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# DIAGNOSTIC/FEASIBLITY STUDY REPORT
# McCOOK LAKE
# UNION COUNTY, SOUTH DAKOTA

SOUTH DAKOTA CLEAN LAKES PROGRAM
DIVISION OF WATER RESOURCES MANAGEMENT
SOUTH DAKOTA DEPARTMENT OF
WATER AND NATURAL RESOURCES
APRIL 1990

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MARCH, 1990

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## INTRODUCTION

The purpose of this report is to provide information gathered from a Diagnostic/Feasibility Study of McCook Lake and to recommend alternatives for the restoration of the lake. The study was conducted from June, 1988 through September, 1989 and involved the cooperation of the South Dakota Department of Water and Natural Resources, the town of North Sioux City, local residents, and the local chapter of the Izaak Walton League.

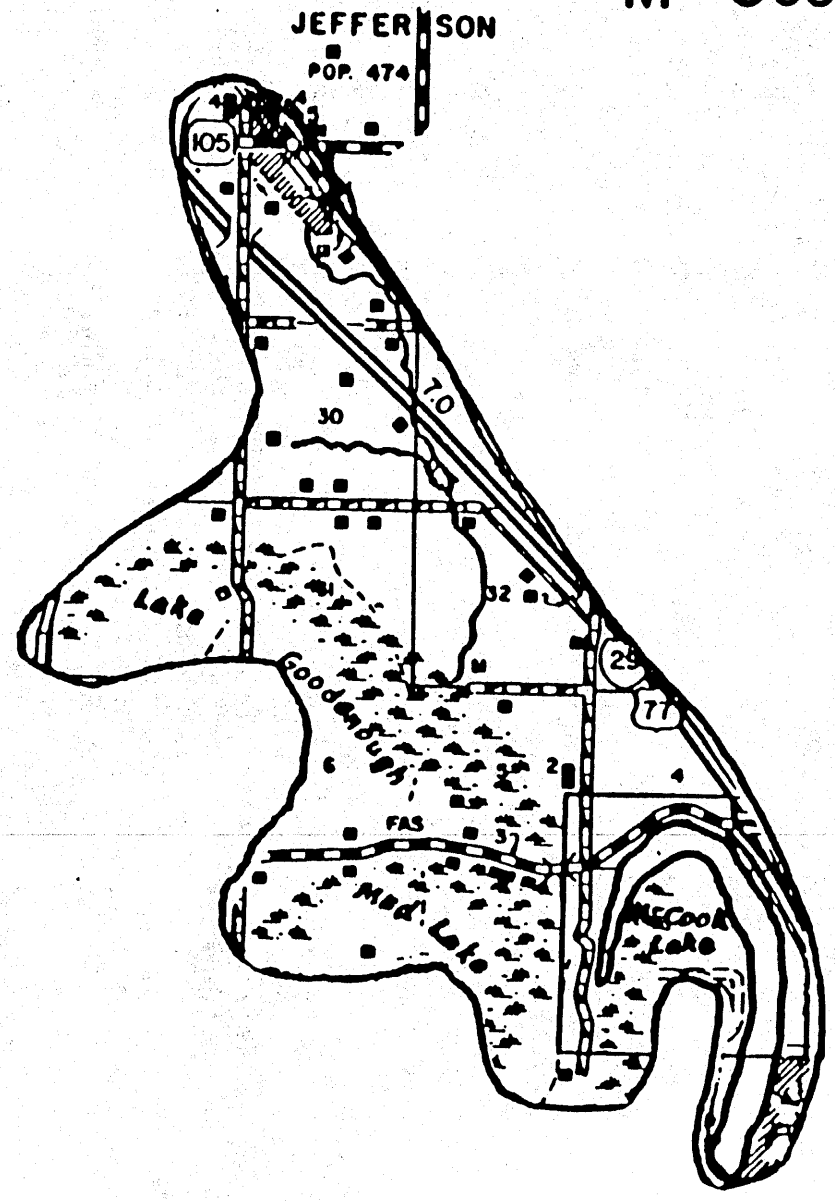
Excess sediment and poor water quality have plagued McCook Lake for many years and have resulted in a loss of water depth and reduced recreational use. The study was initiated at local request to identify and assess the current status of the lake, determine water quality problems and pollution sources, and develop specific restoration alternatives. This report presents the results of data analyses, identification of significant lake impairments, and recommendations for restoration.

## LAKE DESCRIPTION AND HISTORY

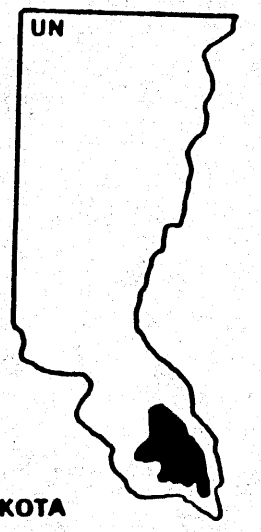
McCook Lake is a eutrophic, oxbow lake formed by an old cutoff of the Missouri River in extreme southeastern South Dakota. The lake is located in Union County, Big Sioux Township, South Dakota (Figure 1). McCook Lake has a surface area of approximately 183 acres and a watershed of approximately 500 acres. The lake has a mean depth of approximately 4 feet and a volume of approximately 732 acre-feet. Fifty percent of the shoreline is covered with cattail and bulrush. Potamogeton sp. is a common floating or submergent leafed macrophyte. McCook Lake has no surface tributaries flowing into or out of the lake basin; the level of the lake is controlled primarily by groundwater. McCook Lake is directly connected to the Missouri River by the existing water table.

During the 1930's, locks were constructed at each end of the lake as a part of the WPA program. These locks were intended to allow the Missouri River water to flow into the lake during periods of high flow in an effort to stabilize the lake level. Since construction of the main stem dams on the Missouri River, high flows on the river have been eliminated. This, together with river bed degradation in the Missouri, has rendered the locks ineffective. Another effect of this degradation has been the steadily declining water levels of McCook Lake. However, since 1981, the lake level has remained relatively constant. The local residents have attempted to maintain the lake level by pumping from the Missouri River since 1970. A few years later a well was added to supplement the water in the lake.

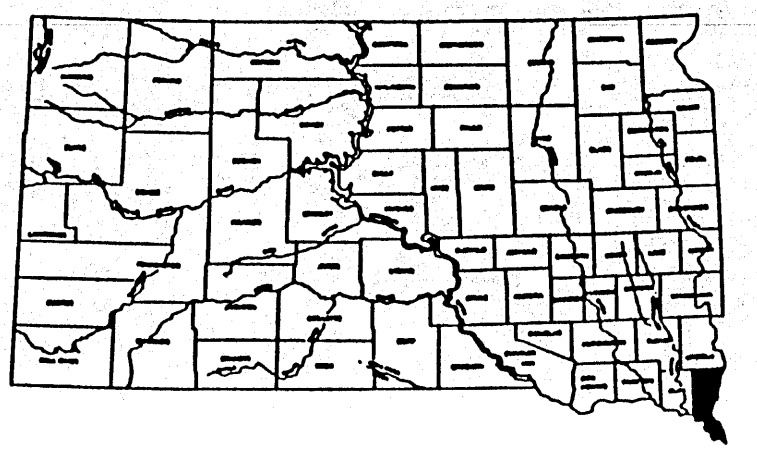
FIGURE 1. Mc Cook Lake




6927 acres




SOUTH DAKOTA



The outer shoreline of the oxbow has been developed with year-round homes. The McCook Lake Sanitary District was formed in 1967. Currently, all lake homes are connected to a central sewer system.

