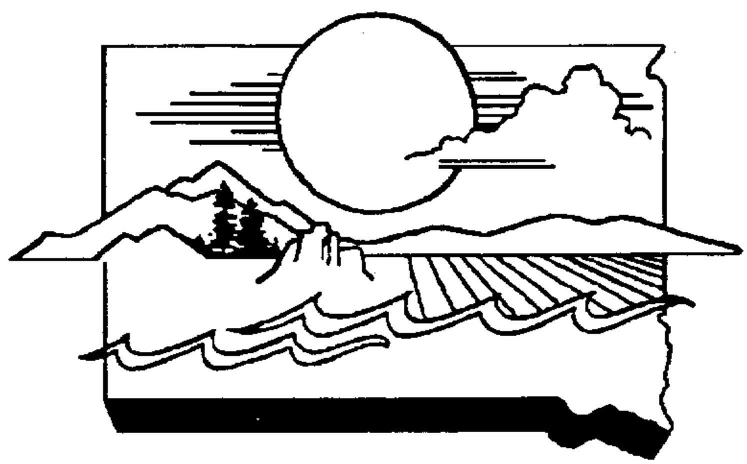
LAKE ASSESSMENT REPORT
EAST LAKE EUREKA
McPHERSON COUNTY, SOUTH DAKOTA



DIVISION OF WATER RESOURCES MANAGEMENT
SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ROBERT E. ROBERTS, SECRETARY

August, 1993

EXECUTIVE SUMMARY

East Lake Eureka is a man-made lake that has been experiencing two major problems which are negatively effecting its beneficial uses. An odor problem caused by high sulfate concentrations and a loss of depth due to sedimentation. This study was initiated by the Department of Environment and Natural Resources at the request of the City of Eureka. The purpose of the study was to provide a general assessment of the lake and identify the source of problems impairing the lakes recreational use.

East Lake Eureka has very little surface watershed. The only apparent source of surface water to the lake are the municipal storm sewers which discharge directly to the lake. The lake receives a constant flow of water from a deep artesian well.

The Study consisted of water quality monitoring of the lake, review of existing data on the soils and groundwater resources of the surrounding area, a sediment survey, and sediment sampling. Field data collection for the study was completed on April 28, 1993.

The results of the study indicate that nutrients do not appear to be excessive in Lake Eureka. There is no indication of a problem with fecal coliform bacteria. The lake does have consistently high concentrations of sulfate and total dissolved solids. East Lake Eureka has approximately 2 to 3 feet of soft sediment throughout the lake. The sediment samples collected from the lake do not show excessive levels of petroleum hydrocarbons or metals.

The source of the high sulfates appears to be the artesian well which flows continuously into the lake via the city storm sewers. Sulfates are most likely the cause of the odor problem experienced by swimmers.

Recommendations for lake restoration included dredging of the lake to recover the depth lost to sedimentation over the past 60 years and no action at this time for the sulfate concentration in the lake. In addition, the state recommends that the city consider investigating the possibility of implementing some urban best management practices to control pollution from the storm sewers. A citizens information and education program by the city explaining the proper use of lawn chemicals and fertilizers and also the proper disposal of hazardous waste may be helpful in protecting the water quality of their lake.

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LAKE ASSESSMENT PROJECT FOR EAST LAKE EUREKA

INTRODUCTION

East Lake Eureka is a man-made lake within the city limits of the town of Eureka, McPherson County, South Dakota. East Lake Eureka is connected to West Lake Eureka by a narrow channel on the west end of the lake. The sponsor of this project is the City of Eureka. The city contacted the South Dakota Department of Environment and Natural Resources (DENR) and requested assistance with a local project to restore the lake. East Lake Eureka has been experiencing degraded conditions in recent years due to sedimentation and declining water quality. The lake has historically had problems with nuisance growth of aquatic macrophytes and poor recreational fishing. The lake also serves as the swimming pool for the community and there have been reports of swimmers experiencing swimmers itch and an unpleasant odor in the water.

In response to local inquiries for assistance, the SD DENR working in cooperation with the local community, designed a Lake Assessment project for the lake. The study was implemented to identify and assess the current water quality condition of the lake, determine water quality problems and pollution sources, and develop lake restoration alternatives.

Comprehensive water quality monitoring of the in-lake waters was conducted during the period from November, 1992 through March, 1993. The lake has no tributaries so the lake level is maintained by discharge from the city storm sewers and ground water. Therefore, there was no watershed monitoring associated with this project. A sediment survey was conducted during the week of April 26, 1993 and sediment volumes were calculated. Three sediment cores were collected from the lake basin and analyzed by the South Dakota State Health Lab.

Data summaries, discussions, and management recommendations are presented in this report.

STUDY AREA DESCRIPTION AND HISTORY

East Lake Eureka is a small lake approximately 40 acres (11.4 hectares) in surface area (Figure 1.). The origin of the lake goes back to the 1930's. Prior to 1933, the area was used as a solid waste dump and as a discharge point for the city's wastewater sewer line. The Lake was created as a Public Works Administration (WPA) project beginning in 1933. The existing low spot was cleaned up, solid waste was relocated and the sewer line was rerouted away from the lake. Rather than a typical impoundment type reservoir, the lake was excavated, the shoreline rip-rapped, and a park was developed around the perimeter.

