DIAGNOSTIC / FEASIBILITY STUDY

SWAN LAKE

TURNER COUNTY, SOUTH DAKOTA

South Dakota Clean Lakes Program
Division of Water Resources Management
South Dakota Department of
Environment and Natrual Resources

January 1993

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TURNER COUNTY, SOUTH DAKOTA

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EXECUTIVE SUMMARY

SWAN LAKE DIAGNOSTIC/FEASIBILITY STUDY

Swan Lake is a 180-acre natural lake located 3 miles north and 1 mile west of Viborg, South Dakota in Turner County. Swan Lake assumed characteristics of a reservoir in 1914 when an inlet channel was excavated from Turkey Ridge Creek into the lake. When the inlet was completed, the watershed of Swan Lake increased from approximately 1,000 acres to approximately 81,600 acres. Swan Lake water outlets to Turkey Ridge Creek which eventually flows into the Vermillion River. The majority of the topography of the Turkey Ridge Creek watershed is flat to undulating. Contrasting steeper slopes can be found on the western and southwestern boundaries of the watershed. This sudden change in topography is due to the remnants of a glacial moraine from the Late Wisconsin period.

In June of 1990, the South Dakota Department of Environment and Natural Resources (SD DENR) began a Phase I Diagnostic/Feasibility Study at the request of the Swan Lake Improvement Association. The purpose of the study was to assess the general condition of the lake and tributaries. In addition, the study was to identify sources causing the lake's degradation, and propose feasible restoration alternatives to improve water quality in the lake and watershed. Monitoring equipment was installed in the fall of 1990, and sampling began in January of 1991.

The study included water quality monitoring and the use of the Universal Soil Loss Equation (USLE) for assessment of the watershed. The USLE was developed by the U.S. Department of Agriculture to evaluate the sediment input from watersheds. The lake was sampled twice monthly from April through September and monthly from October through March. Samples were collected by a local resident and sent to the South Dakota State Health Laboratory in Pierre for analysis. The data necessary for input in the USLE was gathered by a local resident and personnel from the SD DENR.

The major problems facing Swan Lake are predicated by its shallow depth. Shallow depths can cause high turbidity, and the cloudy or dirty appearance of the water. Turbidity can be caused by algae, tributary input, or resuspension of sediments by wind, boat motors, or bottom feeding fish. Due to the high turbidity experienced in Swan Lake, macrophytes (aquatic weeds) were absent from the lake except for emergent vegetation close to shore. The high turbidity may also be responsible for the lack of nuisance blue-green algal species that form floating mats which are usually present in nutrient-rich lakes similar in size and shape to Swan Lake. Concentrations of dissolved solids in Swan Lake were high enough to classify the lake water as moderately brackish. The high dissolved solids concentration is probably caused by the recharge of groundwater to the lake from springs in the Turkey Ridge Creek watershed. A high concentration of dissolved minerals enters the lake and the concentration further increases due to evaporation.

In-lake sampling also showed Swan Lake to be hypereutrophic. Hypereutrophic is a term which means the lake has an over abundance of nutrients. Nutrients, such as nitrogen and phosphorus, are used by algae and macrophytes for growth and reproduction. Sources for the high nutrients are most likely from agricultural practices in the watershed and possibly septic systems around the lake. The nutrients are carried to the lake mainly through the inlet channel from Turkey Ridge Creek. The groundwater was not tested, however, samples taken in the winter over frozen ground had relatively low concentrations, thus groundwater is not suspected as a nutrient source.

Turkey Ridge Creek proved to be an important hydrologic connection to Swan Lake. During the fall and winter, springs from surficial aquifers start to flow, probably due to reduced demand from vegetation in the watershed (Lindgren and Hanson, 1990). Lake levels at the end of September 1991, were a foot and a half below the level of the outlet. The volume of water needed to fill the lake was greater than 270 acre-feet. The fall and winter recharge from springs in the watershed, flowing through Turkey Ridge Creek filled the lake to the outlet level.

The water quality of Turkey Ridge Creek and its tributaries is relative to the source of the creek water. If the water is from a runoff event, the water typically has high phosphorus, nitrogen and fecal coliform bacteria concentrations. Fecal coliforms are bacteria which live in the intestinal tract of warm blooded animals. These bacteria enter the water system by direct contact with the streams and overland runoff. The most probable source of the high concentrations of fecal coliform were feedlots within the watershed. When the groundwater flows in the fall and winter, a flushing effect takes place and water quality improves to acceptable standards. During this time fecal counts are low to non-detectable and nutrient concentrations are minimal.

The elevation of the lake inlet is below that of the outlet. During periods when the water level of Turkey Ridge Creek is lower than the lake level, water flows back out the inlet to the creek. At other times when the water level of Turkey Ridge Creek is higher than the lake level, water would flow into the lake. Without continuous flow direction and stage height data, a hydrologic and nutrient budget could only be estimated. The loadings into the lake, as stated earlier, were dependant on the source of the water. Water flowing before the spring thaw is considerably better quality than water allowed to flow into the lake after the thaw. By eliminating the water after the thaw, an estimated 50% of the nutrient load could be eliminated from Swan Lake. It also appears Swan Lake is storing a majority of the nutrients which enter the lake. These nutrients appear to be released recycled throughout the year. With the information gathered from this report recommendations could be made.

The recommendations which are aimed at controlling sediment and nutrient input to Swan Lake are as follows:

Primary Activities

1) Control structure repair on valve next to Turkey Ridge Creek
2) Dam structure repair down steam of the inlet channel
3) In-lake sediment removal
4) Bank stabilization
5) Sediment dike
6) Buffer strips or CRP in original watershed
7) Rough fish control
8) Sanitary district development

Secondary Activities

9) Animal waste management systems
10) Dugouts and wells

The recommendations listed above are those which the State suggests to best solve the problems addressed in this report.

LAKE IDENTIFICATION AND LOCATION

Lake Name: Swan Lake

State: South Dakota

County: Turner

Size: 73 hectares (180 acres)

Nearest Municipality: Viborg, South Dakota

Latitude: North 43 deg. 13 min. 18 sec.

Longitude: West 97 deg. 6 min. 00 sec.

EPA Region: 8

EPA Major Basin: Missouri River **Code:** 09

EPA Minor Basin: Vermillion River **Code:** 04

Major Tributary: Turkey Ridge Creek

Receiving Water Body: Turkey Ridge Creek / Vermillion River (Figure 1)

Water Quality Standards:

Designated Uses

1) Warm Water Semi-permanent Fish Propagation
2) Immersion Recreation
3) Limited Contact Recreation
4) Wildlife Propagation and Stock Watering

Applicable Criteria

The water quality criteria established for these beneficial uses are located in Table 1.

GEOLOGICAL AND SOILS DESCRIPTION OF DRAINAGE BASIN

Geological Description Section Summary

The geology of Turkey Ridge is characterized by an abnormally high Cretaceous core topped with glacial drift deposits that attain a height of 1,730 feet above mean sea level. Data gathered from a test hole at the center of the Swan Lake watershed reveals the stratigraphy in Table 2. The tabulated formations will be described from the oldest formation to the youngest material.

Table 2. The Basic Geological Formations Below Swan Lake

FORMATION	FEET
Glacial till	0 - 44
Niobrara Formation	44 - 228
Carlile Shale	228 - 442
Greenhorn Limestone	442 - 473
Graneros Shale	473 - 480
Dakota Formation	480 - 660
Quartzite Wash	660 - 838
Quartzite	838 - 839

Source: South Dakota Geological Survey

Geological Description

The Proterozoic Sioux Quartzite is a thick, fine to medium grained, clastic sequence, varying in shades of pink and maroon to almost transparent. Although the majority of the quartzite is silica sand cemented by pressure from sediments above over time, there are minor mudstone and heterogeneous beds mixed within it. Formed approximately 1.7 billion years ago, the Sioux Ridge, the quartzite mass underlying most of eastern South Dakota and southwestern Minnesota, is a stable feature extremely resistant to erosion, standing prominent throughout most of the Phanoezoic.

Quartzite wash is a fine to medium-grained sand derived from, and usually found adjacent to the Sioux Ridge. It often contains angular to sub-angular grains due to the close proximity of its source. The quartzite wash defies definite classification due to its varied stratigraphic position, though in Turner County, the youngest it could be is Early Cretaceous.

The sequence of sandstones, shales, and limestones that follow make up the Montana group which are found throughout most of South Dakota. These Cretaceous sediments were deposited during five major advance and withdrawal cycles of the Cretaceous inland sea. The Cretaceous sediments probably approach 800 feet in total thickness in the Turkey Ridge Creek area. Some Pierre

Shale may also be found under the highest elevations of Turkey Ridge.

Tertiary sands are also in evidence in the central part of Turner County. These western-derived sands may be comparable to the Ogallala Formation, though lack of stratigraphic control makes correlation tentative at best. These sediments are fine to medium-grained sands and silts and are part of the Turkey Ridge aquifer described in the **Ground Water Hydrology** section below.

Overlying the Cretaceous and Tertiary sediments is late Wisconsin till and outwash. The tills are generally oxidized (yellow-brown) in the upper 10-20 feet, and unoxidized (blue-gray) below. Thickness of the glacial drift in the Turkey Ridge and Swan lake area vary from less than 40 feet to more than 400 feet. The hydraulic conductivity of till ranges from 10^{-4} feet/day in oxidized, highly fractured till to 10^{-8} feet/day in unoxidized till. Hydraulic conductivity is defined as the distance a cubic foot of water travels each day in feet.

Groundwater Hydrology

All the information for this section was researched and gathered from a document published by the U.S. Geological Survey in conjunction with the South Dakota Geological Survey. The document - Water Resources of Hutchinson and Turner Counties, South Dakota can be acquired upon request from the SD DENR or one of the two agencies mentioned above.

In summary, the only groundwater source with documented hydrologic connections to Turkey Ridge Creek or Swan Lake is the Turkey Ridge Creek aquifer. Other aquifers with possible hydrologic connections are the Upper Vermillion-Missouri, Turkey Ridge, and Niobrara aquifers. The Turkey Ridge Creek aquifer has the most connection with Turkey Ridge Creek. After the warm season, use for water subsides and the level of the aquifer rises and discharges into Turkey Ridge Creek. In mild winters the creek has a continuous flow which maximizes the level of Swan Lake through the inlet.

The potentiometric surface of an aquifer is the height the water level can rise above the aquifer. If the material is permeable enough to allow water to pass, the water may move through the confining layer. The Upper Vermillion-Missouri aquifer may have a hydraulic connection directly to Swan Lake. The potentiometric surface of the aquifer is higher than the lake surface which may suggest a slight inflow from the bottom of Swan Lake. The elevation of the sand and gravel in the southeastern part of the Turkey Ridge aquifer does coincide with the elevation of the Turkey Ridge Creek stream bed. Although the data does not indicate a hydraulic connection between Turkey Ridge Creek and the Turkey Ridge aquifer one may still exist. The only bedrock aquifer which is connected to the Swan Lake watershed is the Niobrara aquifer. The Niobrara definitely discharges into the Upper Vermillion-Missouri, and may discharge into the Turkey Ridge Creek aquifer where they are only separated by about fifteen feet of till.

Monitoring Wells

In October of 1991 monitoring wells were placed around Swan Lake by the Geological Survey to document groundwater inputs to Swan Lake, no chemical parameters were taken. A map of the location of the wells and graphs of water levels recorded is located in Appendix A.

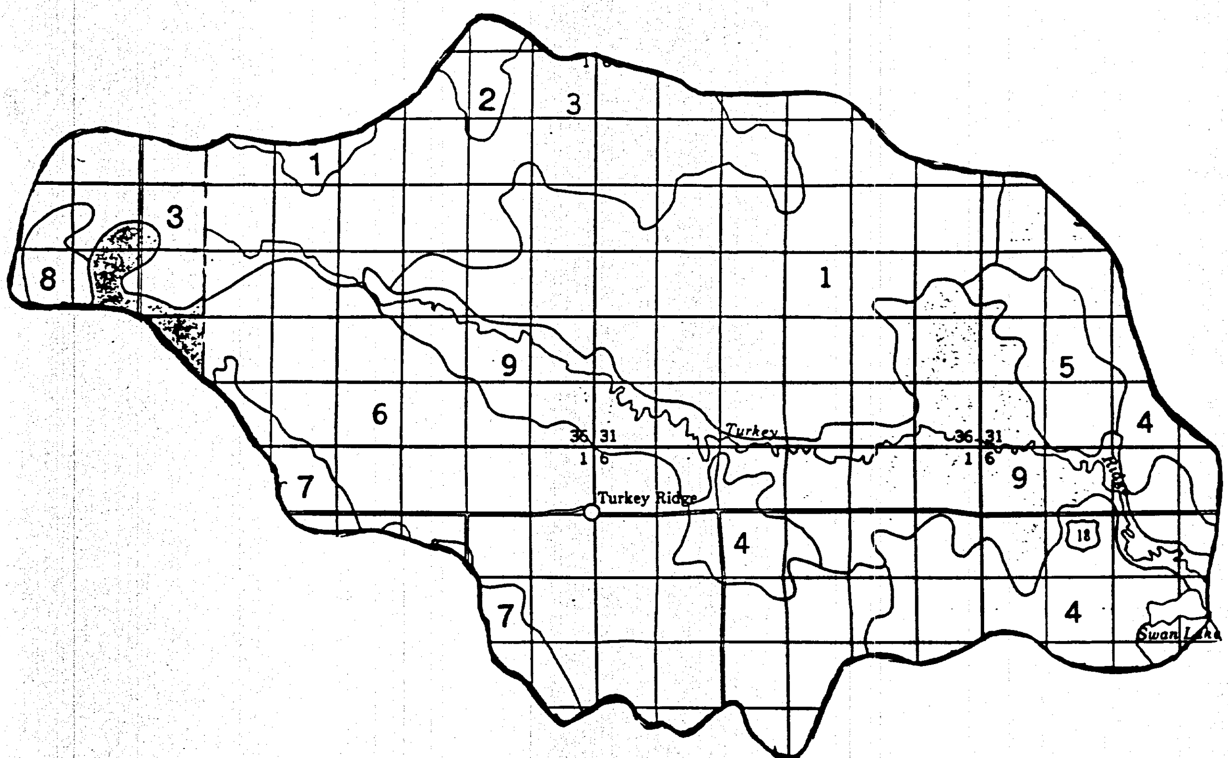
All of the wells increased with the level of the lake, and by early February water levels in four of the wells (2, 3, 4, and 6) showed elevations higher than the lake. Although a gradient of the groundwater towards the lake has been seen, the amount of groundwater entering the lake from these areas is unknown. Some time in late fall the inlet was opened to fill the lake which negated groundwater as the only water source to the lake. The well monitoring will continue in 1992 to see if more accurate data can be acquired.

Soil

The Swan Lake watershed is made up of Turkey Ridge on the far west boundary of the watershed and gently rolling land from the base of the ridge to Swan Lake. Several major soil associations are present in the Swan Lake watershed. Each major association will be described in Appendix B in order of importance (percent of aerial coverage). A map outlining the major associations is shown in Figure 2.

Topography

The Swan Lake watershed has two basic characteristics, flat to rolling plains and a glacial ridge. Approximately 70 percent of the watershed is gently rolling glacial plain with slopes less than 3 percent. Turkey Ridge, located in the west-southwestern boundary of the watershed, is a glacial moraine left from the late Wisconsin period. Turkey Ridge makes up approximately 30 percent of the watershed with slopes ranging from 0 to 25 percent. The higher slopes can only be found in a few ravines on Turkey Ridge. Figure 3 indicates the average slope per section and its location in the watershed. Slopes were calculated from United States Geological Survey (USGS) topographic maps. The



Soil Legend

1 - Clarno-Bonilla association
2 - Clarno-Crossplain-Davison association
3 - Clarno-Ethan association
4 - Egan-Trent association
5 - Wentworth-Chancellor-Wakonda association
6 - Egan-Ethan association
7 - Egan-Worthing association
8 - Hand-Clarno-Davison associaton
9 - Clamo-Lamo association

Figure 2. Major Soil Associations in the **Swan Lake Watershed.**

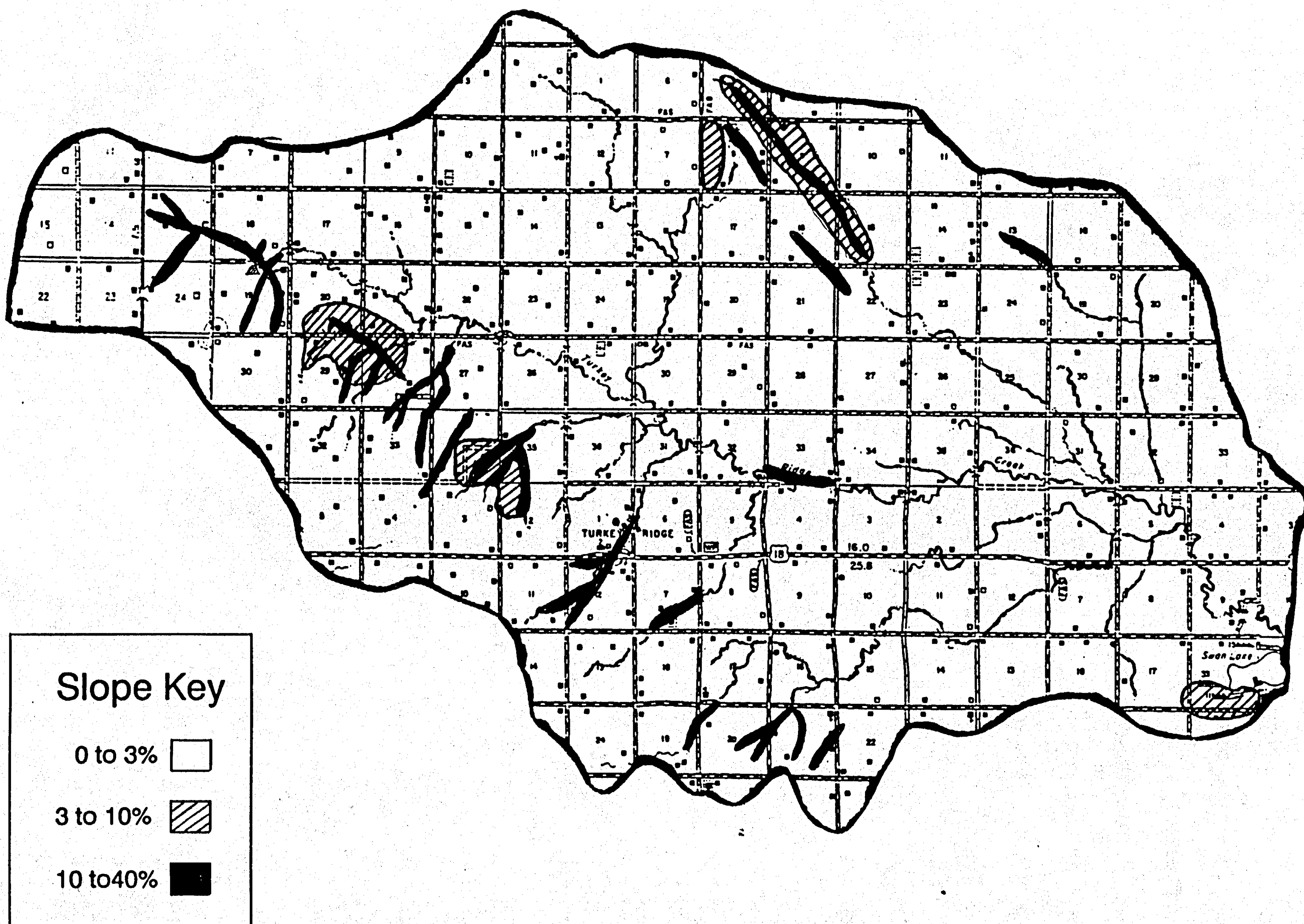


Figure 3. Slopes of the Swan Lake Watershed.

average slopes per section were calculated by averaging random slopes perpendicular to the drainage. Almost all watershed slopes are less than 3 percent. Close to some drainages the slope increases dramatically. These areas are marked as a dark black line. The slope ranges from 10 percent to 40 percent in these areas, however, the length of slope is generally under 1,000 feet.

DESCRIPTION OF PUBLIC ACCESS

Described in Table 3 are six specific areas designated as public access areas around Swan Lake.

Table 3. Description of Public Access at Swan Lake

Name	Responsible Agency	Type	Land Area (ha)*	Lake Front (m)**	Type and Capacity of Facilities
South Landing	SD Game Fish Parks	Boat Launch	0.3	18	Single boat landing parking, no other facilities
SLIA E. Park	Swan Lake Improvement	Public Beach	0.3	61	Swimming beach and picnic area
SLIA W. Park	Swan Lake Improvement	Rec. Area	0.5	88	Picnic area
Swim Beach	Swan Lake	Beach	0.1	72	Swimming Beach
North East Area	Park	Game Management	6.0	91	Shoreline access for fishing and hunting
North Shore	Township	Public Road	1.4	1,368	Shore fishing
North West Park	SD Game, Fish & Parks	State Maintained Area	1.2	46	Camping, picnicking, and shore fishing area
		Totals	9.8	1,744	

* A hectare (ha) = 2.471 acres

** A meter (m) = 1.094 yards

Source: SD GF&P Records and Physical Measurement and Observation

A boat ramp and parking area on the south-central shore of the lake, public swim beach on the south-eastern corner, hunting and shore fishing area on the northeastern shore of the lake, a small camping area north of the lake, and a small park on the northwest corner of the lake give the public excellent access around Swan Lake. The public also has shoreline access on a large portion of the north and east shore along a public road maintained by the county. Figure 4 shows the public access points in relation to access roads and the lake. The boat ramp has an oil road directly leading to the ramp. At the present time there is no dock at the launching site, however the Swan Lake Improvement Association (SLIA) along with the SD Game Fish and Parks (SD GF&P) are working to install a dock in the near future. The swim beach, maintained by the SLIA, has limited access and parking availability. The other three public areas are easily accessible because they are adjacent to a township gravel road maintained by Turner County.

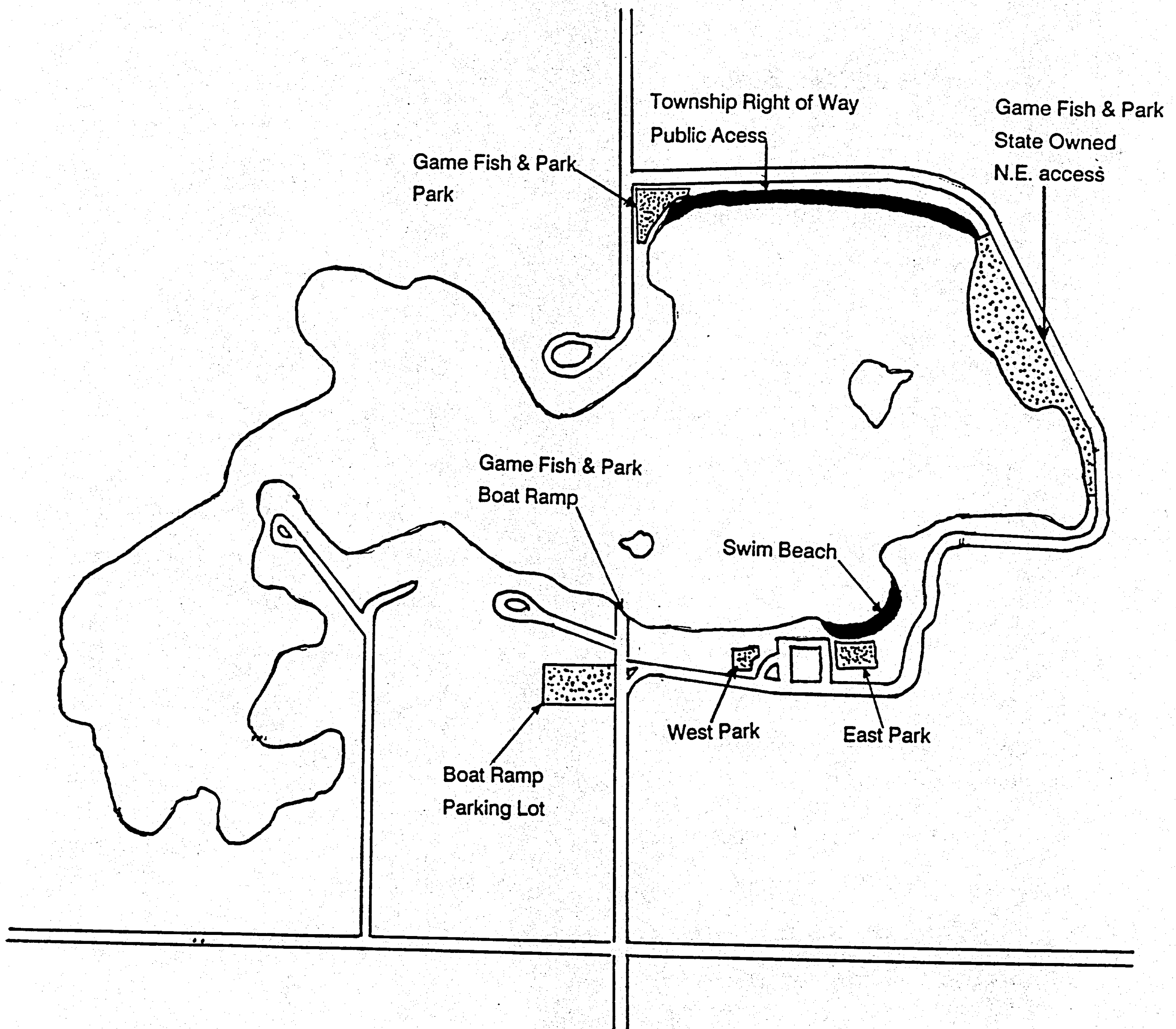


Figure 4. Swan Lake Public Access.

SIZE AND ECONOMIC STRUCTURE OF POTENTIAL USER POPULATION

POPULATION

The number of potential users to be found within 80 kilometers (50 miles) of Swan Lake requires census data from eight South Dakota counties, three Iowa counties, three Nebraska counties, and one Minnesota county (Figure 8). These 15 counties located in four states represent a total of 227 townships and 73 municipalities. To portray the characteristics of the population within the Swan Lake user area, data from these townships and communities were used.

The 1980 and 1990 U.S. population census estimates will serve as sources of population numbers, and 1987 data will be used for per capita income information. Employment data has been gathered from Department of Labor reports.

The total population within a 80 km radius of Swan Lake is 259,830 persons. Eighty percent (209,247) reside in South Dakota with the remaining 20 percent (50,583) residing in adjacent states, primarily in Iowa (30,332). Seventy-four percent (192,723) of the potential user population reside in communities

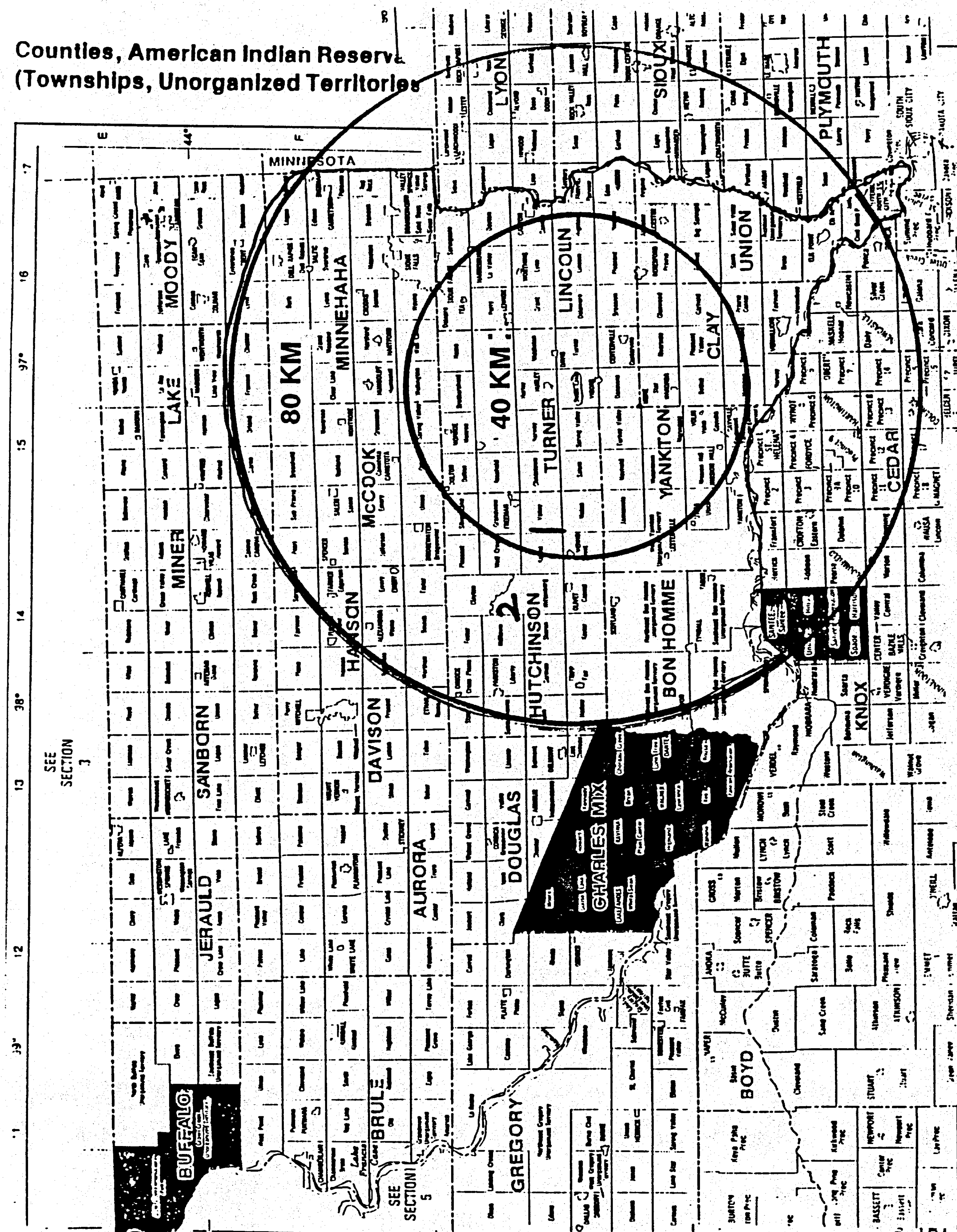


Figure 5. User Area Around Swan Lake.

ranging in size of less than 50 persons to Sioux Falls, a metropolitan area of over 100,000 population. The remaining 26 percent (67,107) of this population are rural residents living on open-country farms or acreages outside incorporated boundaries (Tables 4 and 5).

The more immediate user area within 40 km (25 miles) of the lake incorporates eight South Dakota counties comprised of 67 townships and 22 municipalities (cities). The total population of this area is 28,849 persons of which 12,288 (43%) reside in communities ranging from 43 persons (Dalton, SD) to the largest community, Beresford, SD with 1,849 people.

As stated earlier, Swan Lake encompasses an area of 72.8 hectares (180 acres). Lakeside development includes 80 homes situated near the southern and northwest shoreline. Almost all of an estimated 262 occupants of lakeshore homes are seasonal residents (96%). Approximately 10 occupants are year round residents. Seasonal residency is generally defined as continuous occupancy during the months of May through August.

A comparison of the total population in the local user area (40 km radius) in 1980 and 1990 revealed a net loss of 6 percent or 1,980 persons (Figure 6). A loss of nearly seven percent of the rural population (2,265) was only slightly compensated by a small increase in the urban population (285).

TABLE 4. POPULATION AROUND SWAN LAKE IN 1980

STATE	COUNTY	40 KILOMETER RADIUS RURAL	40 KILOMETER RADIUS URBAN	80 KILOMETER RADIUS RURAL	80 KILOMETER RADIUS URBAN
SOUTH DAKOTA					
	BON HOMME			3,947	6,806
	CLAY	1,781	633	2,920	10,769
	LINCOLN	4,406	3,863	6,554	7,388
	DAVISON			0	0
	MCCOOK	262		2,903	3,541
	HANSON			2,083	1,014
	HUTCHINSON	1,108	2,255	4,223	4,840
	MINNEHAHA	1,369		17,435	91,748
	TURNER	4461	2983	4461	2983
	UNION	558	1,504	4,934	4,050
	YANKTON	4,881	765	5,920	13,032
	MINER			55	
	LAKE			931	
	MOODY			270	
	SUBTOTAL	18,826	12,003	52,689	139,365
NEBRASKA					
	CEDAR			6,608	1,730
	DIXON			2,049	1,057
	KNOX			3,219	1,393
	SUBTOTAL	0	0	11,876	4,180
IOWA					
	LYON			8,312	2,693
	SIOUX			14,047	11,730
	PLYMOUTH			3,994	1,517
	SUBTOTAL	0	0	26,353	15,940
MINNESOTA					
	ROCK			2,897	1,011
	TOTAL	18,826	12,003	97,762	167,302

TOTAL POPULATION OF 40 KILOMETER RADIUS 30,829 PEOPLE

TOTAL POPULATION OF 80 KILOMETER RADIUS 265,064 PEOPLE

TABLE 5. POPUALTION AROUND SWAN LAKE IN 1990

STATE	COUNTY	40 KILOMETER RADIUS RURAL	40 KILOMETER RADIUS URBAN	80 KILOMETER RADIUS RURAL	80 KILOMETER RADIUS URBAN
SOUTH DAKOTA					
	BON HOMME			2,412	3,406
	CLAY	1,429	538	2,614	10,572
	LINCOLN	4,624	4,000	6,826	8,601
	DAVISON			24	312
	MCCOOK	232		2,521	3,167
	HANSON			1,222	958
	HUTCHINSON	981	2,061	3,492	4,528
	MINNEHAHA	972		12,720	110,183
	TURNER	5146	3430	5146	3430
	UNION	394	1,500	2,895	3,766
	YANKTON	2,783	759	5,508	13,744
	MINER			37	
	LAKE			916	
	MOODY			247	
	SUBTOTAL	16,561	12,288	46,580	162,667
NEBRASKA					
	CEDER			4,639	2,708
	DIXON			1,124	1,202
	KNOX			1,415	1,185
	SUBTOTAL	0	0	7,178	5,095
IOWA					
	LYON			3,413	5,101
	SIOUX			5,382	12,720
	PLYMOUTH			1,990	1,726
	SUBTOTAL	0	0	10785	19547
MINNESOTA					
	ROCK			2,564	5,414
		16,651	12,288	67,107	192,723

TOTAL POPULATION OF 40 KILOMETER RADIUS 17,849 PEOPLE

TOTAL POPULATION OF 80 KILOMETER RADIUS 259,830 PEOPLE

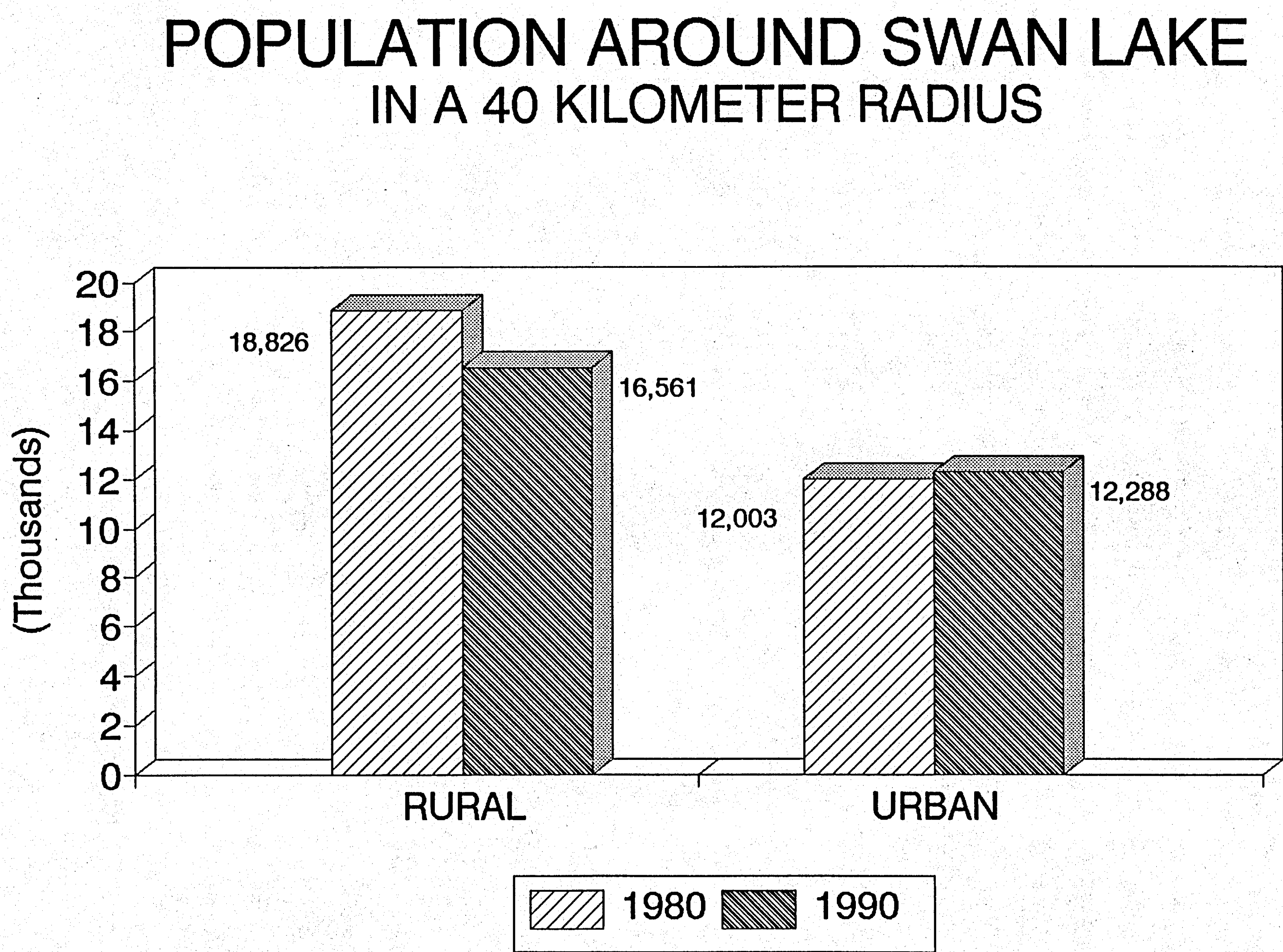


Figure 6. Population Around Swan Lake (40 km).

The population in the 80 km radius of the lake also decreased but proportionately less than that of the 40 km radius area (Figure 7). The total net population loss in the larger user area over the last 10 years was 2 percent or 5,234 people. There was a decrease of 31 percent or 30,655 people in the rural population. However, the urban population increased 13 percent or 25,421 people. The growth of Sioux Falls and its surrounding communities is largely responsible for the increase in the urban population. Due to the rural nature of the area and the drop in the farm economy those areas dependant on the family farm will continue to decline. However, the growth of Sioux Falls will continue to bring people, jobs, and stability to the area and should eventually balance the recent population losses in the rural community.

Employment Profile

Seventy-five percent of the residents within 80 km of Swan Lake are employed in the non-manufacturing type occupations represented by agriculture, agri-business, education and service industries. In Turner County, more than 90% of the work force is employed in agriculture and agricultural related business. The unemployment rate for Turner County in 1990 was approximately 2.5% in a labor force of nearly 4,300 workers (Figure 8). This was substantially below the state average of 3.7% and the

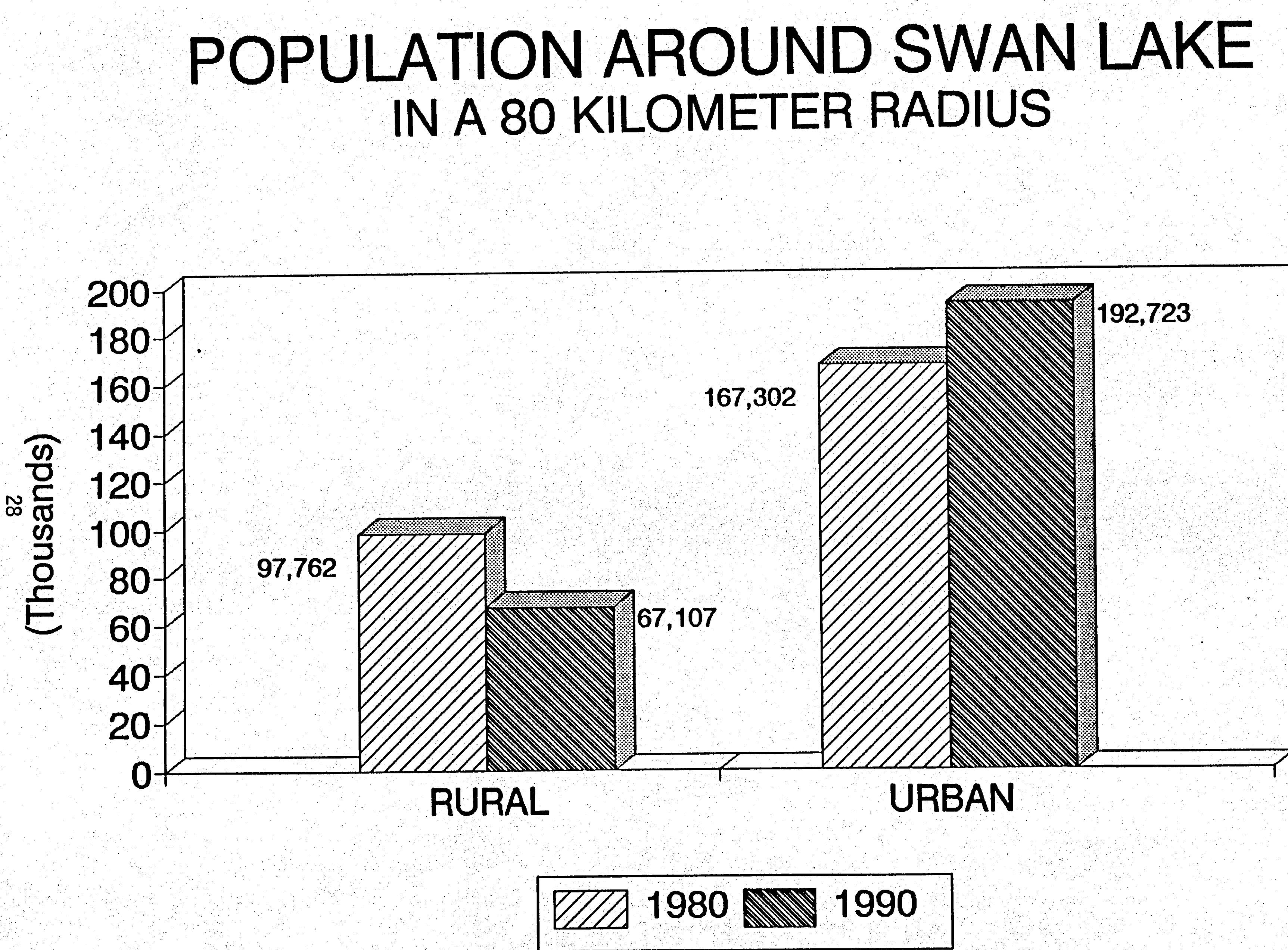


Figure 7. Population Around Swan Lake (80 km).

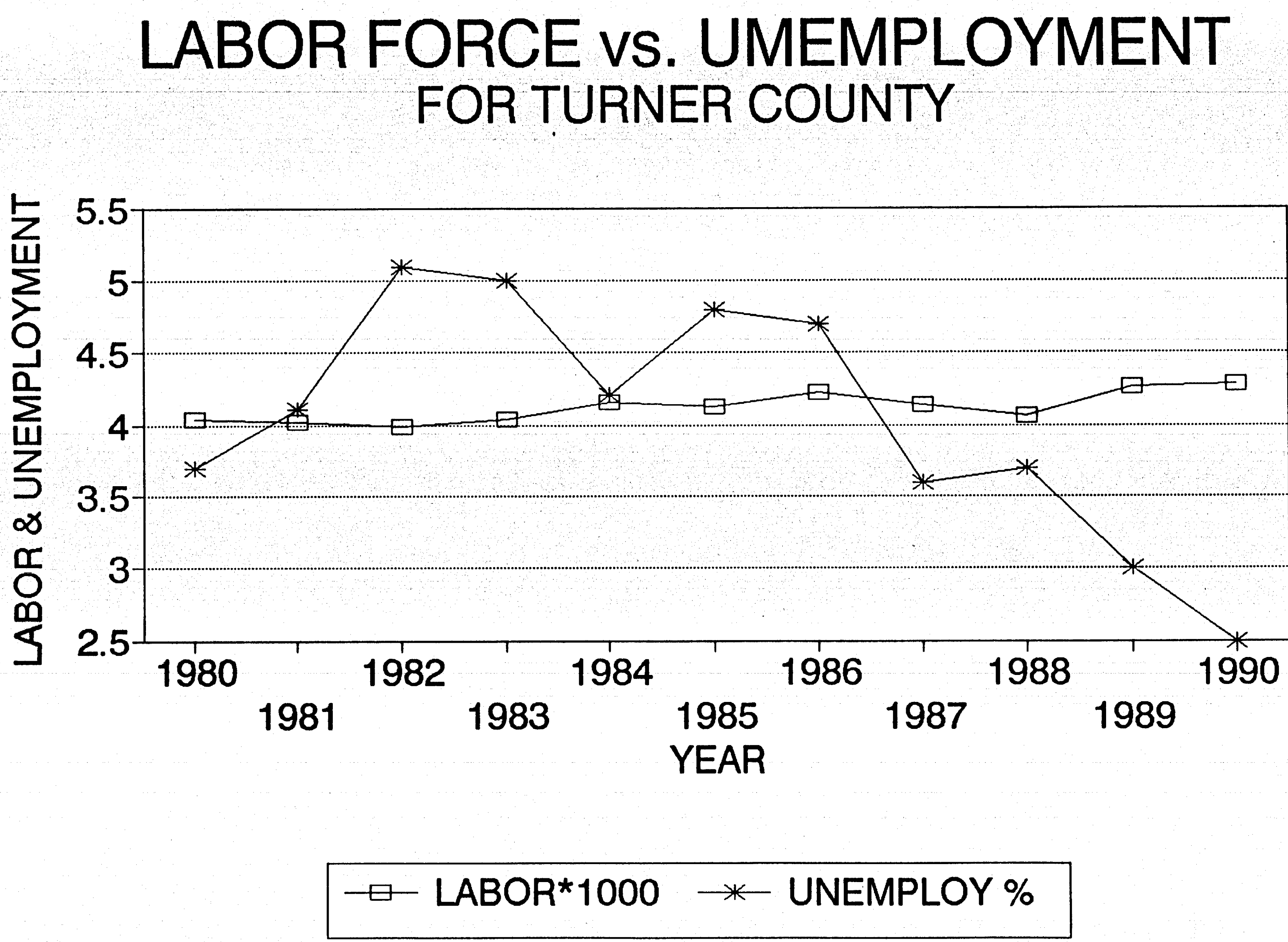


Figure 8. Labor Force and Unemployment for Turner County.

national average of 5.5% for that year. A positive sign for the local economy has been a gradually declining unemployment rate from 1982 to 1991 in the face of increasing available labor (Figure 8).

In 1987, per capita income of rural townships in the 40 km user area was very similar to that of the urban per capita income in the same user area (approximately $8,010). This contrasts with an estimated $8,717 for city residents outside the 40 km radius, reflecting the higher wages paid in the largest city, Sioux Falls, about 46 km northeast of Swan Lake. Per capita income in southeastern South Dakota within an 80 km radius of Swan Lake was substantially below the national average $11,923 (1988) and slightly less than the state average of $8,910 (1988). Since 1979, however, per capita income in the 40 km radius around Swan Lake has increased approximately 51%, and approximately 60% for the area outside the 40 km radius (Figure 9). This reflects more rapid growth of the job market in the larger cities than in the small agricultural areas.

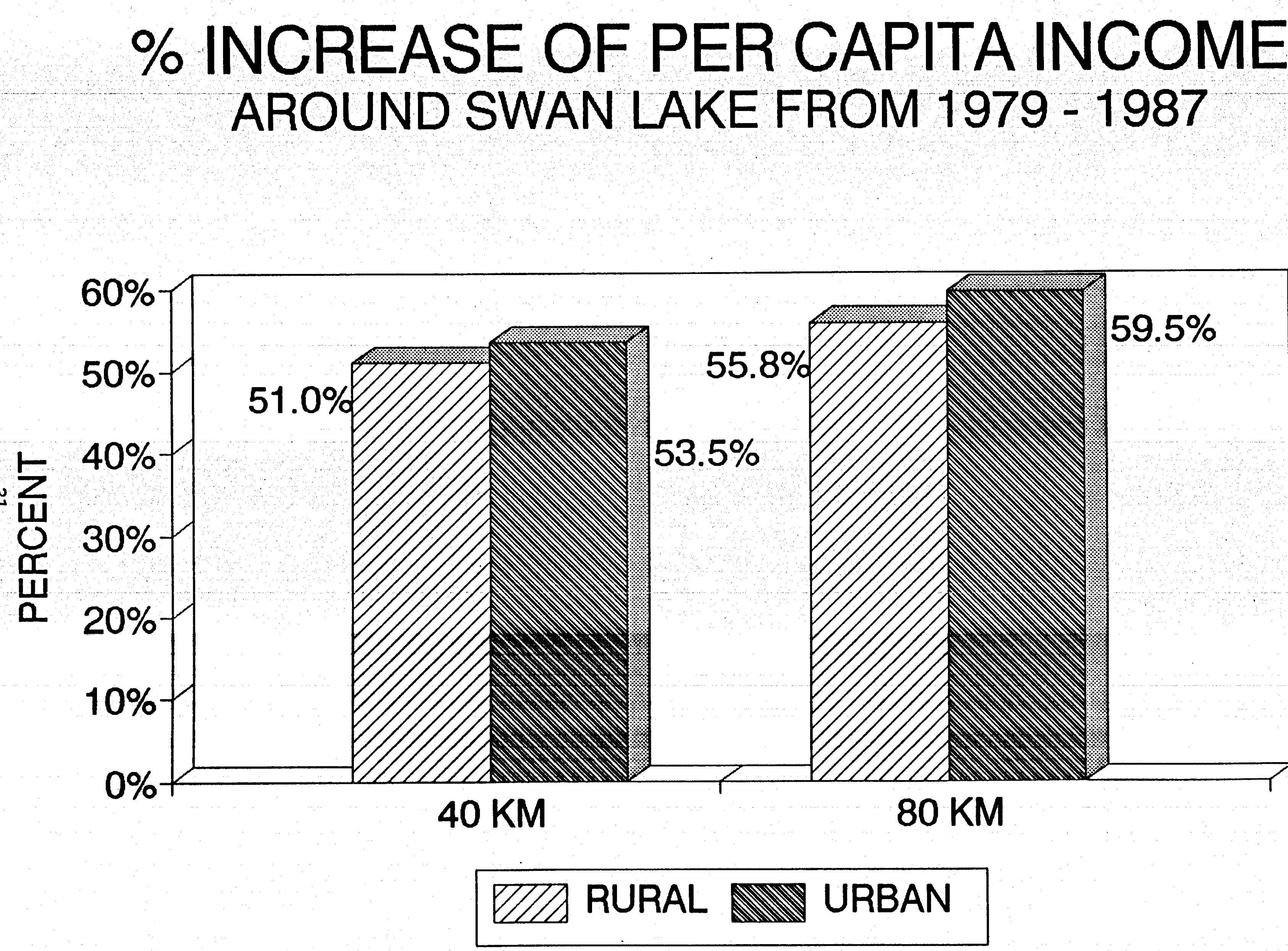


Figure 9. Percent Increases of Per Capita Income.

SUMMARY OF HISTORICAL LAKE USES

Swan Lake is a shallow natural lake in the Vermillion River basin with a surface area of approximately 72.8 hectares (180 acres), a mean depth of 1.4 meter (4.5 ft), and a maximum depth of 1.8 meter (6 ft). There is no enduring summer stratification. Turbid water conditions that usually prevail during the growing season [mean 1991 secchi depth: 0.37 m (<15 inches)] hinder development of submerged aquatic plants. Swan Lake nonetheless supports large populations of planktonic algae during the spring and summer months.

Swan Lake and its surrounding watershed consist of approximately 33,013 hectares (81,576 acres) in southcentral Turner County. This acreages includes the lake's original (natural) watershed estimated at approximately 420 hectares (1,040 acres) as well as the greater part of the nearby Turkey Ridge Creek drainage which was diverted in 1914 by creation of a diversion ditch from lower Turkey Ridge Creek to the northeast corner of the lake. The diversion was constructed to fill the lake each year with spring runoff water to compensate for the considerable seasonal drop in lake water level that occurs in summer due to evaporation and seepage.

To provide control over water inflow, two gated culverts with concrete support structures were installed in the 230 foot long diversion channel with a small sediment settling basin between them. A small check dam of corrugated steel was placed across Turkey Ridge Creek approximately 630 feet downstream of the ditch to raise the water level of the stream sufficiently to ensure a useable gravity flow to Swan Lake (Appendix C). In the 1930's a road was constructed across the lake's natural outlet and three 30-inch oval culverts were installed in the roadway to serve as a spillway. In 1981, this road was raised 15 cm (6 inches) to strengthen its function as a flood barrier.

By 1974, sediment carried into the lake by the diversion ditch and lakeshore erosion had accumulated in this naturally shallow basin (mean depth: 3 meters) to the extent that boating became hazardous during the low water summer season in some areas of the lake. A dredge project was initiated by the SD GF&P which removed approximately 325,000 cubic yards of sediment by the end of 1975. Unfortunately, most benefits of this project are no longer evident, the lake having become re-silted to nearly pre 1975 levels with its shallower areas again a threat to summer boating and waterskiing. However, no significant fish kills have been reported in Swan Lake since completion of the dredging project (Robert Hanten, SD GF&P, verbal communication).

Swan Lake has provided recreational opportunities for Turner County and surrounding areas virtually since early settlement of the region more than a century ago. In the 1870's Swan Lake was a popular site for 4th of July celebrations organized by settlers of the area. A small town named Swan Lake City was established near the Lake and by 1872 had become the county seat.

No doubt an important appeal for settlement of this area was the availability of potable water, and a plentiful supply of waterfowl and fish for consumption and recreational sport. Early narratives particularly note the excellent waterfowl hunting and fishing available in the Swan Lake area. This recreational potential appears to have been maintained well into the present century. Anecdotal accounts relate that common fish species in the lake during the 1930's and 40's consisted of gar, buffalo, carp, black bullhead, sunfish, yellow perch, crappie, northern pike, and walleye in approximate order of abundance. During this period the acceptable water quality of Swan Lake was attested to by the presence of an established ice cutting operation and a permanent ice house located at lakeside.

Actual usage data has never been kept on Swan Lake, so it cannot be established with any confidence when lake usage started to decline, and makes accurate assessment of losses in beneficial hours impossible. Based on circumstantial evidence, conditions may have begun to worsen perceptibly during the 1940's and 1950's as agriculture became more intensive, and as ground water usage increased. The result of intensified land use may have been more sediment-laden runoff due to increased erosion in the Turkey

Ridge Creek watershed. Because of its relatively small acreage and naturally shallow basin, Swan Lake is vulnerable to even moderate levels of sedimentation and loss of water by evaporation and seepage.

Water Quality Standards/Beneficial Uses

Swan Lake is presently classified under the South Dakota Water Quality Standards for the following beneficial uses:

1. Warm-water semi-permanent fish life propagation;
2. Immersion recreation;
3. Limited contact recreation; and
4. Wildlife propagation and stock watering

Water quality criteria for beneficial uses are listed in Table 1.

Lakeshore Development/Lakeside Community

Present lakeshore development includes 80 private residences 75 of which are summer houses and five permanent homes. Located on the south lakeshore is a church camp, a small public swimming beach, and a state boat ramp and parking lot. Located on the north side of the lake is a hunting and large public access area, a small camping area, and a public park. A small general store is located near the south east shore. There has been considerable local interest in the lake as demonstrated by the extensive involvement of the Swan Lake Improvement Association and other local support for past lake restoration projects such as the SD GF&P lake dredging project (1974 and 1975), a riprapping project for the eastern and western shorelines (1978-1980), and an extensive renovation of the lake inlet structure.

Drainage

Approximately 96% of the surface inflow to Swan Lake is provided by Turkey Ridge Creek, an intermittent stream which drains a land area in excess of 32,000 hectares (80,000 acres). From late fall through winter most of the flow is derived from surface aquifer seepage or artesian wells, located approximately 22 km (14 miles) northwest of the lake, rather than from snowmelt or storm water runoff. These winter flows do replace a substantial portion of the lake water volume lost by evaporation. Local residents maintain that there were several seepages or springs located in the lake basin which may have been rendered inactive by sedimentation.

An inlet from the natural drainage enters Swan Lake at the southwest corner. This minor channel carries primarily rainstorm and snowmelt runoff from a small portion of the lake's immediate watershed.

Lake outflows make their way through the culvert spillway at the southeast corner of Swan Lake and into a channel that directs spillway water back into lower Turkey Ridge Creek. The creek flows in a general southeasterly direction to its confluence with the Vermillion River, a straight line distance of nearly 16 km (10 miles) southeast of the lake.

Over the years the loss of depth in the southwest bay located near the Christian Camp has caused the SD GF&P to prohibit motor boats from using the area. The benefits which were hoped to be gained by this action were to reduce the sediment suspended by boat motors, reduce shoreline erosion from excessive wave action, have a place to canoe with less danger, and enhance wildlife in the area.

Wildlife Propagation

The southern and eastern shores of Swan Lake are surrounded by a border of trees comprised of a number of species such as ash, cottonwood, silver maple, aspen, elm, locust, box-elder and others. Scattered groups of honey locust are found in the grassland areas bordering much of the lake perimeter. This type of varied habitat has attracted a diverse assemblage of birds including waterfowl, shore birds, and songbirds. Field personnel incidentally noted 20 species of birds in the short space of two hours in mid May 1992.