Public access to the lake is available at two locations. The city of North Sioux City owns a public boat ramp and access area on the outer shore of the east arm of the lake. On the outer shore of the western arm of the lake is the Club House of the Izaak Walton League. The local Izaak Walton members allow free public access to the lake from their property. Historically, the lake has experienced high public use, particularly fishing, swimming, boating, and water skiing.

## WATER QUALITY STANDARDS

The water quality standards for the State of South Dakota are based on the highest ranking beneficial use assigned to a body of water. The highest beneficial use assigned to McCook Lake is warmwater semipermanent fish life propagation waters. Other beneficial uses assigned to McCook Lake include immersion recreation, limited contact recreation, and wildlife propagation and stock watering. The water quality standards for McCook Lake are listed in Table 1.

Table 1.-McCook Lake Water Quality Standards

| Parameter | Standard |
|---|---|
| Total Chlorine Residual | <0.02 mg/l |
| Un-Ionized Ammonia Nitrogen | <0.04 mg/l |
| Total Cyanide | <0.02 mg/l |
| Free Cyanide | <0.005 mg/l |
| Dissolved Oxygen | >5.0 mg/l |
| Undisassociated Hydrogen Sulfide | <0.002 mg/l |
| pH | >6.5 units and <8.3 units |
| Suspended Solids | <90 mg/l |
| Temperature | <90° F |
| Polychlorinated Biphenyls | <0.000001 mg/l |
| Fecal Coliform Organisms | <200 per 100 ml* |

*Based on geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period, and they may not exceed this value in more than 20 percent of the samples examined in this 30-day period. A sample may not exceed 400 per 100 ml in any one sample from May 1 to September 30.

## PREVIOUS INVESTIGATIONS

There have been numerous documents written concerning the restoration of McCook Lake. The following is a list of all of known documents and a brief summary of their results.

North Sioux City, South Dakota Common Council. McCook Lake Restoration Project. 1980. Document contained a diagnostic\feasibility study and an in-depth study of groundwater in McCook Lake area.

Buell, Winter, Mousel, and Associates, Sioux City, Iowa. Preliminary Engineering Report of Proposed Dredging Work at McCook Lake. 1980. Document listed plans for dredging the lake.

Smith, Leonard E. Comprehensive Plan for the Preservation and Restoration of McCook Lake. Document outlined a 5 phase restoration proposal for McCook Lake.

South Dakota Department of Water and Natural Resources. Ordinary High Water Mark Investigation For McCook Lake. 1981. OHWM set at 1090.7 feet msl and OHWL set at 1090.3 feet msl.

South Dakota Department of Water and Natural Resources, South Dakota Lakes Survey. 1981. Document presented geographical, physio-chemical, biotic, edaphic, and other descriptive information on McCook Lake.

Union County Conservation District. Soil and Water Conservation Plan. United States Department of Agriculture Soil Conservation Service. 1982. Document included soil loss estimated for selected plots near McCook Lake.

Corps of Engineers. Feasibility Study For Water Level Maintenance at McCook Lake. Omaha District, South Dakota. 1983. Proposed that dredging of the lake to the sand bottom will result in more rapid equilibration of the lake and ground water levels.

## METHODS AND MATERIALS

Water quality sampling for this study was limited to three sites in McCook Lake (Figure 2). Unlike the standard lake environment, McCook has no clearly defined surface tributaries flowing either into or out of the basin. Although it can be assumed that there is a very limited amount of sheet flow into the lake from those areas directly adjacent (immediate shoreline property), the groundwater is the predominant source of recharge and the principal receiving body. The specific location and rational for the in-lake sites is as follows:

