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Ecological Research Series

Silt Removal From A Lake Bottom

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EPA-660/3-74-017
February 1975

SILT REMOVAL FROM A LAKE BOTTOM

by

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Research Grant No. 16010 ELF
Program Element 1BA031

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PREFACE

The Lake Herman Development wishes to express appreciation to the following for their assistance with the project.

1. City of Sioux Falls, South Dakota for leasing the dredge for the project.

2. Kenneth Vaughn, engineer for the Sioux Falls Water Treatment Plant, for assistance with clean-up of the dredge after its enundation, and for remodeling the electric motors on the dredge.

3. South Dakota National Guard, 153rd Engineering Battalion, Company B, for the loan of their equipment such as tractors, low-boys, bulldozers, trucks, for moving the dredge, building dikes, and assisting on many occasions with the operation of the dredge. A special thanks to Sgt. Stewart Bradbury who oversaw much of the guard work and who also operated much of the heavy machinery used in the project.

4. George Hilde who loaned and operated his crane for unloading the dredge after its move from Sioux Falls.

5. East River Electric Power Cooperative for the loan of its cranes on two occasions to help with the project.

6. Lake County Board of Commissioners for allocating $5,000 per year toward financing the project.

7. South Dakota Game, Fish and Parks Department for supplying fuels and lubricants for the dredge.

8. Dakota State College scientists for assisting with the research for the project.

9. Office of Economic Opportunity for Supplying a number of positions to assist with the operation of the dredge.

10. Hall Equipment Company, Sioux Falls, for supplying a bulldozer to build a loading ramp and to assist with loading the dredge for its move to Lake Herman.

11. Dr. Clyde K. Brashier and Dr. Connie Churchill of Dakota State College for assisting with the chemical analyses and for supplying data from other lake research projects.

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SECTION I

INTRODUCTION

Lake Herman is a recreational lake in southeastern South Dakota (Figure 1). It is used mainly for boating, fishing, water skiing, and swimming, and is adjacent to Lake Herman State Park, the second-most frequently visited park in South Dakota. Visitations to the park in 1971 numbered approximately 340,000 people, an important factor in the summer economy of the area. There are relatively few residences on the lake, with only about 3,000 m (10,000 ft) of the approximately 13 kilometers (8 miles) of shoreline extensively developed with cabins and resorts. Approximately 4877 m (16,000 ft) of the shoreline is included in Lake Herman State Park, a 4-H Club Camp, and Isaac Walton League Conservation area. The South Dakota Game, Fish and Parks Department, in addition to maintaining the State Park, annually stocks the lake with game fish such as Northern pike, walleye pike, bluegills and bass.

This warm water prairie lake was formed by glacial action. It has a surface area of 546 hectares (1350 A.), and a meandering area of 536 hectares (1325.6 A.). The watershed is approximately 145 square kilometers (56 square miles) and is composed mainly of glacial till. The watershed (Figure 2) contains numerous sloughs and potholes, many of which were drained to increase available farmland. The area is extensively farmed and grazed, but much of it lacks modern conservation practices of terracing and contour plowing. As a result of erosion of the watershed, an average of 2 m (6.5 ft) of silt has been deposited in Lake Herman. Maximum depth of silt is 3 m (9.7 ft) whereas the water in the lake has a maximum of 2.4 m (8.0 ft), and an average depth of 1.7 m (5.5 ft) (Figure 3). The runoff from the watershed feeds four interconnected lakes; Lake Herman, the first in the series, acts as a silt trap for the others (Figure 4).

The nutrient components of the lake show high levels of nitrogen and phosphorus. According to Brashier et al. (Brashier, C.K., C.L. Churchill, and G. Leidahl, Effect of Silt and Silt Removal in a Prairie Lake, Environmental Protection Agency, Washington, D.C., Publication No. EPA-R3-73-037, July 1973. 200 p.), high values for ammonia have been 2.51 mg NH_3-N/l; nitrate, 1.32 mg NO_3-N/l; for