There was, in past decades, considerable use of the lake for waterfowl hunting. However, this activity has declined in recent years in part due to smaller numbers of waterfowl in the area and throughout the nation, and to a lesser extent, shoreline development. Nevertheless, the lake still serves as a significant staging and resting area for migratory waterfowl.

Swan Lake is located on or near the migratory routes of not only waterfowl but other types of birds as well. The number and variety of trees near the lake provides a tree-lined shelter for both migratory and nesting bird species and attracts woodland birds not ordinarily found in fields or grasslands.

Sport Fishing/Commercial Harvest

In the first decades of this century Swan Lake supported an active warm-water fishery for game and pan fishes notably northern pike, walleye, sunfish, yellow perch, and crappie. Subsequent years saw an increase in lakeside development; intensification of agriculture; utilization of groundwater; and diversion of the Turkey Ridge Creek watershed into the lake. In the last few decades, lake nutrient concentrations and consequent algal populations have reached hypereutrophic levels. Other signs of lower water quality are increased turbidity and winter oxygen deficits (<5 mg\L). Most serious, however, is the present low water clarity and the severe siltation problem that has developed in Swan Lake primarily from the Turkey Ridge diversion and, secondarily, from lakeshore erosion. Large accumulations of silt and organic matter have hindered swimming and boating and produced extensive winter fish kills. Former game and panfish populations have been replaced by large populations of carp, buffalo, bullhead, and other rough fish. As a result, sport fishing activity has declined appreciably in the last ten years despite periodic stocking of walleye and northern pike by SD GF&P and attempts to remove rough fish by commercial seining.

Table 6 suggests that rough fish are favored by the present conditions in Swan Lake (shallow, silty, and turbid), despite repeated stocking of game fish juveniles and fry during the early

1980's (Table 7). Rough fish such as carp and black bullheads compete with other species for habitat and food resources. These bottom feeding fish may also contribute substantially to water turbidity in Swan Lake by constantly stirring up shallow lake sediments. Clearly, additional efforts should be made to improve lake habitat to the advantage of the more valuable fish species.

Table 6. Trap Net Survey Data (1971-1985) and stocking records (1976-1991) from Swan Lake.

Total catch of 7 trap nets (mesh size 3/4 - 1"), July 12-14, 1971

Species	No.	%	Wt.	%	Average Inch	Average Lbs.
Black Bullhead	465	57.1	172.00	35.1	8.0	0.37
Green Sunfish	123	15.1	19.68	4.1	5.7	0.16
Carp	104	12.8	116.48	23.7	13.3	1.12
White Sucker	81	9.9	30.78	6.3	9.8	0.38
Buffalo	21	2.6	143.00	29.2	21.6	6.81
Orange Sunfish	11	1.3	1.00	0.2	4.6	0.09
Bluegill	7	0.9	0.77	0.2	5.2	0.11
Crappie	2	0.2	2.32	0.4	12.1	1.16
Northern Pike	1	0.1	3.80	0.8	24.0	3.80
Rough Fish	671	82.3	462.26	94.4		
Game Fish	144	17.7	27.57	5.6		

Total catch of six trap nets (mesh size 3/4"), June 28-30, 1976.

Species	No.	%	Wt.	%	Average Inch	Average Lbs.
Yellow Perch	163	30.2	33.42	14.1	7.5	0.21
Black Bullhead	125	23.1	42.88	18.1	8.3	0.34
Green Sunfish	101	18.7	13.90	5.9	5.5	0.34
Carp	78	14.4	62.76	26.5	12.2	0.80
White Sucker	59	10.9	48.48	20.4	12.5	0.82
Orange Sunfish	9	1.7	0.45	0.1	3.7	0.05
Buffalo	4	0.7	21.51	9.1	20.7	5.38
Northern Pike	1	0.2	13.80	5.8	37.2	13.80
Rough Fish	266	49.3	175.63	74.0		
Game Fish	274	50.7	61.57	26.0		

Total catch of 14 trap nets (mesh size 3/4"), June 22-23, 1980.

Species	No.	%	Wt.	%	Average Inch	Average Lbs.
Yellow Perch	892	36.4	267.5	24.7	8.26	0.30
Bullhead	617	25.2	296.2	27.3	8.98	0.48
White Sucker	543	22.2	385.5	35.6	11.80	0.71
Green Sunfish	197	8.1	37.4	3.5	6.18	0.19
Orange Sunfish	164	6.7	6.6	0.6	3.84	0.04
Buffalo	15	0.6	51.2	4.7	17.33	3.41
Carp	15	0.6	22.5	2.1	14.48	1.50
Walleye	5	0.2	17.5	1.6	20.82	3.50
Rough Fish	1,190	48.6	755.4	69.7		
Game Fish	1,258	51.4	329.0	30.3		

Total catch of 3 trap nets (mesh size 3/4 -1"), March 28, 1985.

Species	No.	%	Wt.	%	Average Inch	Average Lbs.
Black Bullhead	535	84.3	NA	NA	NA	NA
Buffalo	21	3.3	NA	NA	NA	NA
Northern Pike	17	2.7	NA	NA	NA	NA
White Sucker	17	2.7	NA	NA	NA	NA
Walleye	15	2.4	NA	NA	NA	NA
Carp	13	2.0	NA	NA	NA	NA
Yellow Perch	12	1.9	NA	NA	NA	NA
Green Sunfish	3	0.4	NA	NA	NA	NA
Rough Fish	586	92.6	NA	NA	NA	NA
Game Fish	47	7.4	NA	NA	NA	NA

Source: SD GF&P, Swan Lake Management Reports 1971, 1976, 1980 and 1985.

Table 7. Stocking Records

Year	Number	Species	Size
1976	33,275	Bluegill	Fingerling
	18,000	Largemouth Bass	Fingerling
	180,000	Northern Pike	Fry
	180,000	Walleye	Fry
1977	180,000	Northern Pike	Fry
1979	180,000	Northern Pike	Fry
1980	200,000	Northern Pike	Fry

1980	886	Northern Pike	Fry
1981	100,000 9,100	Walleye Walleye	Fry Fingerling
1982	350,000	Northern Pike	Fry
1983	180,000	Northern Pike	Fry
1989	200 900	Northern Pike Walleye	Adult Fingerling
1991	20,000	Walleye	Fingerling

Source: SD GF&P, Swan Lake Yearly Stocking Reports.

Relatively small quantities of rough fish were removed from Swan Lake when commercial netting operations began about 15 years ago. For fiscal year 1976-1977, 13,050 pounds of carp and buffalo were taken. During the following fiscal year this total dropped to 6,235 pounds (Table 8). As a result, fishing was discontinued for a period of 10 years. Commercial catches of rough fish improved considerably when seining resumed in 1989 but fell to negligible levels in 1990 and 1991 (Table 8). The explaination was because of the large catch in the 1989-1990 season, the population was depleted and it was not economically feasible.

Table 8. South Dakota Commercial Fish Catch (pounds) in Swan Lake, 1976 to 1992.

Fiscal Year	Carp	Buffalo	Black Bullhead	Total
1976-77	5,375	7,675	--	13,050
1977-78	1,000	5,200	--	6,200
1978-88	--	--	--	Not Fished
1989-90	24,850	21,500	4,640	50,990
1990-91	--	Negligible Catch		--
1991	--	Negligible Catch		--

Source: SD GF&P Records

POPULATION SEGMENTS ADVERSELY AFFECTED

BY LAKE DEGRADATION

Turner County is one of the more sparsely populated counties in eastern South Dakota with a total of 8,576 residents. Swan Lake development, therefore, represents an important local tax base. The assessed valuation of lakeside homes and properties is $727,070 with a levied tax of $20,590 that accrues to the county each year.

It is likely that as present conditions in the lake show no perceptible improvement or undergo further deterioration, lakeside property values may decline and this tax base may erode. In addition, individual local businesses such as a lakeside general store and the nearby towns of Viborg and Hurley may experience financial reverses if recreational fishing and boating potential remains marginal as it has been for the recent past. Thus, the economic health of certain businesses in these small rural communities could be seriously affected unless steps are taken to improve the recreational quality of Swan Lake.

COMPARISON OF LAKE USES TO USES OF OTHER LAKES IN THE REGION

Swan Lake lies within the lower half of the Vermillion River Basin in southeastern South Dakota. This basin borders the Big Sioux Coteau on the north, a region which contain a relatively large number of freshwater lakes of good quality. In the area within an 80 km radius of Swan Lake, lakes of similar quality are comparatively few. Within state boundaries, seven lakes with a total area of slightly over 5,000 acres, have comparable public facilities to those of Swan Lake, not including Lewis and Clark Reservoir on the Missouri River (Table 9). Most of the other lakes identified in an 80 km radius of Swan Lake have marginal fisheries with reduced access and few facilities such as serviceable boat ramps. Because of the sizable population within this perimeter (259,830), there is estimated to be a large unfulfilled demand for water based recreation in this region of southeastern South Dakota.

Table 9. Lakes Within an 80 km Radius of Swan Lake and Their Uses.

WATERBODY	PARKS	RAMPS	*USES	NEAREST MUNICIPALITY
Lake Madison	1	4	B,C,F,P,S	Madison, SD
Brandt Lake	1	3	B,C,F,P,S	Chester, SD
Fairview Pond	0	0	F	Inwood, IA
Lake Pahoja	0	1	B,C,F,H,P,S	Larchwood, IA
Burbank Lake	0	0	F,S	Burbank, SD
Lake Cole	0	0	F	--
Beaver (State) Lake	0	1	F	Utica, SD
Westside Lake	0	0	F	--
Marindahl Lake	0	1	B,F,S	Irene, SD
Lake Yankton	1	1	B,F,S	Yankton, SD
Lewis & Clark Reservoir	1	4	B,C,F,P,S	Yankton, SD
Clear Lake	0	0	F,S	--
Lake Henry	0	1	F,S	Scotland, SD
Kloucek Lake	0	0	F	Tabor, SD
Lake Menno	0	0	F,S	Menno, SD
Lake Dimock	0	1	F,S	Dimock, SD
Lake Tripp	0	1	F	Tripp, SD
Silver Lake	0	1	F	Dolton, SD
Swan Lake	**1**	**1**	**B,C,F,H,P,S**	**Viborg, SD**
Lake Marion	0	0	F	Marion, SD
Baureles (Schultz) Lake	0	0	F	Spencer, SD
Gross Lake	0	0	F	Spencer, SD
Schimmels Lake	0	0	F	Spencer, SD
Tuschens Slough	0	0	H	Spencer, SD
East Lake Vermillion	1	3	B,F,P,S	Humbolt, SD
Wall Lake	1	1	B,F,P,S	Hartford, SD
Baltic Lake	0	0	F,S	Baltic, SD
Beaver Lake	0	1	F,S	Humbolt, SD
Clear Lake	0	1	F,H	Colton, SD
Lost Lake	0	0	F,H	Humbolt, SD
Covell Lake	0	0	F,S	Sioux Falls, SD
Dell Rapid Lake	0	1	F	Dell Rapids, SD
Loss Lake	0	1	F	Hartford, SD
Lake Alvin	1	2	B,F,H,P,S	Harrisburg, SD
Pattee Creek Watershed Reservoir #1 (Lakota)	1	1	B,F,S	Fairview, SD
Pattee Creek Watershed Reservoir #2	0	0	F,S	Fairview, SD
Hanson Lake	0	1	B,F,S	Alexandria, SD
Lake Ethan	0	1	F	Ethan, SD
Fulton Lake	0	0	F	Fulton, SD

*Uses: B = Boating C = Camping F = Fishing
H = Hunting P = Picnicking S = Swimming

Source: SD GF&P

INVENTORY OF POINT SOURCE

POLLUTION DISCHARGES

There are no known point source dischargers located in the Swan Lake watershed.

LAND USES AND NONPOINT POLLUTANT LOADINGS

Land Uses In The Watershed

The Swan Lake watershed has approximately 81,576 acres of primarily agricultural land. The percentage of land use was estimated by planimetering one-half of the (even numbered sections) ASCS aerial section photos in the watershed. This constituted one-half of the watershed. A digital planimeter was used to set the scale for each sheet. Once the land uses for each section were planimetered, the acreages were added, and divided by the total acreages in the section. Since only one-half of the sections were planimetered, the total was doubled to arrive at an estimate of the entire watershed. An estimate of four acres was given to each mile of road (transportation) surrounding a section. In the Swan Lake watershed, cropland (77.02%) and pasture (13.71%) make up over 90 percent of the watershed. The remaining uses total less than 2.5 percent each. Figure 10 summarizes the land uses in the watershed. The acreages of the sections planimetered are located on Table 10.

Percentages for sub-watersheds were also calculated (Table 11). Sub-watersheds were chosen by their location, type of topography and size (Figure 11). Subwatershed 1 is the natural drainage

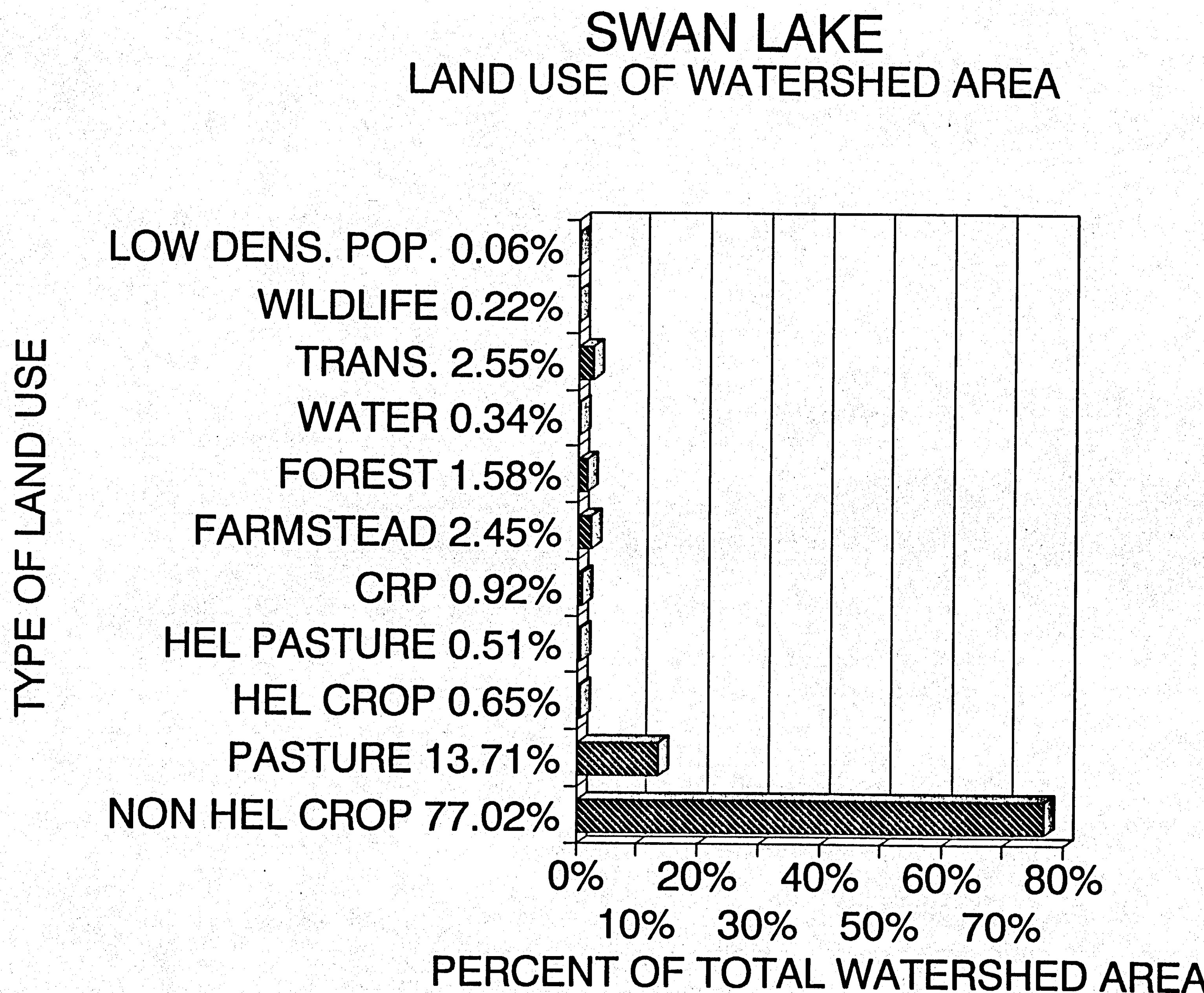


Figure 10. Land Use of the Watershed Area.

TABLE 10. LAND USE FOR SWAN LAKE WATERSHED

LOCATION		DESCRIPTION											
TOWNSHIP - RANGE	SECT.	CROP-LAND	PASTURE	HEL CROPLAND	HEL PASTURE	CRP	FARM-STEAD	FOREST	WATER	TRANS.	WILDLIFE	LOW DENS. POPULATION	TOTAL PER SECTION
97-53	2	137.3											137.3
97-53	4	507.9	47.9				22.9	15.64		16			610.34
97-53	6	322.7	297.3				12.6	9.9		16			658.5
97-53	10	329	147				9.2			16			501.2
97-53	16	386.9	97				3	4	87.6	16		25.8	620.3
97-53	18	592.7	5.9				10	0.8		16			625.4
97-53	20	144.4								6	97.7		248.1
97-53	8	558.8	48.9				8.1			16			631.8
97-54	2	550.7	111.2				3.2			16			681.1
97-54	4	521.8	45.7				4.5	14.9		16			602.9
97-54	6	509.9	51.3				18.2	20.4		16			615.8
97-54	8	572.5	75				22.6	16.4		16			702.5
97-54	10	536.1	115.9				6.7	5		16			679.7
97-54	12	466.6	141.8					4.1		16			628.5
97-54	14	585.1	48.9				8.1			16			658.1
97-54	16	478	57				24			16			575
97-54	18	376	111.9		8.5		24	3	0.5	16			539.9
97-54	20	350.7	159.8		5.8	105.1	16			16			653.4
97-54	22	524	49				24.4			16			613.4
97-54	28	530	89		11.5		37.7			16			684.2
97-54	30	352.5	24.2		87.7		31.8			16			512.2
97-55	2	418.4	156	12			12.7	21		16			636.1
97-55	4	498.5	87.8	14.1			27.1		2	16			645.5
97-55	10	484.4	6.8				21.7	11.9		16			540.8
97-55	12	413.9	130.1	4.1			8.5	37.5		16			610.1
97-55	14	476.5	35.4			87	14.8	10		16			639.7
97-55	22	368.1	151	49.9	9.6		6	2	6.4	16			609
97-55	24	430.5	119.9	34.2			23.1	6.8	3.8	16			634.3
97-55	26	351.2	93.3	10.7		111.8	21.9	13	17.1	16			635
98-53	18	394.8					13.6			8			416.4
98-53	20	595.4	9.3				21.4	3.6		16			645.7
98-53	28	329.1	5				10.6	18		8			370.7
98-53	30	554.3	40				7.2	4	2	16			623.5
98-53	32	598.6	8.4				11.3	2	9.7	16			646
98-53	34	250.1					13.2	3		8			274.3
98-54	4	278.9	7					9.9		8			303.8
98-54	6	439.8	180.7				10.4	20.2		16			667.1
98-54	8	510.4	38.3			39.7	21.4	6.5	1.6	16			633.9
98-54	10	603					19.2	3.2		16			641.4
98-54	12	566.9	26				9.9	11.6		16			630.4
98-54	14	584.9					15.2	15.7		16			631.8
98-54	16	513.3	40.7				13.5	7.5		16			591
98-54	18	458.2	121.7				9.4	5		16			610.3
98-54	20	574.7	3.6				18.8	16.3		16			629.4
98-54	22	565.7	65.4				9.8	4		16			660.9
98-54	24	527.4	75.5				14.4	13		16			646.3
98-54	26	414.5	143.4				15.8	17.7	0.5	16			607.9
98-54	28	547	5.7				11.7	5.6		16			586
98-54	30	504.6	102.3				8	11		16			641.9
98-54	32	517.5	62.9				12.5	24.2		16			633.1
98-54	34	522.7	43.8				23.9	10	0.5	12			612.9
98-54	36	516.2	107.8				2.3			16			642.3
98-55	2	464	38.4				11	18.1		16			547.5
98-55	4	69.6	0.8							3			73.4
98-55	8	369.6	38				16.2	15.3	7.2	16			462.3
98-55	10	555.6	3.5				39.8	9.6		16			624.5
98-55	12	356	251.2		5.2		23.7	12		16.7			664.8
98-55	14	487	92.9				16.6	4.8		19.6			620.9
98-55	16	506.7	82.3				16	9.2	4.9	16			635.1
98-55	18	457.4	183.8		13.4	5	16	7.1		16			698.7
98-55	20	366.7	172.6		36.5		26.8	13.9		16			632.5
98-55	22	443	192.7				15	30.4		16			697.1
98-55	24	583	2.6				22.1	12		16			635.7
98-55	26	493.9	107.5				10.2	17		16			644.6
98-55	28	258.4	287.8	19.1			12.5	21		16			614.8
98-55	30	507.9	67.3			12	13	12.7	2	16			630.9
98-55	32	416.6	85.4	103			7.7	5	3	16			636.7
98-55	34	184.1	377.8	36			5.5	49		12			664.4
98-55	36	422.6	178.6				18.2			16			635.4
98-56	10	86.7					7			4			97.7
98-56	12	325	5.5		43	41	15.2			16			445.7
98-56	14	560.8					13.8	15.8		16			606.4
98-56	22	503.3	97.7				17.1	10.3		16			644.4
98-56	24	512.1	104.1				4.7	8.6		16			645.5
99-55	34	568.1	23.7				25.2	10		16			643
	TOTAL	33641.2	5986.7	283.1	221.2	401.6	1069.6	690.14	148.8	1113.3	97.7	25.8	43679.14

PERCENTAGE OF TOTAL	CROP-LAND	PASTURE	HEL CROPLAND	HEL PASTURE	CRP	FARM-STEAD	FOREST	WATER	TRANS.	WILDLIFE	LOW DENS. POPULATION
	77.02%	13.71%	0.65%	0.51%	0.92%	2.45%	1.58%	0.34%	2.55%	0.22%	0.06%

TABLE 11. LANDUSE OF SUB-BASINS.

BASIN	CROP	PASTURE	HEL CRO	HEL	CRP	FARM	FORESTS	WATER	TRANS.	WILDIFE PRODUCTIO	LOW DENS. POP.	TOTAL ACRES	TOTAL HECTARES
1	58.5%	17.3%					0.7%	15.6%	28.5%		4.6%	1,038.2	420.2
2	86.8%	6.6%				2.6%	1.4%	2.1%	2.5%			7,938.1	3,212.6
3	85.2%	8.2%			0.5%	1.9%	1.6%	0.1%	2.5%			15,241.6	6,168.3
4	77.8%	14.8%		0.2%		0.3%	2.4%		2.4%			7,736.0	3,131.0
5	75.9%	14.6%		0.4%	0.1%	3.2%	2.0%	0.3%	3.5%			8,441.2	3,416.5
6	82.8%	74.8%		1.4%	1.4%	2.8%	1.5%		2.7%			4,826.5	1,953.3
7	68.9%	20.3%	2.1%	0.4%	1.0%	2.3%	2.6%	0.1%	23.6%			20,705.0	8,379.3
8	75.1%	15.6%	0.4%	0.3%	1.4%	2.5%	0.9%	0.0%	2.6%	1.3%		15,647.3	6,332.5

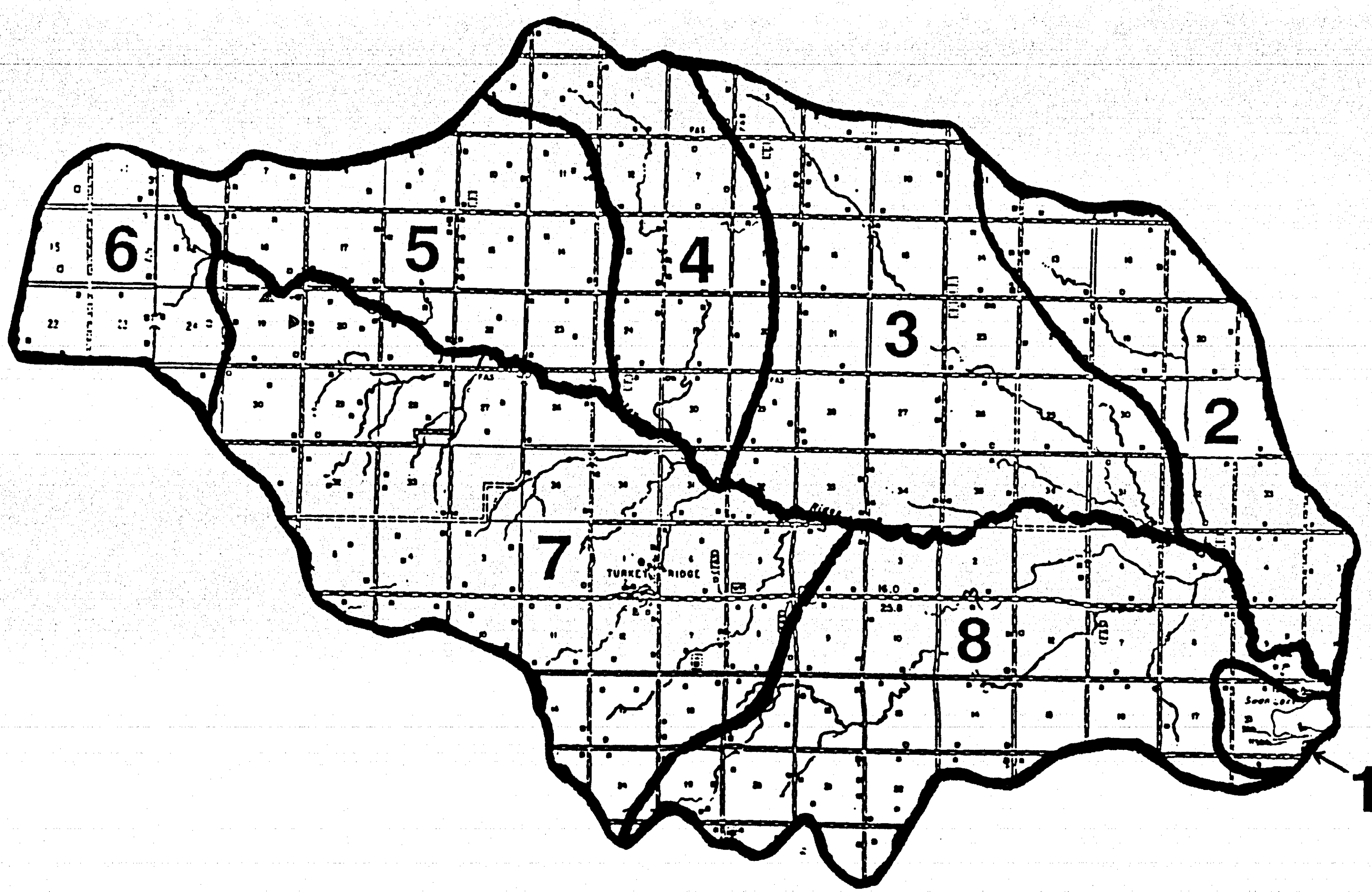


Figure 11. Sub-Basins in the Swan Lake Watershed.

area before the inlet channel was constructed on the north side of the lake. The other seven sub-watersheds where added to the Swan Lake watershed when the inlet was constructed, connecting the lake to Turkey Ridge Creek.

Nonpoint Source Loadings

By Land Use

Nonpoint source loadings were determined by calculating the soil loss from the sections divisible by four (one half of the sections planimetered for land use). As suggested by the EPA Clean Lakes Guidance Manual (EPA, 1980), the Universal Soil Loss Equation (USLE) was used to estimate the soil loss on specific sections. Because one-quarter of the sections were used to estimate soil loss, the total for the entire watershed was derived by multiplying the loss per section by four. It must be noted that the USLE will give an estimate and should not be taken at face value. The USLE gives an approximation of the amount of soil leaving the land and does not calculate how much of that sediment is actually delivered to the lake. It is better used as a comparison to find areas of highest soil loss.

The equation of the USLE (A=RLSKCP) estimates soil loss (A) by multiplying specific factors: 1) R = rainfall factor, 2) L = slope length, 3) S = slope steepness, 4) K = erodability factor,

5) C = cropping factor and 6) P = conservation practice. Every soil type in the watershed has a given RKLS factor. The C and P factors were acquired from the Turner County SCS office. The P factor of 1 was given for the entire watershed, indicating good conservation practices in the watershed. The cropping or C factor is dependant on the type of cropping rotation on a piece of land. From files of the ASCS office it was determined that 80 percent of the crop planted in the watershed is in a corn and bean rotation. Ten percent is rotated between corn, beans and oats, and 10 percent between corn, bean, oats, and alfalfa. Each land parcel was given these percentages for calculation, using the C factors given below. The C factors given to the crop areas were 0.38 for corn bean rotations, 0.33 for corn bean oats and 0.26 for corn bean oats alfalfa. The C factors usually given to pastures vary from 0.1 for pastures in poor condition to 0.01 for pastures in good condition. A factor of 0.05 was used as an average for all pastures in the watershed. By giving all of the sections the same P factor 1, and each parcel the same C factor the only variable is soil type. The calculated soil losses will give the a comparison for potential of each area to lose soil. The actual soil loss can be either higher or lower depending on the cropping practices applied to the land. Table 12 is a compilation of all sections calculated, soils, and land use.

The soil loss was totaled for each subwatershed. Not all of the sediment which comes off the land will reach a stream or lake. Much of the sediment is simply relocated. To obtain a more

TABLE 12. SEDIMENT LOSS PER SECTION.

TOWNSHIP	SECTION	TYPE	ACREAGE	SOIL	RKLS	C-B 80% CROP	C-B-O 10% CRO	C-B-O-A 10% CRO	TOTAL SOIL LOSS	TOTAL LOSS PER ACRE
97-53	4	C	210	EFA	6.4	408.58	44.35	34.94	487.87	2.32
97-53	4	C	150	ETB	23.1	1,053.36	114.35	90.09	1,257.80	8.39
97-53	4	C	100	EGB	21.2	644.48	69.96	55.12	769.56	7.70
97-53	4	C	80	EEB	26.4	642.05	69.70	54.91	766.66	9.58
97-53	4	C	20	CA	3.5	21.28	2.31	1.82	25.41	1.27
97-53	4	P	30	EFA	6.4				19.2	0.64
97-53	4	P	24	LA	4.8				11.52	0.48
97-53	4	P	14	EFA	6.4				8.96	0.64
97-53	4	P	7	ETB	23.1				16.17	2.31
97-53	4	P	5	EEB	26.4				13.2	2.64
97-53	8	C	320	EFA	6.4	622.59	67.58	53.25	743.42	2.32
97-53	8	C	280	WCA	5.2	442.62	48.05	37.86	528.53	1.89
97-53	8	C	40	LA	4.8	58.37	6.34	4.99	69.70	1.74
97-53	16	C	350	EFA	6.4	680.96	73.92	58.24	813.12	2.32
97-53	16	C	100	EEB	26.4	802.56	87.12	68.64	958.32	9.58
97-53	16	C	40	ETB	23.1	280.90	30.49	24.02	335.41	8.39
97-53	16	C	33	WO	4.6	46.15	5.01	3.95	55.10	1.67
97-53	16	P	55	EEB	26.4				145.2	2.64
97-53	16	P	25	ETC	29.1				72.75	2.91
97-53	16	P	24	EFA	6.4				15.36	0.64
97-53	16	P	16	BA	4.6				7.36	0.46
97-53	16	P	5	ETB	23.1				11.55	2.31
97-53	16	P	2	TE	4.8				0.96	0.48
97-53	20	C	165	EFA	6.4	321.02	34.85	27.46	383.33	2.32
97-53	20	C	20	BA	4.6	27.97	3.04	2.39	33.40	1.67
97-53	20	P	30	WO	4.6				13.8	0.46
97-53	20	P	25	BB	4.6				11.5	0.46
97-53	20	P	25	EFA	6.4				16	0.64
97-54	4	C	320	EFA	6.4	622.59	67.58	53.25	743.42	2.32
97-54	4	C	180	LA	4.8	262.66	28.51	22.46	313.63	1.74
97-54	4	C	34	AC	5.6	57.88	6.28	4.95	69.12	2.03
97-54	4	P	95	RO	6.4				60.8	0.64
97-54	4	P	11	CD	5.3				5.83	0.53
97-54	8	C	250	EGB	21.2	1,611.20	174.90	137.80	1,923.90	7.70
97-54	8	C	130	EEB	26.4	1,043.33	113.26	89.23	1,245.82	9.58
97-54	8	C	120	EFA	6.4	233.47	25.34	19.97	278.78	2.32
97-54	8	C	50	AC	5.6	85.12	9.24	7.28	101.64	2.03
97-54	8	C	20	CA	3.5	21.28	2.31	1.82	25.41	1.27
97-54	8	P	50	CC	5.6				28	0.56
97-54	8	P	22	EEB	26.4				58.08	2.64
97-54	12	C	450	EFA	6.4	875.52	95.04	74.88	1,045.44	2.32
97-54	12	C	50	CD	5.3	80.56	8.75	6.89	96.20	1.92
97-54	12	C	30	LA	4.8	43.78	4.75	3.74	52.27	1.74
97-54	12	P	70	BA	4.6				32.2	0.46
97-54	12	P	40	CA	3.5				14	0.35
97-54	16	C	250	EEB	26.4	2,006.40	217.80	171.60	2,395.80	9.58
97-54	16	C	200	AC	5.6	340.48	36.96	29.12	406.56	2.03
97-54	16	C	125	EFA	6.4	243.20	26.40	20.80	290.40	2.32
97-54	16	C	25	ETC	29.1	221.16	24.01	18.92	264.08	10.56
97-54	16	P	45	CC	5.6				25.2	0.56
97-54	20	C	500	EEB	26.4	4,012.80	435.60	343.20	4,791.60	9.58
97-54	20	C	30	EFA	6.4	58.37	6.34	4.99	69.70	2.32
97-54	20	C	30	ETC	29.1	265.39	28.81	22.70	316.90	10.56
97-54	20	C	20	CA	3.5	21.28	2.31	1.82	25.41	1.27
97-54	20	P	60	BEE	140				840	14.00
97-54	28	C	430	EEB	26.4	3,451.01	374.62	295.15	4,120.78	9.58
97-54	28	C	40	AC	5.6	68.10	7.39	5.82	81.31	2.03
97-54	28	C	40	TE	4.8	58.37	6.34	4.99	69.70	1.74
97-54	28	C	20	CA	3.5	21.28	2.31	1.82	25.41	1.27
97-54	28	P	71	EEB	26.4				187.44	2.64
97-54	28	P	40	SA	3.7				14.8	0.37
97-55	4	C	340	EEB	26.4	2,728.70	296.21	233.38	3,258.29	9.58
97-55	4	C	145	EGB	21.2	934.50	101.44	79.92	1,115.86	7.70
97-55	4	C	20	CA	3.5	21.28	2.31	1.82	25.41	1.27
97-55	4	C	18	EEB	26.4	144.46	15.68	12.36	172.50	9.58
97-55	4	P	40	ETC	29.1				116.4	2.91
97-55	4	P	20	EGB	21.2				42.4	2.12
97-55	4	P	20	ESD	63				126	6.30
97-55	4	P	7	TE	4.8				3.36	0.48
97-55	12	C	320	EEB	26.4	2,568.19	278.78	219.65	3,066.62	9.58
97-55	12	C	80	EGB	21.2	515.58	55.97	44.10	615.65	7.70
97-55	12	C	50	ETC	29.1	442.32	48.02	37.83	528.17	10.56
97-55	12	C	40	ETB	23.1	280.90	30.49	24.02	335.41	8.39
97-55	12	P	60	BEE	140				840	14.00
97-55	12	P	50	ESD	63				315	6.30
97-55	12	P	50	EEB	26.4				132	2.64
97-55	12	P	30	ETC	29.1				87.3	2.91
97-55	12	P	20	CA	3.5				7	0.35
97-55	24	C	200	EEB	26.4	1,605.12	174.24	137.28	1,916.64	9.58
97-55	24	C	80	ETC	29.1	707.71	76.82	60.53	845.06	10.56
97-55	24	C	30	CA	3.5	31.92	3.47	2.73	38.12	1.27

Table 12 continued.

TOWNSHIP	SECTION	TYPE	ACREAGE	SOIL	RKLS	C-B 80% CROP	C-B-O 10% CRO	C-B-O-A 10% CRO	TOTAL SOIL LOSS	TOTAL LOSS PER ACRE
97-55	24	C	30	EEB	26.4	240.77	26.14	20.59	287.50	9.58
97-55	24	C	20	TE	4.8	29.18	3.17	2.50	34.85	1.74
97-55	24	P	60	WO	4.6				27.6	0.46
97-55	24	P	43	ETC	29.1				125.13	2.91
97-55	24	P	5	WO	4.6				2.3	0.46
98-53	20	C	328	EFA	6.4	638.16	69.27	54.58	762.01	2.32
98-53	20	C	150	CA	3.5	159.60	17.33	13.65	190.58	1.27
98-53	20	C	80	EGB	21.2	515.58	55.97	44.10	615.65	7.70
98-53	20	C	32	BA	4.6	44.75	4.86	3.83	53.43	1.67
98-53	20	C	20	EEB	26.4	160.51	17.42	13.73	191.66	9.58
98-53	20	P	27	EFA	6.4				17.28	0.64
98-53	28	C	315	EFA	6.4	612.86	66.53	52.42	731.81	2.32
98-53	28	C	15	WCA	5.2	23.71	2.57	2.03	28.31	1.89
98-53	28	C	10	ETC	29.1	88.46	9.60	7.57	105.63	10.56
98-53	28	C	5	EGB	21.2	32.22	3.50	2.76	38.48	7.70
98-53	28	P	15	EFA	6.4				9.6	0.64
98-53	28	P	7	EEB	26.4				18.48	2.64
98-53	32	C	179	WCA	5.2	282.96	30.72	24.20	337.88	1.89
98-53	32	C	160	BKA	4	194.56	21.12	16.64	232.32	1.45
98-53	32	C	110	EFA	6.4	214.02	23.23	18.30	255.55	2.32
98-53	32	C	33	DO	3.6	36.12	3.92	3.09	43.12	1.31
98-53	32	C	33	WCA	5.2	52.17	5.66	4.46	62.29	1.89
98-53	32	C	33	LA	4.8	48.15	5.23	4.12	57.50	1.74
98-53	32	C	30	BMB	11.8	107.62	11.68	9.20	128.50	4.28
98-53	32	C	20	LA	4.8	29.18	3.17	2.50	34.85	1.74
98-53	32	P	13	WCA	5.2				6.76	0.52
98-54	4	C	180	CHB	16.5	902.88	98.01	77.22	1,078.11	5.99
98-54	4	C	50	COB	21	319.20	34.65	27.30	381.15	7.62
98-54	4	C	50	CHA	3.9	59.28	6.44	5.07	70.79	1.42
98-54	8	C	150	COB	21	957.60	103.95	81.90	1,143.45	7.62
98-54	8	C	90	COB	21	574.56	62.37	49.14	686.07	7.62
98-54	8	C	62	COC	29.1	548.48	59.54	46.91	654.92	10.56
98-54	8	C	60	CKA	3.5	63.84	6.93	5.46	76.23	1.27
98-54	8	C	60	COB	21	383.04	41.58	32.76	457.38	7.62
98-54	8	C	40	COB	21	255.36	27.72	21.84	304.92	7.62
98-54	8	C	40	CHA	3.9	47.42	5.15	4.06	56.63	1.42
98-54	8	C	30	CKA	3.5	31.92	3.47	2.73	38.12	1.27
98-54	8	C	20	CHB	16.5	100.32	10.89	8.58	119.79	5.99
98-54	8	C	20	COC	29.1	176.93	19.21	15.13	211.27	10.56
98-54	8	C	20	CR	3	18.24	1.98	1.56	21.78	1.09
98-54	8	P	30	COC	29.1				87.3	2.91
98-54	8	P	10	COB	21				21	2.10
98-54	8	P	10	DAA	5.1				5.1	0.51
98-54	12	C	320	CHA	3.9	379.39	41.18	32.45	453.02	1.42
98-54	12	C	80	CKA	3.5	85.12	9.24	7.28	101.64	1.27
98-54	12	C	80	CHB	16.5	401.28	43.56	34.32	479.16	5.99
98-54	12	P	115	COB	21				241.5	2.10
98-54	12	P	22	CHA	3.9				8.58	0.39
98-54	16	C	375	CHB	16.5	1,881.00	204.19	160.88	2,246.06	5.99
98-54	16	C	150	CKA	3.5	159.60	17.33	13.65	190.58	1.27
98-54	16	P	36	COC	29.1				104.76	2.91
98-54	16	P	12	CHB	16.5				19.8	1.65
98-54	16	P	8	CHB	16.5				13.2	1.65
98-54	20	C	235	CHA	3.9	278.62	30.24	23.83	332.69	1.42
98-54	20	C	210	CKA	3.5	223.44	24.26	19.11	266.81	1.27
98-54	20	C	100	CKA	3.5	106.40	11.55	9.10	127.05	1.27
98-54	20	C	45	COB	21	287.28	31.19	24.57	343.04	7.62
98-54	20	P	13	CHA	3.9				5.07	0.39
98-54	20	P	13	CHA	3.9				5.07	0.39
98-54	24	C	185	SA	3.7	208.09	22.59	17.80	248.47	1.34
98-54	24	C	140	CHB	16.5	702.24	76.23	60.06	838.53	5.99
98-54	24	C	65	WCA	5.2	102.75	11.15	8.79	122.69	1.89
98-54	24	C	60	COB	21	383.04	41.58	32.76	457.38	7.62
98-54	24	C	60	CHA	3.9	71.14	7.72	6.08	84.94	1.42
98-54	24	C	45	EFA	6.4	87.55	9.50	7.49	104.54	2.32
98-54	24	C	30	WCA	5.2	47.42	5.15	4.06	56.63	1.89
98-54	24	C	10	CHA	3.9	11.86	1.29	1.01	14.16	1.42
98-54	24	C	10	CHB	16.5	50.16	5.45	4.29	59.90	5.99
98-54	24	P	14	CHB	16.5				23.1	1.65
98-54	24	P	10	WCA	5.2				5.2	0.52
98-54	28	C	220	CKA	3.5	234.08	25.41	20.02	279.51	1.27
98-54	28	C	200	CHA	3.9	237.12	25.74	20.28	283.14	1.42
98-54	28	C	120	CKA	3.5	127.68	13.86	10.92	152.46	1.27
98-54	28	C	40	CR	3	36.48	3.96	3.12	43.56	1.09
98-54	28	P	20	CHA	3.9				7.8	0.39
98-54	32	C	90	COB	21	574.56	62.37	49.14	686.07	7.62
98-54	32	C	80	CHA	3.9	94.85	10.30	8.11	113.26	1.42
98-54	32	C	80	DAA	5.1	124.03	13.46	10.61	148.10	1.85
98-54	32	C	60	RO	6.4	116.74	12.67	9.98	139.39	2.32
98-54	32	C	40	EFA	6.4	77.82	8.45	6.66	92.93	2.32
98-54	32	C	30	CHB	16.5	150.48	16.34	12.87	179.69	5.99
98-54	32	C	20	COC	29.1	176.93	19.21	15.13	211.27	10.56

Table 12 continued.

TOWNSHIP	SECTION	TYPE	ACREAGE	SOIL	RKLS	C-B 80% CROP	C-B-O 10% CRO	C-B-O-A 10% CRO	TOTAL SOIL LOSS	TOTAL LOSS PER ACRE
98-54	32	C	20	LA	4.8	29.18	3.17	2.50	34.85	1.74
98-54	32	P	30	RO	6.4				19.2	0.64
98-54	32	P	10	DAA	5.1				5.1	0.51
98-54	32	P	8	CHA	3.9				3.12	0.39
98-54	36	C	190	LA	4.8	277.25	30.10	23.71	331.06	1.74
98-54	36	C	105	EFA	6.4	204.29	22.18	17.47	243.94	2.32
98-54	36	C	105	WCA	5.2	165.98	18.02	14.20	198.20	1.89
98-54	36	C	50	RO	6.4	97.28	10.56	8.32	116.16	2.32
98-54	36	C	50	BMB	11.8	179.36	19.47	15.34	214.17	4.28
98-54	36	C	40	SA	3.7	44.99	4.88	3.85	53.72	1.34
98-54	36	P	74	SA	3.7				27.38	0.37
98-54	36	P	5	WO	4.6				2.3	0.46
98-55	4	C	70	COB	21	446.88	48.51	38.22	533.61	7.62
98-55	8	C	370	CKA	3.5	393.68	42.74	33.67	470.09	1.27
98-55	12	C	80	COB	21	510.72	55.44	43.68	609.84	7.62
98-55	12	C	80	CKA	3.5	85.12	9.24	7.28	101.64	1.27
98-55	12	C	80	COB	21	510.72	55.44	43.68	609.84	7.62
98-55	12	P	160	COB	21				336	2.10
98-55	12	P	160	COB	21				336	2.10
98-55	12	P	80	COB	21				168	2.10
98-55	16	C	387	COB	21	2,470.61	268.19	211.30	2,950.10	7.62
98-55	16	P	97	COB	21				203.7	2.10
98-55	20	C	160	EEB	26.4	1,284.10	139.39	109.82	1,533.31	9.58
98-55	20	C	104	EEB	26.4	834.66	90.60	71.39	996.65	9.58
98-55	20	C	102	EEB	26.4	818.61	88.86	70.01	977.49	9.58
98-55	20	C	80	EGB	21.2	515.58	55.97	44.10	615.65	7.70
98-55	20	C	80	EEB	26.4	642.05	69.70	54.91	766.66	9.58
98-55	20	P	58	CC	5.6				32.48	0.56
98-55	20	P	56	EEB	26.4				147.84	2.64
98-55	24	C	320	CHA	3.9	379.39	41.18	32.45	453.02	1.42
98-55	24	C	320	CKA	3.5	340.48	36.96	29.12	406.56	1.27
98-55	28	C	150	EGB	21.2	966.72	104.94	82.68	1,154.34	7.70
98-55	28	C	80	EEB	26.4	642.05	69.70	54.91	766.66	9.58
98-55	28	C	20	EEB	26.4	160.51	17.42	13.73	191.66	9.58
98-55	28	C	11	EGB	21.2	70.89	7.70	6.06	84.65	7.70
98-55	28	C	11	EEB	26.4	88.28	9.58	7.55	105.42	9.58
98-55	28	P	68	BEE	140				952	14.00
98-55	28	P	35	EGB	21.2				74.2	2.12
98-55	28	P	30	BEE	140				420	14.00
98-55	28	P	20	CC	5.6				11.2	0.56
98-55	28	P	15	ETC	29.1				43.65	2.91
98-55	28	P	11	LA	4.8				5.28	0.48
98-55	28	P	10	EFA	6.4				6.4	0.64
98-55	28	P	10	DGB	23.2				23.2	2.32
98-55	28	P	10	ESD	63				63	6.30
98-55	28	P	10	CC	5.6				5.6	0.56
98-55	28	P	8	EEB	26.4				21.12	2.64
98-55	28	P	5	CC	5.6				2.8	0.56
98-55	32	C	130	EEB	26.4	1,043.33	113.26	89.23	1,245.82	9.58
98-55	32	C	80	EEB	26.4	642.05	69.70	54.91	766.66	9.58
98-55	32	C	60	EGB	21.2	386.69	41.98	33.07	461.74	7.70
98-55	32	C	40	EEB	26.4	321.02	34.85	27.46	383.33	9.58
98-55	32	C	35	EEB	26.4	280.90	30.49	24.02	335.41	9.58
98-55	32	C	30	EGB	21.2	193.34	20.99	16.54	230.87	7.70
98-55	32	C	30	CA	3.5	31.92	3.47	2.73	38.12	1.27
98-55	32	C	25	EGB	21.2	161.12	17.49	13.78	192.39	7.70
98-55	32	C	25	ETC	29.1	221.16	24.01	18.92	264.08	10.56
98-55	32	C	20	CA	3.5	21.28	2.31	1.82	25.41	1.27
98-55	32	C	20	EFA	6.4	38.91	4.22	3.33	46.46	2.32
98-55	32	C	20	ETC	29.1	176.93	19.21	15.13	211.27	10.56
98-55	32	C	12	EGB	21.2	77.34	8.40	6.61	92.35	7.70
98-55	32	C	10	EGB	21.2	64.45	7.00	5.51	76.96	7.70
98-55	32	C	10	WO	4.6	13.98	1.52	1.20	16.70	1.67
98-55	32	C	10	EFA	6.4	19.46	2.11	1.66	23.23	2.32
98-55	32	P	40	ETC	29.1				116.4	2.91
98-55	32	P	27	EEB	26.4				71.28	2.64
98-55	32	P	13	ESD	63				81.9	6.30
98-55	36	C	280	RO	6.4	544.77	59.14	46.59	650.50	2.32
98-55	36	C	160	EFA	6.4	311.30	33.79	26.62	371.71	2.32
98-55	36	C	140	LA	4.8	204.29	22.18	17.47	243.94	1.74
98-55	36	P	40	EFA	6.4				25.6	0.64
98-55	36	P	20	LA	4.8				9.6	0.48
98-56	10	C	30	CDB	9.5	86.64	9.41	7.41	28.5	0.95
98-56	10	C	60	CNC	24.4	445.06	48.31	38.06	146.4	2.44
98-56	12	C	325	CNC	24.4	2,410.72	261.69	206.18	793	2.44
98-56	12	C	20	CB	4.2	25.54	2.77	2.18	8.4	0.42
98-56	12	C	50	CDB	9.5	144.40	15.68	12.35	47.5	0.95
98-56	12	C	50	ETC	29.1	442.32	48.02	37.83	145.5	2.91
98-56	14	C	70	CDB	9.5	202.16	21.95	17.29	66.5	0.95
98-56	14	C	250	EGB	21.2	1,611.20	174.90	137.80	530	2.12
98-56	14	C	75	WW	4.1	93.48	10.15	8.00	30.75	0.41
98-56	14	C	60	TW	2.9	52.90	5.74	4.52	17.4	0.29

accurate estimate of sediment loss in the watershed a delivery ratio was derived for each subwatershed. Methods for arriving at a delivery ratio are given in a table in the Clean Lake Guidance Manual section 4 (EPA, 1980). The size of the subwatershed is divided by the length of stream miles in the subwatershed. That number is located on a table to give the corresponding percent of delivery ratio. Table 13 shows the soil loss from each subwatershed. Figure 12 is a map of the measured sections and the areas where high erosion rates (>6 tons/acre) were found.

The subwatershed which seems to have the largest amount of soil loss is subwatershed 7. Subwatershed 7 is located on the steep sloping ridge of the watershed. Subwatershed 8 is also relatively high in per acre loss as the tributaries approach Turkey Ridge Creek and the land flattens to less than a three percent slope. Subwatershed 1 located adjacent to the lake, considered the natural watershed, also has one of the highest soil losses per acre and has the most direct drainage to the lake.

Fifty-five percent of subwatershed acreages have soil losses of less than 2.5 tons per hectare or approximately 1 ton per acre. These are insignificant soil losses compared to those in the remaining 45 percent of the watershed discussed above.

Table 12 continued.

TOWNSHIP	SECTION	TYPE	ACREAGE	SOIL	RKLS	C-B 80% CROP	C-B-O 10% CRO	C-B-O-A 10% CRO	TOTAL SOIL LOSS	TOTAL LOSS PER ACRE
98-56	14	C	35	CDA	4	42.56	4.62	3.64	14	0.40
98-56	14	C	20	DEA	5.6	34.05	3.70	2.91	11.2	0.56
98-56	14	C	65	HCA	4	79.04	8.58	6.76	26	0.40
98-56	14	P	5	CDB	9.5				4.75	0.95
98-56	14	P	5	CDA	4				2	0.40
98-56	22	C	120	CNC	24.4	890.11	96.62	76.13	292.8	2.44
98-56	22	C	130	HCA	4	158.08	17.16	13.52	52	0.40
98-56	22	C	225	HMB	8.6	588.24	63.86	50.31	193.5	0.86
98-56	22	C	10	HMB	8.6	26.14	2.84	2.24	8.6	0.86
98-56	22	C	70	ETD	61.6	1,310.85	142.30	112.11	431.2	6.16
98-56	22	C	60	CDB	9.5	173.28	18.81	14.82	57	0.95
98-56	22	C	10	TE	4.8	14.59	1.58	1.25	4.8	0.48
98-56	22	P	15	HCA	4				6	0.40
98-56	22	P	25	CNC	24.4				61	2.44
98-56	24	C	60	EAC	31.7	578.21	62.77	49.45	190.2	3.17
98-56	24	C	100	ETD	61.6	1,872.64	203.28	160.18	616	6.16
98-56	24	C	100	EBC	24.6	747.84	81.18	63.96	246	2.46
98-56	24	C	50	EAC	31.7	481.84	52.31	41.21	158.5	3.17
98-56	24	C	320	EGB	21.2	2,062.34	223.87	176.38	678.4	2.12
98-56	24	P	5	EBC	24.6				12.3	2.46
98-56	24	P	15	CB	4.2				6.3	0.42
98-56	24	P	5	EAC	31.7				15.85	3.17
		TOTAL	21,553.00			78,593.42	8,531.52	6,721.81	88,614.66	4.11

TABLE 13. SEDIMENT LOSS BY SUB-BASIN IN THE SWAN LAKE WATERSHED.

SUB-BASIN	SUB-BASIN SIZE (ACRES)	SUB-BASIN SIZE (HECTARES)	SEDIMENT LOSS PER SUB-BASIN (TONS)	DELIVERY RATIO	ESTIMATED SEDIMENT DELIVERED (TONS)	ESTIMATED SEDIMENT DELIVERED PER ACRE (TONS)	ESTIMATED SEDIMENT DELIVERED PER HECTARE (TONS)
1	1,038.2	420.2	4,042.2	0.30	1,212.7	1.17	2.89
2	7,938.2	3,212.6	23,387.5	0.28	6,548.5	0.83	2.04
3	15,241.8	6,168.3	17,951.9	0.25	4,488.0	0.29	0.73
4	7,736.7	3,131.0	8,180.0	0.31	2,535.8	0.33	0.81
5	8,441.3	3,416.2	30,042.0	0.27	8,111.3	0.96	2.37
6	4,826.6	1,953.3	6,222.2	0.28	1,742.2	0.36	0.89
7	20,705.3	8,379.3	129,765.6	0.33	42,173.8	2.04	5.03
8	15,647.5	6,332.5	73,430.3	0.30	22,029.1	1.41	3.48
				TOTAL -->	88,841.4	TONS	

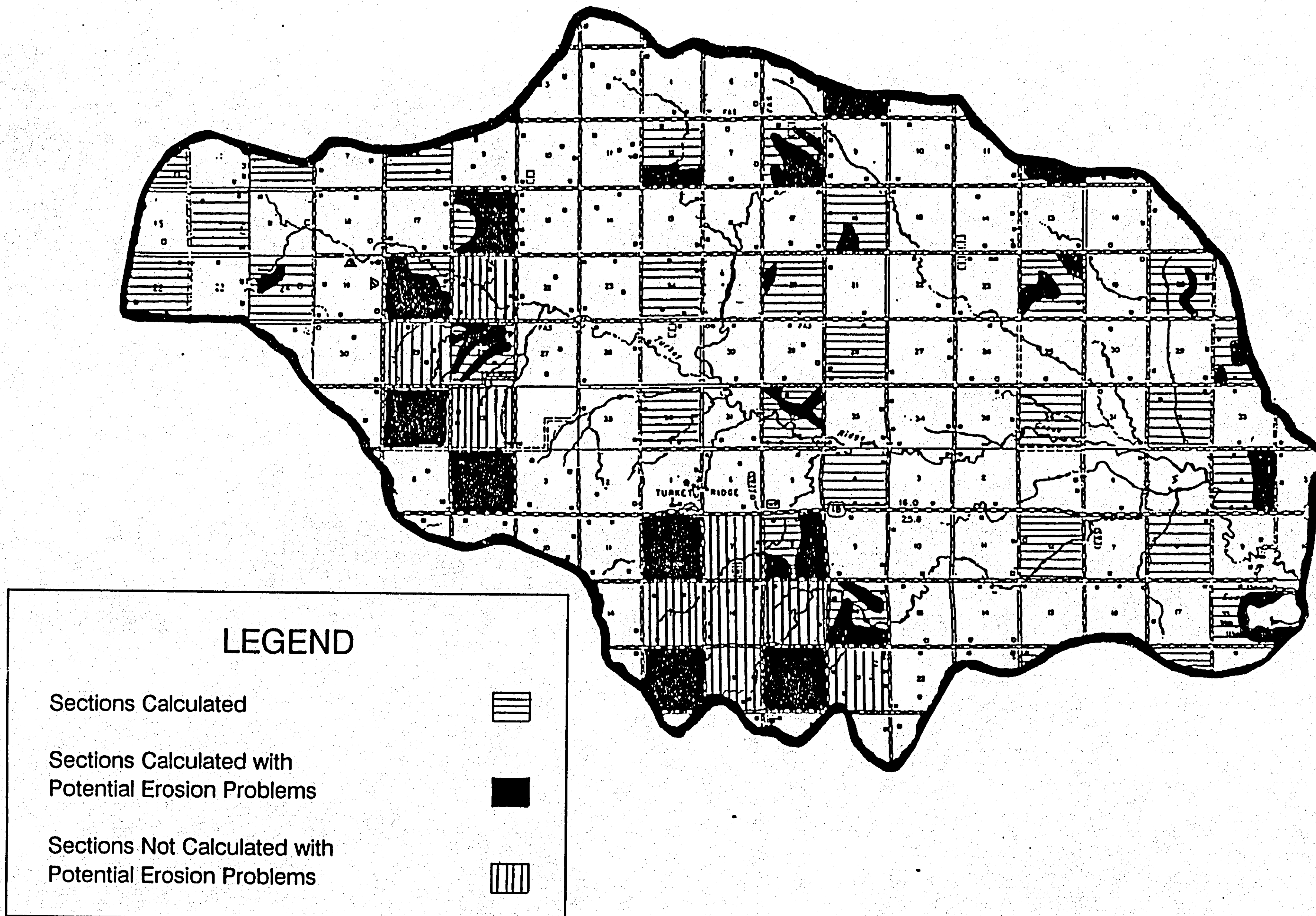


Figure 12. Estimated Areas of Soil Loss in the Swan Lake Watershed.