During the 1980's, an experiment to control aquatic macrophytes was

LAKE EUREKA ASSESSMENT PROJECT

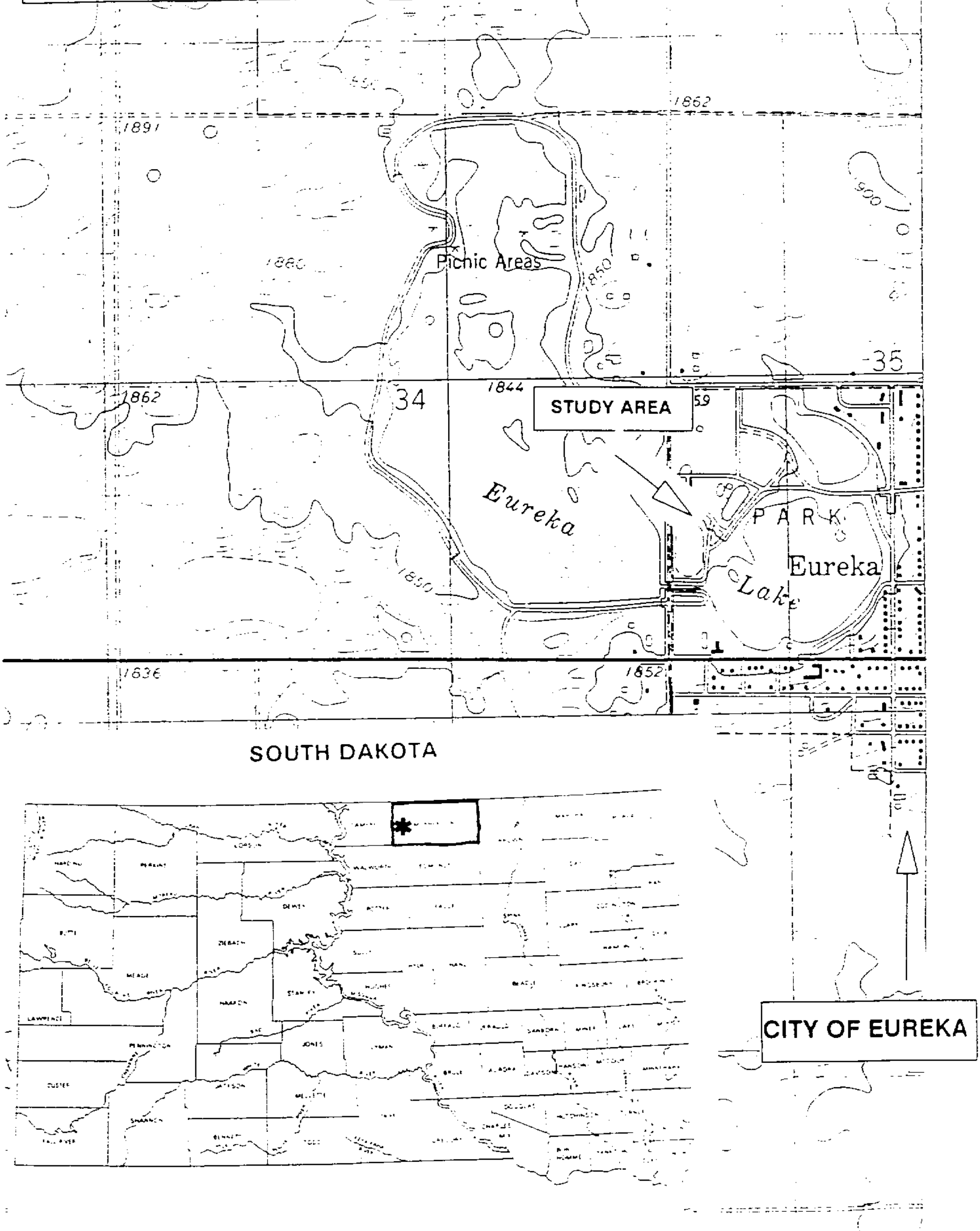

FIGURE 1 . STUDY AREA MAP

undertaken and triploid grass carp were released into the lake. At the time, the study was deemed unsuccessful because there was no measurable change in the macrophyte biomass. At the present time macrophytes do not seem to be a problem for the lake, most likely due to the turbidity of the lake and hence, the lack of sunlight transmission to the bottom sediments.

The lake has only a very small surface watershed with the exception of the municipal storm sewers. The soils of the Lake Eureka area are of the Williams-Vida association. The soils of this association are described as being well drained, undulating to hilly, loamy soils on uplands.

For most of the lake's existence, the water level has been maintained by use of an artesion well. The average annual precipitation for the Lake Eureka area is 16.94 inches. East Lake Eureka discharges to West Lake Eureka which discharges to a wetland complex that appears to be a closed basin.

The City of Eureka has a population of 1,197 according to the 1990 census records. The city has developed recreational use of East Lake Eureka with the construction of a public beach with a swimming dock and bath house. The beach is regularly maintained and in good condition. The beach is monitored for fecal coliform bacteria and has no recorded exceedences or records of closure to the public. The lake has picnic and shorefishing areas around the shore and a boat ramp. The fishery consists of northern pike and panfish for the most part.

WATER QUALITY STANDARDS

The water quality standards for East Eureka Lake are based upon the beneficial uses assigned to the lake by the State of South Dakota. Each beneficial use category has a set of water quality criteria established for it. East Lake Eureka has the assigned beneficial uses of warmwater semipermanent fish life propagation, immersion recreation, limited contact recreation, and wildlife propagation and stock watering. The water quality criteria for East Lake Eureka are a summary of the criteria defined for all the use categories using the most stringent values for individual parameters. The water quality criteria for East Lake Eureka are listed in Table 1.

Table 1. East Lake Eureka Water Quality Standards

Parameters	Criterion
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
Undissassociated Hydrogen Sulfide	≤ 0.002 mg/l
pH	>6.5 units and
	<8.3 units
Total Alkalinity	≤ 750 mg/l
Total Dissolved Solids	≤ 2500 mg/l
Conductivity	≤ 4000 micromhos/cm
Nitrates	≤ 50 mg/l (as N)
Suspended Solids	≤ 90 mg/l
Temperature	$\leq 90^{\circ}$ F
Polychlorinated Biphenyls	≤ 0.000001 mg/l
Fecal Coliform Organisms	≤ 200 per 100ml*

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

METHODS AND MATERIALS

Water Quality Sampling

Water samples were collected from three sites in East Lake Eureka (Figure 2.). There were no tributary samples collected as part of this study because there are no surface tributaries that enter the lake. The descriptions of the sampling site locations are as