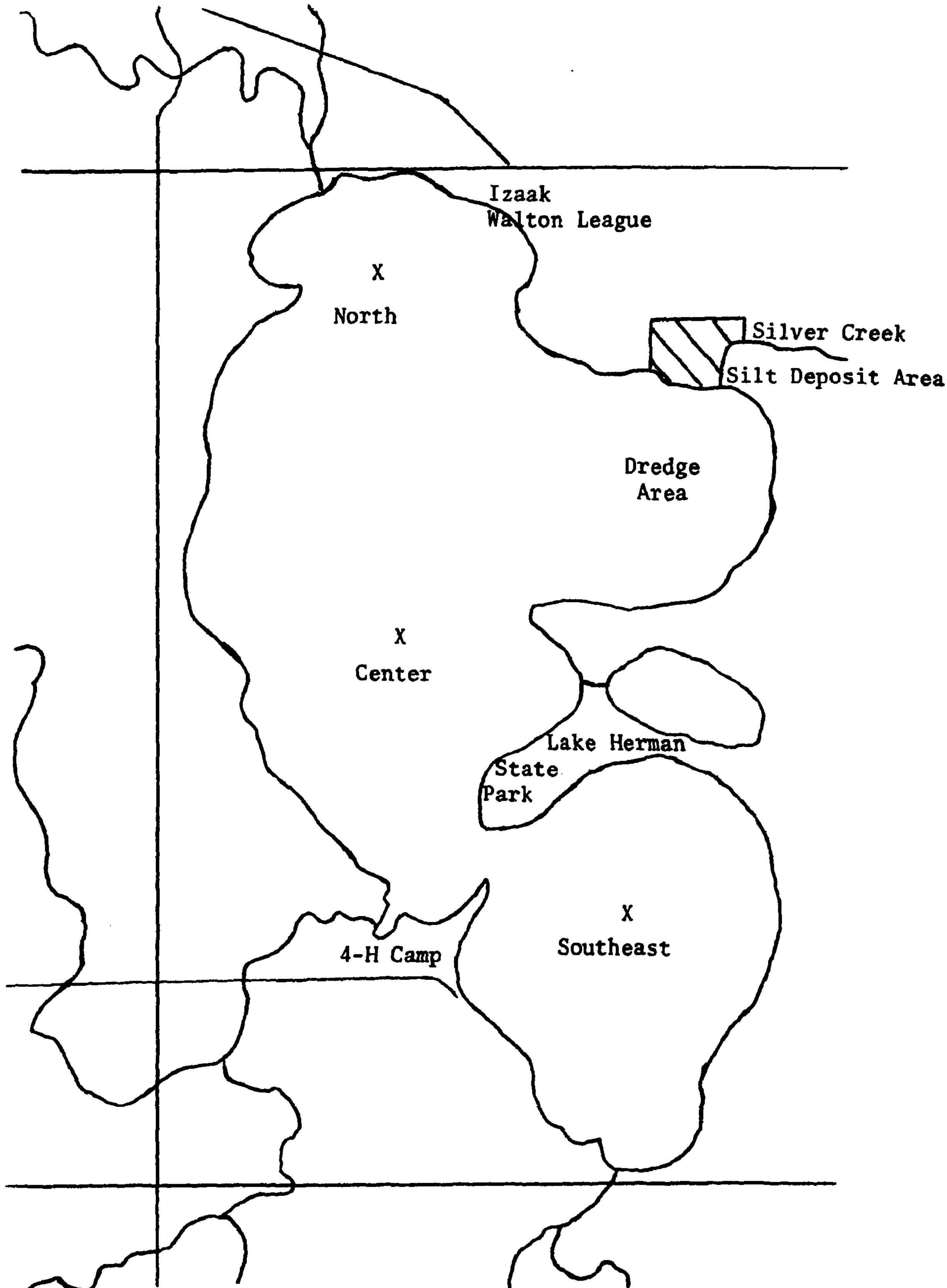

Figure 1. Map of Lake Herman

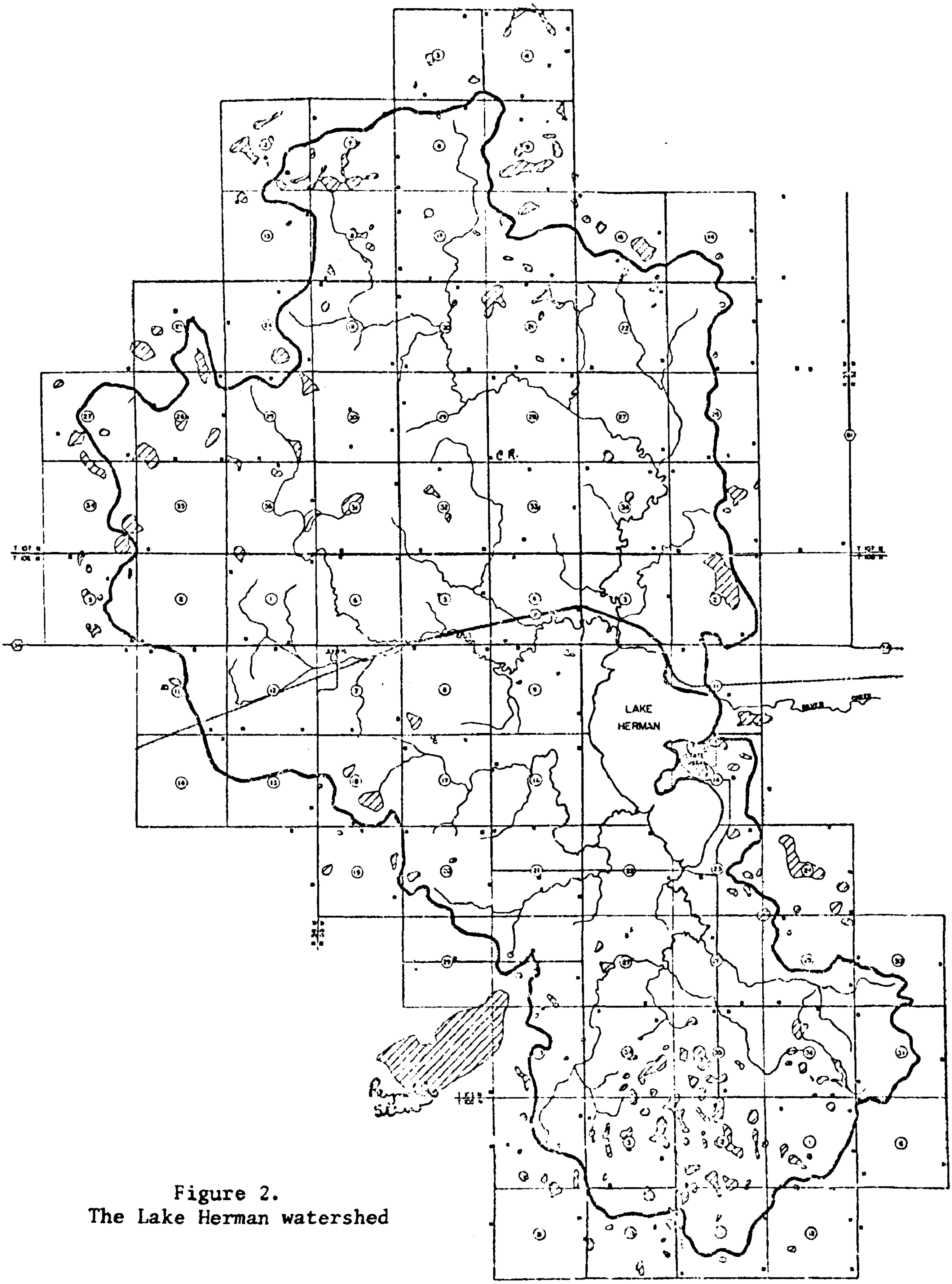

Figure 2.
The Lake Herman watershed

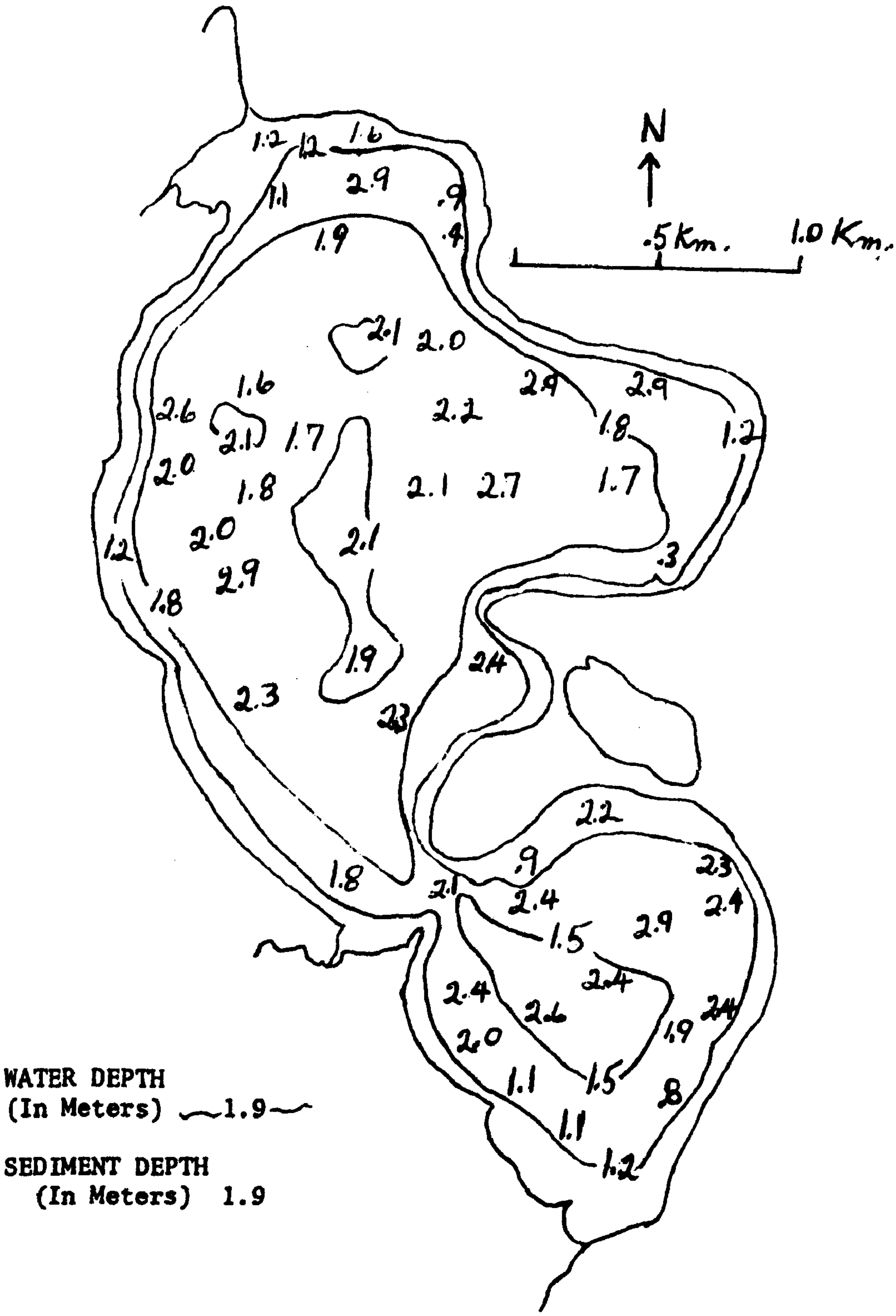

Figure 3. Water and sediment depths in Lake Herman
(South Dakota Dept. of Game Fish & Parks, January 1967)

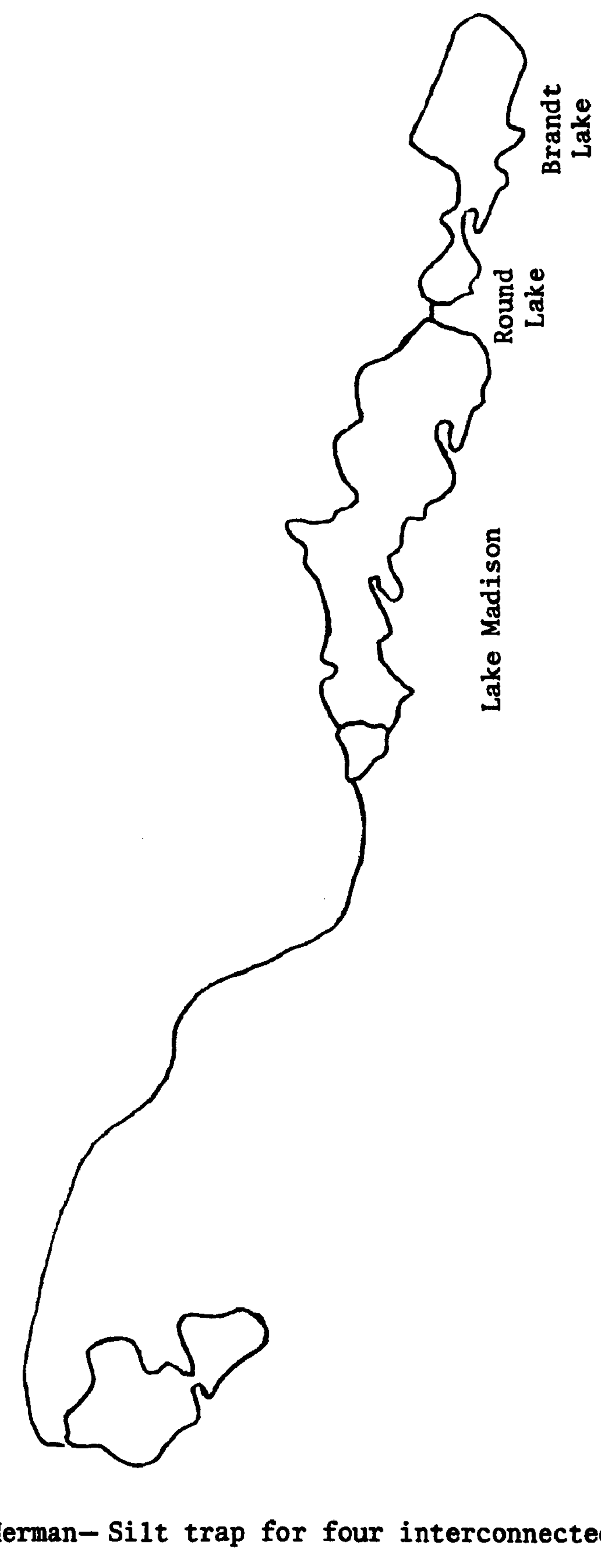

Figure 4. Lake Herman— Silt trap for four interconnected lakes

nitrite, 97.4 mg NO_2-N/ml. High values for orthophosphate have been 1.35 mg PO_4/l; for total phosphorus, 4.33 mg PO_4/l. During the development of very heavy algal blooms, nitrogen concentrations decline, in some cases to 0.0 mg NO_3-N/l, while at the same time total phosphorus and orthophosphate remain relatively high. The pH during the months of July to September is over 9.0, reaching a high of 10.17 in the first week of August, 1970. During the rest of the year, the pH is over 8.0 except for January and February when the pH averages 7.5.

