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Expected Effects of In-Lake Dikes on Water Levels and Quality in the Farmington Bay and the East Shore Areas of the Great Salt Lake, Utah (Executive Summary)

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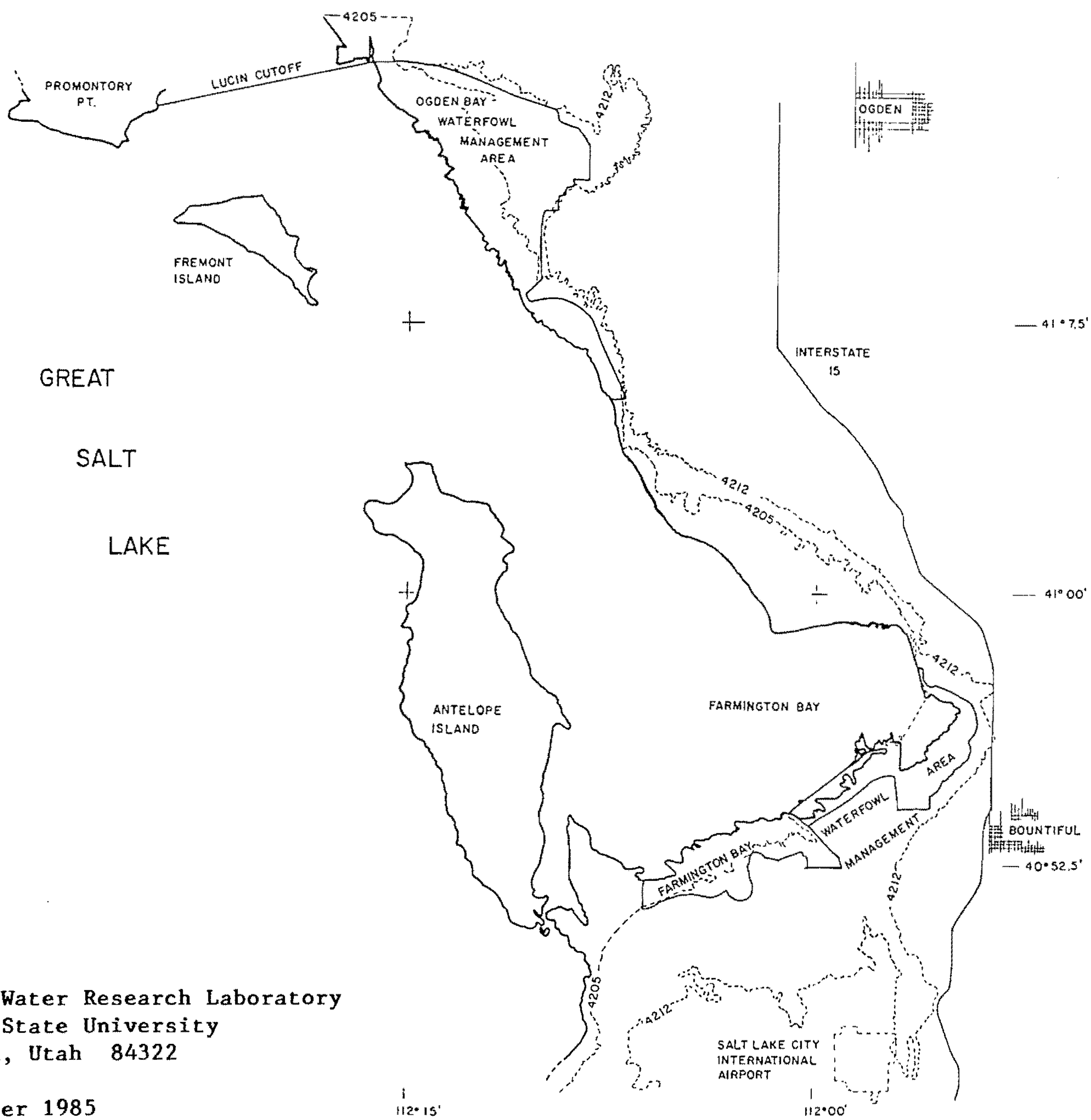

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EXPECTED EFFECTS OF IN-LAKE DIKES ON WATER LEVELS AND QUALITY IN THE FARMINGTON BAY AND THE EAST SHORE AREAS OF THE GREAT SALT LAKE, UTAH

by

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EXECUTIVE SUMMARY

Introduction

The Great Salt Lake is a terminal lake and as such is one of the major inland bodies of salt water in the world, and the largest lake of brine in the western hemisphere. Its unique features, including its mineral rich waters and interesting shores and islands, make it appealing to both industry and vacationers. Until recently, some of the great waterfowl sanctuaries in the U. S. existed along the easterly and northerly shores of the lake. However, during the past three years record breaking inflow volumes and lower than normal evaporation rates have caused an unprecedented rate of rise in the elevation of the lake surface. The rising waters already have caused extensive damages to both public and private properties, including roads, highways, railroads, hunting club facilities, mineral extraction facilities, waterfowl areas, homes, water treatment facilities, and agricultural lands. For example, the Southern Pacific Railroad Company has spent many millions of dollars raising the level of the causeway which crosses the lake between Promontory Point and Lakeside on the western shore, and a causeway which was constructed by the State to provide access to a State park on the northern tip of Antelope Island now stands under approximately three feet of water. Continued increases in the lake level would create further damage to homes, transportation links (including the Salt Lake City International Airport), lakeside industries, and recreation facilities.