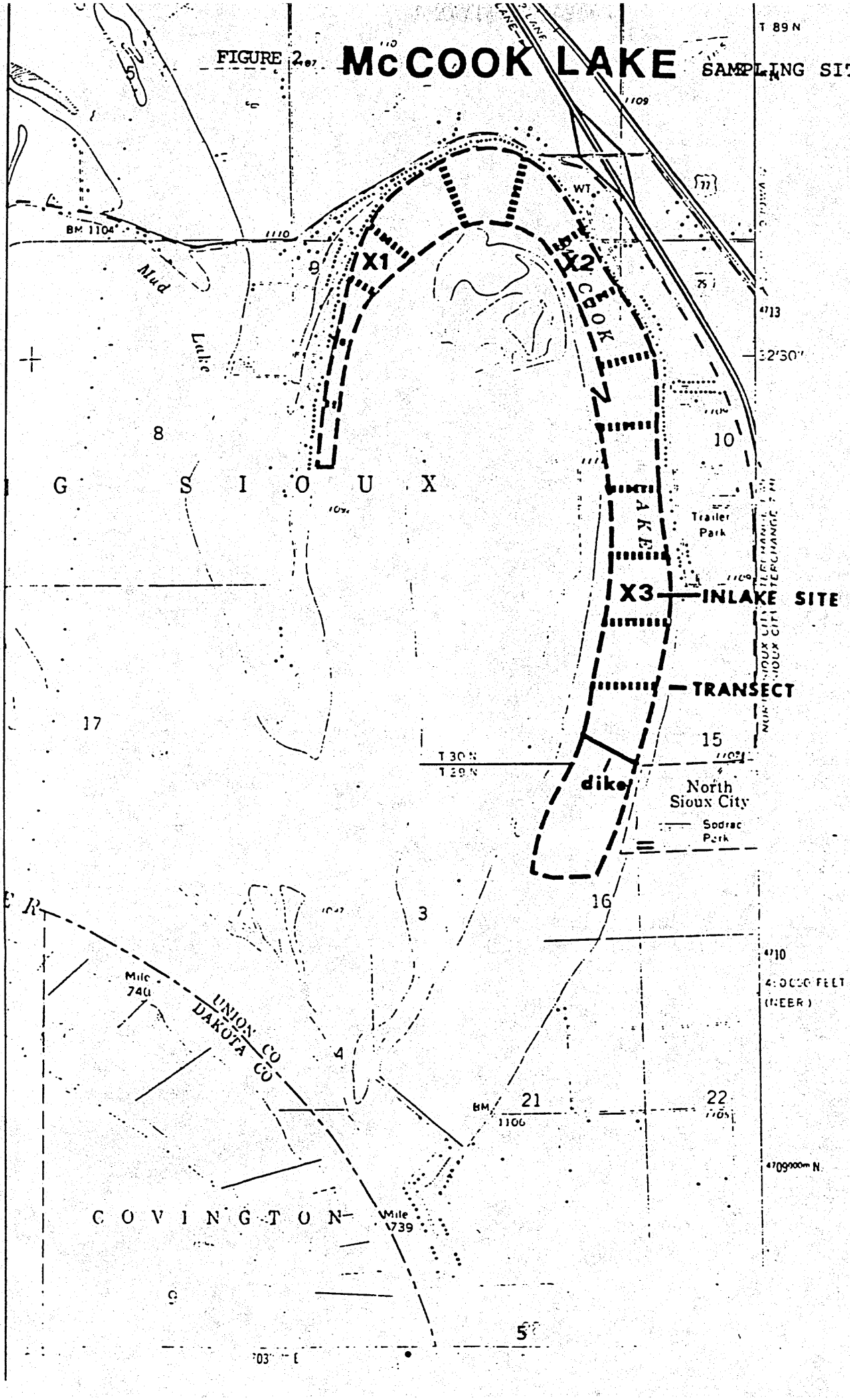


FIGURE 2.
McCOOK LAKE SAMPLING SITES
T 89 N
X1
X2
X3
INLAKE SITE
TRANSECT
McCOOK LAKE
Mud Lake
G S I O U X
COVINGTON
North Sioux City
Trailer Park
Sodrac Park
dike
UNION CO
DAKOTA CO
Mile 740
Mile 739
BM 1104
BM 1106
T 30 N
T 29 N
8
10
15
16
17
21
22
3
4
5

Site 1 - Located in the west arm of the lake near the point where the lake broadens to the north. Latitude: 42 deg 32 min 17 sec N. Longitude: 96 deg 31 min 17 sec. Site 1 samples are representative of water quality in the west arm of McCook Lake.

Site 2 - Located in the northeast area of the lake slightly south of the northern point of the inner land mass. Latitude: 42 deg 32 min 41 sec N. Longitude: 96 deg 30 min 33 sec. Site 2 samples are representative of water quality in the widest portion of McCook Lake.

Site 3 - Located in the east arm and approximately equidistant between the trailer park and the newly constructed dike. Latitude: 42 deg 31 min 54 sec N. Longitude: 96 deg 30min 45 sec. Site 2 samples are representative of water quality in the east arm of McCook Lake.

As listed in the following table (Table 2), the sampling period for this study extended from August 4, 1988, through September 25, 1989. During that period, a total of 66 samples were collected from the three sites.

TABLE 2. SAMPLING PERIOD AND NUMBER OF SAMPLES

| SITE # | SAMPLE TIME PERIOD FROM: | | TO: | # OF SAMPLES |
|---|---|---|---|---|
| 1 | 8/4/88 | - | 9/25/89 | 22 |
| 2 | 8/4/88 | - | 9/11/89 | 21 |
| 3 | 8/4/88 | - | 9/25/89 | 23 |

The schedule for the collection of water quality samples at the three in-lake sites was comparable to that used at other D/F Study projects. At each of three sites, two samples were collected per month from April through September, and one sample was collected per month from October through March except during unsafe ice periods. Under average conditions, samples are collected at the surface and bottom at each site. However, because of the relatively shallow depth of McCook Lake - average of approximately 4 feet - only surface samples were collected. The "surface" sample is actually a grab sample collected approximately 6 inches below the water surface.

The laboratory analyses were conducted by the South Dakota State Health Laboratory in Pierre, South Dakota. Field sample collection and analyses were done by local residents. Groundwater data for the McCook Lake area was provided by the

Division of Water Rights of the SD Department of Water and Natural Resources.

The raw water quality data was compiled by the Water Resources Management Division of the Department of Water and Natural Resources. Water quality data was loaded onto computer files and was analyzed for trends. A minimum, mean, and maximum were calculated for each of the parameters.

The water quality parameters that were sampled for at each of the three in-lake sites are shown in Table 3. A description of each of the parameters may be found in Appendix A.

Table 3. Water Quality Parameters

| Parameter | |
|---|---|
| Water Temperature | Total Solids |
| Air Temperature | Total Dissolved Solids |
| Secchi Disk | Total Suspended Solids |
| Dissolved Oxygen | Ammonia |
| Field pH | Nitrates + Nitrites |
| Fecal Coliform Bacteria | Total Kjeldahl Nitrogen |
| Specific Conductance | Total Phosphorus |
| Laboratory pH | Orthophosphate |
| Total Alkalinity | Unionized Ammonia |

A sediment survey was completed for McCook Lake during July of 1989. Topographic maps showing bottom contours and sediment depth contours of the lake is included in Appendix B. Elutriate samples have been collected and sent to the U.S. Army Corps of Engineers Laboratory in Omaha, Nebraska. Results of the elutriate samples will be available during mid-1990. An elutriate sample is sediment sample which is analyzed for toxic chemicals and/or metals. The results of these analyses will be appended to this report at a later date.

## RESULTS AND DISCUSSION

A review of the water quality samples from the three in-lake sites produced somewhat predictable results. Most of the concentrations of the parameters were within the legal limits set by the Surface Water Quality Standards of the State of South Dakota (Table 1). However, factors such as Secchi Disk for determining water clarity and total phosphorus to predict biomass are not subject to standards limitations. Therefore, a simple review of standards violations is somewhat misleading.

Generally, the established standards for the concentrations of selected parameters are based upon the results of a 24-hour representative, composited sample. The numerical value of a parameter found in any one grab sample collected during the period may not exceed 1.75 times the applicable criterion. As an

example, any single grab sample what yields a suspended solids number in excess of 157.5 mg/l is in violation of the standards (90 mg/l·x 1.75). Also, the standard for pH states that the applicable criterion is to be maintained at all times, without exception. For McCook Lake, the pH should not be below 6.5 units or above 8.3 units. All of the water quality samples collected for this project were individual grab samples. The results of the water quality sampling analyses for the McCook Lake Diagnostic/Feasibility are summarized in Table 4.

Table 4. McCook Lake Water Quality Data

| Site # | 1 | 2 | 3 |
|---|---|---|---|
| # of Samples | 22 | 21 | 23 |
| **Water Temperature (°F)** | | | |
| minimum | 34.0 | 34.0 | 34.0 |
| maximum | 82.0 | 82.0 | 80.0 |
| mean | 64.4 | 64.2 | 64.0 |
| **Air Temperature (°F)** | | | |
| minimum | 20.0 | 20.0 | 20.0 |
| maximum | 85.0 | 89.0 | 85.0 |
| mean | 65.0 | 65.6 | 65.7 |
| **Secchi Depth (ft.)** | | | |
| minimum | 0.5 | 0.5 | 0.5 |
| maximum | 3.5 | 3.0 | 3.0 |
| mean | 1.7 | 1.7 | 1.6 |
| **Dissolved Oxygen (mg/l)** | | | |
| minimum | 6.2 | 6.9 | 6.0 |
| maximum | 18.5 | 14.5 | 17.0 |
| mean | 9.6 | 9.5 | 9.3 |
| **Field pH (standard units)** | | | |
| minimum | 6.0 | 6.3 | 6.2 |
| maximum | 8.8 | 8.9 | 8.4 |
| mean | 7.7 | 7.8 | 7.6 |
| **Fecal Coliform (organisms/100ml)** | | | |
| minimum | 10 | 0 | 10 |
| maximum | 260 | 50 | 240 |
| mean | 36 | 15 | 56 |
| **Conductivity (mg/l)** | | | |
| minimum | 708 | 634 | 774 |
| maximum | 1060 | 1081 | 1134 |
| mean | 833 | 827 | 861 |
| **Laboratory pH (standard units)** | | | |
| minimum | 8.08 | 8.03 | 7.85 |
| maximum | 8.86 | 8.83 | 8.63 |
| mean | 8.42 | 8.37 | 8.30 |
| **Total Alkalinity (mg/l)** | | | |
| minimum | 119 | 119 | 137 |
| maximum | 264 | 286 | 356 |
| mean | 182 | 187 | 211 |