The development of an algae bloom is a regular occurrence in Lake Herman. The predominant organism in the bloom is a blue-green alga, Microcystis aeruginosa. The bloom, developing by the first week in July, occurs when water temperature rises and when wave action is almost nil. The presence of gas vacuoles in the cells of Microcystis causes the plants to rise to the surface forming a 13 mm (0.5 in.) surface film which, upon exposure to sunlight, becomes bleached giving the appearance of vinyl plastic. The consistency of the bloom at its worst is that of latex paint.

Heavy fish kills occur approximately once every three years during the winter months. An ice cover, occurring by November 15 and developing to a depth of 56-71 cm (22-28 in.), is followed by an irregular snow depth varying from 0 to 61 cm (0-24 in.) on various parts of lake ice. Average snow cover is 15 cm (6 in.). As a result of the snow and ice cover, photosynthesis ceases, and the dissolved oxygen content sometimes falls to nearly 0.0 ppm by December or January. Total or near-total fish kills have been recorded by the South Dakota Game, Fish and Parks Department on an average of every third or fourth winter. In addition there have been summer fish kills, but not all were due to oxygen depletion. In July, 1971, for example, heavy kills of game fish were caused by the fish louse, Argulus spp.

Concern by lake residence owners and other interested citizens over the deterioration of the lake for recreational purposes led to the establishment of the Lake Herman Development Association, Inc. The activities of the Association included the development of fish-rearing ponds, the promotion of thoroughfare development, and the initiation of a feasibility study for the removal of sediments from the lake bottom. Members of the Association assisted the East Dakota Conservancy Sub-District personnel in writing the 1969 Lake Herman Report, an extensive compilation of available data concerning the lake and its watershed and a list of recommendations for lake improvement. These recommendations included improved land treatment measures in the Lake Herman watershed and the initiation of a dredging program.

SECTION II

SUMMARY

Dredging was used as a method to remove 47,860 m^3 (62,000 yd^3) of silt from Lake Herman during the summers of 1970, 1971, and 1972. The silt was transported via a pipeline to a silt deposit area adjacent to the northeast corner of the lake. The water removed by the dredging process drained by gravity along a gradual slope, dropping its silt and losing nutrients to the lush vegetation, and eventually returned to the lake.

In the bay area where dredging occurred water depth was increased from 1.7 m (5.5 ft) to approximately 3.4 m (11 ft). There was no significant change in the levels of organisms or nutrients, except for phosphorus, which increased just after the dredging began. Whether dredging actually caused the increase is still debatable. Vegetation in the deposit area became extremely lush. Water returning to the lake from the deposit area was lower in nutrients than the water in the lake.

This report was submitted in fulfillment of Research Grant Number 16010 ELF under partial sponsorship of the Office of Research and Development, Environmental Protection Agency.

SECTION III

CONCLUSIONS

1. Significant amounts of silt and nutrients can be removed from a lake by dredging.

2. Removal of silt from a limited area within the lake did not significantly change the dynamics of the lake.

3. Water mixed with the silt in the dredging operation was extremely high in nutrients, especially phosphates.

4. Water from the silt deposit area that was allowed to gradually return to the lake, after settling of its silt load and passage through vegetation, was less basic and less fertile than the lake water.

5. Recently deposited silt on the lake bottom was much more fertile than earlier deposits.

6. Holes dredged in the accumulated silt on the lake bottom will frequently partially refill because of wind and wave action.

7. An increase in vegetation occurred in the slurry deposit area after deposition was begun.

8. Greenhouse chrysanthemums grown in silt exhibited larger stems, leaves and flowers, but more poorly developed root systems than those grown in certain commercial greenhouse preparations.

9. Flowers on the plants grown in silt did not survive as long as those grown in the commercial preparations.

SECTION IV

RECOMMENDATIONS

1. Dredging operations on a lake should be carried on continuously—24 hours a day, seven days a week—during dredging seasons.

2. A project should be initiated to remove the upper 0.3 to 0.6 m (1 to 2 ft) of silt from Lake Herman. Since the upper 0.3 m (1 ft) of silt is much more fertile, removal of nutrients might be more significant in removal of 0.3 m from most of the lake bottom rather than 1.8 m (6 ft) from a small part of the lake.

3. A smaller lake should be dredged completely to determine the effects of complete silt removal on the dynamics of a lake.

4. Efficient conservation practices—contour plowing, terracing, grassed waterways, and no plowing within 15 to 20 m of streams or temporary streams that empty a watershed—should be established for the watersheds of all lakes that have significant recreational and economic value.

5. The responsibility for dredging operations should be assumed by a governmental entity or agency to help insure its efficiency and its continuation.

SECTION V

DREDGE DESIGN AND DISCHARGE AREA

A schematic design of the dredge is shown in Figure 5. The dredge, measuring 7.3 m (24 ft) x 18.2 m (60 ft), consists of a Fremont 25 cm (10 in.) pump, a 7.3 m (24 ft) cutter ladder with a suction intake, and a pipeline discharge system. At peak capacity it can pump silt slurry at the rate of 76.4 m^3 (100 yd^3) per hour.

The suction pump is run by a G.M.C. Diesel 2-cycle, 8-cylinder motor which has maximum of 336 H.P. at 2,300 rpm but produces 227 H.P. at 1800 rpm under normal operating procedures.

A. U.S. Motor Diesel generator, 30 K.W., 3-phase, 220 volts with a 6-cylinder Hercules engine is the power plant, and can produce 37.5 KVA at 1800 rpm. This generator provides power for electrical equipment, such as the electric welding machine. The generator provides power for ten electric motors; two operate the leg winches, two the port and starboard bow winches, one the cutter head, three are used to prime the pump and two others are available for operating bilge pumps when necessary. The pump motor and the generator were both purchased new prior to the commencement of dredging.

At the bow of the dredge is located the cutter ladder and cutter head. The cutter head is a spiral closed-nose basket type with three rotary blades which turn at 20 rpm.

A slurry discharge pipeline system was constructed using 6 m (20 ft) length spiral weld 25 cm (10 in.) pipe with 4.8 mm (3/16 in.) wall thickness joined together by 0.9 m (3 ft) rubber connectors. The connectors were of the wedge-lock type that allowed 12° flexibility. The internal spiral of the pipe allows for a more rapid movement of water through the discharge line than does straight line pipe. The pipeline system was held afloat by using floatation units each consisting of five 0.2 m^3 (55 gal.) drums with wooden harnesses.

Pierce (1970) stated that "procurement of adequate disposal areas for the dredged material is a major problem in lake dredging." Although this may usually be true, easements to a low-lying area immediately