Feedlots

A feedlot survey was conducted to determine the number of livestock operations within three-quarters of a mile from Turkey Ridge Creek. Thirty-two feedlots were located in all. Sixteen of these feedlots were found adjacent to the main channel of Turkey Ridge Creek. The lots ranged in size from 185+ head to 6+ head of cattle, with an average of 35+ head and a median of approximately 20+ cattle. There were a few hog and sheep operations but cattle were the most abundant livestock raised.

Sixteen more feedlots where counted within three-quarters of a mile of Turkey Ridge Creek, but not directly on the main channel. Numbers of cattle could only be counted on eight of the feedlots. The number of cattle ranged from 200+ head to 2+ head. The median number of cattle was approximately 23 head.

BIOLOGICAL AND ECOLOGICAL RELATIONSHIPS

SECTION SUMMARY

Swan Lake has a large variety and concentration of algae, however, Swan Lake does not experience the typical floating mats (blooms) of algae. Aquatic plants are not present in the lake basin, however, cattails, bulrushes, and other aquatic plants cover approximately 15 percent of the shoreline.

Swan Lake experiences large numbers of migratory birds (waterfowl and song) in the spring and fall. In the summer, the bay on the southwest corner is home to various species of breeding ducks.

BIOLOGICAL AND ECOLOGICAL RELATIONSHIPS

Algae

Swan Lake is a highly eutrophic waterbody that supports large populations of algae despite prevailing water turbidity. Chlorophyll a concentration ranged from 51 to 188 mg/m^3 from 1978 to 1980. Algal diversity for 1979 was low (d = 0.88) but typical of shallow, highly enriched lakes.

The indigenous free-floating algal species apparently do not form conspicuous blooms nor do they appear to produce the objectionable surface scums and mats frequently observed in some other state lakes of similar trophic status. In 1979, abundant algal taxa in Swan Lake were Oscillatoria, Spirulina and Synedra (Table 14).

The algal assemblages that occurred in Swan Lake during late spring and summer of 1979 and 1989 were not typical of communities found in most other state lakes (Tables 14 and 15). Summer algal blooms of eutrophic state lakes are usually comprised of one or more of the ubiquitous blue-green genera Aphanizomenon, Microcystis and Anabaena. These taxa apparently were absent or uncommon in Swan Lake during 1979 and 1989. The reason may lie in the lake conditions of high dissolved solids (>2000 mg/L) concentration and high water turbidity that characterize this waterbody. The blue-green alga Spirulina is abundant in shallow saline lakes (playa lakes) as are some Oscillatoria species. Synedra, Nitzschia and Navicula are diatom genera not usually common in the open water of lakes but more often occur living on substrates (rocks, gravel, and rubble) in shallow water from which they are frequently dislodged by wave action. Their presence as prominent members of the plankton community often denotes a shallow water habitat. The remaining algal taxa collected in Swan Lake are typical of eutrophic waters.

TABLE 14. ALGAL SPECIES AND VOLUMES FOR SWAN LAKE.

	6/1/79		7/30/79	
	Cells/ml	Micrometers Cubed	Cells/ml	Micrometers Cubed
Ankistrodesmus falcatus	244	12,200	541	27,050
Closterium sp.	2	1,000		
Melosira granulata	92	27,600		
Navicula cuspidata	25	193,750		
Oscillatoria limnetica			3,480,357	31,323,213
O. tenuis			52,205	835,280
Pediastrum duplex var. clathratum	52	32,500		
Peridinium bipes			155	3,975,750
Scenedesmus quadricauda	381	400,050		
S. quadricauda var. longispina			309	324,450
Spirulina princeps			8,353	44,772,080
Synedra acus	4,512	2,955,360		
TOTAL	5,308	3,622,460	3,541,920	81,257,823

Koth, 1981.

TABLE 15. ALGAL SPECIES IN SWAN LAKE.

Taxa	June 26, 1989 Number	June 26, 1989 Units/ml	June 31, 1989 Number	June 31, 1989 Units/ml
Merismopedia	88	34,037	6	2,500
Aphanocapsa	64	24,754	28	11,667
Lyngbya contorta	51	19,726	-	-
Algae (other)	23	8,896	22	9,167
Lyngbya diguetii	17	6,575	17	7,083
Dactylococcopsis	16	6,189	-	-
Nitzschia reversa	11	4,255	3	1,250
Green Algae (other)	10	3,868	-	-
Cryptomonas	8	3,094	-	-
Tetrastrum	5	1,934	-	-
Scenedesmus	4	1,547	2	833
Nitzschia	4	1,547	29	12,083
Aphanizomenon flos-aquae	4	1,547	-	-
Blue-green (other)	3	1,160	2	833
Diatom (pennate)	3	1,160	-	-
Phacus	1	1,160	-	-
Loefgrenia anamala	-	-	159	66,250
Lyngbya contorta	-	-	42	17,500
Algae (flagellate)	-	-	1	417
Total	312	121,449	311	129,583

Stewart, 1989.

The summer plankton in 1989 as in 1979 was dominated by blue-green algae, notably Merismopedia, two Lyngbya species, Loefgrenia anamala, and Aphanocapsa. The diatom Nitzschia was also common in the plankton (Table 15).

The Lyngbya species collected are very common in hardwater lakes and apparently are tolerant of turbid water conditions. Nitzschia diatoms may become abundant in plankton of shallow, eutrophic lakes and Nitzschia reversa may be an indicator of high dissolved solids (TDS) content, being also present in Angostura Reservoir in southwest South Dakota, and Redfield Lake in central South Dakota where TDS levels commonly exceed 2,000 mg/L and 1500 mg/L, respectively.

Like the blue-green taxa present in Swan Lake during 1979, Lyngbya, Merismopedia, Loefgrenia, and Aphanocapsa usually do not clot or agglutinate to form noticeable floating masses, at least within local lakes.

Free-floating algae interact in a number of important ways with their habitat and neighboring organisms within the ecosystem of a lake. Through the process of daytime photosynthesis and nighttime respiration, algae may affect water quality by increasing fluctuations in pH, alkalinity, and dissolved oxygen. Algae serves as food for zooplankton (planktonic animals) and benthic invertebrates (bottom dwellers). As such, the growth and composition of algae in a lake influences the abundance of local aquatic animal life to the extent that it feeds on them. More conspicuously, however, dense algal populations reduce water clarity, and as they sink to the lake bottom at the end of each growing season may continually add to the sedimentation and internal nutrient load of waterbodies such as Swan Lake

Aquatic Plants

While turbid water conditions in Swan Lake showed no evidence of affecting phytoplankton growth and abundance, they were inhibitory to the development of vascular aquatic plants and restricted periphyton growth (substrate-associated algae), such as diatoms and attached green algae. Emergent macrophytes were found close to shore and water depths of less than 0.7 meter. Floating and submerged plants were not observed in Swan Lake. Additional factors that may have prevented establishment of rooted submergent vegetation were fluctuating water levels and wave action on unstable sand substrates. Wind protected areas are important for development of floating macrophytes. The absence of floating vegetation in Swan Lake may result from the lack of wind sheltered bays.

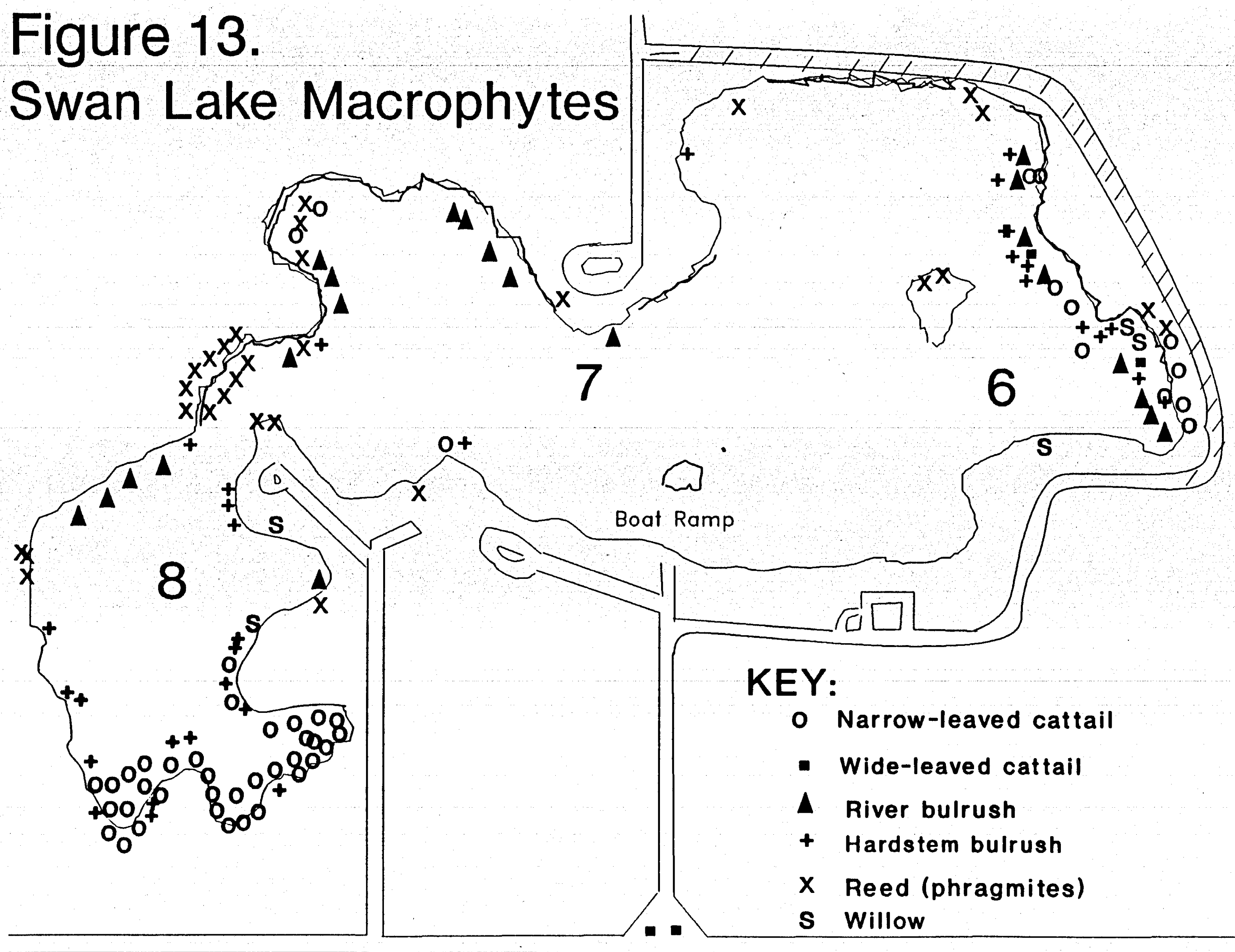
Emergent aquatic vegetation was present around the lake periphery. Results of a recent plant survey are presented in the next section.

Aquatic Plant Inventory

An aquatic vegetation survey was conducted in Swan Lake on May 14, 1992. Common emergent macrophytes in approximate order of abundance were: Narrow-leaved cattail (Typha angustifolia), hardstem bulrush (Scirpus acutus), river bulrush (Scirpus fluviatilis), and giant reed grass (Phragmites australis). Less frequently observed were broad-leaved cattail (Typha latifolia) and willow (Salix sp.). Floating and submerged vascular aquatic plants were absent in Swan Lake probably due primarily to water turbidity.

Except for the bay-like southwestern part of Swan Lake and the eastern shore, only scattered patches of emergent vegetation were found in the water. None were observed more than 3 meters from the shoreline and most were within half that distance to the water's edge. There are extensive riprapped areas, beach front development, and rocky shoreline where human activities have disturbed or removed the emergent plant communities. Diversity of emergent macrophytes in Swan Lake appeared rather low at the time of the survey. Probably both diversity as well as aerial plant coverage increases as the growing season progresses. Aerial coverage was estimated as 15 to 20 percent of the shoreline in mid May 1992. The primary plant species observed along the shoreline and in the water are shown in Figure 13.

Figure 13.
Swan Lake Macrophytes



Principal aquatic plants that may also occur in Swan Lake or its watershed and surrounding area, or whose range extends into southeastern South Dakota are listed in Table 16.

Terrestrial Plants

The Swan Lake watershed lies on the periphery of the Eastern Deciduous Forest Province. Finger-like projections of this region extend north along the Big Sioux River to the northern border of Lincoln County and west along the Missouri River to Charles Mix County. Newton Hills Park and an adjoining game preserve in adjacent Lincoln County are remnants of this extensive natural vegetation region which once covered large areas of the eastern U.S. and reached its western limit in eastern South Dakota. Typical trees of the Eastern Deciduous Flora in this area include basswood (Tilia americana), bur oak (Quercus macrocarpa), silver maple (Acer saccharinum), american elm (Ulmus americana), black walnut (Juglans nigra), and green ash (Fraxinus pennsylvanica). Some herbaceous plants typical of these deciduous forests are common nettle (Urtica dioica), woods anemone (Anemone quinquefolia), geranium (Geranium maculatum), wild ginger (Asarum canadense), bellwort (Uvularia grandiflora) and blue cohosh (Caulophyllum thalictoides).

TABLE 16. AQUATIC\EMERGENT PLANTS OCCURRING IN SWAN LAKE AND ITS WATERSHED

COMMON NAME	SCIENTIFIC NAME
Common Cattail	*Typha latifolia*
Narrow-leaved Cattail	*Typha augustifolia*
Leafy Pondweed	*Potamogeton foliosus*
Sago Pondweed	*Potamogeton pectinatus*
Richardson Pondweed	*Potamogeton richardsonii*
Flatstem Pondweed	*Potamogeton zosteriformis*
Widgeon Grass	*Ruppia occidentalis*
Horned Pondweed	*Zannichella palustris*
Slender Naiad	*Najas flexilis*
Naiad	*Najas marina*
Broadleaf Water Plantain	*Alisma plantago-aquatica*
Northern Arrowhead	*Sagittaria cuneata*
Waterweed	*Anacharis occidentalis*
Eel Grass	*Vallisneria americana*
Reed Grass	*Phragmites australis*
Wild Rice	*Zizania aquatica*
Slender Spikerush	*Eleocharis acicularis*
Common Spikerush	*Eleocharis palustris*
Hardstem Bulrush	*Scirpus acutus*
Sofstem Bullrush	*Scirpus validus*
Three Square	*Scirpus americanus*
River Bulrush	*Scirpus fluviatilis*
Slender Bulrush	*Scirpus heterochaetus*
Alkali Bulrush	*Scirpus paludosus*
Sweet Flag	*Acorus calamus*
Lesser Duckweed	*Lemna minor*
Star Duckweed	*Lemna trisulca*
Giant Duckweed	*Spirodela polyrhiza*
Water Stargrass	*Heteranthera dubia*
Coontail	*Ceratophyllum demersum*
Northern Water Milfoil	*Myriophyllum exalbescens*
Common Bladderwort	*Utricularia vulgaris*
Giant Reed Grass	*Phragmites australis*

Harlo, and Harrar, 1950.

Turner County, which contains the Swan Lake watershed, falls almost entirely within the Tall Grass Prairie vegetation region in South Dakota. However, very little of the natural prairie still remains. A few small remnants still exist but the majority of this land has been plowed, overgrazed, and so disturbed that only indicator plant species can be found (Van Bruggen, 1976). A few remaining examples of true prairie can be seen on railroad-roadside right-of-ways, state parks, and openings in wooded areas (ibid.).

Table 17 lists the principal trees and shrubs observed or expected to occur in the Swan Lake area or whose range is known to extend into southeastern South Dakota. Table 18 lists locally occurring terrestrial and aquatic plant taxa that have been considered state and federal threatened and endangered.

Fish

Since 1914 Swan Lake has been part of the Turkey Ridge Creek watershed which drains into the Vermillion River - a tributary of the Missouri River. Its aquatic life is potentially replenished and supplied with diversity by this connection. Fish known to inhabit Swan Lake are listed in Table 19. These fish species have been caught in test nettings conducted by the SD GF&P but do not necessarily represent the total species possible. It is more

TABLE 17. NATIVE TREES & SHRUBS IN THE SWAN LAKE WATERSHED.

COMMON NAME	SCIENTIFIC NAME
Black Willow	*Salix niger*
Quaking Aspen	*Populus tremuloides*
Bigtooth Cottonwood	*Populus tacamahacca*
Eastern Cottonwood	*Populus deltoides*
Paper Birch	*Betula paprifera*
Bur Oak	*Quercus macrocarpa*
American Elm	*Ulmus americana*
Slippery Elm	*Ulmus rubra*
Rock Elm	*Ulmus thomasi*
Hackberry	*Celtis occidentalis*
Silver Maple	*Acer saccharium*
Boxelder	*Acer negundo*
Basswood	*Tilia americana*
Green Ash	*Fraxinus pennsylvanica*
Honey Locust	*Gleditsia triacanthos*
Black Walnut	*Juglans nigra*
Wild Plum	*Prunus americana*
Gooseberry	*Ribes missouriense*
Smooth Sumac	*Rhus glabra*
Poison Ivy	*Toxicodendron rydbergii*
Silver Buffalo Berry	*Shepherdia argentea*

Harlo, and Harrar, 1950.

TABLE 18. LIST OF RARE PLANTS IN THE SWAN LAKE REGION.

COMMON NAME	SCIENTIFIC NAME
Sugar Maple	*Acer saccharum*
Sweetflag	*Acorus americanus*
Wood Anemone	*Anemone quinquefolia*
Spikenard	*Aralla racemosa*
Wild Ginger	*Asarum candense*
Rush Aster	*Aster borealis*
Flattop Aster	*Aster umbellatus*
Indian Plantain	*Cacalla plantaginea*
Hair Sedge	*Carex capillaris*
Lake Sedge	*Carex lacustris*
Pednuncled Sedge	*Carex pedunclata*
Blue Cohosh	*Caulophyllum thalictroides*
Pale Coral-Root	*Corallorhiza trifida*
White Lady Slipper	*Cypripedium candidum*
Toothwort	*Dentaria laciniata*
Downy Gentian	*Gentiana puberulenta*
Small Fringed Gentian	*Gentianopsis procera*
Wild Cranesbill	*Geranium maculatum*
Bottlebrush Grass	*Hystrix patula*
Virginia Cutgrass	*Leersia virginica*
Water Nymph	*Najas marina*
Balsam Popular	*Populus balsamifera*
Nodding Trillium	*Trillium cernum*
Declining Trillium	*Trillium flexipes*
Large-flowered Bellwart	*Ulvularia grandiflora*
Wildrice	*Zizania aquatica*

Moyle, 1954.
Van Bruggen, 1976.

TABLE 19. FISH SPECIES IN SWAN LAKE

COMMON NAME	SCIENTIFIC NAME
Black Bullhead	*Ictalurus melas*
Yellow Perch	*Perca flavescens*
White Sucker	*Catostomus commersoni*
Northern Pike	*Esox lucius*
Carp	*Cyprinus carpio*
Smallmouth Buffalo	*Ictiobus bubalus*
Bigmouth Buffalo	*Ictiobus cyprinellus*
Walleye	*Stizostedion vitreum*
Blue Gill	*Lepomis macrochirus*
Black Crappie	*Pomoxis nigromaculatus*
White Crappie	*Pomoxis annularis*
Fathead Minnow	*Pimephales promelas*
Orangespotted Sunfish	*Lepomis humilis*
Gizzard Shad	*Dorosoma cepedianum*
Sand Shiner	*Notropis straminus*
River Carpsucker	*Carpiodes carpio*
Largemouth Bass	*Micropterus salmoides*
Green Sunfish	*Lepomis cyanellus*
Channel catfish	*Ictalurus punctatus*

Koth, 1986.
Sharps and Benzon, 1984
South Dakota Department of Game, Fish, & Parks (1987-1990)

than likely, for example, that some small minnow species in the lake may have avoided capture.

Many species inhabiting the Vermillion River have the potential to reach the vicinity of Swan Lake. Fish taxa other than those in Table 19 that have previously been reported in the Vermillion River drainage are listed in Table 20.

Reptiles and Amphibians

Table 21 presents a list of reptiles and amphibians possible in the Swan Lake watershed. This list was compiled from observation and descriptions of the ranges of these taxa in recent literature. About half of the listed species are at the western or northern boundaries of their known ranges in extreme southeastern South Dakota. The majority of these are taxa characteristic of the eastern U.S. and others are most prevalent in the middle and southern plains states. Several are western species whose range reaches its eastern limit in the study area or follows the Missouri River along a narrow band in South Dakota. Among the above mentioned are six taxa that have been designated by the state as threatened species (Table 21).

TABLE 20. FISH SPECIES POSSIBLE IN THE SWAN LAKE WATERSHED

COMMON NAME	SCIENTIFIC NAME
Shortnose Gar	*Lepisosteus platostomus*
Goldeye	*Hiodon alosoides*
Mudminnow*	*Umbra limi*
Silvery Minnow	*Hybognathus nuchalis*
Golden Shiner	*Notemigonos crysoleucas*
Banded Killifish*	*Fundulus diaphanus*
Sauger	*Stizostedion canadense*
Creekchub	*Semotilus atromaculatus*
Common Shiner	*Notropis cornutus*
Red Shiner	*Notropis lutrensis*
Topeka Shiner	*Notropis topeka*
Flathead Chub	*Hybopsis gracilis*
Blacknose Dace	*Rhinichthys atratulus*
Emerald Shiner	*Notropis atherinoides*
Bigmouth shiner	*Notropis dorsalis*
Brassy Minnow	*Hybognathus hankinsoni*
Bluntnose Minnow	*Pimephales notatus*
Stoneroller	*Campostoma anomalum*
Shorthead Redhorse	*Moxostoma macrolepidotum*
Stonecat	*Noturus flavus*
Plains Topminnow*	*Fundulus sciadicus*
Brook Stickleback	*Culaea inconstans*
Johnny Darter	*Etheostoma nigrum*
Iowa Darter	*Etheostoma exile*
Freshwater Drum	*Aplodinotus grunniens*
American Eel	*Anquilla rostrata*

*Fish species on either state or federal endangered or threatened species lists.

Harper & Row, 1981.
SD GF&P, 1992.

TABLE 21. REPTILES AND AMPHIBIANS POSSIBLE IN THE SWAN LAKE WATERSHED

COMMON NAME	STATUS	SCIENTIFIC NAME
Painted Turtle		*Chrysemys picta*
Snapping Turtle		*Chelydra serpentina*
Common Garter Snake		*Thamnophis sirtalis*
Smooth Green Snake	L	*Opheodrys vernalis*
Bullsnake		*Pituophis melanoleucus*
Tiger Salamander		*Ambystoma tigrinum*
American Toad	L	*Bufo americanus*
Great Plains Toad		*Bufo cognatus*
Woodhouse's Toad		*Bufo woodhousii*
Plains Spadefoot		*Scaphiopus bombifrons*
Prairie Rattlesnake	L	*Crotalus viridis*
Red Milk Snake	L	*Lampropeltis triangulum*
Western Fox Snake		*Elaphe vulpina*
Yellowbelly Racer	L	*Coluber constrictor*
Eastern Hognose Snake	L, ST	*Heterodon platirhinos*
Prairie Ringneck Snake	L	*Diadophis punctatus*
Northern Redbelly Snake	L, ST	*Storeria occipitomaculata*
Lined Snake	L, ST	*Tropidoclonium lineatum*
Western Plains Garter Snake		*Thamnophis radix*
Blanding's Turtle	L, ST	*Emydoidea blandingii*
Western Spiny Softshell Turtle	L, ST	*Trionyx spinifera*
Midland Smooth Softshell Turtle	L	*Trionyx mutica*
Ornate Box Turtle	L	*Terrapena ornata*
False Map Turtle	L, ST	*Graptemys pseudogeographica*
Northern Prairie Skink		*Eumeces septentrionalis*
Gray Tree Frog	L	*Hyla versicolor*
Plains Leopard Frog	L	*Rana blairi*
Northern Leopard Frog		*Rana pipiens*
Bullfrog	L	*Rana catesbeiana*
Blanchard's Cricket Frog		*Acris crepitans*
Chorus Frog		*Pseudacris triseriata*

Harper & Row, 1981.
Conant and Collins, 1991.

L = boundary of range in extreme southeastern South Dakota
ST = state threatened species

Birds

Swan Lake and its watershed are located on the Central Flyway and receive heavy use in the spring and fall by migrating and breed birds. Waterfowl as well as other birds dependent on water are the most prevalent especially during migration and are listed on Table 22. Swan Lake has many attributes which make it a regular stop-over for a variety of breeding species as well (Table 23). The southwest bay, due to its shallow depth, has been restricted from motor boat use. The bay also has a large amount of emergent macrophytes creating an excellent area for nesting and raising young. A list of raptors which either pass through or breed in the Swan Lake area is listed on Table 24. Swan Lake also attracts a variety of nesting or migrating song birds. Migrating or unique birds observed in the spring of 1992 included: Yellow-rumped Warbler (Dendroica coronata), Yellow Warbler (Dendroica petechia), American Redstart (Setophaga ruticilla), Northern Oriole (Icterus galbula), and American Goldfinch (Carduelis tristis). With reference to birds dependent on water for habitat, 91 species not including an occasional incidental, may be seen in the Swan Lake watershed. A third of those species may nest in or around the lake. Table 25 lists all of the federal and state threatened or endangered birds which can be found in the Swan Lake area.

TABLE 22. MIGRATIONAL BIRDS IN THE SWAN LAKE AREA DEPENDENT ON WATER

COMMON NAME		SCIENTIFIC NAME
LOONS		
Common Loon	U	*Gavia immer*
GREBES		
Red-Necked Grebe	U	*Podiceps grisegena*
Horned Grebe		*Podeceps auritus*
PELICANS AND CORMORANTS		
White Pelican		*Pelecanus erythrorhynchos*
Double Crested Cormorant		*Phalacrocorax auritus*
SWANS AND GEESE		
Tundra Swan		*Cygnus columbianus*
Greater White-Fronted Goose		*Anser albifrons*
Snow Goose		*Chen caerilescens*
Ross' Goose		*Chen rossii*
PUDDLE DUCKS		
Green-Winged Teal		*Anas crecca*
American Widgeon		*Anas americana*
BAY DUCKS		
Ring-Necked Duck		*Aythya colloris*
Greater Scaup		*Aythya marila*
Lesser Scaup		*Aythya affinis*
SEA DUCKS		
Common Goldeneye		*Bucephala clangula*
Bufflehead		*Bucephala albeola*
Oldsquaw	R	*Clangula hyemalis*
Black Scoter		*Melanitta nigra*
Surf Scoter		*Melanitta perspicillata*
White-Winged Scoter	R	*Melanitta fusca*
MERGANSERS		
Hooded Merganser	U	*Lophodytes cucullatus*
Common Merganser		*Mergun merganser*
Red-Brested Merganser	R	*Mergus serrator*
CRANES		
Sandhill Crane		*Grus canadensis*
Whooping Crane		*Grus americana*
BITTERNS, HERONS AND IBISES		
Great Egret	U	*Casmerodius albus*
Snowy Egret	U	*Egretta thula*
Little Blue Heron	R	*Egretta caerulea*
Cattle Egret	U	*Bubulcus ibis*
Yellow-Crowned Night-Heron	R	*Nyctanassa violacea*
White-Faced Ibis	R	*Plegadis chihi*
PLOVERS		
Black-Bellied Plover	U	*Pluvialis squatarola*
Lesser Golden Plover		*Pluvialis dominica*
Semipalmated Plover		*Charadrius semipalmatus*
SANDPIPERS AND PHALAROPES		
Greater Yellowlegs		*Tringa melanoleuca*
Lesser Yellowlegs		*Tringa flavipes*
Solitary Sandpiper		*Tringa solitaria*
Hudsonian Godwit		*Limosa haemastica*
Marbled Godwit		*Limosa fedoa*
Ruddy Turnstone	R	*Arenaria interpres*
Sanderling	U	*Calidris alba*
Semipalmated Sandpiper		*Calidris pusilla*
Western Sandpiper	U	*Calidris mauri*
Least Sandpiper	U	*Calidris minutilla*
White-Rumped Sandpiper		*Calidris fuscicollis*
Baird's Sandpiper		*Calidris bairdii*
Pectoral Sandpiper		*Calidris melanotos*
Dunlin		*Calidris alpina*
Stilt Sandpiper		*Calidris himantopus*
Buff-Breasted Sandpiper	R	*Tryngites subruficollis*
Short-Billed Dowitcher		*Limnodromus griseus*
Long-Billed Dowitcher		*Limnodromus scolopaceus*
Red-Necked Phalarope		*Phalaropus lobatus*
GULLS AND TERNS		
Franklin's Gull		*Larus pipixcan*
Bonaparte's Gull		*Larus philadelphia*
Ring-Billed Gull		*Larus delawarensis*
California Gull	U	*Larus californicus*
Herring Gull		*Larus argentatus*
Caspian Tern	R	*Sterna caspia*
Common Tern		*Sterna hirundo*
Least Tern		*Sterna antillarum*

The South Dakota Ornithologists' Union, 1991.

U = Uncommon Occurrence
R = Rare Occurrence

TABLE 23. BREEDING BIRDS IN THE SWAN LAKE AREA DEPENDENT ON WATER

COMMON NAME		SCIENTIFIC NAME
GREBES		
Eared Grebe		*Podiceps nigricollis*
Western Grebe		*Aechmophorus occidentalis*
Pie-Billed Grebe		*Podilymbus podiceps*
GEESE		
Canada Goose		*Branta canadensis*
PUDDLE DUCKS		
Mallard		*Anas platyrhnchos*
Gadwall		*Anas strepera*
Northern Pintail		*Anas acuta*
Blue-Winged Teal		*Anas discors*
Northern Shoveler		*Anas clypeata*
Wood Duck		*Aix sponsa*
DIVING DUCKS		
Canvasback		*Aythya valisineria*
Redhead		*Aythya americana*
Ruddy Duck		*Oxyura iamaicensis*
BITTERNS AND HERONS		
Least Bittern	U	*Ixobrychus exillis*
American Bittern	U	*Botaurus lentiginosus*
Green-Backed Heron		*Butorides striatus*
Great Blue Heron		*Ardea herodias*
Black-Crowned Night Heron	U	*Nycticorax nycticorax*
RAILS AND COOTS		
Virginia Rail		*Rallus limicola*
Sora		*Porzana carolina*
American Coot		*Fulica americana*
PLOVERS AND AVOVETS		
Killdeer		*Charadrius vociferus*
American Avocet		*Recurvirostra americana*
SANDPIPERS AND PHALAROPES		
Willet		*Catoptrophorus semipalmatus*
Spotted Sandpiper		*Actitis macularia*
Common Snipe		*Gallinago gallinago*
American Woodcock		*Philohela minor*
Wilson Phalarope		*Phalaropus tricolor*
TERNS		
Forester's Tern		*Sterna forsteri*
Black Tern		*Chlidonias niger*

The South Dakota Ornithologists' Union, 1991.

U = Uncommon Occurrence

TABLE 24. RAPTORS POSSIBLE IN THE SWAN LAKE REGION.

COMMON NAME		SCIENTIFIC NAME
PERMANENT OR BREEDING SPECIES		
Great Horned Owl		*Bubo virginianus*
Barred Owl	U	*Strix varia*
Short-Eared Owl	U	*Asio flammeus*
Long-Eared Owl	R	*Asio otus*
Barn Owl	R	*Tyto alba*
Eastern Screech Owl		*Otus asio*
Red-Tailed Hawk		*Buteo jamaicensis*
Swainson's Hawk		*Buteo swainsoni*
Rough-Legged Hawk	U	*Buteo lagopus*
Norther Harrier		*Circus cynaneus*
Kestrel		*Falco sparverius*
Gyrfalcon	R	*Falco rusticolus*
MIGRATIONAL SPECIES		
Turkey Vulture	U	*Cathartes aura*
Northern Goshawk	R	*Accipiter gentilis*
Sharpshinned Hawk		*Accipiter striatus*
Golden Eagle		*Aquila chrysaetus*
Bald Eagle	U	*Haliaeetus leucocephalus*
Osprey	U	*Pandio haliaetus*
Coopers Hawk	U	*Acciper cooperii*
Broad-Winged Hawk		*Buteo platypterus*
Merlin	U	*Falco columbarius*
Peregrine Falcon	U	*Falco peregrinus*
Prairie Falcon	U	*Falco mexicanus*

South Dakota Ornithologists' Union, 1991.

U = Uncommon Occurrence
R = Rare Occurrence

TABLE 25. BIRD SPECIES ON STATE AND FEDERAL ENDANGERED OR THREATENED SPECIES LISTS, COMMON AND MIGRATIONAL IN THE SWAN LAKE REGION

COMMON NAME		SCIENTIFIC NAME
Piping Plover	ST,FT	*Charadrius semipalmatus*
Whooping Crane	SE,FE	*Grus americana*
Least Tern	SE,FE	*Sterna antillarum*
Peregrine Falcon	SE,FE	*Falco pergrinus*
Bald Eagle	SE,FE	*Haliaeetus leucocephalus*
Osprey	ST	*Pandio haliaetus*

Houtcooper, et. al. 1985.

ST = State Threatened
SE = State Endangered
FT = Federal Threatened
FE = Federal Endangered

Mammals

The mammals listed in Table 26 are found in the Swan Lake watershed. Many are dependent on readily available water for their survival. Three of the species in Table 26 are considered rare or uncommon to the area: least shrew (Cryptotis parva), keen's myotis (Myotis keenii) and silver-haired bat (Lasionycteris noctivagans). None of the animals on the list are considered threatened or endangered. The remaining taxa are common to the area or at least have the potential to be found in the Swan Lake watershed.

TABLE 26. MAMMALS OF THE SWAN LAKE REGION

COMMON NAME	SCIENTIFIC NAME
Short-Tailed Shrew	*Blarina brevicauda*
Masked Shrew	*Sorex cinereus*
Least Shrew	*Cryptotis parva*
Eastern Mole	*Scalopus aquaticus*
Keen's Myotis	*Myotis keeni*
Big Brown Bat	*Eptesicus fuscus*
Red Bat	*Lasiurus borealis*
Eastern Cottontail	*Sylvilagus floridanus*
White-Tailed Jackrabbit	*Lepus townsendi*
Eastern Chipmunk	*Tamias striatus*
Richardson's Ground Squirrel	*Spermophilus richardsonii*
Thirteen-Lined Ground Squirrel	*Spermophilus tridecemlineatus*
Franklin's Ground Squirrel	*Spermophilus franklinii*
Fox Squirrel	*Sciurus carolinensis*
Grey Squirrel	*Sciurus niger*
Plains Pocket Gopher	*Geomys bursarius*
Plains Pocket Mouse	*Perognathus flavescens*
Beaver	*Caster canadensis*
Deer Mouse	*Peromyscus maniculatus*
White-Footed Deer Mouse	*Peromyscus leucopus*
Meadow Vole	*Microtus pennsylvanicus*
Muskrat	*Ondatra zibethica*
Porcupine	*Erethizon dorsatum*
Coyote	*Canis latrans*
Red Fox	*Vulpes vulpes*
Racoon	*Procyon lotor*
Long-Tailed Weasel	*Mustela frenata*
Mink	*Mustela vision*
Badger	*Taxidea taxus*
Striped Skunk	*Mephitis mephitis*
White-Tail Deer	*Odocoilus virginianus*
Norweigan Rat	*Rattus norvegicus*
Opossum	*Didelphis marsupialis*
Silver-Haired Bat	*Lasionycteris noctivagans*
Hoary Bat	*Lasiurus cinereus*
Least Weasel	*Mustela rixosa*
Western Harvest Mouse	*Reithrodontomys megalotis*
Northern Grasshopper Mouse	*Onychomys leucogaster*
Prairie Vole	*Microtus ochrogaster*
Meadow Jumping Mouse	*Zapus hudsonius*
House Mouse	*Mus musculus*

Burt and Grossenheider, 1976.

WATER QUALITY MONITORING

SECTION SUMMARY

The overall water quality of the tributaries in the Swan Lake watershed is poor due to high levels of nutrients during run-off events and relatively good when water is from the ground water recharge of the Turkey Ridge Creek aquifer. Fecal coliform counts, total phosphorus and nitrogen concentrations increase during run-off events. The number of feedlots directly on Turkey Ridge Creek are the most probable source of these high nutrient levels during run-off events. There is also a large resident beaver colony on the creek which may be adding to the impaired water quality. Turkey Ridge Creek serves as the major inlet to Swan Lake and is designed to keep the lake full in dry periods. Turkey Ridge Creek could better serve its purpose if the high nutrient peaks could be lessened or diverted from entering the lake. Two control structures were constructed to keep out sediment and nutrient rich water, allowing only cleaner ground water from Turkey Ridge Creek to enter. Improper management of these structures, however, have had an ill effect on the lake.

Swan Lake is considered a hypereutrophic lake, which means it has an over abundance of nutrients (ie. nitrogen and phosphorus). Swan Lake averages approximately 4 feet in depth (720 acre/feet of volume). Swan Lake receives 24 inches of precipitation and 41 inches of evaporation (net loss of 17 inches). Other sources or recharge include run-off from approximately 1,000 acres of Swan Lakes original watershed, and approximately 81,600 acres of the Turkey Ridge Creek watershed.

The major losses of beneficial use are due to Swan Lake's shallow depth. Because of the shallow depth, the turbidity (lack of water clarity) in Swan Lake is high. Algae, along with resuspension of sediments, are responsible for the high turbidity. Wind and subsequent waves action, motorboats, and rough fish are the most probable cause of the sediment resuspension.

Swan Lake experiences its highest nutrient levels in the summer. The best water quality is found in the winter when input to the lake is from groundwater and metabolic activity is slowed.

WATER QUALITY MONITORING

Monitoring Procedure

The Swan Lake study was designed to: 1. identify, monitor, and evaluate pollutants (sediment - nutrients and their primary sources) entering Swan Lake from the Turkey Ridge Creek watershed; 2. assess the current in-lake water quality conditions and the status of the watershed; 3. document how sediment and nutrient loadings have affected public uses of the lake; 4. identify specific and cost-effective measures available that would restore the water quality to uses of the lake, and 5. develop specific implementation recommendations which are feasable to the State and local sponsor.

The data collection phase of the study consisted of water quality sampling under the best possible conditions to obtain the most accurate data/information possible. Data collection was the responsibility of the Swan Lake Improvement Association (SLIA). The SLIA hired Arlo Andersen to conduct the water quality sampling, and collection the other information needed in the Phase I study. The project was supervised DENR. The sample collection, preservation, and analysis was conducted in accordance with the Quality Assurance Program of the DENR Division of Water Resources Management (WRM). Chemical analysis was conducted by the EPA certified State Health Lab in Pierre, SD, in accordance with their approved Quality Assurance Program. The raw data was analyzed and evaluated by DENR.

Data evaluation consisted of a thorough analysis of all the data including computer modeling and statistical testing. Products included: current trophic status of Swan Lake, nutrient loadings from the watershed, in-lake water quality analysis, and sources of nutrients. From this information, alternatives for restoration were developed.

<u>Special Monitoring Circumstances</u>

Throughout the project, discretionary samples were taken to show other causes/sources of nutrient loading to the lake or to a tributary. The same information was collected as in the established tributary or in-lake monitoring, depending on the situation.

Tributary Sampling

Five tributary monitoring sites were strategically placed in the watershed for the best comprehensive coverage with the available equipment. The placement also attempted to target certain areas with suspected water quality problems in the watershed. The sites selected for sampling are shown in Figure 14, and the descriptions are as follows:

Site 1. Turkey Ridge Creek, a large concrete culvert at a gravel road access 2 miles west and 3 miles north of Turkey Ridge in the SE1/4, SE1/4, SE1/4, SE1/4, Section 22; T98N, R55W; Latitude: 43^{o} 17' 7" N, Longitude: 97^{o} 19' 8" W.

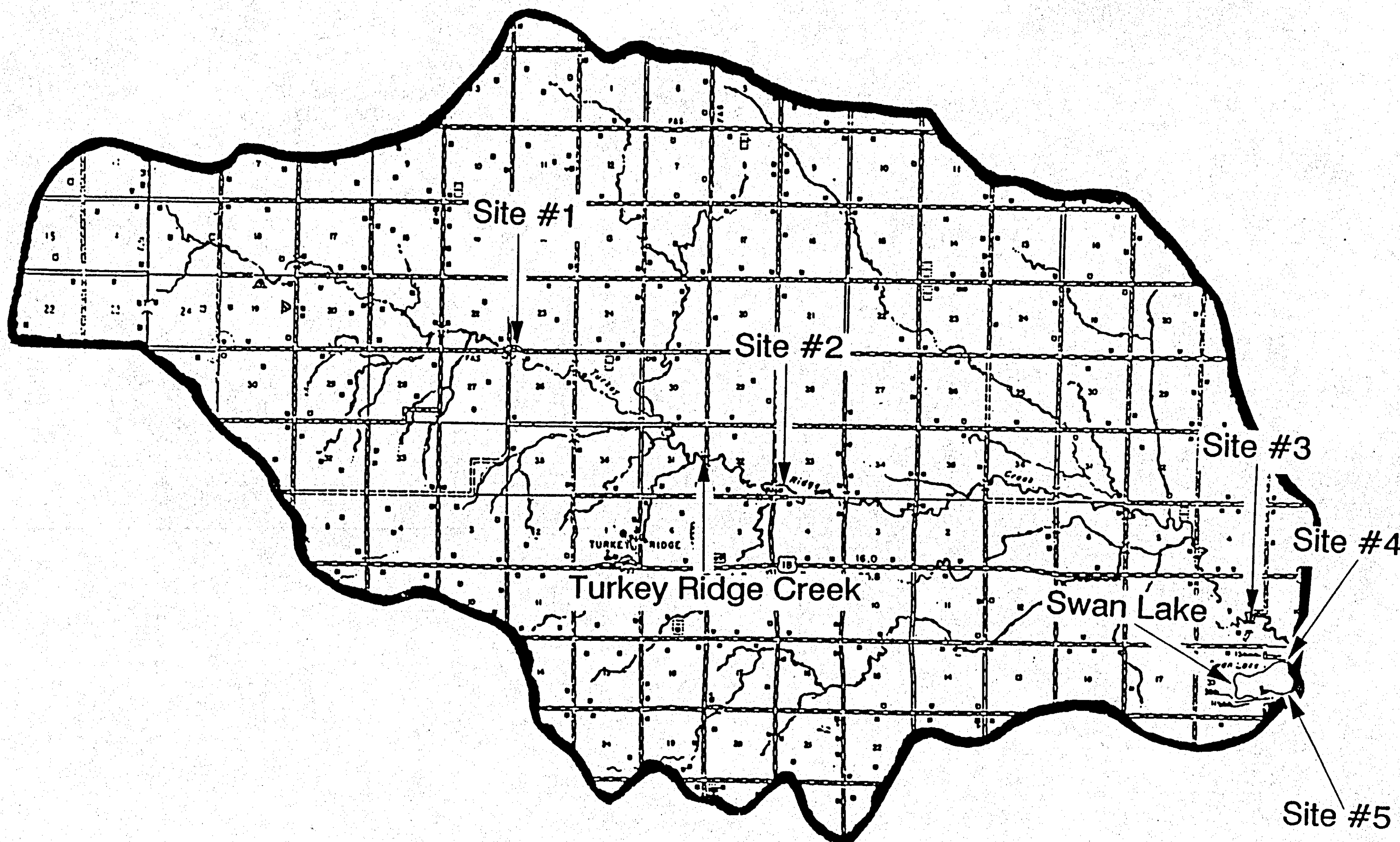


Figure 14. Tributary Sites in the Swan Lake Watershed.

Site 2. Turkey Ridge Creek, at a gravel road access 1 mile north of Highway 18 and 2 miles east of Turkey Ridge. The site is in the SE1/4, SE1/4, SE1/4, SE1/4, of Section 32; T97N, R54W; Latitude: 43° 15' 32" N, Longitude: 97° 14' 23" W.

Site 3. Turkey Ridge Creek, 1 mile north of Swan Lake. The sampling site was located at the gravel road access to Turkey Ridge Creek located in the NE1/4, SW1/4, NE1/4, SE1/4 of Section 9; T97N, R53W; Latitude 43° 14' 0" N, Longitude 97° 6' 12" W.

Site 4. The Diversion channel between Turkey Ridge Creek and Swan Lake. The sampling site was at the road access in the SW1/4, SW1/4, NE1/4, NW1/4, Section 15; T97N, R53W; Latitude: 43° 13' 30" N, Longitude 97° 5' 41" W.

Site 5. Swan Lake Outlet, located at the southeast corner of Swan Lake on the outlet structure on the west side of the road in the NE1/4, NE1/4, NE1/4, SW1/4 of Section 15; T97N, R53W; Latitude: 43° 13' 12" N, Longitude 97° 5' 33" W.

A pressure transducer, placed in a well screen located in the bottom of the stream, was used to collect hourly stage heights. The stages were recorded by digital data loggers secured in metal protective boxes. The data loggers were checked at least once a week to assure they were properly recording the data. The stage information was retrieved from the data loggers by DENR personnel twice during the sampling season. Flow data was collected by taking point velocities with a Marsh-McBirney flow meter and using a cross-section of the tributaries to calculate cubic feet/second (cfs).

Since the flow of Turkey Ridge Creek is intermittent, especially during dry periods, sampling was modified according to flow volume at each site. It was imperative that a complete stage and discharge record was kept from the beginning to the end of the sampling season so a hydrologic budget could be calculated. Ideally, sample collection was to be taken at the height of the runoff event for the best understanding of occurrences in the watershed, however, due to untimely run-off events samples were taken as close to the peak run-off event as possible.

The following sampling schedule was observed whenever possible. All the tributary sites were to be sampled twice weekly during the first week of snow-melt runoff and once a week thereafter until runoff stops. Samples were to be taken during or after storm events which induce a runoff event. When storm events or snow-melt were not occurring, base flow samples were to be taken once a month from the spring snow-melt until the winter freeze. This schedule was to be followed as closely as possible. It was left to the discretion of the sampler with guidance provided by DENR to decide if and when adjustments to the original schedule were needed to improve the data collection procedure.

Certain parameters were chosen to characterize lake inflow and outflow and to develop a nutrient and sediment budget. These samples were collected according to established methods of the State Health Laboratory. The parameters analyzed for were as follows.

Bottle A	Bottle B	Bottle C	Bottle D
Alkalinity	Ammonia-N	Fecal Coliform	Total Dis. PO4-P
Total Solids	NO3-NO2-N		
Total Dis. Solids	TKN-N		
Total Susp. Solids	Total PO4-P		
Volatile Solids			

Field personnel were also requested to make note of conditions that may affect the nutrient concentrations or flow of water. The field parameters to be analyzed and visual observations to be recorded by the sample collector were:

Water Temp. (^{o}C)	Air Temp. (^{o}C)	pH
Precipitation	Dead Fish	Wind
Surface Water Film	Odor	Turbidity
Septic Conditions	Water Color	Animal Activity

Tributary Data

The Swan Lake tributary sites were chosen to target watershed areas which could be a source of nutrient and sediment loadings. Table 27 summarizes the tributary samples taken by listing the median of the selected parameters for each site. The median was chosen because it was a more accurate representation of what was happening throughout the year. The mean values were somewhat higher than the median value because of one or two run off events in which concentrations were a magnitude or more higher than the vast majority of the other samples. The actual concentrations can be found in Appendix D.

In most incidences the concentrations increase as the water passes through sites 1, 2, to 3. Concentrations at site 4, however, are lower due to the influence of the hydrologically connected lake water. Site 5 does have higher values in suspended sediment which is probably the result of resuspension of sediments by wind and wave action. The nitrogen values are also somewhat higher than the tributary sites. Reasons for these increases may be the break-down of organic matter or the input from waste disposal systems around the lake. A site by site explanation is given after Table 27.

Table 27. Median Concentrations of Selected Parameters on Tributary Sites.

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5
Fecal Coliform	115	80	140	32	30
Total Susp. Solids	22 mg/L	38mg/L	48 mg/L	25 mg/L	22 mg/L
Non-volatile Susp. Solids	10 mg/L	18 mg/L	33 mg/L	16 mg/L	22 mg/L
Ammonia	.02 mg/L	.03 mg/L	.02 mg/L	.04 mg/L	.20 mg/L
NO_2-NO_3	.10 mg/L	.10 mg/L	.30 mg/L	.10 mg/L	.20 mg/L
Total Kjeldahl Nitrogen	.46 mg/L	.74 mg/L	.75 mg/L	.81 mg/L	1.34 mg/L
Total Phosphorus	.115 mg/L	.159 mg/L	.186 mg/L	.108 mg/L	.125 mg/L

Site 1

Site 1 (Figure 14) is classified for the beneficial uses of stock watering, wildlife propagation and irrigation. No exceedences of the South Dakota Water Quality Standards were found during sampling. Fecal coliform counts were found to be high during spring rain events showing evidence of either domestic livestock, wild animal, or human waste in the stream. Concentrations of phosphorus were also highest at this time. When phosphorus and nitrogen loadings were calculated, the highest daily loads were found in the spring.

Site 1 of Turkey Ridge Creek is recharged by snow-melt, rain, and ground water. The ground water recharge to site 1 is significant especially in fall and winter when springs upstream of the site flow freely. In summer, however, dry conditions and the fact that the creek loses large amounts water to evapotranspiration, the stream to lose its usual flow. The water quality, of what is ground water recharge, is relatively good compared to run-off events. However, fecal coliform counts are still high during periods of flushing by ground water. For example the fecal coliform count on October 15, 1991, was 570 counts per 100 ml (Appendix D). There was no rain during the time of the sample, but the stream did begin to rise and flow because of ground water recharge. The stream first started to flow on October 4, 1991. In the watershed above site 1 there are four feedlots which discharge directly to Turkey Ridge Creek and approximately seven more within 3/4 of a mile of the main drainage.

The drainage into site 1 is very steep which causes intense runoff. The feedlots in these areas may be the cause of the high fecal counts during rainfall events. The overall water quality of site 1 is relatively good. The estimated discharge at site 1 during the sampling period (March 6, 1992 to October 15, 1992) was 540,613,938 liters/year (438 acre-feet/year). The estimated load of total phosphorus at site 1 during the sampling period was 82 kilograms (kg) or 180.8 pounds. The estimated total nitrogen load was 490.16 kg (1,080 lbs.). The suspended solid load can be divided into organic and in-organic components, the organic solids were estimated at 5,272 kg (5.8 tons). Inorganic compounds (sediment) were estimated at 6,802 kg (7.5 tons).

Site 2

Site 2 has the beneficial uses of stock watering, wildlife propagation and irrigation. Indicators of water quality degradation are increased concentrations of fecal coliform, total phosphorus and nitrogen. Possible reasons for these increases are 12 feedlots located within 3/4 of a mile of the main channel between site 1 and site 2. In addition, there is a large population of beavers in the area which may be adding to the nutrient and fecal coliform problem.

The recharge to site 2, as with site 1, is snow-melt, rainfall and groundwater. The drainage to site 2 comes from the steep slopes of Turkey Ridge as well as the relatively flat land for miles around the stream. Water flow is very slow in this stream segment due to the level slopes and beaver activities. Due to the large amounts of water, the river is wider and deeper at site 2 than at site 1. Unlike site 1 where there is open water almost year round, the sluggish current at site 2 allows the cold temperatures of winter to freeze the surface of the creek. Water still passes under the ice but was not sampled during the winter months. Evidence of better water quality during the winter months is that the concentrations of all nutrient parameters were found to be lowest in early spring when the ground was still frozen.

The amount of water which passed by site 2 during the sampling year (March 6, 1992 to October 29, 1992) was estimated at 784,636,701 liters/year (636.1 acre-feet/year) with sixteen more days of sampling then at site 1. The increase in the water load from site 1 to site 2 is 45%. To remain consistent with the watershed which drains into site #1, the increases in the loadings of all the parameters should also increase 45%. Total solids increased approximately 58%, a percent relatively similar to the increase in water from the two points. There was a significant increase in suspended solids from site 1 to site 2.

The suspended solids (13.3 tons) at site 1 were 1.5% of the total solids (866.5 tons), at site 2 the suspended solids (49.9 tons) were 3.6% of the total solids (1,372 tons). The increase in suspended solids was 267%. Suspended solids consist of organic and in-organic particles. The organic solids are parts of an organism which is or was living. In-organic solids, for the most part, are considered sediments. The inorganic solid load at site 1 was 7.5 tons, at site 2 the inorganic solids increased (352%) to 33.9 tons. The increase in in-organics can be attributed to increased farming activity between sites 1 and 2. Organic solids also increased but not as much as the in-organic solids.

Nutrients also increased more than the 45% of the water load. Total phosphorus increased from 82 kg at site 1 to 272 kg at site 2 (231%). Total nitrogen increased 490 kg at site 1 to 1,325 kg at site 2 (170%). The percent increase in ammonia was the highest however, 480%. The increase was from 32.38 kg (site 1) to 187.76 kg (site 2). These nutrient loads are also the result of increased agricultural activity.

The overall quality of the water at site 2, was relatively good considering the size of the drainage above the site (Appendix E). This again can be explained by the recharge of ground water to the creek. This is not to say that the creek does not need corrective measures. Large increases in the percent of the loads took place between these first two sites. Also, the sampling season (1991) was one of low runoff due to below normal rainfall.

Site 3

Site 3 is given the beneficial uses of warm-water marginal fish propagation, limited contact recreation, wildlife propagation, stock watering, and irrigation. During the study there were exceedences of the standard for fecal coliform. The standard for limited contact recreation is 1,000 colonies of bacteria per 100 ml. On April 29, 1991 the bacteria per 100 ml was 38,000 colonies (Appendix D). The probable reason for the exceedence is the presence of a feedlot adjacent to Turkey Ridge Creek and directly above the sample site. On June 13, 1991, the fecal bacteria concentration reached 2,700 per 100 ml (Appendix D). Again the probable explanation is the close proximity of the feedlot to site 3. Site 3 also exceeded the standard on July 8, 1991. The bacteria count at the time was 2,000 per 100 ml (Appendix D). As with the prior exceedences, feedlots are the most probable source.

Site 3 was placed as close to the inlet of the lake as possible. The reason for this placement was to see the difference between what was entering the lake and what was passing by the lake inlet and flowing down stream. Unfortunately, in the fall of 1990, when the transducer was put in place, beavers had erected a dam which created a pool where the transducer was set. Snow-melt in the spring of 1991 removed the beaver dam leaving the transducer dry by the middle of June, 1991. As a result loads could only be calculated to this point (Appendix E).

The increase in the water load from site 2 to site 3 from March 6, 1991, to June 13, 1991, was 38%. As discussed in the section about site 2, if the nutrients and sediment loads increase the same as the water load between two sites, the watershed for the lower site is not adding more nutrients than the above watershed.

The total solids load for site 3 increased 14%, since the discharge increased 38% it appears that the drainage below site 2 does not pick up as many solids as would be expected. Dissolved solids increased only 13% and suspended solids increased 26%.

The smaller sediment load is probably due to the low slope between sites 2 and 3. The flatter slopes would have less velocity and thus have less ability to move sediment.

Total phosphorus increased 48%, dissolved phosphorus increased 51%. These percentage increases, although a little higher, are very similar to the the percent increases in the discharge of the stream (38%). Nitrogen loadings reacted differently than the phosphorus loadings. The nitrogen loadings had a very little increase from site 2 to 3. Total nitrogen increased only 3% from site 2 to site 3. The biggest change was in ammonia which decreased 65% between the two sampling sites. It appears the high concentrations of ammonia found at site 2 were oxidized and converted to NO_2-NO_3 while traveling downstream (NO_2-NO_3 increased 58%).

Site 3 is the most nutrient rich of the three sites. This would be expected since it has more of the watershed run-off flowing thru it than the two upstream sites. The site does have high nutrient loads in the spring which are largely caused by livestock pastured and confined along the drainage. However, the highest nutrient increase is occurring in the watershed between sites 1 and 2. The increased loading of nutrients and sediment at site 3 is relatively low when compared to the increased water flow at site 3. The total annual load cannot be calculated due to the circumstances mentioned earlier. As with site 2, no winter samples were taken which could show the water quality of the ground water recharge in the stream.

Site 4

Site 4 is located at the control structure downstream of both the inlet channel and a small settling pond to Swan Lake. Unforeseen problems were encountered in attempting to calculate flows through the inlet. The inlet to the lake is lower in elevation than the outlet of the lake (water flows both in and out of the same culvert). Because of this circumstance accurate flows are not available and a stage-discharge table could not be calculated. Depending on lake level, water may be flowing in, out, or not at all with similar stages at different times in the year. Discussion of the water quality at this site will be limited to concentrations since no loading data is available.

Water is diverted into site 4 by a sheet steel check dam approximately 500 feet downstream of the inlet channel. The elevation of the lowest part of the dam is slightly over 1 foot higher than the elevation of the culvert at site 4. Water will enter the lake before water can overflow the dam.

High nutrient concentrations were observed throughout the sampling season. Although samples taken during March through May of 1991, show drops in fecal coliform counts between site 3 and site 4; run-off events later in the year showed high fecal coliform counts. On June 13, 1991 the fecal coliform count at site 4 was 1,200 colonies per 100 ml. On the same date dissolved oxygen levels at this site were 1.1 mg/L, (low enough to kill fish). At this time many carp were observed trapped in the sediment settling basin, the SD Department of GF&P was notified and an estimated 2,000 pounds of carp were seined out. On February 19, 1992 the fecal count was 2,500 colonies per 100 ml. This was the first flush from snow melt that spring, and run-off from feedlots was probably the cause. Phosphorus and nitrogen concentrations were also high when fecal counts were high.

