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HYDROLOGY AND WATER QUALITY: BERKELEY AQUATIC PARK

by

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SUMMARY

Aquatic Park includes three separate tidal lagoons covering approximately 100 acres. The main lagoon (60 acres) is approximately one mile long, 400-600 feet wide, and 4 to 8 feet deep; it contains 400 to 600 acre-feet of water.

South of it, the Model Boat Pond (MBP) covers 4.9 acres and is 3-5 feet deep. The southernmost pond (Radio Tower Pond: RTP), privately owned, covers about 3.9 acres. It is shallow, with a greater daily tidal range than the two ponds to the north, and functions primarily as shorebird habitat.

The three lagoons contain a total of twelve culverts linking the ponds to the Bay and to each other. In addition, a number of gates and weirs have provided hydraulic control. At present, the circulation system is in relatively poor condition. Sand transport by wave action has blocked all of the Bay-lagoon culverts, except the Radio Tower Pond (RTP) culvert. As a result, tidal circulation is extremely limited.

Water quality, although only sporadically analyzed, varies significantly on a seasonal basis. During winter rainstorms, overflow from the storm sewers discharges to the lagoons, carrying a variety of urban chemical and organic pollutants in a dilute form. Subsequent water quality is strongly affected by the amount of tidal circulation and flushing. When the hydraulic system permits normal circulation, the main lagoon is probably suitable for contact recreation during the summer; however, this

has not been established by a regular monitoring system. During the rainy season, bacteriological contamination probably exceeds the standards for contact or non-contact recreation.

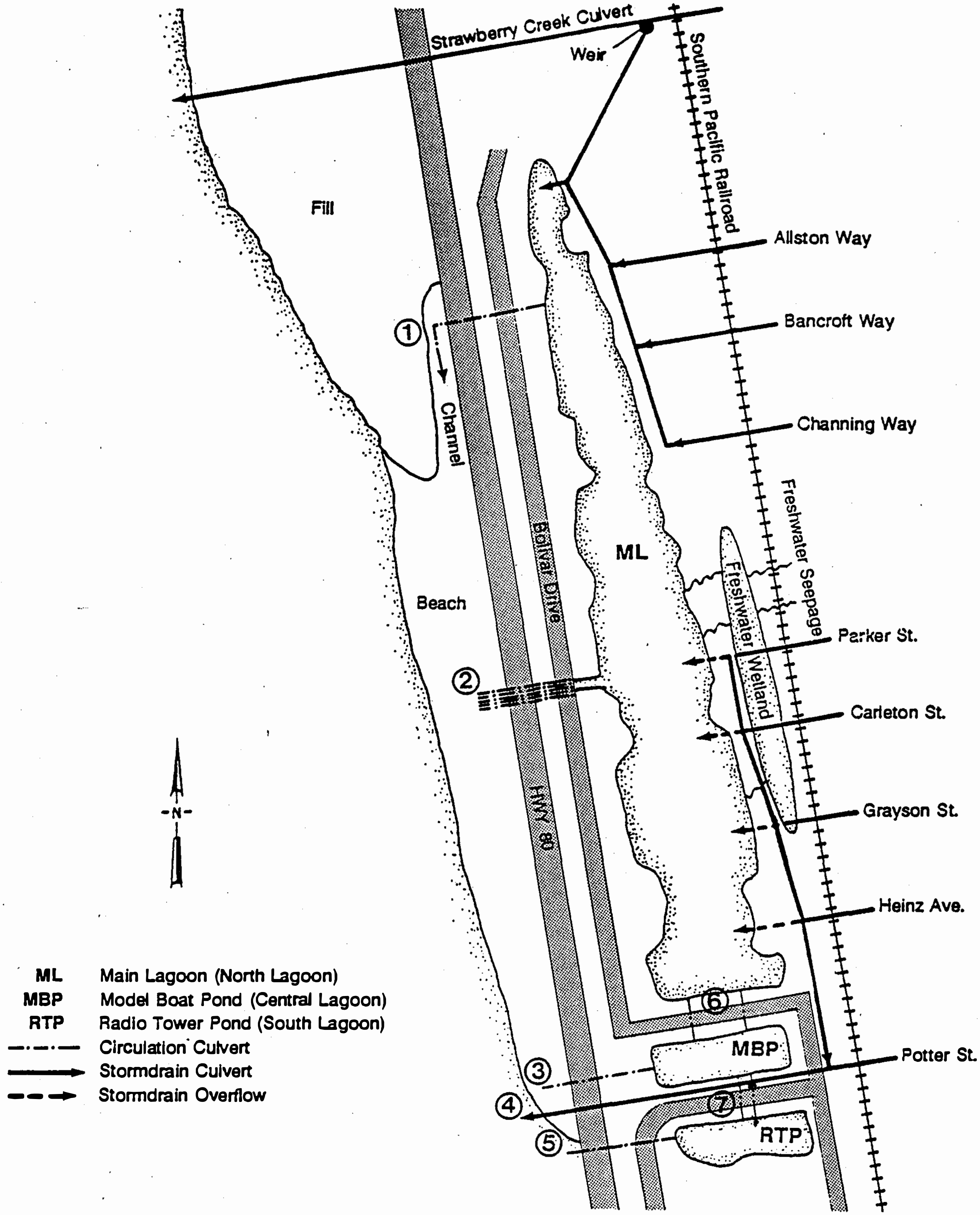
Aquatic Park is subject to potential flooding during periods of exceptionally high tides or a combination of intense rainfall and high tides. Because of the complexity of the hydraulic system and the present (deteriorated) conditions of the Aquatic Park culverts, estimated past flood predictions may not be correct. At present, the threat of tidal flooding is low, while potential rainfall runoff flooding is higher, since the Bay-Lagoon culvert (which would let tidal water in an excess storm drain flow out) are blocked. However, from a legal standpoint, the existing FEMA (Federal Emergency Management Agency) 100-year flood hazard elevation of 6.0 ft. NGVD would still apply. Thus, any new buildings constructed would have to have the finished floor elevation 1.0 ft. above the 100-year flood elevation.

A comprehensive hydrology and water quality study is needed to adequately describe the existing conditions, analyze alternative circulation schemes, determine flood hazards, and develop a water quality monitoring program. The Plan would provide design and repair criteria for hydraulic structures (culverts, gates, weirs, etc.), shoreline treatment, water depths, bottom configuration, and water level management, etc. to meet the desired uses of the park as established by the Master Plan.

I. INTRODUCTION

As shown in Figure 1, Aquatic Park includes a large tidal lagoon and a smaller lagoon originally designed for use by model boats. A third small pond, located south of the model boat pond, is partially owned by a local radio station. The pond areas were originally part of San Francisco Bay, but were separated from the Bay during the mid-1930s by the construction of Interstate 80 to the west. During the 1940s, the lagoons were dredged and the fill used to raise the surrounding areas for subsequent landscaping as a park. Excellent descriptions of the history of Aquatic Park are available in two UC Berkeley reports (Ferlin, 1983; and Razani, 1989).

In this section, we provide an overview of the hydrologic characteristics of Aquatic Park, existing hydraulic structures and circulation, and water quality issues at the Master Plan level. As the existing condition of the lagoons and facilities is relatively poor, and the information on the above issues is relatively sparse, a workplan to develop a more detailed understanding of: 1) the existing conditions (bathymetric, hydraulic structures, circulation, water quality, vegetation, aquatic organisms, etc.); 2) recommendations for restoration or replacement of the hydraulic control structures; and 3) a lagoon management plan, are also presented. In general, the hydraulic structures have not been adequately maintained and are in poor condition. Because of this, management of the lagoons has been difficult. For these and other reasons, water quality and



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Hydraulic Structures at Berkeley Aquatic Park
(Modified from Ferlin [1983])

FIGURE 1

circulation in the lagoons has often been poor during the past 40 years. Upgrading the water quality regime will require a substantial commitment in additional planning, construction, maintenance, and management cost and effort.