In order to reduce future damages from the rising waters of the lake, various diking options, among other alternative flood control possibilities, are being considered by the State. Some of the diking options were addressed in a recent feasibility-level engineering study completed by James M. Montgomery, Consulting Engineering, Inc., and a team of sub-consultants (Montgomery 1984). The study evaluates several on-shore (or perimeter) diking alternatives to protect specific facilities, such as waste-water treatment plants. In addition, the study looks at some in-lake diking alternatives which provide certain management options by compartmentalizing the lake.

The in-lake diking options presented by the Montgomery study include various configurations between points on the east shore of the lake and the Antelope and Fremont Islands. As might be expected, the Montgomery study shows that the in-lake dikes, although more comprehensive (less selective) in the protection provided, are considerably more costly both to construct and to maintain than perimeter dikes for the same area. Various possible perimeter dike configurations to protect properties on the east shore are discussed by the Montgomery report. The costs of these structures are compared with the much higher costs for in-lake dikes needed to protect the same properties. However, the report, by design, addresses the in-lake dikes purely from a flood protection point of view and does not consider other possible advantages of in-lake diking, including:

1. Possible freshening of the waters in areas enclosed by dikes along the east shoreline to enhance boating and swimming and to enable these waters to be used for irrigation, municipal, and industrial purposes.

2. Capabilities to manage the levels of the water adjacent to the east shoreline in order to optimize conditions for waterfowl sanctuaries.

3. Providing road access to the Antelope Island State Park, and even the possibility of an additional north-south transportation route by-passing Salt Lake City.

Each of these three issues needs careful study to evaluate the potential physical and economic impacts. For example, a study of items (1) and (2) should address questions such as: (a) Can water in the impounded areas be freshened sufficiently to permit its use for boating and swimming, irrigation, and/or municipal and industrial purposes? (b) To what extent will freshening create odors (anaerobic conditions), promote algae growth, and cause other water quality problems within the impounded areas? (c) Will regulation to maintain water and salinity levels suitable for waterfowl habitat preclude other uses such as boating and swimming, irrigation, and/or municipal and industrial?

Objectives

The primary objective of this study is to evaluate management alternatives for the easterly portion of the Great Salt Lake in terms of water quantity (impounded water levels which can be maintained) and water quality. Impounded water surface levels affect use of the stored water. For example, in the case of Farmington Bay, personnel from the Division of Wildlife Resources suggest that the optimum levels for the waterfowl sanctuaries lie between 4195 and 4200 feet above mean sea level (msl), whereas to provide adequate depth for boating and swimming, water levels should not be less than 4202 feet amsl. With respect to water quality, only the salinity component is included in the computer model used for the study. Salinity is a critical quality parameter for irrigation, industrial, and municipal uses. In addition, biological activity is strongly linked to water salinity levels. The waters and sediments of Farmington Bay in particular contain high nutrient levels, so that reduced salinity levels will promote algae growth and create anaerobic conditions. In January 1985, the Utah Water Research Laboratory (UWRL) completed a preliminary study (funded by the State Division of Water Resources) (Israelsen et al. 1985) to evaluate the odor potential associated with freshening of the Farmington Bay waters. This work was extended as part of the current study and utilized in interpreting the likely effects of freshening within both the Farmington and East Bay areas of the lake. However, the biological quality component was not directly incorporated into the hydro-salinity model used for the study.

In the conduct of the study, two possible in-lake diking configurations were assumed (see Figure 1) namely:

1. Farmington Bay. Enclosure of the Farmington Bay area by a dike extending southward from the southern tip of Antelope Island and a second dike following the route of the now submerged Syracuse Causeway. It was assumed that the dikes would be constructed to a sufficient height to prevent overtopping from the main body of the lake.

2. East Bay. Enclosure of the entire easterly portion of the lake by three in-lake dikes, with the first extending southward from Antelope Island as in the first configuration, the second connecting Antelope and Fremont Islands, and the third extending northward from Fremont Island to Promontory Point. Under this configuration all flows from the Bear, Weber, and Jordan Rivers (except for diversions from the Jordan River through the Surplus Canal to the Goggin Drain) would enter the impounded area.

The potential for freshening the waters enclosed by the two preceding diking configurations was investigated by application of a computer simulation model. Under earlier study at the UWRL, Chadwick and others (1983) developed a hydro-salinity model for Farmington Bay. For the current study, needed changes were made in the model structure.

The model was applied with sequences generated to represent flow probabilities based on a specific period of historic record. The model simulates monthly inflows to the impoundment areas (surface and groundwater flows and precipitation quantities) and evaporation and flows to the main lake from these areas over a particular period of time. In the case of this study, these quantities were generated for a period of 50 years. By generating a series of possible time sequences (for this study 50 sequences were generated) for a particular set of management conditions, it was possible to develop estimates of (1) the most likely water and salinity levels in the impounded areas, and (2) the variations in these parameters which are likely to occur under a given set of management conditions.