LAKE EUREKA ASSESSMENT PROJECT

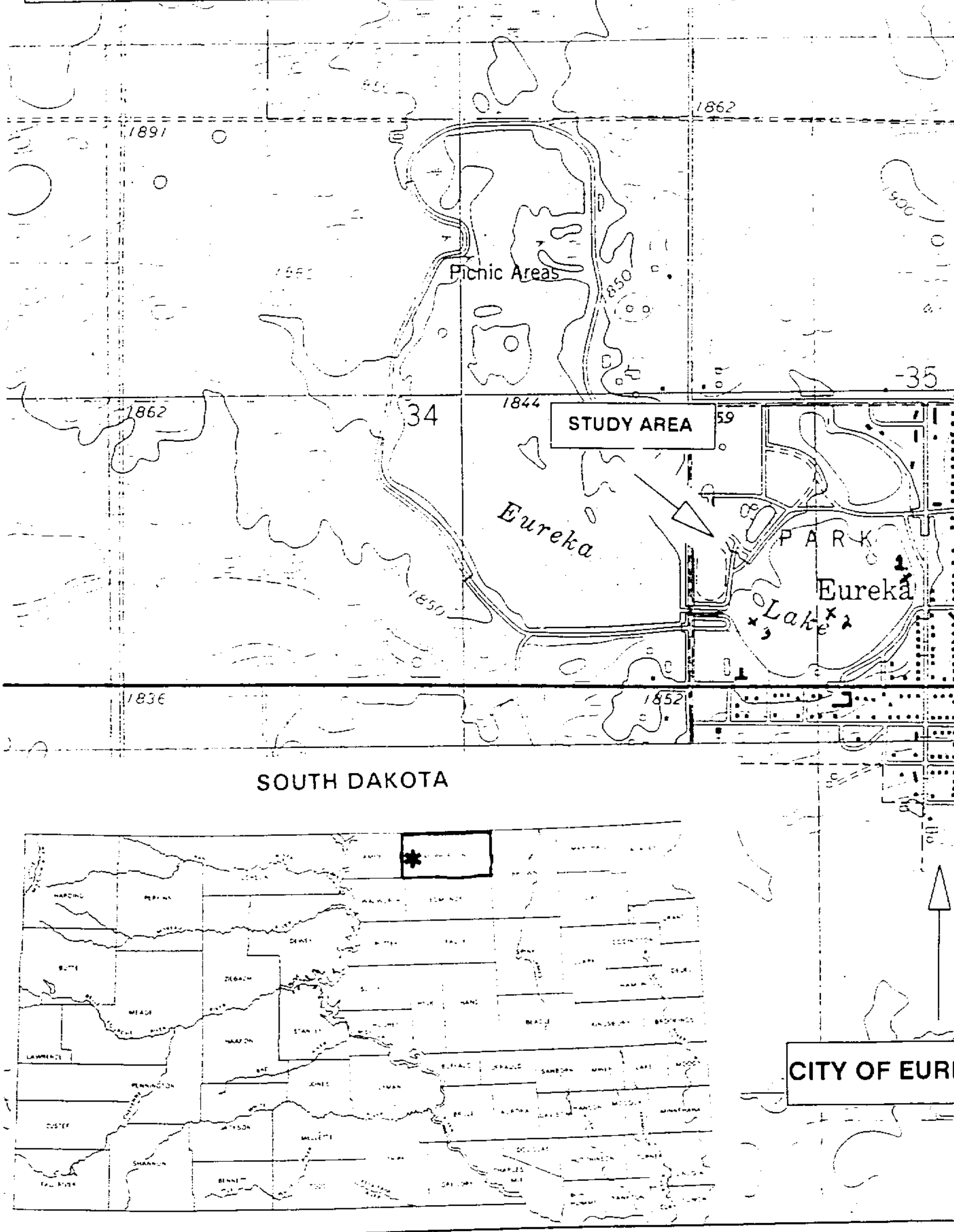

FIGURE 2. WATER QUALITY AND SEDIMENT SAMPLING SITES

follows:

Site 1 - Located at the discharge point of a city storm drain, on the east side of the lake approximately 30 feet from the shoreline. Latitude 45°46'20"N. Longitude 99°37'37". Site 1 samples are representative of the lake in the vicinity of the storm sewer discharge.

Site 2 - Located mid-lake straight out from the end of the swimming pier. Latitude 45°46'21"N. Longitude 99°37'44". Site 2 samples are representative of mid-lake conditions in East Lake Eureka.

Site 3 - Located near the west end of the lake near the outlet channel into West Lake Eureka. Latitude 45°46'21"N. Longitude 99°37'58". The conditions near Site 3 are shallow with emergent vegetation along the entire west shore of the lake.

TABLE 2.-Sample Period and Number of Samples

SITE #	SAMPLE FROM	SAMPLE TO	# OF SAMPLES
1	Nov 17, 1992	Mar 23, 1993	9
2	Nov 17, 1992	Mar 23, 1993	9
3	Dec 16, 1992	Mar 23, 1993	7
		Total Samples	25

In lake sites were sampled twice a month .5 to 1 foot below the surface. Surface samples were used because the lake is shallow with a maximum depth of no greater than 14 feet. As a result of the shallow depths, the lake is generally well mixed by winds in the area and does not stratify. Table 3 includes the parameters that were analyzed for the lake water samples. For a description of each of the water quality parameters refer to Appendix A.

The laboratory analyses of the water samples was conducted by the South Dakota State Health Laboratory. The analytical methods used for the sample analyses may be found in the Clean Lakes Standard Operating Procedures for Field Samplers.

Sediment Sampling and Survey

A sediment and water depth survey was conducted during the week of April 26, 1993. Cross sections of the lake were surveyed with the use of a total station and a boat. The depth of the water was measured with a stadia rod and the depth of the soft sediment was probed by the use of a length of steel rebar. Cross Sections were spaced at approximately 200 ft. intervals and points along the cross sections were approximately every 150 ft.

Also during the week of April 26, 1993, three sediment core samples were taken at sites 1, 2, and 3. The sediment cores were analyzed for petroleum hydrocarbons and metals by the South Dakota State Health Laboratory.

Table 3.-Water Quality Parameters

Water Temperature	Total Dissolved Solids
Air Temperature	Total Suspended Solids
Secchi Depth	Ammonia
Dissolved Oxygen	Nitrate
Total Alkalinity	Total Kjeldahl Nitrogen
Total Solids	Total Phosphorus
Total Dissolved Phosphorus	Sulfate
Fecal Coliform Bacteria	

RESULTS AND DISCUSSION

In-lake water quality data is summarized in Table 4. The complete water quality and sediment data may be found in Appendix B.

Trophic State

Lakes are commonly classified according to trophic condition. Trophic condition refers to the amount of nutrients present in the lake. There are three basic trophic states which classify most North American Lakes. The first is **oligotrophic** which describes a lake that is nutrient poor, low in biological productivity, very clear water with low fish populations. The second trophic state are mesotrophic lakes. Mesotrophic lakes are lakes which have slightly enriched nutrient concentrations and measurably higher levels of biological productivity. **Eutrophic** lakes are lakes which have high concentrations of nutrients and high biological productivity. Nuisance levels of vegetation such as weeds or algae are common. **Hyper-eutrophic** lakes are lakes which have extremely high concentrations of nutrients and large nuisance populations of aquatic plants or algae. In South Dakota, often these lakes have become shallow due to soil erosion in the watershed and sedimentation in the lake. Most lakes in South Dakota are either eutrophic or hyper-eutrophic.

The Carlson Trophic State Index (TSI) is a method of ranking the trophic condition of the lake based on total phosphorus, Secchi depth, and chlorophyll a concentration. Carlson's method places lakes on a scale ranging from 0 to 100 with lakes having a value greater than 50 considered eutrophic. Each increase of 10 in the TSI represents a doubling in the amount of algae.

Based upon total phosphorus concentration and Secchi depth, East Lake Eureka has a TSI of 57. This number indicates that the lake is slightly eutrophic.

Table 4.-In-Lake Sampling Results

PARAMETERS	COMBINED MEAN VALUES FOR ALL SITES
Water Temperature	1.9 degrees C
Air Temperature	-3.1 degrees C
Secchi Depth	5.6 feet
Dissolved Oxygen	14.1 mg/l
Total Alkalinity	131.7 mg/l
Total Solids	3,497 mg/l
Total Dissolved Solids	3,486 mg/l
Total Suspended Solids	11 mg/l
Ammonia	0.30 mg/l
Nitrate	0.11 mg/l
Total Kjeldahl Nitrogen	1.28 mg/l
Total Phosphorus	0.053 mg/l
Total Dissolved Phosphorus	0.015 mg/l
Fecal Coliform Bacteria	<10 colonies per 100 ml
Sulfate	2161 mg/l

Phosphorus

Phosphorus is an essential nutrient for plant growth and is typically the cause of excessive plant growth. Total Phosphorus concentrations of 0.025 mg/l appear to be the threshold for a nuisance "bloom" of blue-green algae to occur. The mean total phosphorus concentration for East Lake Eureka for the study period is 0.053 mg/l. The maximum concentration of total phosphorus found during the sampling period was 0.205 mg/l and the minimum was 0.005 mg/l. The data indicates a surplus of phosphorus is present in the lake. The sources of phosphorus to a lake can include the soil, detergents, human and/or animal waste, crop and lawn fertilizers, or simply decay of plants in the lake or watershed.