The current four foot deep sediment retention pond has lost most of its ability to collect sediment out of the water column. The concentrations of total suspended solids at site 4 are only slightly less than those at of site 3. The retention pond also has grazing along it's borders which have caused bank erosion.

The fall and winter ground water recharge to Turkey Ridge Creek enters Swan Lake through the inlet channel (site 4). The concentration of the nutrients flowing into the lake during the winter groundwater recharge period are the lowest concentrations in the sampling year (Appendix D).

Site 5

Site 5 serves as the outlet from Swan Lake back to Turkey Ridge Creek. There is a large build up of macrophytes, trees, and sediments on the head wall which retards flow to the outlet. This build-up acts as a dam and raises the water level of the lake higher that that of the outlet. The outlet consists of three oval shaped culverts approximately 3.5 feet wide and 2.3 feet high which sit flush on a concrete apron. The discharge end of the culvert has a steel flap gate to keep flood flows and animals out. The flap gate also retards flow. The maximum outflow measured during 1991 monitoring period was slightly over .5 cubic feet/second which calculates to slightly more than 1 acre foot/day. The duration of these outflows lasted approximately seven weeks. Outflow started about April 25, 1991 and ended approximately July 12, 1991. The maximum loss of water through the outlet during the 1991 sampling season was estimated between 45 and 60 acre-feet. By May 21, 1991, the lake level had reached the level of the creek and water was flowing out of the inlet also.

From the samples taken at the outlet of the lake, the median concentrations of many of the parameters in Table 27 are higher than the median concentrations in the tributaries. The concentrations listed on Table 27 show site 5 to be higher in non-volatile suspended solids than many of the tributary sites. This is probably due to the resuspended sediment in the shallow lake. Ammonia is much higher in concentration than in the tributary, as is kjeldahl nitrogen. The increases in ammonia may be directly related to the increase in kjeldahl (organic) nitrogen. As vascular vegetation decomposes large amounts of organic nitrogen (kjeldahl minus ammonia) are released. Much of this nitrogen is absorbed by the sediments, where bacteria break it down into ammonia and other inorganic forms. This process is reversed in flowing rivers where ammonia is easily oxidized and converted into nitrate+nitrite.

Hydrologic Budget

Because of the problems experienced at the inlet with water flowing both directions at site 4, an accurate hydrologic and nutrient budget can not be calculated the usual way. Using the lake elevation and the outlet flow estimation, the volume of water that entered the lake can be estimated. Continuous lake elevation data is not available until November 1991. The most consistent sample data was taken from February 1991. It is assumed that the lake elevation behaved similarly in the winter of 1990-1991 as it did during the winter 1991-1992. The nutrient budget is estimated for 1991 by using representative 1991 and 1992 concentrations, 1991 outlet information, and 1992 lake elevation data.

The total volume of Swan Lake is 888,206 cubic meters (720 acre-feet). In November of 1991, Swan Lake was approximately 0.46 meters (1.5 feet) low (333,077 cubic meters or 270 acre-feet). As stated earlier, it will be assumed that the lake elevation was also 0.46 meters low in 1990. Because the groundwater component was not measured, it will be assumed that the input and output from groundwater was equal. Water losses to the lake system are from evaporation, which is approximately 758,676 cubic meters (615 acre-feet), and outflow through site 5, approximately 74,017 cubic meters (60 acre-feet). The estimated inputs to the lake were from both surface water, approximately 388,590 cubic meters (315 acre-feet) and rainfall which was approximately 444,103 cubic meters (360 acre-feet). The hydraulic residence time for Swan Lake in 1991 was approximately 12 years. The flow out of the lake may have been a little more since water was observed flowing out site 4. Estimations of this amount are around 24,672 cubic meters (20 acre-feet), so the hydraulic residence time may be closer to 9 years. These figures are based on data for only one year, however the drop in the lakes elevation are fairly consistent from year to year.

Nutrient Budget

To calculate a nutrient budget, representive mean concentrations were multiplied with the volume estimations. The concentrations were chosen by correlating a concentration to dates which were representative of a flow at a certain time.

From November to February the lake elevation rose 0.38 meters (1.25 feet) or 277,564 cubic meters (225 acre-feet).

Representative nutrients and solids concentrations taken from the time water was flowing when the ground was frozen, were averaged. The mean of the February 11, and March 6 samples taken in the winter of 1991 and one sample taken December of 1991 were applied to the 277,564 cubic meters (225 acre-feet) which entered the lake during this time period.

From February to April the lake rose another 0.076 meters (0.25 feet). Since flow remained somewhat constant discharge is assumed to be equal on each day. Three samples were taken during this two month period. The concentrations were averaged and that mean was multiplied by the volume (55,513 cubic meters or 45 acre-feet) which entered the lake.

The input from May to July was also approximately 0.076 meters (45 acre-feet). Two samples were taken during this period, as with the previous concentrations, they were averaged. The mean concentrations for all of the time periods are listed on Table 28.

To calculate loads for this period, the load (277,564 cubic meters) was converted to liters (multiplying by 1,000). The converted load (277,564,320 liters) was then multiplied by the concentration of the chosen parameter (ie. total solids 1,444 mg/L). The result was the milligrams of "total solids" entering the lake at the time (400,802,416,080 mg). This number was then

Table 28. Mean Concentrations Used in Calculating Inputs.

Time Period ------->	Nov. - Feb.	Feb. - Apr.	May - Jul.
Cubic Meters ------>	277,564	55,513	55,513
Parameter	Concentration in Milligrams/Liter		
1) Total solids	1,444.00	1,601.00	1,188.00
2) Total suspended solids	8.00	43.00	34.00
3) Volatile suspended solids	3.70	14.00	15.00
4) Non-volatile suspended solids	4.30	29.00	19.00
5) Total nitrogen	0.94	1.73	1.82
6) Total organic nitrogen	0.48	1.11	0.79
7) Total Kjeldahl nitrogen	0.58	1.25	1.37
8) Nitrate-Nitrite	0.37	0.66	0.48
9) Ammonia	0.09	0.14	0.58
10) Total phosphorus	0.081	0.254	0.405
11) Total dissolved phosphorus	0.062	0.139	0.217

converted into kilograms (400,802 kg) by dividing by 1,000,000. The resulting number was the load in kg/time period.

The loadings from Table 29 show that from November to the end of February the lake receives the 2.5 times more water than it does the rest of the year. Input from frozen ground are shown in the first column in Table 29. The other two columns depict loadings when the ground had thawed and the tributaries were receiving increased non-point source run-off from the watershed. Table 30 shows the loadings to the lake when the ground was frozen and when the ground was thawed, the purpose is to compare the changes in concentrations under the two different conditions.

Table 29. Loading of Parameters in Kg/Time Period.

Time Period ------->	Nov. - Feb.	Mar. - Apr.	May - Jul.
Cubic Meters ------>	277,564	55,513	55,513
Parameter	Load in Kilograms		
1) Total solids	400,802	88,876	65,949
2) Total suspended solids	2,221	2,387	1,887
3) Volatile suspended solids	1,026	777	833
4) Non-volatile suspended solids	1,194	1,610	1,056
5) Total nitrogen	261	96	101
6) Total organic nitrogen	133	62	44
7) Total Kjeldahl nitrogen	161	69	76
8) Nitrate-Nitrite	103	37	27
9) Ammonia	25	8	32
10) Total phosphorus	22	14	22
11) Total dissolved phosphorus	17	8	12

The third column in Table 30 shows the percent change from the frozen to the thawed ground. If the water quality would remain the same from the winter inflow and the spring and summer inflow, the percent in load change should remain relatively close to the percent change in volume (- 60%). The only parameter which had a drop in load close to - 60% was total solids. This can be explained because the largest component in total solids is dissolved solids. Total dissolved solid concentrations stay relatively constant through out the sampling year. All other parameters were higher than the - 60% decrease in load, in many cases instead of a comparative decrease, the loads actually increased with 2.5 times less water.

Table 30. Differences in Loadings Over Time.

Time Period -------> Cubic Meters ------>	Frozen Nov. - Feb. 277,564	Thawed Mar. - Jul. 111,026	% Increase or Decrease - 60%
Parameter	Load in Kilograms		
1) Total solids	400,802	154,825	- 61%
2) Total suspended solids	2,221	4,274	+ 92%
3) Volatile suspended solids	1,026	1,610	+ 57%
4) Non-volatile suspended solids	1,194	2,666	+ 123%
5) Total nitrogen	261	197	- 25%
6) Total organic nitrogen	133	106	- 20%
7) Total Kjeldahl nitrogen	161	145	- 10%
8) Nitrate-Nitrite	103	64	- 38%
9) Ammonia	25	40	+ 60%
10) Total phosphorus	22	36	+ 64%
11) Total dissolved phosphorus	17	20	+ 18%

The largest percent increase was in total suspended non-volatile solids. The percent change from column 1 to column 2 (Table 30) was a positive 123%. This verifies the increase sedimentation through the inlet when the ground is thawed. The second largest increase was in suspended sediment (+ 92%), of which non-volatile solids are a sub-component. Since phosphorus sorbs onto sediment, it also increased (+ 64%) in load with a decrease in water volume.

Although the nitrogen components also increased, most did not increase as high in percentage as the other parameters. Ammonia levels did increase + 60%, which may indicate an increase in fertilizer or waste products.

The volume of water which flowed through the outlet of Swan Lake was estimated at 74,017 cubic meters (60 acre-feet). The samples taken at the site were prorated verses time, and concentrations then multiplied by the appropriate volume to arrive at the estimated load which left the lake (Table 31).

Table 31 also shows the load which is retained or stored in the lake in a year. According to the estimations 387,571 kg (427.3 tons) of total solids are stored in Swan Lake. Of these, only 4,154 kg (4.65 tons) are suspended solids. This may explain the high dissolved solid concentrations experienced in the lake. However, dissolved solids alone can not account for the turbid conditions in a lake. The small colloidal clay particles and suspended sediment are probably the most likely reasons for the lakes cloudy appearence. The suspended sediment components, volatile and non-volatile solids, are approximately the same. Considering the nutrients which are stored in the lake, nitrogen accumulates in much greater concentrations than phosphorus. Although the loadings stored are relatively small, the lake can not effectively release the nutrients through the outlet. This inability causes a reservoir of nutrients which can be released and recycled throughout the year.

Although the phosphorus levels are relatively low, plants use much less phosphorus than nitrogen for growth. The lower phosphorus loads are probably responsible for the same if not

TABLE 31. Estimated Net Gain of Selected Parameters to Swan Lake

	TSOL KG/YEAR	TSSOL KG/YEAR	VOLATILE SOLIDS KG/YEAR	NON-VOL. SOLIDS KG/YEAR	AMMON KG/YEAR	NO3+2 KG/YEAR	TKN-N KG/YEAR	ORGANIC NITROGEN KG/YEAR	TOTAL NITROGEN KG/YEAR	TPO4P KG/YEAR	TOTAL DISS. PO4 KG/YEAR
OUTLET	166,056	2,341	680	1,662	13	20	99	87	120	11	2
INLET	553,627	6,495	2,636	3,860	65	167	306	239	458	58	37
LAKE STORAGE -- kg/yr	387,571	4,154	1,956	2,198	52	147	207	152	338	47	35
LAKE STORAGE -- lb/yr	854,593	9,159	4,314	4,847	115	324	456	336	746	103	76
LAKE STORAGE -- tons/yr	427.3	4.6	2.2	2.4	0.06	0.16	0.23	0.17	0.37	0.05	0.04

more growth than the larger loads of nitrogen. As expected, the amount of total dissolved phosphorus leaving the lake is low due to its availability and up-take by plants and animals and also its adsorbtion to sediment particles. The total phosphorus levels, are caused by adsorbtion as mentioned above, plus the fact that the high in-lake oxyegen levels seldom allow for the phosphorus to be released from the sediment. The most likely way for phosphorus to leave the lake is through the outlet on days when wind and waves resuspend the sediments.

In conclusion Swan Lake is storing nutrients which can be used and recycled throughout the year. The lake does not appear to be receiving large loads of sediment from the inlet, however, data was collected in a relatively dry year. The sediment accumulation in the lake may have come from large flood events which have entered the lake before the road was raised.

By stopping the flow of water to the lake once the ground has thawed, the estimated loads could be reduced by 50% in most cases, while only loosing approximately 15.24 centimeters (6 inches) of surface water volume. If additional groundwater enters the lake, there may be no water volume lost.

In-lake Sampling

Three in-lake sampling sites were selected for Swan Lake (see Figure 15), and the descriptions are as follows:

Site 6 In-lake depth approximately 1.5 meters, located on the southeast side of the lake halfway between the far east island and the south shore.
Latitude: 43° 13' 15" N,
Longitude: 97° 5' 45" W.

Site 7 In-lake depth approximately 1.55 meters, located in the center of the lake between the boat ramp and the shore directly north of the boat ramp, the boat ramp runs directly on a section line which can be seen from either shore.
Latitude: 43° 13' 15" N,
Longitude: 97° 6' 5" W.

Site 8 In-lake depth approximately 0.75 meters, located in the center of the far west bay. The site is straight west of the small cove to the east, and straight north of the small cove to the south. If the site is unreachable

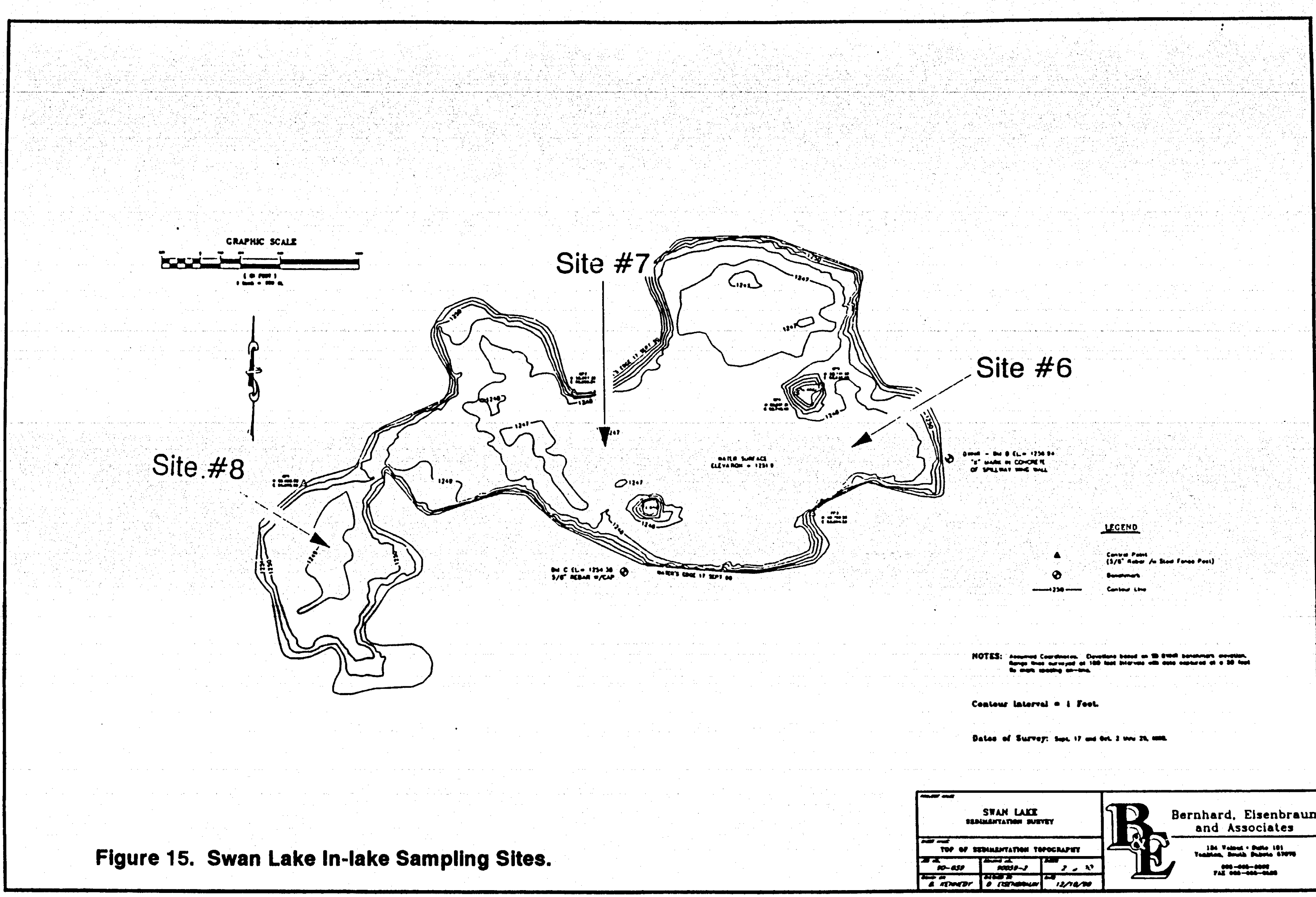


Figure 15. Swan Lake In-lake Sampling Sites.

due to boating restrictions, the sample was taken as far into the west bay as possible.
Latitude: 43° 13' 6" N,
Longitude: 97° 6' 35" W.

The sampling schedule for the in-lake sites was monthly from October through March and twice a month from April to September. There were about four weeks between each monthly sampling and two weeks between each bimonthly sampling. Early winter or late spring samples were taken only if ice conditions were safe.

The chemical parameters assigned to the tributary sampling were the same for lake sampling but also included chlorophyll a analysis. This parameter was field filtered by the sampler and then put on ice for examination by DENR personnel at a later time. Field analysis included:

Water Temp. (°C)	Air Temp. (°C)	pH
Dis. Oxygen (mg/L)	Secchi Disk (m)	Water Depth (m)
Ice Thickness (m)	Chlorophyll a (field filtered)	

Dissolved oxygen (DO) was measured with a YSI meter. Water temperature and DO were taken at the center of the water column because of the shallow depth of Swan Lake. Also, due to the shallowness of Swan Lake, only a surface grab sample was collected. The grab samples were taken at depths from 0.4m to 0.6m.

Surface visual observations were conducted by the sampler to record any circumstances which would effect the sampling data. They included but were not limited to:

Precipitation	Dead Fish	Wind
Surface Water Film	Odor	Turbidity
Septic Conditions	Water Color	Algal Blooms
Inflow From Tributaries		

In-lake Data

The in-lake water quality will be discussed by parameter. The parameters which will be discussed are those which have an existing water quality standard or which may be responsible for limiting the beneficial uses of the lake. Graphs comparing the in-lake sites can be found in Appendix F.

Table 32. In-lake Mean Concentrations.

Parameters	Concentrations Sites 6 & 7	Site 8
Water Temperature	18.2°C	17.5°C
Total Depth	1.54 M	0.75 M
Secchi Disk	0.74 M	0.31 M
Dissolved Oxygen	8.35 mg/L	7.6 mg/L
Field pH	8.15 units	8.10 units
Laboratory pH	8.26 mg/L	8.22 mg/L
Total Alkalinity	121.5 mg/L	140.9 mg/L
Total Solids	2,306.5 mg/L	2,458.8 mg/L
Total Dissolved Solids	2,269.4 mg/L	2,403.3 mg/L
Total Suspended Solids	37.1 mg/L	55.5 mg/L
Volatile Solids	14.6 mg/L	19.3 mg/L
Non-volatile Solids	25.1 mg/L	45.4 mg/L
Ammonia	0.105 mg/L	0.11 mg/L
Un-ionized Ammonia	0.0074 mg/L	0.0045 mg/L
Nitrate-Nitrite	0.29 mg/L	0.3 mg/L
Total Kjeldahl	1.29 mg/L	1.61 mg/L
Organic Nitrogen	1.19 mg/L	1.50 mg/L
Total Nitrogen	1.58 mg/L	1.89 mg/L
Total Phosphorus	0.146 mg/L	0.211 mg/L
Total Dissolved Phosphorus	0.040 mg/L	0.040 mg/L
N:P Ratio	11.7:1	10.47:1
TSI for Phosphorus	74.5	80.29
TSI for Secchi Disk	71.86	77.62

Depth

The mean depth at the sites 6 and 7 are both approximately 1.5 meters (4.8 feet). The mean depth at site 8 is 0.75 meters (2.46 feet). The depth differences between sites 8 and sites 6 and 7 can cause significant changes in concentrations of certain parameters. The effect wind and waves have on concentrations of certain parameters at the shallow depths of site 8 can be documented. Because phosphorus is usually attached to sediments, and wind and waves resuspend sediemnt in the water column, total phosphorus levels increase with resuspension.

Changes in depths at the individual sites can be attributed to the increases and decreases in lake level. Swan Lake can vary approximately 0.6 meters (2 feet) during a year. Also, even though every attempt was made to position the boat in the same position at every site, slight variations were experienced.

Dissolved Oxygen

The State of South Dakota has assigned the beneficial use of warm-water, semi-permanent fish life propagation to Swan Lake. Therefore, dissolved oxygen (DO) concentrations should not fall below 5.0 mg/L.

In general, DO concentrations were adequate to sustain fish and aquatic life. Annual means for in-lake sites ranged from 7.6 to 8.35 mg/L for the in-lake sites. No exceedences of the standards occurred during the the sampling season. The lowest DO value (5.0 mg/L) was recorded at site #8 on August 15, 1991 (Appendix F). The drop in DO was probably due to the increased biological activity which occurs during the summer months. The increase in algal production causes an increase in decomposition as the algae dies. Decomposition takes place at the expense of oxygen, thus increased activity by detritus will lower oxygen levels. Dissolved oxygen values at in-lake sites were generally lower from late May through September 1991 but increased to high values from October to April. Although the data displays only surface DO measurements, when the DO probe was dropped near the bottom, there was no difference in DO levels were detected until the probe hit the sediments. The thorough mixing of the water column is most likely due to the lake's shallow depths and mixing caused by wind and wave action.

Relatively high DO was also recorded in February 1991 for all sites. This was most likely due to an under the ice algal bloom. In comparing all the in-lake sites, lowest surface oxygen levels were usually recorded at shallowest site, #8.

Fecal Coliform

As previously stated, Swan Lake has been assigned the beneficial use of immersion recreation. Therefore, fecal coliform levels are limited to 200 per 100 ml as a geometric mean based on a minimum of not less than five samples obtained during separate 24-hour periods for any 30-day period, nor shall they exceed this value in more than 20% of the samples examined in the above described 30-day period; nor shall they exceed 400 per 100 ml in any one sample from May 1 to September 30.

In-lake fecal coliform concentrations were low or at undetectable levels during the monitoring program for sites 6 and 7. Site 8, located in the near the Christian Camp, experienced two samples with coliform colony counts at least 9 times higher than the mean at the other in-lake sites. The counts on April 3, 1992, and September 11, 1992 were 110 and 70 counts per 100 ml respectively. The high counts on April 3 may have been due to land run-off or the increasing groundwater levels flushing drain fields of the camp into the lake. Since there was no recorded rain fall on the September 11 sample, the septic systems of the camp are the most probable cause of the increased fecal count on that day. Although there are detectable levels of fecal coliform at all of the sites some time during the study, the maximums at site 6 and 7 were 20 and 30 counts respectively. Since the tributary was blocked from the lake during the most of the sampling season the slight increases in the lake can only come from non-tributary sources.

pH

The most stringent criterion for pH occurs under the beneficial use category of immersion recreation. The pH shall be greater than 6.5 units and less than 8.3 units.

During the recent monitoring period (February 1991 - April 1992) the <8.3 limit was exceeded in 41 percent of in-lake pH readings (Appendix F). Lake pH values ranged from 7.6 to 8.5. Mean pH values were similar for the three in-lake sites, 8.1 at sites 6 and 8, and 8.2 at site 7. Water flowing into the lake from Turkey Ridge Creek site 3 was observed to have a lower annual mean pH of 7.9 with a range from 7.5 to 8.3.

Most streams and lakes of eastern South Dakota have relatively hard water with typically high pH ($\geq$ 8.0). Large algal populations (such as those present in Swan Lake) may easily remove enough dissolved carbon di-oxide from surface waters to increase daytime pH to 8.3 or higher.

Alkalinity

Alkalinity can be defined as the sum total of components in the water that tend to elevate the pH of water above mean value of 4.5 (EPA, 1976). Therefore, it can be considered as representing the buffering capacity of a lake or stream. Buffering in waterbodies is important for the maintenance of a aquatic life since most lethal effects occur when the pH is less than 4.5 or greater than 9.5 (Wetzel, 1983).

Alkalinity level in nature can are usually found from 20 mg/L to 200 mg/L (Lind, 1985). Swan Lake is a well buffered lake with mean annual alkalinity, measured as mg $CaCO_3$ per liter of water, ranging from 120.6 mg/L at site 7 to 140.9 mg/L at site 8 (Appendix F). Data indicate the alkalinity levels remained fairly stable over the annual cycle of the lake.

At the range of pH's in Swan Lake (7.6 - 8.5), alkalinity is present primarily as HCO_3 (bicarbonates). Waterbodies with alkalinity above 100 mg/L have significant buffering capacity. Waters with concentrations above 200 mg/L such as Turkey Ridge Creek have large buffering capacity.

Total Dissolved Solids

Dissolved solids is a term associated with freshwater systems and consists of inorganic salts, small amounts of organic matter, and dissolved material (EPA, 1976). The principal inorganic anions (negatively-charged ions) dissolved in water include carbonates, chlorides, sulfates, and nitrates. The most abundant anion in Swan Lake is sulfate (SO_4) followed distantly by carbonate. The principal cations (positive ions) in freshwater lakes are calcium, magnesium, sodium, and potassium. In Swan Lake, calcium is the most abundant cation (220 mg/L) followed by magnesium (160 mg/L). Sodium is about one-half as abundant and potassium about one-tenth as abundant as calcium.

Sulfate accounts for the largest percentage of total dissolved solids in Swan Lake. The concentration of SO_4 ranged from 668 to 1112 mg/L during 1974 and averaged 725 mg/L in 1979. No recent sulfate measurements have been performed but it is possible levels have increased since 1979 based on significantly higher TDS readings obtained in 1991. Total dissolved solids generally ranged from 2143 to 2825 mg/L. Based on the beneficial uses assigned to Swan Lake total dissolved solids should not exceed 2500 mg/L. During 1991, this level was exceeded in 19 percent of the lake samples (Appendix F).

Total Suspended Solids

The limits for suspended solids established for a warmwater semipermanent fishery is 90 mg/L. Excessive suspended solids in a body of water can have a detrimental effect on a lake's fishery. In 1965, the European Fisheries Advisory Committee identified four means by which suspended solids can affect fish and fish food populations (EPA, 1976). Fish swimming in waters with high suspended solids can be killed directly, their growth rate reduced, or their resistance to disease reduced. In addition, suspended solids can prevent the successful development of fish eggs and larva and reduce the abundance of food available to fish.

Only one exceedence of suspended solids was observed in Swan Lake during 1991 (site 8, 108 mg/L, Appendix F). Annual mean TSS values were 55.5 mg/L at site 8 and 31.7 mg/L at sites 6 and 7 (Table 28). Site 8 is the shallowest station (Figure 18) and thus likely to be the most turbid due to greater resuspension of bottom sediments by wind and wave action. Literature indicates that growth and production of more desirable fish species and fish food organisms begin to be seriously affected at the TSS levels encountered in Swan Lake.

The water clarity and aesthetic appearance of a lake is often not apparent on examination of TSS levels. When suspended particles are very small, such as colloidal clays, it does not require a large amount of TSS to make the water turbid. An important factor that contributes to persistent turbidity in Swan Lake and other similar lakes is the amount of dispersed colloidal clay in the drainage area. In addition, due to the very shallow nature of Swan Lake, bottom sediments over most of the lake basin are subject to resuspension by wind and wave action. Finally, sizable populations of rough fish such as black bullhead and particularly carp stir up bottom sediment contributing to turbid conditions. Boat motors have also been implicated in stirring up lake sediments.

A visible biological effect of this algal and non-algal turbidity is the lack of submersed rooted and floating-leaved aquatic plants. Macrophyte populations in moderate numbers is beneficial to fish and general lake ecology.

Volatile and Non-Volatile Solids

Volatile solids are a percent of suspended solids which are generally considered organic (something that is or was living). Non-volatile solids are the percent of suspended solids which are generally considered inorganic (sediment).

Site 8 is approximately twice as shallow as sites 6 and 7. The occurrence of wind and wave action along with bottom feeding fish greatly increases the percentage of non-volatile solids. Shallow depth is the most probable reason that approximately 70% of the suspended solids are inorganic or sediment. Evidence of the effect of wind on the resuspension of sediment at site 8 was demonstrated on days when there was ice cover or no wind. The volatile solids percentage exceeded the non-volatile percentage on February 11, 1991 and June 19, 1991 (Appendix F).

Unlike site 8, sites 6 and 7 are both located in a unrestricted boating area. Resuspension of sediments by boat motors in depths of only 1.5 meters (4.5 feet) can be significant. As with site 8 wind and wave resuspension seemed to play a large part in increasing the percentage of inorganic solids in the water column. Each sample when the volatile solid percentage exceeded the non-volatile percentage occurred when the wind was calm. The only exception to the last statement occurred at site 6 on July 2, 1992. The percent of volatile to non-volatile solids on that day was 53% and 47% respectively. A large algal bloom or piece of organic matter (ie. a leaf, or part of a macrophyte) entering the bottle at the time of the sampling may have altered the volatile and non-volatile percentages.

Nitrates and Nitrites

Average concentrations of nitrates+nitrites (NO_2-NO_3) for sites 6-7, and 8 were 0.29 mg/L and 0.30 mg/L respectively (Table 28). Levels of NO_2-NO_3 ranged from a minimum of 0.1 mg/L to a maximum value of 0.8 mg/L, which was found at site 7. The nitrate and nitrite levels show a significant increase beginning June 19 and ending August 15, 1991. All three in-lake sampling sites exhibit this increase during the same time period. It was interesting however that the increase of nitrates occurred while the more readily available ammonia what still detectable in the lake. During these months, sources of inorganic nitrogen may arise from several areas.

NO_2-NO_3 increases can be caused by break-down of organic nitrogen or nitrification of ammonia. (Nitrification is the process of adding oxygen to NH_4^+ to get NO_2 or NO_3 depending on how far the oxidation proceeds.) Intensive agricultural activities may contribute more nitrogen to the lake than any other non-point source. Also, the evaporation of water from the lake may increase concentration by decreasing the water volume, thus increasing the concentrations.

Ammonia/Un-ionized Ammonia

Un-ionized ammonia concentrations are calculated using a formula including pH, water temperature, and ammonia. Un-ionized ammonia is assigned a state standard of no more than 0.04 mg/L under the warm-water semipermanent fishery beneficial use. Levels of un-ionized ammonia did not exceed this value. Average levels of un-ionized ammonia from in-lake sampling sites 6-7, and 8 were 0.0074 mg/L, and 0.0045 respectively (Table 28). Maximum values ranged from 0.0326 mg/L at site 7 and 0.0295 mg/L at site 6 to 0.01588 mg/L at site 8. Two sites, 7 and 8, had maximum values of un-ionized ammonia present during the June and July sampling periods. One reason for this increase may be due to the fact that ammonia is an important nitrogenous end product of the heterotrophic bacterial breakdown of organic substances. During June and July it may become very prominent in the summer hypolimnion of eutrophic lakes (Cole, 1983). Even though no DO concentrations of 0.0 mg/L were recorded, sediment in the lake is under anoxic conditions and may be releasing ammonia. Septic waste from drainage systems around the lake may also be a probable source.

Total Kjeldahl Nitrogen (TKN)

TKN is used to measure organic nitrogen which is TKN minus the ammonia concentration. The TKN averages for sites 6-7, and 8 were 1.29 mg/L and 1.61 mg/L respectively (Table 28). TKN levels were not significantly different from each other during sampling times, however site 8 on the average had higher values. Organic nitrogen may be released from large quantities of decaying macrophytes or algae which may be the reason for the high values at site 8. Site 8 is surrounded by species of wetland plants.

Total Nitrogen

Organic forms of nitrogen usually make up from 75% to 80% of the total nitrogen. Unlike inorganic nitrogen, organic nitrogen does not make itself readily available as nutrients for plants. It is inevitable however, that the organic form will be broken down by detritus and transformed into an inorganic state which can be used by living matter. During the summer, as the total nitrogen in the lake increases so does the percent of organic nitrogen (around 90%). This can be expected because of increased production of algae and also aquatic macrophytes along the shores of the lake. During winter spring and fall, the inorganic percent does increase but not at a highly significant rate. The low availability of nitrogen (mostly in organic form) in the lake may be the reason the lake sometimes becomes nitrogen limited. When comparing total nitrogen concentrations of the water in the tributaries to the water leaving the lake, the concentrations leaving the lake are generally higher. These higher concentrations are probably due to the increased biological activity in the lake creating organic nitrogen and eventually inorganic nitrogen.

Total Phosphorus

Phosphorus is essential for the growth of all living things. In excessive levels, phosphorus can be the cause of nuisance algal blooms which can hamper most contact recreation activities. The minimum in-lake concentrations needed for algal growth varies among different species allowing for diversity in aquatic systems however any concentration above 0.02 mg/L can stimulate most green and blue-green growth (Wetzel, 1983). Average total phosphorus levels for site 6-7 and 8 were 0.146 mg/L and 0.211

mg/L respectively (Table 28). The high average phosphorus level in site 8 may be attributed to the low mean depth in the area. Site 8 may have its sediments resuspended by wave action distributing phosphorus throughout the entire water column. This may also occur in sites 6 and 7 but to a lesser degree because of their greater depths. July and August are also the times when algal blooms are most prevalent, adding to the total phosphorus in the water column.

Total phosphorus levels may increase during summer as a result of increased algal productivity and also soil particles releasing phosphorus when dissolved oxygen levels are depleted, although few if any anoxic levels were recorded. Other sources which may also contribute to this increase in phosphorus are agricultural activities and breakdown of aquatic macrophytes or algae.

Total Dissolved Phosphorus

The total dissolved phosphorus, or available phosphorus, levels averaged 0.040 mg/L for all in-lake sites (Table 28). The minimum in-lake level for total dissolved phosphorus was 0.010 mg/L at sites 7 and 8. Samples taken at in-lake sites 6 and 8 in late July and early August revealed total dissolved phosphorus levels exceeding 0.110 mg/L (Appendix F). This level of phosphorus is more than 5 times the amount required for optimum growth of many algal species (Wetzel, 1983). The percentage of available phosphorus compared to total phosphorus at site 6 was approximately 27%, at sites 7 and 8 the percentage of available phosphorus is approximately 18%. Some reasons which could explain the increases in percent availability at site 6 are: 1) an increase in algal activity which may release available phosphorus as it dies and is decomposed, 2) site 6 is closest to the retention pond near the inlet, dissolved oxygen levels in the pond were recorded at near anoxic levels. If some anoxic water present in the settling pond managed to seep into the lake through the closed off stop logs during the summer, phosphorus may have been released from the sediments.

It appears that the lake is acting as a sorb for the available phosphorus in the tributaries. As water enters the tributaries it is approximately 68% available phosphorus. As more and more non-volatile solids enter the tributary system it appears that the phosphorus sorbs to the sediments. Once the water enters highly turbid Swan Lake, phosphorus continues to sorbs with the sediments and hold it until released from the sediment by low oxygen levels. The low percentage of total dissolved phosphorus in the lake and leaving the outlet are evidence that the sediment is acting a large reservoir for the phosphorus and is not releasing it because of high DO levels throughout the water column.

Limiting Nutrient (N/P ratio)

If an organism is to survive in a given environment, it must have the necessary nutrients to maintain itself and be able to reproduce. If an essential material approaches a critical minimum, this material will be the limiting factor (Odum, 1971). Phosphorus (P) is often the nutrient that is limiting in aquatic ecosystems. However, a number of highly eutrophic lakes in eastern South Dakota are known to develop nitrogen (N) limitation.

In order to determine which nutrient will tend to be limiting, Wetzel (1983) has suggested a N to P ratio of 10:1. If the ratio is greater than 10:1 the lake is assumed to be phosphorus limited. If the ratio is less than 10:1 the lake is assumed to be nitrogen limited. The further the calculated ratios are from 10:1, the more confident the analyst is in the conclusion.

Appendix F shows the nitrogen-phosphorus (N/P) ratios for Swan Lake during 1991. The graph indicates considerable temporal and spatial variability exists in the relative abundance of nitrogen and phosphorus over a yearly cycle.

Annual mean ratios were 11.7:1 at sites 6-7, and 10.47:1 at site 8 (Table 28). Therefore over an annual cycle Swan Lake would be considered a lake with a slight tendency toward phosphorus limitation. Considering the large algal populations present in

Swan Lake, and the shading effect exerted by water turbidity, it is doubtful whether either nitrogen or phosphorus limitation plays an important role in limiting planktonic algal growth or diversity in this highly eutrophic waterbody.

Trophic State Index

The Trophic State Index (TSI) is an index which can be used to measure the relative eutrophic state of a water body. Carlson's Index was used to measure the trophic status of both phosphorus and secchi disk. In the Carlson Index, TSI levels 65 and above are considered hypereutrophic. Swan Lake exceeds the hypereutrophic level using both phosphorus and secchi disk in the calculation. February 11, 1991, Swan Lake's TSI level was below 65. The influx of relatively clean springwater is the most probable cause for the low TSI levels. The mean TSI for phosphorus on sites #6-#7, and #8 were 74.5 and 80.29 respectively (Table 28).

Chlorophyll a

Chlorophyll a samples were collected, filtered and frozen during June, July, and August of 1991. These three samples will be analyzed in the winter of 1992. Once analysis is complete, the information will be added to the Lake Assessment document which is updated annually or available upon request. Information available will be Carlson's TSI using chlorophyll a concentrations in mg/m^3, and as a qualification of phytoplankton standing crop (Lind, 1985).

Sediment Sampling

An in-lake sediment and water samples (elutriate sample) were taken on March 14, 1990. The main reason for the sample is to test to see if sediment removal would cause any health problems or add contaminates to the area where the sediments spoils are placed. The sample was sent to the Corp of Engineers Laboratory in Omaha, Nebraska. The sample set consisted of a sediment sample and a receiving water sample. The two samples were tested, then mixed, agitated, and tested again (elutriate water).

In the Swan Lake sample, nutrient data was taken from the water and the elutriate and not from the sediment. However assumptions can be made about the nutrient content in the sediment because of increases in concentrations from the water sample to the mixed elutriate. The nutrients which were tested were: 1) ammonia-N, 2) nitrate + nitrite-N, 3) total kjeldahl-N, and 4) total phosphorus. From the data, it can be assumed that the sediments are holding more nutrients then are being released. The sediment appears to release ammonia-N from the bacteria decomposing organic material, kjeldahl-N which could be organic material not yet decomposed, and phosphorus which sorbs on to sediments and may not be available to plants until released by low oxygen levels. The shallow nature of Swan Lake keeps oxygen levels well mixed throughout the water column so oxygen depletion at the sediment water interface is a very infrequent occurrence. The only nutrient parameter which decreased in the elutriate sample was nitrate+nitrite-N. A probable reason for the decrease in concentration is that the nitrate+nitrite-N was reduced to ammonia-N or that the amount of sediment diluted the soluble nitrate+nitrite to where the concentrations dropped.

The information on toxins and metals is the main reason for the elutriate sample. After mixing the sediment with the water no toxic levels or concentrations of metals increased compared to the receiving water sample (Appendix G). The results indicate that the sediment does not appear to contain any high concentrations of contaminated material.

Sediment Survey

As stated earlier Swan Lake has a shallow mean depth of 1.4 meters (4.5 feet). A major concern of the local residents/users is that the shallow depth has restricted many beneficial uses. Although local residents claim the lake was 20 feet deep and had a gravel bottom, no accurate measurements could be found. To quantify the amount sediment in the lake for removal if the dredging option was selected, a sediment survey was conducted.

In the fall of 1990 a contract was signed with Bernhard, Eisenbraun and Associates (B&E) of Yankton, South Dakota, to conduct a sediment survey of Swan Lake. The contractor used echo-sonic sounding of two different frequencies to acquire the elevation of the top and bottom of the sediment layers. The echo-sonic soundings were taken at 50 foot intervals across the entire lake. From the sediment depths of the cross-sections, an estimate of the amount of sediment was calculated.

From the sediment survey it was found that Swan Lake was never extremely deep. The origin of the sedimentation is probably from a number of sources. One definite source is the inlet through Turkey Ridge Creek. Also, the elevation difference between Turkey Ridge Creek and Swan Lake is relatively flat. In past years water has flooded over into the lake. The lake association recently raised the road between the creek and the lake to stop the spring or summer storm floods from rising over the banks and into the lake. Sedimentation may have also occurred from erosion of shorelines around the lake. Wind and wave action has moved the lake sediment to where the bottom is relatively flat leaving no evidence to where heaviest loads of sediment have occurred.

The deepest potential depth found by the echo-sonic sounding was 4.26 meters (14 feet). The potential average depth of the lake was estimated at 2.5 meters (8 to 9 feet). The total amount of sediment calculated was estimated at 1.3 million cubic yards. A map of the top and the bottom sediment elevations along with the B&E contract is included in Appendix H or upon request from this Department.

Quality Control/Quality Assurance

The quality control/quality assurance (QA/QC) monitoring program approved by EPA was followed as closely as possible. Three different QA/QC samples were to be taken: 1) Field Duplicate, 2) Blank (distilled water), and 3) Phosphorus Spike. Because the spike solution arrived near the end of the sampling season only two were taken. A total of 83 water samples were taken during the sampling season along with 6 QA/QC sample sets (Table 29).

Large concentrations of dissolved phosphorus were found during our first samplings in the blank QA/QC sample set. To correct the problem the State Health Lab stopped adding acid (preservative) to the bottle. The liner in the dissolved phosphorus bottle was being eaten away by the acid causing the higher concentrations. Also the distilled water on certain

Table 33. QUALITY ASSURANCE/QUALITY CONTROL FOR SWAN LAKE

-- BLANK --

DATE	TIME	SITE	SAMP	DEPTH	WTEMP C	ATEMP C	FPH su	FECA /100ml	LABPH su	TALKAL mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	VOLATILE SOLIDS mg/l	NON VOLATILE SOLIDS mg/l	AMMON mg/l	UNIONIZED AMMONIA mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4P mg/l	TOTAL DISS. PO4 mg/l
15-Apr-91	1115	4B	GRAB	SURFACE	18.4	9.4	7.8	2	8.48	3	5	-2	7	5	2	0.02	0.00044	0.1	0.13	0.02	0.031
24-Apr-91	1330	7B	GRAB	SURFACE	15.6	22	6.7	2	7.56	3	9	-7	16	4	12	0.02	0.00003	0.1	0.01	0.008	0.027
16-Jul-91	1045	7B	GRAB	SURFACE	26	29	8.3	10	8.17	6.2	13	9	4	0	4	0.02	0.00217	0.5	0.34	0.272	0.295
12-Aug-91	1150	3B	GRAB	SURFACE	20	24	8.5	2	8	4.8	14	-2	16	12	4	0.02	0.00223	0.7	0.1	0.251	0.326
11-Sep-91	1130	7B	GRAB	SURFACE	22.2	24		10	8.16	7.4	5	3	2			0.02	0.00126	0.1	0.1	0.007	0.268
07-Apr-92	1145	7B	GRAB	SURFACE	15.5	17		2	7.64	9	3	3	0			0.02	0.00025	0.1	0.1	0.005	0.005

-- FIELD DUPLICATE --

DATE	TIME	SITE	SAMP	DEPTH	WTEMP C	ATEMP C	FPH su	FECA /100ml	LABPH su	TALKAL mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	VOLATILE SOLIDS mg/l	NON VOLATILE SOLIDS mg/l	AMMON mg/l	UNIONIZED AMMON mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4P mg/l	TOTAL DISS. PO4 mg/l
15-Apr-91	1115	4D	GRAB	SURFACE	10	9.4	7.7	40	8.03	235	1511	1477	34	12	22	0.02	0.00019	0.1	0.52	0.102	0.041
15-Apr-91	1115	4	GRAB	SURFACE	10	9.4	7.7	34	8	243	1512	1468	44	22	22	0.02	0.00019	0.01	0.58	0.102	0.034
24-Apr-91	1045	7D	GRAB	SURFACE	12	11	7.6	2	8.13	123	2394	2374	20	10	10	0.02	0.00017	0.1	1.54	0.129	0.02
24-Apr-91	1045	7	GRAB	SURFACE	12	11	7.6	2	8.44	124	2388	2350	38	6	32	0.02	0.00017	0.1	1.51	0.153	0.041
16-Jul-91	830	7D	GRAB	SURFACE	26	29	8.3	10	8.15	128	2328	2278	50	2	48	0.09	0.00977	0.6	1.64	0.2	0.068
16-Jul-91	830	7	GRAB	SURFACE	26	29	8.3	10	8.2	127	2342	2288	54	10	44	0.09	0.00977	0.6	1.5	0.19	0.075
12-Aug-91	1050	3D	GRAB	SURFACE	21	26	8.1	150	7.95	176	1930	1836	94	26	66	0.02	0.00102	1	0.74	0.274	0.066
12-Aug-91	1050	3	GRAB	SURFACE	21	26	8.1	140	7.84	171	1909	1829	80	24	56	0.04	0.00204	1	1.06	0.234	0.071
11-Sep-91	900	7D	GRAB	SURFACE	21	20		10	8.42	112	2602	2570	32			0.08	0.00606	0.1	1.78	0.132	0.034
11-Sep-91	900	7	GRAB	SURFACE	21	20		30	8.44	108	2618	2582	36			0.21	0.02211	0.1	1.73	0.122	0.024
07-Apr-92	830	7D	GRAB	SURFACE	11	9	7.8	4	8.28	131	2174	2142	32			0.02	0.00025	0.1	1.32	0.096	0.007
07-Apr-92	830	7	GRAB	SURFACE	11	9	7.8	4	8.28	130	2179	2143	36			0.02	0.00025	0.1	1.22	0.123	0.013

-- PHOSPHORUS SPIKE --

DATE	TIME	SITE	SAMP	DEPTH	TPO4P mg/l	DIFFERENCE mg/l
12-Aug-91	1050	3S	GRAB	SURFACE	0.422	0.171
12-Aug-91	1050	3	GRAB	SURFACE	0.251	
11-Sep-91	1155	7S	GRAB	SURFACE	0.259	0.137
11-Sep-91	1155	7	GRAB	SURFACE	0.122	

Underlined concentrations have exceeded the EPA holding time.

occasions became contaminated such as the blank samples taken July 16, 1991 and August 12, 1991.

The duplicate samples were very similar to the "original" samples. The majority of the samples were well within 80% of the QA/QC samples taken. There were occasions when one or more of the parameters sent to the lab exceeded the EPA holding time before the tests could be run. The numbers which are bold and italicized on Table 32 are parameters for which EPA holding times were exceeded. Even when these holding were exceeded, the QA/QC assured samples taken where acceptable.

CONCLUSIONS

Until 1914, Swan Lake was a small 180 acre natural glacial lake with approximately 1,038 acres of watershed. In 1914 a channel was excavated from Turkey Ridge Creek to Swan Lake to assist in maintaining consistent water levels in Swan Lake. The resulting watershed increased from about 1,000 acres to approximately 81,600 acres. A corrugated steel dam was placed downstream of the inlet to ensure creek flow into the lake. The elevation of the inlet to Swan Lake is below both the steel dam and the lake outlet. The dam allows first flushes of run-off to flow in the lake before going over the steel dam. The low inlet permits water to leave the lake from the inlet if the lake elevation rises high enough.

A sediment basin located between the inlet channel and the lake has filled-in and no longer effectively removes sediment from the water before it enters Swan Lake. There are control structures located on the inlet before and after the sediment basin. The first structure, at the head of the basin, cannot be closed and needs to be repaired. The second structure is a stop log system which does hold back water as long as it doesn't flow over the top board.

Two major problems lie in the present gate system. In the winter, groundwater, which flows from aquifers in the Turkey Ridge Creek watershed, recharges the lake. The gates are opened in the fall as the springs begin flowing when there is less demand on the aquifer's water. The water flows throughout the winter and brings the lake level to that of the outlet. The first problem occurs in the spring when the gates should be closed off. Ice forms around the gate structures preventing the gates from being closed. This allows all of the spring runoff to flow into the lake. The second problem arises any time the lake level becomes low. Local citizens open the gate on their own volition in an attempt to fill the lake. When spring and summer storms arrive the sediment and nutrient laden runoff flows directly into Swan Lake.

Presently the 81,600 acre watershed is approximately 77% cropland and 14% pasture. Along with the large percentages of agricultural land use in the drainage, there is an estimated 16 feedlots directly on Turkey Ridge Creek, and another 16 3/4 mile off the creek's main channel. That does not include other feedlots located on tributaries off the main channel of Turkey Ridge Creek. The high agricultural use of the watershed creates a potential for nutrient and sediment loadings to the lake.

A sediment survey completed under contract for the Swan Lake project, shows approximately 1.3 million cubic yards of sediment in the lake. The present depth averages approximately 4 feet.

If all the sediment was removed, the average depth would be approximately 9 to 10 feet. There are a number of possibilities which may have caused the sedimentation of Swan Lake. Three of the most likely causes are 1) erosion from the watershed entering the lake, 2) floods which have passed over the land separating the lake and Turkey Ridge Creek, and 3) in-lake shoreline erosion. At least 50 percent of the shoreline has been riprapped. There are still some areas which need and should be stabilized.

The water quality of the creek varies greatly depending on whether the water is from runoff events or from ground water. Higher nutrient and sediment loads are typical of the runoff events. The water discharged from the ground water is relatively low in nutrients and suspended solids.

The water quality in the lake is typical for lakes in the region. Two things make Swan Lake different from the "typical" south eastern South Dakota lake. One is that the lake's dissolved solid concentrations are among the highest in the state (Lake Assessment, 1989). The second is that Swan Lake also has high chlorophyll levels but no algal species which typically produce floating mat blooms. The turbidity in Swan Lake is also very high, blocking sunlight and preventing growth of macrophytes.

Since the lake is recharged annually by groundwater from springs in the watershed, the lake level in the spring usually rises to the outlet level. Eliminating the high nutrient spring runoff events from the lake would greatly reduce the nutrient problems from Turkey Ridge Creek. If sediment could be kept from entering the lake and shorelines stabilized, removal of existing sediment would conceivably provide long-term benefits to the lake as a natural resource.

Future water quality monitoring can be based on the same basic sampling plan as used in the Phase I study, with only minor changes in the tributary sample locations.

Changes in the monitoring plan should be contingent on the objective of the monitoring. If the objective is to measure changes in the lake alone, then many of the tributary sites could be eliminated. To sample Swan Lake only, three tributary sites, along with the same in-lake and outlet sites would be needed.

To calculate the hydrologic budget, site 3 should be moved and located at the junction of Turkey Ridge Creek and Highway 18, between sections 9 and 4 in T97, R53, Latitude $43^{o}14"33.5'$, Longitude $97^{o}07"1.5'$. This site would replace the current site 3 which experienced flow and gaging problems, and data could be gathered to document the water flowing through Turkey Ridge Creek from the watershed. Site 9, located at the dam downstream of inlet channel, was added to this Phase I when site 3 proved no longer functional. This site would be used to calculate the amount of water passing over the dam. The differences in site 3 and site 9 should be what is entering the lake minus evaporation, transpiration, and losses to groundwater, thus eliminating the current site 4. The other possible way to measure the flow into the lake from Turkey Ridge Creek is by recording discharge at site 4 with a flow meter, during every run-off event in addition to flows three times a week. Averages would have to be calculated to find the discharge on days when flows are not taken. The flow meter data, collected at the inlet would be more accurate than calculating the differences from site 3 to site 9, as long as frequent and accurate measurements were taken.

In addition, a site should be place on the tributary entering the south west bay. The significance of this site is to document the water quality entering the lake from the "natural watershed". There are also tiles located in the south west bay which should be sampled to see if more intense monitoring is required. These changes in the monitoring program would allow for a more accurate in-lake hydrologic budget.

If both the watershed and the lake are to be studied, all of the changes made to study the in-lake sites listed above should be included. The only other change would be to add one more site on Turkey Ridge Creek as close to the head waters as possible. This site would give you background data on the water quality before it passes through any of the watershed. The data could also be compared to the quality of the spring water which enters the lake in the winter.

RESTORATION ALTERNATIVES

There are many ways to correct problems in watersheds and increase recreational benefits in lakes. However, every lake has different problems so not all restoration alternatives can be considered viable corrective measures. The alternatives considered for restoration of the Turkey Ridge Creek watershed and Swan Lake have been chosen because of their effectiveness, cost, and their ability to be accomplished. The alternatives include the following:

1. No action
2. Construct retention dams
3. Dig dugouts and wells
4. Plant Buffer strips
5. Promote the Conservation Reserve Program
6. Build animal waste management systems
7. Build sediment dike
8. Remove rough fish
9. Stabilize shorelines
10. Repair control structures on the inlet
11. Rebuild control structure
12. Build new dam down stream of the inlet channel
13. Remove sediment
14. Conduct information and education programs
15. Develop a Sanitary District

No Action

The "No action" alternative consists of no changes to the lake or the adjacent watershed. Since the natural succession of a prairie lake is from an aquatic to terrestrial state, the lake will continue to deteriorate. The lake may lose more depth and result in increased fish kills. Traditional lake recreation may be increasingly impaired and aesthetic beauty may be lost. A result of the degradation may be a drop in the assessed property values around the lake, resulting in a reduced tax base.

Construct Retention Dams

Building retention dams in the drainage ways of Turkey Ridge Creek would retard water flow. As the water slows, sediment drops out of the water column. The major benefits would be less suspended solids downstream of the structure. Although cattle may still use the creek for watering, nutrient levels may still decrease. However, the decrease would be minimal. Currently, the U.S. Fish and Wildlife Service has developed a program to install small sediment structures which can also be used for waterfowl habitat.

Dig Dugouts and Wells

A source of both sediment and nutrient loadings are cattle with direct access to streams. Impacts come from direct input of animal waste and stream bank degradation from hoof action. Dugouts or wells for watering placed away from streams could prevent this from happening. This alternative needs to include grazing management systems to work effectively. Private contractors would be needed to drill wells and may also assist in the design of the dugouts. Designs should be prepared so the dam or well could be low maintenance so the idea will be more palatable for farmers. Benefits, as stated earlier, would be lower sediment and nutrient loads when cattle are in the water.

Plant Buffer Strips

Buffer strips consist of vegetation planted between the river and an erosion or nutrient source. A buffer strip will help filter out suspended solids and may trap and use nutrients which otherwise would end up in a tributary or lake.

Promote Conservation Reserve Program

The Conservation Reserve Program (CRP) is managed by the U.S. Dept. of Agriculture. The program pays farmers a contracted amount per acre to plant a selected field to natural prairie vegetation. The most benefit from this alternative would be from CRP contract fields located in highly erosive and riparian areas. The vegetation would remove sediment from the water column, eliminate erosion, and provide habitat for wildlife.

Build Animal Waste Management Systems

Animal Waste Management Systems (AWMS) are used to eliminate feedlot runoff from entering drainage areas. A usual system consists of first routing as much clean water away from the feedlot as possible. Two different types of holding ponds may be built, 1) an evaporation pond which doesn't have to be cleaned out but takes a large surface area and 2) a storage pond, which covers a smaller surface area and is pumped out and applied to cropland at appropriate times by the land owner.

Large nutrient loadings have been attributed to feedlots. The benefits of AWMS can be significant although the costs can be a deterrent. A small AWMS can cost from $8,000 to $12,000, while large systems can range up to $70,000.

Build Sediment Dike

A sediment dike constructed on the north and east side of Swan Lake would assist in keeping Turkey Ridge Creek from flowing over land and into the lake. Flood waters carry large amounts of sediment and may be responsible for much of the lakes sedimentation. The township road on the north and the east side of the lake was raised after the last flood. To assess if a dike is needed a qualified consultant will have to be contacted. If construction of a dike is needed an easement would have to be obtained from the landowner before construction begins.

Remove Rough Fish

Rough fish can cause turbidity in the lake and also take up much of the forage base which could be used by more desirable game fish. Several alternatives are available for rough fish control. Killing all the fish in the lake is one avenue which could be pursued. The chemical, rotenone, is usually used to eliminate all the fish in a lake. In some cases, killing off a whole lake is an excellent choice for lake restoration. Swan Lake however is utilized by many local fishermen. The two years it would take to repopulate the lake is unacceptable to local fishermen. Test nets do show that rough fish are the most prevalent species in Swan Lake but there are fair numbers of game fish in the lake. Because of the Turkey Ridge Creek connection, rough fish could enter the lake as soon as the inlet was opened.

Removal of rough fish by commercial netting could also be considered. The SD GF&P test nets lakes for rough fish. If the rough fish population is significant, a contract is signed with a private company to remove a recommended amount of fish, under the supervision of SD GF&P. This alternative would allow the SD GF&P to remove only rough fish and keep the population of more desired species intact.

Stabilize Shorelines

Sedimentation from collapsing banks can be significant. Bank stabilization usually consists of placing riprap or rock gabions along cut banks to prevent shorelines from slumping into the lake. The local lake association has already acquired the proper permits and riprapped much of the shoreline. Design and cost estimates would have to be obtained from a qualified consultant for additional shoreline work.

Repair Control Structures on the Inlet

Both structures in the inlet channel to Swan Lake could be corrected. The existing concrete structure with a wheel operated metal gate cannot be completely closed. Frequent blockage by rock and sediment prevent the gate from holding runoff waters out of the inlet. The sediment basin between the inlet channel and the lake holds and traps these nutrient-rich waters and flushes them into the lake when the stop-boards are raised. The stop-board structure between the sediment basin and lake also needs repair. Boards which are to prevent runoff waters from entering the lake are taken out by local people when the lake level is lower than desired. A more secure system should be placed at the inlet so nutrient rich water can be withheld from entering the lake.