Management Variables

Salinity concentrations and surface elevations of the impounded waters are governed by the rate of evaporation from the impounded waters, the rate of inflow to the impoundments, the quality (salinity)

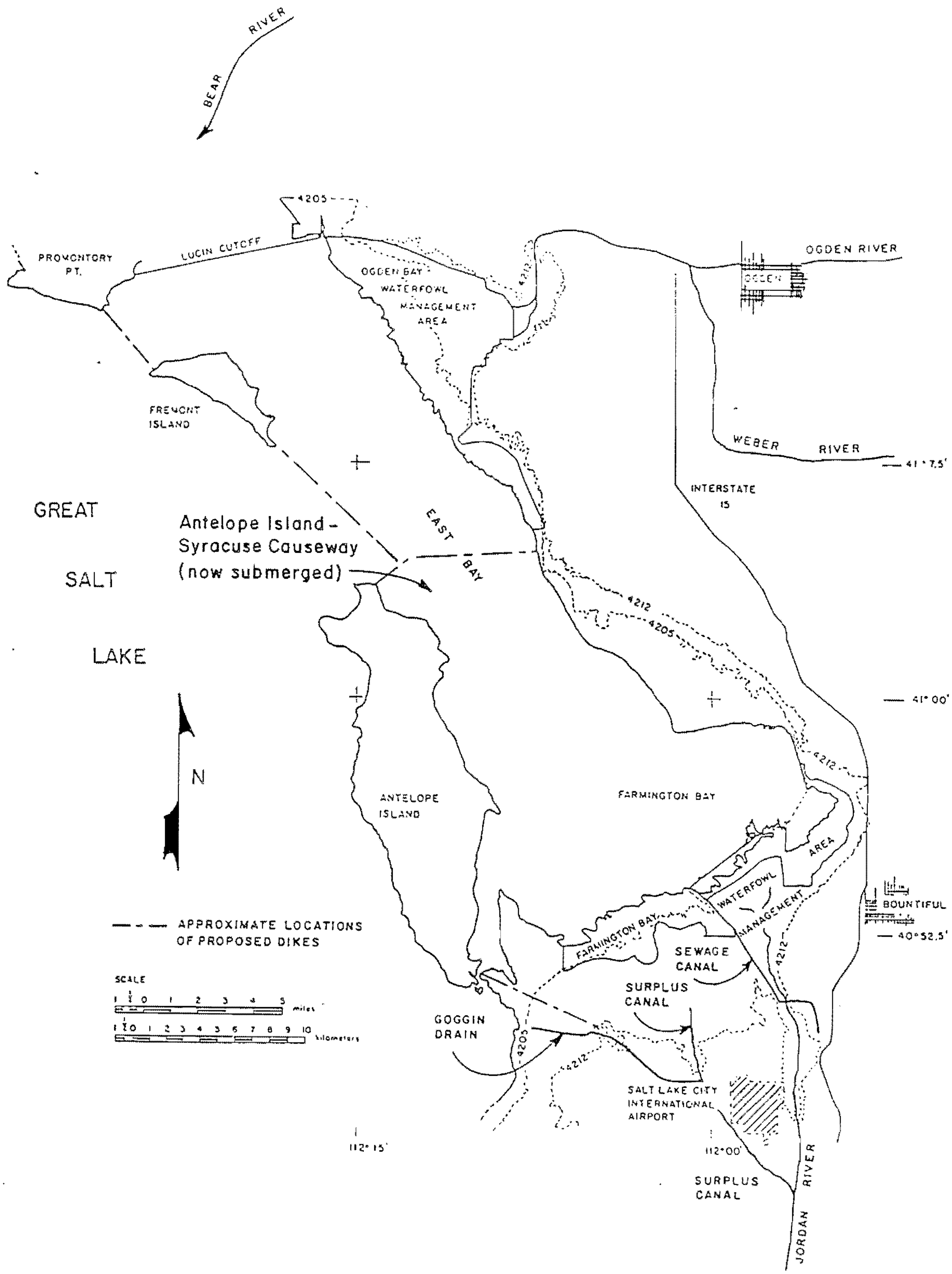


Figure 1. The east shoreline of the Great Salt Lake at a water level of 4200 feet above mean sea level and showing the proposed Farmington Bay and East Bay impoundment areas.

of the inflowing streams, the rate of outflow from the impoundment, and the levels at which the surface of the impounded waters are maintained (either by pumping or by means of an overflow weir). Some degree of management control for each of these variables is possible except for the rate of evaporation from the surface of the impounded waters. For a particular operating level (storage volume), decreases in the salinity levels of the impounded waters result for 1) increases in the rate of throughput (inflows and outflows) and 2) reductions in the salinities of the inflowing waters. For a given rate of throughput and a specific salinity level in the inflowing stream, impoundment salinities also are reduced by decreasing the stored volume. This effect occurs because the reservoir surface area is decreased and evaporation losses are correspondingly less. It is noted also that a reduced storage volume for a given rate of throughput results in increased flushing, and thus less time is required to produce the lowered equilibrium salinity level.

