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Chapter 2

WATER QUALITY IN AQUATIC PARK: CHEMICAL AND PHYSICAL PARAMETERS AFFECTING RECREATION AND WILDLIFE

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Introduction

Aquatic Park, located in Berkeley's heavily industrialized west side, surrounds a lagoon connected to San Francisco Bay (Figure 1, p. 134) and serves as an important recreational site for the City of Berkeley. Besides being an East Bay haven for water skiers, sailors and windsurfers, the lagoon supports an array of wildlife. However, the lagoon also serves as a receptacle for city storm drains which collect runoff from the surrounding urban/industrial area. The nature of the surrounding area and the park's location make it susceptible to pollution. This paper investigates some chemical and physical parameters of water quality in the park that may affect its use by wildlife or recreationists and also attempts to determine if pollutants are entering the park through the storm drains.

Background on Parameters Tested

The tests conducted for this report include parameters that affect general water quality related to the lagoon's uses. The parameters tested--temperature, dissolved oxygen, pH, conductivity, ammonia, organic nitrogen, turbidity, mercury, cadmium, and lead--are described below.

Water temperature is affected by many things, such as solar radiation and the amount and temperature of inflow. Water temperature affects the solubility of other parameters tested, and is especially important in determining dissolved oxygen concentrations.

Dissolved oxygen (DO) levels are dependent on the physical, chemical, and biochemical activities prevailing in the water (APHA, 1975). Temperature, chloride concentrations, and photosynthetic activity all affect dissolved oxygen. Decay of plant material and high temperatures may lower dissolved oxygen. Decay of plant material and high temperatures may lower dissolved oxygen levels to the point where aquatic organisms such as fish are adversely affected. The DO goal set by the Regional Water Quality Control Board (RWQCB) for waters inland from the Golden Gate is 5 mg/l dissolved oxygen.

pH is a measure of how acidic or basic the water is. pH affects the solubility of many different substances in water and is also an indicator of severe pollution problems. The RWQCB standard that applies to Aquatic Park is a range from 6.5 to 8.5 (RWQCB, 1975).

Conductivity, the ability of water to carry electrical current, depends on how much dissolved ionic solids are in the water, and thus may be an approximate indication of salinity or total dissolved solids. Good quality distilled water has a specific conductance of 1 umho/cm; excellent quality raw water (nondistilled) has a conductance of about 50 umhos/cm, and sea water has a conductance of about 50,000 umhos/cm (Figure 2).