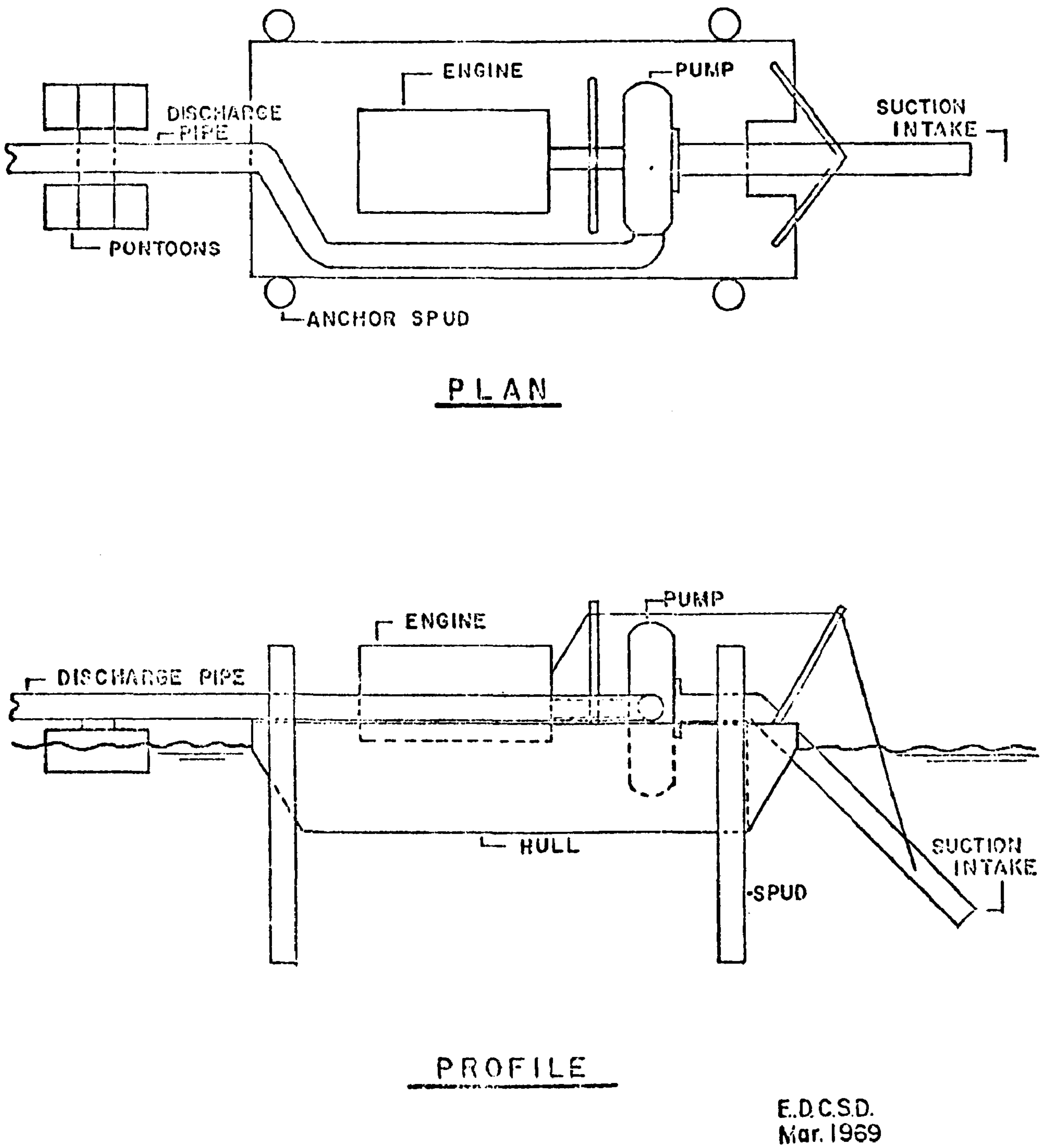

Figure 5. Schematic diagram of the dredge

across the lakeshore road were readily obtained. This area approximately 122 m (400 ft) x 305 m (1000 ft), was a low, wet grassland with a slight easterly slope. One and one-half meter (5 ft) dikes were constructed along the perimeter of the deposit area (moat). At the west end of the moat a pipe was placed beneath the lake road, connected to the terminal end of the discharge system. Thus the slurry entered the moat at this location, moved slowly down the easterly gradient and dropped its silt load. At the east end, the water, free of silt, returned to the lake through the moat outlet, a pipe beneath the roadbed. The elevation of the return pipe was such that the water would stand for several hours before reentering the lake.

SECTION VI

OPERATIONAL AND EVALUATION PHASE

Dredging began in early July, 1970, and continued through mid-November. Dredging was carried on in 1971 for five months, and in 1972 for three months, closing down in early August at the end of the three-year period.

Over the three dredging seasons a total of 272,183 m^3 (356,000 yd^3) of slurry, 47,861 m^3 (62,600 yd^3) of which were solids, were removed from the dredge area (Figure 1). A 4.2 hectares (10.5 A.) area of lake bottom was dredged free of silt during the three-year program and a total of about 40,700 m^3 (33 acre-feet) of silt removed. According to recent studies by the engineering department of the Soil Conservation Service, approximately 12,335 m^3 (ten acre-feet) of silt per year is now entering Lake Herman from its watershed. Thus with a partial dredging operation such as this, more silt was being removed from the lake than was entering. With a full dredging operation, the siltation trend in Lake Herman could be reversed.

The silt was removed from the bottom as a slurry averaging approximately 18 percent solids and 82 percent water. The slurry initially consisted of about ten percent solids and 90 percent water. By the end of the operation improved efficiency resulted in a composition of 23 percent solids and 77 percent water.

The slurry was transported from the dredge through a pipeline to the deposit area (Figure 1), an abandoned farm that had become a dumping area for local lake residents. Bulldozers were used to construct a dike around the area.

Chemical analyses of the dredged materials were performed by Dr. Constance Churchill and her staff at the Division of Science and Mathematics, Dakota State College, Madison. The water in the slurry as it came out of the pipeline was rich in nutrients, especially in total phosphates. The lowest concentration observed was 2.41 mg PO_4/1 and the highest 109.63 mg PO_4/1 (See Appendix A). Orthophosphates, however, were uniformly lower in the slurry, in the deposit area, and in the return pipe than they were in the lake water at the point of dredging (See Table 1). As the slurry drained by gravity from the pipeline toward the east, the silt dropped out. The vegetation in the silt deposit area through which the water moved was lush, suggesting nutrient removal by the vegetation. At the east end of the deposit area the water returned to the lake through the pipe under the road.

The silt deposit area was approximately 3.4 hectares (8.4 A.). The silt that was dropped from the slurry filled the deposit area to an average of 1.4 m (4.6 ft). At the end of the three-year project we found that drying reduced the bulk of the silt until it occupied approximately 50-60 percent of the original volume.

The vegetation in the deposit area was quite luxuriant and according to Brashier et al. there were over twice as many plant species growing in the area after the silt deposition than before.

A local wholesale greenhouse used samples of dredged silt in chrysanthemum growth experiments. In pure silt the chrysanthemums grew larger flowers, larger and greener leaves and stouter stems. However, the root system was more poorly developed, probably because of the compactness of the silt. The blooms did not last as long as did those on the chrysanthemums grown in commercial greenhouse preparation, probably an indirect effect of a poorly developed root system. Mixtures of silt and commercial preparation showed intermediate results.

Shortly after dredging commenced the phosphate concentration in the lake water increased from 0.5 mg PO_4/l to 1.5 mg PO_4/l (Figure 6). Hardness, silica and turbidity also increased. Agreement was not reached as to whether this was a result of resuspension of silt by the dredging operation. Dredging did not result in extensive muddying of the lake water, which some observers believed would be necessary if the increase were to be related to dredging. Further, no phosphate gradient was observed from the dredge to the surrounding lake, which would probably be expected if the dredging did indeed cause the phosphate increase (See Appendix B). Not only was there no gradient from the dredge area to the surrounding lake, but occasionally other parts of the lake exhibited even higher phosphate concentrations than did the dredge area. Also, high winds, which occur frequently in South Dakota, may stir the bottom to a greater extent than the dredge. However, it must be pointed out that there were no other noticeable environmental changes that could readily account for this dramatic increase in phosphates. For example, there was no heavy runoff at that time that could have brought phosphate fertilizers into the lake, and no extensive algal die-off which could have released large quantities of phosphates to the water.

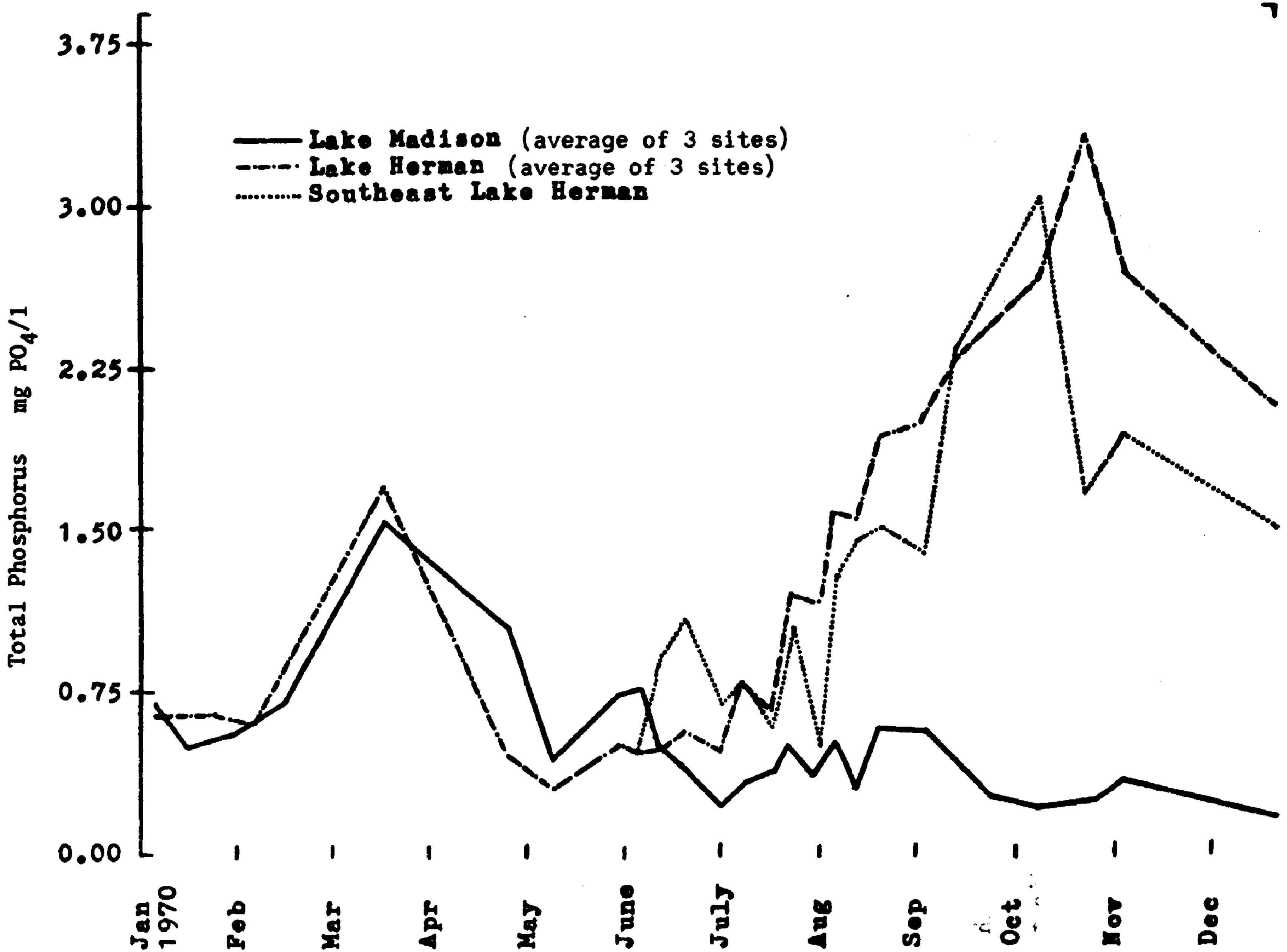

Figure 6. Total phosphorus levels in Lakes Herman and Madison during 1970

Table 1. CHANGES IN ORTHOPHOSPHATE FROM LAKE TO SILT DEPOSIT AREA
mg $PO_4/1$

Date	Dredge Bay of Lake	Dredge Pipe Effluent	Silt Deposit Area	Deposit Area Outlet
7/28/70	0.88	--	0.45	--
8/11/70	1.14	0.72	0.88	0.80
8/18/70	1.16	0.72	0.85	--
8/26/70	--	0.72	0.90	0.62
9/3/70	1.48	1.08	0.60	0.35
9/22/70	1.52	0.40	0.34	0.38
10/6/70	1.66	0.32	--	0.51
10/13/70	1.61	0.88	--	0.29
10/21/70	1.72	0.38	--	0.27
11/3/70	1.72	--	0.19	0.17
7/13/71	1.47	0.29	--	--
8/18/71	1.29	0.19	0.45	--
8/25/71	1.59	0.35	0.48	0.57
9/13/71	1.25	0.54	0.30	--