The tidal lagoons at Aquatic Park are similar to a number of other salt water lagoons and lakes in the Central Coast. These include those at Stinson Beach (Marin County), Lake Merritt (Oakland), the salt water lagoon at Baylands (Palo Alto), Laguna Grande and Roberts Lake (Seaside), and Lake El Estero (Monterey). Experience gained in the design and maintenance of these facilities will be helpful in guiding restoration at Aquatic Park.

II. EXISTING CONDITIONS

A. TOPOGRAPHY/BATHYMETRY[1]

The main (north) lagoon is approximately 1 mile long and 400 to 600 feet wide, and occupies 67 acres. There is no current bathymetric map to indicate bottom contours in any of the three lagoons. Several representative lagoon cross-sections made in this study of the locations are shown in Figure 3, and the cross-sections in Figures 4 through 9. These suggest that existing water depths range from 4 to 8 feet. The main lagoon is relatively narrow and deep in the north end, with a soft layer of organic mud (1-3 feet deep) on the bottom. To the south, it is wide and shallow, with a hard sandy bottom (the organic mud is likely dispersed by turbulence from the ski boats). The MBP has bottom depths at -2 to -3 ft. At the time of the survey, the water surface elevation was 1.5 feet NGVD[2]. The main lagoon contains about 400-600 acre-feet of water.

Siltation and deposition of organic matter have apparently reduced water depths somewhat. A 1970 report (ES, 1970) indicates that depths at that time ranged from 8 to 15 feet.

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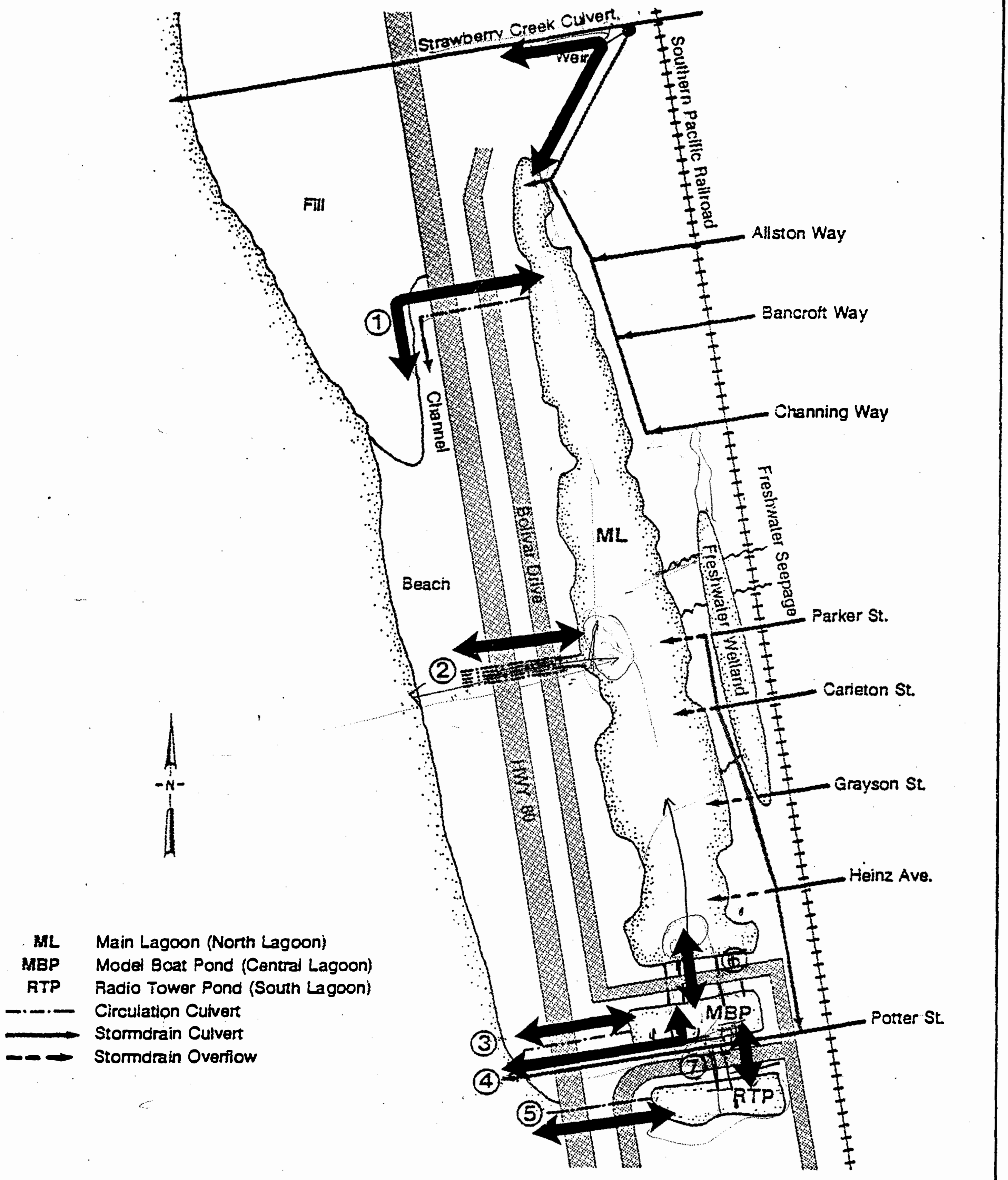
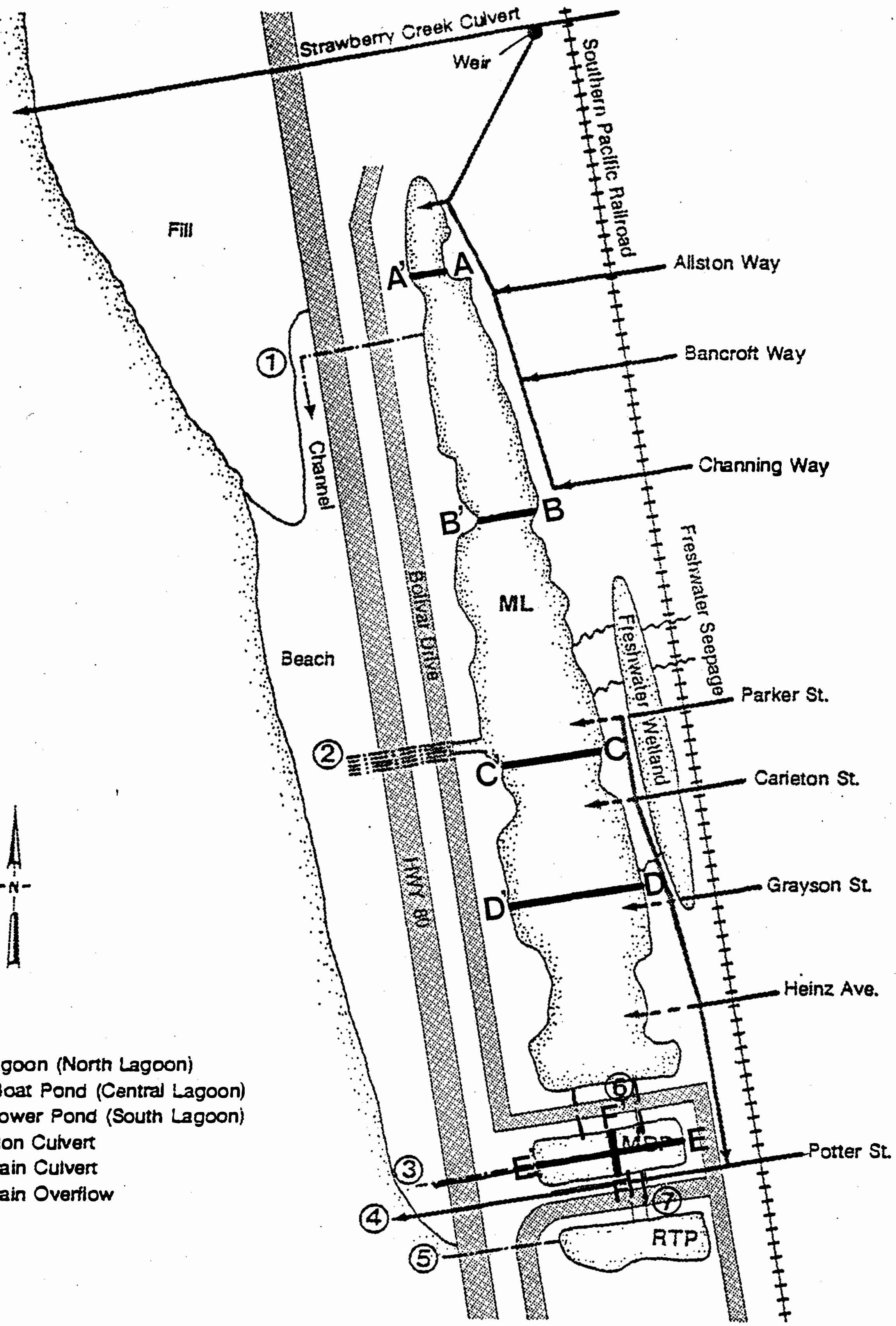
1 Topography refers to landform elevations, while bathymetry refers to below-water shoreline and bottom configuration.

