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Great Salt Lake Interisland Diking: Water Quality Considerations, Executive Summary

Utah Water Research Laboratory

J. P. Riley

J. I. Blandamer

W. J. Doucette

R. R. Dupont

A. W. Grover

See next page for additional authors

Authors
Utah Water Research Laboratory, J. P. Riley, J. I. Blandamer, W. J. Doucette, R. R. Dupont, A. W. Grover, J. Herrick, J. M. Ihnat, J. E. McLean, M. W. Nath, S. R. Rushforth, J. L. Sims, R. C. Sims, and W. A. Wurtsbaugh

EXECUTIVE SUMMARY

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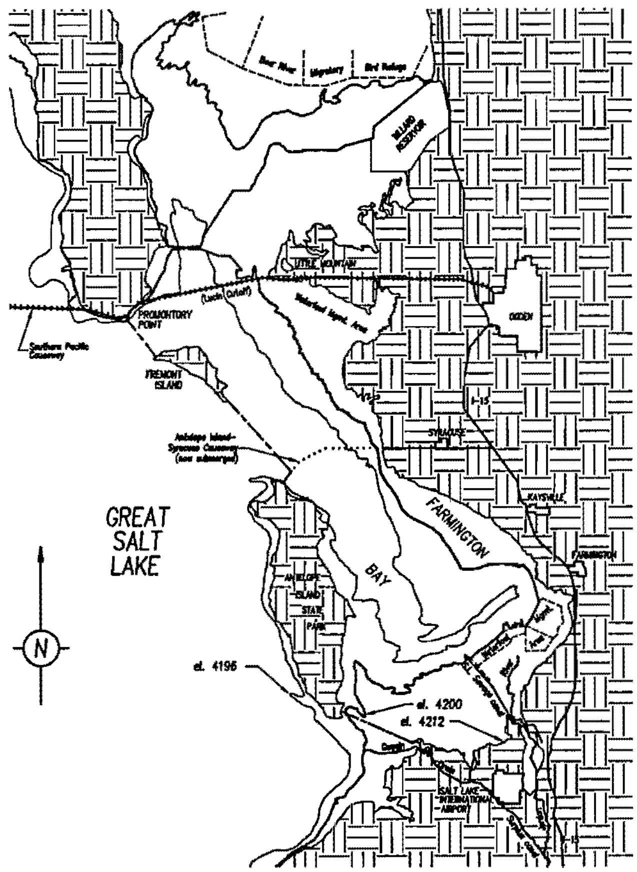

for the

Utah Department of Natural Resources
Division of Water Resources
Salt Lake City, Utah

Utah Water Research Laboratory
Utah State University
Logan, Utah

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CONCLUSIONS

Sediment pollution

1. Lead, cadmium, mercury, arsenic, and chromium concentrations in the sediments at various sites in the East Bay of Great Salt Lake were much higher than "natural" concentrations.

2. Total metal concentrations decrease with depth, suggesting that the pollution is relatively recent.

3. Water soluble metals concentrations were low in all samples, and below detection limits in most samples.

4. Methylmercury (a mercury form that is highly prone to accumulation and concentration in organisms) is apparently not formed in mercury contaminated sediments under oxygen depleted, freshwater conditions. Other mechanisms for release of metals from the sediment and biological uptake need to be investigated.

5. Metals were found to occur together with oil and grease in the sewage canal outlet area, suggesting a common source for these pollutants.

6. The high oil and grease content of some low-lying sediments in the vicinity of the sewage canal suggests that the pollution is from the petroleum industry.

7. Very low concentrations of polynuclear aromatic hydrocarbon compounds, which are known to cause cancer, were found in the sediment samples.

8. Some chlorinated organic compounds and industrial solvents were also found in very low concentrations, but no evidence of pesticide contamination was found.

9. Very low or undetectable concentrations of fecal indicator bacteria were found in sediment samples, and intestinal virus analyses failed to recover infectious virus from any sediment samples.

Health hazards

10. Extremely low water solubility of toxic heavy metals and organic compounds precludes a serious health hazard by direct ingestion of the water overlying the polluted sediments.

11. Biological accumulation and/or concentration of metals or toxic organics through the food chain could be a potential health hazard to persons consuming fish or other aquatic animals, and should be investigated further.