Much of the phosphorus in the lake is in a particulate form. Approximately twenty eight percent of the total phosphorus is dissolved. The dissolved phosphorus is referred to as that fraction that is immediately available for plant growth. The data indicates the dissolved phosphorus ranges between 0.005 mg/l and 0.076 mg/l, with a mean of .015 mg/l. This is not a high concentration for a South Dakota Lake.

Sulfate

Sulfates in East Lake Eureka ranged from 1088 mg/l to 2892 mg/l with a mean concentration of 2161 mg/l for the study period. These concentrations are considered extremely high levels for in-lake ambient concentrations. Sulfates in the above mentioned concentrations may have detrimental effects on growth rates of aquatic species and are suspect in odor problems experienced by recreational users of the lake.

The source of the sulfate ions in the lake is the deep ground water supplied by the artesian well that maintains the lake. Once the artesian well water enters the lake, removal of the sulfate is not feasible. The concentration of sulfate increases as lake water evaporates during summer. Without a significant in-flow of surface water, the in-lake concentration of sulfate will probably continue to gradually increase.

The only solution to this problem would be to pre-treat the well water before it enters the lake. The only available technology to treat water for sulfates include reverse osmosis or distillation. These are expensive processes and the feasibility of such a project would need to be evaluated.

Solids

The standard for total dissolved solids was exceeded at all three sampling sites during the study. The total dissolved solids standard for the lake is 2500 mg/l and was exceeded 3 times at site 1, 8 times on site 2 and 6 times at site 3. These were the only exceedences noted during the study.

The water quality standard for total dissolved solids is based on recommendations from the US EPA. One of the primary reasons for setting the standard is the effect of high concentrations on reproduction in waterfowl. The concentrations in the lake ranged from 2180 mg/l to 4633 mg/l. These concentrations, while considered high, are not extreme. These levels may effect growth rates in young waterfowl but are not considered high enough to result in mortality to the birds.

As with sulfates, the levels of total dissolved solids are most likely due to the influence of deep groundwater from the artesian well. Dissolved solids will probably continue to increase in concentration over time. The dissolved solids are not present at a high enough concentration to affect the fishery at this time.

Total suspended solids had a maximum concentration of 64 mg/l near the outlet of a city storm sewer. The mean concentration for suspended solids was 11 mg/l. Suspended solids concentration did not appear to be a problem for the lake at any time during the study period.

Nitrogen and Bacteria

Concentrations of nitrates, ammonia, and Kjeldahl nitrogen were all well within the acceptable range when compared to the State Water Quality Standards. Nitrogen in various forms is the second most important nutrient for the growth of plants and algae. Inorganic nitrogen concentrations in excess of 0.3 mg/l is considered sufficient to stimulate algal growth. The concentrations of nitrates ranged from 0.1 to 0.2 mg/l in the lake during the sampling period. It should be noted that certain species of blue-green algae have the ability to fix atmospheric nitrogen similar to the bacteria which live in the roots of legume plants. As a result, if the phosphorus concentrations are sufficient, blue-green algae can flourish regardless of the nitrogen concentrations.

The sampling included analysis for fecal coliform bacteria. Fecal coliform bacteria are organisms which live in the digestive tracts of warm blooded animals. These bacteria are used as "indicator species" to determine if contamination is present from human sewage or animal waste. There were no detections of fecal coliform bacteria for any of the samples collected during the monitoring period.

Sediment Samples

Sediment samples were collected from each of the in-lake monitoring sites. These samples were analyzed for metals and petroleum hydrocarbons. Since there are no water quality standards for sediments, the results were compared with the drinking water standards. There were no violations of drinking water quality standards for any of the parameters tested. The parameters and mean concentrations are included in Table 5.

Table 5.-In-Lake Sediment Results

PARAMETERS	COMBINED MEAN VALUES
Petroleum Hydrocarbons	3.23 ppm**
Arsenic, Total	2.38 ug/g
Cadmium, Total	0.192 ug/g
Chromium, Total	11.3 ug/g
Copper, Total	12.2 ug/g
Lead, Total	17.6 ug/g
Nickel, Total	10.5 ug/g
Zinc, Total	56.7 ug/g
Mercury, Total	<.11 ug/g
Iron, Total	9.4 ug/g

** 3.23 ppm was found at site #1 near the discharge point of a city storm sewer. There were no petroleum hydrocarbons detected in samples from sites #2 and #3.

Sediment Survey

DENR in cooperation with Helms and Associates, conducted a sediment depth survey on April 26 - 28, 1993 to measure the accumulation of loose, soft sediments in East Lake Eureka. Maps were plotted showing both the water depth and the soft sediment depth. Figure 3 is a map of the water depth in East Lake Eureka and Figure 4 is a map of the depth of the water and the soft sediment. The total measured volume of soft sediment in the lake is 139,599.5 cubic yards.

CONCLUSIONS

1. East Lake Eureka has accumulated nearly 140,000 cubic yards of soft sediment since the lake was created during the 1930's. The source of this sediment is most likely from storm sewers of the City of Eureka, SD, wind carried sediments, and organic matter from vegetation in the lake itself.

2. Total dissolved solids concentrations are relatively high in the lake. While the mean concentrations exceed the water quality standard slightly, recreational use is probably not seriously impacted.

3. Sulfate concentrations are extremely high in the lake due to the influence of deep ground water. Odor problems for swimmers are most likely due to sulfates. Hydrogen sulfide does not appear to be a problem because the lake is well oxygenated and does not stratify.