Farmington Bay

The surface water inputs to Farmington Bay include several small streams which flow from the Wasatch Range and the Jordan River which flows north from Utah Lake. In addition, the Salt Lake City sewage canal conveys treated sewage effluent to the bay. Rates of Jordan River inflow to Farmington Bay can be moderated by diversions from the river through the Surplus Canal and thence to the Goggin Drain (Figure 1) which discharges into the main lake west of Farmington Bay. The maximum diversion rate to the main lake is limited by the capacity of the Goggin Drain which was assumed to be 1,000 cfs for this study. The two primary reasons for diverting flows of the Jordan River directly to the main lake are to reduce 1) costs of pumping water from the bay in order to maintain a specific water surface elevation and 2) inflows from this source during periods (if any) when salinity levels in the lower Jordan River might be higher than those in the bay. In order to satisfy water right constraints in the Farmington Bay area, a minimum flow of 500 cfs was assumed to be required in the lower Jordan River system. Thus, diversions to the main lake through the Goggin Drain could occur only when flow rates in the lower Jordan exceeded 500 cfs.

The study also assumed that water could be imported to the Farmington Bay by diversion from the Weber River in the vicinity of Plain City. Conveyance works associated with this diversion are not addressed by the study, but a canal capacity of 300 cfs was assumed. A further constraint on this diversion is that the rate cannot exceed 75 percent of the flow available in the river at the Plain City gage.

It was assumed that impoundment levels within the Farmington Bay were independent of main lake levels. During periods when water surface elevations in the main lake exceed those of the bay, a pumping facility would be required to maintain a specific level within the bay. During periods when water surface levels of the bay exceeds those of the main lake, a siphon (perhaps in conjunction with the pumping facility) or spillway structure would be adequate. A pumping capacity of 1000 cfs was assumed.

East Bay

The surface water inputs to this impoundment include those of Farmington Bay, several additional small streams and drains, and the Weber and Bear Rivers. Although the Goggin Drain is available for diversions from the Jordan River (the same constraints were applied as for the Farmington Bay impoundment), there is relatively very little management control possible over inflows to the East Bay impoundment. Like Farmington Bay, it was assumed that water levels within the impoundment could be managed independently of main lake surface elevations through the use of a combination of pumps and gravity drainage facilities. A pumping capacity of 8,000 cfs was assumed.

Procedures

This study was divided into two basic components as follows:

1. Modification and application of a hydrologic-salinity computer model to predict salinity levels within the impounded waters as a function of time.

2. Field sampling and laboratory studies to examine the salt and heavy metal content of the sediments of the proposed impoundment areas with emphasis on Farmington Bay. In addition, the nutrient (phosphorus) loadings of the impoundments were approximated to provide estimates of the algae producing potential of these waters under fresh water conditions. The salt release characteristics of the bay sediments as a function of salinity in the overlying bay waters were incorporated into the model.

The procedures followed in conducting each of these components of the study are summarized briefly in the following paragraphs.

The hydro-salinity model

Bay area was developed under an earlier study (Chadwick et al. 1983). The model, which was somewhat altered and refined for this study, utilizes a monthly time increment and is based on a mass balance of salt and water which is of the form:

$$I - O = \Delta S$$

in which

- I = total inflow (water volume or salt mass) to the impoundment area per month.
- O = total bay outflow (water volume or salt mass) from the impoundment area per month.
- ΔS = change in storage (water volume or salt mass) within the impoundment area per month.

Inflows to the impoundment areas are grouped into three main categories, namely, surface streams, precipitation, and groundwater. Of these three, only the rate of input by surface streams is subject to management control. Outflows occur as evaporation from the impounded waters and discharges into the main lake. Rates of discharge to the lake, whether by pumping or by gravity (overflow weir and/or siphon), are subject to management requirements, and for a given rate of inflow, are dependent upon the selected control elevation.

A mass balance representation for the impounded areas ideally should include seepage flows between the impounded waters and the main lake. However, for the three reasons given below these flows were not included in the model.

1. It is understood that the proposed dike design includes a clay core so that seepage rates are expected to be low.

2. Seepage rates depend directly on the head differential across the dikes. Thus, a realistic estimation of seepage quantities would require that water surface levels in the main lake be simulated in conjunction with those within the impoundment areas. In the case of this study, the main lake levels were not simulated.

3. Seepage from the impoundment area to the main lake would not significantly affect salinity levels of the impounded waters. On the other hand, seepage from the main lake to the impounded waters (because of the normally higher salinity levels in the lake than in the bay) would tend to somewhat increase salinity levels in the impounded water. Thus, under these conditions actual salinity values would likely be slightly higher than those predicted by the present version of the model. In other words, the actual degree of freshening within the impoundment would be somewhat less than that indicated by the model results.

The model was calibrated by using either measured or estimated values of the parameters in the preceding mass balance equation. During the period October 1980 through December 1982 an extensive data gathering program was conducted for Farmington Bay. Flow rate and quality measurements were made at regular intervals for the inflowing surface streams, and quality samples were taken at various locations within the bay. The Farmington Bay model was calibrated using data and estimated values for this period.

Evaporation rates from the impoundment areas were estimated by taking into account the effects of salinity on evaporation. In this connection, within Farmington Bay, marsh and mud flat areas become increasingly significant as water levels fall below an elevation of 4203 feet above mean sea level (msl). Thus, evaporation rates from the exposed marshes and mud flats below 4203 feet are estimated differently than in the case of open water surfaces.

After verifying that the water and salt balance submodels for both the Farmington Bay and the East Bay were functioning satisfactorily, a stochastic component was added to complete the hydrologic-salinity model. Thus, beginning with known or assumed initial conditions, possible traces of water surface levels and salinity concentrations can be generated for any specificed time period and for a particular set of management conditions. The initial conditions used for this study were estimated values for October 1, 1985 (the beginning of the 1986 water year).