| Site # | 1 | 2 | 3 |
|---|---|---|---|
| # of Samples | 22 | 21 | 23 |
| **Total Solids (mg/l)** | | | |
| minimum | 544 | 446 | 547 |
| maximum | 782 | 827 | 845 |
| mean | 638 | 639 | 670 |
| **Total Diss. Solids (mg/l)** | | | |
| minimum | 515 | 419 | 522 |
| maximum | 760 | 760 | 805 |
| mean | 577 | 578 | 599 |
| **Total Susp. Solids (mg/l)** | | | |
| minimum | 27 | 21 | 16 |
| maximum | 149 | 129 | 142 |
| mean | 63 | 60 | 71 |
| **Ammonia (mg/l)** | | | |
| minimum | 0.02 | 0.02 | 0.02 |
| maximum | 0.52 | 0.15 | 0.75 |
| mean | 0.09 | 0.04 | 0.11 |
| **Nitrate + Nitrite (mg/l)** | | | |
| minimum | 0.1 | 0.01 | 0.1 |
| maximum | 0.2 | 0.4 | 0.2 |
| mean | 0.1 | 0.11 | 0.1 |
| **Total Kjeldahl Nitrogen (mg/l)** | | | |
| minimum | 0.17 | 0.27 | 0.10 |
| maximum | 1.27 | 1.12 | 1.29 |
| mean | 0.56 | 0.56 | 0.55 |
| **Total Phosphorus (mg/l)** | | | |
| minimum | 0.041 | 0.024 | 0.037 |
| maximum | 0.170 | 0.203 | 0.231 |
| mean | 0.091 | 0.098 | 0.103 |
| **Orthophosphate (mg/l)** | | | |
| minimum | 0.005 | 0.005 | 0.005 |
| maximum | 0.025 | 0.058 | 0.022 |
| mean | 0.009 | 0.011 | 0.008 |
| **Unionized Ammonia (mg/l)** | | | |
| minimum | 0.000 | 0.000 | 0.000 |
| maximum | 0.024 | 0.024 | 0.017 |
| mean | 0.002 | 0.003 | 0.003 |

Based on the results of the data evaluation, the parameters of concern for McCook Lake are pH, suspended solids, sediment accumulation and fecal coliform. Each one of these parameters exhibits either violations of existing standards and/or may be responsible for limitations on beneficial uses. The following discussion details the rational for focusing on each parameter.

**pH**

As noted above, the water quality standard for pH states that the pH must fall in a range between 6.5 units and 8.3 units. The field pH measurements were below the minimum standard at site 1 and site 2 on June 26, 1989, and at site 3 on March 20, 1989 and August 2, 1989. During the sampling period, the maximum standard for pH was exceeded 7 times each at site 1 and site 2 and, 3 times at site 3. The total number of samples collected during the study was 66. Of these, 26 percent of the samples were above the maximum standard for pH. The maximum pH for all of the samples was 8.9. This is 0.6 units above the maximum standard for the immersion recreation beneficial use classification for McCook Lake. Limited evidence indicates that pH in excess of 8.3 units may cause minor eye irritation in swimmers. The high pH values are attributed to the soil conditions in the area.

**Suspended Solids**

The standard concentration for suspended solids at McCook Lake is 90 mg/l. As noted earlier, when dealing with individual grab samples the standard concentration may be multiplied by 1.75 for an allowable concentration of 157.5 mg/l. A total of 15 grab samples had total suspended solid concentrations in excess of 90 mg/l. Approximately 26 percent of the samples had concentrations of suspended solids above 90 mg/l with a maximum of 149 mg/l. While none of the sample concentrations exceeded the 157.5 mg/l standard and were therefore not considered in violation of the standard, these concentrations are excessive. Concentrations of suspended solids at this level impair recreation by giving the water a muddy appearance and subsequent reduced appeal. The resultant decrease in lake use could have an adverse effect on the local economy. High concentrations of suspended solids in the lake may also adversely effect sight feeding species of fish, reduce oxygen intake by clogging gills and inhibit the growth of desirable aquatic plants by reducing light transmission.

**Fecal Coliform**

Fecal coliform organisms are the bacteria which inhabit the digestive systems of warm-blooded animals. The presence of these bacteria in water is indicative of human or animal waste. The water quality standards for fecal coliform organisms state that a sample may not exceed a count of 400 per 100 ml in any one sample from May 1 to September 30. None of the samples exceeded 400 per 100 ml sample during the sampling period. The standard for a geometric mean based on a minimum of 5 samples during separate

24-hour periods is 200 per 100 ml. One sample from site 1 on August 4, 1988 and one sample from site 3 on September 11, 1989 exceeded 200 ml per 100 ml. While this does not represent a violation of standards, these numbers indicate potential for a violation. Possible sources of this bacteria in McCook Lake include wild mammals or birds, domestic animals or livestock, or malfunctioning sewer system for homes near the lake.

**Sediment**

McCook Lake has a mean sediment depth of approximately 4.5 feet. The total volume of soft sediment in the lake is estimated to be approximately 1,700,000 cubic yards. The soft sediment consists of fine clay particles, with fine sand lying below the clay.

Because of shallow depths, the fine sediment is constantly stirred up by the wind, power boat propellers, jet skis, etc. This fine sediment inhibits light transmission through the water column and gives the water a dirty appearance. The lake has no tributary system and a very small watershed. Therefore, McCook Lake receives almost no surface loading of sediment or nutrients.

Most of the sediment was deposited in the lake during floods of the Missouri River. The Missouri River floods of the 1950s, in particular, deposited a large amount of silt into McCook Lake. In 1952 a local dredge project was initiated but was abandoned due to lack of funds. In 1955, Public Law 163, 84th Congress, authorized the U.S. Army Corps of Engineers to spend up to $150,000 to restore a reasonable water level in the lake, provided that State and local interests contributed an equal amount for the restoration. Construction funds were allotted in August, 1955, and 1,210,000 cubic yards of material were removed by dredging. The project was completed in 1956 at a cost of $147,600.