2 NGVD refers to National Geodetic Vertical Datum. This is the standard elevation datum in use throughout the U.S. It corresponds closely with Mean Sea Level (MSL). It was established in 1929. The City of Berkeley has its own datum, which is 3.17 feet above NGVD and 6.23 feet above Mean Lower Low Water (MLLW), the standard datum used in referencing tidal elevations.



Philip Williams & Associates, Ltd. Consultants in Hydrology	Potential Tidal Circulation Schemes at Aquatic Park	FIGURE 2



ML	Main Lagoon (North Lagoon)
MBP	Model Boat Pond (Central Lagoon)
RTP	Radio Tower Pond (South Lagoon)
—·—·—	Circulation Culvert
——→	Stormdrain Culvert
— — →	Stormdrain Overflow

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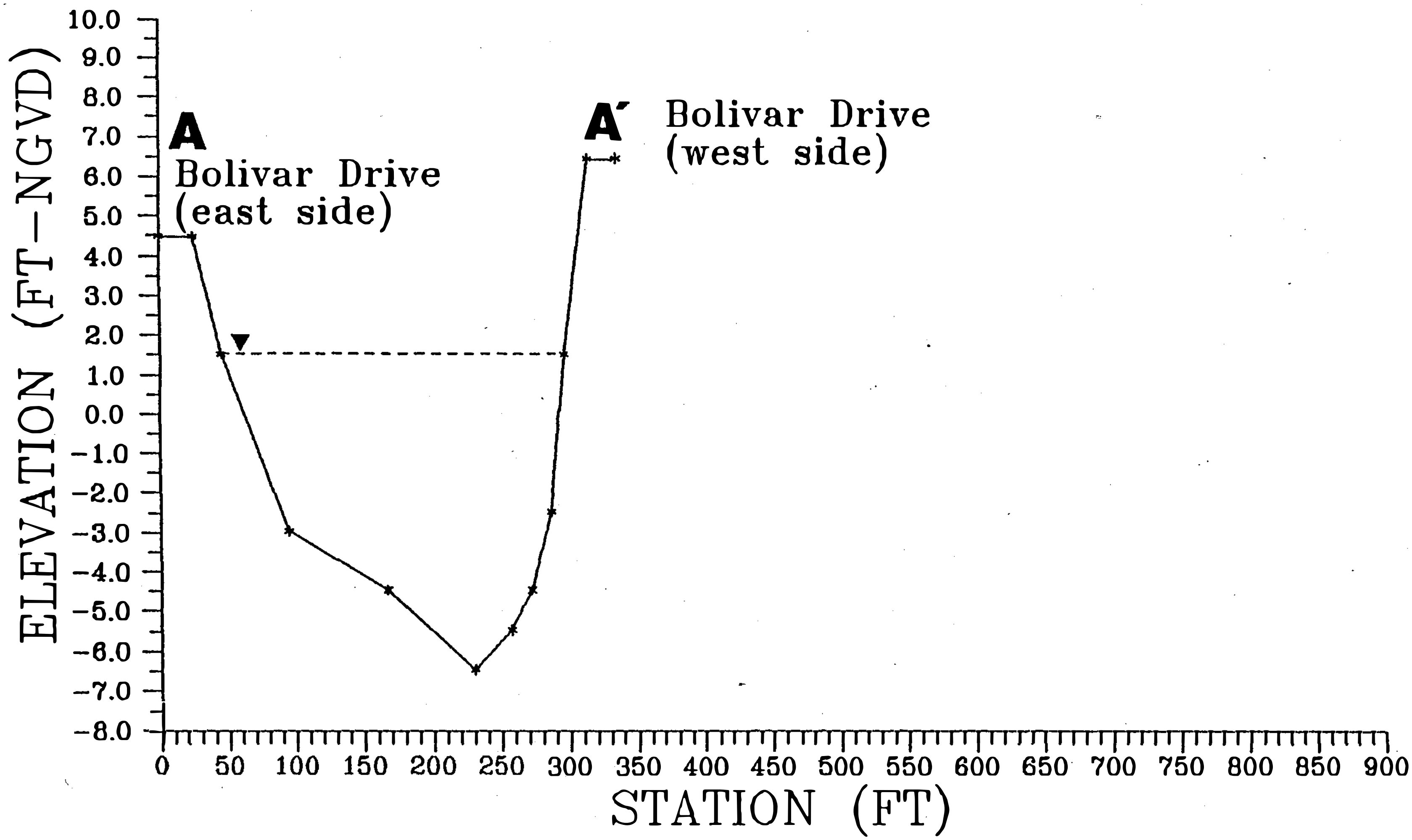
Location of Lagoon Cross-Sections