Field sampling and laboratory studies

Four sediment samples were collected from Farmington Bay on April 1 and 3, 1985, for evaluation of odor production potential under fresh water conditions. For each sediment type, four replicate quantities of sediment were placed in 20 liter glass microcosms. Two replicate microcosms were filled with water from the Great Salt Lake and two with water from the Logan River. After incubation in the dark at 25°C and with gentle mixing three times a week, sample dilution series were prepared for evaluation by an odor panal on May 22 and 23. The point where 50 percent of the panelists could detect an odor was designated as the Threshold Odor Number (TON_{50}) for that odor microcosm.

Sediment core samples were collected from six sites in Farmington Bay and the East Bay on April 1 and 3, 1985. Overlying Great Salt Lake water was replaced with Weber River water. Salinity and nutrient dynamics were studied in three replicates of each sediment type under both oxic and anoxic conditions by sampling the water column every 3 to 5 days from April 9 to May 14, 1985. Two of these sediment cores from the south Farmington Bay were examined for heavy metal contamination.

Water samples were analyzed for ortho-phosphorus, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, total phosphorus, total nitrogen, total dissolved solids and specific conductance by EPA - approved methods. Five additional water samples were collected from Farmington Bay on May 22, 1985, for odor evaluation, analysis of chlorophyll a and identification of dominant algal species.

Using estimates of total phosphorus loading to the impoundments, and an empirical model of eutrophication potential in freshwater lakes and reservoirs (Jones and Lee 1982), predictions of the eutrophication potential of Farmington Bay and the East Bay were made.

Results

The hydro-salinity model

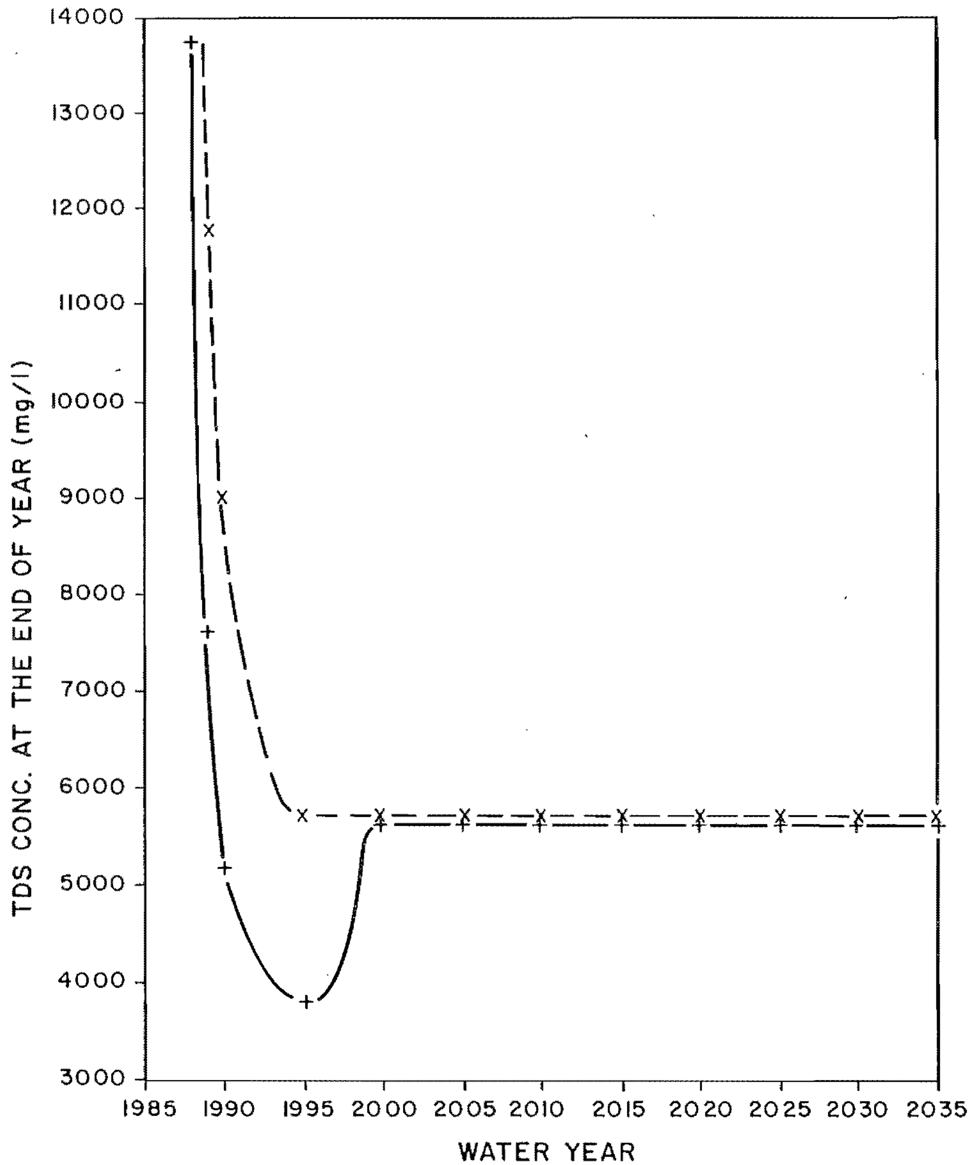
The computer model was used to determine the expected water surface elevations and salinity levels for various management alternatives. For the Farmington Bay impoundment, it was assumed that water could be imported from the Weber River, and that a portion of the Jordan River flows could be excluded from the system if desired by diversions through the surplus canal into the Goggin Drain which discharges directly into the main lake (Figure 1). The Goggin Drain diversions are limited by two constraints, namely: (1) the drain capacity of approximately 1000 cfs, and (2) a minimum discharge of 500 cfs from the Jordan River to the Farmington Bay as required by existing water rights. This latter condition cannot, of course, be met when Jordan River flows at 2100 South are less than 500 cfs. During periods when the surface level of the impounded waters is less than that of the main lake, pumping from the impoundment is, of course, necessary and exports reduce the pumping costs.