During the 1989 sediment survey of the lake it was found that the fine clay sediment lies on top of a sand bottom. This silt varies in thickness from 1.8 feet. to 10+ feet, with a mean soft sediment thickness of approximately 4.5 feet. Removal of this soft sediment layer by dredging would have a long term effect of clearing the water by removing the source of the suspended solids. In addition to removing the suspended solids, the total phosphorus concentration would also be lowered by removing the clay particles. Phosphate ions in a lake have the tendency to sorb on to the clay particles. Therefore, removal of the clay will result in a reduction of phosphorus in the water column.

## CONCLUSION

Water quality in McCook lake is generally better than most eastern South Dakota prairie lakes. Nutrient concentrations in the lake are within acceptable limits with regard to the potential for producing nuisance aquatic vegetation. The lack of depth and existence of fine clay sediment are the factors which cause recreation in the lake to be impaired.

The surface level of McCook Lake is controlled almost entirely by the groundwater table surrounding the lake. The water level in the lake is roughly in equilibrium with the water table of the surrounding area. By examining the water table elevation in the area around the lake, it is evident that the groundwater gradient slopes from the northeast towards the Missouri River to the south. Because of this gradient, the lake level will continue to decline as a result of bed degradation in the Missouri River.

When the groundwater table drops, the lake level also decreases. The clay sediment layer in the lake probably retards the lake level response to the groundwater changes.

## RESTORATION ALTERNATIVES

The alternatives considered for restoration of McCook Lake include the following:

1. No action.
2. Selective Dredging/Boating Restrictions.
3. Whole Lake Dredging.

### No Action:

If the no action alternative is selected, the lake will not improve. There is virtually no new external loading of suspended solids. The lake will continue to lose depth due to the degradation of the bed of the Missouri River. As the lake becomes too shallow for water based recreation, emergent macrophytes will take over the lake. Odor problems may develop due to decaying vegetation. Recreation will be increasingly impaired.

### Selective Dredging/Boating Restrictions:

If selected areas in the lake basin are dredged, there will be several improvements. Fish habitat will be enhanced and the threat of summer and winter fishkill will be reduced. There will be better control of macrophytes in the dredged areas. Selective dredging is less expensive and less time-consuming than whole

lake dredging. Fewer sediment disposal ponds would need to be constructed - an additional cost saving. Suspended solids may remain a problem, depending on how much sediment is removed, due to resuspension of the remaining sediment by wind or recreation activities. If dredging is concentrated in areas with greatest sediment accumulation that is prone to wind and wave action, lake improvements would be most noticeable. In addition, dredging thick layers of sediment would improve dredging efficiency. In areas with less than three feet of sediment, establishment of boating restrictions (slow zones or no-wake zones) would tend to minimize resuspension of bottom sediment. Hydraulic residence time (time for water to move through the lake) will be decreased from present conditions but would not be reduced as much as with whole lake dredging.

Whole Lake Dredging:

If the entire lake is dredged, there will be several effects. Fish habitat will be enhanced and the threat of summer and winter fishkill will be reduced. Suspended solids in the water column will be reduced and the lake will be aesthetically improved. Whole lake dredging is the most expensive and time-consuming of the alternatives considered. More sediment would be removed by whole lake dredging compared to selective dredging, but additional disposal ponds would be needed for the additional sediment. Either selective dredging or whole lake dredging will extend the life of the lake by increasing volume and depth in attempts to offset the declining lake level. Recreation will be enhanced under either scenario.

Dredging Considerations

Dredging of McCook lake does have some potential problems which should be considered before any restoration activity is started. In an extended drought, the groundwater table could fall below the lake bottom causing the lake to go dry. If either selective or whole lake dredging were completed, the effectiveness of pumping additional water into the lake would be decreased. Due to the improved (cleared) groundwater connection, water pumped into the lake from the Missouri River or the well on the east side of the lake would be lost more rapidly to the groundwater system.

Removal of the soft sediment (clay) may result in a faster response time for lake level fluctuations as the groundwater table rises or falls. Because of the more rapid response time to the groundwater table, it can be assumed that if the lake was either selectively or completely dredged, the lake level would drop more rapidly during drought periods and fill more rapidly during wet periods. With selective dredging, the response would be quicker than current conditions but slower than if the entire lake was dredged. However, the effect of dredging would be to extend the useful life of the lake as a recreational resource.

By removing sediment from the lake, the suspended solids concentration will be reduced in the water column. With the lower concentrations of suspended solids, the transparency of the water will increase. With increased transparency, more light may reach the bottom of the lake and stimulate aquatic plant growth. The lake should be monitored for plant growth and if plants start to become a problem, corrective measures such as harvesting, chemical treatment, or bottom sealing should be considered.

## RECOMMENDATION

Based on the information collected in the course of this study and an evaluation of historical baseline data, the Water Resources Management Division of the Department of Water and Natural Resources recommends that restoration activities of McCook Lake be accomplished using a two-step approach beginning with selective dredging in areas with maximum sediment accumulation and establishment of boating restrictions, then continued dredging, as funding permits, in areas with lesser amounts of sediment.

This choice appears to be the most logical and economically feasible alternative. Important factors of this decision are cost and effectiveness. We believe that the desire to return the lake to a high quality multiple use resource is best accomplished using cost-effective, and efficient methods.

The cost of dredging (estimated from state experience) would be approximately $200,000 per year, using a 10 inch dredge. This cost includes operation and maintenance of the dredge, fuel, labor, sediment disposal pond construction, administration, and amortization of equipment (Figure 3). This cost is intended as an estimate and may vary with conditions and over time.

At present, all state dredges are committed under contract or are in contract negotiation stages with other lake restoration projects in the state. Since a dredge exists at McCook Lake - the old Lake Herman dredge - The Department suggests that a serious attempt be made to use that dredge on site. The Department is willing to offer technical assistance for dredge inspection, maintenance, crew training, water quality training and monitoring, and project operation.

The Department suggests that initial dredging be concentrated in the areas indicated on Figure 4. The areas identified contain sediment in excess of four feet (up to 10+ ft) and would represent areas where dredging efficiency would be the greatest. If desired, an access channel could be dredged from the boat dock/public access areas to the open-water dredged areas. In addition, we suggest establishing boating regulations that would minimize resuspension of sediment in narrow and shallow areas not dredged (see Figure 4). Regulations such as a "Slow Zone" or a "No-Wake Zone" may accomplish the desired results.