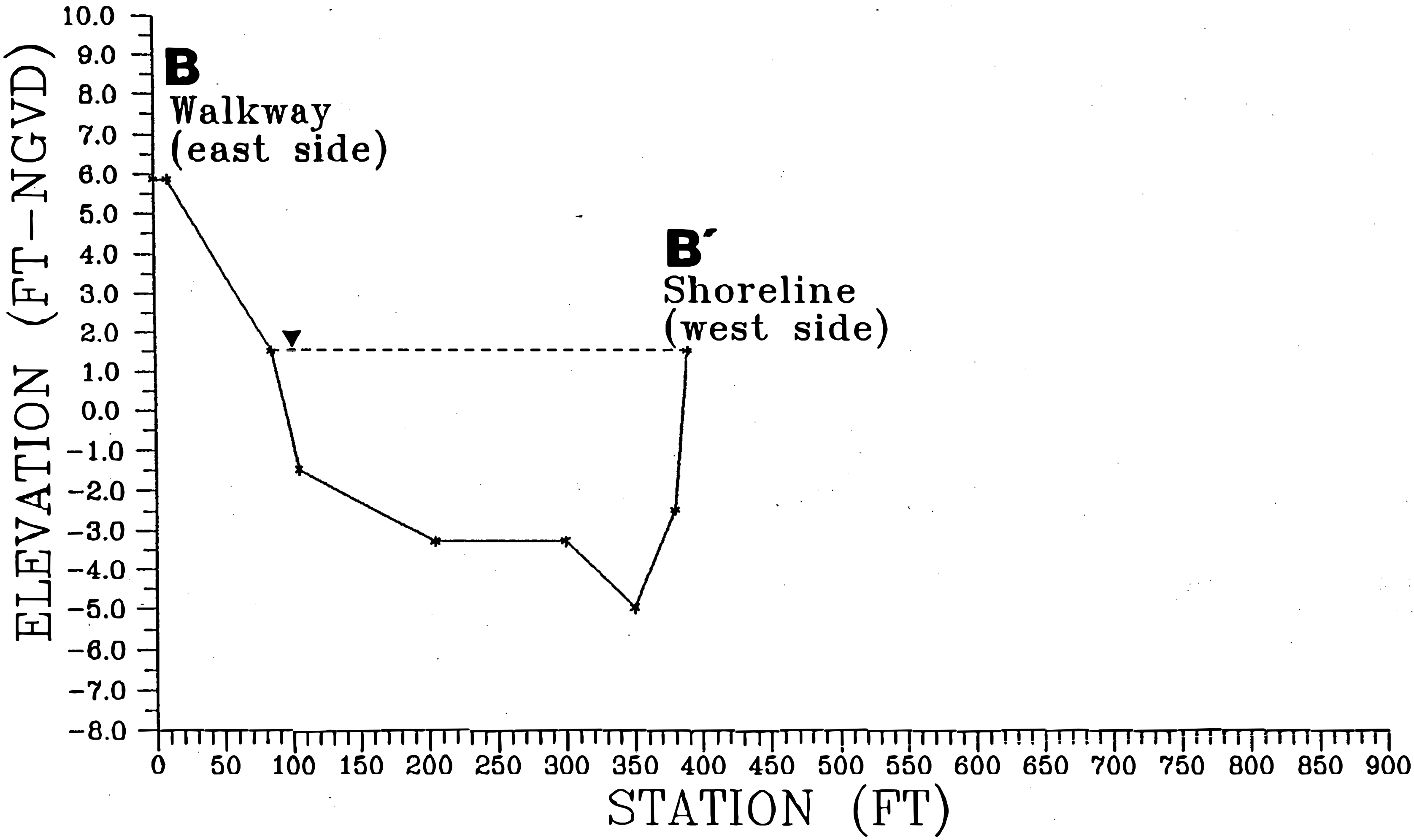
FIGURE 3

AQUATIC PARK CROSS-SECTION A



		Philip Williams & Associates, Ltd Pier 35, The Embarcadero San Francisco, California 94133	FIGURE 4

AQUATIC PARK CROSS-SECTION B



		Philip Williams & Associates, Ltd Pier 35, The Embarcadero San Francisco, California 94133	FIGURE 5