Discharge volumes from the impoundment areas to the main lake are a function of pump capacity (or weir crest length) and the elevation of the water control level within the impoundment. Computer runs were made for both the pump and weir forms of level control. As might be expected, the only difference between the two sets of results is that fluctuations of the impounded water surface elevations are somewhat less for pumping than for weir control. Thus, only the reuslts for pumping are included in this report. In actual practice both forms of control (that is, pumping and a gravity flow devise, such as a weir or siphon) would be installed to accommodate the differences in the relative water surface elevations which will occur across the dike during the life of the project.

Farmington Bay. Figure 2 shows time traces for average year salinity values within the bay at exceedence probabilities of 50 percent (median values) and for control elevations of 4200.5 feet and 4205.0 feet msl. In each case, the assumed discharge pumping capacity is 1000 cfs. For both traces, exports from the Jordan River through the Goggin Drain occurred when the surface level of the impounded waters exceeded the control elevation, provided, of course, the river flow rate exceeded 500 cfs. There were no imports of water from the Weber River for either of the two cases illustrated.

Because a greater degree of flushing occurs for the low control elevation (4200.5 feet) than for the high control elevation of 4205 feet, freshening is more rapid for the low control than for the high control. In both cases flushing of the salt accumulations within the bottom sediments occurs during the first two or three years of the project operation. For the low control case, the significant dip in the curve between the water years 1990 and 2000 results from higher than average water supply years during the initial stages of the project. This situation reflects the effects on the model results of the high initial conditions represented by those projected for October 1, 1985. As might be expected, the equilibrium or long-term position for the low control trace is somewhat less than that of the high control trace, but the difference between the two is not significant. For each case, the average equilibrium salinity of the bay is estimated to be approximately 5600 mg/l. At this level of salinity, the waters would not be suitable for agricultural, municipal, or most industrial purposes but likely could be used for recreation, such as boating and swimming.

East Bay. Figure 3 shows for the East Bay impoundment the same time traces as Figure 2, namely, average end of water year salinity values within the bay at exceedence probabilities of 50 percent (median values) and for control elevations of 4200.5 feet and 4205.0 feet msl. The pumping capacity for discharge from the bay to the main lake was taken as being 8000 cfs. Exports through the Goggin Drain are assumed to be constrained in the same manner as those for Farmington Bay. Again, because of the increased flushing, the trace for the low control elevation shows consistently lower salinity levels than that for the high control elevation. Because of the large inflow volumes from



Legend
+ Control elevation = 4200.5 feet amsl
x Control elevation = 4205.0 feet amsl

Notes

1) Pump capacity for discharge to the main lake = 1000 cfs.

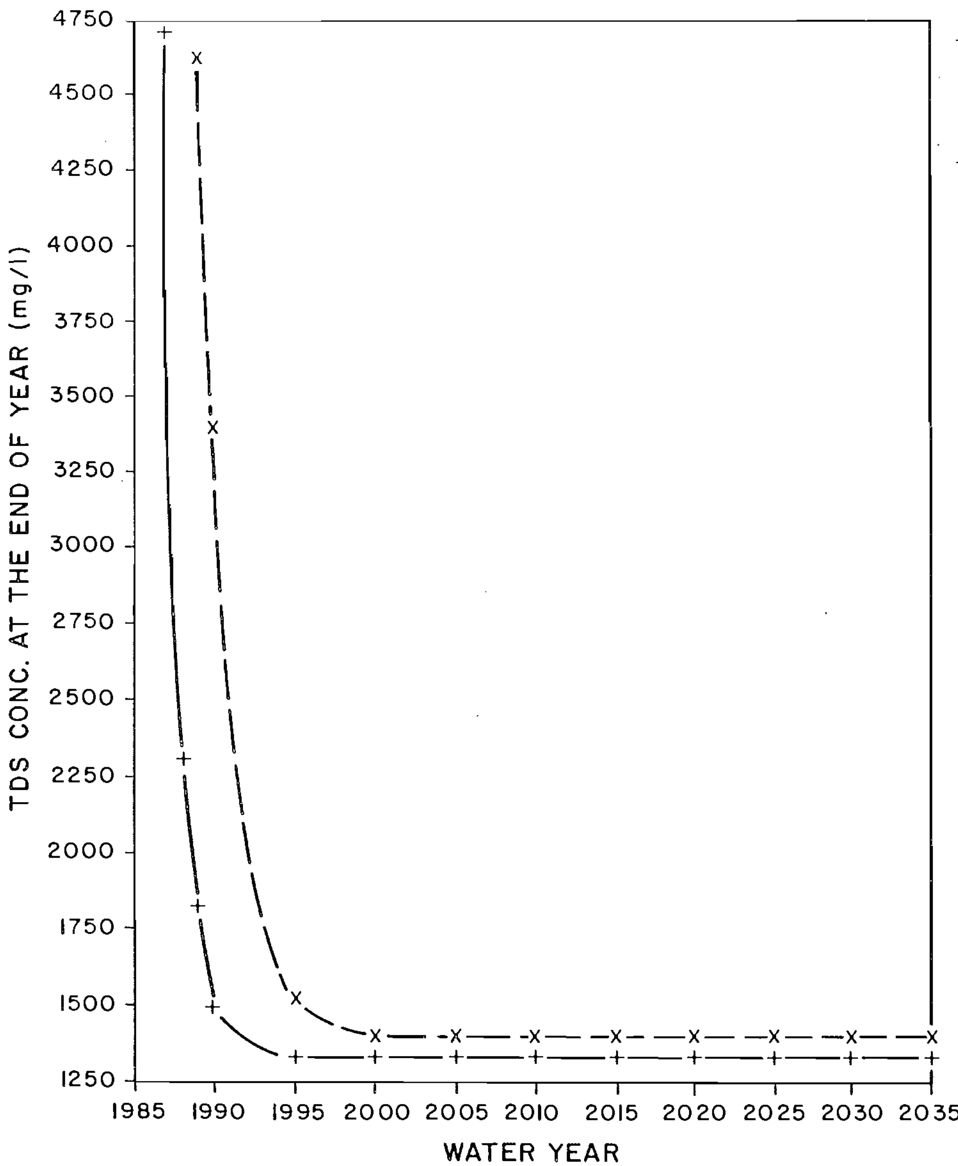
2) Minimum discharge rate from the Jordan River to Farmington Bay as limited by water rights requirements = 500 cfs.