4. Nitrogen and phosphorus concentrations in the lake are not

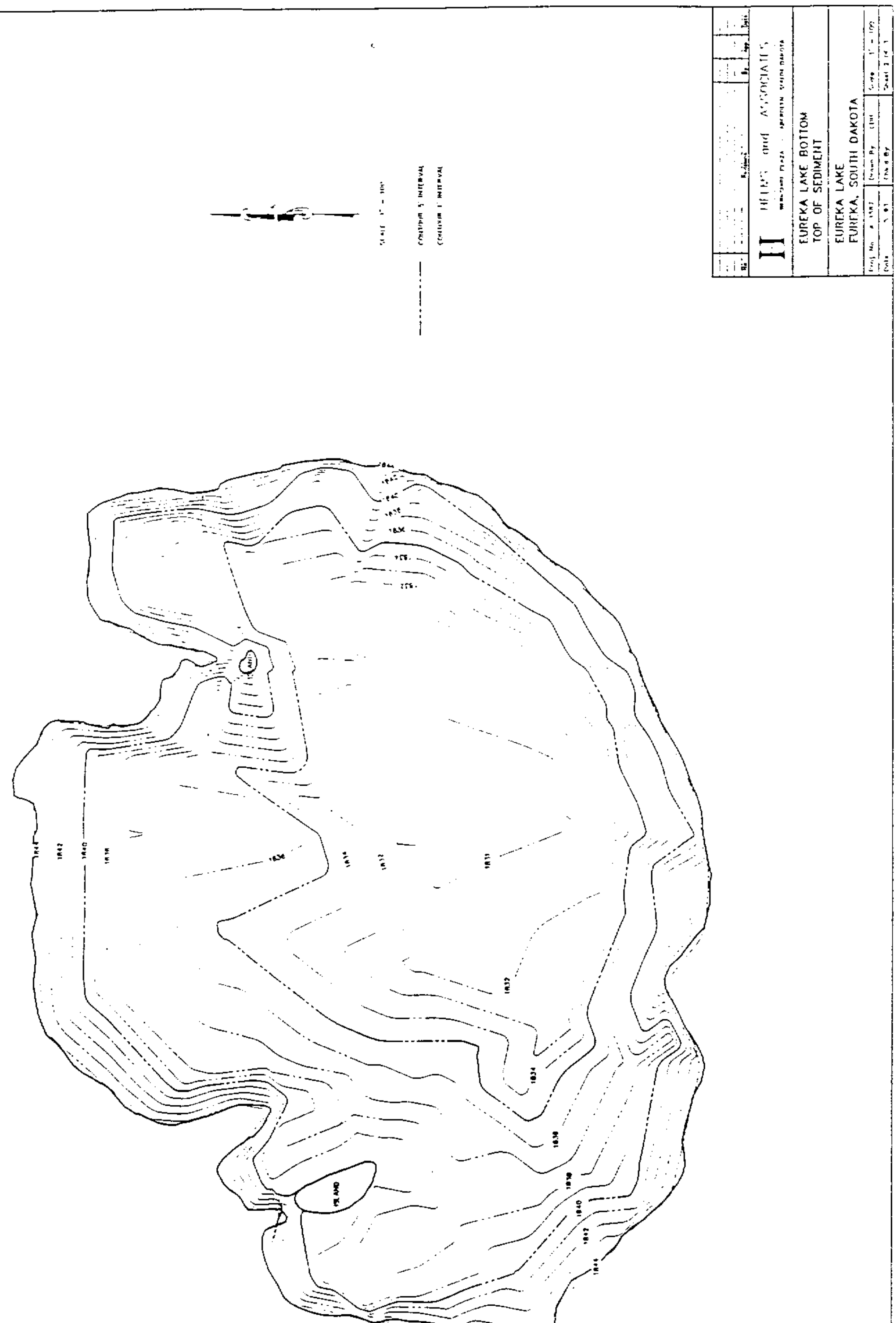

FIGURE 3. CONTOUR MAP OF WATER DEPTH

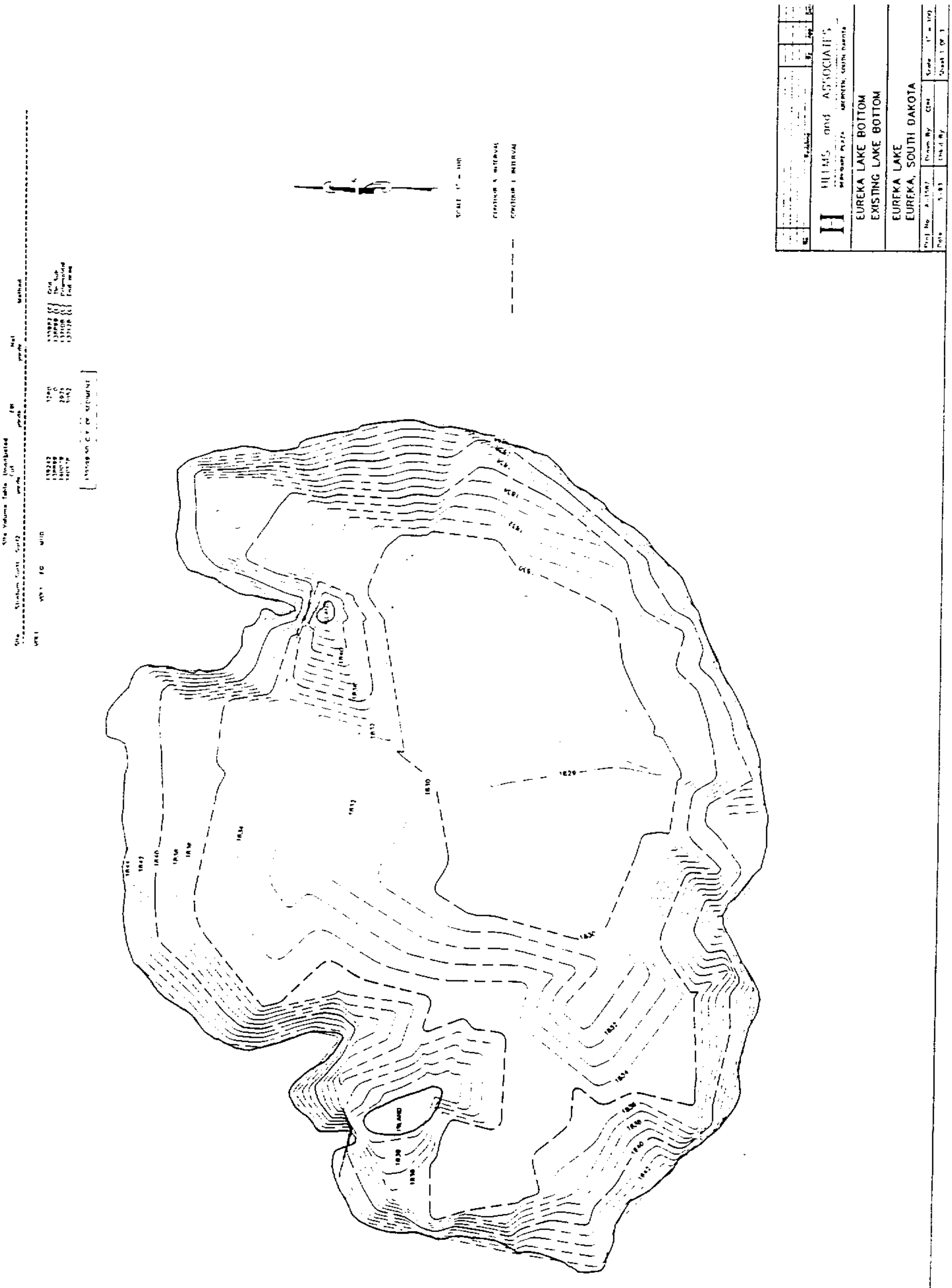

FIGURE 4. CONTOUR MAP OF WATER AND SEDIMENT DEPTH

excessive for a South Dakota lake. Nutrients do not appear to be an impairment to recreational use in East Lake Eureka.