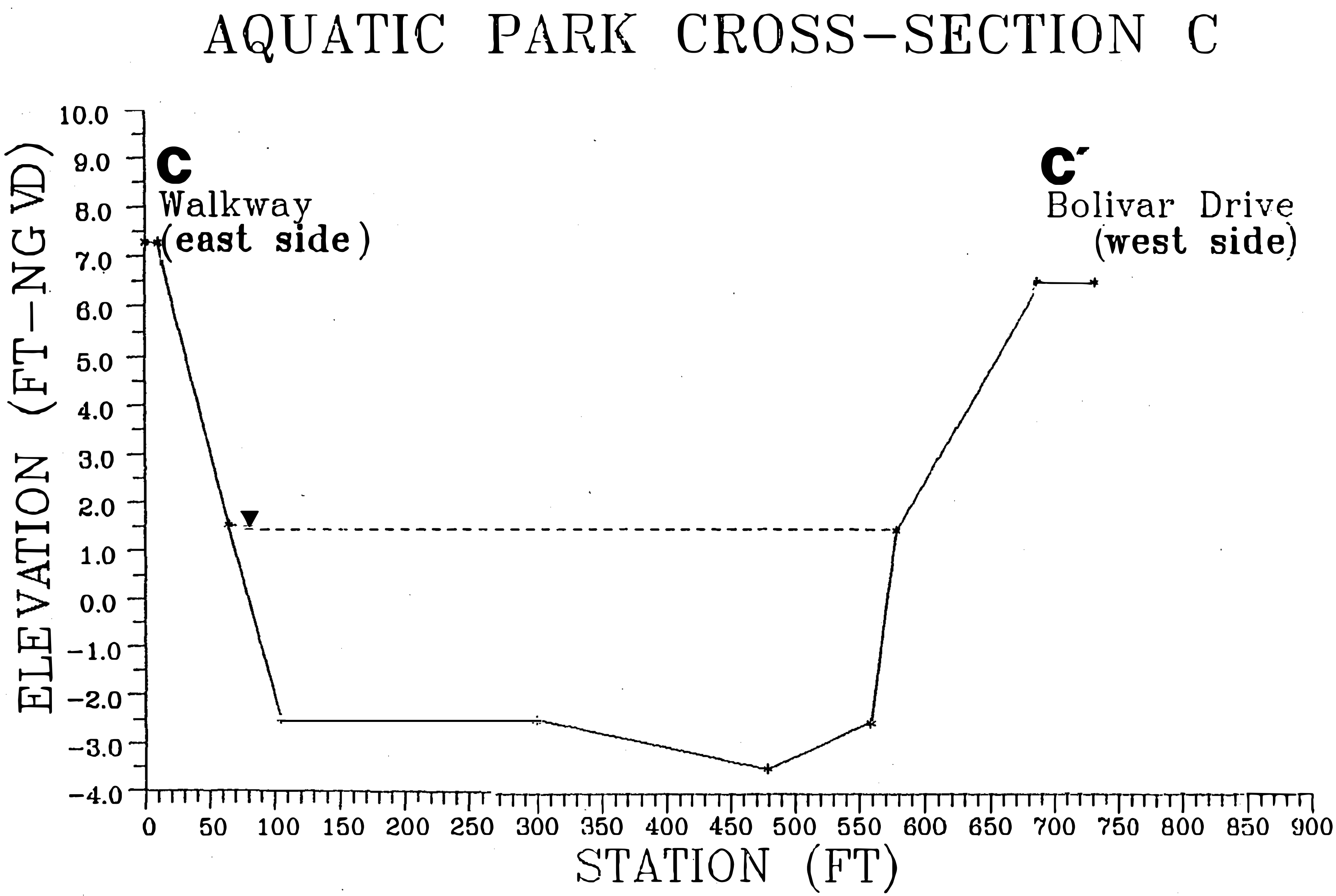


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FIGURE 6

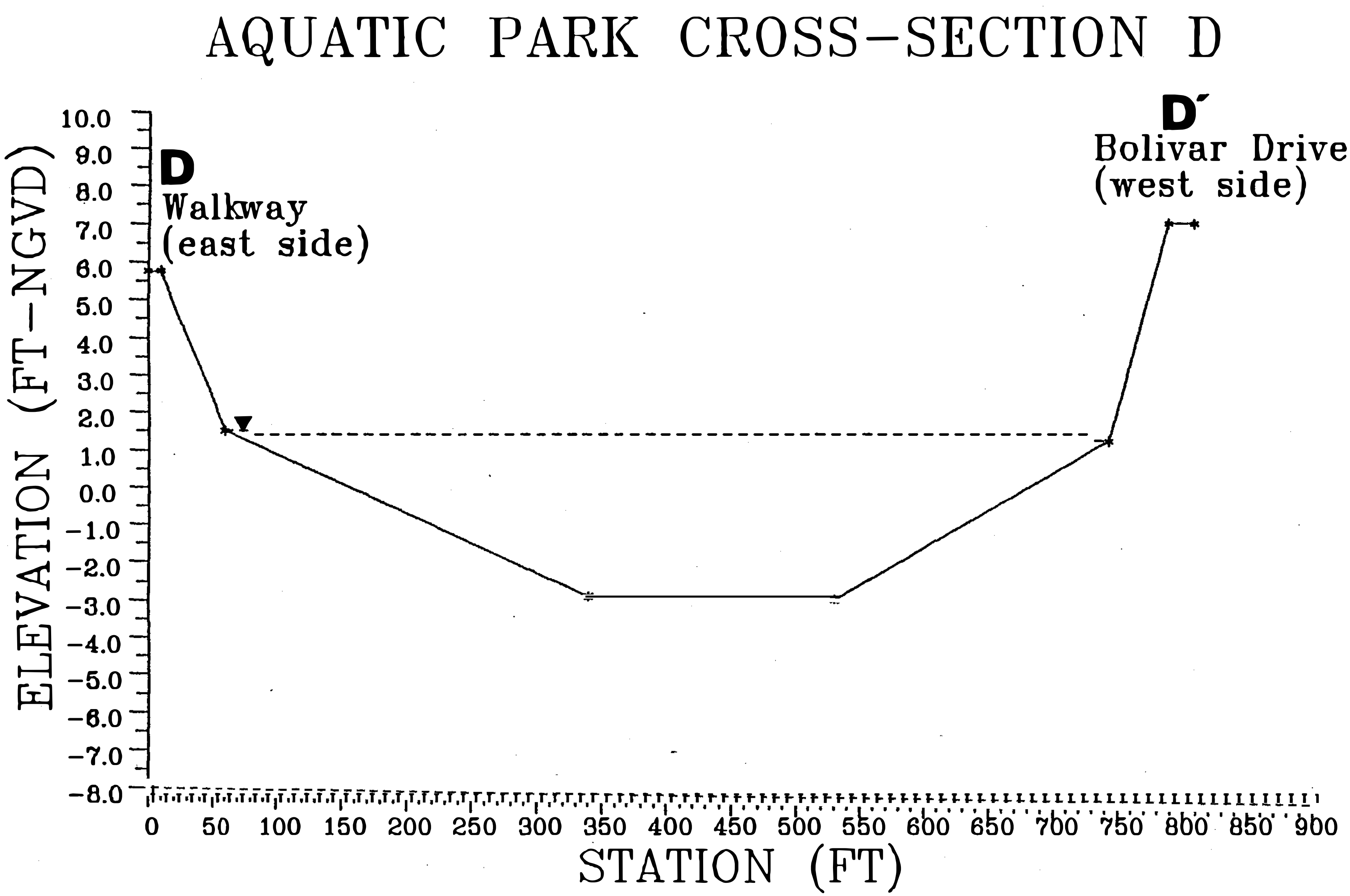

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FIGURE 7

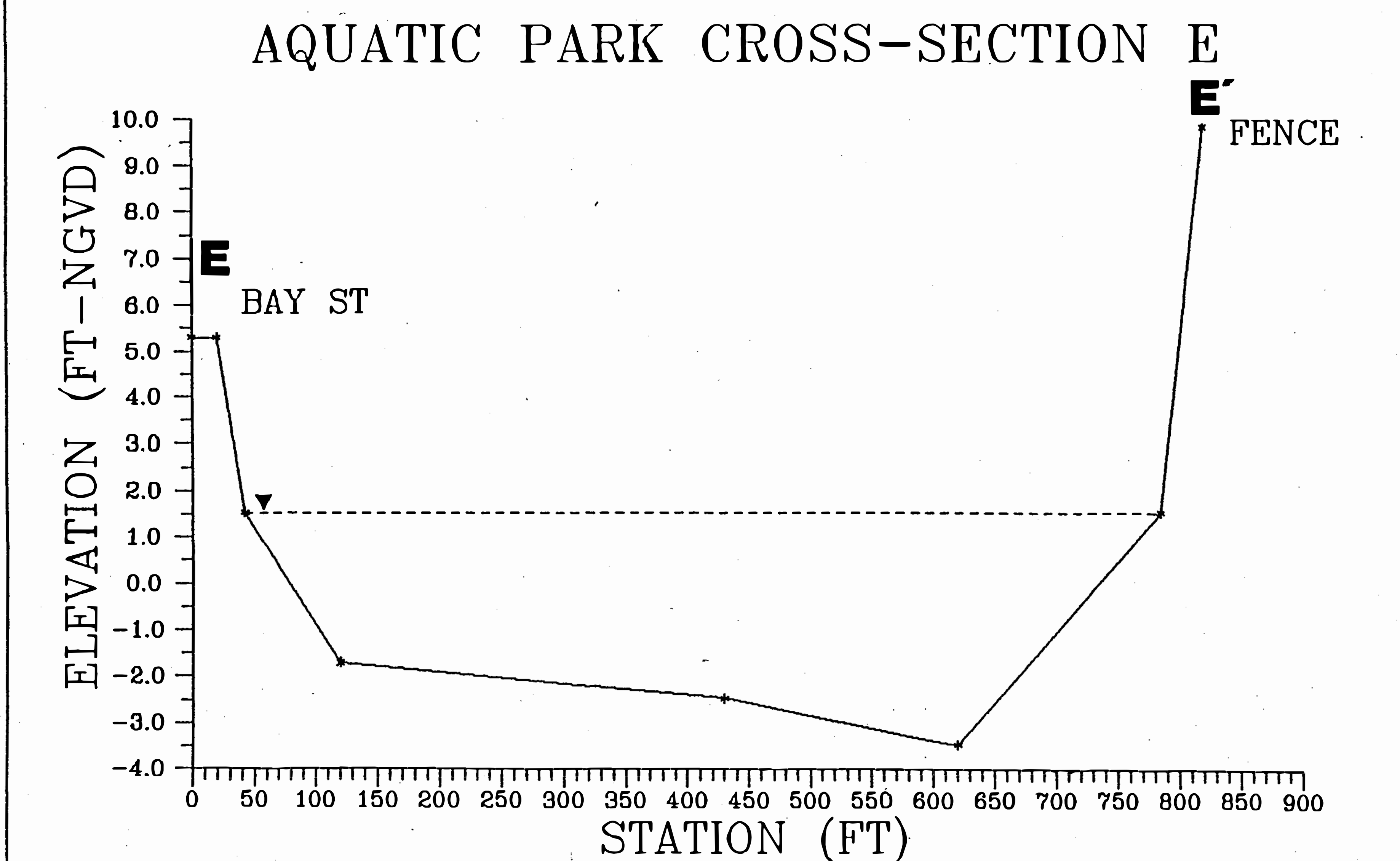

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FIGURE 8

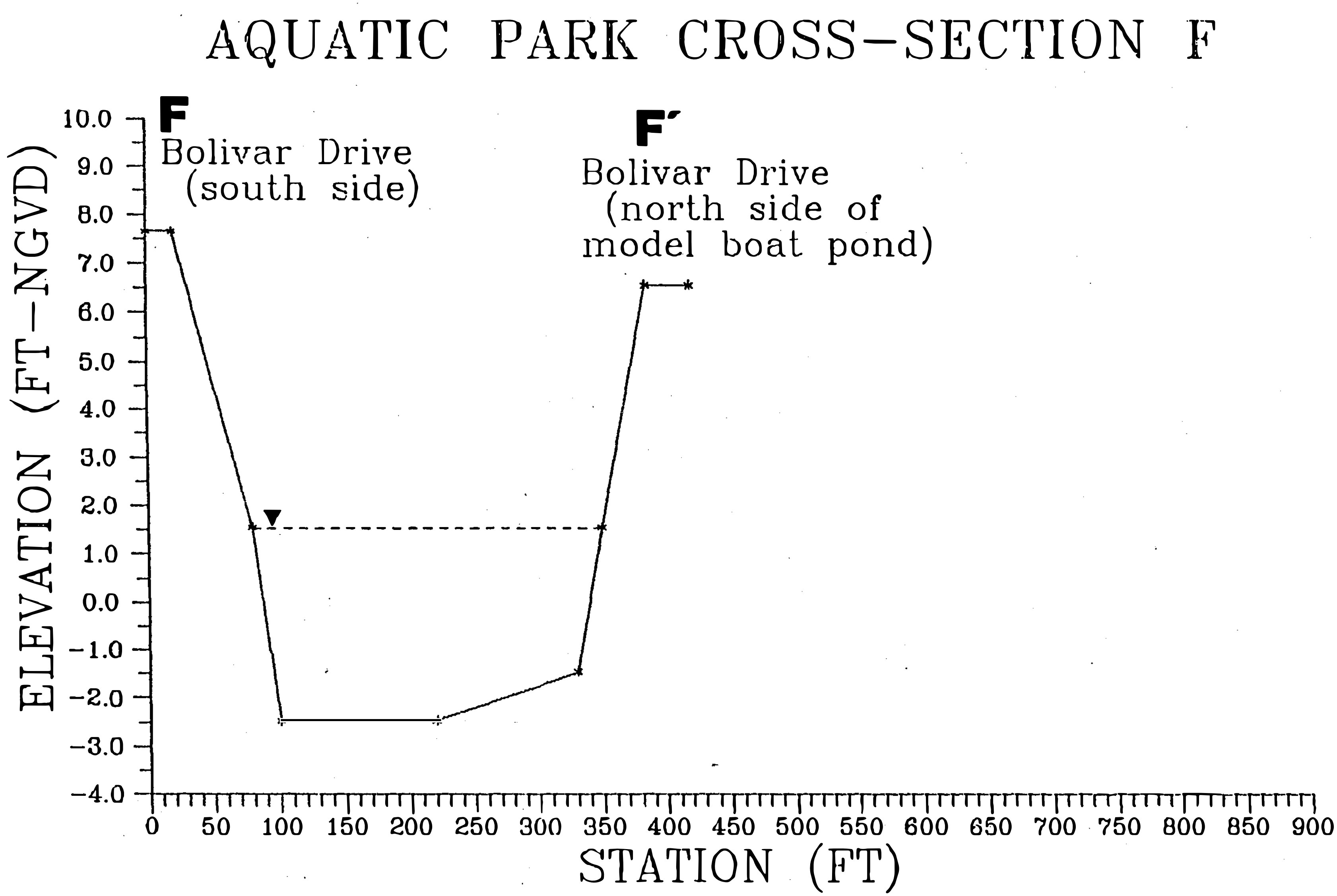

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FIGURE 9

Apparently, dredging has been conducted in the park, although no substantial dredging has occurred in recent years.