Table 2. CHANGES IN pH FROM LAKE TO SILT DEPOSIT AREA

Date	Dredge Bay of Lake	Dredge Pipe Effluent	Silt Deposit Area	Deposit Area Outlet
7/28/70	9.07	--	8.26	--
8/11/70	9.12	8.08	7.69	7.20
8/18/70	9.19	7.30	7.80	--
8/26/70	--	7.60	7.28	7.27
9/3/70	9.32	8.39	8.35	7.98
9/22/70	9.16	8.50	8.44	8.28
10/6/70	9.07	8.34	--	8.16
10/13/70	8.93	8.27	8.53	7.89
10/21/70	8.97	8.32	--	8.14
11/3/70	8.85	--	7.98	7.97
7/13/71	9.19	8.06	--	--
8/18/71	8.98	8.13	8.55	--
8/25/71	9.13	8.49	8.57	7.83
9/13/71	8.80	8.15	7.95	--

One interesting aspect of the dredging that was not anticipated was the fact that dredged holes partially refilled when strong winds roiled the bottom. The silt from the surrounding lake bottom that refilled the holes was relatively soft and was easily removed by subsequent dredging. However, this did require dredging to continue in a given location longer than was originally expected.

Core samples taken from the bottom of the lake were analyzed by Mr. Arnold R. Gahler, Pacific Northwest Environmental Research Laboratory, E.P.A., Corvallis, Oregon, at about the time that dredging began. It was almost impossible to obtain cores greater than three feet in length. The top 0.3 m (1 ft) of the silt was relatively soft but compactness increased rapidly with sediment depth. By the time the 0.9 m (3 ft) depth was reached any attempts to proceed beyond that resulted in breaking the lining of the core sampler. Gahler summarized the results as follows:

1. "Relatively high concentrations of soluble orthophosphate, total phosphorus, ammonia, and total Kjeldahl nitrogen occur in the interstitial water of the sediment."

2. "The C/N ratios in the sediment are relatively high, i.e., 11/1 to 12/1 which indicates pollutional effects."

3. "The carbon and nitrogen decrease greatly with depth in the area where dredging will occur. On the single core, the carbon decreased from 6.7 to 2.5% and the nitrogen from 0.7 to 0.19%."

The complete analysis of the interstitial water of the Lake Herman sediments are given in Appendix C. Locations of core sampling sites are shown on Figure 1.

SECTION VIII

DISCUSSION

Dredging has been suggested by many as a method of removing nutrients from a lake and as a method of prolonging the life of lakes. Several dredging operations such as those at Worthington, Minnesota, and Owatona, Minnesota, have been used to prolong the life of lakes. The operation at Worthington, Minnesota, has also used the dredged silt to fill in nearby low areas, which have subsequently been used for residential developments, public building areas, and recreational areas.

This study has contributed further evidence that dredging can prolong the life of a lake. Silt removal from the lake exceeded input rates from nearby farmland erosion. However, silt loads to the lake are more or less evenly distributed over the lake bottom, whereas removal of silt by dredging is localized. Therefore, the dredging has benefited only a restricted portion of Lake Herman. Water throughout most of the lake averages about 1.7 m (5½ ft) in depth. When that drops to 1.2-1.4 m (4-4½ ft) in late summer, especially in dry years, the bays become clogged with Potamogeton spp. A heavy rain of one-in-fifty-years frequency or perhaps even a rain of one-in-twenty-five-years frequency might bring enough silt into the lake to decrease the water depth to the critical level where the lake assumes the characteristics of a marsh. Even if such a heavy rain does not occur, biologists from the South Dakota Game, Fish and Parks Department and from Dakota State College believe that enough silt will probably enter the lake over the next 25 years to 50 years to decrease the water depth to the critical level where the lake will begin its transformation to a marsh. This suggests that if Lake Herman is to be prolonged a much more extensive dredging program will be necessary. One possibility is to remove by dredging only 0.3 to 0.6 m (1 to 2 ft) of silt, and try to do this in all of the bays and shallow areas, rather than dredging to the original bottom in one relatively small part of the lake. Based on the data from this study, this type of dredging might well have very beneficial side effects. As earlier discussed, the surficial sediment is the most fertile. This is undoubtedly because of the use of increased amounts of fertilizers in crop production in the watershed in recent years. If this were the part removed by dredging, significant amounts of nutrients would be removed from many areas of the lake. It was also shown by this project that silt could be used to grow flowers. However, root systems were not able to develop properly under greenhouse conditions. By taking only the top foot of silt a much greater uniformity in the fertility of the silt would prevail, and the entire amount removed would be much more fertile than that removed in this project. A much smaller silt to garden soil ratio or silt to commercial greenhouse preparation might be necessary to produce stout stems, luxuriant leaf growth and larger blooms. The relative small amount of silt in this combination would probably eliminate the excessive compactness which caused poor root development.

An overall lake improvement program is needed. Dredging can be only a partial answer to the problems of prairie lakes such as Lake Herman. Extensive land management programs in lake watersheds should be promulgated. If the lakes are to persist, silt loading must be curtailed as much as possible. Where necessary, contour plowing and terracing should be encouraged. Grassed waterways with gradual slopes should be used to drain the land. Dugouts and stock dams should be promoted in tributary streams, slowing water and allowing silt to settle out. Silted-in dugouts can be easily and inexpensively cleaned with nitrate explosives. All streams in the watershed should have adjacent grassland, to slow movement of water into the stream and retard transport of silt.

Sanitary districts for each lake, such as Lake Herman, should be established and regulations regarding lake activities drawn up, including distance between residences, distance from residences to lake, and types of acceptable sewage disposal programs. Lake shores should be zoned for residential, business, and recreational uses. Permanent surveillance programs in conjunction with colleges or universities, where possible, should be established to monitor for changes in pollution levels, winter oxygen deficiencies, and changes in dynamics. This type of program should be especially important in heavily populated areas and where lakes are sparce. If lake recreation is important, and a significant part of the people believe that it is, then the lakes that are heavily used for recreation should be given priority for programs that will insure their maintenance. Some sort of standardization should be worked out for programs for the various types of lakes, and these programs set up with federal, state and local government support and control. If the initiative is left up to the local citizenry, a select few lakes will receive the benefits of available programs, but the vast majority will be left to deteriorate.

PUBLICATIONS AND PAPERS

The following publications and papers are related to this project.

1. Brashier, C. K. and R. G. Anderson, 1972, Lake Dredging— A Biological Viewpoint, presented to Phycological Society of America at the annual AIBS meetings at the University of Minnesota, Minneapolis.

2. Anderson, R. G., C. K. Brashier, and G. Leidahl, 1971, Viable Algae in Chironomid Larvae, presented to Phycological Society of America at joint meeting of AIBS and Canada Botanical Society in Edmonton.

3. Churchill, C. L., 1971, A Preliminary Report on Some Effects of Dredging a Lake, presented at the annual meeting of South Dakota Academy of Science.