12. The low levels of fecal indicator bacteria and viruses indicate that the sediments present little or no hazard from intestinal disease.

Algae production potential

13. High phosphorus inputs, combined with a long hydraulic residence time, and shallow depth are likely to result in high production of algae in the proposed reservoir.

14. Algae populations developing in the reservoir are likely to be dominated by odor causing blue-green algae.

Wastewater treatment plant costs

15. To protect aquatic life, wastewater treatment plants discharging to the proposed East Bay Reservoir would require approximately $38,436,000 for construction and $17,819,000 (present value) for 20 years of operation and maintenance of ammonia removal and dechlorination processes.

Water salinity

16. Model studies indicate that during high flow periods, salinity levels could fall as low as 500 milligrams per liter, but average values can be expected to be in the range of 1,000 to 1,500 milligrams per liter.

17. Salinity in this range is acceptable for recreational use, is marginally acceptable for irrigation and many industrial uses, but cannot be recommended for municipal water supplies. Utah's standards for salinity allow the use of water exceeding 1,000 milligrams per liter for municipal supply only upon specific approval of the Utah Safe Drinking Water Committee.

Mosquito production

18. The freshwater environment, with extensive areas of shallow water having a relatively stable elevation during the summer months, would be expected to provide good habitat for the production of mosquitoes.

GREAT SALT LAKE AND EAST BAY USES

Great Salt Lake (Figure 1) is a saline, terminal lake that receives water from the drainage of a large basin. It is fed principally by the Bear, Weber and Jordan Rivers. The lake has been used for minerals extraction, waterfowl management, recreation, and waste disposal. Most of the uses have been concentrated in the eastern bays of the lake. Diking proposals which would enclose an "East Bay Reservoir" of fresh water and allow increased usefulness of the water resources of the lake have been set forth since the 1930s. Dikes extending from the southern shore to Antelope Island, from there to Fremont Island, and then to Promontory Point would enclose the reservoir (Figure 2). The rapid rise of the lake since 1982 and the ensuing damage to public works and private property have resulted in a renewed interest in diking the East Bay to control shoreline elevations on the eastern and part of the southern side of the lake. The fresh water reservoir thus created could possibly be used for boating, swimming, fishing, irrigation, and municipal and industrial water supply. Controlled water elevations may allow optimization of conditions for waterfowl sanctuaries. Roads built on the dikes would allow access to Antelope Island State Park, and may provide an additional north-south transportation route bypassing Salt Lake City.

ENVIRONMENTAL HEALTH CONCERNS

The history of wastewater disposal into Farmington Bay has raised questions about risks to the health of persons using the bay for recreational purposes. Warnings of infectious agents, and evidence of toxic materials in the sediments have been cause for concern. Industrial wastes and petroleum spills have also found their way into Farmington Bay. Organic materials and heavy metals from these sources may be toxic. Some organics may cause cancer.

SALINITY AND POTENTIAL WATER USES

An earlier study applied a computer simulation model to investigate the salinity reductions in the water comprising the East Bay impoundment and a Farmington Bay impoundment. Based on projected salinity, the water's potential for recreation, irrigation, industrial, and municipal use was assessed. It was concluded that East Bay salinity would be in the range of 1,000 to 1,500 mg/L; only marginally acceptable for most uses. The effects on salinity of modified reservoir construction and operation plans on expected salinity have been evaluated in the current study.

ALGAE PRODUCTION CONCERNS

Algal laden waters are generally perceived to be less attractive for recreational use, especially when full body contact with the water is involved. Algal respiration during the night may consume sufficient oxygen from the water to threaten fish and other aquatic life. Some algae are known to produce toxins. The production of algae in the proposed impoundment may be similar to that currently occurring in the bays, hence the algae production of the proposed impoundments was evaluated as part of the current study.