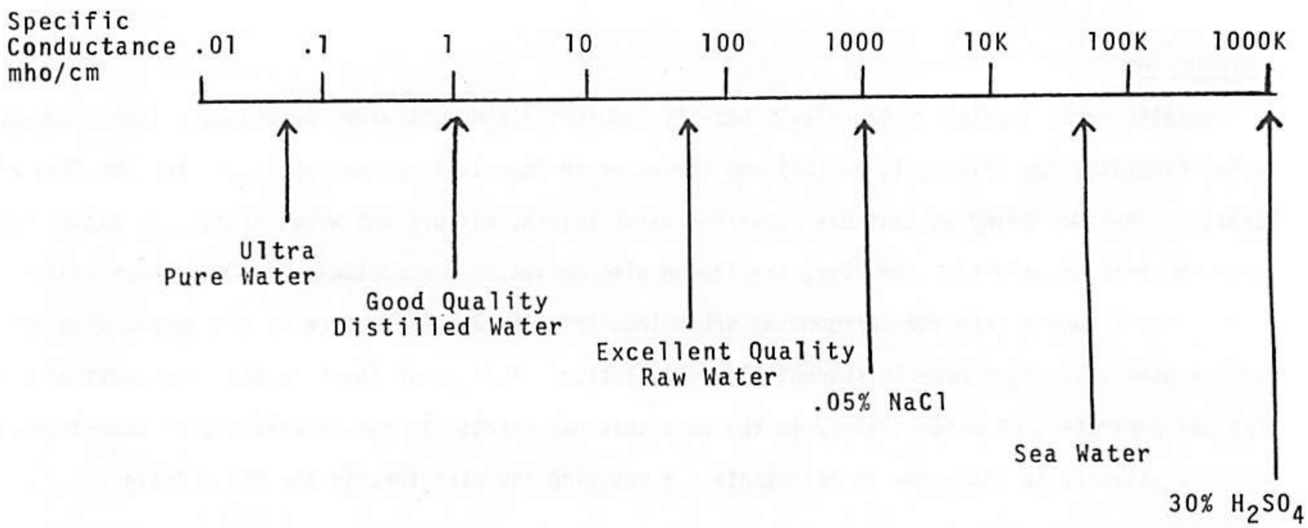

Figure 2. General Conductivities
Source: Thomas, 1983

Ammonia is naturally present in surface waters and is produced by hydrolysis of urea and deamination of organic nitrogen. It may also be produced by the reduction of nitrate under anaerobic conditions (APHA, 1975). RWQCB standards for ammonia concentrations that apply to Aquatic Park are an annual median of 0.025 mg/l as nitrogen and a maximum of 0.4 mg/l as nitrogen (RWQCB, 1975).

Organic nitrogen includes such things as proteins, peptides, nucleic acids, urea and numerous synthetic organic materials. Clean drinking water, generally, may contain organic nitrogen levels of 10 mg/l and waste waters may contain levels as high as 10 mg/l (APHA, 1975).

Turbidity is caused by the presence of suspended matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms (APHA, 1975). The RWQCB set a goal that all waters shall be free of changes in turbidity that cause a nuisance or adversely affect beneficial use (RWQCB, 1975).

Mercury is very toxic, especially in aquatic environments. The major sources are the electrochemical industry and certain fungicides. The standard for recreational waters is .002 mg/l (RWQCB, 1982).

Cadmium may be toxic to certain species of fish at concentrations of 200 mg/l. Cadmium is found in drinking water in concentrations of 0.4 to 60 mg/l. Main sources of cadmium are industry and the deterioration of galvanized pipes (APHA, 1975). It was estimated that 35% of the cadmium consumed in 1968 was released to the atmosphere (Davis, 1979). Thus, one source of cadmium in surface waters may result from the metal being washed out in rain fall. The standard for cadmium concentrations in recreational waters is .03 mg/l (RWQCB, 1982).

Lead enters the environment in many different ways. The path of most concern in urban areas stems from the combustion of leaded gasolines. The atmospheric input from this source is 20% of the annual production (1968) or lead (Davis, 1979). Lead pollution in streams has been found to originate in storm water runoff (Davis, 1979). Natural waters seldom contain more than 20 mg/l of lead, but levels as high as 400 mg/l have been reported (APHA, 1975). The concentration goal for recreational waters is 0.2 mg/l (RWQCB, 1982).

Oil enters waters in urban areas mainly through stormwater runoff from city streets. One danger from oil is the toxic fractions it may contribute to water. As oil stands in water, it begins to divide into different fractions. Some of these are volatile and evaporate quickly, whereas others will take a longer time and different pathways to disperse. The goal for surface waters is that they shall not contain oils, greases or waxes that result in a visible film or coating (RWQCB, 1975).

All these parameters have some effect on water quality. There are many variables that determine how much of a problem any one of these will become, including amount of input, sedimentation, reactions of substances with the environment, biochemical processes, and the hydrologic regime of the water body.

Hydrologic Regime

The lagoon in Aquatic Park is a long oval which runs north-south between Allston Way and Potter Street (Figure 1). Water depth in the lagoon ranges from three to fifteen feet (Raxter, 1983, pers. comm.).

Tide gates provide the link to San Francisco Bay (Figure 1). They have been in effect since Interstate 80 was built to the west of the park. They consist of a series of five 24-inch culverts extending under the freeway from the lagoon to the bay (Berkeley, 1970). These culverts are always left open, providing continuous flow between Aquatic Park and the bay. Water is also circulated through a 24-inch culvert in the north part of the park and two 18-inch pipes at the south end of the lagoon. The south gates are opened when the lake level exceeds 5.4 feet, based on tide levels at mean high high water (mhhw) (Raxter, 1983, pers. comm.). This system of connections allows continuous circulation between the park and the bay. Thus, water levels in the park rise and fall with the incoming and outgoing tides.