The shoreline edge is relatively steep, with a vertical stone bulkhead built at some locations and loose rip-rap placed around other reaches of the shore. Shoreline erosion caused by wind- and boat-generated waves is evident at some locations. The stone bulkhead has deteriorated in many locations, which are currently experiencing moderate erosion.

The Model Boat Pond (MBP) is 3 to 5 feet deep, with sloped, vegetated banks. It contains about 17 acre-feet of water when the water surface is at +1.5 ft. NGVD. It has two concrete box structures on the north bank (which supports the 18-inch diameter culverts to the main lagoon) and a concrete bulkhead in the southeast corner (which contains two culverts). A single concrete bulkhead on the west side supports the gate and culvert which previously connected the MBP to the Bay.

The Radio Tower Pond (RTP) is relatively shallow (0.5 to 2 feet deep). It contains a variety of shallow ponding areas and low areas. Unlike the Main Lagoon and MBP (which represent urban lakes), the RTP is more characteristic of a natural tidal wetland. Although the tidal range (difference in water level between high and low tide) is damped compared with the Bay, it is greater than the other two lagoons. This daily ebb and flow of Bay water produces the characteristic salt marsh vegetation, shallow ponding, and mudflats in the RTP, and provides excellent shorebird habitat.

Constructed by placing fill over what was previously part of San Francisco Bay, much of Aquatic Park's grassy picnic areas, roads, and walkways are at low elevations compared with the Bay. Elevations range from 3 to 5 ft. NGVD. Considering that spring tides in the Bay exceed 4 ft. NGVD and that the 1983 high tide exceeded +6.0 ft. NGVD, the relatively low elevations affect drainage and flood hazards at the site. While flooding has evidently not represented a serious problem in the past, provision for avoiding flood hazards must be included in the operation of the circulation system and the construction of any new structures in the area.

B. CIRCULATION

The three ponds at Aquatic Park represent tidal lagoons; the primary source of water circulation is via tidal circulation of salt water from San Francisco Bay. In addition, during intense winter rainstorms, the ponds receive overflow water from the City storm drain system.

The hydraulic structures which affect Aquatic Park are shown in Figure 2 and described in Table 1. The results described below represent a reconnaissance-level inspection of the system. Surveying of culvert invert (flowline) elevations was conducted by the Berkeley Public Works Department.

In the main lagoon, five 24-inch diameter concrete culverts connect the lagoon with San Francisco Bay. On the lagoon side, the culverts end in a concrete box structure which previously

TABLE 1:

DATA ON CIRCULATION CULVERTS AT BERKELEY AQUATIC PARK[1]

Culvert[2] #	Type[3]	Diameter (Inches)	Invert Elev.[4] (Lagoon)	Invert Elev. (Bay)	Comments
A. Culverts Connecting Lagoons to San Francisco Bay					
1	RCP	24	-0.07	NF[5]	Culvert has slide gate on Lagoon side. Bay side completely buried by fill; culvert inoperative.
2	RCP (5)	24	-1.23	+0.77	Culverts completely plugged with sand. Lagoon side concrete hydraulic structure had flap gates and weir deteriorated. Culvert inoperative.
3	RCP	24	-1.53	NF	Culvert completely buried on the Bay side. Inoperative.
4	RCB	96 (wide) 84 (high)	-2.43	-5.43 (?) Pipe invert -0.43 (sand)	Culvert partially filled (about 3.5-4.5 feet) with sand. Vertical opening 2 1/2 to 3 1/2 feet. High tide flows up culvert beyond junction with MBP. Conveys some fresh water at all times from Potter Creek.
5	RCB	24	-2.63	-2.63	Open on both lagoon and Bay sides. Slide gate on pond side is kept open.
B. Culverts Interconnecting Lagoons					
6	RCP (2)	18	-0.53 (w) -1.03 (e)	NF	Connect main lagoon and MPB. Condition uncertain. One main blocked.

Culvert2 #	Type	Diameter (Inches)	Invert Elev.4 (Lagoon)	Invert Elev. (Bay)	Comments
7	RCB (2)	18	-0.13		Connect MPB to Potter St. Culvert. 1 slide gate (damaged).
		24	?	?	1 slide gate missing (replaced by piece of plywood).

1 Does not include storm system culverts on east side

2 Culvert is keyed to Figure 1

3 RCP = reinforced concrete pipe
RCB = reinforced concrete bar

4 All invert elevations in Ft. NGVD

5 NF (Not Found)

included flap gates to allow water inflow from the Bay while preventing outflow. At present, the tidal flap gates are inoperable. Furthermore, all five culverts are completely plugged with sand on the Bay side, preventing any tidal circulation at this time. It will reportedly cost about $80,000 to clean the culverts. The problem of sand blockage has apparently been ongoing since the lagoon was originally built. The Berkeley shoreline experiences moderate wind-generated waves 1 to 3 feet high as a result of the strong summer westerly sea breeze. This suspends the Bay sand and carries it into the culverts. When the culverts are open and tidal water flows into the lagoon, the suspended sand is deposited as the water passes through the culverts. In the past, the flap gates for the lagoon side of the culverts prevented back flow, which would have helped scour the sand out of the culverts and carry it back to the Bay. Even if the culverts were cleaned and full tidal action allowed to enter and exit the culverts (i.e., no flap gates), it is possible that wave-generated sand transport may still block the culverts. However, blockage frequency would be greatly reduced. Blockage of these culverts represents the major water-quality problem affecting Aquatic Park at the present time.

In the north end of the main lagoon, a single 18-inch concrete culvert previously connected the Bay and the lagoon. Although there is no design document describing the original circulation of the lagoon, it is likely that the north culvert was intended to create a net counter-clockwise circulation, with Bay inflow through the 5 main culverts and outflow through the north culvert. However, on the Bay side of I-80, extensive fill has been placed and the end of the culvert buried. It is completely inoperative at this time.

In the south end of the lagoon, two 18-inch culverts connect the main lagoon with the model boat pond. These are always open (no gates), and water levels in these two water bodies are the same. These culverts are apparently functional, although there may be some accumulated sediment. A single culvert also connects the model boat pond to the Bay. This culvert is non-functional, with the end on the Bay side completely buried in sand (its location was tentatively identified, and it probably could be excavated and flushed if desired). Two short (one 18-inch, one 24-inch) culverts also connect the model boat pond to the Potter Street outfall. These two culverts had slide gates, now deteriorated, on the MBP side.

The Potter Street storm sewer drain flows west under the street separating the model boat pond and the radio tower pond and discharges to the Bay. (Adjacent to the MBP, it is horseshoe-shaped [9 feet wide, 7 feet high] with its invert at -2.43 ft. NGVD.) At its discharge location, the Potter Street outfall is apparently a rectangular box culvert, 96 inches wide; it is partially filled with sand, with a vertical opening of 2.5 to 3.5 feet. Assuming it is still 7 feet high, there is 3.5 to 4.5 feet of sand above its invert. The Potter Street culvert carries rainstorm runoff from a large area of West Berkeley; it replaced Potter Creek (one of the eight creek systems which flowed through Berkeley prior to development) and apparently contains some freshwater flow at all times. In addition, because of its low elevation, tidal waters flow from the Bay up the culvert during high tides. During the past summer, with the main lagoon culverts blocked by sand, the gates on the short connect culvert between the Potter Street culvert and the MBP were manually opened during high tides to provide some circulation and keep the MBP and main lagoon water elevation high.