5. There were *no detections of fecal coliform bacteria in the* water quality samples. Human or animal waste was not a problem during the sampling period.

6. During the sampling period and the sediment survey, aquatic vegetation was not observed to be present in nuisance populations.

7. During the study effort, no significant erosion of shoreline areas was noted. The lake shore appears to be adequately stabilized.

RECOMMENDATIONS

Based on the results of this study, the DENR recommends the following alternatives for restoration. These recommendations should provide a basis for the development of a complete restoration work plan and subsequent implementation. The recommendations are provided for review only. These recommendations are not to be considered the only possible methods of restoration.

1. <u>Sediment Removal</u>

In-lake restoration is recommended to include full lake dredging. The purpose of this dredging is to remove accumulated sediment and deepen the lake for recreation. Dredging should be conducted to create deep water areas to limit growth of nuisance aquatic vegetation and provide habitat for gamefish. Since lake sediments contain and often recycle nutrients to the lake, they represent a pollution source to the lake. Lake deepening can increase storage capacity, prevent winterkills, expand recreational areas, decrease area available for plant growth, and may aid in the reduction of suspended sediments and therefore increase water clarity.

If the lake is deepened enough to cause stratification of the lake water, an anoxic condition may result in the lower layer (hypolimnion) of the lake. If the hypolimnion does become devoid of oxygen, hydrogen sulfide may be produced. Hydrogen sulfide is a gas that smells strongly of rotten eggs and is toxic to fish and other aquatic organisms. There is abundant sulfate present in the lake to make this a real possibility. If this were to happen, aeration of the lake could be used to mix the layers and oxygenate the bottom waters, thus eliminating the problem.

Full lake dredging is estimated to take approximately 2 years to complete with a 10-inch dredge.

2. <u>Sulfate Reduction</u>

Due to the high concentration of sulfate in Lake Eureka, odor will continue to be a problem for swimmers. During a year of abundant precipitation, the sulfate concentration may decrease temporarily due to increased surface water entering the lake resulting in dilution. There is no known method of treating the water after it is in the lake. The only method for dealing with the sulfate problem is to treat the water before it enters the lake. The process most often used for treating water for sulfates is reverse osmosis or distillation. The feasibility of either of these treatments is questionable due to the high cost of installation and maintenance. The cost of installation of a reverse osmosis treatment facility for the well is approximately $100,000, not including operation and maintenance.

The best information that we have indicates that the artesian well discharges approximately 85 gallons per minute or approximately 145 acre/ft. per year. Conversely, the amount of water lost to the lake through evaporation in an average year is 40 inches. The net loss to evaporation amounts to approximately 133 acre/ft. per year. This indicates that the well water makes up for the evaporation loss. If flow from the well were eliminated to control the loading of sulfate, the lake would be 3 to 4 feet lower during an average year. For this reason, discontinuing use of the well to supply the lake with water is not advised.

The recommendation for the sulfate problem in Lake Eureka is no action at this time. The reason for this recommendation is that there appears to be no feasible solution to the problem. There is currently research under way to find a cost effective treatment method for sulfates. The mining industry is having problems with sulfate concentrations after treatment for acid mine drainage. If this office becomes aware of any new methods of dealing with sulfates, the City of Eureka will be informed.

3. <u>Storm Sewers</u>

Storm sewer discharge to the lake from the city of Eureka is a potential source for contamination. This source is also an important source of water for Lake Eureka. Since re-routing the storm drains is not a feasible alternative at this time, efforts should be made to minimize the adverse effects. An aggressive street cleaning program needs to be followed to reduce sediments or salts from sanding during winter. Proper snow removal and disposal is helpful in reducing contamination. The city may wish to look into the feasibility of installing sediment traps in the storm sewer system. Information and education for citizen use of lawn fertilizers and pesticides can reduce contaminant loads to the lake.

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APPENDIX A

Water Quality Parameters

WATER QUALITY PARAMETERS

1. **Laboratory Analysis:**

   a. Fecal Coliform (organisms/100 mL) are used as indicators of human pathogens and thus potential human health hazards. Fecal coliform bacteria live in the digestive tract of warm-blooded animals. These bacteria are considered to be an indicator of sewage pollution, livestock manure.

   b. Total Alkalinity (mg/L) refers to the quantity of different compounds that shift the pH to the alkaline (basic) side of neutrality. Alkalinity is generally the result of bicarbonates but is expressed as a sum of hydroxide, carbonate, and bicarbonate. Carbonate and bicarbonate are common in water because these materials are common in nature. The contribution to alkalinity by hydroxides is rare in nature. Thus alkalinity is directly related to geography. Expected total alkalinities in nature range from 20 to 200 mg/L.

   c. Total Solids (mg/L) are all the materials, suspended and dissolved, which are present in water. These are the materials may include salts, sediment or organic matter (particulate or dissolved). High total solids may add to the turbidity of a lake, restricting light penetration.

   d. Total Dissolved Solids (mg/L) include salts and organic residue which pass through a filtered water sample. Total dissolved solids can also be determined by subtracting the total solids by the suspended solids.

   e. Total Suspended Solids (mg/L) include organic and inorganic materials that are not dissolved. This parameter can be used to indicate the sediment load into a body of water. High suspended solid values may also be the result of suspension of materials from the bottom sediments wind, wave, fish, and boat motors.

   f. Ammonia-Nitrogen (mg/L) is generated by bacteria as a primary end product of decomposition of organic matter. Ammonia is the form of nitrogen directly available to plants as a nutrient for growth. High ammonia concentrations can be used to demonstrate organic pollution.

   g. Unionized Ammonia (mg/L) is a portion of ammonia-nitrogen which is highly toxic to many organisms, especially fish. Unionized ammonia can be derived from a calculation and increases with temperature and pH.

   h. Nitrate+Nitrite Nitrogen (mg/L) is often the most abundant inorganic form of nitrogen. Nitrate constitutes the inorganic form of nitrogen assimilated by algae and larger hydrophytes. In natural waters the concentrations are usually low, around 0.1 mg/L. Some sources for inorganic nitrogen are agricultural activities, sewage, and atmospheric pollution by man.

i. Total Kjeldahl Nitrogen (mg/L) is used to measure both total nitrogen and organic nitrogen. Ammonia is subtracted from total kjeldahl nitrogen to acquire the amount of organic nitrogen present. Organic forms of nitrogen can be broken down into different compounds which are then used by phytoplankton. Organic nitrogen can be released from living macrophytes and large quantities can also be released from decaying macrophytes.

j. Total Nitrogen (mg/L) is the sum of nitrate+nitrite nitrogen plus total kjeldahl nitrogen. Total nitrogen to total phosphorus ratios are used to identify which nutrient is limiting to algae growth in lake waters. A lake is usually defined as phosphorus limited if the total nitrogen/total phosphorus ratio is greater than 10:1.

k. Total Phosphorus (mg/L) represents all of the phosphorus found in the water sample. Phosphorus is an element which is essential to all life. Not all phosphorus is immediately available to aquatic plants and algae. Soil can sorb to phosphorus which is released when dissolved oxygen levels are depleted. When concentrations are high, nuisance growth of aquatic plants or algae may result. Sources of phosphorus are from agriculture, sewage, and the decomposition of organic matter.

l. Total Dissolved Phosphorus (mg/L) is a form of phosphorus which is more readily available for uptake by plants. The sample is field filtered to remove most suspended particles.