RESEARCH OBJECTIVES

Specific objectives of the current study address the concerns outlined above, and are as follows: (1) Determine the extent of sediment pollution with toxic chemicals and intestinal pathogens in the East Bay with emphasis on the southern portion of Farmington Bay. (2)

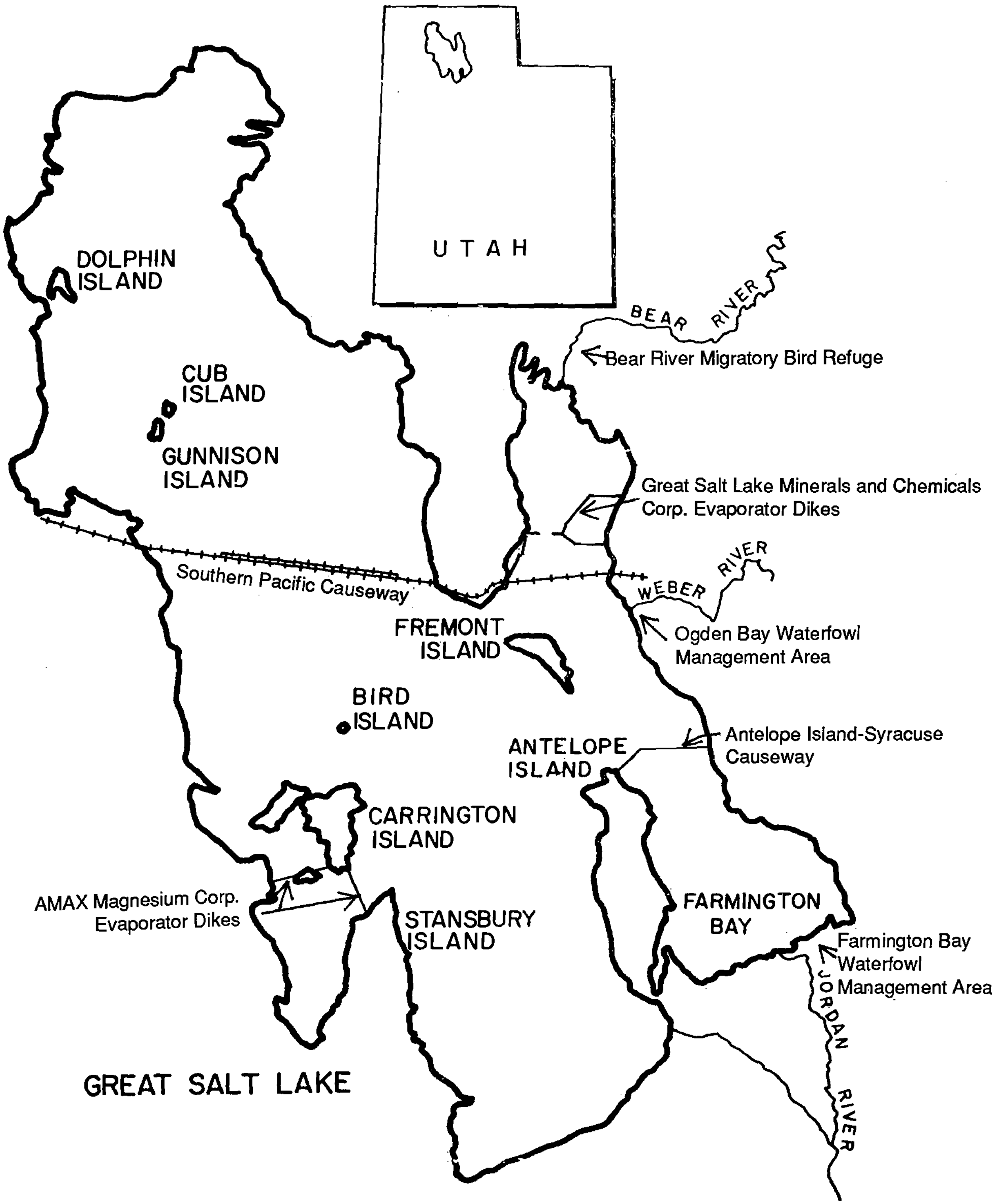


Figure 1. Map of Great Salt Lake.

Estimate the hazard to human health associated with toxic chemicals and pathogens in the sediments by evaluating routes and probability of exposure. (3) Describe the algal production of the East Bay and estimate the production likely to develop in the proposed impoundment. (4) Estimate the salinity of the impounded water and evaluate its potential for beneficial use. (5) Evaluate the brinefly and mosquito production potential of the fresh water environment created by the impoundment.