# FIGURE 3. COMPARATIVE DREDGING COSTS

## Projected Average Annual Expenses

| Activity | 8-Inch Dredge | 10-Inch Dredge | 14-Inch Dredge |
|---|---|---|---|
| Labor | $55,000 | $60,000 | $70,000 |
| Fuel | $25,000 | $30,000 | $40,000 |
| Repair | $20,000 | $25,000 | $35,000 |
| Misc. | $25,000 | $25,000 | $40,000 |
| Constr. | $40,000 | $50,000 | $75,000 |
| Admin. | $9,500 | $3,000 | $9,500 |
| Subtotal | ($174,500) | ($193,000) | ($269,500) |
| Equipment | $12,500 | $16,700 | $35,000 |
| TOTAL | $187,000 | $209,700 | $304,500 |

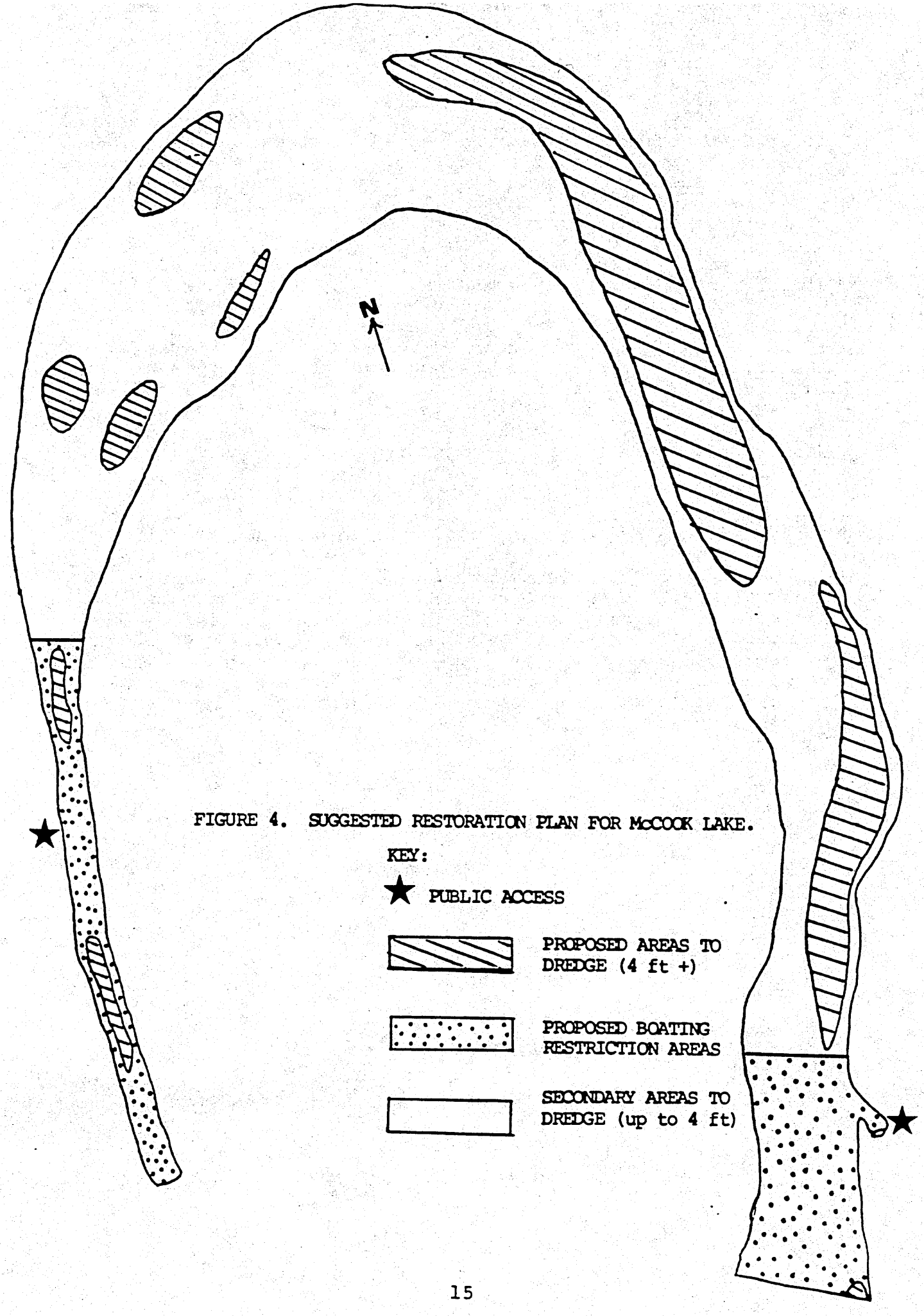



FIGURE 4. SUGGESTED RESTORATION PLAN FOR McCOOK LAKE.

If dredging progressed satisfactorily with the existing dredge, sediment removal activities could be expanded to areas with less than four feet of sediment. Efficiency, however, may decrease since movement of the dredge would be more frequent, but maximum sediment removal should be the final restoration goal.

With selective dredging, lake depths would be increased significantly in areas dredged (Figure 5). Depths would at least be doubled from 4.5 feet to 9 or 10 feet. In several locations, primarily in the northeast and southeast areas, depths would be increased by three or four times to a maximum of nearly 16 feet. The effect of increasing depth would promote improvement in water quality and would also benefit the sport fishery. The diversity of varying depths and substrates would also be beneficial to the fisheries and its forage base as it would provide a wide range of habitat and potentially an array of oxygen and thermal zones.

There is a possibility that a state-owned dredge may become available during the life of this project. If the old Herman dredge is in poor operating condition or becomes inefficient to operate, the local sponsor may request use of the state dredge. The project, at that time should be included on the State Water Plan and if the sponsors intend to request state funding assistance, a formal application must be submitted for Consolidated Water Facilities Construction funds. If current negotiations with other project sponsors are successful and all state dredges become committed on those projects, the earliest estimated date that a dredge would be available for work on McCook Lake would be 1992.