2. Field Analysis:

a. Water Temperature (^{o}C) has a considerable effect on the chemical process in a lake. Temperature can change the biological metabolism of aquatic organisms which could change nutrient and pH concentrations in the system. Temperature can also be the limiting factor to fish life and other aquatic species.

b. Field pH (su) is a measure of the hydrogen ion activity which directly effects the toxicity (solubility) of heavy metals in water, among other items. The pH scale is based on a range of numbers 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. Deviation, from the neutral pH 7, is a result of the decomposition of salts as they reacted with water. Gases such as carbon dioxide, hydrogen sulfide, and ammonia have a significant effect on pH. The pH of a lake is directly related to the geography of the surrounding area.

c. Dissolved Oxygen (mg/L) the dissolved oxygen content of water results from the activities of growth and decomposition and also the air-water interface. Aquatic plants release oxygen during photosynthesis, decomposing organisms use oxygen in the breakdown of organic matter. At the air-water interface, oxygen is added and released from the water column by mixing through wind and wave action. Oxygen levels less than 3.0 mg/L are stressful to aquatic vertebrates and most other aquatic life.

d. Climate Conditions - wind, precipitation, air, and temperature (^{o}C).

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

f. Water Depth in tributaries it is taken to assist in calculating flow measurements. Water depth in lakes are used as reference points and to notice changes in lake elevation.

g. Secchi Disk is taken for a comparison of lake trophic status using Carlson's Index.

APPENDIX B: Water Quality Data

m? or ft?

Record as below
delete P ≤ AL notation?
no column for

PROJECT	WATERBODY	SITE	DATE	TIME	SAMPLE	TYPE	DEPTH	WTEM	ATEMP	SECCHI	DISOX	TALKA	TSOL	TDSOL	TSSOL	AMMONIA	NITRATE	TKN	TPO4	TDPO4	FECAL	SULFATE
EAST LAKE EUREKA	LAKE	1	17-Nov-92	800	BOSCHE	GRAB	SURFACE	2.4	5.0		14.5	142.2	2259	2253	6	0.52	0.10	0.70	0.005	0.005	<10	1428
EAST LAKE EUREKA	LAKE	1	03-Dec-92	1410	BOSCHE	GRAB	SURFACE	5.0	1.5	3.0	15.0	149.6	2251	2247	4	0.57	0.10	1.15	0.005	0.005	<10	1390
EAST LAKE EUREKA	LAKE	1	16-Dec-92	1420	BOSCHE	GRAB	SURFACE	7.0	3.0	0.5	14.0	150.2	2239	2236	3	0.55	0.10	0.97	0.060	0.005	<10	1353
EAST LAKE EUREKA	LAKE	1	06-Jan-93	1350	BOSCHE	GRAB	SURFACE	0.0	-22.0	6.0	15.0	149.8	2191	2180	11	0.41	0.10	0.71	0.005	0.005	<10	1377
EAST LAKE EUREKA	LAKE	1	20-Jan-93	1320	BOSCHE	GRAB	SURFACE	0.0	-6.0	6.0	16.0	149.0	2204	2198	6	0.55	0.10	0.82	0.005	0.005	<10	1357
EAST LAKE EUREKA	LAKE	1	02-Feb-93	1330	BOSCHE	GRAB	SURFACE	4.0	3.0	2.0	14.0	127.8	4596	4587	9	0.40	0.10	1.79	0.037	0.020	<10	2785
EAST LAKE EUREKA	LAKE	1	16-Feb-93	1330	BOSCHE	GRAB	SURFACE	0.0	-18.0	7.0	15.0	138.6	3849	3841	8	0.28	0.10	1.51	0.070	0.023		1674
EAST LAKE EUREKA	LAKE	1	02-Mar-93	1304	BOSCHE	GRAB	SURFACE	2.0	4.0	3.0	13.0	143.0	464	400	64	0.54	0.20	1.43	0.205	0.006		1088
EAST LAKE EUREKA	LAKE	1	23-Mar-93	1307	BOSCHE	GRAB	SURFACE	6.0	6.0	5.0	14.0	128.2	3881	3872	9	0.09	0.10	1.02	0.060	0.013	<10	2365
EAST LAKE EUREKA	LAKE	2	17-Nov-92	800	BOSCHE	GRAB	SURFACE	1.6	5.0	4.5	14.5	86.8	3699	3687	12	0.10	0.10	0.99	0.023	0.010	<10	2685
EAST LAKE EUREKA	LAKE	2	03-Dec-92	1340	BOSCHE	GRAB	SURFACE	3.0	1.5	5.0	14.0	101.0	4082	4076	6	0.10	0.20	0.72	0.027	0.005	<10	2497
EAST LAKE EUREKA	LAKE	2	16-Dec-92	1445	BOSCHE	GRAB	SURFACE	1.0	3.0	4.0	15.0	106.0	3970	3966	4	0.11	0.10	0.71	0.005	0.005	<10	2612
EAST LAKE EUREKA	LAKE	2	06-Jan-93	1410	BOSCHE	GRAB	SURFACE	0.0	-22.0	7.0	14.5	117.2	4529	4516	13	0.10	0.10	1.09	0.033	0.005	<10	2863
EAST LAKE EUREKA	LAKE	2	20-Jan-93	1345	BOSCHE	GRAB	SURFACE	0.0	-6.0	7.0	15.0	127.6	4604	4596	8	0.34	0.10	1.82	0.033	0.023	<10	2794
EAST LAKE EUREKA	LAKE	2	02-Feb-93	1400	BOSCHE	GRAB	SURFACE	0.0	3.0	7.0	13.0	127.8	3330	3324	6	0.41	0.10	1.17	0.033	0.010	<10	2042
EAST LAKE EUREKA	LAKE	2	16-Feb-93	1330	BOSCHE	GRAB	SURFACE	0.0	-18.0	13.0	13.0	141.0	4498	4484	14	0.25	0.10	2.02	0.146	0.017		2439
EAST LAKE EUREKA	LAKE	2	02-Mar-93	1340	BOSCHE	GRAB	SURFACE	2.0	4.0	8.0	12.0	153.0	3199	3181	18	0.40	0.10	1.49	0.052	0.006	<10	1903
EAST LAKE EUREKA	LAKE	2	23-Mar-93	1330	BOSCHE	GRAB	SURFACE	5.0	6.0	4.0	14.0	140.0	2210	2204	6	0.48	0.10	0.86	0.037	0.017		1378
EAST LAKE EUREKA	LAKE	3	16-Dec-92	1510	BOSCHE	GRAB	SURFACE	1.0	3.0	4.0	14.0	109.6	4241	4235	6	0.11	0.10	1.07	0.013	0.009	<10	2593
EAST LAKE EUREKA	LAKE	3	06-Jan-93	1445	BOSCHE	GRAB	SURFACE	0.0	-22.0	4.0	14.0	120.6	4589	4573	16	0.11	0.10	1.43	0.053	0.005		2892
EAST LAKE EUREKA	LAKE	3	20-Jan-93	1330	BOSCHE	GRAB	SURFACE	0.0	-6.0	6.0	15.0	135.6	4633	4625	8	0.03	0.10	1.70	0.050	0.017	<10	2830
EAST LAKE EUREKA	LAKE	3	02-Feb-93	1430	BOSCHE	GRAB	SURFACE	0.0	3.0	7.0	13.0	129.8	4566	4559	7	0.39	0.10	1.83	0.046	0.043	<10	2729
EAST LAKE EUREKA	LAKE	3	16-Feb-93	1330	BOSCHE	GRAB	SURFACE	0.0	-18.0	12.0	13.5	138.4	4390	4374	16	0.26	0.10	2.08	0.189	0.033		2646
EAST LAKE EUREKA	LAKE	3	02-Mar-93	1430	BOSCHE	GRAB	SURFACE	2.0	4.0	7.0	13.3	154.0	2792	2775	17	0.42	0.10	1.56	0.039	0.005	<10	1599
EAST LAKE EUREKA	LAKE	3	23-Mar-93		BOSCHE	GRAB	SURFACE	5.0	6.0	8.0	13.0	125.8	4171	4161	10	0.02	0.10	1.29	0.096	0.076	<10	2712