Storm drains discharge into the lagoon along the east side at a number of different locations (Figure 1). At one time, runoff entered the park through storm drains opposite Parker, Carleton, Grayson, and Heinze Streets. A storm drain intercept was proposed between Parker and Potter Streets in 1970 (Berkeley, 1970). This intercept line now diverts the flow from these storm drains into the bay rather than allowing them to discharge into the park (Spencer, 1983, pers. comm.). Currently storm drains run into the east side of the lagoon from Allston Way, BAncroft Way, and Channing Way (Raxter, 1983, pers. comm.). In addition to these drains there is also an overflow line running from Strawberry Creek to a drain emptying into the north end of the park during heavy storms (Figure 1) (Berkeley, 1970). The line actually runs from University Avenue storm drains into the park with a flow of 300 cubic feet per second (Raxter, 1983, pers. comm.). This drain is used about twice in normal rainfall years, but this year it was probably used much more due to the unusually heavy rains.

These storm sewers collect a number of different types of runoff. Most drainage is from residential and light industrial areas, although there is some drainage from large industrial manufacturers, such as Cutter laboratories (Berkeley, 1970).

A number of industries have, in the past, discharged water into the park. These include Colgate/ Palmolive, Cutter Laboratories, Macaulay Foundry, and Durkee Famous Foods (Berkeley, 1970).

Past Pollution Concerns

In past years there have been water quality problems in the park. Some sources of these problems have been known, others unknown. Industrial contamination, eutrophication, and the everyday uses of the park all contributed to the degree of water quality problems. Industries located near the park have caused concern both in regard to spills and to the quality of their discharges into the park. When a spill is discivered, the RWQCB is notified to investigate the cause and advise on cleaning it up.

The Colgate/Palmolive company was the last industry to discharge its water into Aquatic Park. Colgate ceased production on December 18, 1981. At times the City of Berkeley diverted Colgate's effluent into the park in order to keep the water level of the lagoon at an acceptable level. The diversion was accomplished by manually rerouting water from the Potter Street storm drain into the lagoon (RWQCB, 1979).

The RWQCB has set general water quality standards for receiving waters of effluent. The dissolved oxygen level should not reach below 5 mg/l; pH must be kept within the range of 6.5 and 8.5 and should not change natural water pH by more than 0.2 pH units. Additional standards set for the effluent are: dissolved sulfide should not exceed 0.1 mg/l, and the temperature of the discharge should not exceed 100^{o}F. Standards for total suspended solids, biological and chemical oxygen demand (BOD and COD), and other parameters were also set. These parameters were monitored by Colgate and the results filed with RWQCB (RWQCB, 1980). Sporadic violations of these standards occurred, but there were no long-term or extreme violations during Colgate's last three years of operation.

In 1970 a study was conducted on the effects the Colgate plant had on water quality in the park (Berkeley, 1970). Findings of this study included:

1) BOD was high at times.
2) Phosphorus concentrations were high enough to cause excessive algal growth, though the phosphorus was not necessarily coming from the Colgate/Palmolive plant.
3) Colgate's discharge was 5-10^{o}F warmer than the receiving waters.
4) Colgate's effluent frequently contained more oxygen than the receiving water.

There were four spills at the Colgate plant between June 1965 and December 1969, but only one spill, of fat, actually reached the park waters (Berkeley, 1970). In March 1976 Colgate was also responsible for an oil spill of 2500 gallons into the park (Berkeley Independent Gazette, 3/5/76).

Industrial spills from other companies have also contaminated the park waters. In March of 1980, 50 gallons of heavy oil from Cutter Laboratories spilled into the park after a Pacific Gas & Electric crew digging on Parker Street discovered three 1,100 gallon tanks of oil (Independent Gazette, 3/12/80). A line coming from the tanks was ruptured, resulting in the oil leak. Cutter claimed they didn't know the tanks existed.