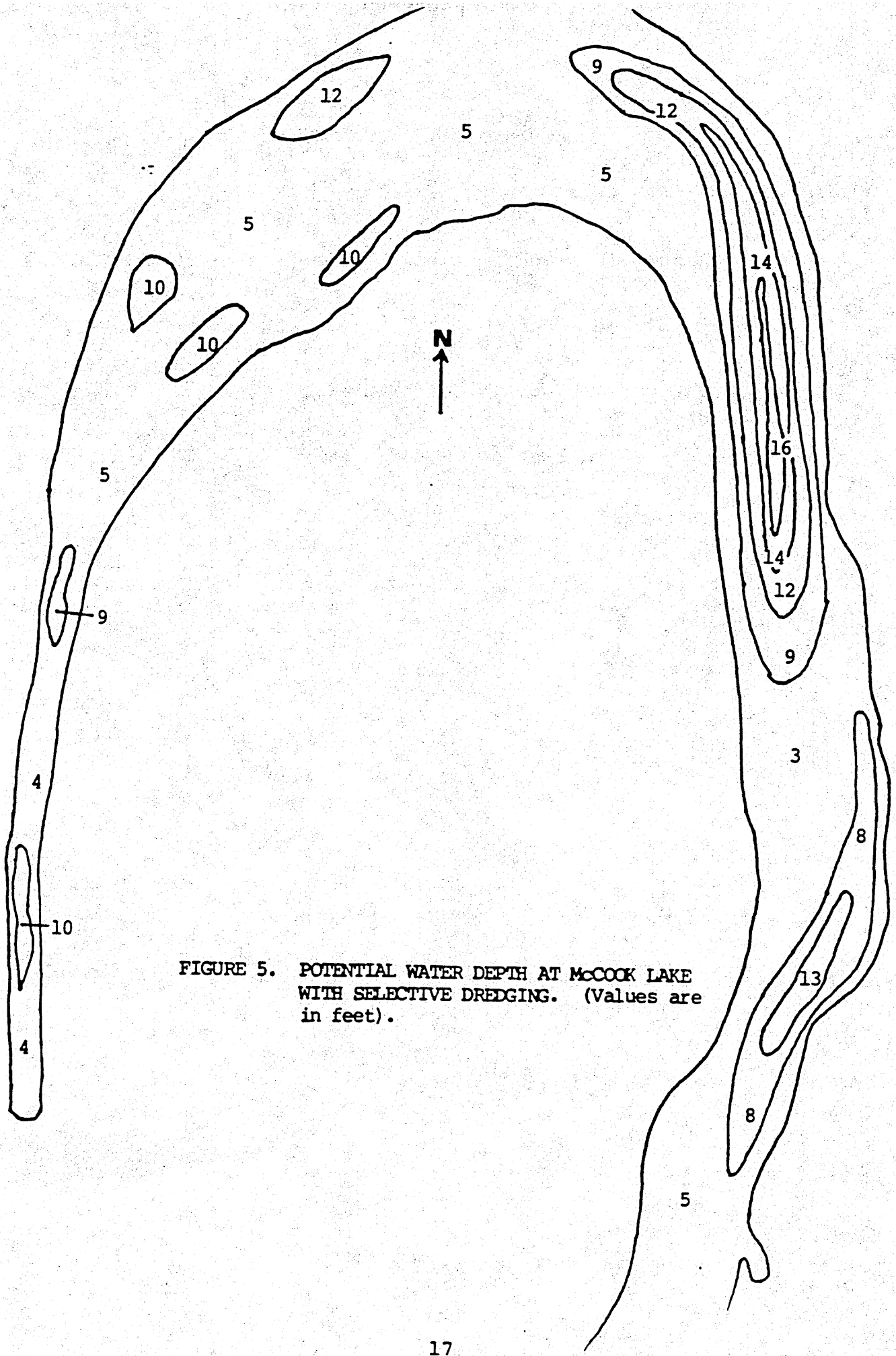



FIGURE 5. POTENTIAL WATER DEPTH AT McCOOK LAKE WITH SELECTIVE DREDGING. (Values are in feet).

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# APPENDIX A. DESCRIPTIONS OF WATER QUALITY PARAMETERS

## WATER QUALITY PARAMETERS

1. **Laboratory Analysis:**

   a. Fecal coliform (organisms/100ml) can indicate fecal contamination and thus potential human health hazards. Fecal coliform bacteria are bacteria which live in the digestive tract of warm-blooded animals. These bacteria are considered to be an indicator of sewage pollution or livestock manure. Fecal coliform bacteria are not found in the digestive tract of cold-blooded animals such as fish, amphibians or reptiles. Some fecal coliform will exist in nature from the fecal material of wild animals or birds.

   b. Biochemical oxygen demand (BOD) (mg/l) is used to measure the organic content in polluted waters. BOD is a measurement of the potential for oxygen removal from the water and an indicator of organic pollution. As organisms die, the process of decomposition by bacteria removes dissolved oxygen from the water. The more nutrient rich the environment, the more potential for growth of aquatic organisms; hence, there will be more bacterial decomposition.

   c. Laboratory pH (su) is a measurement of the hydrogen ion activity which directly affects the toxicity (solubility) of heavy metals in water, among other items. The pH scale is a number range between 1 and 14, with 7 being neutral. Any value less than 7 is considered acidic and any value greater than 7 is considered basic.

   d. Suspended solids (mg/l) can indicate the sediment load into a body of water and possible problems to the biological community. Suspended solids does not include a measure of larger particles that are moved along the stream bed during high flows.

   e. Total solids (mg/l) are used to determine dissolved solids by subtracting suspended solids from total solids. Dissolved solids may have a detrimental affect on the biological community.

   f. Ammonia-nitrogen (mg/l) is a product of the first oxidative step in degrading organic material. It is directly available to plants as a nutrient for growth. Ammonia can be used as evidence of organic pollution and the unionized fraction of ammonia is toxic to fish.

   g. Nitrate-nitrogen (mg/l) constitutes the inorganic nitrogen fraction which is used by phytoplankton. Nitrate-nitrogen also indicates pollution from animal

wastes, fertilizers or nitrogenous organic matter which are used by algae. It gives an indication as to what may be causing pollution in a lake (i.e., fertilizers, animal wastes, nitrogenous organic matter).

h. Total Kjeldahl Nitrogen (mg/l) is used to measure both ammonia and organic nitrogen. Ammonia is subtracted from TKN and results in the organic nitrogen fraction which can be broken down to nitrogen compounds which are utilized by phytoplankton.

i. Total phosphorus (mg/l) represents all of the phosphorus found in the water sample. Not all of the phosphorus is immediately available to aquatic plants and algae. Phosphorus is an element which is essential to all life and is the least available to living organisms. For this reason, phosphorus is commonly the limiting factor for biological productivity. When phosphorus concentrations are high, nuisance growth of aquatic plants or algae may result.

j. Ortho-phosphorus (mg/l) is analyzed because it is phosphorus which is immediately available to algae.

2. **Field Analysis:**

a. Water temperature (F or C) is taken since it has considerable effect on the chemical processes in a lake. Also, temperature is important to fish life and other aquatic species.

b. Field pH (su) measures the hydrogen ion activity which can affect the toxicity of heavy metals in the water, as well as other factors.

c. Dissolved oxygen (mg/l) is an indicator of the overall health of the lake and it is needed to sustain most aquatic animal life.

d. Climatic conditions - wind, precipitation, air temperature (F or C).

e. Visual observations - septic conditions, odor, water color, turbidity or anything unusual (e.g. dead fish).

f. Tributary flow depth (ft.) to calculate flows entering the lake.