4. Churchill, C. L., 1971, Lake Restoration, presented at the annual Gooch-Stephens Seminar at Baylor University.

SECTION IX

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	pH	Alkalinity mg $CaCO_3$/l	Dissolved Oxygen mg O_2/l	COD mg/l	Conductivity μmhos/cm at 25°C.	Chloride mg Cl/l	Silica mg SiO_2/l	Ortho Phosphate mg PO_4/l	Total Phosphorus mg PO_4/l	Ammonia mg NH_3-N/l	Nitrate mg NO_3-N/l	Nitrite mg NO_2-N/l
July 21, 1970												
Dredge	8.85	150	8.7		784	5.05	15.2	0.67	1.29	0.19	0.005	3.2
Dredge Pipe (End)	8.1	149			794	5.53	17.2	0.73	2.41	1.48	0.009	3.0
Moat					804							
Moat Outlet												
28												
Dredge	9.07	170	12.1		778	5.29	19.4	0.88	1.16	0.27	0.02	1.23
Dredge Pipe (End)												
Moat	8.26	154	5.4		8.09	5.77	17.6	0.45	0.99	2.0	0.06	18.10
Moat Outlet												
August 4												
Dredge	8.87	161	6.2	55.0	788	5.77	19.8	1.11	1.66	0.20	0.02	2.22
Dredge Pipe (End)												
Moat												
Moat Outlet												
11												
Dredge	9.12	159	15.0	62.6	768	5.77	19.9	1.14	1.45	0.18	0.058	4.09
Dredge Pipe (End)	8.08	171		376	819	5.05	15.9	0.72	13.36	2.47	0.012	6.31
Moat	7.69	168		38.1	829	5.77	22.0	0.88	1.15	5.14	0.004	
Moat Outlet	7.20	163		57.7	829	6.01	21.9	0.80	1.10	3.36	0.005	8.36

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	pH	Alkalinity mg $CaCO_3$/1	Dissolved Oxygen mg O_2/1	COD mg/1	Conductivity µmhos/cm at 25°C.	Chloride mg Cl/1	Silica mg SiO_2/1	Ortho Phosphate mg PO_4/1	Total Phosphorus mg PO_4/1	Ammonia mg NH_3^-N/1	Nitrate mg NO_3^-N/1	Nitrite mg NO_2^-N/1
August 18, 1970												
Dredge	9.19	163	9.0	56.9	778	4.8	27.0	1.16	1.89	0.07	0.013	3.16
Dredge Pipe (End)	7.30	148		36.4	788	5.0	25.3	0.72	10.73	1.07	0.020	1.22
Moat	7.80	153	3.1	90.1	942	6.5	14.5	0.85	2.02	2.03	0.022	1.92
Moat Outlet												
26												
Dredge												
Dredge Pipe (End)	7.6	163		263	835	5.7	20.5	0.72	7.95	4.16	0.008	5.21
Moat	7.28	160	7.95	65.5	835	6.2	42.5	0.90	21.34	1.18	0.017	2.09
Moat Outlet	7.27	160	2.75	57.1	835	6.7	19.8	0.62	1.39	0.59	0.006	4.53
September 3												
Dredge	9.32	176		59.8	797	6.7	26.3	1.48	1.96	0.06	0.036	4.19
Dredge Pipe (End)	8.39	200		900	817	5.4	25.1	1.08	35.90	2.14	0.015	15.5
Moat	8.35	186		139	827	6.2	24.0	0.60	3.41	2.35	0.013	16.7
Moat Outlet	7.98	153		46.6	817	10.8	22.0	0.35	1.24	0.42	0.013	15.5
22												
Dredge	9.16	179	10.9	54.5	800	8.78	23.9	1.52	2.15	0.04	0.010	2.18
Dredge Pipe (End)	8.50	179		681	806	8.01	19.2	0.40	28.41	1.13	0.045	3.07
Moat	8.44	176	6.8	68.1	816	6.72	18.9	0.34	2.18	2.13	0.015	5.32
Moat Outlet	8.28	168	4.6	50.7	826	6.72	13.5	0.38	1.17	1.90	0.016	4.13

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	pH	Alkalinity mg $CaCO_3$/1	Dissolved Oxygen mg O_2/1	COD mg/1	Conductivity µmhos/cm at 25° C.	Chloride mg Cl/1	Silica mg SiO_2/1	Ortho Phosphate mg PO_4/1	Total Phosphorus mg PO_4/1	Ammonia mg NH_3-N/1	Nitrate mg NO_3^-N/1	Nitrite mg NO_2^-N/1
October 6, 1970												
Dredge	9.07	187	9.5	46.7	873	6.20	24.5	1.66	2.80	0.24	0.020	2.02
Dredge Pipe (End)	8.34	182		2117	883	6.97		0.32	25.63			
Moat												
Moat Outlet	8.16	177	6.1	44.7	893	6.97		0.51	1.05			
13												
Dredge	8.93	185	10.4	51.5	874	6.72	24.8	1.61	3.01	0.15	0.125	1.50
Dredge Pipe (End)	8.27	244		53.3	895	6.46	24.0	0.88	109.63		0.007	0.01
Moat	8.53	208		54.3	885	7.23	19.2		14.07	3.17	0.020	0.01
Moat Outlet	7.89	176	2.4	39.0	866	6.46	19.2	0.29	0.76	2.64	0.167	59.4
21												
Dredge	8.97	188	10.8	38.4	873	6.20	16.8	1.72	2.02	0.12	0.025	4.64
Dredge Pipe (End)	8.32	215		2613	862	6.20	19.0	0.38	27.60	2.90	0.027	4.18
Moat												
Moat Outlet	8.14	181	3.6	42.6	852	6.20	12.5	0.27	1.04	1.50		80.6
November 3												
Dredge	8.85	190	12.3	39.7	873	6.20	14.6	1.72	2.46	0.02	0.051	1.11
Dredge Pipe (End)												
Moat	7.98	159		34.0	834	6.20	8.25	0.19	1.10	0.18	1.01	31.5
Moat Outlet	7.97	156		37.0	785	5.17	5.50	0.17	1.11	0.30	1.88	51.4

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	pH	Alkalinity mg $CaCO_3$/1	Dissolved Oxygen mg O_2/1	COD mg/1	Conductivity µmhos/cm at 25° C.	Chloride mg Cl/1	Silica mg SiO_2/1	Ortho Phosphate mg PO_4/1	Total Phosphorus mg PO_4/1	Ammonia mg NH_3^-N/1	Nitrate mg NO_3^-N/1	Nitrite mg NO_2^-N/1
July 13, 1971												
Dredge	9.19	197	13.5	62.9	757	5.2	13.4	1.47	2.21	0.05	0.013	0.8
Dredge Pipe (End)	8.06	190		907	777	5.8	4.9	0.29	66.72	2.32	0.081	29.8
Moat												
Moat Outlet												
20												
Dredge	9.23	197	15.1	46.1	776	5.1	31.4	1.23	2.15	0.00	0.027	1.4
Dredge Pipe (End)	7.90	201		584	806	5.3	28.6	0.33	28.50	1.10	0.048	4.5
Moat												
Moat Outlet												
August 18												
Dredge	8.98	209	8.5	72.1	842	6.6	35.1	1.29	2.12	0.00	0.013	3.8
Dredge Pipe (End)	8.13	195			848	7.1	24.2	0.19	75.3	0.76	0.021	5.0
Moat	8.55	209	4.5		850	7.1	28.9	0.45	2.42	0.50	0.046	4.4
25												
Dredge	9.13	219	4.3	67.0	839	6.6	37.0	1.59	2.57	0.01	0.034	3.5
Dredge Pipe (End)	8.49	207		504.6	850	6.6	28.3	0.35	41.6	1.77	0.034	2.4
Moat	8.57	217	4.0	874.6	850	7.1	30.2	0.48		2.17	0.003	4.4
Moat Outlet	7.83	206	1.2	56.4		7.6	31.4	0.57	1.44	0.86	0.320	5.7

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	pH	Alkalinity mg $CaCO_3$/l	Dissolved Oxygen mg O_2/l	COD mg/l	Conductivity μmhos/cm at 25° C.	Chloride mg Cl/l	Silica mg SiO_2/l	Ortho Phosphate mg PO_4/l	Total Phosphorus mg PO_4/l	Ammonia mg NH_3^-N/l	Nitrate mg NO_3^-N/l	Nitrite mg NO_2^-N/l
September 1, 1971												
Dredge	8.80	211	7.7	60.5	844	5.8	37.9	1.52	2.52	0.03	0.016	3.1
Dredge Pipe (End)												
Moat	7.40	150	3.6	48.5	575	5.1	20.2	0.89	2.13	1.07	0.040	85.1
Moat Outlet												
13												
Dredge	8.80	219	8.8	88.0		6.0	39.4	1.25		0.10	0.018	2.4
Dredge Pipe (End)	8.15	216		796		5.8	34.2	0.54		0.69	0.041	5.5
Moat	7.95	217		910		7.3	24.8	0.30		2.18	0.063	11.4
Moat Outlet												
30												
Dredge	8.79	223	8.9	51.9	942	6.1	36.2	1.07	1.67	0.01	0.131	0.0013
Dredge Pipe (End)	8.56	254		429	1002	6.6	35.4	0.91	8.59	0.23	0.013	0.0013
Moat												
Moat Outlet	8.47	227		52.8	1102	7.6	31.6	0.37	5.46	0.93	0.069	0.0086
June 12, 1972												
Dredge	9.00	176	14.45	50.2	817	6.2	21.8	0.53	1.39	0.031	0.0	0.0
Dredge Pipe (End)	8.34	242		209.4	838	6.2	20.4	0.46	5.33	0.287	0.019	0.0003
Moat	7.93	411		448.3	858	5.9	16.2	0.15	27.63	1.808	0.0	0.0121
Moat Outlet												

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	pH	Alkalinity mg $CaCO_3$/1	Dissolved Oxygen mg O_2/1	COD mg/1	Conductivity μmhos/cm at 25° C.	Chloride mg Cl/1	Silica mg SiO_2/1	Ortho Phosphate mg PO_4/1	Total Phosphorus mg PO_4/1	Ammonia mg NH_3^-N/1	Nitrate mg NO_3^-N/1	Nitrite mg NO_2^-N/1
June 19, 1972												
Dredge	9.15	175	13.35	82.2	802	7.6	22.3	0.50	1.67	0.024	0.018	0.0003
Dredge Pipe (End)	8.47	177		147.0	832	6.7	21.5	0.45	5.46	0.436	0.003	0.0056
Moat	8.17	168		865.1	842	6.7	17.9	0.15	29.27	2.559	0.073	0.0069
Moat Outlet												
26												
Dredge	8.66	175	7.80	27.6	854	6.4	21.2	0.60	0.75	0.150	0.023	0.0037
Dredge Pipe (End)	7.95	168		1992.2	854	7.3	16.7	0.10	30.32	2.750	0.012	0.0066
Moat												
Moat Outlet												