The Radio Tower Pond (RTP) is connected to the Bay by a single 24-inch RCP; although there is a slide gate on the RTP end of the culvert, this is apparently never closed, and the culvert is open to full tidal inflow and outflow. On the Bay side, this culvert (unlike the five main lagoon culverts, the north culvert, the MBP culvert, and the Potter Street outfall) is not experiencing sand blockage. There are three reasons for this:

- The culvert experiences full inflow and <u>outflow</u> during each tidal cycle (unlike the five main lagoon culverts). Thus, sand deposited in the culvert during tidal inflow is flushed from the pipe during the next tidal outflow.

- The culvert extends further into the Bay (about 35 feet west of the frontage road) than the five main culverts (which discharge at the base of the road). Thus, it is less subject to wave action.

- The beach elevation is slightly lower and much narrower at this location. This is the southern extent of the beach, and there is much less sand available to plug the culvert.

In addition to the above culverts, which connect the three ponds to the Bay and to each other, a series of storm system culverts (shown in Figure 1) drain to the east side of the main lagoon from developed areas of Berkeley further east. As originally constructed, these storm drains discharged directly into the main lagoon, since this represents the area of lowest elevation. Although dry during the summer, they convey relatively high flow during winter rainstorms. This rainfall runoff contains a variety of pollutants which degrade water quality in the lagoons. To partially alleviate this problem, a bypass culvert was constructed which captures the storm runoff from Parker, Carleton, Grayson, and Heinz Streets and conveys it to the Potter Street culvert and then to the Bay. This apparently functions during small-to-moderate rainstorm events; large events exceed the bypass pipe capacity and the excess is discharged to the lagoon. The northern storm drains in Figure 1 convey all runoff from Channing, Bancroft, and Allston Way directly to the north end of the main lagoon. In addition, a weir/diversion line in Strawberry Creek Culvert (the main culvert draining Central Berkeley and Strawberry Creek flow to the Bay) will discharge excess runoff from that culvert to the main lagoon during large rainstorms.

The final source of water in Aquatic Park comes from a series of seeps and springs which emerge from the Southern

Pacific Railroad berm along the central portion of the main lagoon. There is a large elevation drop (10 to 12 feet) between the land east of the railroad and Aquatic Park. The seepage areas indicate that this steep slope has intercepted the groundwater table. The seepage supports a long narrow fringe of freshwater wetland along the east park border which provides vegetation diversity and freshwater habitat.

C. FLOOD HAZARDS

Aquatic Park is subject to potential flooding during extreme high tides or during a combination of high tides (which restrict outflow) and heavy rainstorms. The area is included in the 1974 FEMA flood study of Berkeley. In this study, the 100-year flood elevation is shown as +6.0 ft. NGVD. This is the same as the 100-year estimated high tide in the Bay (the 100-year high tide has been subsequently revised to +6.3 ft. NGVD). The assumption in this study was that since the lagoons are connected to the Bay, high water levels would be the same in each. This simplistic assumption is incorrect, since the size of the culverts would restrict the flow of water from the Bay into the lagoons. At present, the culverts are blocked and the risk of tidal flooding is low.

The most serious flood hazard in the Aquatic Park area would probably result from a severe winter rainstorm in conjunction with high tides (which would restrict outflow from the major culverts). Excess storm runoff would pond in the lagoons, raising their level. To adequately quantify this risk, a flood routing study would be required. Such a study would be complex, since it must include both local inflow to the Aquatic Park area from the surrounding drainage basin, but also overflows from the major Strawberry Creek and/or Potter Street systems.

Legally, the FEMA flood hazard elevation is still official, and any new buildings in this area would have to have the finished floor elevation set at +7.0 feet NGVD as a minimum. Much of the land surrounding the lagoons is at low elevation and may be subject to occasional inundation. This is not likely to cause extensive damage.

The existing radio station building to the south (on private land) adjacent to the RTP is at a very low elevation and likely subject to high flood hazard. If this is rebuilt, it should setback out of the wetland area and at a higher elevation.

D. WATER QUALITY

No new water quality tests were conducted during this review. The results represent an analysis of the (sparse) previously collected information (Altamirano, 1983; Rezani, 1989; Betts, 1983; and Engineering Science, 1970).

Water quality in the three lagoons results from the complex interaction of inflow water and circulation from the Bay, stormwater runoff from the east, and the internal physical and biological processes within the system. Typically, water quality is described by a variety of physical, chemical, and biologic parameters. Potential uses of a water body, depending on its water quality, are established by the Regional Water Quality Control Board (RWQCB). The RWQCB has established levels of various parameters which must be met in order for water bodies to be acceptable for "contact" or "non-contact" recreation. Although the City has established a reasonable pattern (summer use only) for use of the lagoon by water skiers (contact recreation) and others, there has been no consistent program of ongoing water quality monitoring on a seasonal and annual basis to determine long-term water quality and to verify what types of recreation are suitable. This is discussed in greater detail in the section on recommended future studies.

The major water quality issues can be discussed in relation to circulation in the lagoons and pollutant inflow from the storm drains.

Circulation of water between the Bay and the three lagoons is critical to provide flushing of suspended pollutants and to prevent eutrophication of lagoon waters. It has been problematic throughout the history of Aquatic Park, but has become critical in recent years. The problems result from a combination of natural factors, lagoon design, and lagoon management.

The bottom of the lagoons are below the invert of the Bay-lagoon culverts. Thus, it is impossible to drain the lagoons or even exchange a significant portion of the lagoon water with the Bay on any single tidal cycle. Thus, the goal must be to exchange a portion of the lagoon water during each tidal cycle and assume that sufficient internal mixing of lagoon water occurs such that on a monthly basis, all of the lagoon water is replaced with Bay water. The culverts connecting the lagoons to the Bay are relatively small (low flow capacity) in relation to the bottom of the lagoon. Thus, even if all the culverts were functioning and there were no tidal gates, tidal circulation would be limited. However, because of the present blockage of the five main culverts in the main lagoon and the long-term blockage of the north culvert and the MBP culvert, there is virtually no circulation at present. (The City has managed to get some circulation through the Potter Street system.) Even if the culverts are open, the goal of maintaining a relatively constant water elevation in the main lagoon (about +1.5 to +2.0 ft. NGVD) greatly restricts the potential for tidal circulation; water can only enter through the lagoons during periods of high tide. Primarily water in the surface layer (top 1 to 2 feet) of the lagoons will be exchanged, while lower water zones will likely remain trapped for months. This stratification is enhanced by both thermal and salinity gradients, such that warmer, less salty water overlies colder, saltier water. The only source of mixing is wind- or boat-generated turbulence.

As a result of the lack of circulation, fish kills and algal blooms have occurred in the past. Fish kills usually result from lower dissolved oxygen levels, which are a consistent problem in the lagoons (ES, 1970). The algal blooms are also indicative of poor circulation, resulting from elevated nutrient levels and higher water temperatures. At Aquatic Park, these nutrients are transported to the lagoons through the storm drains as urban runoff (lawn and garden fertilizer, animal and human waste, etc.). When summer circulation is inadequate, the nutrients remain in the system and warmer air and water temperatures encourage algal growth. Thus, eutrophication results as a direct combination of poor circulation and storm sewer pollutant inflow. While neither of these will be simple to correct, improved circulation should have a higher priority than reducing storm sewer overflows.