RESEARCH APPROACH

Sediment samples were collected at locations thought to be affected by the Jordan, Weber, and Bear Rivers, the Goggin Drain, the Salt Lake City Sewage Canal, the North Davis and Central Davis wastewater treatment plant effluents, and the C-7 Canal that passes through the Kennecott Copper smelter area (Figure 2). Sediment samples were analyzed for oil and grease, arsenic cadmium, chromium, copper, lead, mercury, nickel, zinc, fecal indicator bacteria, and intestinal viruses. Selected sediment cores were analyzed for radium-226 as a tracer for radioactive products from the uranium processing industry.

To study the water chemistry and algal productivity of the east bay, 34 sampling stations were established along three lines. The longest sampling line extended from the sewage canal over the length of the bay to the Southern Pacific Transportation Company causeway. Two shorter lines extended northwesterly and northeasterly through Farmington Bay and joined the long sampling line near the sewage canal. Samples were collected, at first, twice monthly and then approximately monthly from July 25, 1986, to December 22, 1986. Temperature, dissolved oxygen, pH, oxidation/reduction potential, light penetration, total dissolved solids, nitrate and ammonium nitrogen, total and orthophosphorus, and chlorophyll *a* were measured. The kinds (species or groups) of algae in the water samples were identified and counted.

A hydro-salinity model which calculated a mass balance of salt and water was used to predict East Bay impoundment salinity concentrations under designated operating criteria and two basic hydrologic scenarios. Water inflows came from surface streams, precipitation, and groundwater. Outflows were principally through evaporation or pumping to the main lake.

FINDINGS

Sediment organic contamination

Sediment sample oil and grease concentrations ranged from 40 to 332,000 milligrams per kilogram. Higher concentrations of oil and grease were typically found in the sewage canal area. The high oil and grease content observed in the sediments suggested contamination from petroleum sources. Therefore emphasis was placed on searching for organic compounds of environmental health concern that are typically associated with petroleum wastes, in particular polynuclear aromatic (PNA) compounds, some of which cause cancer. PNA compounds were found most frequently in samples taken in the sewage canal area. Concentrations of PNAs were so low (less than 0.2 parts per billion) that there is probably no public health risk.

Many miscellaneous hydrocarbon compounds typical of petroleum were identified along with some chlorinated compounds and industrial solvents. No evidence of pesticide pollution was found.