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	Temperature °C.	Depth of Water (feet)	Secchi Disk (cm)	Turbidity (Jackson Turbidity Units)	Hardness mg $CaCO_3$/1	Calcium mg Ca/1	Copper µg Cu/1	Iron mg Fe/1	Magnesium mg Mg/1	Manganese mg Mn/1	Sodium mg Na/1	Potassium mg K/1
July 21, 1970												
Dredge	22.5	7	30	35.2	363	82.0	0.00	0.03	36.0	0.03	32	17.2
Dredge Pipe (End)				4437	395	93.9	0.01	0.24	32.3	0.13	32	18.9
Moat												
Moat Outlet												
28												
Dredge	26.5	7	47	31.4	368	73.4	0.01	0.02	30.4	0.01	33	17.3
Dredge Pipe (End)												
Moat		1		56.5	388	73.4	0.00	0.04	28.1	0.29	34	19.3
Moat Outlet												
August 4												
Dredge	23	7	20	35.9	375	73.4	0.00	0.02	28.1	0.06	32	17.9
Dredge Pipe (End)												
Moat												
Moat Outlet												
11												
Dredge	28	7		19.3	365	77.9	0.00	0.02	38.6	0.01	32	17.2
Dredge Pipe (End)				3200	400	77.1	0.01	0.02	38.0	0.94	34	19.4
Moat				44	365	76.5	0.00	0.03	38.0	0.63	33	18.4
Moat Outlet				18.0	360	74.7	0.00	0.08	37.6	0.79	32	20.7

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	Temperature °C.	Depth of Water (feet)	Secchi Disk (cm)	Turbidity (Jackson Turbidity Units)	Hardness mg $CaCO_3$/1	Calcium mg Ca/1	Copper µg Cu/1	Iron mg Fe/1	Magnesium mg Mg/1	Manganese mg Mn/1	Sodium mg Na/1	Potassium mg K/1
August 18, 1970												
Dredge	24.5	7	35	22.4	370	80.7	0.00	0.06	40.2	0.03	34	17.6
Dredge Pipe (End)				2176.5	380	78.4	0.01	0.02	36.4	0.70	33	18.0
Moat				37.1	410	91.5	0.00	0.02	41.9	0.31	36	26.8
Moat Outlet												
26												
Dredge												
Dredge Pipe (End)				1558	360	77.9	0.00	0.03	35.4	0.81	35	21.8
Moat				166	375	77.1	0.00	0.01	36.4	0.62	34	19.5
Moat Outlet	26			17.7	385	77.9	0.00	0.04	36.4	0.88	35	21.1
September 3												
Dredge		8		27.5	385	78.9	0.01	0.03	39.2	0.02	36	18.1
Dredge Pipe (End)				2588	360	78.9	0.01	0.03	39.2	0.02	36	18.1
Moat		3		350	360	77.9	0.01	0.06	36.4	0.86	37	20.7
Moat Outlet		0.5		22.5	360	75.6	0.00	0.04	37.0	0.14	37	19.4
22												
Dredge	19	7	24	45	390	81.2	0.00	0.10	40.8	0.04	39	18.1
Dredge Pipe (End)	18			4670	375	80.2	0.00	0.12	36.4	0.78	37	18.5
Moat	20			1670	365	80.2	0.00	0.10	36.4	0.81	38	18.8
Moat Outlet	18			75	365	79.8	0.00	0.07	36.4	0.61	38	18.8

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	Temperature °C.	Depth of Water (feet)	Secchi Disk (cm)	Turbidity (Jackson Turbidity Units)	Hardness mg $CaCO_3$/1	Calcium mg Ca/1	Copper ug Cu/1	Iron mg Fe/1	Magnesium mg Mg/1	Manganese mg Mn/1	Sodium mg Na/1	Potassium mg K/1
October 6, 1970												
Dredge	16	7	41	20.5	405	85.9	0.00	0.02	44.1	0.03	39	18.9
Dredge Pipe (End)				3891								
Moat												
Moat Outlet	18			41.1								
13												
Dredge	7	7		26.3	395	81.7	0.01	0.04	42.4	0.04	38	18.2
Dredge Pipe (End)				6625	390	77.9	0.00	0.08	41.3	1.06	39	18.4
Moat	7.5	3		5250	375	8.12	0.00	0.18	40.8	0.63	39	19.4
Moat Outlet	8.5			40.0	365	79.8	0.00	0.06	39.2	0.69	39	18.5
21												
Dredge	10	7	50	21.0	400	83.5	0.01	0.04	47.8	0.02	38	18.2
Dredge Pipe (End)	10			1540	377	82.1	0.00	0.31	43.4	1.12	40	18.3
Moat												
Moat Outlet	12	1		56.5	385	81.2	0.00	0.18	43.4	0.76	40	18.6
November 3												
Dredge	3	6	50	21.3	408	82.1	0.00	0.03	46.5	0.04	39	18.1
Dredge Pipe (End)												
Moat	2	2"		40.9	368	76.5	0.01	0.08	37.3	0.27	36	17.5
Moat Outlet	2	1		49.8	375	72.0	0.01	0.22	36.4	0.59	34	16.5

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	Temperature °C.	Depth of Water (feet)	Secchi Disk (cm)	Turbidity (Jackson Turbidity Units)	Hardness mg $CaCO_3$/1	Calcium mg Ca/1	Copper µg Cu/1	Iron mg Fe/1	Magnesium mg Mg/1	Manganese mg Mn/1	Sodium mg Na/1	Potassium mg K/1
July 13, 1971												
Dredge	24	10	43	27.5	359	80.2	0.000	0.011	43.3	0.51	33.3	18.0
Dredge Pipe (End)				4590	365	73.7	0.004	0.082	34.9	2.67	34.5	18.7
Moat												
Moat Outlet												
20												
Dredge	28	7	46	27.2	379	83.7	0.008	0.022	42.0	0.04	34.0	17.2
Dredge Pipe (End)	22			5900	359	84.1	0.004	0.176	37.8	2.72	32.5	19.3
Moat												
Moat Outlet												
August 18												
Dredge	25	6	32	44.0	412	94.5	0.007	0.018	40.7	0.02	33.4	19.3
Dredge Pipe (End)	24.5			7600	392	88.7	0.003	0.106	33.3	1.94	32.8	21.0
Moat	25.5			4200	399	88.7	0.005	0.023	36.5	1.38	33.9	20.3
Moat Outlet												
25												
Dredge	24	6	22	40.0	426	92.9	0.003	0.013	39.2	0.41	36.4	19.6
Dredge Pipe (End)				6100	412	85.3	0.004	0.063	35.5	1.93	35.3	21.1
Moat		3		4570	405	85.7	0.002	0.040	36.0	1.43	34.7	21.7
Moat Outlet		½		39.0	439	93.7	0.003	0.019	35.8	1.74	35.3	22.2

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	Temperature °C.	Depth of Water (feet)	Secchi Disk (cm)	Turbidity (Jackson Turbidity Units)	Hardness mg $CaCO_3$/l	Calcium mg Ca/l	Copper µg Cu/l	Iron mg Fe/l	Magnesium mg Mg/l	Manganese mg Mn/l	Sodium mg Na/l	Potassium mg K/l
September 1, 1971												
Dredge	23	6	33		405	86.6	0.003	0.022	37.0	0.20	32.9	19.1
Dredge Pipe (End)												
Moat	23	1			250	50.6	0.007	0.108	23.1	0.70	21.1	17.1
Moat Outlet												
13												
Dredge	19	6	30	37	446	92.0	0.003	0.040	37.8	0.04	33.5	19.1
Dredge Pipe (End)	19			2600	422	88.3	0.005	0.105	35.1	1.19	33.5	20.0
Moat				3800	431	88.3	0.011	0.102	34.8	1.55	34.3	22.3
Moat Outlet												
30												
Dredge	15		33	33.2	422	92.0	0.000	0.010	37.5	0.02	35.1	18.7
Dredge Pipe (End)	15			1317	419	87.8	0.005	0.006	38.5	0.34	35.7	18.9
Moat												
Moat Outlet	17			449	419	87.0	0.007	0.008	36.0	1.58	34.9	19.7
June 12, 1972												
Dredge	24	6	55	23.1	393					0.013		
Dredge Pipe (End)				544	413					0.037		
Moat				3147	410					0.337		
Moat Outlet												

APPENDIX A. Results of Chemical Analysis of Dredged Materials

Date	Temperature °C.	Depth of Water (feet)	Secchi Disk (cm)	Turbidity (Jackson Turbidity Units)	Hardness mg $CaCO_3$/1	Calcium mg Ca/1	Copper µg Cu/1	Iron mg Fe/1	Magnesium mg Mg/1	Manganese mg Mn/1	Sodium mg Na/1	Potassium mg K/1
June 19, 1972												
Dredge	21	8	40	34.7	396					0.010		
Dredge Pipe (End)				596.0	426							
Moat				3333.3	377							
Moat Outlet												
26												
Dredge	20.5	8	80	23.7	406							
Dredge Pipe (End)				3935.8	383							
Moat												
Moat Outlet												