A spill of chromic acid from the Electro Coatings Company reached the park in April of 1976 (The Daily Californian, 4/29/76). Many other spills have probably occurred from surrounding industries.

In September of 1969 oxygen depletion in the water resulted in a large fish kill. This occurred when conduits linking the park to the bay were clogged, creating poor circulation, which, together with high temperatures and the decay of algae, caused dissolved oxygen levels to drop. When the tide gates were cleaned, the lagoon eventually recovered (Spencer, 1983, pers. comm.).

Maintenance of Aquatic Park

Aquatic Park is owned and operated by the City of Berkeley. The City has a maintenance plan that includes care of the tide gates, water quality testing, weed harvesting, and other general maintenance activities.

The tide gates are inspected weekly during the summer and may soon be inspected daily. The level of the lagoon is checked daily. When the water level exceeds 5.4 feet mean high high water (mhhw), the south gates (Figure 1) are manually opened. The gates are cleaned twice yearly by running an apparatus similar to a plumbing snake through the pipes (Raxter, 1983, pers. comm.).

The City tests the water quality only for biological parameters. Furthermore, testing is done only when a complaint is filed, just before ski season, or "when there is a need" (Spencer, 1983, pers. comm.). For a complete discussion of the biological parameters, see the paper by Irvin Betts in this report.

Aquatic weeds are controlled by mechanical harvesting. The City has recently purchased a new harvester to be used starting this spring. The weeds are harvested each spring, when there is the greatest amount of weed growth. The weeds are cut and removed so that they will not decay in the lagoon, causing a drop in oxygen levels or clogging the tide gates. Other methods of weed control, such as chain dredging and chemical herbicides, have been attempted in the past. In 1967, in cooperation with the State Department of Fish and Game, trials with Casoron W-50, an herbicide, gave satisfactory results for weed control and had no detectable adverse affects on the fish population. However, the Department of Fish and Game will not authorize use of this chemical to control weeds (Berkeley, 1970). According to a City Manager's report in 1970, weed control in Aquatic Park was to be investigated by the City, UC Berkeley, and the Department of Agriculture. Until alternate methods are investigated and deemed feasible, the City will continue to use mechanical harvesting.

Periodic dredging may also be required. The lagoon has been dredged many times in the past. In 1964 the lake was dredged to a minimum depth of six to eight feet (Berkeley, 1970). This process may be required in future years to maintain an acceptable depth in the lagoon.

Methods of Water Quality Investigation

For this project tests for water quality were made at four different sample sites (FIgure 1):

Site A: At the end of a pipe, across from Grayson Avenue.

Site B: Near the mouth of a small "creek" on the east side.

Site D: At the extreme northeast section near the storm overflow.

Site E: Off the small pier near the tide gates on the west side of the park.

Samples were collected during both "wet" and "dry" periods. These periods were determined by examining the amount of rainfall during the 48 hours before testing. The dry period had no precipitation before testing. One wet period had 1.07 inches of rainfall, and the other, wetter, period had 2.22 inches before testing (U.S. Weather Bureau, Berkeley, 1983). These distinctions are made in order to determine the effects of runoff and storm drain input on water quality.

Samples were collected in one-gallon plastic jugs, which were rinsed with the sample water at least three times before the sample was collected. The sample was taken by immersing the jub about one foot below the surface and allowing it to fill. All samples and field readings were taken from the shore with the exception of sample E which was taken from the end of the pier. The top of each jug was covered with parafilm and the plastic top after collection. The samples were then transported to the laboratory where they were either tested immediately or refrigerated until testing could be performed.

Water quality tests were performed both in the field and in the laboratory. Dissolved oxygen, temperature, and pH were tested in the field at the time of sample collection. Dissolved oxygen and temperature were measured with a portable dissolved oxygen meter made by Leeds & Northrup. A "pH Master" pH meter was employed to measure the pH immediately after the sample was collected.

Tests performed in the laboratory include an acidimetric test for the determination of ammonia, Kjeldahl tests for organic nitrogen, conductivity tests using a self-contained conductivity meter (YSI Model 131), and tests to determine turbidity using a Hach turbidimeter. Each of these tests was conducted in accordance with Standard Methods (APHA, 1975).