Rebuild Control Structures

A new control structure could be built at the mouth of the inlet channel to Swan Lake. The secured structure should have a feature which would allow it to be closed in late winter when ice may line the channel. Such a structure would allow more control on what and when water should enter the lake. A pipe should run directly from the creek to the lake which would eliminate the sediment basin. The pipe would eliminate the nutrients which are trapped in the basin and those nutrients delivered from the livestock now using the sediment basin as a watering hole.

Build a New Dam Downstream of the Inlet Channel

At the present time, a four foot sheet piling dam raises the level of Turkey Ridge Creek high enough so Turkey Ridge Creek can flow into Swan Lake. Not only has the dam held back water but it has also acted as a sediment basin. Sediment has filled Turkey Ridge Creek to the top of the dam. Because the water cannot be flushed passed the dam, the sediment held back by the dam enters the lake. The dam needs to be constructed with a control allowing base flow and run-off events to pass downstream. When the groundwater springs start to run in the fall the gate should be left open to allow Turkey Ridge Creek to "clean itself out". Once clear water flows down the creek the gate can be closed and the cleaner water routed into the lake.

Remove In-lake Sediment

If the sediment is removed from lake basin, several improvements will be evident. Fish habitat can be enhanced and the threat of summer and winter fish kills is usually reduced. There can be better control of macrophytes in deeper areas. The water is generally clearer because the deeper depths help keep waves from resuspending solids in the water column.

Both whole lake and selective dredging would be beneficial to the lake. Selective dredging is less expensive and less time consuming than whole lake dredging. Fewer sediment disposal ponds are needed. A negative effect is that not as much nutrient-rich sediment is removed. Suspended solids would still be a problem in the areas not chosen for sediment removal and these areas may have a negative impact on the entire lake.

Whole lake dredging is more expensive but also more effective in the long term. The estimated amount of sediment in Swan Lake is 1.3 million cubic yards (Appendix H). The average cost of a ten-inch dredge for a year, running 2 ten-hour shifts a day, 5 days a week, for 36 weeks is $325,000 plus a one time mobilization cost. A ten-inch dredge will remove an average of 125,000 cubic yards of sediment during the 1987-1990 dredging seasons. The total cost for whole lake dredging is estimated at

$3,250,000 over 10 years and approximately $20,000 for the one-time mobilization cost.

The average cost of a fourteen-inch dredge for a year, running for the same length of time as the ten inch dredge mentioned above, is $425,000 plus one time mobilization cost. In past years the fourteen-inch dredge has moved approximately 500,000 cubic yards of sediment a year. The total cost for whole lake dredging with the fourteen inch dredge is $1,275,000 over 3 years, plus approximately $50,000 for one-time mobilization costs.

Conduct Information and Education Programs

Public education is needed to inform people about lake restoration and of the unique situation of the ground water entering Swan Lake. A properly implemented information and education program can change the way people manage the land and water resources. These changes may result in improvements which will benefit the lake. Without an effort being made to educate the public about why specific restoration activities have been chosen, rumors and bad publicity can result. Public meetings, question and answer sessions, and publications could all be used to inform the public what is being done and why. The Swan Lake Improvement Association, Department of Environment and Natural

Resources, or the Department of Game, Fish and Parks should coordinate these activities to inform the public on all aspects of the project.

Develop a Sanitary District

The formation of a sanitary district would benefit Swan Lake by overseeing the disposal of waste, water and garbage. Taxes levied by the sanitary district could be used to sponsor assessments of the condition of the waste collection facilities around the lake, take enforcement on known polluters to the lake, and implement a central collection system.

RECOMMENDATIONS

Based on the information collected during the course of this study and the evaluation of the historical data, the Water Resource Management Division of the SD DENR recommends the following activities for the improvement of Swan Lake and its watershed in order of priority:

Primary Activities

1) Control structure repair on valve next to Turkey Ridge Creek
2) Dam structure repair down steam of the inlet channel
3) In-lake sediment removal
4) Bank stabilization
5) Sediment dike
6) Buffer strips or CRP in original watershed
7) Rough fish control
8) Sanitary district development

Secondary Activities

9) Animal waste management systems
10) Dugouts and wells

Discussion of Primary Activities

Primary activities are those which have the most direct benefit to the lake. These are the activities which need to be addressed first. It is the policy of the Clean Lakes Program that all sources of lake degradation be addressed before in-lake restoration begins. A major cause of Swan Lake's degradation at this time is sedimentation.

The most direct way to prevent the sediments and nutrients of Turkey Ridge Creek from entering Swan Lake is to eliminate the inlet structure. However, eliminating Turkey Ridge Creek from the Swan Lake hydrologic system would stop the recharge the lake usually receives from groundwater springs in the winter and fall. To keep the groundwater recharge entering the lake, the inlet to Swan Lake should be reconstructed. The structure should be secured and controlled by a single entity agreed upon by the SD DENR, SD GF&P, and the SLIA. The inlet should be managed to allow only high quality water to enter the lake. The inlet should also be constructed as close to the main channel of Turkey Ridge Creek as possible. Building the structure close to the creek would keep the sediment and nutrient laden water from settling in the inlet channel. A direct pipe should be placed between the creek and the lake thus eliminating the sediment basin in the current system. Elimination of the sediment pond would keep cattle, carp, and other animals from adding sediment and nutrients to the sediment basin and eventually the lake.

The dam located downstream of the inlet channel has also created a water quality problem which needs to be addressed. The function the current four foot dam is to raise the water level of Turkey Ridge Creek higher than that of the lake, so it can enter the lake. Within Turkey Ridge Creek, the dam mentioned above, has created a sediment basin between dam and the inlet channel. The sediment level of this area has nearly reached the top of the dam. A control needs to be installed on the dam to flush away the sediment from the inlet and downstream. The expected benefit is that the sediment and nutrient ladened material from the entire watershed will flow by the inlet before it is opened. The result should be cleaner water entering the lake.

As stated in the alternatives, dredging would be very beneficial to Swan Lake. The shallow depths are largely responsible for the lack of water clarity of the lake. Dredging would enhance the uses of the lake. Resuspension of sediment from boat motors and summer winds would be reduced, risk of fish kills would be reduced, and the potential for increasing a hydrologic connection to groundwater would be increased.

On an average year Swan Lake loses approximately 1 meter (41 inches) of water to evaporation each year and only averages (0.6 meters) 24 inches of rainfall. The net loss to evaporation at the present time is 0.43 meters (17 inches) or approximately 30 percent of the total volume of the lake not including what enters from the tributaries. Doubling the depth would make it possible for the lake to sustain the temporary loss by evaporation (15 percent of total water volume) until the fall/winter groundwater inflow would again raise the elevation.

Whole lake dredging would be the most beneficial to Swan Lake. As stated in the alternatives it would be more time efficient and cost effective to secure use of the 14-inch dredge. In three years the entire basin of Swan Lake could be cleaned out and at an estimated cost of 1.325 million dollars. The cost estimated in the alternatives is representative of average costs over the lasts three years of the State owned dredge. Since that time, it has been mandated that the dredges be sold, so costs under different ownership cannot be estimated.

The local share of the entire project at current cost estimations is $320,000, plus a $50,000 mobilization cost. The local sponsor can use either cash or in-kind work to match the state and federal dollars usually required in a dredging project.

Lake shoreline stabilization on cut banks would prevent wave action from further cutting into already degraded shorelines. Shorelines in the southwest bay are most in need of stabilization. In 1978 and 1979, the SLIA acquired a grant for stabilization of the north and east shore and completed the project. Most of the south shore is maintained by local residents who own the land. After the shores in the southwest bay are protected, there will be little chance for further shoreline collapse. Approximately 3,000 feet of shoreline need riprapping at an average vertical of approximately 7 feet. The estimated cost of this project is $30,000.

Although the road between the Turkey Ridge Creek and Swan Lake has been raised, a flood control dike may need to be constructed between Turkey Ridge Creek and Swan Lake would help in preventing flood waters from flowing over the narrow strip of land between the two waterbodies. Because of the volume of overland flow, flood waters usually carry large amounts of nutrients and sediment. The road or dike should be high enough to repel these waters and long enough to force the waters past the lake.

Buffer strips placed along the lake or fields placed in the Conservation Reserve Program (CRP) would settle out some of the suspended solids carried in run-off. Buffer strips also keep lake banks from deteriorating and falling into the lake.

Rough fish can be a significant cause of turbidity and the loss of macrophytes. By controlling rough fish in Swan Lake there may be more macrophyte growth which would add oxygen to the lake, and reduce turbidity, which is desired by locals who use the lake for contact recreation. The most effective method to control rough fish would be removal by commercial means when populations are significant enough. If removal is desired and the number of rough fish is not large enough to make it feasible for the private entity, an incentive payment could be instituted to ensure the rough fish would be removed. Controlling rough fish would be a maintenance restoration alternative and would require constant monitoring of rough fish populations with cooperation from the SD GF&P.

A final primary recommendation is that the Swan Lake Improvement Association develop a sanitary district which could oversee an extensive inventory of the waste and water disposal systems of the cabins around the lake. Because of the number of homes around the relatively small lake, septic waste disposal systems could be a source of nutrient loadings to the lake. A sanitary district would be responsible for the correction of waste disposal problems. From taxes levied on the home owners, the sanitary district could build a complete and contained disposal system which would eliminate failing waste water systems and also the eliminate the possibility of leaching of nutrients from properly constructed systems.

Discussion of Secondary Recommendations

The secondary recommendations are given because of considerable water quality problems in the Turkey Ridge Creek watershed.

Controlling feedlot runoff in any watershed can greatly improve water quality. Tributary sample data revealed large fecal coliform counts. The large counts of fecal coliform occurred during runoff events which would point to feedlots and possibly grazing near riparian areas as the most probable source. The information gathered during the study showed 16 feedlots of various sizes adjacent to the main channel of Turkey Ridge Creek. Sixteen other feedlots were counted within 3/4 of a mile of the main channel. No feedlot information was gathered in the tributaries running into the Turkey Ridge Creek. It is the recommendation of the DENR that a feedlot inventory be conducted and ranked according to the Feedlot Model developed by Dr. Young at the Agriculture Research Institute in Morris Minnesota. Once this is completed, the feedlots which are shown to have the highest potential for nutrient loads should be addressed. The SCS has been utilized in past projects to design feedlot systems.

Dugouts and wells placed away from the streams would also be instrumental in the stabilizing tributary stream banks. Another benefit of dugouts and wells is that cattle, which normally water in tributaries, would not stir up sediments, assist in bank erosion, or add nutrients directly to the waterways through their waste.

ENVIRONMENTAL EVALUATION

Displacement of People

Should a dredging program be initiated for Swan Lake, the needed dredge spoil disposal ponds would be located on farmland some distance away from any lakeside development. Existing roads would be used for access. Any new roadways required will be short and constructed on non-residential land. Therefore, a proposed dredging or any other recommendations would not displace any people from residences or places of business.

Defacement of Residential Areas

The initial "setting-up" and launching of a hydraulic dredge in Swan Lake may involve limited disruption of the land in the path of the launch. Work on the shorelines and the inlet structure will also take place away from residential areas. These disturbances will take place away from lakeside residential acreages and should be minor, temporary and easily repaired.

Settling and temporarily storing dredged lake sediment may initially require a number of dredge spoil ponds. The size of the ponds varies but the total will probably not exceed 40 acres. Some land disruption will occur during construction of the ponds but this will take place on farmland and will not affect aesthetic values or native plant and animal life. When completed, low-lying berms (dikes) of the ponds will not obstruct the local landscape. The ponds are relatively unobtrusive after their construction site have been policed and the slopes of berms grassed. In any case, the ponds are temporary constructions whose dikes are to be leveled and the sites reverted to farmland approximately two years after the completion of the dredging project.

Changes in Land Use Patterns

No major land use changes are anticipated as a result of this project. There is considerable lakeside development on Swan Lake at the present time and little remaining lakeshore acreage is available for construction. The primary benefits of the project will be increased lake use, particularly from boating, fishing, and swimming, which will give a boost to the local economy.

Impacts on Prime Agricultural Land

The sites of the dredge spoil ponds will be on agricultural land. It is estimated a maximum of 15 hectares (40 acres) of farmland may temporarily be taken out of production for two to four years as the project continues. After dredging is completed, the collected lake sediment will be allowed to settle for one year before it is ready for reclamation and cultivation.

Other work to benefit the lake will have no change on prime agricultural land.

Impacts on Parkland, other Public Land, and Scenic Resources

The Swan Lake restoration project will have no impact on local parkland, other public land, or scenic resources.

Impacts on Historic, Architectural, Archaeological, or Cultural Resources

The possible sites for the ponds have been farmed for many years and so are unlikely to contain significant historic or archaeological artifacts. The other restoration recommendations will have little excavation. However, the possibility exists that such artifacts may in fact be present. Therefore, before the design phase of the project has begun, an archaeological investigation will be conducted on the project site. The design phase will not proceed until clearance has been granted. In the event that archaeological or historical resources are uncovered, the sites will be shown on maps and other alternative sites will be considered or mitigation measured discussed.

Long Range Increases in Energy Demand

Restoration alternatives proposed for Swan Lake do not involve aeration, pumping, maintenance dredging, harvesting, chemical treatments, or any other alternatives which may cause increases in energy demand over a period of time.

Changes in Ambient Air Quality or Noise Levels

Minor short-term air pollution (blowing dust) may occur during some of the restoration project. Insignificant short-term air pollution will be produced by the hydraulic dredge exhaust. Air quality problems on site can be minimized through various construction management measures. Soil erosion (wind and water) on the construction site can be minimized with Best Management Practices (BMP's).

A change in the local noise level due to a dredging project will probably be noticeable during the launching of the dredge and particularly during construction of the spoil ponds. The increase in noise caused by construction machinery will be temporary (short-term) and not excessive since most of the construction activities will take place some distance away from lakeshore residences. The hydraulic dredge produces relatively moderate engine noise during normal operation. There have been very few noise complaints by residents in past dredging projects even those conducted at relatively close quarters in the smaller waterbodies.

Adverse Effects of Chemical Treatment

There are no plans for the use of in-lake chemical treatment in Swan Lake at this time.

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APPENDIX A - Monitoring Wells (Location and Graphs)

MONITORING WELL LOCATIONS

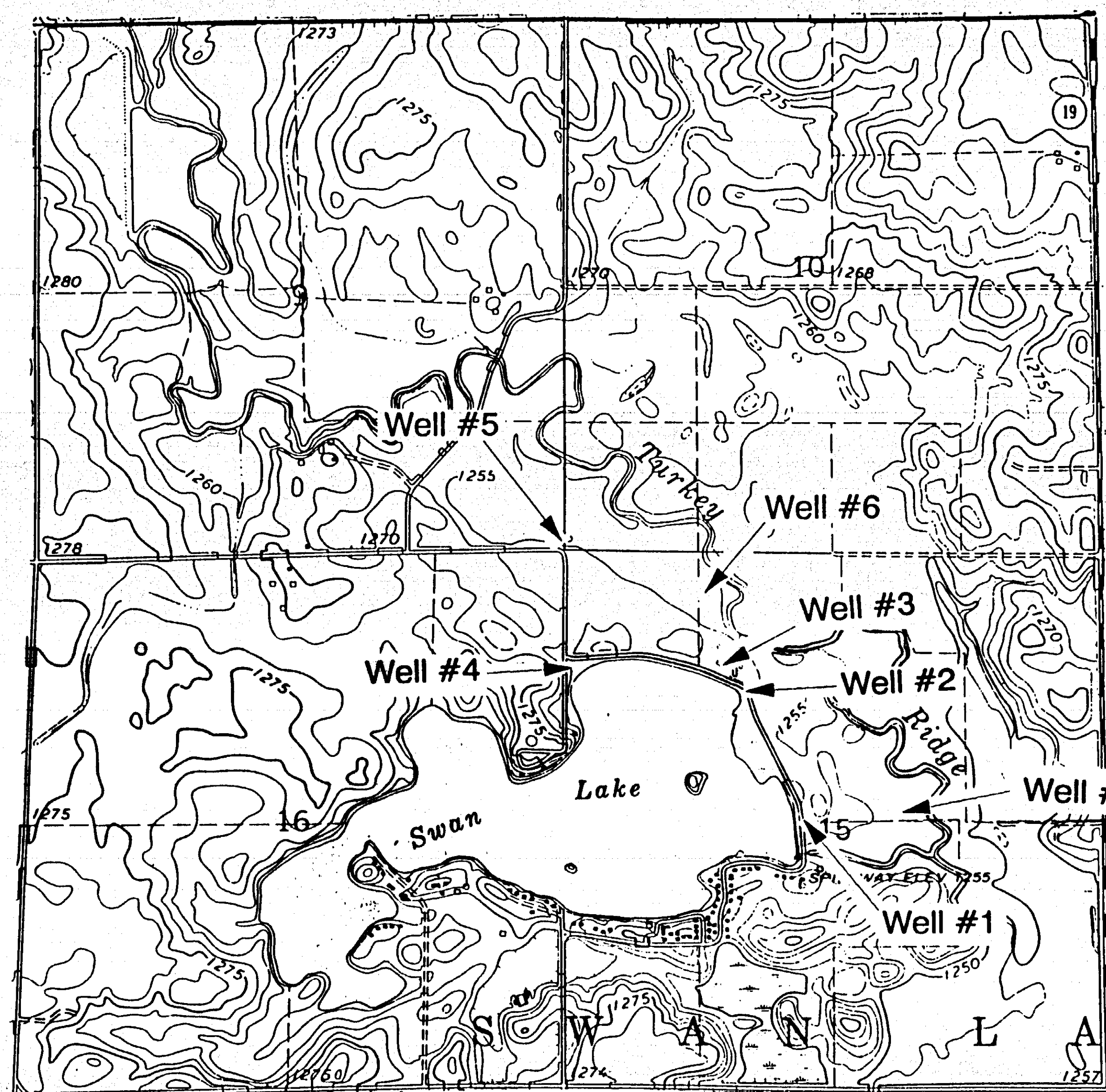


Figure A-1. Monitoring Well Locations

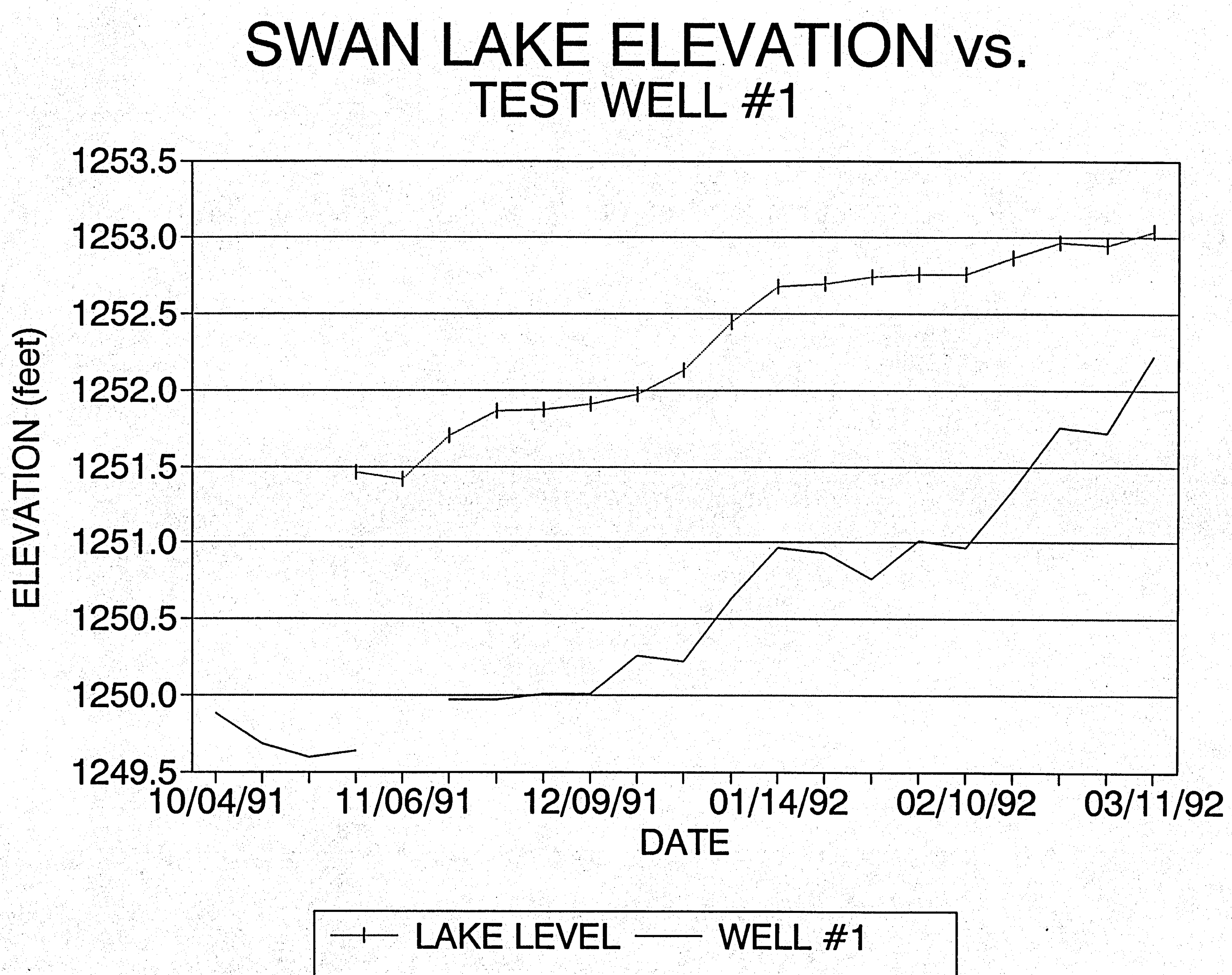


Figure A-2. Test Well #1 Elevations.

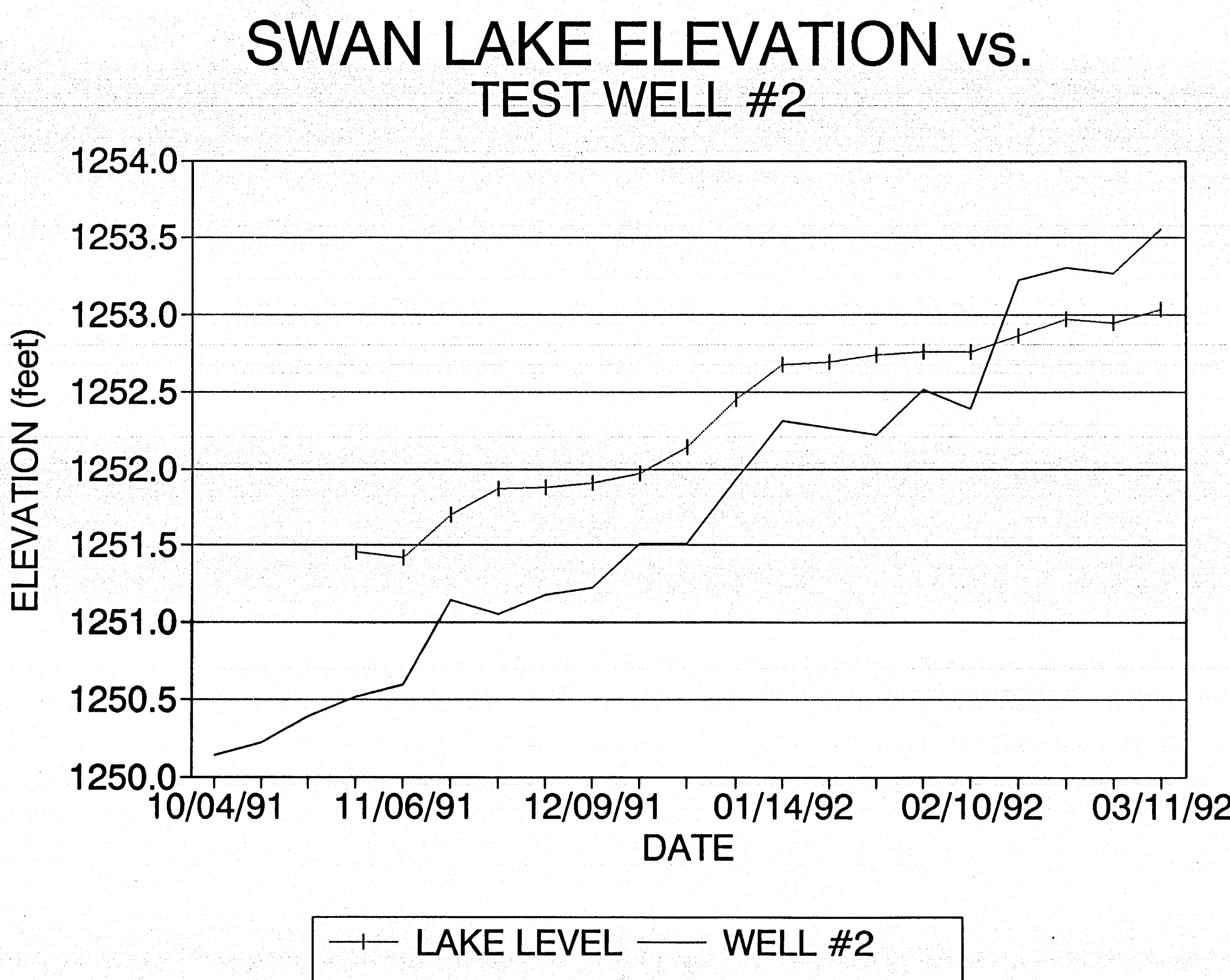


Figure A-3. Test Well #2 Elevations.

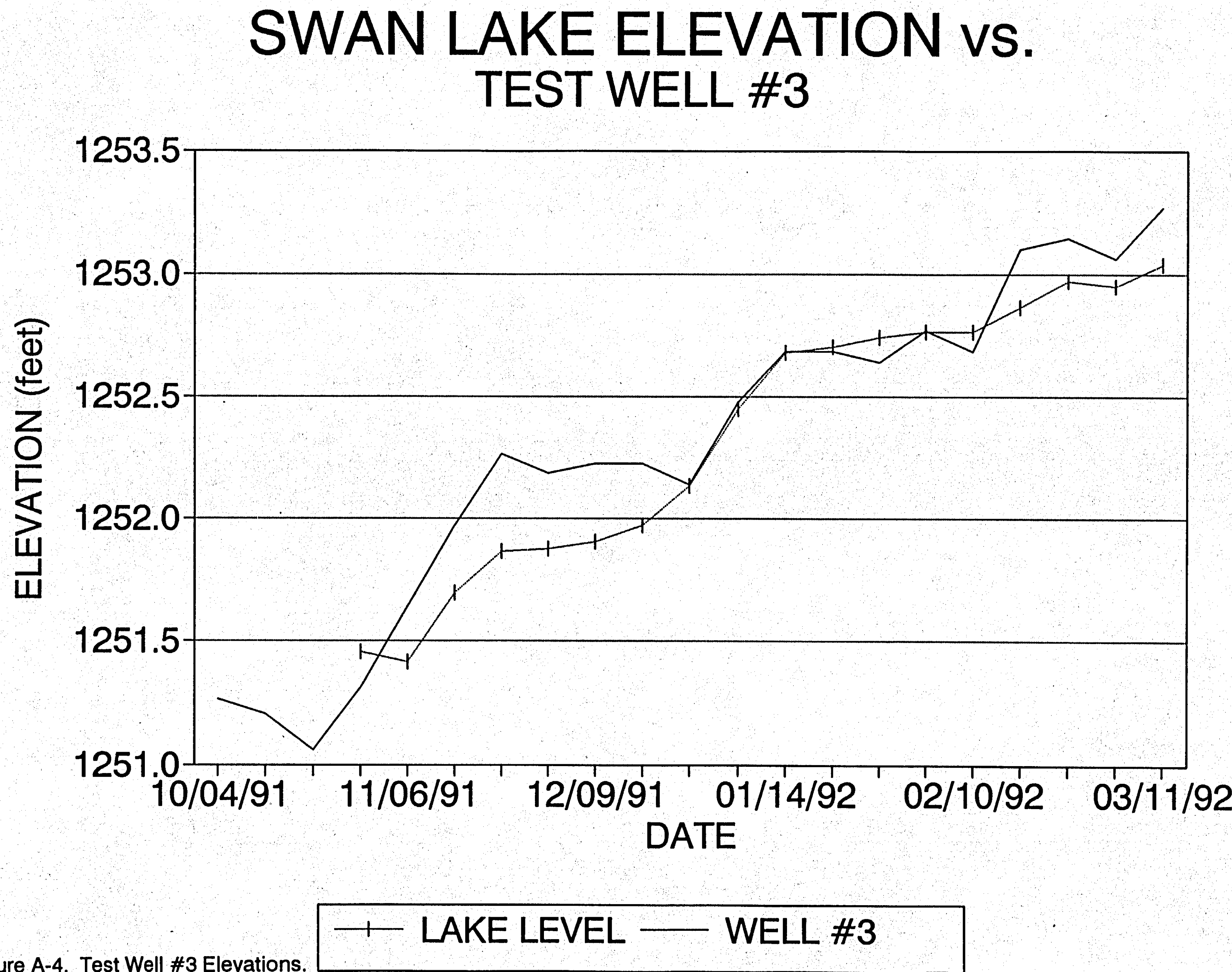


Figure A-4. Test Well #3 Elevations.

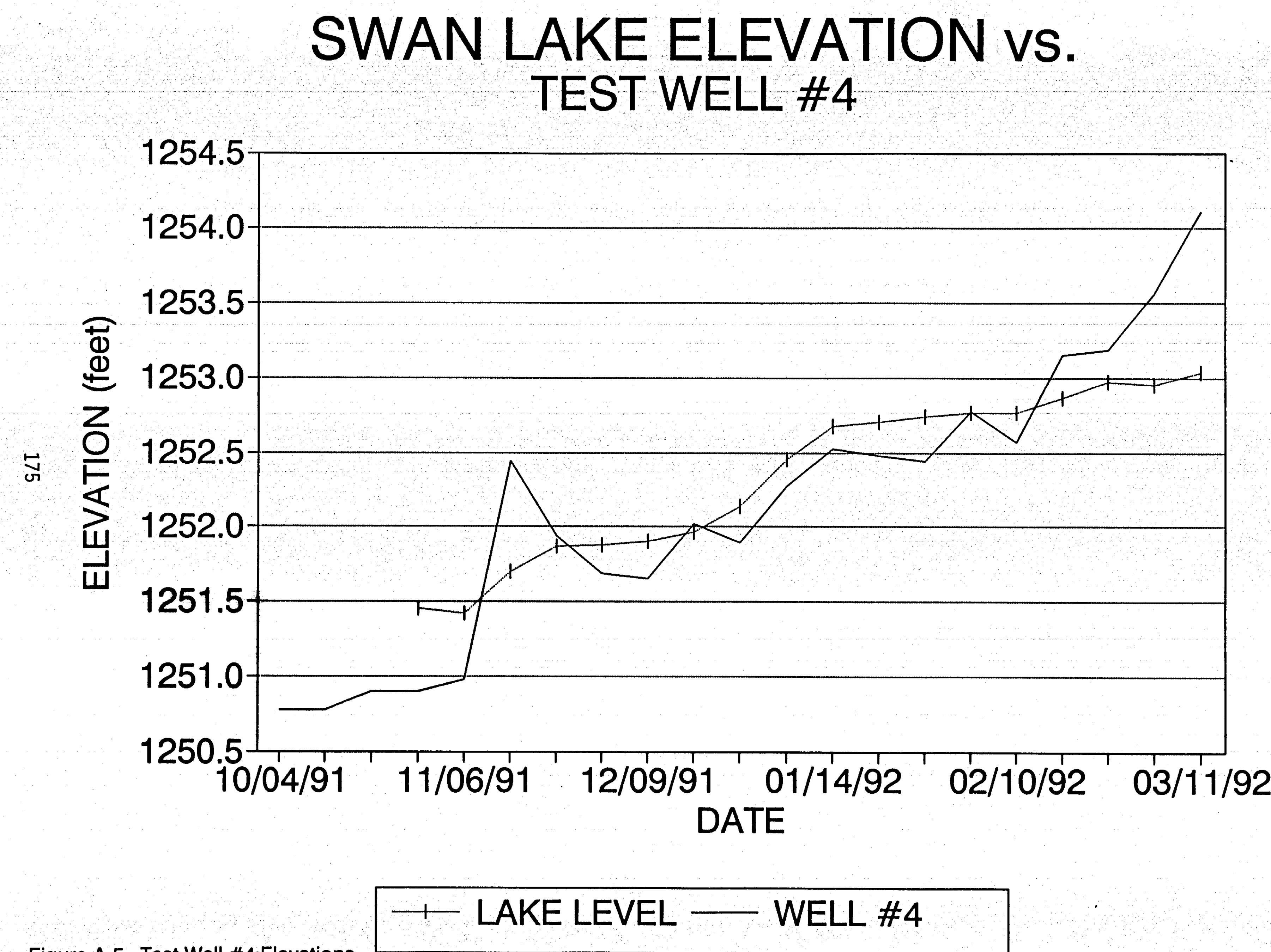


Figure A-5. Test Well #4 Elevations.

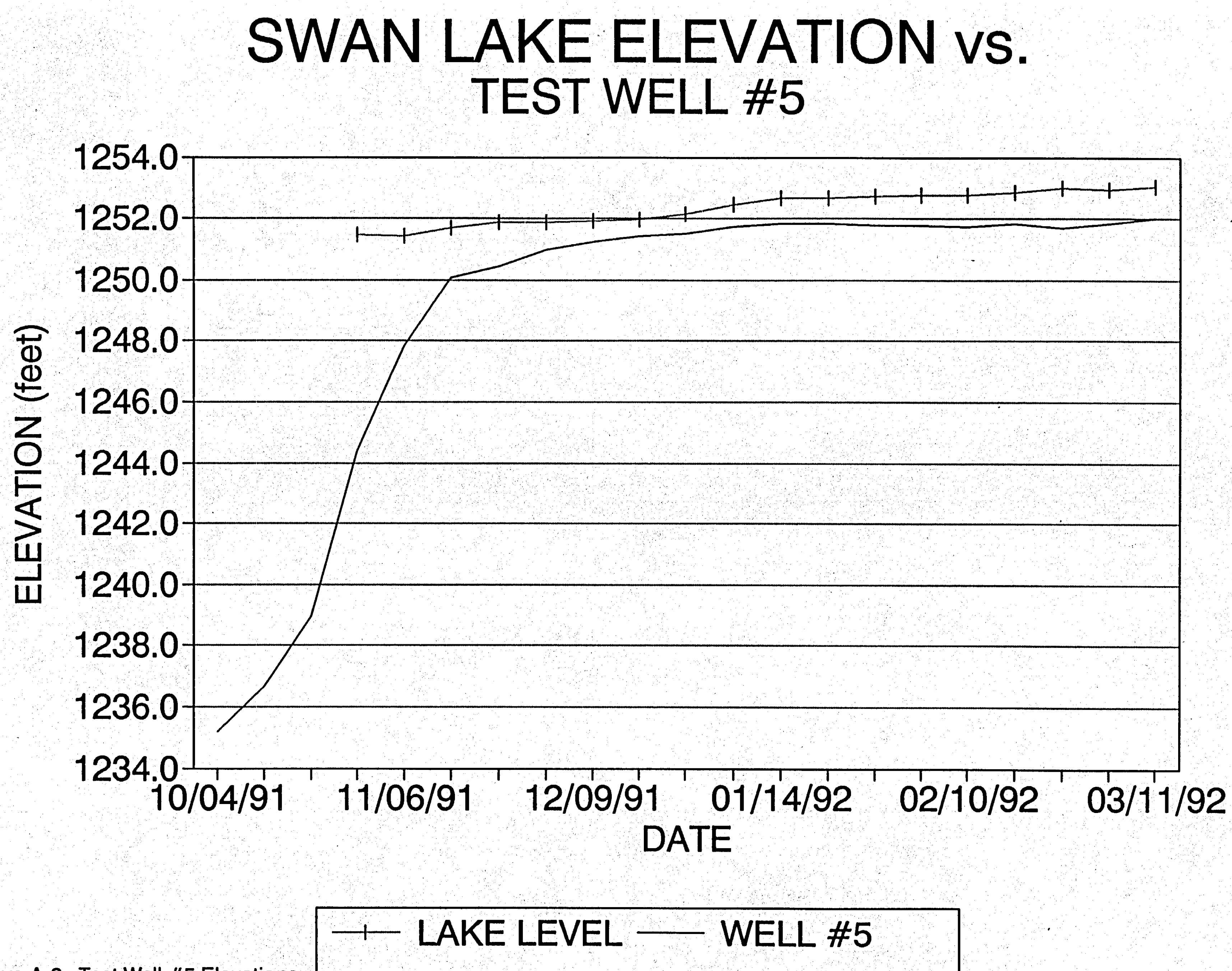


Figure A-6. Test Well #5 Elevations.

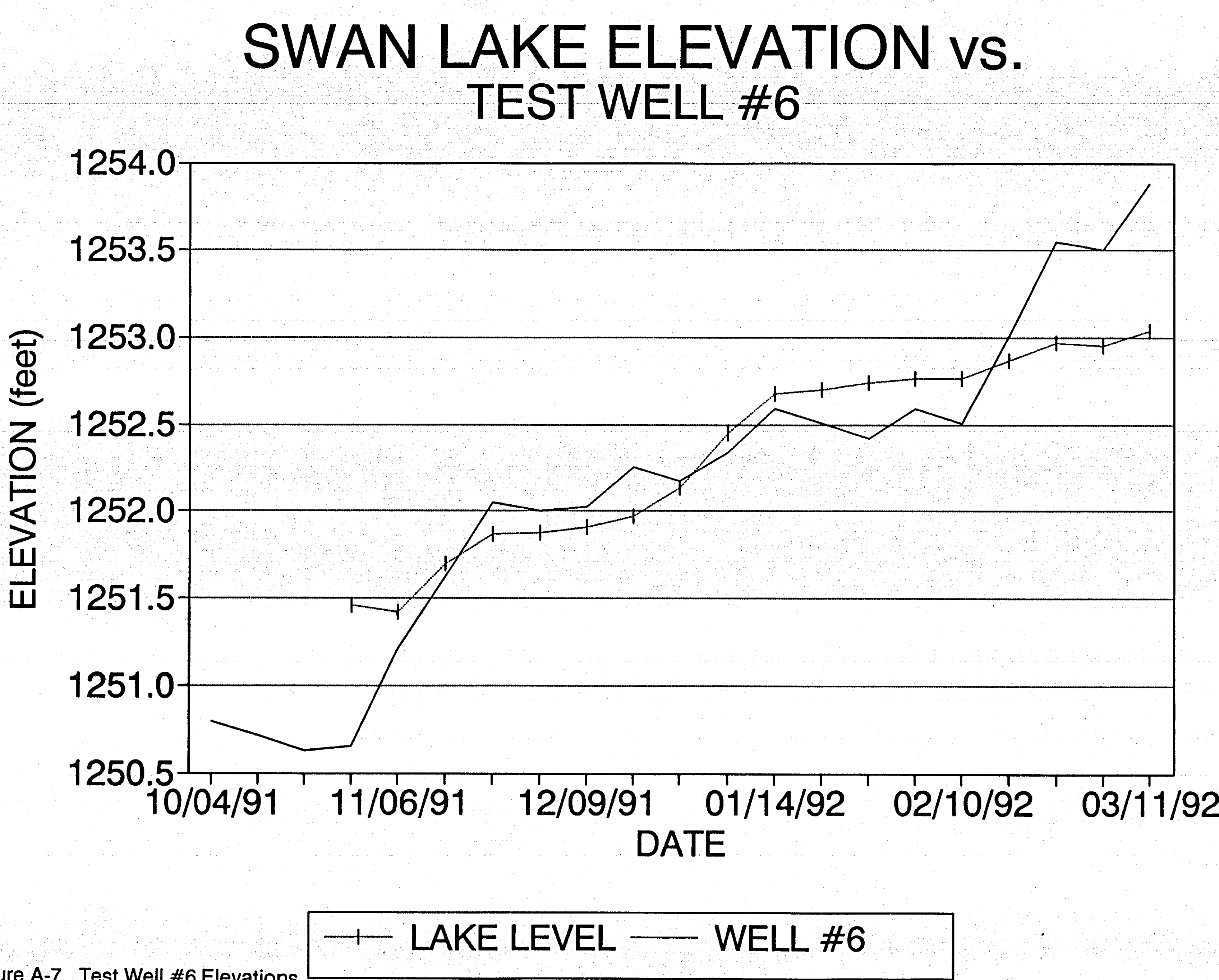


Figure A-7. Test Well #6 Elevations.

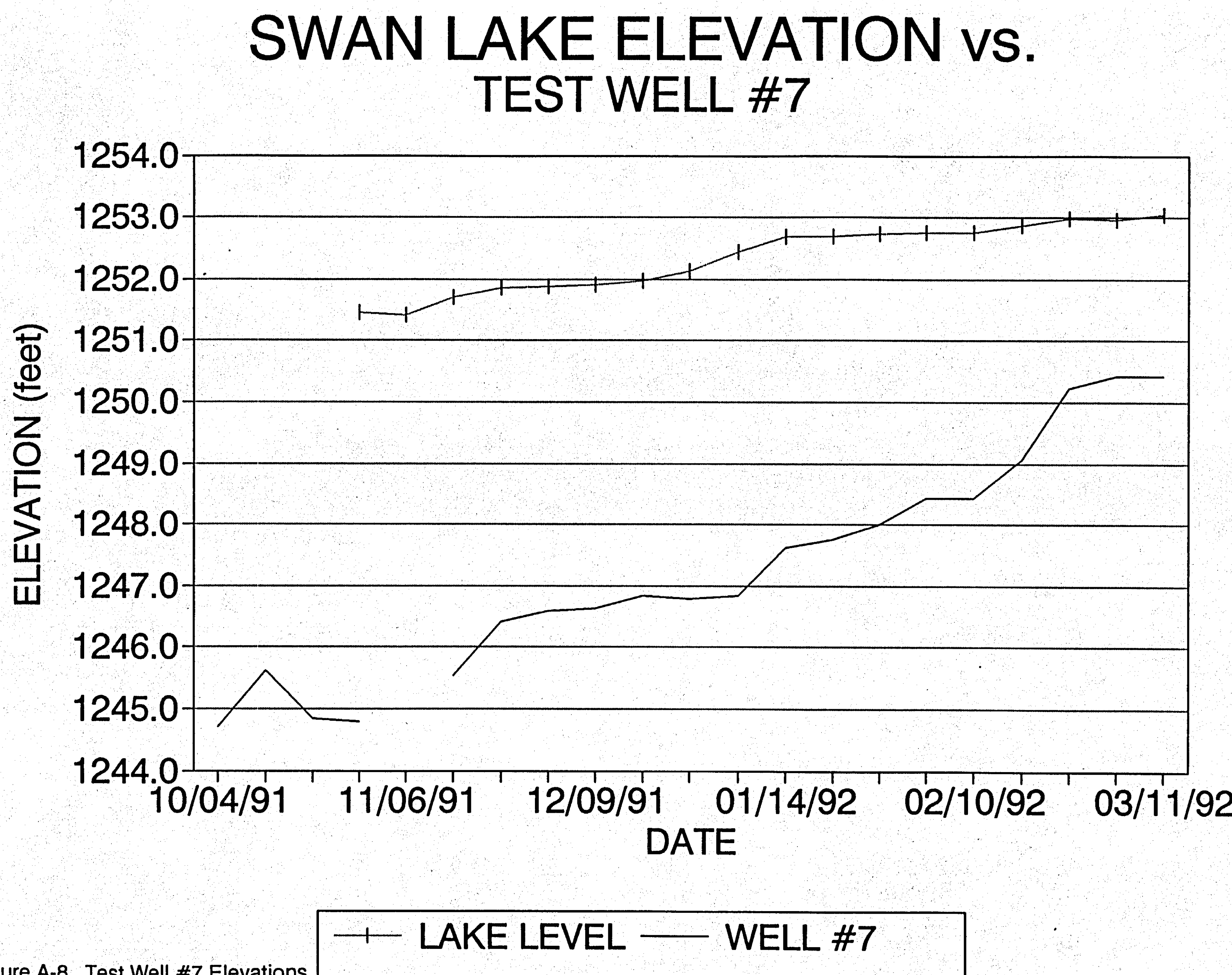


Figure A-8. Test Well #7 Elevations.

APPENDIX B - Soils Associations in the Swan Lake Watershed

Egan-Ethan association - 25%

The Egan-Ethan association is located in southwestern part of the watershed. It is found in upland areas with slopes ranging from 0 to 25 percent. In Turner County the Egan soils make up 50 percent, the Ethan soils-30 percent, and minor soils the remaining 20 percent. The Egan soils are fairly level soils with the surface a dark gray silt clay loam. The subsoil is dark grayish brown, brown, and grayish brown silty clay loam and clay loam. The underlying material is light yellowish brown, mottled, calcareous clay loam. The Ethan soils are found on knolls and upper side slopes. Typically the surface is dark grayish brown loam. The next layer is light brownish gray clay loam. And the underlying material is light gray and pale yellow, mottled clay loam, and calcareous throughout. About 80 percent of the association is used for cropland. The steeper slopes support native grasses and are used for grazing. For crops the major concerns are controlling erosion, conserving moisture, and improving fertility (Soil Conservation Service, 1982).

Clarno-Bonilla association - 19.5%

The Clarno-Bonilla association is located in the upper central part of the watershed. This associations makes up 50 percent of the watershed and is usually found on uplands characterized by many low moist or marshy areas. In Turner County the association consists of about 60 percent Clarno soils, 20 percent Bonilla soils, and 20 percent minor soils. Generally the Clarno soils are on the upland areas and the Bonilla soils are usually located in swales and are subject to flooding. The surface of Clarno soils is typically dark grayish brown loam. The color continues into the subsoil but may also be grayish brown and light grayish brown loam. The underlying material is light yellowish brown, and light gray, mottled, calcareous clay loam. The surface of the Bonilla soils is typically very dark clay loam. The subsoil is dark gray, grayish brown, and light brownish gray gray clay loam. The underlying material is light brownish gray, light yellowish brown, and light gray, mottled, calcareous clay loam. About 90 percent of the association is cropland and in level areas these soils can be used for almost any purpose. In the steeper slopes erosion and conserving moisture are the main concerns (Soil Survey of Turner County, 1982).

Clarno-Ethan association - 17%

The Clarno-Ethan association is located on the northwest side of the watershed. Its slopes are predominately 2 to 25 percent but do range down to 0 percent slope. The surface of Clarno soils is typically dark grayish brown loam. The color continues into the subsoil but may also be grayish brown and light grayish brown loam. The underlying material is light yellowish brown, and light gray, mottled, calcareous clay loam. The Ethan soils are found on the knolls and upper side slopes. Typically the surface is dark grayish brown loam. The next layer is light brownish gray clay loam. And the underlying material is light gray and pale yellow, mottled clay loam. The soils are calcareous throughout. Eighty percent of the association is cropland. The steeper slopes are used for grazing. As in the association mentioned above controlling erosion, conserving moisture, and improving fertility are the major concerns (Soil Conservation Service, 1982).

Clamo-Lamo association - 15.1%

This association is located adjacent to Turkey Ridge Creek, basically it is found in flood plains and has a slope of 0 to 2 percent. This association is about 35 percent Clamo, 25 percent Lamo, and 40 percent other minor soils. The poorly drained Clamo soils are in the low parts of the flood plains. The surface is typically very dark silty clay. The subsurface is dark gray silty clay and silty clay loam. The lower part of the subsurface is calcareous. The underlying layer is gray and light olive gray, mottled, calcareous silty clay loam. The Lamo soils are higher in the flood plain than the Clamo soils. The surface is very dark gray silty clay which continues into the subsurface. The underlying material is light brownish gray and gray, mottled silty loam and also has accumulations of gypsum. The soils are calcareous throughout. Seventy-five percent of the Clamo-Lamo association is cropland. Controlling wetness is the major concern in these soils. Preparing the soil for seeding and improving root penetration is also a concern (Soil Conservation Service, 1982).

Egan-Trent - 12.7%

The Egan-Trent association covers the fifth largest surface area. It is mainly located in the southeastern part of the watershed. This is another upland association, however the slopes only range from 0 to 6 percent. About 60 percent of the association is made up of Egan soils, 15 percent is Trent soils, and the remaining 25 percent are various other soils. The Egan soils are generally found on the higher ground of the landscape. The surface is usually a dark gray silt clay loam. The subsoil is dark grayish brown, brown, and grayish brown silty clay loam and clay loam. The underlying material is light yellowish brown, mottled, calcareous clay loam. The moderately drained, nearly level Trent soils are in swales and subject to flooding. The surface is usually dark gray silty clay loam. The subsoil is very dark grayish brown, grayish brown, and light brownish gray, mottled silty clay loam. It is calcareous in the lower part. The underlying material is light gray, mottled, calcareous silty clay loam. About 90 percent of the association is cropped. In the nearly level areas, these soils have few limitations. In the undulating areas, controlling erosion is a major concern. Conserving moisture is also a concern for the Egan-Trent association (Soil Conservation Service, 1982).

Egan-Worthing association - 5.5%

The 2000 acres in the southwestern part of the watershed are characterized by uplands with many depressions. Slopes are usually short and convex, ranging from 0 to 9 percent. The association is made up of about 45 percent Egan, 15 percent Worthing, and 40 percent other minor soils. The Egan soils are on well drained, nearly level to gently rolling areas. The surface is usually a dark gray silt clay loam. The subsoil is dark grayish brown, brown, and grayish brown silty clay loam and clay loam. The underlying material is light yellowish brown, mottled, calcareous clay loam. The poorly drained, level Worthing soils are in depressions. Typically the surface is very dark, dark grey, and gray silty clay. It is calcareous in the lower part. The underlying material is light gray, mottled, calcareous silty clay loam. About 65 percent of this association is cropland, but most of the Worthing soils are used for grazing or wildlife habitat. As with the other soils controlling erosion and conserving moisture are the main concerns with the Egan soils. Ponding of water is the major concern of the Worthing soils (Soil Conservation Service, 1982).

Wentworth-Chancellor-Wakonda - 2.5%

This association located in the northeastern part of the watershed is on uplands with many drainages terminating in small depressions. The slopes for the Wentworth-Chancellor-Wakonda association range from 0 to 6 percent. The association is made up of about 40 percent Wentworth soils, 25 percent Chancellor soils, 15 percent Wakonda soils, and 20 percent other minor soils. The well drained and moderately well drained, nearly level to undulating Wentworth soils are found on slight rises. The surface layer is very dark gray silty clay loam. The next layer is dark grayish brown, grayish brown, and light brownish gray silty clay loam. It is calcareous and mottled in the lower part. The underlying material is pale yellow and light gray, mottled, calcareous silty clay loam. The Chancellor soils, located in shallow drainages, are poorly drained and are subject to flooding. The surface soil is very dark gray silty clay loam. The subsoil is very dark gray, dark gray, and light brownish gray silty clay and silty clay loam. It too is mottled in the lower part. The bottom layer of material is light yellowish brown and light gray, mottled, calcareous silty clay loam. It may have accumulations of gypsum in the lower part. The moderately well drained Wakonda soils occur intermingled with Wentworth soils above swales and depressions. Typically the surface layer is dark gray silty clay loam. The next layer is dark gray and olive brown silty clay loam. The underlying material is light brownish gray silty clay loam, and pale yellow clay loam. It is mottled and has accumulations of gypsum in the lower part. The soils are calcareous throughout. The association is about 90 percent cropland. The main management concerns are controlling wetness in the Chancellor soils and improving fertility in the Wakonda soils (Soil Conservation Service, 1982).

Clarno-Crossplain-Davison association - 1.2%

The Clarno-Crossplain-Davison association is the smallest association located within the Swan Lake watershed. It covers approximately 2.5 square miles in the upper central part of the watershed. The slopes of this association range from 0 to 6 percent. The Clarno soils which make up 55 percent of the association are typically on slight rises of the landscape. The surface of Clarno soils are typically dark grayish brown loam. The color continues into the subsoil but may also be grayish brown and light grayish brown loam. The underlying material is light yellowish brown, and light gray, mottled, calcareous clay loam. The somewhat poorly drained, nearly level Crossplain soils are in swales and shallow drainages. These soils which can be subject to flooding usually appear as a dark gray clay loam. The subsoil is dark gray, gray, and light brownish gray, mottled clay and clay loam. The underlying material is light brownish gray and light yellowish brown, mottled calcareous clay loam. The moderately drained, gently undulating Davison soils occur as convex areas intermingled with areas of the Clarno soils above swales and depressions. These soils are also known to be wet and appear as a grayish brown loam. The next surface is grayish brown clay loam. The underlying material is light yellowish brown clay loam. It has irregular spots and variations in color and gypsum in the lower part. The Davison soils are calcareous throughout. About 90 percent of this association is cropland. The Clarno soils have few limitations. Controlling wetness on the Crossplain, and improving fertility in the Davison soils are the areas of soil management concern (Soil Conservation Service, 1982).

Hand-Clarno-Davison - 1%

This association is located on the far western edge of the Swan Lake watershed and is glacial plain partly covered by glacial outwash deposits. The association is about 45 percent Hand soils, 25 percent Clarno soils, 15 percent Davison soils, and about 15 percent other minor soils. The Hand soils formed in glacial meltwater deposits. Hand soils are well drained and nearly level to gently rolling. The surface layer is dark grayish brown loam. The subsoil is grayish brown in the upper part and light gray, calcareous loam in the lower part. The underlying material is light yellowish brown and light gray, calcareous silt loam and loam. Clarno soils formed in glacial till. The Clarno soils are also well drained and nearly level. They have a surface layer of dark gray clay loam. The subsoil is dark grayish brown clay loam in the upper part and grayish brown loam in the middle part. The lower part of the subsoil and the underlying material are pale yellow and light yellowish brown, calcareous loam. The Davison soils are in low rises and formed by glacial meltwaters. Davison soils are moderately well drained and nearly level to undulating. The surface layer is grayish brown loam. The underlying material is light yellowish brown loam and silty loam at a depth of 37 inches. Below that, layers are pale yellow fine to very fine sandy loam. The soils are calcareous throughout. Runoff is slow to medium depending on the slope. The soils have a medium fertility. The high content of lime in the Davison soils makes them susceptible to blowing. The main management concerns are controlling erosion in the undulating areas of the association, control of blowing especially in the Davison soils, and maintaining fertility (Soil Conservation Service, 1978).

APPENDIX C - Inlet Control Structures and Dam

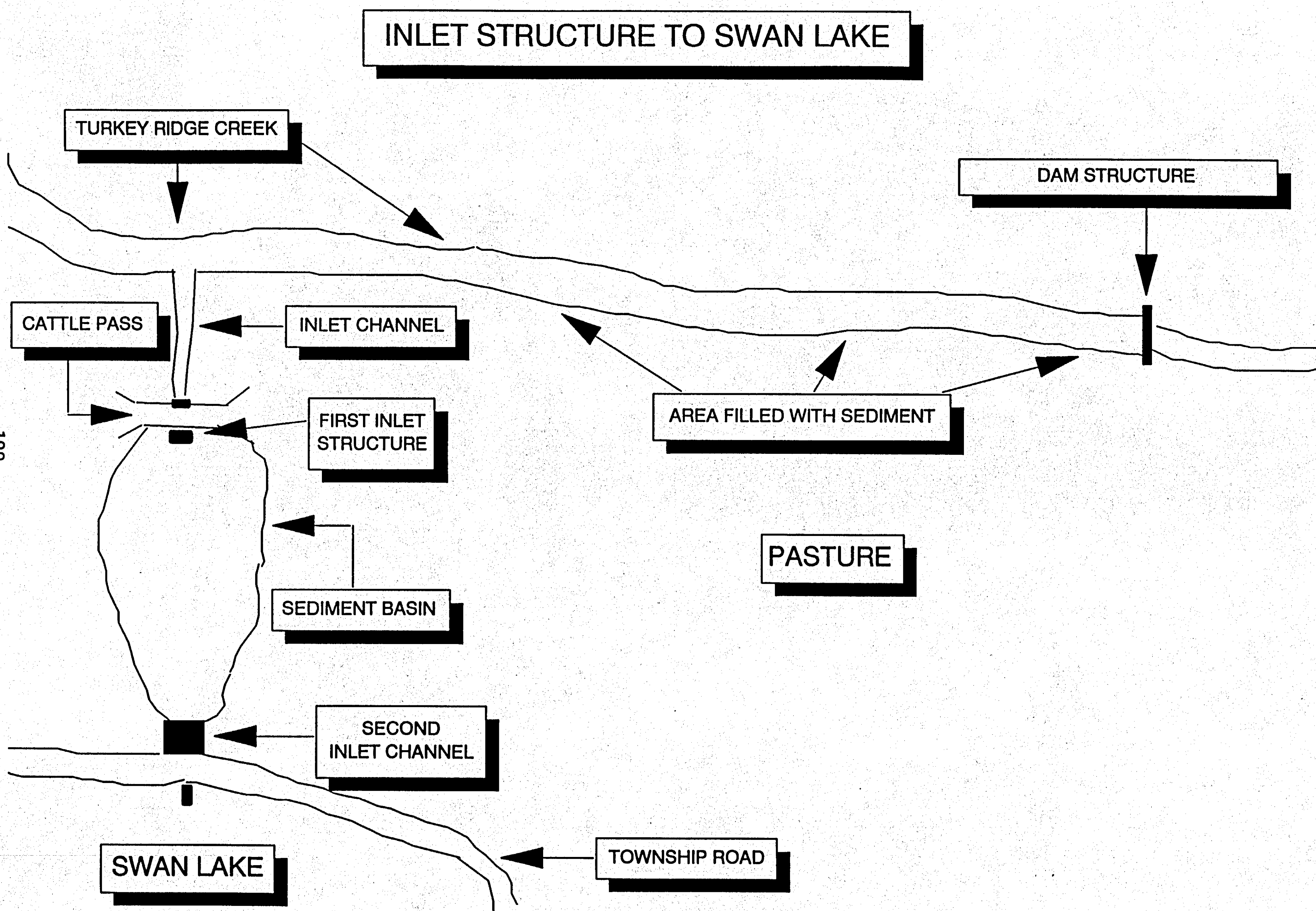
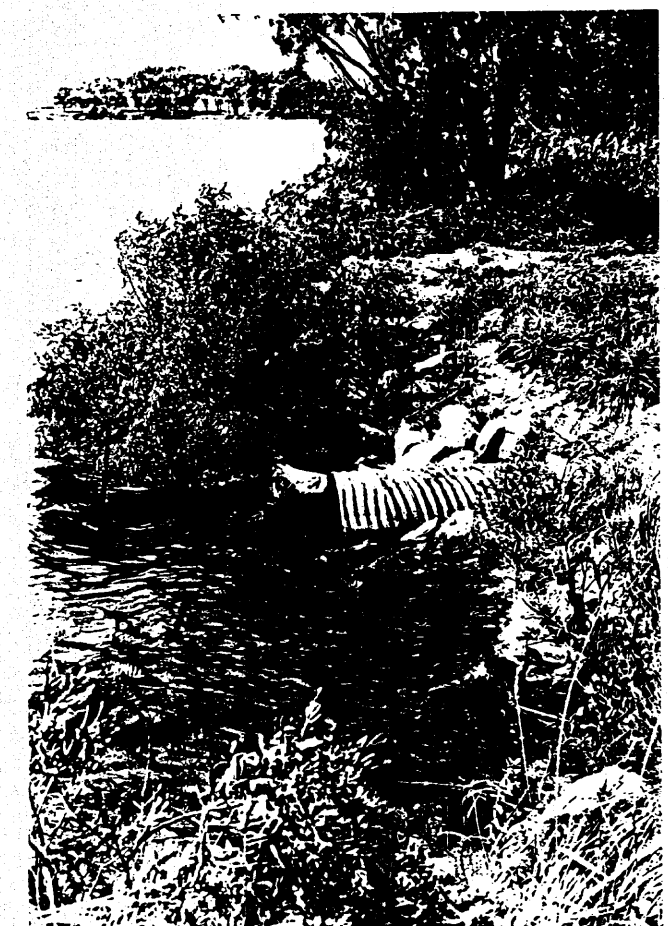


Figure C-1. Swan Lake Inlet Structures.