The Bay circulation and storm drain runoff also control the salinity regime in the lagoons. In freshwater systems, high salinity is usually perceived as a problem. However, since tidal circulation with the Bay is the only source of water circulation, Aquatic Park should be considered as a saline (and occasionally brackish) system. Indeed, it is the storm drains (which discharge fresh water) that contain the major pollutants. Salinity of the Bay is typically 32 to 35 ppt (parts per thousand). Thus, in the lagoons, we would expect similar salinity levels, except during periods of rainfall runoff. Because of the relatively poor circulation with the Bay, salinity in the main lagoon was 18 ppt during mid-July, 1989. The only inflow water at this time was coming into the MBP via tidal flow up the Potter Street culvert. Although primarily Bay water (32 ppt), the inflow salinity (25 ppt) indicated that some freshwater was flowing in the Potter Street system and mixing with the tidal Bay water. Salinity in the RTP was 32 ppt, reflecting regular tidal circulation for the Bay. The 1983 and 1989 UC Berkeley studies at Aquatic Park indicated a wide range of salinities throughout the main lagoon and MBP, again indicating the importance of seasonal freshwater inflow and Bay circulation.

Although there are advantages to a variety of salinity regimes in the various lagoons, the importance of Bay circulation and the pollutant inflow problems from the storm drains suggest that a higher salinity regime is probably preferable. Although some organisms can tolerate a range of salinities, relatively large, sudden shifts between fresh and salt water can create a salinity shock to which most organisms cannot adapt.

The summer freshwater flows in the Strawberry Creek and Potter Street culverts are of better quality than the early winters flows (which contain street runoff). Thus, these could be used to support freshwater wetlands. The freshwater wetland on the east fringe of the park, created by groundwater seepage, appears to be in relatively good condition.

One of the main pollutant concerns affecting human use of the lagoons is bacteriological contamination. The winter rainfall-runoff contains animal fecal material and transports it to the lagoons. In addition, sewer system leaks and overflows contribute some human waste to the storm sewer discharge. Data collected by Betts (1983) suggest that fecal contamination is a significant problem during the winter months, exceeding the standards for both contact and non-contact recreation. This persisted until at least April and possibly later. Thus, summer use of the Park for contact recreation is likely to be acceptable, although again, no long-term studies are available to document this.

Trace elements such as heavy metals are also of concern. The 1983 and 1989 studies indicated that heavy metal contamination was not a severe problem, although slightly elevated levels of mercury were detected. Since heavy metals are often adsorbed to sediment, the organic muck and sediment on the lake bottom may be high in trace elements. If this is ever dredged, testing should be conducted to determine the concentrations and potential danger of resuspension.

III. MASTER PLAN IMPLEMENTATION AND ADDITIONAL STUDIES

The proposed Master Plan would combine the RTP and MBP lagoons into a single expanded tidal salt marsh, create additional wildlife areas in the main lagoon, and expand the freshwater marsh along the eastern park border.

The integration of the Radio Tower Pond and Model Boat Pond is a desirable goal from a wildlife perspective. However, the presence of the Potter Street Outfall will make this difficult. The culvert presently extends from -2.4 ft. (at its invert) to +5.5 ft. at the top, and would effectively separate the two wetland areas if it is not relocated.

The Potter Street culvert represents the simplest potential source of tidal inflow to the expanded wetland. The section of culvert through the new marsh could possibly be completely eliminated, allowing full tidal action. The stormwater flow from the creek would be discharged to the marsh, exiting at the western side where the culvert goes under the freeway. Further study would be required to determine if this is desirable from a salinity and water quality perspective.

This alternative would require several feet of filling in the MBP to raise the pond bottom. At present, it has a bottom elevation of -3.0 ft. NGVD. Typically, coastal salt marshes are at elevation +1.0 to +3.0 feet (with deeper channels). Thus, 4-6 feet of fill would be required to raise the bottom of the MBP. Material from the berm separating the two ponds could be used for this. In addition, increased tidal circulation in these ponds would almost certainly require relocation of the radio station building to a higher elevation.

It is possible that this project would be accomplished in phases, with the ponds initially remaining separated, but with wetland restoration and tidal action initiated in the MBP.

The continuation of existing uses in the main lagoon will require improved circulation, while maintaining a relatively small range in depth variation to accommodate water-skiing.

The circulation and water quality regime at Aquatic Park is complex and poorly understood, and requires significant improvement. Both circulation and water quality must be adapted to the desired uses of the Park. For example, recreational boating and water-skiing require relatively constant water depths, while a tidal saltmarsh benefits from a large daily tidal range. Likewise, water contact sports such as water-skiing and swimming require higher water quality than boating.

A detailed hydrology and water quality study is needed to refine the preliminary information in this report and to achieve the Master Plan goals. Such a study should include:

1. A detailed bathymetric map is required to describe the existing lagoon elevation-volume characteristics. This will be needed to determine the size of future culverts necessary to provide improved circulation.

2. Water Quality Monitoring

An ongoing water quality monitoring program should be established to document the seasonal and annual variation of critical water quality parameters. The selection of parameters to monitor will be based on the desired uses as established by the Master Plan. This program will be developed in conjunction with the RWQCB to ensure that it complies with criteria for various classes of recreational use.

3. Develop Alternative Circulation Systems

A variety of circulation schemes are feasible using existing or new hydraulic structures. A number of schemes should be analyzed which meet the circulation needs of each lagoon. Such a system would have the following goals:

- Provide the needed circulation at the least cost in terms of installation and maintenance.
- Minimize potential failure by sediment blockage, mechanical breakdown, etc.
- Minimize the complexity of the system.
- Minimize the amount of active management required by the City.

A computer model capable of simulating various culvert and weir connections between the pond and the Bay would be used to analyze potential circulation schemes.

A full range of options would be analyzed for each of the lagoons. These would include:

A. <u>Measure to Improve Water Circulation and Quality in the Main Lagoon</u>

a. Clean the existing 5 main culverts to the Bay. Allow increased tidal flooding to reduce future sediment deposition.

b. Repair and modify the headwall structures on the lagoon side of the five culverts as needed to meet circulation goals.

c. Provide an intake structure for the five culverts on the Bay side to prevent sand blockage.

d. Locate and excavate the Bay side end of the north culvert in the main lagoon to restore tidal circulation.

e. Use tidal circulation from the Strawberry Creek culvert as a source of water to the main lagoon.

f. Expand the daily range of water elevations in the lagoons to improve water quality.

g. Examine various combinations of flap gate structures to create a net circular flow of water through the lagoons.

h. Use of mechanical pumps or aerators to meet water level and quality objectives.

B. Measures to Improve Circulation in the Model Boat Pond (In Its Present Condition or as a Tidal Wetland

a. If the MBP is hydraulically connected to the main lagoon, either with culverts or by a weir, all the measures which improve water quality in the main lagoon will also improve water quality in the MBP.

b. Locate and excavate the Bayside end of the model boat culvert and restore tidal circulation.

c. Use tidal circulation from the Potter Street culvert as a major source of water to the MBP.

4. Analyze the Storm Drain and Flood Control Functions of the Lagoons

The frequency and amount of storm drain inflow to Aquatic Park is an important component of the winter water balance in the Park. The behavior of these systems during typical and extreme winter storms would be analyzed. This would include a review of the size of areas draining to the park, the hydraulic capacity of the culverts and bypass lines, and the severity of design rainstorms.

5. Shoreline Configuration and Water Depths

The type of shoreline treatment, bottom configuration, and operating water depths in the lagoons are dependent on the selected uses. For urban lakes, vertical stone or wooden bulkheads are often preferred to provide shore protection and proximity of walkways or grass to the water edge. Stone rip-rap placed on a shallow slope also provides some protection. Flatter, vegetated slopes are more appropriate for wildlife areas. In wetland areas for shorebird use, shallow ponding areas and ground surface elevations must be carefully designed in relation to the tidal regime to maximize vegetation establishment and subsequent wildlife use. A greater variation in daily tidal range is desirable to simulate natural salt marsh habitat. Thus, the detailed design of the circulation system, the grading plan, shoreline treatment, landscape treatment, and restoration by native vegetation must all be designed to achieve the variety of uses specified by the Master Plan.

The cost for the above studies is uncertain, but likely to range from $50.00 to $100,000. Potential funding sources besides the City should be explored. For example, the State Coastal Conservancy may be willing to fund the wetland portion of the Master Plan. Other state agencies may be willing to fund the main lagoon study.

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