from San Francisco south to Redwood City. Residential and light industrial complex spread from Sausalito to San Rafael.

Fish and Wildlife Resources

Historical Review

Historically, San Francisco Bay supported substantial fish and wildlife use. Numerous commercial fisheries including but not limited to salmon, shrimp, and oyster occurred on the Bay. Over the years these fisheries have declined. The principal cause being habitat degradation brought about by industrial and domestic wastes, direct habitat destruction through diking and land fills and through construction of upstream water development projects. With an estimated loss of 80 percent of the marshland and tideland habitat there is at least a proportional loss or reduction in the inhabiting population of wildlife that depend on these habitats. The effect of fills and dikes on the various fish populations and fisheries is less clearly understood; nonetheless, the loss of fish nursery and rearing habitat in both quantity and quality is substantial.

With the advent of stringent water quality controls coupled with mass building of waste treatment facilities, water quality is improving as evidenced by the reappearing of shrimp at their former locations and sport fishing occurring where none has taken place for many years.

Fish Resources

Important anadromous fish species include striped bass, chinook salmon, sturgeon, steelhead trout, and American shad. Striped bass use virtually the entire Bay and spend most, if not all, their life in the Bay complex, while American shad, chinook salmon, and steelhead trout utilize it as a nursery area and migration route to spawning areas in tributary streams.

Bait and forage fish include anchovies, herring, and smelt. Herring use the Bay as spawning and nursery grounds. Several species of smelt inhabit the plankton-rich tidal flats and along with the anchovies are important food sources for other fishes.

Sole utilize the Bay as a nursery ground in tremendous numbers and as they mature they move to the ocean. Stary flounder and sea-surf perches are common throughout the Bay. A variety of primarily marine species also inhabit the Bay including sharks, rays, several species of rock fish, and bottom fish. Oysters and little-neck clams are common at favorable locations in San Pablo and San Francisco Bays; however, because of contamination, human comsumption is prohibited. Shrimp are common and are found throughout the Bay. The Dungeness crab is also common and immature crabs are found in abundance throughout San Francisco and San Pablo Bays. Available information indicated that about 100 species of fish directly or indirectly supporting commercial and sport fisheries utilize the Bay in varying numbers throughout the year.

Wildlife Resources

San Francisco Bay is the largest river-mouth area along the entire California coast. It is a vitally important resting place, feeding area, and wintering grounds for hundreds of thousands of birds of the Pacific Flyway. Some birds are found in only one habitat while others depend upon a variety of different habitats. Water associated birds utilizing the area can be grouped into four categories: waterfowl--canvasback,

greater scaup, ruddyduck, green-winged teal, American widgeon, pintail, and mallard; shorebirds--western sandpiper, sanderling, black-bellied plover; and curlew; seabirds--gulls and terns; and marsh birds--great blue heron, American bittern, and American egret. Terns and bitterns, although common, cannot be considered abundant. Ducks and shorebirds are present seasonally in tremendous numbers.

It is estimated that at least 75 different species of waterbirds visit the area. About 66 percent of the canvasback wintering population in the State of California and about 50 percent of the entire Pacific Flyway winter on the lands and waters of the San Francisco Bay complex. Similarly, the majority of the flyway scaup population depends on Bay environment for wintering habitat. The large expanse of tideflats are migration and wintering grounds for thousands upon thousands of shorebirds. Estimates are that up to 70 percent of the shorebirds of the Pacific Flyway depend on this area for their survival. In addition, numerous terrestrial species inhabit the adjacent marshes, grasslands, and uplands.

Rare or endangered wildlife including the California Clapper Rail, California Black Rail, and Tule white-fronted goose are associated with the wetlands adjacent to San Francisco Bay. About 18,000 acres are specifically devoted to wildlife conservation and are managed by the California Department of Fish and Game. Private sanctuaries total about 4300 acres and about 68,000 acres are under lease to various hunting clubs.