Figure C-2. Inlet Culvert to Swan Lake



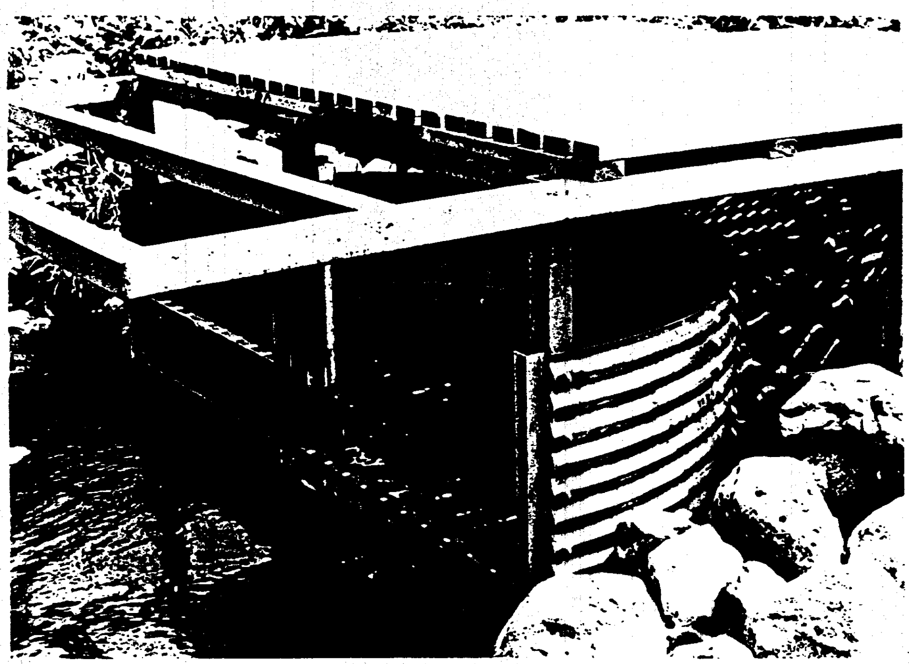


Figure C-3. Second Control Structure Before the Inlet to Swan Lake.

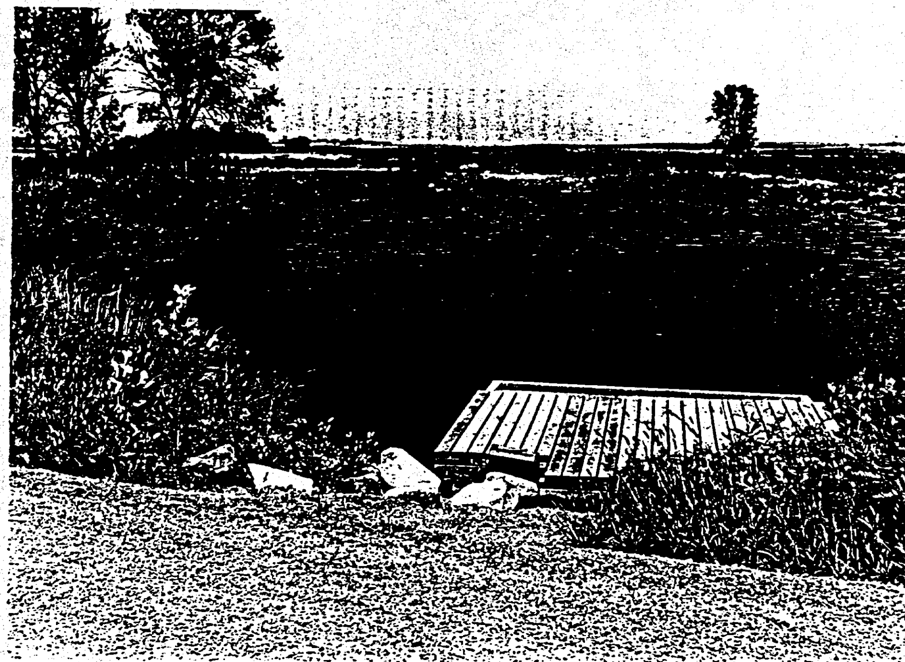


Figure C-4. Sediment Basin Between Turkey Ridge Creek and Swan Lake.

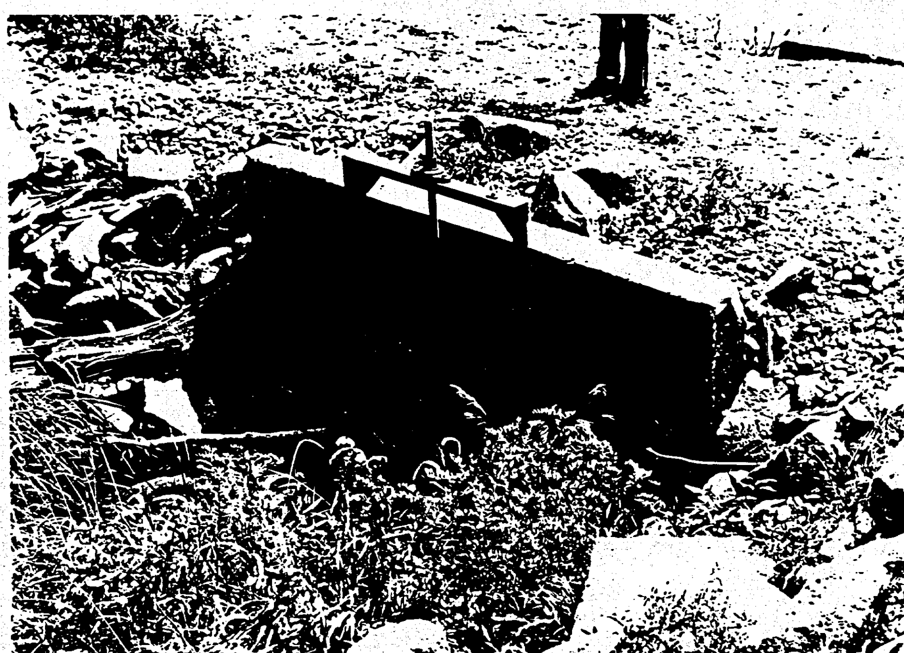


Figure C-5. Control Structure Before the Sedimetn Basin.

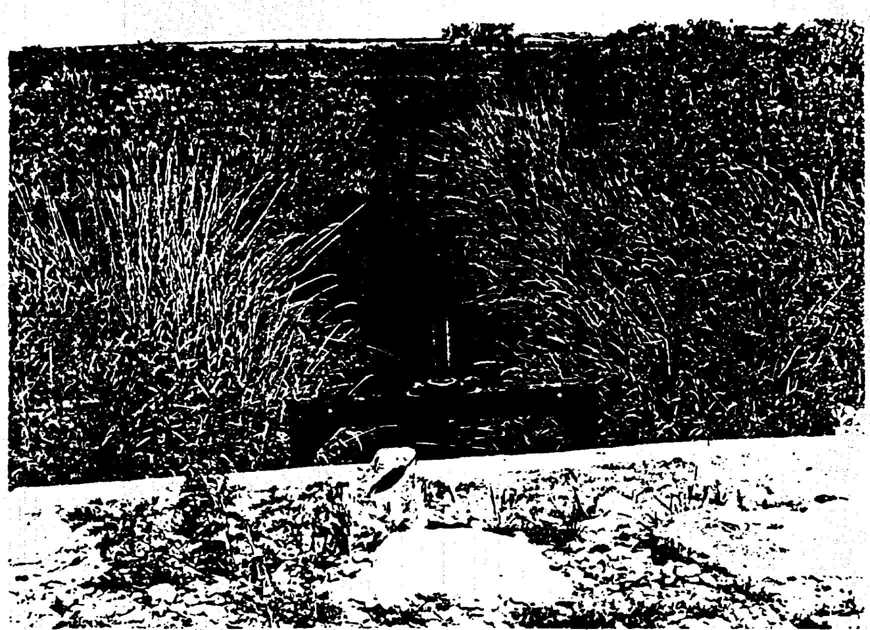


Figure C-6. Inlet Channel From Turkey Ridge Creek.

Figure C-7. Turkey Ridge Creek between the Inlet Channel and Dam.

Figure C-8. Dam Structure Downstream from the Inlet Channel.

APPENDIX D - Tributary Sample Concentrations

Table D-1. Tributary Samples

SURFACE/GRAB SAMPLES FOR SWAN LAKE TRIBUTARIES

SITE # 1

DATE	TIME	SITE	SAMP	DEPTH	WTEMP C	ATEMP C	FPH UNITS	FECAL /100 ml	LABPH UNITS	TALKAL mg/L	TSOL mg/L	TDSOL mg/L	TSSOL mg/L	VOLATILE SOLIDS mg/L	FIXED SOLIDS mg/L	AMMON mg/L	UNIONIZED AMMONIA mg/L	NO3+2 mg/L	TKN-N mg/L	TPO4P mg/L	TOTAL DISS. PO4P mg/L
06-Mar-91	1235	1	GRAB	SURFACE	1.4	(3.9)	7.8	28		252	1,222	1,220	2	2	0	0.12	0.0007	0.9	0.51	0.115	0.108
25-Mar-91	1100	1	GRAB	SURFACE	0.7	17.8	8.0	2	7.85	313	1,465	1,463	2	2	0	0.03	0.0003	0.1	0.51	0.095	0.068
15-Apr-91	1045	1	GRAB	SURFACE	7.5	7.2	7.7	60	8.04	314	1,554	1,524	30	20	10	0.02	0.0002	0.1	0.46	0.102	0.056
29-Apr-91	1030	1	GRAB	SURFACE	9.5	8.3	7.4	170	7.85	290	1,430	1,406	22	6	16	0.02	0.0001	0.1	0.43	0.115	0.061
04-May-91	900	1	GRAB	SURFACE	6.5	5.5	7.5		7.89	287	1,523	1,503	20	18	2	0.02	0.0001	0.1	0.27	0.153	0.102
13-Jun-91	900	1	GRAB	SURFACE	21.0	22.0	7.8	3,800	7.84	306	1,439	1,393	46	10	36	0.12	0.0032	0.7	1.24	0.295	0.183
08-Jul-91	945	1	GRAB	SURFACE	20.0	23.0	8.0	1,100	7.92	301	1,356	1,296	60	16	44	0.15	0.0057	0.6	0.77	0.275	0.180
12-Aug-91	945	1	GRAB	SURFACE	18.0	21.1	8.1	290	7.9	340	1,617	1,581	36	4	32	0.11	0.0046	0.8	0.23	0.180	0.129
15-Oct-91	1000	1	GRAB	SURFACE	3.0	6.7		570	8.01	47	1,589	1,549	40	10	30	0.02	0.0000	0.1	0.43	0.108	0.068
16-Dec-91	1100	1	GRAB	SURFACE	2.0	0.0		50	7.95	372	1,678	1,673	5	4	1	0.02	0.0000	0.7	0.4	0.106	0.100
25-Mar-92	1015	1	GRAB	SURFACE	5.5	7.0	8.3	2	8.1	281	1,543	1,538	5	0	5	0.02	0.0005	0.1	0.49	0.050	0.043
			MEAN ------>		8.6	10.2	7.8	607	7.94	282	1,492	1,468	24	8	16	0.06	0.0014	0.39	0.52	0.145	0.100
			MAXIMUM --->		21.0	23.0	8.3	3,800	8.10	372	1,678	1,673	60	20	44	0.15	0.0057	0.90	1.24	0.295	0.180
			MINIMUM --->		0.7	(3.9)	7.4	2	7.84	47	1,222	1,220	2	0	0	0.02	0.0000	0.10	0.23	0.050	0.043

SITE # 2

DATE	TIME	SITE	SAMP	DEPTH	WTEMP C	ATEMP C	FPH UNITS	FECAL /100 ml	LABPH UNTIS	TALKAL mg/L	TSOL mg/L	TDSOL mg/L	TSSOL mg/L	VOLATILE SOLIDS mg/L	FIXED SOLIDS mg/L	AMMON mg/L	UNIONIZED AMMONIA mg/L	NO3+2 mg/L	TKN-N mg/L	TPO4P mg/L	TOTAL DISS. PO4P mg/L
06-Mar-91	1330	2	GRAB	SURFACE	1.0	(1.1)	8.0	2		205	1,055	1,049	6	6	0	0.02	0.00018	0.20	0.35	0.061	0.020
25-Mar-91	1100	2	GRAB	SURFACE	7.0	18.3	8.0	10	7.78	271	1,480	1,478	2	1	1	0.03	0.00043	0.10	0.56	0.108	0.054
15-Apr-91	1120	2	GRAB	SURFACE	9.0	9.4	7.7	90	8.00	279	1,564	1,532	32	20	12	0.03	0.00026	0.10	0.58	0.122	0.075
29-Apr-91	1100	2	GRAB	SURFACE	12.0	9.8	7.5	70	7.96	260	1,476	1,438	38	0	38	0.06	0.00041	0.10	0.74	0.159	0.064
04-May-91	945	2	GRAB	SURFACE	7.0	6.7	7.7		8.01	264	1,426	1,386	40	22	18	0.19	0.00139	0.10	0.78	0.254	0.132
13-Jun-91	930	2	GRAB	SURFACE	22.0	24.5	7.8	1,700	7.67	299	1,783	1,707	76	18	58	0.64	0.01803	0.90	1.79	0.417	0.173
08-Jul-91	1020	2	GRAB	SURFACE	23.0	24.0	8.1	1,700	7.91	168	1,559	1,485	74	20	54	0.02	0.00117	0.60	1.18	0.532	0.081
12-Aug-91	1015	2	GRAB	SURFACE	21.0	24.0	7.9	42	7.72	254	1,685	1,623	62	22	40	0.43	0.01411	0.90	1.20	0.295	0.098
25-Mar-92	1045	2	GRAB	SURFACE	6.0	7.0	8.0	100	8.05	252	1,657	1,641	16	2	14	0.02	0.00027	0.10	0.73	0.076	0.073
			MEAN ------>		12.0	13.6	7.9	464	7.89	250	1,521	1,482	38	12	26	0.16	0.0040	0.34	0.88	0.225	0.086
			MAXIMUM --->		23.0	24.5	8.1	1,700	8.05	299	1,783	1,707	76	22	58	0.64	0.0180	0.90	1.79	0.532	0.173
			MINIMUM --->		1.0	(1.1)	7.5	2	7.67	168	1,055	1,049	2	0	0	0.02	0.0002	0.10	0.35	0.061	0.020

SITE # 3

DATE	TIME	SITE	SAMP	DEPTH	WTEMP C	ATEMP C	FPH UNITS	FECAL /100 ml	LABPH UNITS	TALKAL mg/L	TSOL mg/L	TDSOL mg/L	TSSOL mg/L	VOLATILE SOLIDS mg/L	FIXED SOLIDS mg/L	AMMON mg/L	UNIONIZED AMMONIA mg/l	NO3+2 mg/L	TKN-N mg/L	TPO4P mg/L	TOTAL DISS. PO4P mg/L
06-Mar-91	1400	3	GRAB	SURFACE	1.5	(1.1)	8.0	2		189	1,048	1,045	3	3	0	0.02	0.0002	0.10	0.27	0.047	0.020
25-Mar-91	1215	3	GRAB	SURFACE	11.0	18.3	8.0	2	7.95	230	1,344	1,328	16	12	4	0.02	0.0004	0.10	0.42	0.081	0.054
15-Apr-91	1200	3	GRAB	SURFACE	9.0	9.4	7.8	140	8.00	265	1,552	1,474	78	14	64	0.03	0.0003	0.10	0.57	0.159	0.034
29-Apr-91	1130	3	GRAB	SURFACE	10.0	8.9	7.5	38,000	8.01	227	1,538	1,454	84	8	76	0.11	0.0006	0.80	1.18	0.424	0.156
04-May-91	1020	3	GRAB	SURFACE	8.0	7.0	7.8		8.07	236	1,424	1,402	22	18	4	0.02	0.0002	0.10	0.43	0.186	0.065
13-Jun-91	1000	3	GRAB	SURFACE	22.5	25.5	8.0	2,700	7.53	159	780	732	48	18	30	0.18	0.0082	1.00	1.04	0.661	0.356
08-Jul-91	1100	3	GRAB	SURFACE	22.0	24.0	8.3	2,000	8.19	162	1,605	1,473	132	20	112	0.02	0.0017	1.40	1.28	0.610	0.075
12-Aug-91	1050	3	GRAB	SURFACE	21.0	26.0	8.1	140	7.84	171	1,909	1,829	80	24	56	0.04	0.0020	1.00	1.08	0.234	0.071
25-Mar-92	1130	3	GRAB	SURFACE	6.0	7.0	7.9	14	8.28	215	1,974	1,938	36	3	33	0.02	0.0002	0.30	0.75	0.098	0.030
			MEAN ------>		12.3	13.9	7.9	5,375	7.98	208	1,464	1,406	55	13	42	0.05	0.0015	0.54	0.78	0.278	0.098
			MAXIMUM --->		22.5	26.0	8.3	38,000	8.28	265	1,974	1,938	132	24	112	0.18	0.0082	1.40	1.28	0.661	0.356
			MINIMUM --->		1.5	(1.1)	7.5	2	7.53	159	780	732	3	3	0	0.02	0.0002	0.10	0.27	0.047	0.020

Table D-1 cont.

SURFACE/GRAB SAMPLES FOR SWAN LAKE TRIBUTARIES (Continued)

SITE # 4

DATE	TIME	SITE	SAMP	DEPTH	WTEMP C	ATEMP C	FPH UNTIS	FECAL /100 ml	LABPH UNITS	TALKAL mg/L	TSOL mg/L	TDSOL mg/L	TSSOL mg/L	VOLATILE SOLIDS mg/L	FIXED SOLIDS mg/L	AMMO mg/L	UNIONIZED AMMONIA mg/L	NO3+2 mg/L	TKN-N mg/L	TPO4P mg/L	TOTAL DISS. PO4P mg/L
11-Feb-91	1515	4	GRAB	SURFACE	1.0	9.0	7.5	10		298	1,584	1,565	19	7	12	0.22	0.0006	0.60	0.82	0.108	0.075
06-Mar-91	1425	4	GRAB	SURFACE	1.0	-1.1	8.0	2		170	1,043	1,041	2	2	0	0.02	0.0002	0.10	0.23	0.041	0.041
25-Mar-91	1250	4	GRAB	SURFACE	10.0	18.9	8.0	2	8.28	136	2,150	2,136	14	14	0	0.03	0.0005	0.10	1.14	0.095	0.041
15-Apr-91	1230	4	GRAB	SURFACE	10.0	9.4	7.7	34	8.00	243	1,512	1,468	44	22	22	0.02	0.0002	0.10	0.58	0.102	0.034
29-Apr-91	1215	4	GRAB	SURFACE	12.0	10.0	7.9	32	8.02	196	1,757	1,715	42	2	40	0.02	0.0003	0.10	0.79	0.108	0.020
04-May-91	1100	4	GRAB	SURFACE	9.0	9.0	7.7		8.04	178	1,863	1,841	22	20	2	0.04	0.0003	0.10	0.52	0.125	0.020
13-Jun-91	1030	4	GRAB	SURFACE	25.0	28.0	7.8	1,200	7.33	110	512	466	46	10	36	1.11	0.0385	0.80	2.21	0.685	0.414
16-Dec-91	1130	4	GRAB	SURFACE	2.0	1.0	7.8	80	7.63	347	1,704	1,701	3	2	1	0.04	0.0002	0.40	0.68	0.093	0.070
19-Feb-92	1015	4	GRAB	SURFACE	1.0	1.0	7.7	2,500	7.66	112	548	462	86	24	62	0.61	0.0025	2.00	2.68	0.835	0.541
25-Mar-92	1145	4	GRAB	SURFACE	6.0	7.0	7.9	2	8.48	131	2,037	2,009	28	9	19	0.02	0.0002	0.10	1.05	0.129	0.060
			MEAN ——>		7.7	9.2	7.8	429	7.93	192	1,471	1,440	31	11	19	0.21	0.0044	0.44	1.07	0.232	0.132
			MAXIMUM —>		25.0	28.0	8.0	2,500	8.48	347	2,150	2,136	86	24	62	1.11	0.0385	2.00	2.68	0.835	0.541
			MINIMUM —>		1.0	-1.1	7.5	2	7.33	110	512	462	2	2	0	0.02	0.0002	0.10	0.23	0.041	0.020

DATE	TIME	SITE	SAMP	DEPTH	WTEMP C	ATEMP C	FPH UNITS	FECAL 100/ml	LABPH UNITS	TALKAL mg/L	TSOL mg/L	TDSOL mg/L	TSSOL mg/L	VOLATILE SOLIDS mg/L	FIXED SOLIDS mg/L	AMMO mg/L	UNIONIZED AMMONIA mg/l	NO3+2 mg/L	TKN-N mg/L	TPO4P mg/L	TOTAL DISS. PO4P mg/L
28-Mar-91	1115	5	GRAB	SURFACE	5.0	4.4	8.0	2	7.94	128	2,282	2,268	16	9	7	0.02	0.0002	0.10	1.38	0.159	0.024
04-Jun-91	930	5	GRAB	SURFACE	24.0	22.0	8.3	100	7.69	134	2,259	2,268	40	2	38	0.19	0.0182	0.10	1.25	0.122	0.041
19-Jun-91	1045	5	GRAB	SURFACE	26.0	28.0	8.4	20	8.10	129	2,227	2,268	18	16	2	0.28	0.0372	0.60	1.61	0.125	0.027
02-Jul-91	1115	5	GRAB	SURFACE	26.0	32.0	8.0	150	8.13	144	2,273	2,268	56	22	34	0.35	0.0201	0.80	1.34	0.231	0.037
19-Feb-92	1035	5	GRAB	SURFACE	1.0	0.0	7.7	30	8.29	178	1,806	2,268	22	12	10	0.20	0.0009	0.20	1.03	0.070	0.040
			MEAN ——>		16.4	17.3	8.1	60	8.03	143	2,169	2,268	30	12	18	0.21	0.0153	0.36	1.32	0.141	0.034
			MAXIMUM —>		26.0	32.0	8.4	150	8.29	178	2,282	2,268	56	22	38	0.35	0.0372	0.80	1.61	0.231	0.041
			MINIMUM —>		1.0	0.0	7.7	2	7.69	128	1,806	2,268	16	2	2	0.02	0.0002	0.10	1.03	0.070	0.024

APPENDIX E - Tributary Loads

Table E-1. Site #1 Daily Loads.

Daily Loads at Site #1 in Kilograms Per Day

DATE	TIME	SITE	STAGE	FLOW	DAILY LOAD	TALKAL	TSOL	TDSOL	TSSOL	VOLATILE SOLIDS	FIXED SOLIDS	AMMON	UNIONIZED AMMONIA	NO3+2	TKN-N	TPO4P	TOTAL DISS. PO
06-Mar-91	1235	1	0.85	3.59	8,778,423	2,212.16	10,727.23	10,709.68	17.56	17.56	0.00	1.05	0.00614	7.90	4.48	0.948	0.948
07-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
08-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
09-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
10-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
11-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
12-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
13-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
14-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
15-Mar-91			0.85	3.59	8,778,423	2,479.90	11,793.81	11,776.25	17.56	17.56	0.00	0.66	0.00469	4.39	4.48	0.922	0.773
16-Mar-91			0.84	3.11	7,612,053	2,150.40	10,226.79	10,211.57	15.22	15.22	0.00	0.57	0.00407	3.81	3.88	0.799	0.670
17-Mar-91			0.82	2.71	6,641,384	1,876.19	8,922.70	8,909.42	13.28	13.28	0.00	0.50	0.00355	3.32	3.39	0.697	0.584
18-Mar-91			0.81	2.38	5,829,863	1,646.94	7,832.42	7,820.76	11.66	11.66	0.00	0.44	0.00311	2.91	2.97	0.612	0.513
19-Mar-91			0.79	2.10	5,148,295	1,454.39	6,916.73	6,906.44	10.30	10.30	0.00	0.39	0.00275	2.57	2.63	0.541	0.453
20-Mar-91			0.78	1.87	4,573,262	1,291.95	6,144.18	6,135.03	9.15	9.15	0.00	0.34	0.00244	2.29	2.33	0.480	0.402
21-Mar-91			0.77	1.67	4,085,893	1,154.26	5,489.40	5,481.22	8.17	8.17	0.00	0.31	0.00218	2.04	2.08	0.429	0.360
22-Mar-91			0.75	1.48	3,616,780	1,021.74	4,859.14	4,851.91	7.23	7.23	0.00	0.27	0.00193	1.81	1.84	0.380	0.318
23-Mar-91			0.80	2.22	5,426,102	1,532.87	7,289.97	7,279.12	10.85	10.85	0.00	0.41	0.00290	2.71	2.77	0.570	0.477
24-Mar-91			0.80	2.22	5,426,102	1,532.87	7,289.97	7,279.12	10.85	10.85	0.00	0.41	0.00290	2.71	2.77	0.570	0.477
25-Mar-91	1100	1	0.70	1.05	2,579,892	807.51	3,779.54	3,774.38	5.16	5.16	0.00	0.08	0.00067	0.26	1.32	0.245	0.175
26-Mar-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
27-Mar-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
28-Mar-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
29-Mar-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
30-Mar-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
31-Mar-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
01-Apr-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
02-Apr-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
03-Apr-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
04-Apr-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
05-Apr-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
06-Apr-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
07-Apr-91			0.70	1.05	2,579,892	808.80	3,894.35	3,853.07	41.28	28.38	12.90	0.06	0.00053	0.26	1.25	0.254	0.163
08-Apr-91			0.69	0.99	2,428,369	761.29	3,665.62	3,626.77	38.85	26.71	12.14	0.06	0.00050	0.24	1.18	0.239	0.153
09-Apr-91			0.74	1.40	3,424,121	1,073.46	5,168.71	5,113.92	54.79	37.67	17.12	0.09	0.00070	0.34	1.66	0.337	0.216
10-Apr-91			0.80	2.12	5,193,197	1,628.07	7,839.13	7,756.04	83.09	57.13	25.97	0.13	0.00106	0.52	2.52	0.512	0.327
11-Apr-91			0.85	3.50	8,553,884	2,681.64	12,912.09	12,775.23	136.86	94.09	42.77	0.21	0.00174	0.86	4.15	0.843	0.539
12-Apr-91			0.90	6.28	15,367,192	4,817.61	23,196.78	22,950.90	245.88	169.04	76.84	0.38	0.00313	1.54	7.45	1.514	0.968
13-Apr-91			0.86	3.99	9,756,379	3,058.62	14,727.25	14,571.15	156.10	107.32	48.78	0.24	0.00199	0.98	4.73	0.961	0.615
14-Apr-91			0.82	2.66	6,516,461	2,042.91	9,836.60	9,732.33	104.26	71.68	32.58	0.16	0.00133	0.65	3.16	0.642	0.411
15-Apr-91	1045	1	0.78	1.87	4,573,262	1,436.00	7,106.85	6,969.65	137.20	91.47	45.73	0.09	0.00070	0.46	2.10	0.466	0.265
16-Apr-91			0.78	1.87	4,573,262	1,381.13	6,823.31	6,704.40	118.90	59.45	59.45	0.09	0.00053	0.46	2.04	0.496	0.318
17-Apr-91			0.78	1.87	4,573,262	1,381.13	6,823.31	6,704.40	118.90	59.45	59.45	0.09	0.00053	0.46	2.04	0.496	0.318
18-Apr-91			0.77	1.72	4,217,146	1,273.58	6,291.98	6,182.34	109.65	54.82	54.82	0.08	0.00049	0.42	1.88	0.458	0.293
19-Apr-91			0.77	1.72	4,210,438	1,271.55	6,281.97	6,172.50	109.47	54.74	54.74	0.08	0.00049	0.42	1.87	0.457	0.293
20-Apr-91			0.77	1.67	4,093,920	1,236.36	6,108.13	6,001.69	106.44	53.22	53.22	0.08	0.00048	0.41	1.82	0.444	0.285
21-Apr-91			0.77	1.67	4,097,942	1,237.58	6,114.13	6,007.58	106.55	53.27	53.27	0.08	0.00048	0.41	1.82	0.445	0.285
22-Apr-91			0.76	1.62	3,964,362	1,197.24	5,914.83	5,811.76	103.07	51.54	51.54	0.08	0.00046	0.40	1.76	0.430	0.276
23-Apr-91			0.75	1.47	3,590,163	1,084.23	5,356.52	5,263.18	93.34	46.67	46.67	0.07	0.00042	0.36	1.60	0.390	0.250
24-Apr-91			0.74	1.39	3,390,486	1,023.93	5,058.60	4,970.45	88.15	44.08	44.08	0.07	0.00040	0.34	1.51	0.368	0.236

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25-Apr-91			0.73	1.28	3,130,560	945.43	4,670.80	4,589.40	81.39	40.70	40.70	0.06	0.00037	0.31	1.39	0.340	0.218
26-Apr-91			0.74	1.37	3,354,362	1,013.02	5,004.71	4,917.49	87.21	43.61	43.61	0.07	0.00039	0.34	1.49	0.364	0.233
27-Apr-91			0.80	2.16	5,284,656	1,595.97	7,884.71	7,747.31	137.40	68.70	68.70	0.11	0.00062	0.53	2.35	0.573	0.367
28-Apr-91			0.76	1.55	3,797,212	1,146.76	5,665.44	5,566.71	98.73	49.36	49.36	0.08	0.00044	0.38	1.69	0.412	0.264
29-Apr-91	1030	1	0.84	3.33	8,137,037	2,359.74	11,635.96	11,456.95	179.01	48.82	130.19	0.16	0.00073	0.81	3.50	0.936	0.659
30-Apr-91			0.82	2.59	6,342,367	1,829.77	9,364.50	9,231.32	133.19	76.11	57.08	0.13	0.00057	0.63	2.22	0.850	0.580
01-May-91			0.76	1.58	3,866,491	1,115.48	5,708.87	5,627.68	81.20	46.40	34.80	0.08	0.00035	0.39	1.35	0.518	0.354
02-May-91			0.74	1.36	3,324,703	959.18	4,908.92	4,839.11	69.82	39.90	29.92	0.07	0.00030	0.33	1.16	0.446	0.304
03-May-91			0.86	4.19	10,255,825	2,958.81	15,142.73	14,927.35	215.37	123.07	92.30	0.21	0.00092	1.03	3.59	1.374	0.938
04-May-91	900	1	0.91	7.42	18,149,273	5,208.84	27,641.34	27,278.36	362.99	326.69	36.30	0.36	0.00161	1.81	4.90	2.777	1.851
05-May-91			0.75	1.51	3,698,430	1,100.28	5,477.37	5,355.33	122.05	51.78	70.27	0.26	0.00285	1.48	2.79	0.828	0.490
06-May-91			0.72	1.20	2,943,547	875.71	4,359.39	4,262.26	97.14	41.21	55.93	0.21	0.00227	1.18	2.22	0.659	0.390
07-May-91			0.71	1.13	2,755,634	819.80	4,081.09	3,990.16	90.94	38.58	52.36	0.19	0.00212	1.10	2.08	0.617	0.365
08-May-91			0.75	1.45	3,550,785	1,056.36	5,258.71	5,141.54	117.18	49.71	67.46	0.25	0.00273	1.42	2.68	0.795	0.470
09-May-91			0.74	1.39	3,390,486	1,008.67	5,021.31	4,909.42	111.89	47.47	64.42	0.24	0.00261	1.36	2.56	0.759	0.449
10-May-91			0.72	1.22	2,993,026	890.43	4,432.67	4,333.90	98.77	41.90	56.87	0.21	0.00230	1.20	2.26	0.670	0.397
11-May-91			0.71	1.16	2,829,864	841.88	4,191.03	4,097.64	93.39	39.62	53.77	0.20	0.00218	1.13	2.14	0.634	0.375
12-May-91			0.70	1.05	2,569,991	764.57	3,806.16	3,721.35	84.81	35.98	48.83	0.18	0.00198	1.03	1.94	0.576	0.341
13-May-91			0.73	1.29	3,160,327	940.20	4,680.44	4,576.15	104.29	44.24	60.05	0.22	0.00243	1.26	2.39	0.708	0.419
14-May-91			0.70	1.08	2,648,843	788.03	3,922.94	3,835.52	87.41	37.08	50.33	0.19	0.00204	1.06	2.00	0.593	0.351
15-May-91			0.72	1.16	2,848,330	847.38	4,218.38	4,124.38	93.99	39.88	54.12	0.20	0.00219	1.14	2.15	0.638	0.377
16-May-91			0.77	1.76	4,315,306	1,283.80	6,390.97	6,248.56	142.41	60.41	81.99	0.30	0.00332	1.73	3.26	0.967	0.572
17-May-91			0.75	1.53	3,750,866	1,115.88	5,555.03	5,431.25	123.78	52.51	71.27	0.26	0.00289	1.50	2.83	0.840	0.497
18-May-91			0.78	1.94	4,747,708	1,412.44	7,031.36	6,874.68	156.67	66.47	90.21	0.33	0.00366	1.90	3.58	1.063	0.629
19-May-91			0.78	1.80	4,407,846	1,311.33	6,528.02	6,382.56	145.46	61.71	83.75	0.31	0.00339	1.76	3.33	0.987	0.584
20-May-91			0.76	1.64	4,022,495	1,196.69	5,957.32	5,824.57	132.74	56.31	76.43	0.28	0.00310	1.61	3.04	0.901	0.533
21-May-91			0.76	1.59	3,892,487	1,158.01	5,764.77	5,636.32	128.45	54.49	73.96	0.27	0.00300	1.56	2.94	0.872	0.516
22-May-91			0.75	1.46	3,563,838	1,060.24	5,278.04	5,160.44	117.61	49.89	67.71	0.25	0.00274	1.43	2.69	0.798	0.472
23-May-91			0.76	1.62	3,956,705	1,177.12	5,859.88	5,729.31	130.57	55.39	75.18	0.28	0.00305	1.58	2.99	0.886	0.524
24-May-91			0.75	1.44	3,521,676	1,047.70	5,215.60	5,099.39	116.22	49.30	66.91	0.25	0.00271	1.41	2.66	0.789	0.467
25-May-91			0.73	1.29	3,152,166	937.77	4,668.36	4,564.34	104.02	44.13	59.89	0.22	0.00243	1.26	2.38	0.706	0.418
26-May-91			0.73	1.27	3,106,526	924.19	4,600.76	4,498.25	102.52	43.49	59.02	0.22	0.00239	1.24	2.35	0.696	0.412
27-May-91			0.71	1.15	2,820,700	839.16	4,177.46	4,084.37	93.08	39.49	53.59	0.20	0.00217	1.13	2.13	0.632	0.374
28-May-91			0.70	1.05	2,569,991	764.57	3,806.16	3,721.35	84.81	35.98	48.83	0.18	0.00198	1.03	1.94	0.576	0.341
29-May-91			0.72	1.22	2,985,522	888.19	4,421.56	4,323.04	98.52	41.80	56.72	0.21	0.00230	1.19	2.25	0.669	0.396
30-May-91			0.85	3.46	8,455,269	2,515.44	12,522.25	12,243.23	279.02	118.37	160.65	0.59	0.00651	3.38	6.38	1.894	1.120
31-May-91			0.76	1.54	3,772,151	1,122.22	5,586.56	5,462.08	124.48	52.81	71.67	0.26	0.00290	1.51	2.85	0.845	0.500
01-Jun-91			0.73	1.28	3,133,249	932.14	4,640.34	4,536.94	103.40	43.87	59.53	0.22	0.00241	1.25	2.37	0.702	0.415
02-Jun-91			0.78	1.85	4,531,083	1,348.00	6,710.53	6,561.01	149.53	63.44	86.09	0.32	0.00349	1.81	3.42	1.015	0.600
03-Jun-91			0.74	1.41	3,439,577	1,023.27	5,094.01	4,980.51	113.51	48.15	65.35	0.24	0.00265	1.38	2.60	0.770	0.456
04-Jun-91			0.74	1.39	3,405,712	1,013.20	5,043.86	4,931.47	112.39	47.68	64.71	0.24	0.00262	1.36	2.57	0.763	0.451
05-Jun-91			0.77	1.70	4,167,215	1,239.75	6,171.65	6,034.13	137.52	58.34	79.18	0.29	0.00321	1.67	3.15	0.933	0.552
06-Jun-91			0.74	1.37	3,357,350	998.81	4,972.23	4,861.44	110.79	47.00	63.79	0.24	0.00259	1.34	2.53	0.752	0.445
07-Jun-91			0.75	1.46	3,563,838	1,060.24	5,278.04	5,160.44	117.61	49.89	67.71	0.25	0.00274	1.43	2.69	0.798	0.472
08-Jun-91			0.71	1.14	2,784,508	828.39	4,123.86	4,031.97	91.89	38.98	52.91	0.19	0.00214	1.11	2.10	0.624	0.369
09-Jun-91			0.70	1.03	2,525,206	751.25	3,739.83	3,656.50	83.33	35.35	47.98	0.18	0.00194	1.01	1.91	0.566	0.335
10-Jun-91			0.71	1.13	2,768,901	823.75	4,100.74	4,009.37	91.37	38.76	52.61	0.19	0.00213	1.11	2.09	0.620	0.367
11-Jun-91			0.71	1.11	2,718,578	808.78	4,026.21	3,936.50	89.71	38.06	51.65	0.19	0.00209	1.09	2.05	0.609	0.360
12-Jun-91			0.64	0.77	1,881,421	559.72	2,786.39	2,724.30	62.09	26.34	35.75	0.13	0.00145	0.75	1.42	0.421	0.249
13-Jun-91	900	1	0.55	0.48	1,167,461	359.58	1,679.98	1,626.27	53.70	11.67	42.03	0.14	0.00368	0.82	1.45	0.344	0.190
14-Jun-91			0.55	0.46	1,131,401	344.51	1,581.13	1,521.17	59.96	14.71	45.26	0.15	0.00484	0.74	1.14	0.322	0.194
15-Jun-91			0.63	0.72	1,765,044	537.46	2,466.65	2,373.10	93.55	22.95	70.60	0.24	0.00755	1.15	1.77	0.503	0.303
16-Jun-91			0.64	0.77	1,872,856	570.28	2,617.32	2,518.06	99.26	24.35	74.91	0.25	0.00801	1.22	1.88	0.534	0.321
17-Jun-91			0.53	0.43	1,045,351	318.31	1,460.88	1,405.47	55.40	13.59	41.81	0.14	0.00447	0.68	1.05	0.298	0.179

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18-Jun-91			0.53	0.41	998,579	304.07	1,395.51	1,342.59	52.92	12.98	39.94	0.13	0.00427	0.65	1.00	0.285	0.171
19-Jun-91			0.52	0.38	929,064	282.90	1,298.37	1,249.13	49.24	12.08	37.16	0.13	0.00397	0.60	0.93	0.265	0.159
20-Jun-91			0.52	0.38	931,582	283.67	1,301.89	1,252.51	49.37	12.11	37.26	0.13	0.00399	0.61	0.94	0.266	0.160
21-Jun-91			0.51	0.37	910,582	277.27	1,272.54	1,224.28	48.26	11.84	36.42	0.12	0.00390	0.59	0.92	0.260	0.156
22-Jun-91			0.53	0.43	1,042,012	317.29	1,456.21	1,400.98	55.23	13.55	41.68	0.14	0.00446	0.68	1.05	0.297	0.179
23-Jun-91			0.53	0.43	1,048,690	319.33	1,465.54	1,409.96	55.58	13.63	41.95	0.14	0.00449	0.68	1.05	0.299	0.180
24-Jun-91			0.53	0.42	1,021,972	311.19	1,428.21	1,374.04	54.16	13.29	40.88	0.14	0.00437	0.66	1.03	0.291	0.175
25-Jun-91			0.53	0.41	996,071	303.30	1,392.01	1,339.22	52.79	12.95	39.84	0.13	0.00426	0.65	1.00	0.284	0.171
26-Jun-91			0.51	0.36	891,231	271.38	1,245.50	1,198.26	47.24	11.59	35.65	0.12	0.00381	0.58	0.90	0.254	0.153
27-Jun-91			0.49	0.31	770,272	234.55	1,076.46	1,035.63	40.82	10.01	30.81	0.10	0.00330	0.50	0.77	0.220	0.132
28-Jun-91			0.48	0.28	691,232	210.48	966.00	929.36	36.64	8.99	27.65	0.09	0.00296	0.45	0.69	0.197	0.119
29-Jun-91			0.47	0.26	629,296	191.62	879.44	846.09	33.35	8.18	25.17	0.08	0.00269	0.41	0.63	0.179	0.108
30-Jun-91			0.47	0.25	619,147	188.53	865.26	832.44	32.81	8.05	24.77	0.08	0.00265	0.40	0.62	0.176	0.106
01-Jul-91			0.46	0.22	536,926	163.49	750.35	721.90	28.46	6.98	21.48	0.07	0.00230	0.35	0.54	0.153	0.092
02-Jul-91			0.50	0.33	802,513	244.37	1,121.51	1,078.98	42.53	10.43	32.10	0.11	0.00343	0.52	0.81	0.229	0.138
03-Jul-91			0.54	0.44	1,084,588	330.26	1,515.71	1,458.23	57.48	14.10	43.38	0.15	0.00464	0.70	1.09	0.309	0.186
04-Jul-91			0.55	0.46	1,131,401	344.51	1,581.13	1,521.17	59.96	14.71	45.26	0.15	0.00484	0.74	1.14	0.322	0.194
05-Jul-91			0.50	0.32	788,944	240.23	1,102.55	1,060.74	41.81	10.26	31.56	0.11	0.00338	0.51	0.79	0.225	0.135
06-Jul-91			0.47	0.24	594,679	181.08	831.06	799.55	31.52	7.73	23.79	0.08	0.00254	0.39	0.60	0.169	0.102
07-Jul-91			0.48	0.27	664,900	202.46	929.20	893.96	35.24	8.64	26.60	0.09	0.00284	0.43	0.67	0.189	0.114
08-Jul-91	945	1	0.48	0.28	685,283	206.27	929.24	888.13	41.12	10.96	30.15	0.10	0.00393	0.41	0.53	0.188	0.123
09-Jul-91			0.47	0.25	623,374	199.79	926.65	896.72	29.92	6.23	23.69	0.08	0.00322	0.44	0.31	0.142	0.096
10-Jul-91			0.48	0.28	677,637	217.18	1,007.31	974.78	32.53	6.78	25.75	0.09	0.00350	0.47	0.34	0.154	0.105
11-Jul-91			0.49	0.30	744,786	238.70	1,107.12	1,071.37	35.75	7.45	28.30	0.10	0.00385	0.52	0.37	0.169	0.115
12-Jul-91			0.48	0.27	658,959	211.20	979.54	947.91	31.63	6.59	25.04	0.09	0.00341	0.46	0.33	0.150	0.102
13-Jul-91			0.47	0.25	616,612	197.62	916.59	887.00	29.60	6.17	23.43	0.08	0.00319	0.43	0.31	0.140	0.095
14-Jul-91			0.45	0.19	459,099	147.14	682.45	660.41	22.04	4.59	17.45	0.06	0.00237	0.32	0.23	0.104	0.071
15-Jul-91			0.52	0.39	950,035	304.49	1,412.23	1,366.63	45.60	9.50	36.10	0.12	0.00491	0.67	0.48	0.216	0.147
16-Jul-91			0.51	0.36	887,021	284.29	1,318.56	1,275.98	42.58	8.87	33.71	0.12	0.00459	0.62	0.44	0.202	0.137
17-Jul-91			0.36	0.03	65,602	21.03	97.52	94.37	3.15	0.66	2.49	0.01	0.00034	0.05	0.03	0.015	0.010
18-Jul-91			0.23	0.00	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
19-Jul-91			0.24	0.00	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
20-Jul-91			0.28	0.00	527	0.17	0.78	0.76	0.03	0.01	0.02	0.00	0.00000	0.00	0.00	0.000	0.000
21-Jul-91			0.50	0.34	829,613	265.89	1,233.22	1,193.40	39.82	8.30	31.53	0.11	0.00429	0.58	0.41	0.189	0.128
22-Jul-91			0.51	0.37	901,331	288.88	1,339.83	1,296.57	43.26	9.01	34.25	0.12	0.00466	0.63	0.45	0.205	0.139
23-Jul-91			0.49	0.31	765,177	245.24	1,137.44	1,100.71	36.73	7.65	29.08	0.10	0.00396	0.54	0.38	0.174	0.118
24-Jul-91			0.45	0.20	494,025	158.33	734.37	710.65	23.71	4.94	18.77	0.06	0.00255	0.35	0.25	0.112	0.076
25-Jul-91			0.47	0.26	644,541	206.58	958.11	927.17	30.94	6.45	24.49	0.08	0.00333	0.45	0.32	0.147	0.100
26-Jul-91			0.50	0.34	842,299	269.96	1,252.08	1,211.65	40.43	8.42	32.01	0.11	0.00435	0.59	0.42	0.192	0.130
27-Jul-91			0.51	0.35	860,038	275.64	1,278.45	1,237.16	41.28	8.60	32.68	0.11	0.00445	0.60	0.43	0.196	0.133
28-Jul-91			0.53	0.42	1,018,632	326.47	1,514.20	1,465.30	48.89	10.19	38.71	0.13	0.00527	0.71	0.51	0.232	0.157
29-Jul-91			0.54	0.43	1,055,067	338.15	1,568.36	1,517.71	50.64	10.55	40.09	0.14	0.00545	0.74	0.53	0.240	0.163
30-Jul-91			0.47	0.24	580,381	186.01	862.74	834.88	27.86	5.80	22.05	0.08	0.00300	0.41	0.29	0.132	0.090
31-Jul-91			0.46	0.22	538,589	172.62	800.61	774.76	25.85	5.39	20.47	0.07	0.00278	0.38	0.27	0.123	0.083
01-Aug-91			0.44	0.17	416,918	133.62	619.75	599.74	20.01	4.17	15.84	0.05	0.00216	0.29	0.21	0.095	0.064
02-Aug-91			0.46	0.22	546,912	175.29	812.98	786.73	26.25	5.47	20.78	0.07	0.00283	0.38	0.27	0.124	0.084
03-Aug-91			0.47	0.26	639,457	204.95	950.55	919.86	30.69	6.39	24.30	0.08	0.00331	0.45	0.32	0.145	0.099
04-Aug-91			0.43	0.15	370,590	118.77	550.88	533.09	17.79	3.71	14.08	0.05	0.00192	0.26	0.19	0.084	0.057
05-Aug-91			0.45	0.19	464,745	148.95	690.84	668.54	22.31	4.65	17.66	0.06	0.00240	0.33	0.23	0.106	0.072
06-Aug-91			0.46	0.21	513,745	164.66	763.68	739.02	24.66	5.14	19.52	0.07	0.00266	0.36	0.26	0.117	0.079
07-Aug-91			0.48	0.28	673,390	215.82	1,000.99	968.67	32.32	6.73	25.59	0.09	0.00348	0.47	0.34	0.153	0.104
08-Aug-91			0.60	0.62	1,523,814	488.38	2,265.15	2,192.01	73.14	15.24	57.90	0.20	0.00788	1.07	0.76	0.347	0.235
09-Aug-91			0.53	0.41	1,002,758	321.38	1,490.60	1,442.47	48.13	10.03	38.10	0.13	0.00518	0.70	0.50	0.228	0.155
10-Aug-91			0.51	0.35	851,594	272.94	1,265.89	1,225.02	40.88	8.52	32.36	0.11	0.00440	0.60	0.43	0.194	0.132

Site #1 cont.

11-Aug-91			0.47	0.25	614,077	196.81	912.83	883.35	29.48	6.14	23.33	0.08	0.00317	0.43	0.31	0.140	0.095
12-Aug-91	945	1	0.44	0.16	393,546	133.81	636.36	622.20	14.17	1.57	12.59	0.04	0.00179	0.31	0.09	0.071	0.051
13-Aug-91			0.50	0.34	843,144	163.23	1,351.56	1,319.52	32.04	5.90	26.14	0.05	0.00146	0.38	0.28	0.121	0.083
14-Aug-91			0.52	0.40	977,671	189.28	1,567.21	1,530.06	37.15	6.84	30.31	0.06	0.00169	0.44	0.32	0.141	0.096
15-Aug-91			0.33	0.01	12,776	2.47	20.48	19.99	0.49	0.09	0.40	0.00	0.00002	0.01	0.00	0.002	0.001
16-Aug-91			0.48	0.28	681,885	132.01	1,093.06	1,067.15	25.91	4.77	21.14	0.04	0.00118	0.31	0.23	0.098	0.067
17-Aug-91			0.43	0.13	326,103	63.13	522.74	510.35	12.39	2.28	10.11	0.02	0.00056	0.15	0.11	0.047	0.032
18-Aug-91			0.78	1.93	4,717,982	913.40	7,562.93	7,383.64	179.28	33.03	146.26	0.31	0.00817	2.12	1.56	0.679	0.465
19-Aug-91			0.49	0.29	715,884	138.60	1,147.56	1,120.36	27.20	5.01	22.19	0.05	0.00124	0.32	0.24	0.103	0.071
20-Aug-91			0.50	0.32	792,337	153.40	1,270.12	1,240.01	30.11	5.55	24.56	0.05	0.00137	0.36	0.26	0.114	0.078
21-Aug-91			0.33	0.01	18,968	3.67	30.41	29.68	0.72	0.13	0.59	0.00	0.00003	0.01	0.01	0.003	0.002
22-Aug-91			0.15	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
23-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
24-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
25-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
26-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
27-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
28-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
29-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
30-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
31-Aug-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
01-Sep-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
02-Sep-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
03-Sep-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
04-Sep-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
05-Sep-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
06-Sep-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
07-Sep-91			0.01	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
08-Sep-91			0.14	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
09-Sep-91			0.21	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
10-Sep-91			0.22	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	0.000	0.000
11-Sep-91			0.38	0.04	102,899	19.92	164.95	161.04	3.91	0.72	3.19	0.01	0.00018	0.05	0.03	0.015	0.010
12-Sep-91			0.56	0.49	1,195,243	231.40	1,915.98	1,870.56	45.42	8.37	37.05	0.08	0.00207	0.54	0.39	0.172	0.118
13-Sep-91			0.47	0.24	580,381	112.36	930.35	908.30	22.05	4.06	17.99	0.04	0.00100	0.26	0.19	0.084	0.057
14-Sep-91			0.63	0.70	1,717,418	332.49	2,753.02	2,687.76	65.26	12.02	53.24	0.11	0.00297	0.77	0.57	0.247	0.169
15-Sep-91			0.46	0.21	522,004	101.06	836.77	816.94	19.84	3.65	16.18	0.03	0.00090	0.23	0.17	0.075	0.051
16-Sep-91			0.31	0.00	4,769	0.92	7.64	7.46	0.18	0.03	0.15	0.00	0.00001	0.00	0.00	0.001	0.000
17-Sep-91			0.29	0.00	1,304	0.25	2.09	2.04	0.05	0.01	0.04	0.00	0.00000	0.00	0.00	0.000	0.000
18-Sep-91			0.29	0.00	854	0.17	1.37	1.34	0.03	0.01	0.03	0.00	0.00000	0.00	0.00	0.000	0.000
19-Sep-91			0.30	0.00	2,579	0.50	4.13	4.04	0.10	0.02	0.08	0.00	0.00000	0.00	0.00	0.000	0.000
20-Sep-91			0.33	0.01	12,776	2.47	20.48	19.99	0.49	0.09	0.40	0.00	0.00002	0.01	0.00	0.002	0.001
21-Sep-91			0.31	0.00	3,693	0.72	5.92	5.78	0.14	0.03	0.11	0.00	0.00001	0.00	0.00	0.001	0.000
22-Sep-91			0.30	0.00	1,762	0.34	2.83	2.76	0.07	0.01	0.05	0.00	0.00000	0.00	0.00	0.000	0.000
23-Sep-91			0.29	0.00	1,176	0.23	1.89	1.84	0.04	0.01	0.04	0.00	0.00000	0.00	0.00	0.000	0.000
24-Sep-91			0.33	0.00	11,921	2.31	19.11	18.66	0.45	0.08	0.37	0.00	0.00002	0.01	0.00	0.002	0.001
25-Sep-91			0.33	0.01	15,635	3.03	25.06	24.47	0.59	0.11	0.48	0.00	0.00003	0.01	0.01	0.002	0.002
26-Sep-91			0.30	0.00	1,943	0.38	3.11	3.04	0.07	0.01	0.06	0.00	0.00000	0.00	0.00	0.000	0.000
27-Sep-91			0.31	0.00	4,027	0.78	6.45	6.30	0.15	0.03	0.12	0.00	0.00001	0.00	0.00	0.001	0.000
28-Sep-91			0.30	0.00	1,597	0.31	2.56	2.50	0.06	0.01	0.05	0.00	0.00000	0.00	0.00	0.000	0.000
29-Sep-91			0.29	0.00	1,444	0.28	2.31	2.26	0.05	0.01	0.04	0.00	0.00000	0.00	0.00	0.000	0.000
30-Sep-91			0.29	0.00	854	0.17	1.37	1.34	0.03	0.01	0.03	0.00	0.00000	0.00	0.00	0.000	0.000
01-Oct-91			0.28	0.00	545	0.11	0.87	0.85	0.02	0.00	0.02	0.00	0.00000	0.00	0.00	0.000	0.000
02-Oct-91			0.28	0.00	612	0.12	0.98	0.96	0.02	0.00	0.02	0.00	0.00000	0.00	0.00	0.000	0.000
03-Oct-91			0.30	0.00	2,827	0.55	4.53	4.42	0.11	0.02	0.09	0.00	0.00000	0.00	0.00	0.000	0.000

Site #1 cont.

04-Oct-91			0.46	0.23	555,254	107.50	890.07	868.97	21.10	3.89	17.21	0.04	0.00096	0.25	0.18	0.080	0.055
05-Oct-91			0.59	0.57	1,394,279	269.93	2,235.03	2,182.05	52.98	9.76	43.22	0.09	0.00241	0.63	0.46	0.201	0.137
06-Oct-91			0.59	0.59	1,439,561	278.70	2,307.62	2,252.91	54.70	10.08	44.63	0.09	0.00249	0.65	0.48	0.207	0.142
07-Oct-91			0.59	0.59	1,439,561	278.70	2,307.62	2,252.91	54.70	10.08	44.63	0.09	0.00249	0.65	0.48	0.207	0.142
08-Oct-91			0.59	0.59	1,439,561	278.70	2,307.62	2,252.91	54.70	10.08	44.63	0.09	0.00249	0.65	0.48	0.207	0.142
09-Oct-91			0.59	0.58	1,430,426	276.93	2,292.97	2,238.62	54.36	10.01	44.34	0.09	0.00248	0.64	0.47	0.206	0.141
10-Oct-91			0.58	0.55	1,349,885	261.34	2,163.87	2,112.57	51.30	9.45	41.85	0.09	0.00234	0.61	0.45	0.194	0.133
11-Oct-91			0.58	0.54	1,332,343	257.94	2,135.75	2,085.12	50.63	9.33	41.30	0.09	0.00231	0.60	0.44	0.192	0.131
12-Oct-91			0.58	0.56	1,358,700	263.04	2,178.00	2,126.36	51.63	9.51	42.12	0.09	0.00235	0.61	0.45	0.196	0.134
13-Oct-91			0.54	0.43	1,061,211	205.45	1,701.12	1,660.80	40.33	7.43	32.90	0.07	0.00184	0.48	0.35	0.153	0.105
14-Oct-91			0.54	0.45	1,111,323	215.15	1,781.45	1,739.22	42.23	7.78	34.45	0.07	0.00192	0.50	0.37	0.160	0.109
15-Oct-91	1000	1	0.57	0.54	1,314,910	62.06	2,089.39	2,036.80	52.60	13.15	39.45	0.03	0.00044	0.13	0.57	0.142	0.089
					540,613,938	157,304	785,973	773,899	12,073	5,272	6,802	32.38	0.4749	188.97	301.19	82.28	54.54

Table E-2. Site #2 Daily Loads.