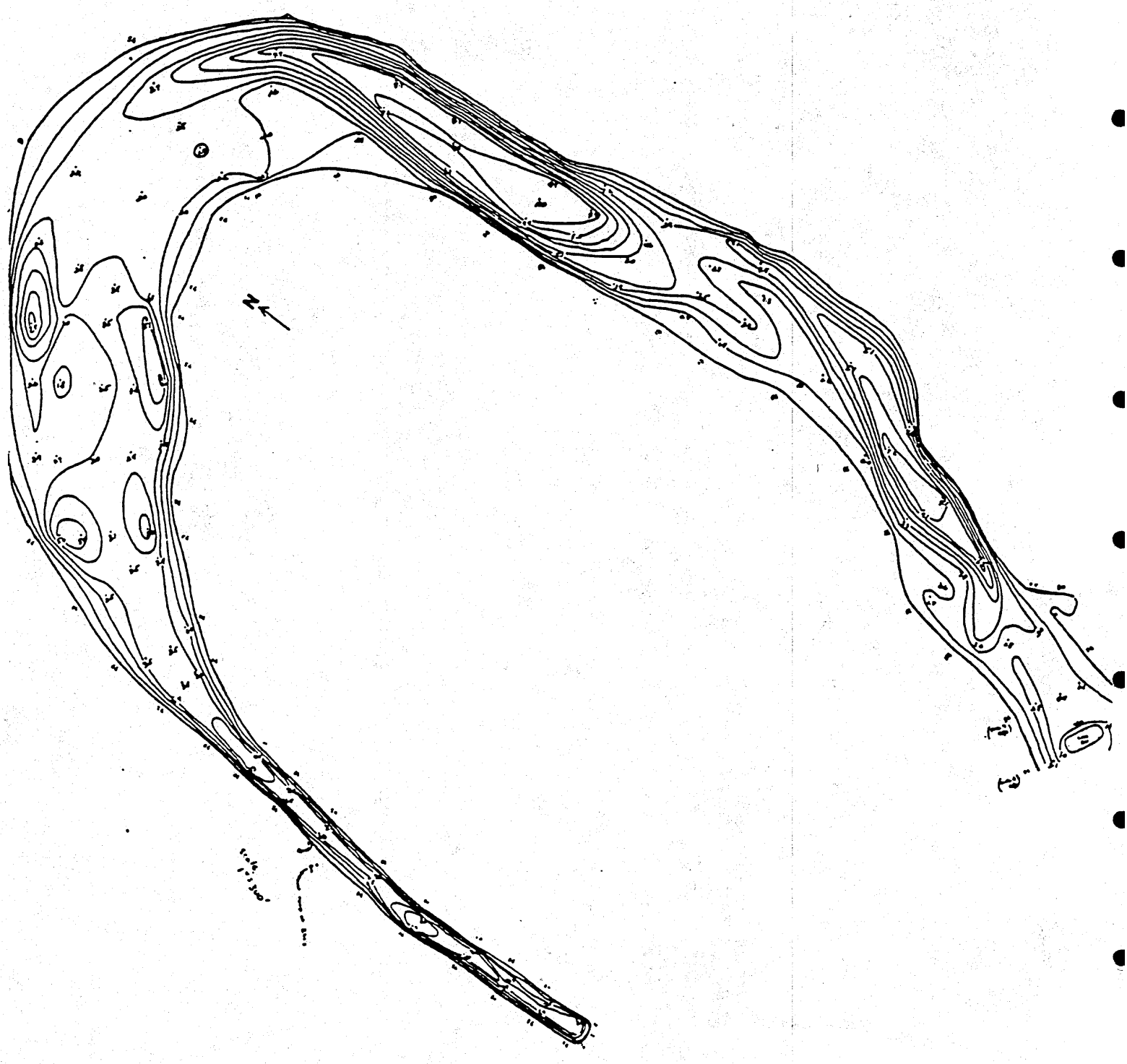
g. The following additional measurements are taken for in-lake analysis: water depth, oxygen profiles, composite sampling at various lake depths (surface, mid-depth, and bottom), chlorophyll a, secchi disc (visibility) and phytoplankton identification.

3. **In-lake Sediment Sampling:**

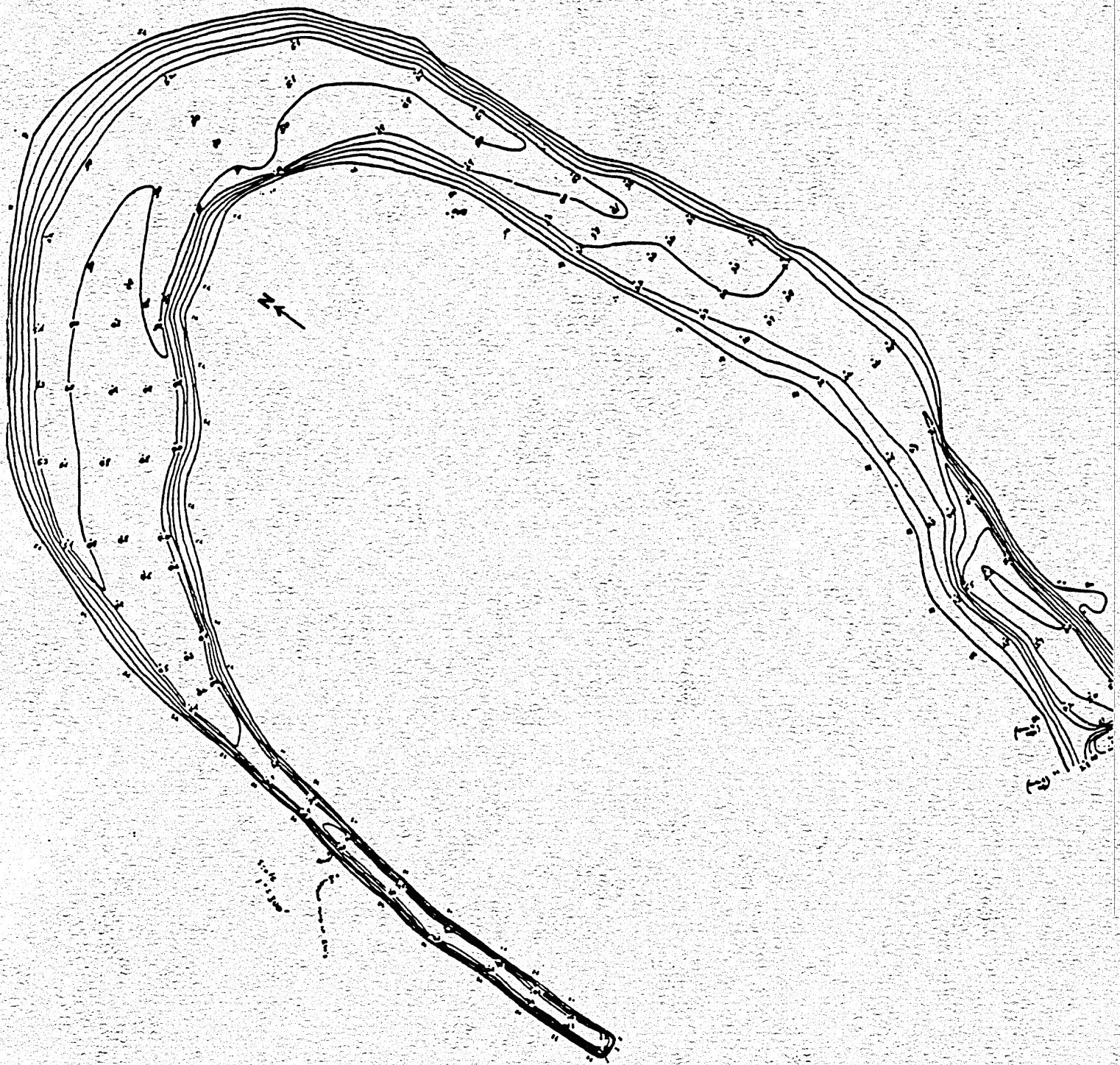
a. Corps of Engineers elutriate test for some of the above mentioned parameters plus selected pesticides: such as endrin, ddt, parathion, etc., is used to determine what is in the sediments.

b. Sediment topographic surveys and sediment depth measurements are used to determine sediment volumes in the lake.

# APPENDIX B. CONTOUR MAPS OF SEDIMENT AND WATER DEPTHS OF McCOOK LAKE



Sediment depth of McCook Lake. Contour interval = 1 foot




Water depth of McCook Lake. Contour interval = 1 foot