Marine Mammals

Harbor seals, California and Steller's sea lions utilize the Bay. The hauling grounds where young pups and adults can leave the water and rest are important and their destruction would be a limiting factor to species occurance.

Fresh-water Mammals

Mammals of economic importance inhabiting adjacent marshes and tributaries include beaver, muskrat, mink, otter, weasel, and raccoon.

Public Use

Total recreation use of the Bay and its resources is unknown. Human benefits from fish and wildlife of the Bay includes food, industry, recreation, research, education, and an environment for living. Estimates have been made for specific recreational uses of the Bay for 1967 and include about 505,000 man-days of hunting, 370,000 user-days of bird watching, and 3,660,000 man-days of fishing. In addition, about $2,000,000 worth of fish were harvested from the Bay and processed in 1965.

Present Uses of the Bay and Shoreline

Commercial	X
Deep draft transportation	X
Boating	X
Mining and minerals	X
Fisheries	X
Wildlife	X
Waste Disposal	X
Recreation	X
Aquaculture	
Residential	X
Industrial	X
Education-Research	X
Water supply	X
Agriculture	X
Other	

Other Items of Interest

An integrated comprehensive plan for San Francisco Bay has been formulated and its implementation has been approved by the State legislature Many of the colleges and universities in the Bay area use the Bay for research purposes.

Management Problems

Filling & Diking

Until recently fills and diking of marshlands and tidelands for agriculture, residential, and industrial sites are a continuing problem. Approximately 75 percent of all the marshland that existed around the

Bay and about 20 percent of the mud flats have been filled or diked off. In total about 250 to 300 square miles of marshland, tideland, and water area have been lost to diking and land fills. (see section on Institutional Management)

Pollution

San Francisco Bay is a receptable for waste from domestic, industrial, and agricultural sources throughout its tributary area. About 60 percent of the domestic waste flowing into the Bay receives only primary treatment. Dumps and sanitary fill comprise the remainder. There are about 60 miscellaneous type of possible pollution sources to the Bay. The pollution sources discharge about 1,065 billion gallons of waste per day. Pollution restricts the harvesting of oysters and other shellfish from the Bay. It causes serious water quality problems in South Bay and forces the closing or restricting of use on some of the public beaches around the Bay. Water quality conditions are improving as evidence by the return of shrimp to many parts of the Bay; however, pollution is an ever present problem.

Dredging

Maintenance of navigation channels and depth at dockside is a continuing problem. Estimates are that $3,000,000 is spent annually to maintain 200 miles of deep-water channels and 300 miles of shallow water channels. About 11 million cubic yards of material are removed annually. Most of the material dredged is dumped in another part of the Bay. Since the incoming silt load is estimated at 6 million cubic yards, the quantity of material removed annually is obviously rehandling part of the same material several times. An authorized navigation improvement will deepen the channels of the Bay. In addition, the Corps spends about $2,806,000 annually for removal and disposal of floating debris from the Bay.

Public Access

Public access is poor and is limited to a few shoreline parks and marinas. Most of the Bay frontage is in private holdings.

Industrial Development

Many industrial complexes have been constructed along the water's edge. These complexes are so located because they needed access to the Bay for raw materials, ease of transportation, or because large tracts of land were available at a low price. While the shoreline must be made available for those industries needing a water-front location, all aspects of industry do not have to be located at the water's edge and siting of these industries elsewhere will benefit the Bay.

Commercial Development

In many locations these developments have competed with other private interests as well as the public interest in occupying the shoreline thereby, restricting public use to such areas. Areas attractive in their natural or near natural state have been spoiled by mass commercial developments whose construction did not apparently consider naturalness surroundings.