Daily Loads at Site #2 in Kilograms Per Day

DATE	TIME	STAGE	FLOW	DAILY FLOW	TALKAL KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	VOLATILE SOLIDS KG/DAY	FIXED SOLIDS KG/DAY	AMMON KG/DAY	UNIONIZED AMMON KG/DAY	NO3+2 KG/DAY	TKN KG/DAY	TPO4P KG/DAY	TOTAL DISS. PO4 KG/DAY
06-Mar-91	1330	1.50	0.15	377,138	77	398	396	2.26	2.26	0.00	0.01	0.00	0.08	0.13	0.02	0.01
07-Mar-91		1.54	0.17	422,135	100	535	533	1.69	1.48	0.21	0.01	0.00	0.06	0.19	0.04	0.02
08-Mar-91		1.57	0.19	471,301	112	597	595	1.89	1.65	0.24	0.01	0.00	0.07	0.21	0.04	0.02
09-Mar-91		1.60	0.21	524,917	125	665	663	2.10	1.84	0.26	0.01	0.00	0.08	0.24	0.04	0.02
10-Mar-91		1.64	0.24	583,275	139	739	737	2.33	2.04	0.29	0.01	0.00	0.09	0.27	0.05	0.02
11-Mar-91		1.67	0.26	646,680	154	820	817	2.59	2.26	0.32	0.02	0.00	0.10	0.29	0.05	0.02
12-Mar-91		1.71	0.29	715,449	170	907	904	2.86	2.50	0.36	0.02	0.00	0.11	0.33	0.06	0.03
13-Mar-91		1.74	0.32	789,911	188	1,001	998	3.16	2.76	0.39	0.02	0.00	0.12	0.36	0.07	0.03
14-Mar-91		1.78	0.36	870,411	207	1,103	1,100	3.48	3.05	0.44	0.02	0.00	0.13	0.40	0.07	0.03
15-Mar-91		1.81	0.39	957,303	228	1,213	1,210	3.83	3.35	0.48	0.02	0.00	0.14	0.44	0.08	0.04
16-Mar-91		1.85	0.43	1,050,958	250	1,332	1,328	4.20	3.68	0.53	0.03	0.00	0.16	0.48	0.09	0.04
17-Mar-91		1.88	0.47	1,151,758	274	1,460	1,455	4.61	4.03	0.58	0.03	0.00	0.17	0.52	0.10	0.04
18-Mar-91		1.92	0.52	1,260,101	300	1,597	1,592	5.04	4.41	0.63	0.03	0.00	0.19	0.57	0.11	0.05
19-Mar-91		1.95	0.56	1,376,399	328	1,745	1,739	5.51	4.82	0.69	0.03	0.00	0.21	0.63	0.12	0.05
20-Mar-91		1.99	0.61	1,501,077	357	1,903	1,897	6.00	5.25	0.75	0.04	0.00	0.23	0.68	0.13	0.06
21-Mar-91		2.02	0.67	1,634,575	389	2,072	2,065	6.54	5.72	0.82	0.04	0.00	0.25	0.74	0.14	0.06
22-Mar-91		2.06	0.73	1,777,349	423	2,253	2,246	7.11	6.22	0.89	0.04	0.00	0.27	0.81	0.15	0.07
23-Mar-91		2.09	0.79	1,929,870	459	2,446	2,438	7.72	6.75	0.96	0.05	0.00	0.29	0.88	0.16	0.07
24-Mar-91		2.13	0.86	2,092,622	498	2,652	2,644	8.37	7.32	1.05	0.05	0.00	0.31	0.95	0.18	0.08
25-Mar-91	1100	2.17	0.93	2,266,107	614	3,354	3,349	4.53	2.27	2.27	0.07	0.00	0.23	1.27	0.24	0.12
26-Mar-91		2.20	1.00	2,450,842	674	3,730	3,689	41.66	25.73	15.93	0.07	0.00	0.25	1.40	0.28	0.16
27-Mar-91		2.24	1.08	2,647,360	728	4,029	3,984	45.01	27.80	17.21	0.08	0.00	0.26	1.51	0.30	0.17
28-Mar-91		2.24	1.09	2,676,427	736	4,074	4,028	45.50	28.10	17.40	0.08	0.00	0.27	1.53	0.31	0.17
29-Mar-91		2.21	1.02	2,505,764	689	3,814	3,771	42.60	26.31	16.29	0.08	0.00	0.25	1.43	0.29	0.16
30-Mar-91		2.24	1.09	2,676,427	736	4,074	4,028	45.50	28.10	17.40	0.08	0.00	0.27	1.53	0.31	0.17
31-Mar-91		2.25	1.12	2,735,324	752	4,163	4,117	46.50	28.72	17.78	0.08	0.00	0.27	1.56	0.31	0.18
01-Apr-91		2.24	1.09	2,676,427	736	4,074	4,028	45.50	28.10	17.40	0.08	0.00	0.27	1.53	0.31	0.17
02-Apr-91		2.21	1.02	2,505,764	689	3,814	3,771	42.60	26.31	16.29	0.08	0.00	0.25	1.43	0.29	0.16
03-Apr-91		2.24	1.09	2,676,427	736	4,074	4,028	45.50	28.10	17.40	0.08	0.00	0.27	1.53	0.31	0.17
04-Apr-91		2.25	1.12	2,735,324	752	4,163	4,117	46.50	28.72	17.78	0.08	0.00	0.27	1.56	0.31	0.18
05-Apr-91		2.26	1.15	2,810,390	773	4,277	4,230	47.78	29.51	18.27	0.08	0.00	0.28	1.60	0.32	0.18
06-Apr-91		2.28	1.19	2,918,225	803	4,442	4,392	49.61	30.64	18.97	0.09	0.00	0.29	1.66	0.34	0.19
07-Apr-91		2.29	1.21	2,965,436	815	4,513	4,463	50.41	31.14	19.28	0.09	0.00	0.30	1.69	0.34	0.19
08-Apr-91		2.28	1.19	2,918,225	803	4,442	4,392	49.61	30.64	18.97	0.09	0.00	0.29	1.66	0.34	0.19
09-Apr-91		2.28	1.19	2,918,225	803	4,442	4,392	49.61	30.64	18.97	0.09	0.00	0.29	1.66	0.34	0.19
10-Apr-91		2.28	1.19	2,910,415	800	4,430	4,380	49.48	30.56	18.92	0.09	0.00	0.29	1.66	0.33	0.19
11-Apr-91		2.31	1.28	3,127,209	860	4,760	4,706	53.16	32.84	20.33	0.09	0.00	0.31	1.78	0.36	0.20
12-Apr-91		2.39	1.49	3,645,721	1,003	5,549	5,487	61.98	38.28	23.70	0.11	0.00	0.36	2.08	0.42	0.24
13-Apr-91		2.39	1.51	3,692,621	1,015	5,620	5,557	62.77	38.77	24.00	0.11	0.00	0.37	2.10	0.42	0.24
14-Apr-91		2.37	1.43	3,507,856	965	5,339	5,279	59.63	36.83	22.80	0.11	0.00	0.35	2.00	0.40	0.23
15-Apr-91	1120	2.36	1.40	3,418,274	954	5,346	5,237	109.38	68.37	41.02	0.10	0.00	0.34	1.98	0.42	0.26
16-Apr-91		2.35	1.38	3,374,170	909	5,129	5,011	118.10	33.74	84.35	0.15	0.00	0.34	2.23	0.47	0.23
17-Apr-91		2.35	1.37	3,356,656	905	5,102	4,985	117.48	33.57	83.92	0.15	0.00	0.34	2.22	0.47	0.23

Site #2 Continued

DATE	TIME	STAGE	FLOW	DAILY FLOW	TALKAL KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	VOLATILE SOLIDS KG/DAY	FIXED SOLIDS KG/DAY	AMMON KG/DAY	UNIONIZED AMMON KG/DAY	NO3+2 KG/DAY	TKN KG/DAY	TPO4P KG/DAY	TOTAL DISS. PO4 KG/DAY
18-Apr-91		2.36	1.40	3,436,043	926	5,223	5,103	120.26	34.36	85.90	0.15	0.00	0.34	2.27	0.48	0.24
19-Apr-91		2.36	1.42	3,462,834	933	5,264	5,142	121.20	34.63	86.57	0.16	0.00	0.35	2.29	0.49	0.24
20-Apr-91		2.35	1.38	3,374,170	909	5,129	5,011	118.10	33.74	84.35	0.15	0.00	0.34	2.23	0.47	0.23
21-Apr-91		2.34	1.34	3,278,735	884	4,984	4,869	114.76	32.79	81.97	0.15	0.00	0.33	2.16	0.46	0.23
22-Apr-91		2.34	1.35	3,313,187	893	5,036	4,920	115.96	33.13	82.83	0.15	0.00	0.33	2.19	0.47	0.23
23-Apr-91		2.34	1.35	3,295,925	888	5,010	4,894	115.36	32.96	82.40	0.15	0.00	0.33	2.18	0.46	0.23
24-Apr-91		2.33	1.33	3,261,616	879	4,958	4,843	114.16	32.62	81.54	0.15	0.00	0.33	2.15	0.46	0.23
25-Apr-91		2.32	1.30	3,177,085	856	4,829	4,718	111.20	31.77	79.43	0.14	0.00	0.32	2.10	0.45	0.22
26-Apr-91		2.34	1.35	3,313,187	893	5,036	4,920	115.96	33.13	82.83	0.15	0.00	0.33	2.19	0.47	0.23
27-Apr-91		2.39	1.51	3,692,621	995	5,613	5,484	129.24	36.93	92.32	0.17	0.00	0.37	2.44	0.52	0.26
28-Apr-91		2.40	1.52	3,711,515	1,000	5,642	5,512	129.90	37.12	92.79	0.17	0.00	0.37	2.45	0.52	0.26
29-Apr-91	1100	2.41	1.57	3,836,208	899	5,012	4,890	122.28	45.08	77.20	0.29	0.00	0.34	2.33	0.58	0.29
30-Apr-91		2.45	1.70	4,147,028	827	4,533	4,413	119.23	55.98	63.24	0.44	0.00	0.31	2.30	0.67	0.35
01-May-91		2.43	1.62	3,954,245	788	4,322	4,208	113.68	53.38	60.30	0.42	0.00	0.30	2.19	0.64	0.33
02-May-91		2.41	1.55	3,787,861	755	4,140	4,031	108.90	51.14	57.76	0.40	0.00	0.28	2.10	0.61	0.32
03-May-91		2.47	1.78	4,347,214	867	4,752	4,627	124.98	58.69	66.30	0.46	0.00	0.33	2.41	0.70	0.36
04-May-91	945	2.54	2.04	4,982,316	1,315	7,105	6,905	199.29	109.61	89.68	0.95	0.01	0.50	3.89	1.27	0.66
05-May-91		2.44	1.66	4,054,800	1,141	6,506	6,271	235.18	81.10	154.08	1.68	0.02	2.03	5.21	1.36	0.62
06-May-91		2.41	1.55	3,787,861	1,066	6,078	5,858	219.70	75.76	143.94	1.57	0.02	1.89	4.87	1.27	0.58
07-May-91		2.41	1.56	3,807,141	1,072	6,109	5,888	220.81	76.14	144.67	1.58	0.02	1.90	4.89	1.28	0.58
08-May-91		2.43	1.62	3,974,196	1,119	6,377	6,146	230.50	79.48	151.02	1.65	0.02	1.99	5.11	1.33	0.61
09-May-91		2.45	1.70	4,167,748	1,173	6,687	6,445	241.73	83.35	158.37	1.73	0.03	2.08	5.36	1.40	0.64
10-May-91		2.44	1.65	4,034,528	1,136	6,473	6,239	234.00	80.69	153.31	1.67	0.02	2.02	5.18	1.35	0.62
11-May-91		2.42	1.60	3,914,583	1,102	6,281	6,054	227.05	78.29	148.75	1.62	0.02	1.96	5.03	1.31	0.60
12-May-91		2.43	1.62	3,974,196	1,119	6,377	6,146	230.50	79.48	151.02	1.65	0.02	1.99	5.11	1.33	0.61
13-May-91		2.43	1.61	3,944,300	1,110	6,329	6,100	228.77	78.89	149.88	1.64	0.02	1.97	5.07	1.32	0.60
14-May-91		2.45	1.68	4,116,102	1,159	6,604	6,366	238.73	82.32	156.41	1.71	0.02	2.06	5.29	1.38	0.63
15-May-91		3.37	8.09	19,792,801	5,572	31,758	30,610	1,147.98	395.86	752.13	8.21	0.12	9.90	25.43	6.64	3.02
16-May-91		2.07	0.75	1,836,079	517	2,946	2,839	106.49	36.72	69.77	0.76	0.01	0.92	2.36	0.62	0.28
17-May-91		1.99	0.61	1,501,077	423	2,408	2,321	87.06	30.02	57.04	0.62	0.01	0.75	1.93	0.50	0.23
18-May-91		2.16	0.91	2,234,317	629	3,585	3,455	129.59	44.69	84.90	0.93	0.01	1.12	2.87	0.75	0.34
19-May-91		2.19	0.97	2,383,540	671	3,824	3,686	138.25	47.67	90.57	0.99	0.01	1.19	3.06	0.80	0.36
20-May-91		2.39	1.50	3,664,424	1,032	5,880	5,667	212.54	73.29	139.25	1.52	0.02	1.83	4.71	1.23	0.56
21-May-91		2.45	1.70	4,147,028	1,167	6,654	6,413	240.53	82.94	157.59	1.72	0.03	2.07	5.33	1.39	0.63
22-May-91		2.46	1.73	4,230,403	1,191	6,788	6,542	245.36	84.61	160.76	1.76	0.03	2.12	5.44	1.42	0.65
23-May-91		2.47	1.76	4,293,804	1,209	6,889	6,640	249.04	85.88	163.16	1.78	0.03	2.15	5.52	1.44	0.65
24-May-91		2.52	1.95	4,770,631	1,343	7,654	7,378	276.70	95.41	181.28	1.98	0.03	2.39	6.13	1.60	0.73
25-May-91		2.47	1.77	4,336,490	1,221	6,958	6,706	251.52	86.73	164.79	1.80	0.03	2.17	5.57	1.45	0.66
26-May-91		2.49	1.82	4,455,618	1,254	7,149	6,891	258.43	89.11	169.31	1.85	0.03	2.23	5.73	1.49	0.68
27-May-91		2.54	2.00	4,899,124	1,379	7,861	7,576	284.15	97.98	186.17	2.03	0.03	2.45	6.30	1.64	0.75
28-May-91		2.54	2.02	4,946,526	1,392	7,937	7,650	286.90	98.93	187.97	2.05	0.03	2.47	6.36	1.66	0.75
29-May-91		2.55	2.08	5,078,764	1,430	8,149	7,854	294.57	101.58	192.99	2.11	0.03	2.54	6.53	1.70	0.77
30-May-91		2.56	2.08	5,090,923	1,433	8,168	7,873	295.27	101.82	193.46	2.11	0.03	2.55	6.54	1.71	0.78
31-May-91		2.46	1.73	4,230,403	1,191	6,788	6,542	245.36	84.61	160.76	1.76	0.03	2.12	5.44	1.42	0.65
01-Jun-91		2.10	0.80	1,958,168	551	3,142	3,028	113.57	39.16	74.41	0.81	0.01	0.98	2.52	0.66	0.30

Site #2 Continued

DATE	TIME	STAGE	FLOW	DAILY FLOW	TALKAL KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	VOLATILE SOLIDS KG/DAY	FIXED SOLIDS KG/DAY	AMMON KG/DAY	UNIONIZED AMMON KG/DAY	NO3+2 KG/DAY	TKN KG/DAY	TPO4P KG/DAY	TOTAL DISS. PO4 KG/DAY
02-Jun-91		2.13	0.86	2,098,630	591	3,367	3,246	121.72	41.97	79.75	0.87	0.01	1.05	2.70	0.70	0.32
03-Jun-91		2.32	1.29	3,160,390	890	5,071	4,888	183.30	63.21	120.09	1.31	0.02	1.58	4.06	1.06	0.48
04-Jun-91		2.45	1.70	4,147,028	1,167	6,654	6,413	240.53	82.94	157.59	1.72	0.03	2.07	5.33	1.39	0.63
05-Jun-91		2.62	2.35	5,742,483	1,617	9,214	8,881	333.06	114.85	218.21	2.38	0.03	2.87	7.38	1.93	0.88
06-Jun-91		2.49	1.83	4,477,555	1,260	7,184	6,925	259.70	89.55	170.15	1.86	0.03	2.24	5.75	1.50	0.68
07-Jun-91		2.41	1.56	3,807,141	1,072	6,109	5,888	220.81	76.14	144.67	1.58	0.02	1.90	4.89	1.28	0.58
08-Jun-91		2.35	1.38	3,374,170	950	5,414	5,218	195.70	67.48	128.22	1.40	0.02	1.69	4.34	1.13	0.51
09-Jun-91		2.33	1.33	3,253,083	916	5,220	5,031	188.68	65.06	123.62	1.35	0.02	1.63	4.18	1.09	0.50
10-Jun-91		2.36	1.42	3,462,834	975	5,556	5,355	200.84	69.26	131.59	1.44	0.02	1.73	4.45	1.16	0.53
11-Jun-91		2.34	1.36	3,339,214	940	5,358	5,164	193.67	66.78	126.89	1.39	0.02	1.67	4.29	1.12	0.51
12-Jun-91		2.32	1.30	3,168,729	892	5,084	4,900	183.79	63.37	120.41	1.32	0.02	1.58	4.07	1.06	0.48
13-Jun-91	930	2.41	1.55	3,787,861	1,133	6,754	6,466	287.88	68.18	219.70	2.42	0.07	3.41	6.78	1.58	0.66
14-Jun-91		2.32	1.30	3,177,085	742	5,309	5,071	238.28	60.36	177.92	1.05	0.04	2.38	4.72	1.51	0.40
15-Jun-91		2.31	1.28	3,127,209	730	5,226	4,991	234.54	59.42	175.12	1.03	0.04	2.35	4.64	1.48	0.40
16-Jun-91		2.25	1.12	2,735,324	639	4,571	4,366	205.15	51.97	153.18	0.90	0.04	2.05	4.06	1.30	0.35
17-Jun-91		2.22	1.04	2,540,584	593	4,245	4,055	190.54	48.27	142.27	0.84	0.03	1.91	3.77	1.21	0.32
18-Jun-91		2.18	0.97	2,363,639	552	3,950	3,772	177.27	44.91	132.36	0.78	0.03	1.77	3.51	1.12	0.30
19-Jun-91		2.17	0.93	2,272,508	531	3,797	3,627	170.44	43.18	127.26	0.75	0.03	1.70	3.37	1.08	0.29
20-Jun-91		2.15	0.90	2,202,884	514	3,681	3,516	165.22	41.85	123.36	0.73	0.03	1.65	3.27	1.05	0.28
21-Jun-91		2.16	0.92	2,240,647	523	3,744	3,576	168.05	42.57	125.48	0.74	0.03	1.68	3.33	1.06	0.28
22-Jun-91		2.16	0.91	2,228,002	520	3,723	3,556	167.10	42.33	124.77	0.74	0.03	1.67	3.31	1.06	0.28
23-Jun-91		2.17	0.94	2,304,728	538	3,851	3,678	172.85	43.79	129.06	0.76	0.03	1.73	3.42	1.09	0.29
24-Jun-91		2.16	0.92	2,240,647	523	3,744	3,576	168.05	42.57	125.48	0.74	0.03	1.68	3.33	1.06	0.28
25-Jun-91		2.14	0.88	2,159,468	504	3,608	3,447	161.96	41.03	120.93	0.71	0.03	1.62	3.21	1.02	0.27
26-Jun-91		2.15	0.90	2,196,639	513	3,671	3,506	164.75	41.74	123.01	0.72	0.03	1.65	3.26	1.04	0.28
27-Jun-91		2.14	0.87	2,134,967	499	3,568	3,407	160.12	40.56	119.56	0.70	0.03	1.60	3.17	1.01	0.27
28-Jun-91		2.12	0.84	2,050,947	479	3,427	3,273	153.82	38.97	114.85	0.68	0.03	1.54	3.05	0.97	0.26
29-Jun-91		2.15	0.89	2,184,193	510	3,650	3,486	163.81	41.50	122.31	0.72	0.03	1.64	3.24	1.04	0.28
30-Jun-91		2.15	0.90	2,190,409	511	3,660	3,496	164.28	41.62	122.66	0.72	0.03	1.64	3.25	1.04	0.28
01-Jul-91		2.17	0.93	2,285,352	534	3,819	3,647	171.40	43.42	127.98	0.75	0.03	1.71	3.39	1.08	0.29
02-Jul-91		2.14	0.88	2,147,190	501	3,588	3,427	161.04	40.80	120.24	0.71	0.03	1.61	3.19	1.02	0.27
03-Jul-91		2.16	0.92	2,240,647	523	3,744	3,576	168.05	42.57	125.48	0.74	0.03	1.68	3.33	1.06	0.28
04-Jul-91		2.19	0.99	2,417,005	564	4,039	3,858	181.28	45.92	135.35	0.80	0.03	1.81	3.59	1.15	0.31
05-Jul-91		2.20	0.99	2,423,742	566	4,050	3,868	181.78	46.05	135.73	0.80	0.03	1.82	3.60	1.15	0.31
06-Jul-91		2.22	1.04	2,540,584	593	4,245	4,055	190.54	48.27	142.27	0.84	0.03	1.91	3.77	1.21	0.32
07-Jul-91		2.26	1.13	2,765,157	646	4,621	4,413	207.39	52.54	154.85	0.91	0.04	2.07	4.11	1.31	0.35
08-Jul-91	1020	2.16	0.92	2,240,647	376	3,493	3,327	165.81	44.81	120.99	0.04	0.00	1.34	2.64	1.19	0.18
09-Jul-91		2.20	1.01	2,464,482	520	3,997	3,830	167.58	51.75	115.83	0.55	0.02	1.85	2.93	1.02	0.22
10-Jul-91		2.26	1.14	2,780,170	587	4,509	4,320	189.05	58.38	130.67	0.63	0.03	2.09	3.31	1.15	0.25
11-Jul-91		2.32	1.29	3,152,069	665	5,113	4,898	214.34	66.19	148.15	0.71	0.03	2.36	3.75	1.30	0.28
12-Jul-91		2.33	1.32	3,236,071	683	5,249	5,029	220.05	67.96	152.10	0.73	0.03	2.43	3.85	1.34	0.29
13-Jul-91		2.31	1.27	3,102,506	655	5,032	4,821	210.97	65.15	145.82	0.70	0.03	2.33	3.69	1.28	0.28
14-Jul-91		2.28	1.20	2,933,895	619	4,759	4,559	199.50	61.61	137.89	0.66	0.03	2.20	3.49	1.21	0.26
15-Jul-91		2.28	1.19	2,902,622	612	4,708	4,511	197.38	60.96	136.42	0.65	0.03	2.18	3.45	1.20	0.26
16-Jul-91		2.25	1.12	2,742,758	579	4,449	4,262	186.51	57.60	128.91	0.62	0.03	2.06	3.26	1.13	0.25

Site #2 Continued

DATE	TIME	STAGE	FLOW	DAILY FLOW	TALKAL KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	VOLATILE SOLIDS KG/DAY	FIXED SOLIDS KG/DAY	AMMON KG/DAY	UNIONIZED AMMON KG/DAY	NO3+2 KG/DAY	TKN KG/DAY	TPO4P KG/DAY	TOTAL DISS. PO4 KG/DAY
17-Jul-91		2.23	1.06	2,604,229	549	4,224	4,047	177.09	54.69	122.40	0.59	0.03	1.95	3.10	1.08	0.23
18-Jul-91		2.19	0.99	2,410,282	509	3,909	3,746	163.90	50.62	113.28	0.54	0.02	1.81	2.87	1.00	0.22
19-Jul-91		2.20	1.01	2,464,482	520	3,997	3,830	167.58	51.75	115.83	0.55	0.02	1.85	2.93	1.02	0.22
20-Jul-91		2.21	1.01	2,478,182	523	4,020	3,851	168.52	52.04	116.47	0.56	0.02	1.86	2.95	1.02	0.22
21-Jul-91		2.29	1.21	2,957,525	624	4,797	4,596	201.11	62.11	139.00	0.67	0.03	2.22	3.52	1.22	0.26
22-Jul-91		2.32	1.31	3,202,259	676	5,194	4,976	217.75	67.25	150.51	0.72	0.03	2.40	3.81	1.32	0.29
23-Jul-91		2.34	1.36	3,321,845	701	5,388	5,162	225.89	69.76	156.13	0.75	0.03	2.49	3.95	1.37	0.30
24-Jul-91		2.29	1.22	2,981,307	629	4,836	4,633	202.73	62.61	140.12	0.67	0.03	2.24	3.55	1.23	0.27
25-Jul-91		2.26	1.13	2,765,157	583	4,485	4,297	188.03	58.07	129.96	0.62	0.03	2.07	3.29	1.14	0.25
26-Jul-91		2.26	1.13	2,772,655	585	4,497	4,309	188.54	58.23	130.31	0.62	0.03	2.08	3.30	1.15	0.25
27-Jul-91		2.27	1.15	2,825,598	596	4,583	4,391	192.14	59.34	132.80	0.64	0.03	2.12	3.36	1.17	0.25
28-Jul-91		2.29	1.22	2,989,268	631	4,849	4,645	203.27	62.77	140.50	0.67	0.03	2.24	3.56	1.24	0.27
29-Jul-91		2.28	1.19	2,910,415	614	4,721	4,523	197.91	61.12	136.79	0.65	0.03	2.18	3.46	1.20	0.26
30-Jul-91		2.26	1.14	2,780,170	587	4,509	4,320	189.05	58.38	130.67	0.63	0.03	2.09	3.31	1.15	0.25
31-Jul-91		2.28	1.19	2,918,225	616	4,733	4,535	198.44	61.28	137.16	0.66	0.03	2.19	3.47	1.21	0.26
01-Aug-91		2.26	1.15	2,802,811	591	4,546	4,356	190.59	58.86	131.73	0.63	0.03	2.10	3.34	1.16	0.25
02-Aug-91		2.26	1.15	2,802,811	591	4,546	4,356	190.59	58.86	131.73	0.63	0.03	2.10	3.34	1.16	0.25
03-Aug-91		2.26	1.14	2,780,170	587	4,509	4,320	189.05	58.38	130.67	0.63	0.03	2.09	3.31	1.15	0.25
04-Aug-91		2.27	1.17	2,856,210	603	4,633	4,439	194.22	59.98	134.24	0.64	0.03	2.14	3.40	1.18	0.26
05-Aug-91		2.27	1.17	2,856,210	603	4,633	4,439	194.22	59.98	134.24	0.64	0.03	2.14	3.40	1.18	0.26
06-Aug-91		2.26	1.13	2,765,157	583	4,485	4,297	188.03	58.07	129.96	0.62	0.03	2.07	3.29	1.14	0.25
07-Aug-91		2.29	1.21	2,957,525	624	4,797	4,596	201.11	62.11	139.00	0.67	0.03	2.22	3.52	1.22	0.26
08-Aug-91		2.28	1.18	2,887,085	609	4,683	4,487	196.32	60.63	135.69	0.65	0.03	2.17	3.44	1.19	0.26
09-Aug-91		2.33	1.33	3,244,568	685	5,263	5,042	220.63	68.14	152.49	0.73	0.03	2.43	3.86	1.34	0.29
10-Aug-91		2.32	1.29	3,160,390	667	5,126	4,911	214.91	66.37	148.54	0.71	0.03	2.37	3.76	1.31	0.28
11-Aug-91		2.26	1.14	2,787,700	588	4,522	4,332	189.56	58.54	131.02	0.63	0.03	2.09	3.32	1.15	0.25
12-Aug-91	1015	2.23	1.08	2,632,920	556	4,271	4,092	179.04	55.29	123.75	0.59	0.03	1.97	3.13	1.09	0.24
13-Aug-91		2.24	1.09	2,654,603	560	4,306	4,125	180.51	55.75	124.77	0.60	0.03	1.99	3.16	1.10	0.24
14-Aug-91		2.26	1.15	2,802,811	591	4,546	4,356	190.59	58.86	131.73	0.63	0.03	2.10	3.34	1.16	0.25
15-Aug-91		2.25	1.13	2,757,674	582	4,473	4,285	187.52	57.91	129.61	0.62	0.03	2.07	3.28	1.14	0.25
16-Aug-91		2.29	1.21	2,957,525	624	4,797	4,596	201.11	62.11	139.00	0.67	0.03	2.22	3.52	1.22	0.26
17-Aug-91		2.29	1.23	3,005,240	634	4,874	4,670	204.36	63.11	141.25	0.68	0.03	2.25	3.58	1.24	0.27
18-Aug-91		2.38	1.47	3,590,067	758	5,823	5,579	244.12	75.39	168.73	0.81	0.04	2.69	4.27	1.48	0.32
19-Aug-91		2.39	1.50	3,664,424	773	5,944	5,695	249.18	76.95	172.23	0.82	0.04	2.75	4.36	1.52	0.33
20-Aug-91		2.26	1.15	2,810,390	593	4,558	4,367	191.11	59.02	132.09	0.63	0.03	2.11	3.34	1.16	0.25
21-Aug-91		2.24	1.10	2,691,056	568	4,365	4,182	182.99	56.51	126.48	0.61	0.03	2.02	3.20	1.11	0.24
22-Aug-91		2.22	1.05	2,575,788	543	4,178	4,003	175.15	54.09	121.06	0.58	0.03	1.93	3.07	1.07	0.23
23-Aug-91		2.18	0.97	2,363,639	499	3,834	3,673	160.73	49.64	111.09	0.53	0.02	1.77	2.81	0.98	0.21
24-Aug-91		2.10	0.80	1,963,867	414	3,185	3,052	133.54	41.24	92.30	0.44	0.02	1.47	2.34	0.81	0.18
25-Aug-91		2.00	0.63	1,552,446	328	2,518	2,413	105.57	32.60	72.96	0.35	0.02	1.16	1.85	0.64	0.14
26-Aug-91		1.98	0.60	1,473,633	311	2,390	2,290	100.21	30.95	69.26	0.33	0.01	1.11	1.75	0.61	0.13
27-Aug-91		1.75	0.32	789,911	167	1,281	1,228	53.71	16.59	37.13	0.18	0.01	0.59	0.94	0.33	0.07
28-Aug-91		1.48	0.14	348,842	74	566	542	23.72	7.33	16.40	0.08	0.00	0.26	0.42	0.14	0.03
29-Aug-91		1.36	0.09	229,479	48	372	357	15.60	4.82	10.79	0.05	0.00	0.17	0.27	0.09	0.02

Site #2 Continued

DATE	TIME	STAGE	FLOW	DAILY FLOW	TALKAL KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	VOLATILE SOLIDS KG/DAY	FIXED SOLIDS KG/DAY	AMMON KG/DAY	UNIONIZED AMMON KG/DAY	NO3+2 KG/DAY	TKN KG/DAY	TPO4P KG/DAY	TOTAL DISS. PO4 KG/DAY
30-Aug-91		1.24	0.06	145,862	31	237	227	9.92	3.06	6.86	0.03	0.00	0.11	0.17	0.06	0.01
31-Aug-91		1.14	0.04	97,068	20	157	151	6.60	2.04	4.56	0.02	0.00	0.07	0.12	0.04	0.01
01-Sep-91		1.07	0.03	71,962	15	117	112	4.89	1.51	3.38	0.02	0.00	0.05	0.09	0.03	0.01
02-Sep-91		1.01	0.02	55,587	12	90	86	3.78	1.17	2.61	0.01	0.00	0.04	0.07	0.02	0.00
03-Sep-91		0.96	0.02	42,056	9	68	65	2.86	0.88	1.98	0.01	0.00	0.03	0.05	0.02	0.00
04-Sep-91		0.89	0.01	28,821	6	47	45	1.96	0.61	1.35	0.01	0.00	0.02	0.03	0.01	0.00
05-Sep-91		0.84	0.01	22,668	5	37	35	1.54	0.48	1.07	0.01	0.00	0.02	0.03	0.01	0.00
06-Sep-91		0.91	0.01	31,926	7	52	50	2.17	0.67	1.50	0.01	0.00	0.02	0.04	0.01	0.00
07-Sep-91		0.92	0.01	33,687	7	55	52	2.29	0.71	1.58	0.01	0.00	0.03	0.04	0.01	0.00
08-Sep-91		0.89	0.01	29,221	6	47	45	1.99	0.61	1.37	0.01	0.00	0.02	0.03	0.01	0.00
09-Sep-91		0.91	0.01	32,359	7	52	50	2.20	0.68	1.52	0.01	0.00	0.02	0.04	0.01	0.00
10-Sep-91		0.84	0.01	22,019	5	36	34	1.50	0.46	1.03	0.00	0.00	0.02	0.03	0.01	0.00
11-Sep-91		0.87	0.01	25,962	5	42	40	1.77	0.55	1.22	0.01	0.00	0.02	0.03	0.01	0.00
12-Sep-91		1.47	0.14	336,042	71	545	522	22.85	7.06	15.79	0.08	0.00	0.25	0.40	0.14	0.03
13-Sep-91		2.30	1.25	3,053,565	644	4,953	4,745	207.64	64.12	143.52	0.69	0.03	2.29	3.63	1.26	0.27
14-Sep-91		2.36	1.41	3,453,885	729	5,602	5,367	234.86	72.53	162.33	0.78	0.03	2.59	4.11	1.43	0.31
15-Sep-91		2.35	1.37	3,356,656	708	5,444	5,216	228.25	70.49	157.76	0.76	0.03	2.52	3.99	1.39	0.30
16-Sep-91		2.30	1.24	3,037,389	641	4,927	4,720	206.54	63.79	142.76	0.68	0.03	2.28	3.61	1.26	0.27
17-Sep-91		2.27	1.17	2,856,210	603	4,633	4,439	194.22	59.98	134.24	0.64	0.03	2.14	3.40	1.18	0.26
18-Sep-91		2.32	1.30	3,185,459	672	5,167	4,950	216.61	66.89	149.72	0.72	0.03	2.39	3.79	1.32	0.29
19-Sep-91		2.34	1.35	3,313,187	699	5,374	5,149	225.30	69.58	155.72	0.75	0.03	2.48	3.94	1.37	0.30
20-Sep-91		2.36	1.42	3,471,802	733	5,631	5,395	236.08	72.91	163.17	0.78	0.03	2.60	4.13	1.44	0.31
21-Sep-91		2.39	1.51	3,683,203	777	5,974	5,724	250.46	77.35	173.11	0.83	0.04	2.76	4.38	1.52	0.33
22-Sep-91		2.40	1.54	3,768,659	795	6,113	5,856	256.27	79.14	177.13	0.85	0.04	2.83	4.48	1.56	0.34
23-Sep-91		2.40	1.53	3,749,534	791	6,082	5,827	254.97	78.74	176.23	0.84	0.04	2.81	4.46	1.55	0.34
24-Sep-91		2.43	1.61	3,944,300	832	6,398	6,129	268.21	82.83	185.38	0.89	0.04	2.96	4.69	1.63	0.35
25-Sep-91		2.47	1.75	4,283,185	904	6,947	6,656	291.26	89.95	201.31	0.96	0.04	3.21	5.10	1.77	0.38
26-Sep-91		2.47	1.76	4,315,105	910	6,999	6,706	293.43	90.62	202.81	0.97	0.04	3.24	5.13	1.78	0.39
27-Sep-91		2.47	1.77	4,336,490	915	7,034	6,739	294.88	91.07	203.82	0.98	0.04	3.25	5.16	1.79	0.39
28-Sep-91		2.50	1.86	4,555,010	961	7,388	7,078	309.74	95.66	214.09	1.02	0.05	3.42	5.42	1.88	0.41
29-Sep-91		2.50	1.87	4,577,335	966	7,424	7,113	311.26	96.12	215.13	1.03	0.05	3.43	5.45	1.89	0.41
30-Sep-91		2.50	1.87	4,577,335	966	7,424	7,113	311.26	96.12	215.13	1.03	0.05	3.43	5.45	1.89	0.41
01-Oct-91		2.53	1.97	4,817,042	1,016	7,813	7,486	327.56	101.16	226.40	1.08	0.05	3.61	5.73	1.99	0.43
02-Oct-91		2.55	2.06	5,030,356	1,061	8,159	7,817	342.06	105.64	236.43	1.13	0.05	3.77	5.99	2.08	0.45
03-Oct-91		2.58	2.20	5,377,049	1,135	8,722	8,356	365.64	112.92	252.72	1.21	0.05	4.03	6.40	2.22	0.48
04-Oct-91		2.63	2.41	5,891,336	1,243	9,556	9,155	400.61	123.72	276.89	1.33	0.06	4.42	7.01	2.44	0.53
05-Oct-91		2.66	2.55	6,241,064	1,317	10,123	9,699	424.39	131.06	293.33	1.40	0.06	4.68	7.43	2.58	0.56
06-Oct-91		2.67	2.59	6,327,405	1,335	10,263	9,833	430.26	132.88	297.39	1.42	0.06	4.75	7.53	2.62	0.57
07-Oct-91		2.67	2.57	6,284,117	1,326	10,193	9,766	427.32	131.97	295.35	1.41	0.06	4.71	7.48	2.60	0.56
08-Oct-91		2.67	2.57	6,298,520	1,329	10,216	9,788	428.30	132.27	296.03	1.42	0.06	4.72	7.50	2.60	0.56
09-Oct-91		2.67	2.57	6,284,117	1,326	10,193	9,766	427.32	131.97	295.35	1.41	0.06	4.71	7.48	2.60	0.56
10-Oct-91		2.67	2.60	6,356,396	1,341	10,310	9,878	432.23	133.48	298.75	1.43	0.06	4.77	7.56	2.63	0.57
11-Oct-91		2.68	2.63	6,429,335	1,357	10,428	9,991	437.19	135.02	302.18	1.45	0.06	4.82	7.65	2.66	0.58
12-Oct-91		2.70	2.71	6,622,096	1,397	10,741	10,291	450.30	139.06	311.24	1.49	0.07	4.97	7.88	2.74	0.59
13-Oct-91		2.70	2.74	6,712,598	1,416	10,888	10,431	456.46	140.96	315.49	1.51	0.07	5.03	7.99	2.78	0.60

Site #2 Continued

DATE	TIME	STAGE	FLOW	DAILY FLOW	TALKAL KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	VOLATILE SOLIDS KG/DAY	FIXED SOLIDS KG/DAY	AMMON KG/DAY	UNIONIZED AMMON KG/DAY	NO3+2 KG/DAY	TKN KG/DAY	TPO4P KG/DAY	TOTAL DISS. PO4 KG/DAY
14-Oct-91		2.72	2.83	6,912,064	1,458	11,211	10,741	470.02	145.15	324.87	1.56	0.07	5.18	8.23	2.86	0.62
15-Oct-91		2.73	2.89	7,068,683	1,491	11,465	10,985	480.67	148.44	332.23	1.59	0.07	5.30	8.41	2.92	0.63
16-Oct-91		2.73	2.89	7,068,683	1,491	11,465	10,985	480.67	148.44	332.23	1.59	0.07	5.30	8.41	2.92	0.63
17-Oct-91		2.73	2.87	7,021,404	1,482	11,389	10,911	477.46	147.45	330.01	1.58	0.07	5.27	8.36	2.90	0.63
18-Oct-91		2.73	2.90	7,084,498	1,495	11,491	11,009	481.75	148.77	332.97	1.59	0.07	5.31	8.43	2.93	0.63
19-Oct-91		2.73	2.85	6,974,376	1,472	11,312	10,838	474.26	146.46	327.80	1.57	0.07	5.23	8.30	2.88	0.62
20-Oct-91		2.75	2.97	7,276,493	1,535	11,802	11,308	494.80	152.81	342.00	1.64	0.07	5.46	8.66	3.01	0.65
21-Oct-91		2.77	3.07	7,505,693	1,584	12,174	11,664	510.39	157.62	352.77	1.69	0.07	5.63	8.93	3.10	0.67
22-Oct-91		2.78	3.12	7,639,220	1,612	12,391	11,871	519.47	160.42	359.04	1.72	0.08	5.73	9.09	3.16	0.68
23-Oct-91		2.76	3.03	7,406,772	1,563	12,014	11,510	503.66	155.54	348.12	1.67	0.07	5.56	8.81	3.06	0.66
24-Oct-91		2.77	3.10	7,588,928	1,601	12,309	11,793	516.05	159.37	356.68	1.71	0.07	5.69	9.03	3.14	0.68
25-Oct-91		2.78	3.14	7,672,895	1,619	12,445	11,924	521.76	161.13	360.63	1.73	0.08	5.75	9.13	3.17	0.69
26-Oct-91		2.80	3.23	7,894,671	1,666	12,805	12,268	536.84	165.79	371.05	1.78	0.08	5.92	9.39	3.26	0.71
27-Oct-91		2.80	3.25	7,946,567	1,677	12,889	12,349	540.37	166.88	373.49	1.79	0.08	5.96	9.46	3.29	0.71
28-Oct-91		2.82	3.34	8,174,594	1,725	13,259	12,703	555.87	171.67	384.21	1.84	0.08	6.13	9.73	3.38	0.73
29-Oct-91		2.82	3.39	8,299,515	1,751	13,462	12,897	564.37	174.29	390.08	1.87	0.08	6.22	9.88	3.43	0.74
				784,636,701	185,954	1,244,311	1,199,020	45,291	14,543	30,748	187.76	5.88	449.16	876.32	272.00	79.52

Table E-3, Site #3 Daily Loads.

Daily Loads at Site #3 in Kilograms Per Day

DATE	TIME	STAGE	FLOW	DAILY FLOW	TALKAL	TSOL	TDSOL	TSSOL	VOLATILE SOLIDS	FIXED SOLIDS	AMMON	UNIONIZED AMMONIA	NO3+2	TKN-N	TPO4P	TOTAL DISS. PO
06-Mar-91	1400	0.40	1.79	4,378,726	828	4,589	4,576	13	13	0	0.09	0.0008	0.44	1.18	0.21	0.09
07-Mar-91		0.42	1.83	4,476,415	938	5,354	5,311	43	34	9	0.09	0.0013	0.45	1.54	0.29	0.17
08-Mar-91		0.43	1.87	4,572,518	958	5,469	5,425	43	34	9	0.09	0.0013	0.46	1.58	0.29	0.17
09-Mar-91		0.45	1.91	4,667,119	978	5,582	5,538	44	35	9	0.09	0.0014	0.47	1.61	0.30	0.17
10-Mar-91		0.46	1.95	4,760,292	997	5,693	5,648	45	36	10	0.10	0.0014	0.48	1.64	0.30	0.18
11-Mar-91		0.48	1.98	4,852,107	1,017	5,803	5,757	46	36	10	0.10	0.0014	0.49	1.67	0.31	0.18
12-Mar-91		0.49	2.02	4,942,627	1,035	5,911	5,864	47	37	10	0.10	0.0014	0.49	1.71	0.32	0.18
13-Mar-91		0.51	2.06	5,031,911	1,054	6,018	5,970	48	38	10	0.10	0.0015	0.50	1.74	0.32	0.19
14-Mar-91		0.53	2.09	5,120,014	1,073	6,124	6,075	49	38	10	0.10	0.0015	0.51	1.77	0.33	0.19
15-Mar-91		0.54	2.13	5,206,985	1,091	6,228	6,178	49	39	10	0.10	0.0015	0.52	1.80	0.33	0.19
16-Mar-91		0.56	2.16	5,292,873	1,109	6,330	6,280	50	40	11	0.11	0.0015	0.53	1.83	0.34	0.20
17-Mar-91		0.57	2.20	5,377,719	1,127	6,432	6,381	51	40	11	0.11	0.0016	0.54	1.86	0.34	0.20
18-Mar-91		0.59	2.23	5,461,566	1,144	6,532	6,480	52	41	11	0.11	0.0016	0.55	1.88	0.35	0.20
19-Mar-91		0.61	2.27	5,544,451	1,162	6,631	6,578	53	42	11	0.11	0.0016	0.55	1.91	0.35	0.21
20-Mar-91		0.62	2.30	5,626,410	1,179	6,729	6,676	53	42	11	0.11	0.0016	0.56	1.94	0.36	0.21
21-Mar-91		0.64	2.33	5,707,476	1,196	6,826	6,772	54	43	11	0.11	0.0017	0.57	1.97	0.37	0.21
22-Mar-91		0.65	2.37	5,787,682	1,213	6,922	6,867	55	43	12	0.12	0.0017	0.58	2.00	0.37	0.21
23-Mar-91		0.67	2.40	5,867,056	1,229	7,017	6,961	56	44	12	0.12	0.0017	0.59	2.02	0.38	0.22
24-Mar-91		0.68	2.43	5,945,627	1,246	7,111	7,054	56	45	12	0.12	0.0017	0.59	2.05	0.38	0.22
25-Mar-91	1215	0.70	2.46	6,022,440	1,385	8,094	7,998	96	72	24	0.12	0.0024	0.60	2.53	0.49	0.33
26-Mar-91		0.66	2.38	5,815,405	1,439	8,421	8,147	273	76	198	0.15	0.0021	0.58	2.88	0.70	0.26
27-Mar-91		0.62	2.29	5,611,435	1,389	8,125	7,862	264	73	191	0.14	0.0020	0.56	2.78	0.67	0.25
28-Mar-91		0.58	2.21	5,401,700	1,337	7,822	7,568	254	70	184	0.14	0.0019	0.54	2.67	0.65	0.24
29-Mar-91		0.54	2.12	5,185,620	1,283	7,509	7,265	244	67	176	0.13	0.0019	0.52	2.57	0.62	0.23
30-Mar-91		0.50	2.03	4,962,510	1,228	7,186	6,952	233	65	169	0.12	0.0018	0.50	2.46	0.60	0.22
31-Mar-91		0.46	1.93	4,731,545	1,171	6,851	6,629	222	62	161	0.12	0.0017	0.47	2.34	0.57	0.21
01-Apr-91		0.42	1.84	4,491,724	1,112	6,504	6,293	211	58	153	0.11	0.0016	0.45	2.22	0.54	0.20
02-Apr-91		0.38	1.73	4,241,807	1,050	6,142	5,943	199	55	144	0.11	0.0015	0.42	2.10	0.51	0.19
03-Apr-91		0.34	1.63	3,980,226	985	5,763	5,576	187	52	135	0.10	0.0014	0.40	1.97	0.48	0.18
04-Apr-91		0.30	1.51	3,704,947	917	5,365	5,191	174	48	126	0.09	0.0013	0.37	1.83	0.44	0.16
05-Apr-91		0.26	1.40	3,413,250	845	4,942	4,782	160	44	116	0.09	0.0012	0.34	1.69	0.41	0.15
06-Apr-91		0.22	1.27	3,101,344	768	4,491	4,345	146	40	105	0.08	0.0011	0.31	1.54	0.37	0.14
07-Apr-91		0.24	1.32	3,234,327	800	4,683	4,531	152	42	110	0.08	0.0012	0.32	1.60	0.39	0.14
08-Apr-91		0.27	1.43	3,500,467	866	5,069	4,904	165	46	119	0.09	0.0013	0.35	1.73	0.42	0.15
09-Apr-91		0.31	1.53	3,752,116	929	5,433	5,257	176	49	128	0.09	0.0013	0.38	1.86	0.45	0.17
10-Apr-91		0.34	1.63	3,991,605	988	5,780	5,592	188	52	136	0.10	0.0014	0.40	1.98	0.48	0.18
11-Apr-91		0.38	1.73	4,220,693	1,045	6,112	5,913	198	55	144	0.11	0.0015	0.42	2.09	0.51	0.19
12-Apr-91		0.41	1.82	4,440,743	1,099	6,430	6,221	209	58	151	0.11	0.0016	0.44	2.20	0.53	0.20
13-Apr-91		0.44	1.89	4,622,994	1,144	6,694	6,477	217	60	157	0.12	0.0017	0.46	2.29	0.55	0.20
14-Apr-91		0.47	1.96	4,799,970	1,188	6,950	6,725	226	62	163	0.12	0.0017	0.48	2.38	0.58	0.21
15-Apr-91	1200	0.50	2.03	4,972,145	1,318	7,717	7,329	388	70	318	0.15	0.0016	0.50	2.83	0.79	0.17
16-Apr-91		0.45	1.91	4,682,547	1,152	7,235	6,855	379	52	328	0.33	0.0023	2.11	4.10	1.36	0.44
17-Apr-91		0.40	1.79	4,378,726	1,077	6,765	6,410	355	48	307	0.31	0.0021	1.97	3.83	1.28	0.42
18-Apr-91		0.35	1.66	4,058,054	998	6,270	5,941	329	45	284	0.28	0.0020	1.83	3.55	1.18	0.39
19-Apr-91		0.31	1.55	3,787,027	932	5,851	5,544	307	42	265	0.27	0.0018	1.70	3.31	1.10	0.36
20-Apr-91		0.32	1.58	3,856,130	949	5,958	5,645	312	42	270	0.27	0.0019	1.74	3.37	1.12	0.37
21-Apr-91		0.33	1.61	3,941,215	970	6,089	5,770	319	43	276	0.28	0.0019	1.77	3.45	1.15	0.37
22-Apr-91		0.29	1.48	3,609,939	888	5,577	5,285	292	40	253	0.25	0.0017	1.62	3.16	1.05	0.34
23-Apr-91		0.23	1.31	3,194,951	786	4,936	4,677	259	35	224	0.22	0.0015	1.44	2.80	0.93	0.30
24-Apr-91		0.14	0.99	2,432,458	598	3,758	3,561	197	27	170	0.17	0.0012	1.09	2.13	0.71	0.23
25-Apr-91		0.15	1.00	2,456,672	604	3,796	3,597	199	27	172	0.17	0.0012	1.11	2.15	0.72	0.23

Site #3 cont.

26-Apr-91		0.23	1.30	3,175,125	781	4,906	4,648	257	35	222	0.22	0.0015	1.43	2.78	0.93	0.30
27-Apr-91		0.26	1.40	3,435,398	845	5,308	5,029	278	38	240	0.24	0.0017	1.55	3.01	1.00	0.33
28-Apr-91		0.26	1.40	3,435,398	845	5,308	5,029	278	38	240	0.24	0.0017	1.55	3.01	1.00	0.33
29-Apr-91	1130	0.37	1.72	4,204,643	954	6,467	6,114	353	34	320	0.46	0.0027	3.36	4.96	1.78	0.66
30-Apr-91		0.48	1.98	4,850,664	1,123	7,184	6,927	257	63	194	0.32	0.0020	2.18	3.90	1.48	0.58
01-May-91		0.56	2.17	5,310,409	1,229	7,865	7,583	281	69	212	0.35	0.0022	2.39	4.27	1.62	0.64
02-May-91		0.50	2.04	4,979,221	1,153	7,374	7,110	264	65	199	0.32	0.0021	2.24	4.01	1.52	0.60
03-May-91		0.52	2.09	5,105,317	1,182	7,561	7,290	271	66	204	0.33	0.0022	2.30	4.11	1.56	0.62
04-May-91	1020	0.55	2.15	5,263,095	1,242	7,495	7,379	116	95	21	0.11	0.0010	0.53	2.26	0.98	0.45
05-May-91		0.95	2.93	7,161,187	1,414	7,892	7,641	251	129	122	0.72	0.0300	3.94	5.26	3.03	1.58
06-May-91		0.59	2.22	5,437,256	1,074	5,992	5,802	190	98	92	0.54	0.0228	2.99	4.00	2.30	1.20
07-May-91		0.43	1.86	4,547,728	898	5,012	4,852	159	82	77	0.45	0.0191	2.50	3.34	1.93	1.00
08-May-91		0.38	1.73	4,228,700	835	4,660	4,512	148	76	72	0.42	0.0177	2.33	3.11	1.79	0.93
09-May-91		0.45	1.91	4,682,547	925	5,160	4,996	164	84	80	0.47	0.0196	2.58	3.44	1.98	1.03
10-May-91		0.40	1.79	4,378,726	865	4,825	4,672	153	79	74	0.44	0.0183	2.41	3.22	1.85	0.97
11-May-91		0.48	1.98	4,850,664	958	5,345	5,176	170	87	82	0.49	0.0203	2.67	3.57	2.05	1.07
12-May-91		0.33	1.61	3,941,215	778	4,343	4,205	138	71	67	0.39	0.0165	2.17	2.90	1.67	0.87
13-May-91		0.27	1.42	3,481,970	688	3,837	3,715	122	63	59	0.35	0.0146	1.92	2.56	1.47	0.77
14-May-91		0.17	1.09	2,667,033	527	2,939	2,846	93	48	45	0.27	0.0112	1.47	1.96	1.13	0.59
15-May-91		0.09	0.76	1,857,450	367	2,047	1,982	65	33	32	0.19	0.0078	1.02	1.37	0.79	0.41
16-May-91		2.14	4.66	11,392,578	2,250	12,555	12,156	399	205	194	1.14	0.0477	6.27	8.37	4.82	2.51
17-May-91		0.50	2.03	4,972,145	982	5,479	5,305	174	89	85	0.50	0.0208	2.73	3.65	2.11	1.10
18-May-91		0.44	1.89	4,622,994	913	5,095	4,933	162	83	79	0.46	0.0194	2.54	3.40	1.96	1.02
19-May-91		0.22	1.27	3,115,077	615	3,433	3,324	109	56	53	0.31	0.0131	1.71	2.29	1.32	0.69
20-May-91		0.03	0.41	1,001,446	198	1,104	1,069	35	18	17	0.10	0.0042	0.55	0.74	0.42	0.22
21-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
22-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
23-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
24-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
25-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
26-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
27-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
28-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
29-May-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
30-May-91		0.50	2.03	4,972,145	982	5,479	5,305	174	89	85	0.50	0.0208	2.73	3.65	2.11	1.10
31-May-91		2.16	4.68	11,441,684	2,260	12,609	12,208	400	206	195	1.14	0.0479	6.29	8.41	4.85	2.52
01-Jun-91		1.67	4.04	9,882,091	1,952	10,890	10,544	346	178	168	0.99	0.0414	5.44	7.26	4.19	2.18
02-Jun-91		0.76	2.58	6,311,239	1,246	6,955	6,734	221	114	107	0.63	0.0264	3.47	4.64	2.67	1.39
03-Jun-91		0.32	1.58	3,856,130	762	4,249	4,114	135	69	66	0.39	0.0162	2.12	2.83	1.63	0.85
04-Jun-91		0.15	1.02	2,504,569	495	2,760	2,672	88	45	43	0.25	0.0105	1.38	1.84	1.06	0.55
05-Jun-91		1.13	3.24	7,925,914	1,565	8,734	8,457	277	143	135	0.79	0.0332	4.36	5.83	3.36	1.75
06-Jun-91		1.13	3.23	7,900,998	1,560	8,707	8,430	277	142	134	0.79	0.0331	4.35	5.81	3.35	1.74
07-Jun-91		0.46	1.95	4,763,511	941	5,249	5,083	167	86	81	0.48	0.0200	2.62	3.50	2.02	1.05
08-Jun-91		0.10	0.80	1,945,289	384	2,144	2,076	68	35	33	0.19	0.0082	1.07	1.43	0.82	0.43
09-Jun-91		0.00	0.00	0	0	0	0	0	0	0	0.00	0.0000	0.00	0.00	0.00	0.00
10-Jun-91		2.00	4.48	10,950,983	2,163	12,068	11,685	383	197	186	1.10	0.0459	6.02	8.05	4.64	2.41
11-Jun-91		1.50	3.80	9,295,933	1,836	10,244	9,919	325	167	158	0.93	0.0390	5.11	6.83	3.94	2.05
12-Jun-91		1.00	3.02	7,379,016	1,457	8,132	7,873	258	133	125	0.74	0.0309	4.06	5.42	3.13	1.63
13-Jun-91	1000	0.74	2.55	6,228,054	990	4,858	4,559	299	112	187	1.12	0.0510	6.23	6.48	4.12	2.22
				440,671,854	96,046	557,880	541,135	16,745	5,916	10,829	27	1	149	272	113	54

APPENDIX F - In-lake Sample Concentrations and Graphs

Table F-1. In-lake Samples - Site #6.