3) Capacity of the Goggin Drain = 1000 cfs.

4) Exports from the Jordan River through the Goggin Drain occur when the impounded water surface level exceeds the control elevation. Export rates are limited by the constraints of items (2) and (3).

5) No imports from the Weber River are assumed to occur.

Figure 2. Projected most likely end of water year salinity concentrations in Farmington Bay.



Legend

+ Control elevation = 4200.5 feet amsl
x Control elevation = 4205.0 feet amsl

Notes

1) Pump capacity for discharge to the main lake = 8000 cfs.

2) Minimum discharge rate from the Jordan River to Farmington Bay as limited by water rights requirements = 500 cfs.

3) Capacity of the Goggin Drain = 1000 cfs.

4) Exports from the Jordan River through the Goggin Drain occur when the impounded water surface level exceeds the control elevation. Export rates are limited by the constraints of items (2) and (3).

Figure 3. Projected most likely end of water year salinity concentrations in the East Bay.

the Bear, Weber, and Jordan Rivers, flushing occurs rapidly in both cases, so that there is no sign of the dip which occurred in the low control level trace for Farmington Bay (Figure 3). The long-term or equilibrium salinity value for the low control level is about 1350 mg/l and for the high control the value is approximately 1400 mg/l. While these values are suitable for waters used for recreation and irrigation, they are too high for municipal and many industrial uses without costly treatment.

Other water quality considerations

Recent analyses by Davis County Health Department personnel indicate that concentrations of bacterial indicators of fecal pollution in Farmington Bay are low and little public health risk exists from fecal pollution. There is no apparent reason to anticipate that this condition will worsen as the impoundment freshens. However, some evidence of contamination of sediments of Farmington Bay by fecal bacteria has been found (Vander Meide and Nicholes 1972), and evaluation should be made of the potential for pathogen release from sediments under freshwater conditions in the impoundments.

Sediments in the southern most portion of Farmington Bay may also be polluted with toxic substances from municipal and industrial discharges to the Jordan River and/or the Salt Lake Sewage Canal. Analysis of two sediment cores from Farmington Bay shows evidence of increased fresh-water-soluble heavy metal accumulation near the Sewage Canal entrance to the Bay. Soluble copper concentration was enriched up to 40 fold and lead concentrations up to 12 fold. More information is needed on the potential for release of toxic metals and organics from these sediments before fresh water recreational use of Farmington Bay is permitted.

Since Great Salt Lake is the final repository for dissolved substances transported in streams from a large watershed, it receives substantial amounts of plant nutrients from natural, agricultural, municipal, and industrial sources. Farmington Bay and East Bay are shallow water bodies and tend to have summertime temperatures as warm as 90^{o}F (32^{o}C). Abundant nutrients and warm temperatures encourage dense algal growth that color the water green, often results in odor problems and may cause skin irritation in swimmers. Eutrophic, algae laden waters of lakes and reservoirs are aesthecally undesirable. In the summer of 1976, a year when the waters of Farmington Bay were being freshened by the flushing action of high stream flows, dense algal growth developed in the Bay. Areas of especially high algae concentration were recorded as "land masses" by NASA Landsat satellite imagry (Figure 4). Currently, large populations of algae develop in the relatively low salinity waters of Farmington Bay and throughout the southern Great Salt Lake. Samples collected May 22, 1985 in Farmington Bay had algal populations approaching eutrophic conditions. It is anticipated that these populations will increase many fold as water temperatures increase through the summer.