Land Use

Silt from upstream areas causes many problems. Historically, the 49'ers worked away the Sierra hillside to expose gold. As a result, rivers carried vast quantities of silt, sand, and clay which were deposited on the bottom of the San Francisco Bay system. Today about six million cubic yards of sediment enter the Bay each year. The source of this problem are the foothills surrounding the Central Valley whose streams lack some form of structural control. It is estimated that only 30 percent of the sediment entering the Bay ever gets to the Pacific Ocean. The remainder settles on the mud flats, marshes, and deep channels of the Bay

Water Supply

Stream inflow and Bay waters serve many and diverse uses. Streamflow water is used for agricultural purposes in the San Joaquin-Sacramento River Delta-Suisun Bay. It also is used for cooling the many stream-electric generation power plants and industrial facilities in the area. An estimated 638 billion gallons are used annually from these sources. Salt water is a basic industrial material with 16 billion gallons used annually for recovering salt and chemicals, and one billion gallons are used for treating or diluting wastes in control ponds.

Potential Water Supply Problems

Nutrients, pesticides, and other organic, and inorganic materials drained from industrial and residential communities, agricultural, and forested land are carried by runoff via streams and rivers to the Bay. The magnitude of this influx of deleterious materials is unknown. The discharge of agricultural drainage waters from the San Joaquin Valley may be concentrated in the Bay system if the San Joaquin Master Drain of the San Luis Interceptor Drain is constructed as proposed.

The proposed upstream water development projects for water supply, flood control, and power development by the Federal and State agencies and numerous other projects will significantly

reduce inflow to the Bay. This will cause a reduction in sediment load entering the system from the Central Valley; intensify salt water intrusion into the Suisun Bay and Western Delta, thereby upsetting the salinity balance and gradient zones in this area so important to fish life and marshland vegetation; impairing water use for municipal, industrial, and agricultural supplies; and reduce flushing.

The combination of these two aspects presents a serious threat to most all beneficial uses of Bay waters.

About 250 million gallons of water are used per day as cooling water which contribute waste heat to surrounding Bay waters. Most of this waste discharge is located in Contra Costa County affecting Suisun and San Pablo Bays. This waste heat or thermal pollution, while not a problem now, could cause serious industrial water use conflicts in the Delta area.

Agriculture

Vast acreage of marshlands have been diked for agricultural purposes. This is particularly true in the Delta-Suisun Bay area. Adjacent to San Pablo Bay and South Bay, the natural marsh was converted to salt pond with small acreage for pasture and crops. The land in the Delta is intensively developed and managed for fruit, nut, and various vegetable crops. The Suisun Bay lands are devoted to a pasture, grain, and cattle economy with waterfowl hunting and wetlands management an important adjunct.

Mining

Bay sand have historically served as the basic source of material for tideland filling. It is of too poor quality for general industrial uses. Oyster shell deposits are dredged from the Bay floor primarly for use as lime. Small amounts go into soil conditioners, cattle feed, and poultry grit. About 2 million cubic yards of shell are dredged annually.

Salt produced from San Francisco Bay is used by the residential and industrial communities. About 50,000 acres of marshlands have been converted to solar evaporation ponds that produce over 1 million tons of salt annually. These ponds are used by waterfowl and shorebirds.

Oil production in the Bay area is of minimum. Natural gas fields are located in the Suisun Bay and Sacramento-San Joaquin Delta area.

Residential

Expanding population rising incomes and the desire to own a water-front property are adding to the mounting pressure to fill parts of the Bay for new home sites of the key variety. Reports by various agencies indicate that sufficient lands are available for home sites without filling in the Bay and adjacent marshlands. Projects involving up to 10,000 acres have been proposed or under construction. Most of this effort is in South San Francisco Bay.

Future Use or Trends[1] (judgement-based on available information)	
	Commercial +
	Deep draft transportation +
	Boating +
	Mining & minerals (sand, shell gravel) +
	Fisheries +
	Wildlife +
	Waste Disposal +
	Recreation +
	Aquaculture +
	Residential +
	Industrial +
	Education-Research +
	Water Supply +
	Agriculture +
	Other specify item describe problem +

[1] To years 1980-2000 indicate increase (+), decrease (-), little or no change anticipated (0)