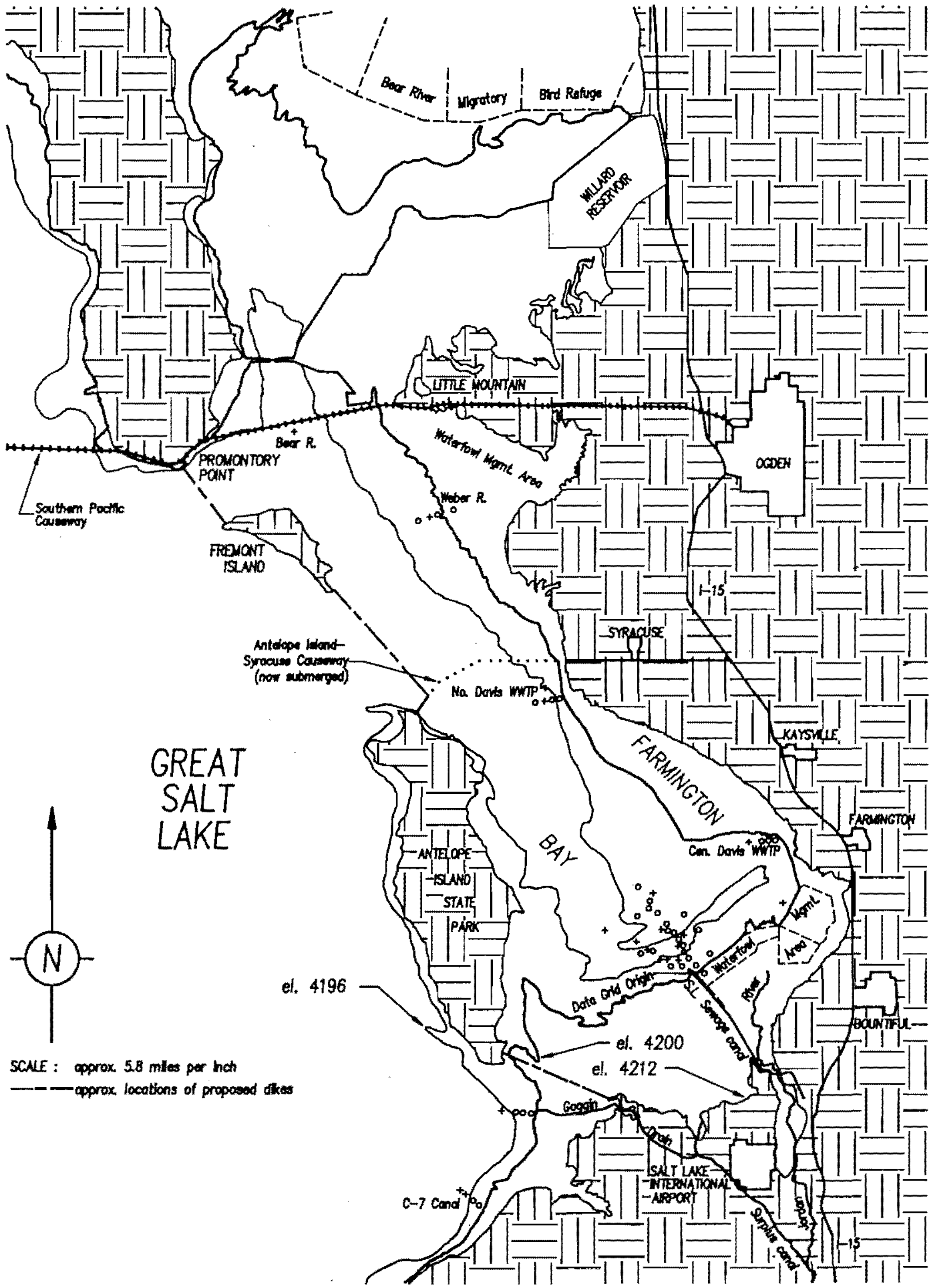


Figure 2. Sediment sampling locations in the East Bay. Surface grab sample locations (o), and core locations (+) are shown.

Sediment metals contamination

Sediments near the sewage canal were contaminated with heavy metals as well as oil and grease. Maximum concentrations of all of the metals in samples from the sewage canal area are typical of contaminated sediments elsewhere in the United States. Areas near the sewage canal that have about the same concentration of lead and cadmium are plotted in Figures 3A and 3B. Apparently, more than 3 square miles of sediment in this area contain more than four times the average background concentration of lead. Statistical analysis indicates that lead, cadmium, nickel, zinc, copper, chromium, mercury and oil and grease tend to occur together, suggesting that they may have had a common source. The relationship to oil and grease implies that the source may have been petroleum refining waste.

One sample taken near the North Davis wastewater treatment plant contained 298 milligrams of cadmium per kilogram of sediment, more than 100 times the estimated background concentration. Chromium and oil and grease were also relatively high.

Lead and mercury concentrations were relatively high in sediment samples taken near the Ogden Bay waterfowl management area. Mercury and arsenic were high (3.13 and 60.4 milligrams per kilogram, respectively) in one sample taken near the C-7 Canal. One sample taken near the Goggin Drain contained 3.3 milligrams of mercury per kilogram.