APPENDIX B. Results of Chemical Analyses of Lake Herman *

Date	pH	Alkalinity mg $CaCO_3$/l	Dissolved Oxygen mg O_2/l	COD mg/l	Conductivity µmhos/cm at 25° C.	Chloride mg. Cl/l	Silica mg SiO_2/l	Ortho Phosphate mg PO_4/l	Total Phosphorus mg PO_4/l	Ammonia mg NH_3-N/l	Nitrate mg NO_3-N/l	Nitrite µg NO_2-N/l
July 21, 1970												
North	8.89	150	8.9		784	5.77	17.7	0.72	1.25	0.28	0.001	2.5
Dredge	8.85	150	8.7		784	5.05	15.2	0.67	1.29	0.19	0.005	3.2
Center	8.57	148	6.8		794	5.53	18.2	0.71	1.06	0.21	0.066	2.6
Southeast	9.58	107	11.0		712	5.33	8.3	0.50	1.04	0.19	0.003	3.6
28												
North	9.10	152	11.5		768	5.53	18.5	0.83	1.19	0.11	0.01	1.36
Dredge	9.07	170	12.1		778	5.29	19.4	0.88	1.16	0.27	0.02	1.23
Center	8.92	152	8.9		778	6.25	18.0	0.86	1.10	0.15	0.01	2.36
Southeast	10.11	114	14.8		747	5.77	8.4	0.10	0.50	0.34	0.00	1.00
Aug. 4												
North	8.89	162	5.8	51.6	778	5.53	20.7	1.07	1.56	0.25	0.00	3.34
Dredge	8.87	161	6.2	>55.0	788	5.77	19.8	1.11	1.66	0.20	0.02	2.22
Center	8.94	160	6.9	>55.0	778	5.29	19.4	0.97	1.48	0.36	0.00	2.78
Southeast	9.47	132	7.4	54.5	747	5.29	13.5	0.75	1.29	0.26	0.03	3.34
11												
North	9.33	158	19.0	71.7	758	5.53	19.5	0.93	1.71	0.26	0.000	3.05
Dredge	9.12	159	15.0	62.6	768	5.77	19.9	1.14	1.45	0.18	0.058	4.09
Center	9.17	156	15.2	53.2	768	5.29	23.9	1.09	1.46	0.29	0.010	2.84
Southeast	10.17	136	15.8	86.4	758	5.53	12.4	0.18	1.45	0.25	0.000	6.75

* See Figure 1 for sampling locations.

APPENDIX B. Results of Chemical Analyses of Lake Herman

Date	pH	Alkalinity mg $CaCO_3$/l	Dissolved Oxygen mg O_2/l	COD mg/l	Conductivity µmhos/cm at 25° C.	Chloride mg Cl/l	Silica mg SiO_2/l	Ortho Phosphate mg PO_4/l	Total Phosphorus mg PO_4/l	Ammonia mg NH_3-N/l	Nitrate mg NO_3-N/l	Nitrite µg NO_2-N/l
Aug. 18, 1970												
North	9.04	163	9.2	62.0	788	4.8	27.8	1.28	1.98	0.10	0.017	4.30
Dredge	9.19	163	9.0	56.9	778	4.8	27.0	1.16	1.89	0.07	0.013	3.16
Center	8.97	163	9.1	55.5	788	4.8	26.3	1.13	1.92	0.07	0.014	3.26
Southeast	9.63	135	11.4	61.3	730	5.8	14.3	0.61	1.51	0.10	0.009	4.20
Sept. 3												
North	9.23	173		54.9	777	5.4	26.2	1.44	2.13	0.07	0.170	1.56
Dredge	9.32	176		59.8	797	6.7	26.3	1.48	1.96	0.06	0.036	4.19
Center	9.23	176		54.6	787	5.7	26.5	1.61	1.91	0.09	0.027	2.09
Southeast	9.99	138		71.3	747	5.4	20.7	0.53	1.39	0.10	0.020	3.13
22												
North	9.16	177	9.8	46.7	806	5.94	21.9	1.50	2.11	0.01	0.013	1.25
Dredge	9.16	179	10.9	54.5	800	8.78	23.9	1.52	2.15	0.04	0.010	2.18
Center	9.15	176	10.2	50.2	800	6.20	23.9	1.56	2.68	0.06	0.021	2.07
Southeast	9.14	168	10.0	58.1	786	7.23	22.5	1.26	2.36	0.03	0.005	1.61
Oct. 6												
North	9.03	186	9.6	48.0	873	5.68	23.3	1.74	2.81	0.03	0.011	1.46
Dredge	9.07	187	9.5	46.7	873	6.20	24.5	1.66	2.80	0.24	0.020	2.02
Center	9.07	186	9.5	42.7	873	5.68	24.5	1.71	2.34	0.01	0.018	1.40
Southeast	8.80	189	9.4	61.3	883	6.72	27.6	1.48	3.03	0.04	0.002	1.00
13												
Dredge	8.93	185	10.4	51.5	874	6.72	24.8	1.61	3.01	0.15	0.125	1.50

APPENDIX C. Analyses of Interstitial Water From Lake Herman Sediments*

Date	Silica Sol.	Ca Hardness	Total Hardness	Na	K	Cl	SO_4	Fe	Mn	Mg	Total Carbon
March 11, 1969											
A-Core #1 (3" top missing from 1st foot)	36.3	370	517			40	238				245
A-Dredge A	30.9	340	700	87	36	30	740				209
B-Dredge B	36.0	340	700			30	700				187
B-Core #3 (Top Foot)	32.4	420	567			30	525				184
B-Core #4 (Bottom 10" of 32" core)	46.8										
C-Core #2 (Top Foot)	31.8	340	400	91	35	35	800				187
July 31											
South Silt	19	260		36	19	46	350	.20	2.4	48	
East Silt	25	293		34	17	39	270	.30	8.4	56	
North Dredge	23	255		34	16	70	310	.30	7.4	48	

*All data in this table has been provided by Arnold Gahler of the Pacific Northwest Water Laboratory, 200 South 35th Street, Corvallis, Oregon.

All concentrations are in mg/l.

Samples from August were delayed during shipment so that results on interstitial water may not be accurate.

APPENDIX C. Analyses of Interstitial Water From Lake Herman Sediments

Date	P Ortho	P Total Sol.	N NH_3	N Total Kjl.	N NO_3	N NO_2	Total Alk.	Cond.	pH
March 11, 1969									
A-Core #1 (3" top missing from 1st foot)	1.0	1.1	9.9		.13	<.01		1183	8.3
A-Dredge A	1.5	1.5	3.0	5.2	.08	<.01	378	1446	8.3
B-Dredge B	2.2		3.0	5.4	.08	<.01		1446	8.3
B-Core #3 (Top Foot)	.84	1.0	5.8		.05	<.01		1407	7.9
B-Core #4 (Bottom 10" of 32" core)	2.4	2.6	14.0						8.2
C-Core #2 (Top Foot)	.56		8.0		.08	<.01	334	999	8.4
July 31									
South Silt	.08	.16	.22	2.9	.02	<.01	196	927	7.5
East Silt	.36	.50	1.9	4.6	.02	<.01	228	986	7.4
North Dredge	.19	.28	1.4	4.0	.04	.01	219	933	7.5
March 2, 1970									
Core A' (Top 5 in.)	.72	.92	6.0		.04	.02		888	
Core A' (Middle 6½")	1.12	1.6	9.6		.06	.01		897	
Core A' (Bottom 7½")	.40	.60	8.1		.05	<.01		703	

All concentrations are in mg/l.

Samples from August were delayed during shipment so that results on interstitial water may not be accurate.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. 660/3-74-017	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE SILT REMOVAL FROM A LAKE BOTTOM		5. REPORT DATE JANUARY 1973 (DATE OF PREPARATION)
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) LAKE HERMAN DEVELOPMENT ASSOCIATION, INC.		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS LAKE HERMAN DEVELOPMENT ASSOCIATION, INC. 524 SOUTHWEST FOURTH STREET MADISON, SOUTH DAKOTA 57042		10. PROGRAM ELEMENT NO. 1BA031
		11. CONTRACT/GRANT NO. 16010 ELF
12. SPONSORING AGENCY NAME AND ADDRESS U.S. ENVIRONMENTAL PROTECTION AGENCY PAC. NW ENVIRONMENTAL RESEARCH LAB, NERC-CORVALLIS 200 SW 35TH STREET CORVALLIS, OREGON 97330		13. TYPE OF REPORT AND PERIOD COVERED FINAL 1970-1972
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Dredging was used as a method to remove 62,600 cubic yards of silt from Lake Herman during the summers of 1970, 1971, and 1972. The silt was transported via a pipeline to a silt deposit area adjacent to the northeast corner of the lake. The water removed by the dredging process drained by gravity along a gradual slope, dropping its silt and losing nutrients to the lush vegetation, and eventually returned to the lake.

In the bay area where dredging occurred water depth was increased from 5.5 feet to approximately 11 feet. There was no significant change in the levels of biological organisms or nutrients, except for phosphorus, which increased just after the dredging began. Whether dredging actually caused the increase is still debatable. Vegetation in the deposit area became extremely lush. Water returning to the lake from the deposit area was lower in nutrients than the water in the lake.

This report was submitted in fulfillment of Contract Number 16010 ELF under partial sponsorship of the Water Quality Office, Environmental Protection Agency.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*EUTROPHICATION, ALGAL BLOOMS, WATER POLLUTION EFFECTS, *SEDIMENTS, *SEDIMENT CONTROL	LAKE HERMAN DREDGING	05 C

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