As impoundment waters freshen and the inhibition of algal growth imposed by salinity decreases, eutrophic conditions are likely to

Figure 4. Landsat satellite image of Farmington Bay in the summer of 1976 showing high concentration of algae as white amorphous areas in the Bay. (Courtesy of Paul Sturm, Utah Geological and Mineral Survey).

continue. Based on estimated phosphorus loads, water depths, and flow-through rates, an empirical model of eutrophication potential (Jones and Lee 1982) predicts algal chlorophyll a concentrations 3 to 10 fold higher than those defined as boarderline eutrophic for the proposed impoundment. Laboratory studies indicate that initially, sediments of Farmington and East Bays immobilize nutrients, including phosphorus, when placed under freshwater. However, the rates of nutrient immobilization decreased over the period of the experiment, and some evidence of nutrient release was observed after about 30 days incubation.

Odor production from Farmington and East Bay sediments did not appear to be greatly affected by exposure to fresh water (Logan River water) as opposed to Great Salt Lake water. An exception may be the more recently inundated marsh sediments such as those near the Ogden Bay waterfowl management area. Anaerobic sediments high in organic matter tend to release more hydrogen sulfide gas and other odorous compounds to the overlying water. Wind and wave actions then transfer the odors from the water into the atmosphere. Apparently, not all Farmington and East Bay sediments are major contributors to odor production, and not all sediments respond to decreasing salinity in the same way (Israelsen et al. 1985).

Appreciable odors are associated with dense populations of blue-green algae growing in Farmington Bay water (Israelsen et al. 1985) and may contribute significantly to odor problems. Relatively low intensity odors were found in Farmington Bay water collected on May 22, 1985, with the strongest odor being in waters in a shallow area near inundated marshes.

A resident of the towns of Buttlerville and Sandy from the years of 1894 through 1915 recalls annoying, "sulfury" odors from Great Salt Lake (Eva Israelsen, personal communication, N. Logan, Utah 1985). Those years encompassed a period of rapid rise in Great Salt Lake from about 4197 to 4203 ft. amsl. Exposed sediments would have been inundated and high river flows would have decreased the salinity in Farmington Bay.

These observations suggest that odor problems associated with Farmington Bay and Great Salt Lake will continue as the proposed impoundments are freshened. Increased anaerobic decomposition in sediments and dense algal production would be major sources of this odor.

Summary

Farmington Bay

Based on the results of the studies reported herein, it appears that Farmington Bay cannot be turned into a freshwater lake by merely stopping the flow of brines from the Great Salt Lake into the bay. The effect of natural concentration, due to evaporation from the normally large surface area of the bay, is sufficient to keep the bay at salinity levels generally not considered suitable for freshwater use. For the management alternatives examined, it was found that the bay could be freshened to salinity levels approaching that normally considered suitable for freshwater recreation only by importing very large quantities of fresh water from the Weber River system. However, even under this management scenario the simulated equilibrium salinity level of the bay exceeded 3000 mg/l, which is too high for most agricultural, municipal, and industrial uses.

As a cautionary note, attempts to lower the salinity concentrations of Farmington Bay could have some adverse impacts. For more than a hundred years Farmington Bay has been the eventual repository of wastes from several population centers along the Jordan River and other communities adjacent to the bay, and natural inputs of nutrients and organic matter has occurred over geologic time. The high salinity levels of Farmington Bay have greatly inhibited the adverse effects normally resulting from high nutrient loadings in a body of water. If the salinity of the bay is lowered to levels that do not inhibit biological activity, consequences might be dramatic. Thus, an alternative management option which might be considered for Farmington Bay is to attempt to maintain high salinity levels within the impoundment (in excess of 100,000 mg/l) so as to inhibit biological activity.

East Bay

Because of the large volumes of freshwater inflows from the three major surface tributaries of the Great Salt Lake, equilibrium salinity levels in the East Bay impoundment are less than those of the Farmington Bay. However, even for the East Bay the equilibrium salinity levels of 1200 to 1500 mg/l, while suitable for recreation and most irrigation, exceed acceptable limits for municipal and many industrial uses.

By way of comparison, average year-end salinity values for the existing Willard Bay Reservoir are in the neighborhood of 500 mg/l. This value is consistent with the average volume-weighted quality of the waters which enter the Willard Bay impoundment from the Weber River of about 250 mg/l. The Weber River water salinity is the lowest of the three major tributaries. This study indicates that non-selective mixing of the three streams, coupled with the concentrating effects of evaporation losses, results in water salinity levels which normally are too high for municipal and industrial purposes.

Conclusions

The principal conclusions of the study from the point of view of water salinity are summarized by the Table 1. With respect to organic decomposition activity and the associated odor production, numerous problems would result from freshening the waters along the east shore of the Great Salt Lake, particularly in the Farmington Bay area. If this management option were pursued, as opposed to maintaining high salinity levels, many additional water quality studies would be needed in order to identify the problems and their possible solutions.

Table 1. Summary of equilibrium salinity levels for Farmington and East Bays.

Impoundment	Most Likely Equilibrium Salinity (mg/l)	Acceptable for Agric.	Fresh Water Rec.	Muni.	Ind.
Farmington Bay					
- No imports	5500	No	Marginal	No	No
- Imports from Weber River	3500	No	Yes	No	No
East Bay	1400	Marginal	Yes	No	No

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