Health risks from polluted sediments

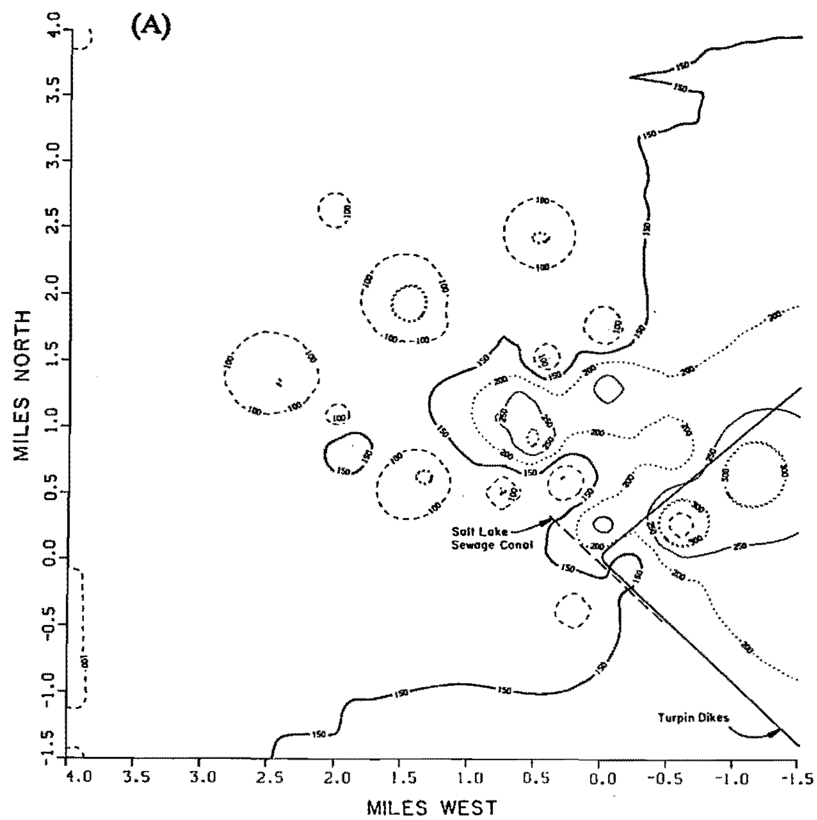
Generally, the heavy metals in the sediments samples were not soluble in either salt or fresh water. The toxic organic compounds identified are not water soluble either. If polluted sediments become suspended in the water, it is possible that suspended toxic metals would exceed concentration limits currently specified for drinking water supplies. If water containing suspended polluted sediment were withdrawn from the proposed reservoir for municipal water supply, the sediment and the associated toxics would be removed in the water treatment process. Little or no hazard to health currently exists since the water is not used for drinking water supply, and the frequency of swimming in the known contaminated sediment areas is nil.

Even if the toxics do not dissolve in water, organisms growing in or on the sediments may accumulate them. This is especially true if the toxics are in a form that is soluble in fat. Methylmercury, for example, can become highly concentrated in fish. Methylmercury concentrations in samples of mercury contaminated sediments near the sewage canal were nil, and no evidence was found for methylmercury formation in these sediments when they were deprived of oxygen and incubated under freshwater for 50 days. It is important that the potential for biological accumulation of other metals from the polluted sediments be evaluated and taken into account in the reservoir development planning process. Fish will almost certainly become established in the proposed freshwater reservoir and the potential is high for these fish to be used for food by people.

The low concentrations of fecal indicator bacteria and infectious viruses indicated that there is little hazard to health from pathogens in the sediments.

Salinity predictions

A water-salinity model was used to calculate East Bay Reservoir salinity using two sets water inflow data. The first ("high lake") used actual inflow data for 1981 to 1987, a



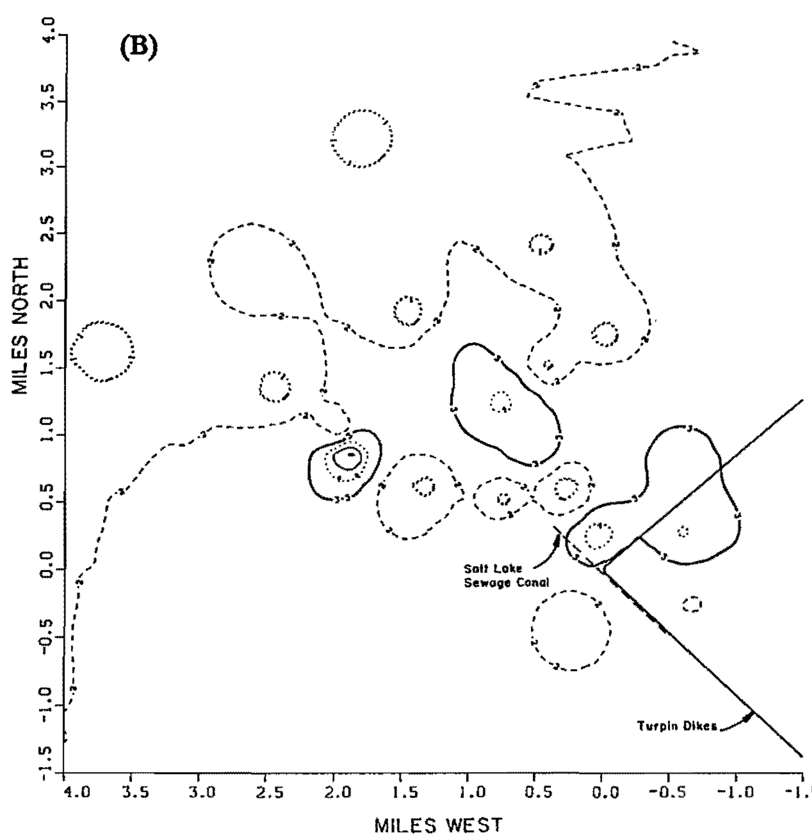


Figure 3. Areas of similar concentrations of lead (A) and cadmium (B) in the sediments near the Salt Lake City Sewage Canal.