WITH SAMPLES	REPORT TO	BILL TO
Eureka Lake		City of Ureka
		Ureka, S.D.

rec'd 4-28-93 completed 4-29-93 analyst Ronald L Frasch $ 180.00 City/contract

	ANALYSIS
LAB NUMBER 93X-48 COLLECTED 10:40A / 4-28-93 TYPE Sediment ID #1 - 4ft. in front of storm sewer outlet IN 02596 93	3.23 ppm. total hydrocarbons from gasoline through diesel fuel
LAB NUMBER 93X-49 COLLECTED 10:54A / 4-28-93 TYPE Sediment ID #2 - 13ft Center of lake in front of swimming beach IN 02598 93	none detected
LAB NUMBER 93X-50 COLLECTED 11:08A / 4-28-93 TYPE Sediment ID #3 - 5-5 West end of lake IN 02599 93	none detected

South Dakota
GREAT FACES. GREAT PLACES.

DEPARTMENT OF HEALTH

LABORATORY SERVICES
500 East Capitol Avenue
Pierre, South Dakota 57501-5093
(605) 773-3368 FAX: (605) 773-6129

Submitter copy to:

Date: 6/25/93

DENR-WATER RESOURCES MANAGEMENT-5110
FOSS BUILDING
523 E CAPITOL
PIERRE, SD 57501

Spec #: E93IN002596
Subm #: 1
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

LAKE EUREKA/SLUDGE

Date Rcvd:	4/28/93	County:	HUGHES
Time Rcvd:	1600	Coll By:	BOSCHEE
Date Coll:	4/28/93	Remarks:	SAMPLE DEPTH 4 FT.
Time Coll:	1040	Source Sampled	SEDIMENT

Final Results

Arsenic, Total		4.10 ug/g
Cadmium, Total		0.255 ug/g
Chromium, Total		11.5 ug/g
Copper, Total		10.2 ug/g
Lead, Total		30.7 ug/g
Nickel, Total		12.5 ug/g
Zinc, Total		87.5 ug/g
	Limit:	
Mercury, Total		<0.11 ug/g
Iron, Total		11.0 mg/g

Specimen Comments:
SAMPLE COLLECTED IN LAKE DIRECTLY IN FRONT OF STORM SEWER OUTLET.

South Dakota
GREAT FACES. GREAT PLACES.

DEPARTMENT OF HEALTH

LABORATORY SERVICES
500 East Capitol Avenue
Pierre, South Dakota 57501-5093
(605) 773-3368 FAX: (605) 773-6129

Submitter copy to:

Date: 6/25/93

DENR-WATER RESOURCES MANAGEMENT-5110
FOSS BUILDING
523 E CAPITOL
PIERRE, SD 57501

Spec #: E931N002598
Subm #: 2
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

LAKE EUREKA/SLUDGE

Date Rcvd:	4/28/93	County:	HUGHES
Time Rcvd:	1600	Coll By:	ROSCHEE
Date Coll:	4/23/93	Remarks:	SAMPLE DEPTH=13 FT.
Time Coll:	1054	Source Sampled	SEDIMENT

Final Results

Arsenic, Total		1.52 ug/g
Cadmium, Total		0.133 ug/g
Chromium, Total		12.4 ug/g
Copper, Total		11.7 ug/g
Lead, Total		11.8 ug/g
Nickel, Total		10.4 ug/g
Zinc, Total		37.2 ug/g
	Limit:	
Mercury, Total		<0.11 ug/g
Iron, Total		6.74 mg/g

Specimen Comments:
SAMPLE TAKEN IN CENTER OF LAKE OUT IN FRONT OF SWIMMING BEACH

DEPARTMENT OF HEALTH

LABORATORY SERVICES
500 East Capitol Avenue
Pierre, South Dakota 57501-5093
(605) 773-3368 FAX: (605) 773-6129

GREAT FACES. GREAT PLACES.

Submitter copy to:

Date: 6/25/93

DENR-WATER RESOURCES MANAGEMENT-5110
FOSS BUILDING
523 E CAPITOL
PIERRE, SD 57501

Spec #: E93IN002599
Subn #: 3
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

LAKE EUREKA/SLUDGE

Date Rcvd: 4/28/93
Time Rcvd: 1600
Date Coll: 4/28/93
Time Coll: 1100

County: HUGHES
Coll By: BOSCHEE
Remarks: SAMPLE DEPTH 5.5 FT.
Source Sampled SEDIMENT

Final Results

Arsenic, Total	1.52 ug/g
Cadmium, Total	0.189 ug/g
Chromium, Total	10.0 ug/g
Copper, Total	14.8 ug/g
Lead, Total	10.7 ug/g
Nickel, Total	8.54 ug/g
Zinc, Total	45.4 ug/g
Limit:	
Mercury, Total	<0.11 ug/g
Iron, Total	10.6 mg/g

Specimen Comments:
SAMPLE TAKEN IN WEST END OF LAKE