Tests were made for cadmium, mercury, and lead, using a Perkon Elmer flame spectrophotometer, following the manufacturer's instructions for use. The cadmium and lead tests were in accordance with the methods described in Standard Methods, but the procedure used to test for mercury was not the method of choice.

General observations of surface conditions were also made at the time of sample collection. Garbage and floating oil and grease were the main parameters noted.

Results

All the test results are within the RWQCB surface water quality objectives for waters inland from the Golden Gate, with the exceptions of pH, mercury, and oil. Even though most parameters comply with current goals, there are some aspects of the test data that should be considered. The results are summarized for each parameter below and are shown on Tables 1 and 2.

The temperature of the lake waters varied from a low of 11.9^{o}C to a high of 20^{o}C.

Dissolved oxygen concentrations were near or above saturation levels at all sites, although site A had consistently lower readings throughout the testing periods.

The pH is lower at site A for all sampling periods. There is also a general increase in pH for all sites from the lowest readings during the wettest period, to the highest readings during the dry period. Two readings in the dry period at sites D and E exceed the RWQCB water quality goals.

There is a general decrease in conductivity values from the wettest period through the dry period, with the lowest readings always at site D.

Ammonia was not detected at any of the three sites tested. Organic nitrogen ranged from 0.79 mg/l to 1.73 mg/l.

Turbidity values generally ranged from 6 to 16 NTUs with the exception of site D in the dry weather sample, which had a low reading of 3.5 NTUs.

site	time	t^0C	DO (ppm)	pH	conductivity 1000 umhos/cm	NH_3	organic N mg/1*	turbidity NTU*
sampling date 3-3-83 - wetter period								
A	2:50	20.0	11.6	6.9	11.4	nond*	--	15
B	3:10	18.6	13.3	7.7	12.0	"	1.73	9
D	3:20	17.7	13.7	7.2	7.0	"	1.63	16
E	3:00	18.8	16.5	7.1	11.25	"	0.79	12
sampling date 3-18-83 - wet period								
A	10:30	12.2	8.6	7.7	8.0	-	-	6
B	11:40	12.8	12.7	8.5	8.3	-	-	6
D	11:00	11.9	11.0	8.5	7.9	-	-	7
E	10:45	13.0	9.8	8.1	9.5	-	-	7
sampling date 4-8-83 - dry period								
A	10:00	13.9	10.9	8.5	8.0	-	-	7.4
B	10:35	14.7	11.6	8.5	8.0	-	-	12.0
D	10:25	14.5	11.9	**8.9	3.0	-	-	3.5
E	10:10	14.4	11.2	**9.2	7.5	-	-	9.0

*nond = none detected
N = nitrogen
NTU = Nephelometric Turbidity Units
(** violates standards)

Table 1. Chemical and Physical Data

Mercury levels were in excess of the goals in six of the eight samples tested. There was also an increase in levels at three sites, in the dry sample.

There was an increase in cadmium on the order of 10 between the dry and wet periods. The values ranged from 0.003 mg/l to 0.02 mg/l.

Lead levels were higher at sites A and E for the dry sample and were the same for sites B and D.

Garbage, such as paper wrappers, stryofoam cups, other miscellaneous trash, and small patches of oil and grease were observed around the edges of the lagoon on each sampling day. Conversations with water skiers in the park indicated that a considerable amount of oily substances appears in the water when the water or sediments are disturbed. Any observable floating oil is in violation of the RWQCB goals; therefore the park was in violation on each sampling occasion.

Discussion

The water quality in Aquatic Park is influenced by its surrounding natural and urban environment. These influences are interrelated in many cases and cannot be distinguished, although for some parameters, such as lead or garbage, the sources, whether man-caused or natural, can be identified. The tests for

MERCURY

site	wet sample 3-18-83 mg/l	dry sample 4-8-83 mg/l
A	0	*1.6
B	*0.6	*1.1
D	*1.1	0
E	*0.25	*0.9

CADMIUM

site	wet sample 3-18-83 mg/l	dry sample 4-8-83 mg/l
A	.02	.003
B	.01	.006
D	.01	.003
E	.02	.013

LEAD

site	wet sample 3-18-83 mg/l	dry sample 4-8-83 mg/l
A	.05	.12
B	.02	.02
D	.02	.02
E	.05	.06

* violates standards

Table 2. Heavy Metals Data

this report attempted to determine the degree of quality of the lake water, the effect of storm water input and the effect of water quality on its uses.