period of far above average inflow, and flow was continued at about this same rate through the year 2000. Flows then were returned to "average." The second data set ("low lake") also used actual inflow data for 1981 to 1987, but then returned to "average" flows. The model calculated a monthly mass balance of water and salts in the reservoir for a period of 30 years. Water elevations within the reservoir were regulated below 4,208 feet above sea level, as far as possible, by pumping to Great Salt Lake with a 6,000 or an 8,000 cubic feet per second pumping station. The larger pumping capacity met this elevation requirement best.

With the high pumping capacity and using the "high lake" inflow data, reservoir salinity fell rapidly to 500 to 600 milligrams per liter. When stream flows and precipitation dropped to a "average" level, salinities rose to about 1,200 milligrams per liter. Under the "low lake" conditions, salinities rose as high as 1,800 milligrams per liter.

These salinities may be low enough to meet the quality requirement for recreational, agricultural, and industrial uses. However, Utah's standards for drinking water salinity allow the municipal use of water sources exceeding 1,000 milligrams per liter only upon specific approval of the Utah Safe Drinking Water Committee. Desalination or blending with higher quality water may be required to allow municipal use.

Algae production potential

High concentrations of algae are currently produced in the East Bay area. In the southern portion of Farmington Bay, concentrations of the plant pigment chlorophyll *a* were as high as 167 micrograms per liter. Most limnologists consider chlorophyll *a* concentrations in excess of 10 micrograms per liter to indicate a nutrient rich, highly productive (eutrophic) condition. The mass of algae produced in the water was dominated by the blue-green alga *Nodularia spumigena* Mertens.

Laboratory simulations (microcosms) of the water quality that is anticipated for the proposed reservoir produced another blue-green alga, *Anabaena spiroides* var. *crassa*. This organism often blooms in Utah Lake. Blue-green algae are frequently the cause of taste and odor problems in lakes and reservoirs. Odor produced in the microcosm water was evaluated by a panel of odor judges, and was found to be quite intense in some samples. Fifty percent of the judges were able to detect odor in a 1-to-250 dilution of one sample.

Phosphorus will limit the production of algae in the proposed reservoir. A phosphorus loading model, based on observations from approximately 70 lakes and reservoirs, indicated that the reservoir is likely to produce high concentrations of algae similar to those observed in the East Bay in the summer and fall of 1986.

Costs for wastewater treatment plant upgrades

To protect fish and other freshwater aquatic life from the toxic effects of ammonia and chlorine, wastewater treatment plants that discharge to the East Bay or to streams in close proximity to the bay will probably be required to discharge water that is low in ammonia, and that has been dechlorinated. The costs of upgrading the Salt Lake City, North Davis, South Davis North, South Davis South, Central Davis and Far West/Plains City treatment plants to meet this requirement was estimated. Construction capital costs for all of the plants were estimated at $39,310,000. The estimated value of 20 years of operation and maintenance of these new processes was $17,819,000. These costs should be considered in the planning of the proposed reservoir.

Mosquito and brinefly production

If the East Bay Reservoir were maintained at an elevation between 4204 and 4208 feet above sea level, 10,000 to 25,000 acres may be covered with water less than one foot deep, where grasses and other vegetation may become established, providing an excellent habitat for mosquito production. Relatively constant water elevations, for 10 to 14 days during the summer, could lead to the production of the western equine encephalitis disease carrying mosquito *Culex tarsalis* in large numbers. Mosquito control efforts over this large area would add to the financial burden of mosquito abatement agencies.

In the past, brinefly populations have been a deterrent to recreational use of the shores of Great Salt Lake. Because brineflies do not tolerate freshwater, populations of these nuisance insects would probably decrease substantially.