Two general categories of park uses are considered, recreational use and wildlife use. There is some overlap of parameters that affect each of these uses, but each parameter will be discussed in relation to the use on which it will probably have the most impact. Parameters that could affect wildlife in the park include heavy metal contamination by lead, mercury, and cadmium, conductivity, dissolved oxygen, pH, temperature, and nitrogen. Parameters that could affect recreational uses are turbidity, garbage, oil and temperature.

Wildlife

Wildlife that use the Park include many species of birds, fish and aquatic plants. There may also be other less visible wildlife that use the waters of the park, such as plankton.

The effect of different concentrations of heavy metals on wildlife is difficult to determine. The low heavy metal concentrations found in this report indicate that, at least by current standards, wildlife would not be affected by cadmium or lead contamination. Mercury levels are very high and could be detrimental to wildlife, but since the method used was not one of choice, the results of this test may be unreliable. Even though cadmium is not at excessive levels, the ten times concentration increase during the wet period indicates that storm water is a major contributor to cadmium concentrations in the park.

The relatively high conductivity values indicate that the park is somewhat saline, as would be expected, since it is connected to the bay. Mr. Spencer in the City of Berkeley's Environmental Health Department has said that the department considers the park water to be the same as the bay water. Conductivity readings for the bay were not readily available, but I would think the park waters would be slightly different. In winter, the park has quite a bit of storm water running into it, and in summer high temperatures may evaporate water, leaving a more saline lake. A low conductivity reading for site D, indicating fresher water at this site, is probably due to the inflow of fresh water from the storm drain. The decrease in overall conductivity values in the dry period was unexpected, since this would indicate a lower amount of dissolved ionic solids. These readings may be due to settling or uptake of the substances during the dry times.

Dissolved oxygen levels measured in the park were very high most of the time; thus, there are no readings low enough to cause any concern about its effects on wildlife. Dissolved oxygen concentrations are probably more of concern in the summer or fall months when there has been a large amount of plant growth and decay.

The pH of the lagoon varied over the testing period and reached 9.2 in one instance, which is rather high. Since this reading was taken off the pier after a motor boat had just left, I suspect that some fluid from the boat may have affected the readings.

Recreation

Recreational activities are enjoyed in aesthetically pleasing environments. Turbidity, oil, and garbage all affect this quality. Different people have different standards for what is aesthetically pleasing and what is unacceptable in a recreational area. The water skiers in the park obviously are not bothered too much by the floating oil, garbage, and turbidity. However, a few I interviewed were concerned with these factors. Many other people are repulsed by the appearance of the water and would not touch it.

Conclusion

Aquatic Park water quality is obviously affected by the surrounding industrial sector and stormwater drainage. In an urbanized area such as this, problems with garbage and stormwater quality occur. The greatest current industrial concern is the occurrence of accidental spills. There is no way to predict spills or their effect on wildlife, as there are so many different substances that may be spilled in that area.

Recreation in the park is affected by the appearance of the water. If there are enough people who want to use the park and don't because of aesthetic degradation of the park, then the City may want to examine methods to clean up the water and the shore.

The City's current maintenance practices address many of the important problems. Care of the tide gates and attention to water level and weed overgrowth are well managed. Garbage is collected around the edges of the park and garbage cans are provided in certain areas. These practices make the park an enjoyable experience for many people.

Many of the park's problems, I think, are caused by the location of such a park in a heavily urbanized/industrialized area. If we want more from the park, we will have to work on solving some of the basic problems in urbanized areas, such as storm runoff quality and prevention of industrial spills.

Some of the quality problems in the park caused by stormwater runoff could be relieved if the city would reroute the storm sewers away from the park.

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