SAMPLE DATA FOR SWAN LAKE FOR 1991-1992
SITE #6 - SURFACE AND GRAB SAMPLES

PROJECT	DATE	TIME	WTEMP	ATEMP	TOTAL DEPTH	SECCHI DISK	DISOX	FPH	FECAL	LABPH	TALKAL	TSOL	TDSOL	TSSOL	VOLATILE SOLIDS	FIXED SOLIDS
UNITS >>>>			C	C	METERS	METERS	mg/L	su	/100mL	su	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SWAN LAKE	11-Feb-91	1455	2.0	9.0	1.90	1.80	11.2	7.8	10.0		33.2	640.0	630.0	10.0	6.0	4.0
SWAN LAKE	03-Apr-91	1030	10.0	12.7	1.70	0.50		7.9	2.0	8.48	121.0	2,295.0	2,268.0	27.0	10.0	17.0
SWAN LAKE	24-Apr-91	1015	12.0	11.1	1.52	0.40	13.5	7.5	2.0	8.14	126.0	2,393.0	2,353.0	40.0	2.0	38.0
SWAN LAKE	28-May-91	930	24.0	21.0	1.60	0.70	8.5	8.4	10.0	7.87	141.0	2,366.0	2,336.0	30.0	28.0	2.0
SWAN LAKE	19-Jun-91	1000	26.0	28.0	1.78	0.50	6.9	8.3	20.0	8.14	131.0	2,231.0	2,203.0	28.0	22.0	6.0
SWAN LAKE	02-Jul-91	1245	27.0	32.0	1.50	0.40	6.8	8.0	10.0	8.09	143.0	2,260.0	2,222.0	38.0	20.0	18.0
SWAN LAKE	16-Jul-91	845	26.0	28.0	1.75	0.25	8.3	8.4	10.0	8.21	135.0	2,323.0	2,287.0	36.0	6.0	30.0
SWAN LAKE	31-Jul-91	910	25.0	26.5	1.60	0.30	7.2	8.4	6.0	8.33	119.0	2,399.0	2,361.0	38.0	6.0	32.0
SWAN LAKE	15-Aug-91	820	25.0	25.5	1.50	0.25	6.2	8.1	10.0	8.28	128.0	2,412.0	2,342.0	70.0	16.0	54.0
SWAN LAKE	28-Aug-91	915	25.0	27.0	1.40	0.25	6.3	8.5	10.0	8.33	126.0	2,519.0	2,467.0	52.0		
SWAN LAKE	11-Sep-91	930	20.0	20.0	1.35	0.25	8.0	8.4	10.0	8.42	102.0	2,585.0	2,553.0	32.0		
SWAN LAKE	25-Sep-91	930	13.0	17.2	1.33	0.50	8.9	8.2	10.0	8.21	163.0	2,601.0	2,575.0	26.0		
SWAN LAKE	15-Oct-91	900	8.0	3.3	1.40	0.50	9.6		10.0	8.49	115.0	2,748.0	2,734.0	14.0		
SWAN LAKE	07-Apr-92	850	11.0	9.0	1.20	0.25	10.4	7.8	2.0	8.28	131.0	2,180.0	2,144.0	36.0		
	MEDIAN --->		22.0	27.3	1.51	0.40	8.4	8.2	10.0	8.28	127.0	2,379.5	2,339.0	34.0	10.0	18.0
	MEAN --->		18.1	19.3	1.54	0.49	8.6	8.1	8.7	8.25	122.4	2,282.3	2,248.2	34.1	12.9	22.3
	MAXIMUM --->		27.0	32.0	1.90	1.80	13.5	8.5	20.0	8.49	163.0	2,748.0	2,734.0	70.0	28.0	54.0
	MINIMUM --->		2.0	3.3	1.20	0.25	6.2	7.5	2.0	7.87	33.2	640.0	630.0	10.0	2.0	2.0

PROJECT	DATE	TIME	AMMON	UNIONIZED AMMONIA	PERCENT UNIONIZE	PKA	NO3+	TKN-N	ORGANIC NITROGEN	TOTAL NITROGEN	TOTAL PO4P	TOTAL DISS. PO4P	N:P RATIO	CARLSON'S INDEX FOR PO4-P	CARLSON'S INDEX FOR SEECHI
UNITS >>>>			mg/L	mg/L			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		
SWAN LAKE	11-Feb-91	1455	0.16	0.00098	0.61	10.01	0.1	1.06	0.90	1.16	0.054	0.020	21.48	61.70	51.52
SWAN LAKE	03-Apr-91	1030	0.02	0.00029	1.46	9.73	0.1	1.09	1.07	1.19	0.132	0.020	9.02	74.59	70.00
SWAN LAKE	24-Apr-91	1015	0.02	0.00014	0.68	9.66	0.1	1.70	1.68	1.80	0.132	0.027	13.64	74.59	73.22
SWAN LAKE	28-May-91	930	0.02	0.00235	11.75	9.28	0.1	0.74	0.72	0.84	0.136	0.034	6.18	75.03	65.15
SWAN LAKE	19-Jun-91	1000	0.25	0.02715	10.86	9.21	0.6	1.38	1.13	1.98	0.136	0.037	14.56	75.03	70.00
SWAN LAKE	02-Jul-91	1245	0.48	0.02950	6.15	9.18	0.7	1.63	1.15	2.33	0.197	0.037	11.83	80.37	73.22
SWAN LAKE	16-Jul-91	845	0.06	0.00798	13.30	9.21	0.6	1.20	1.14	1.80	0.166	0.030	10.84	77.90	80.00
SWAN LAKE	31-Jul-91	910	0.02	0.00250	12.51	9.24	0.5	1.65	1.63	2.15	0.142	0.095	15.14	75.65	77.37
SWAN LAKE	15-Aug-91	820	0.10	0.00669	6.69	9.24	0.6	1.36	1.26	1.96	0.224	0.156	8.75	82.22	80.00
SWAN LAKE	28-Aug-91	915	0.02	0.00305	15.25	9.24	0.1	1.46	1.44	1.56	0.159	0.112	9.81	77.28	80.00
SWAN LAKE	11-Sep-91	930	0.04	0.00363	9.07	9.40	0.1	1.47	1.43	1.57	0.102	0.047	15.39	70.87	80.00
SWAN LAKE	25-Sep-91	930	0.14	0.00503	3.59	9.63	0.1	0.17	0.03	0.27	0.078	0.020	3.46	67.00	70.00
SWAN LAKE	15-Oct-91	900	0.02	0.00094	4.69	9.80	0.1	1.48	1.46	1.58	0.085	0.027	18.59	68.24	70.00
SWAN LAKE	07-Apr-92	850	0.02	0.00074	3.70	9.70	0.1	1.30	1.28	1.40	0.103	0.017	13.59	71.02	80.00
	MEDIAN --->		0.03	0.00268	6.2565	9.3383	0.10	1.37	1.21	1.58	0.134	0.032	12.71	78.68	73.22
	MEAN --->		0.10	0.00650	7.1644	9.4677	0.28	1.26	1.17	1.54	0.132	0.049	12.31	73.68	72.89
	MAXIMUM --->		0.48	0.02950	15.3	10.0	0.70	1.70	1.68	2.33	0.224	0.156	21.48	82.22	80.00
	MINIMUM --->		0.02	0.00014	0.6	9.2	0.10	0.17	0.03	0.27	0.054	0.017	3.46	61.70	51.52

Table F-2. In-lake Samples - Site #7.

SAMPLE DATA FOR SWAN LAKE FOR 1991 - 1992
SITE #7 - SURFACE AND GRAB SAMPLES

PROJECT	DATE	TIME	WTEMP	ATEMP	TOTAL DEPTH	SECCHI	DISOX	FPH	FECAL	LABPH	TALKAL	TSOL	TDSOL	TSSOL	VOLATILE SOLIDS	FIXED SOLIDS
UNITS >>>>			C	C	METERS	METERS	mg/L	su	/100mL	su	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SWAN LAKE	11-Feb-91	1455	2.0	9.0	1.40	0.60	10.9	7.8	10.0		58.0	1,183.0	1,169.0	14.0	9.0	5.0
SWAN LAKE	03-Apr-91	1030	11.0	12.8	1.70	0.50		8.0	2.0	8.49	126.0	2,300.0	2,268.0	32.0	16.0	16.0
SWAN LAKE	24-Apr-91	1045	12.0	11.6	1.52	0.40	13.0	7.6	2.0	8.44	124.0	2,388.0	2,350.0	38.0	6.0	32.0
SWAN LAKE	28-May-91	900	24.0	21.0	1.60	0.60	6.4	8.3	6.0	7.93	141.0	2,361.0	2,309.0	52.0	32.0	20.0
SWAN LAKE	19-Jun-91	930	26.0	26.6	1.70	0.50	6.4	8.3	10.0	8.08	132.0	2,248.0	2,228.0	20.0	18.0	2.0
SWAN LAKE	02-Jul-91	1215	26.0	30.0	1.60	0.50	6.4	8.0	10.0	8.06	145.0	2,294.0	2,218.0	76.0	34.0	42.0
SWAN LAKE	16-Jul-91	830	26.0	29.0	1.75	0.25	7.2	8.3	10.0	8.20	127.0	2,342.0	2,288.0	54.0	10.0	44.0
SWAN LAKE	31-Jul-91	845	25.0	25.5	1.60	0.30	6.6	8.4		8.26	118.0	2,416.0	2,366.0	50.0	14.0	36.0
SWAN LAKE	15-Aug-91	850	25.0	25.5	1.50	0.25	5.9	8.2	10.0	8.08	129.0	2,410.0	2,348.0	62.0	8.0	54.0
SWAN LAKE	28-Aug-91	845	25.0	26.0	1.40	0.25	6.0	8.5	10.0	8.29	129.0	2,521.0	2,461.0	60.0		
SWAN LAKE	11-Sep-91	900	21.0	20.0	1.40	0.30	8.1		30.0	8.44	108.0	2,618.0	2,582.0	36.0		
SWAN LAKE	25-Sep-91	900	14.0	16.7	1.40	0.50	8.6		10.0	8.35	107.0	2,611.0	2,581.0	30.0		
SWAN LAKE	15-Oct-91	845	8.0	2.2	1.55	0.50	9.4		10.0	8.55	115.0	2,759.0	2,757.0	2.0		
SWAN LAKE	07-Apr-92	830	11.0	9.0	1.40	0.25	10.4	7.8	4.0	8.28	130.0	2,179.0	2,143.0	36.0		
	MEDIAN	--->	22.5	20.5	1.54	0.45	6.9	8.3	10.0	8.28	126.5	2,374.5	2,322.5	37.0	14.0	32.0
	MEAN	--->	18.3	18.9	1.54	0.99	8.1	8.2	9.5	8.27	120.6	2,330.7	2,290.6	40.1	16.3	27.9
	MAXIMUM	--->	26.0	30.0	1.75	8.60	13.0	8.5	30.0	8.55	145.0	2,759.0	2,757.0	76.0	34.0	54.0
	MINIMUM	--->	2.0	2.2	1.40	0.25	5.9	7.6	2.0	7.93	58.0	1,183.0	1,169.0	2.0	6.0	2.0

PROJECT	DATE	TIME	AMMON	UNIONIZED AMMONIA	PERCENT UNIONIZED	PKA	NO3+2	TKN-N	ORGANIC NITROGEN	TOTAL NITROGEN	TPO4-P	TOTAL DISS. PO4P	N:P RATIO	CARLSON'S INDEX FOR PO4-P	CARLSON'S INDEX FOR SEECHI
UNITS >>>>			mg/L	mg/L			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L			
SWAN LAKE	11-Feb-91	1455	0.11	0.00067	0.61	10.01	0.1	0.74	0.63	0.84	0.061	0.014	13.77	63.46	67.37
SWAN LAKE	03-Apr-91	1030	0.02	0.00039	1.97	9.70	0.1	1.13	1.11	1.23	0.132	0.020	9.32	74.59	70.00
SWAN LAKE	24-Apr-91	1045	0.02	0.00017	0.86	9.66	0.1	1.51	1.49	1.61	0.153	0.041	10.52	76.72	73.22
SWAN LAKE	28-May-91	900	0.02	0.00191	9.57	9.28	0.1	1.26	1.24	1.36	0.146	0.017	9.32	76.05	67.37
SWAN LAKE	19-Jun-91	930	0.30	0.03258	10.86	9.21	0.6	1.56	1.26	2.16	0.122	0.064	17.70	73.46	70.00
SWAN LAKE	02-Jul-91	1215	0.50	0.02877	5.75	9.21	0.7	1.63	1.13	2.33	0.237	0.020	9.83	83.04	70.00
SWAN LAKE	16-Jul-91	830	0.09	0.00977	10.86	9.21	0.6	1.50	1.41	2.10	0.190	0.075	11.05	79.85	80.00
SWAN LAKE	31-Jul-91	845	0.02	0.00250	12.51	9.24	0.5	1.42	1.40	1.92	0.414	0.027	4.64	91.09	77.37
SWAN LAKE	15-Aug-91	850	0.08	0.00662	8.27	9.24	0.8	1.58	1.50	2.38	0.176	0.020	13.52	78.74	80.00
SWAN LAKE	28-Aug-91	845	0.02	0.00305	15.25	9.24	0.1	1.60	1.58	1.70	0.203	0.051	8.37	80.80	80.00
SWAN LAKE	11-Sep-91	900	0.21	0.02035	9.69	9.37	0.1	1.73	1.52	1.83	0.122	0.024	15.00	73.46	77.37
SWAN LAKE	25-Sep-91	900	0.10	0.00743	7.43	9.60	0.1	0.22	0.12	0.32	0.078	0.024	4.10	67.00	28.96
SWAN LAKE	15-Oct-91	845	0.02	0.00107	5.34	9.80	0.1	1.38	1.36	1.48	0.085	0.017	17.41	68.24	70.00
SWAN LAKE	07-Apr-92	830	0.02	0.00074	3.70	9.70	0.1	1.22	1.20	1.32	0.123	0.013	10.73	73.58	80.00
	MEDIAN	--->	0.05	0.00337	7.95	9.32	0.1	1.46	1.31	1.66	0.139	0.022	10.63	75.32	71.61
	MEAN	--->	0.11	0.00829	7.33	9.46	0.3	1.32	1.21	1.61	0.160	0.031	11.09	75.72	70.83
	MAXIMUM	--->	0.50	0.03258	15.25	10.01	0.8	1.73	1.58	2.38	0.414	0.075	17.70	91.09	80.00
	MINIMUM	--->	0.02	0.00017	0.61	9.21	0.1	0.22	0.12	0.32	0.061	0.013	4.10	63.46	28.96

Table F-3. In-lake Samples - Site #8.

SAMPLE DATA FOR SWAN LAKE FOR 1991 - 1992
SITE #8 - SURFACE AND GRAB SAMPLES

PROJECT	DATE	TIME	WTEMP	ATEMP	TOTAL DEPTH	SECCHI	DISOX	FPH	FECAL	LABPH	TALKAL	TSOL	TDSOL	TSSOL	VOLATILE SOLIDS	FIXED SOLIDS
UNITS >>>>			C	C	METERS	METERS	mg/L	su	/100mL	su	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SWAN LAKE	11-Feb-91	1455	2.0	10.0	0.70	0.30	8.8	7.9	10.0		123.0	2,564.0	2,543.0	21.0	14.0	7.0
SWAN LAKE	03-Apr-91	1030	11.0	7.2	0.75	0.25		7.9	110.0	8.37	139.0	2,325.0	2,273.0	52.0	34.0	18.0
SWAN LAKE	24-Apr-91	930	11.5	10.0	0.75	0.35	10.5	7.6	8.0	8.15	135.0	2,414.0	2,358.0	56.0	4.0	52.0
SWAN LAKE	28-May-91	830	24.0	20.0	0.75	0.40	5.4	8.1	28.0	7.89	154.0	2,423.0	2,337.0	86.0	40.0	46.0
SWAN LAKE	19-Jun-91	845	26.0	25.5	0.99	0.50	6.2	8.3	10.0	8.15	138.0	2,238.0	2,202.0	36.0	22.0	14.0
SWAN LAKE	02-Jul-91	1130	26.0	29.0	0.70	0.30	8.2	8.0	20.0	8.31	143.0	2,324.0	2,234.0	90.0	18.0	72.0
SWAN LAKE	16-Jul-91	815	26.0	25.5	0.99	0.20	5.9	8.1	10.0	7.98	125.0	2,369.0	2,297.0	72.0	16.0	56.0
SWAN LAKE	31-Jul-91	820	25.0	24.0	0.80	0.25	5.5	8.2	2.0	8.09	116.0	2,431.0	2,369.0	62.0	16.0	46.0
SWAN LAKE	15-Aug-91	820	24.0	24.5	0.75	0.25	5.0	8.1	20.0	8.00	130.0	2,468.0	2,360.0	108.0	10.0	98.0
SWAN LAKE	28-Aug-91	815	24.0	24.5	0.70	0.25	5.9	8.4	10.0	8.33	117.0	2,546.0	2,490.0	56.0		
SWAN LAKE	11-Sep-91	830	21.0	20.0	0.60	0.25	7.0	8.2	70.0	8.40	108.0	2,647.0	2,607.0	40.0		
SWAN LAKE	25-Sep-91	830	12.0	15.0	0.55	0.27	9.0	8.3	20.0	8.31	109.0	2,653.0	2,609.0	44.0		
SWAN LAKE	15-Oct-91	820	5.0	1.5	0.55	0.45	11.5		10.0	8.50	305.0	2,839.0	2,825.0	14.0		
SWAN LAKE	07-Apr-92	815	11.0	8.0	0.90	0.25	10.2	7.8	12.0	8.32	131.0	2,182.0	2,142.0	40.0		
	MEDIAN	--->	22.5	20.0	0.75	0.26	7.0	8.1	11.0	8.31	130.5	2,427.0	2,359.0	54.0	16.0	46.0
	MEAN	--->	17.8	17.5	0.75	0.31	7.6	8.1	24.3	8.22	140.9	2,458.8	2,403.3	55.5	19.3	45.4
	MAXIMUM	--->	26.0	29.0	0.99	0.50	11.5	8.4	110.0	8.50	305.0	2,839.0	2,825.0	108.0	40.0	98.0
	MINIMUM	--->	2.0	1.5	0.55	0.20	5.0	7.6	2.0	7.89	108.0	2,182.0	2,142.0	14.0	4.0	7.0

PROJECT	DATE	TIME	AMMON	UNIONIZED AMMONIA	PERCENT UNIONIZED	PKA	NO3+2	TKN-N	ORGANIC NITROGEN	TOTAL NITROGEN	TOTAL PO4P	TOTAL DISS. PO4P	N:P RATIO	CARLSON'S INDEX FOR PO4-P	CARLSON'S INDEX FOR SEECHI
UNITS >>>>			mg/L	mg/L			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L			
SWAN LAKE	11-Feb-91	1455	0.45	0.00347	0.77	10.01	0.1	2.10	1.65	2.20	0.075	0.020	29.33	66.44	77.37
SWAN LAKE	03-Apr-91	1030	0.23	0.00362	1.58	9.70	0.1	2.21	1.98	2.31	0.251	0.031	9.20	83.87	80.00
SWAN LAKE	24-Apr-91	930	0.02	0.00017	0.83	9.68	0.1	1.67	1.65	1.77	0.193	0.061	9.17	80.07	75.15
SWAN LAKE	28-May-91	830	0.02	0.00125	6.26	9.28	0.2	2.06	2.04	2.26	0.275	0.034	8.22	85.18	73.22
SWAN LAKE	19-Jun-91	845	0.06	0.00652	10.86	9.21	0.6	1.27	1.21	1.87	0.197	0.061	9.49	80.37	70.00
SWAN LAKE	02-Jul-91	1130	0.02	0.00115	5.75	9.21	0.6	1.24	1.22	1.84	0.319	0.027	5.77	87.32	77.37
SWAN LAKE	16-Jul-91	815	0.02	0.00143	7.14	9.21	0.5	1.43	1.41	1.93	0.281	0.034	6.87	85.49	83.22
SWAN LAKE	31-Jul-91	820	0.02	0.00165	8.27	9.24	0.5	1.71	1.69	2.21	0.319	0.115	6.93	87.32	80.00
SWAN LAKE	15-Aug-91	820	0.20	0.01251	6.26	9.28	0.7	1.48	1.28	2.18	0.281	0.058	7.76	85.49	80.00
SWAN LAKE	28-Aug-91	815	0.04	0.00470	11.75	9.28	0.1	1.53	1.49	1.63	0.193	0.041	8.45	80.07	80.00
SWAN LAKE	11-Sep-91	830	0.25	0.01586	6.34	9.37	0.1	1.46	1.21	1.56	0.142	0.024	10.99	75.65	80.00
SWAN LAKE	25-Sep-91	830	0.23	0.00957	4.16	9.66	0.1	1.63	1.40	1.73	0.170	0.024	10.18	78.24	78.89
SWAN LAKE	15-Oct-91	820	0.02	0.00076	3.80	9.90	0.1	1.56	1.54	1.66	0.105	0.017	15.81	71.29	71.52
SWAN LAKE	07-Apr-92	815	0.02	0.00081	4.04	9.70	0.1	1.23	1.21	1.33	0.159	0.010	8.36	77.28	80.00
	MEDIAN	--->	0.03	0.00120	6.01	9.32	0.1	1.55	1.45	1.860	0.195	0.03	8.81	80.22	79.44
	MEAN	--->	0.11	0.00453	5.56	9.48	0.3	1.61	1.50	1.890	0.211	0.04	10.47	80.29	77.62
	MAXIMUM	--->	0.45	0.01586	11.75	10.01	0.7	2.21	2.04	2.310	0.319	0.12	29.33	87.32	83.22
	MINIMUM	--->	0.02	0.00017	0.77	9.21	0.1	1.23	1.21	1.330	0.075	0.01	5.77	66.44	70.00

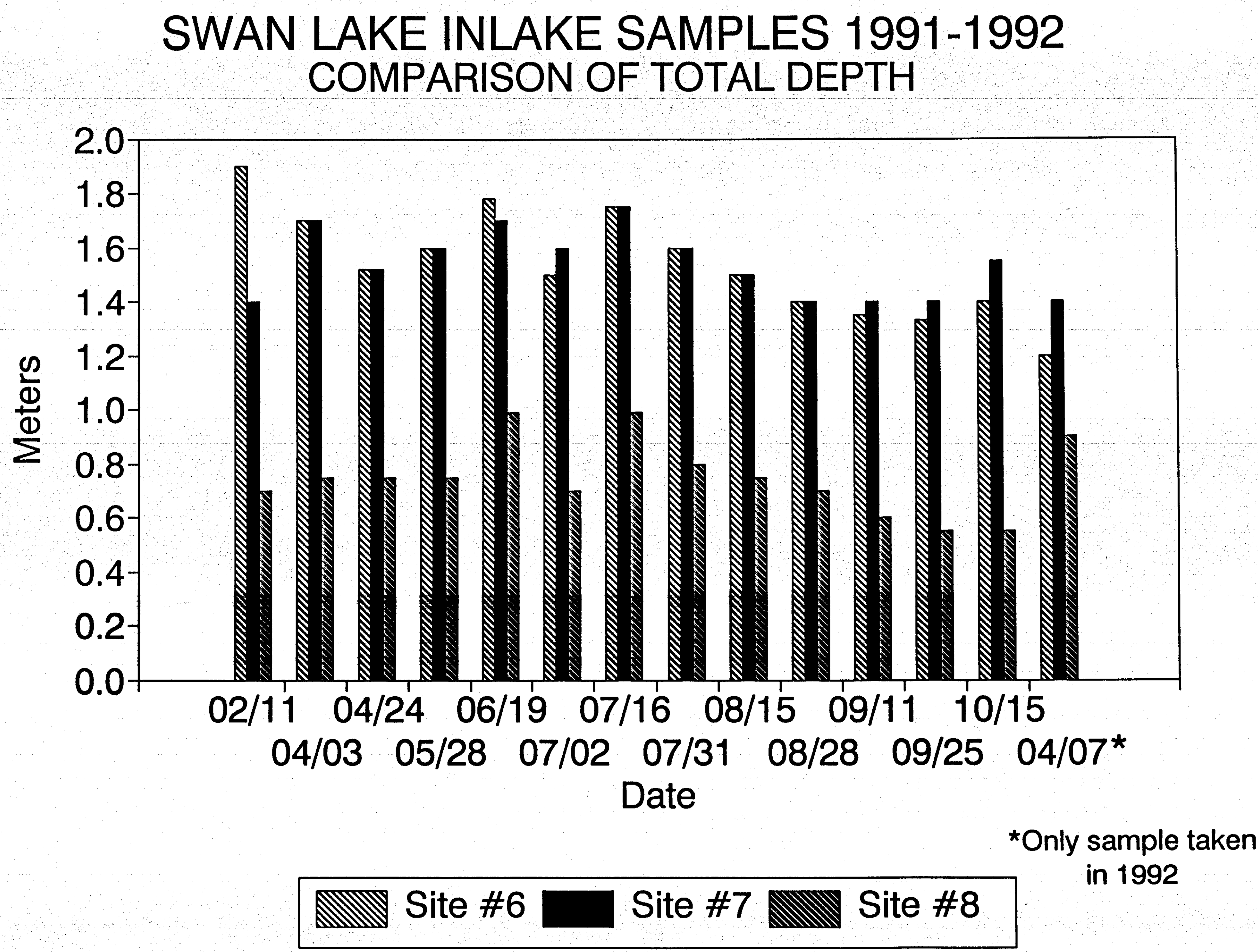


Figure F-1. In-Lake Total Depths.

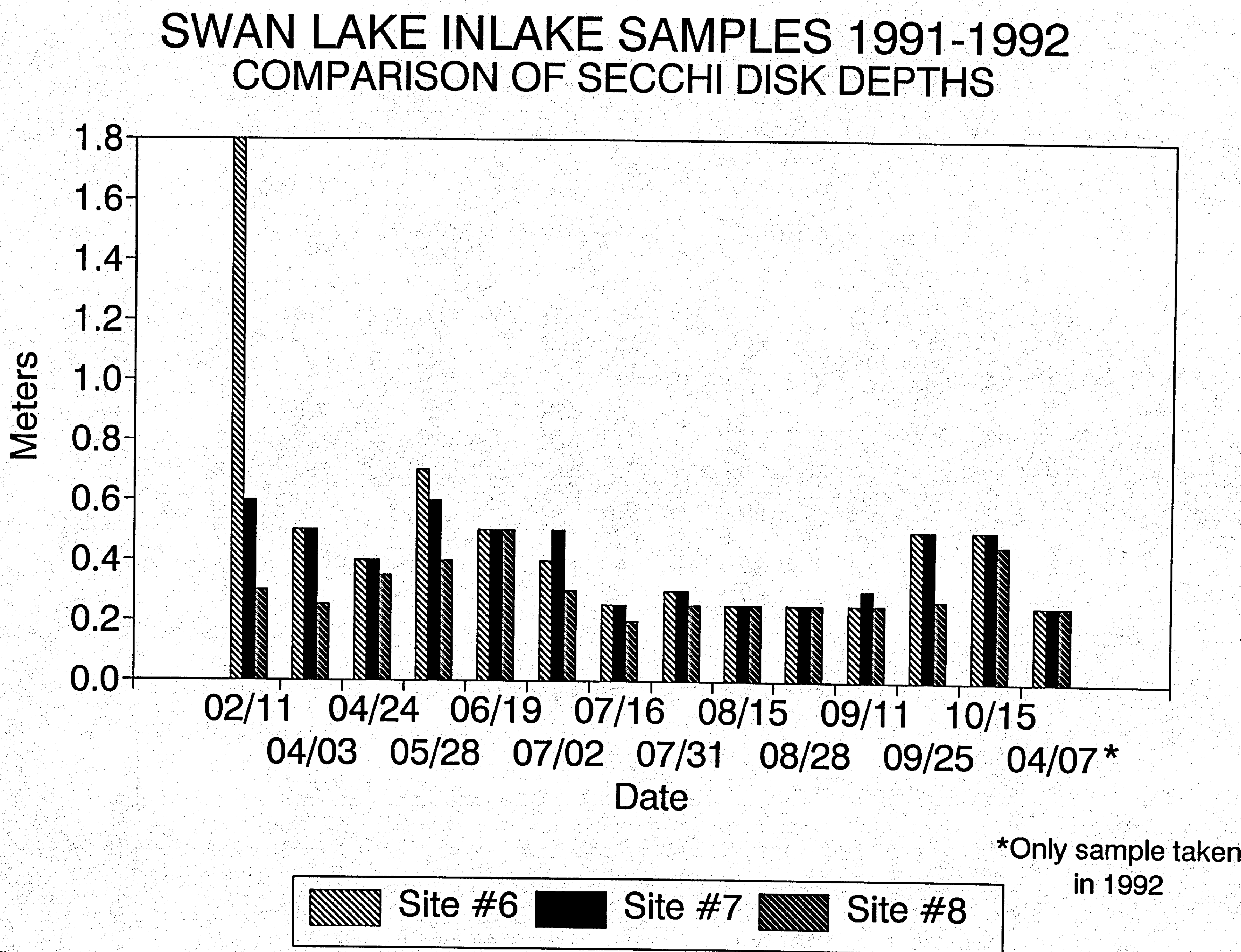


Figure F-2. In-lake Secchi Disk Depths.

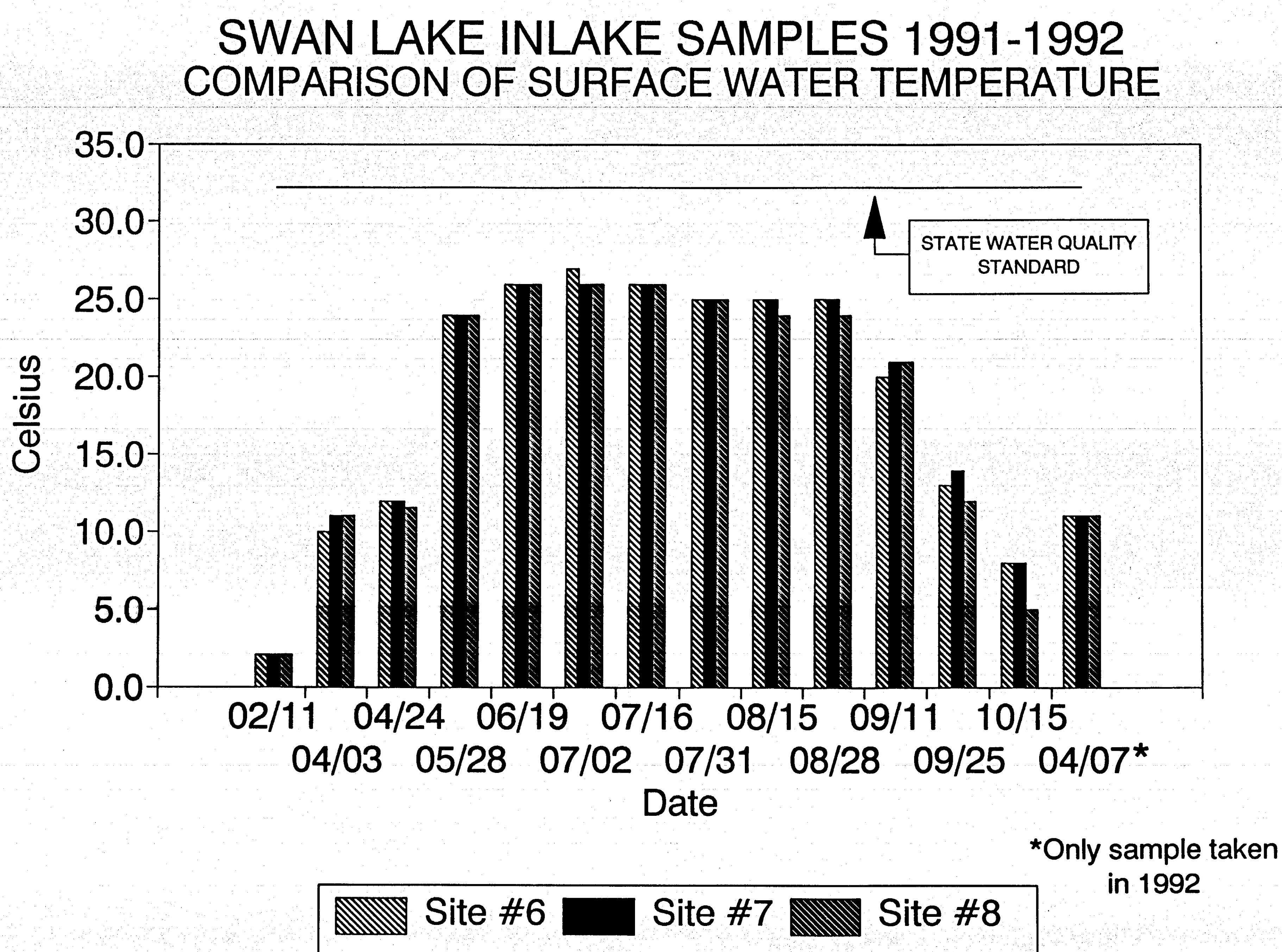


Figure F-3. In-lake Surface Water Temperature.

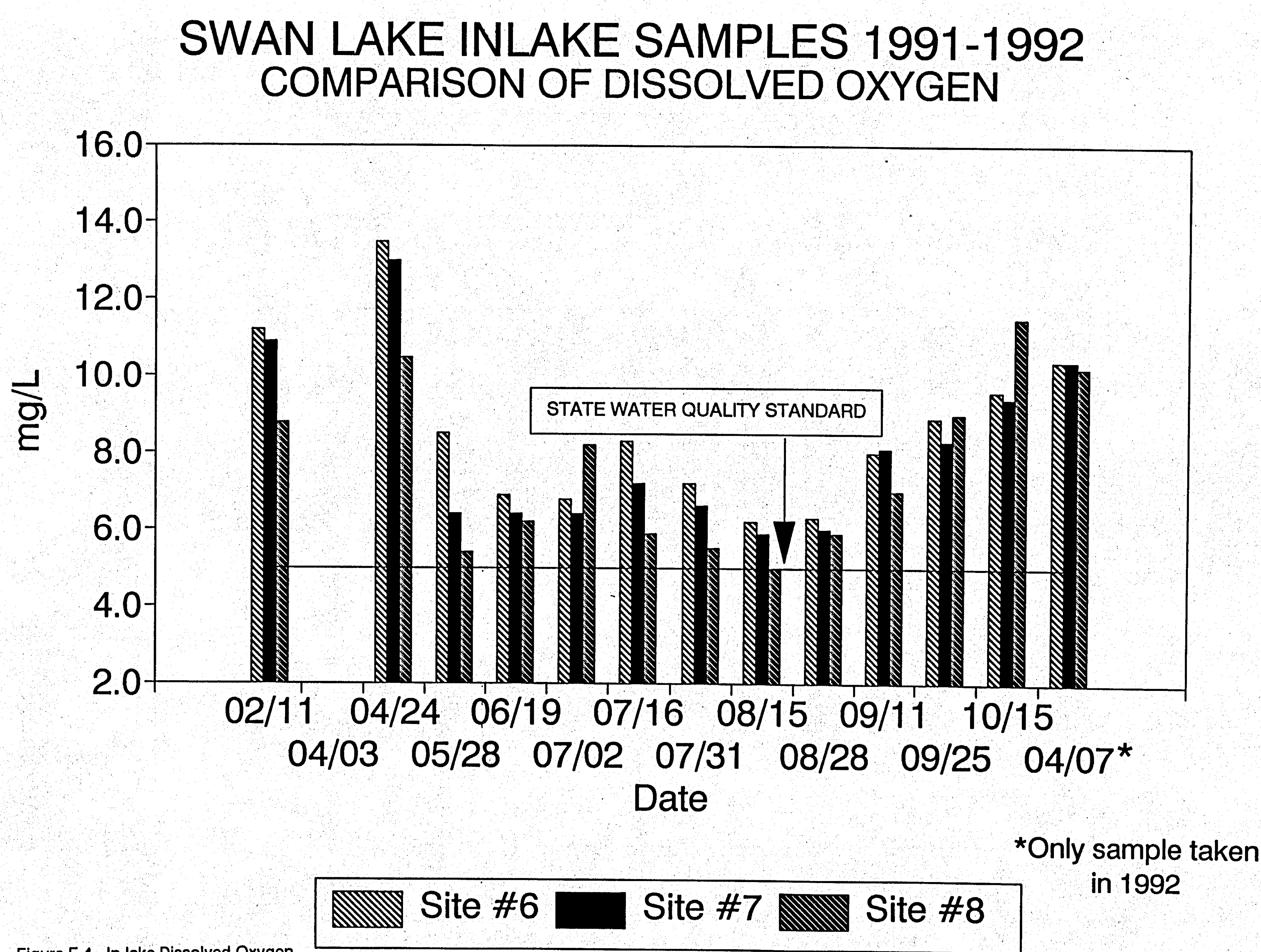


Figure F-4. In-lake Dissolved Oxygen.

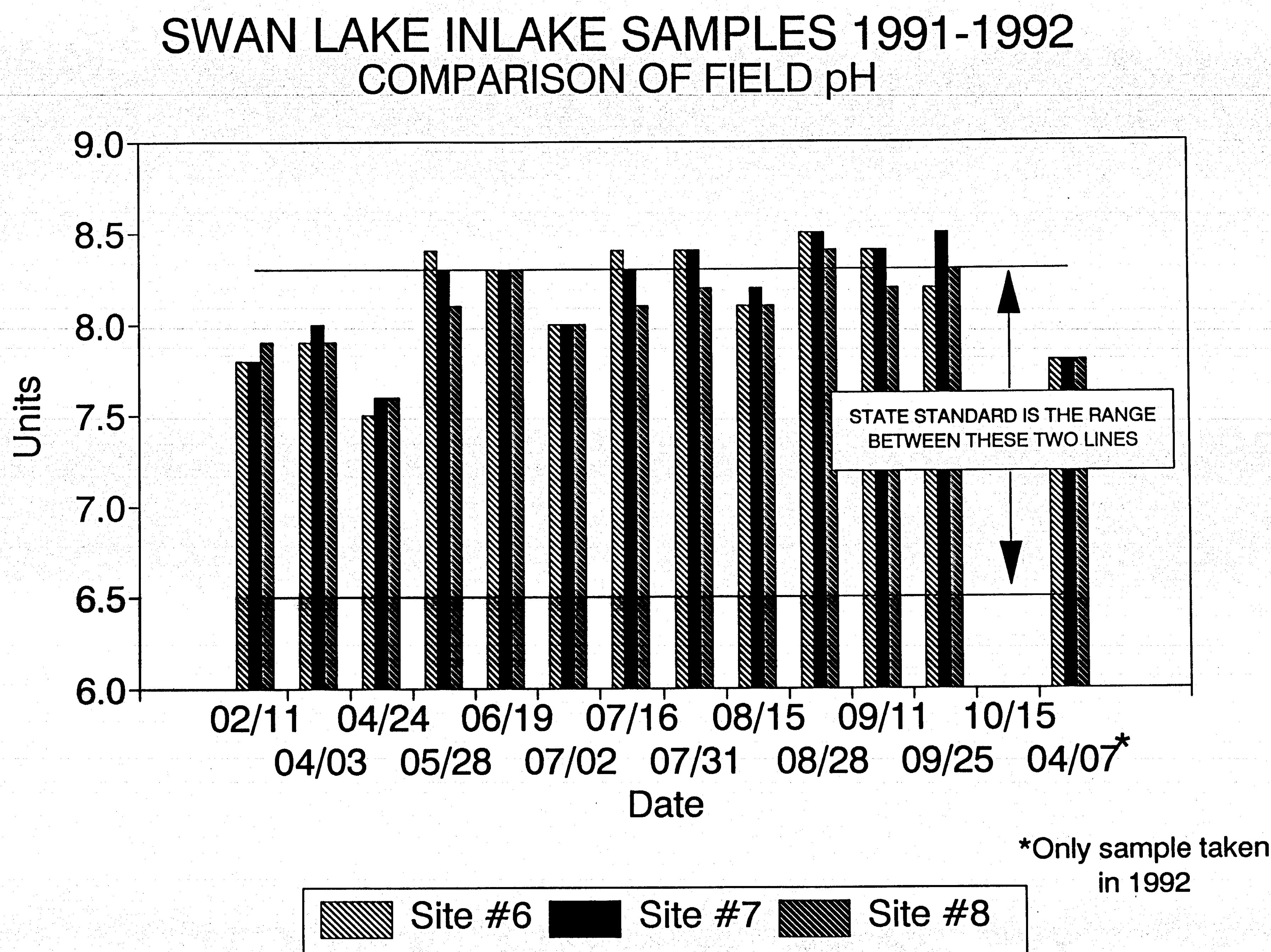
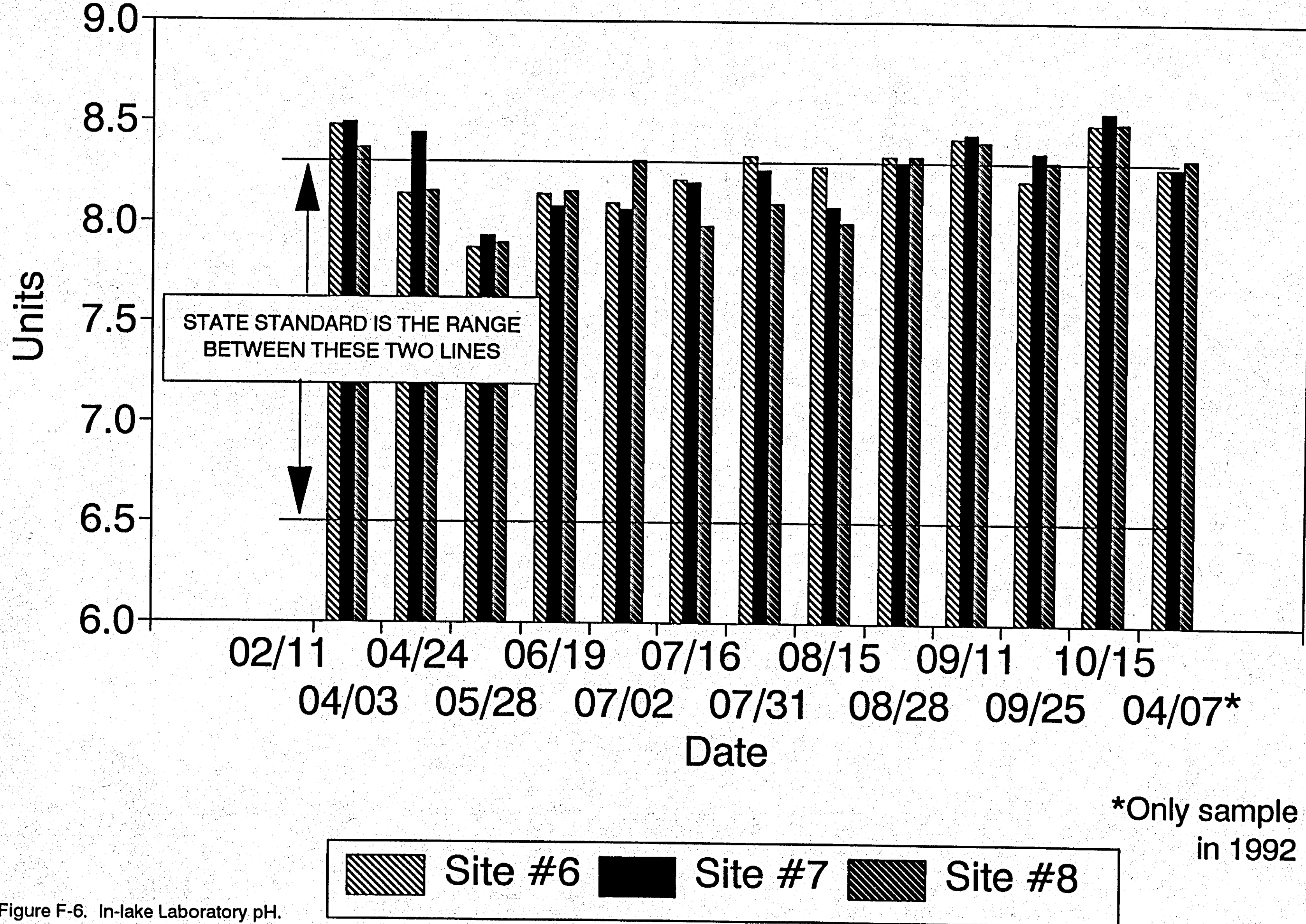


Figure F-5. In-lake Field pH.

SWAN LAKE INLAKE SAMPLES 1991-1992
COMPARISON OF LABORATORY pH



*Only sample taken in 1992

Figure F-6. In-lake Laboratory pH.

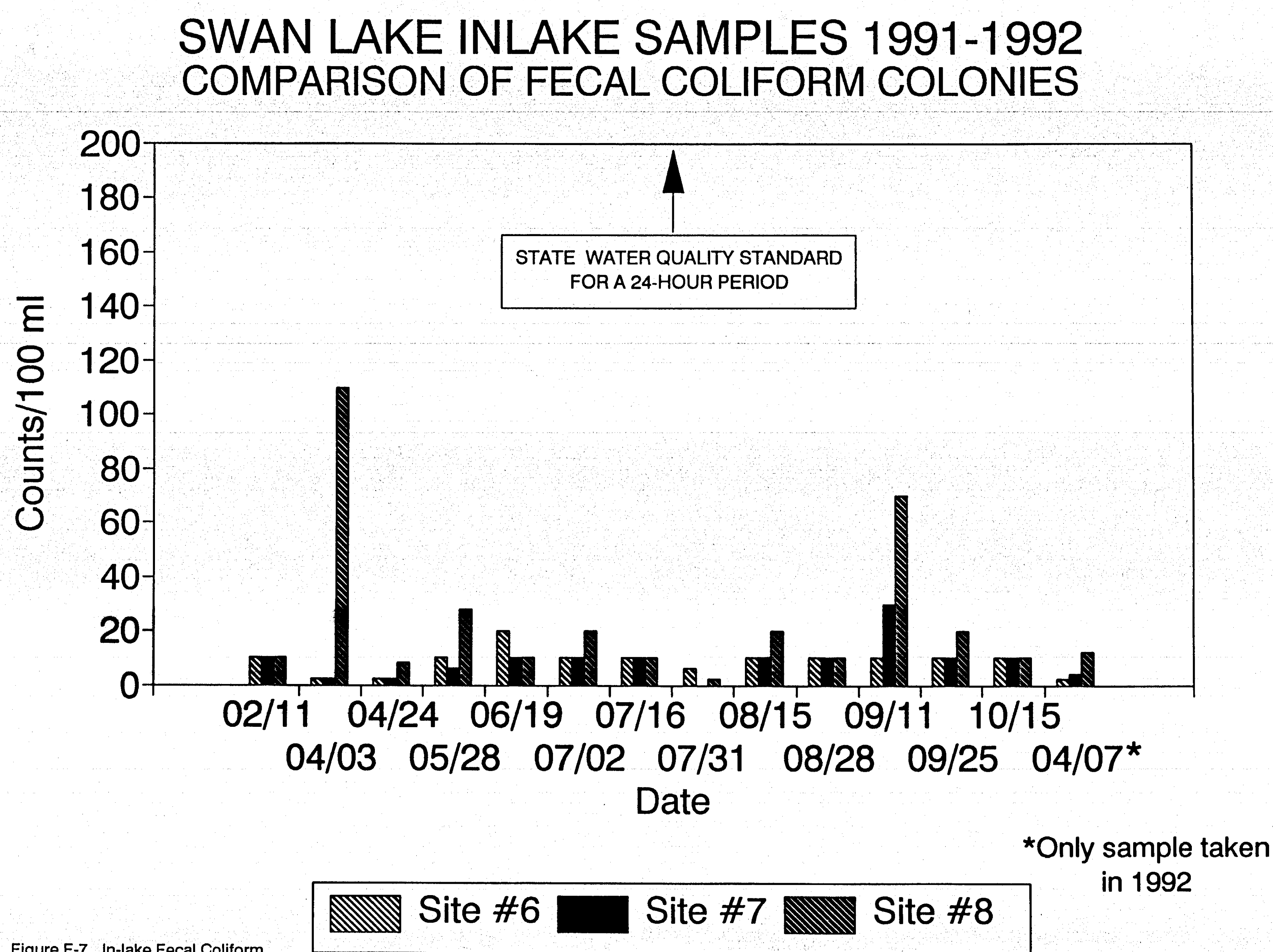


Figure F-7. In-lake Fecal Coliform.

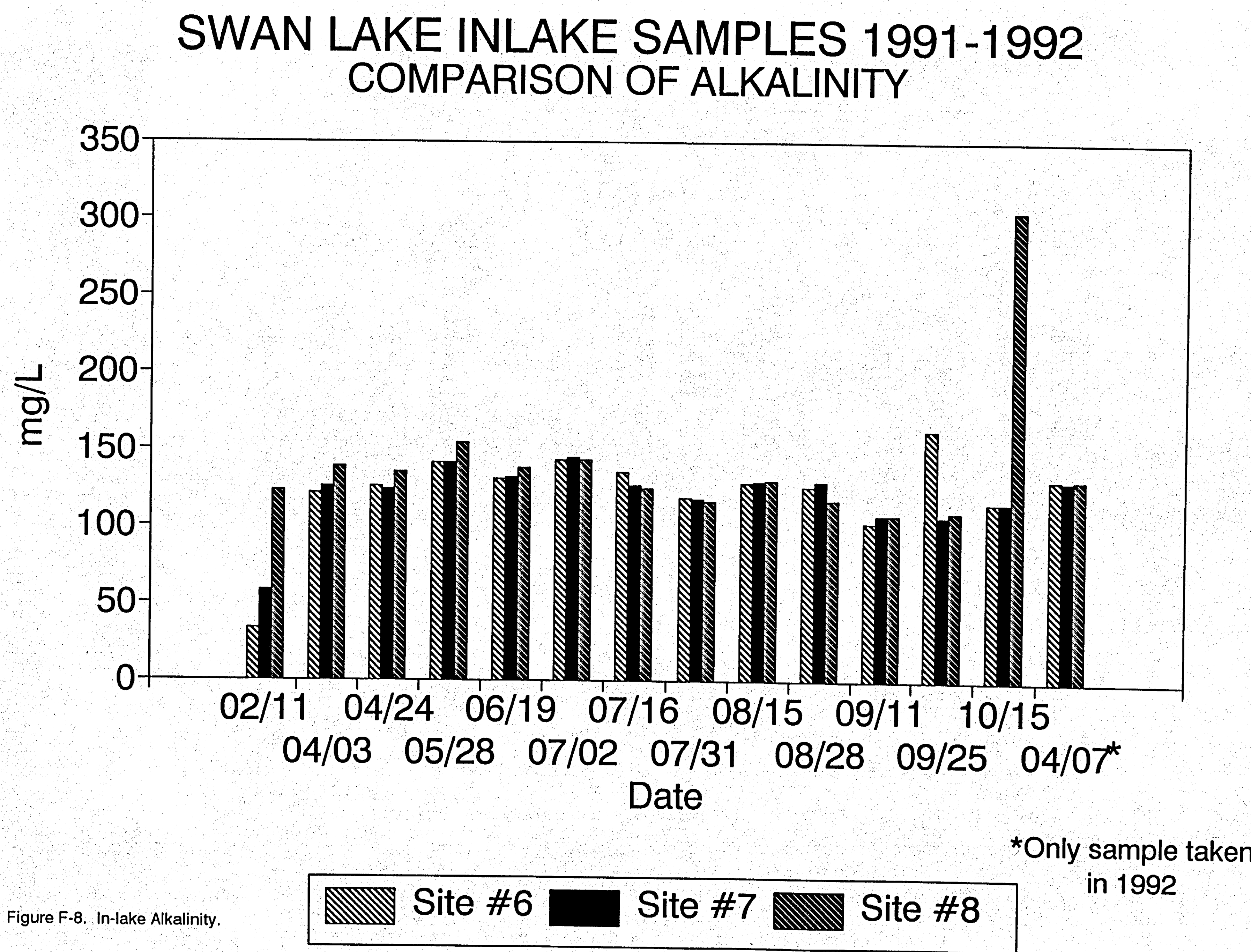


Figure F-8. In-lake Alkalinity.

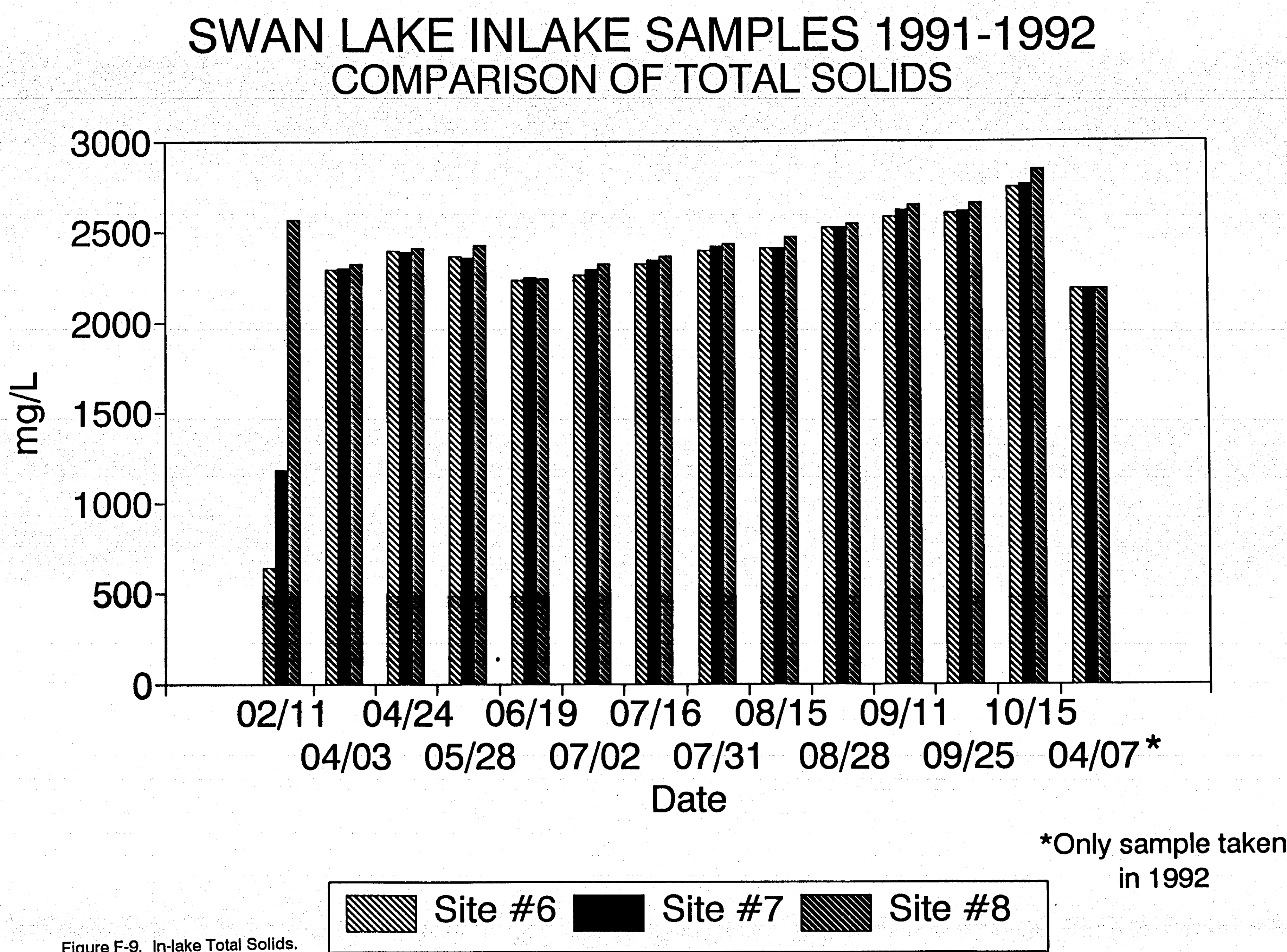


Figure F-9. In-lake Total Solids.

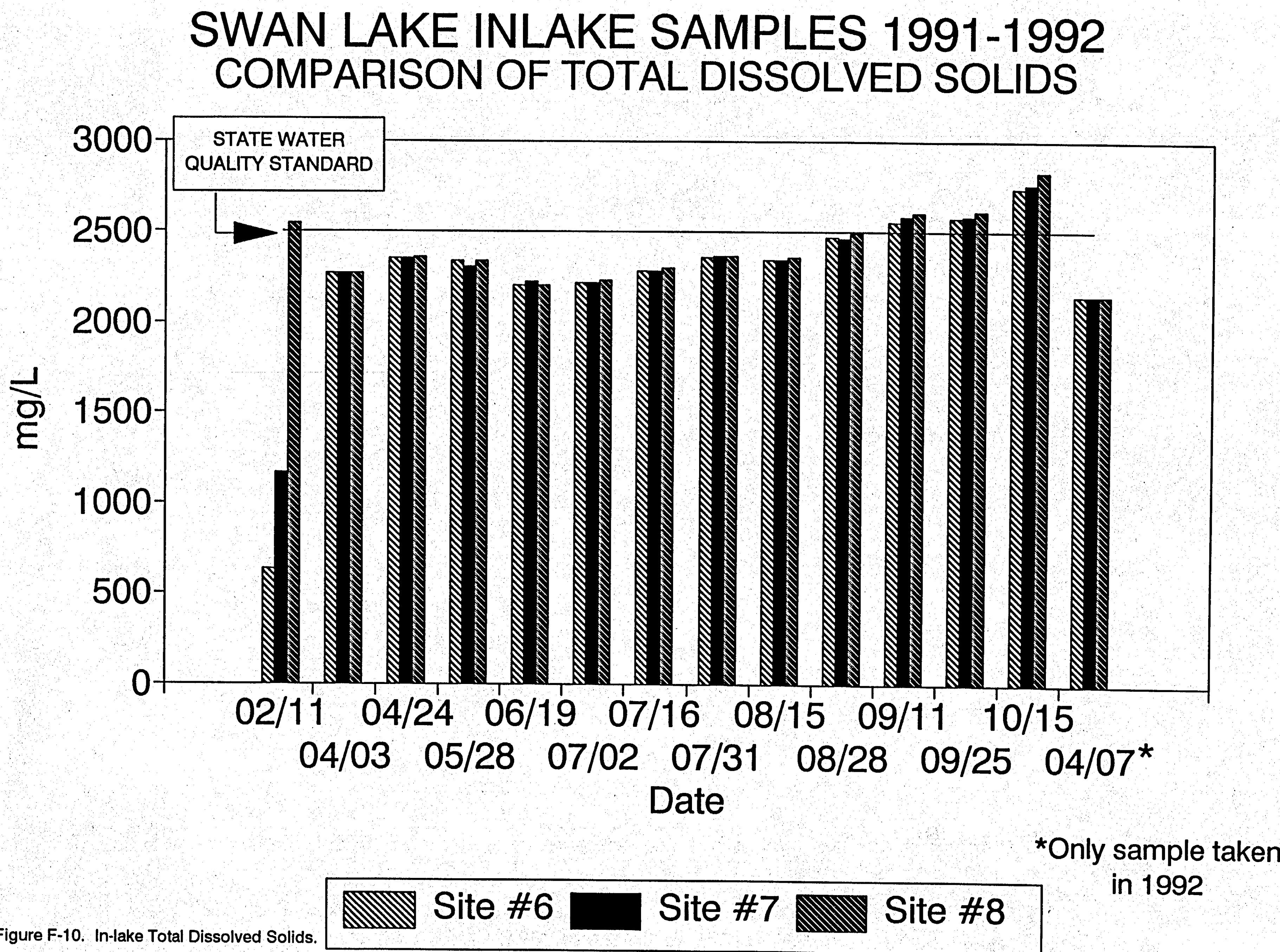


Figure F-10. In-lake Total Dissolved Solids.

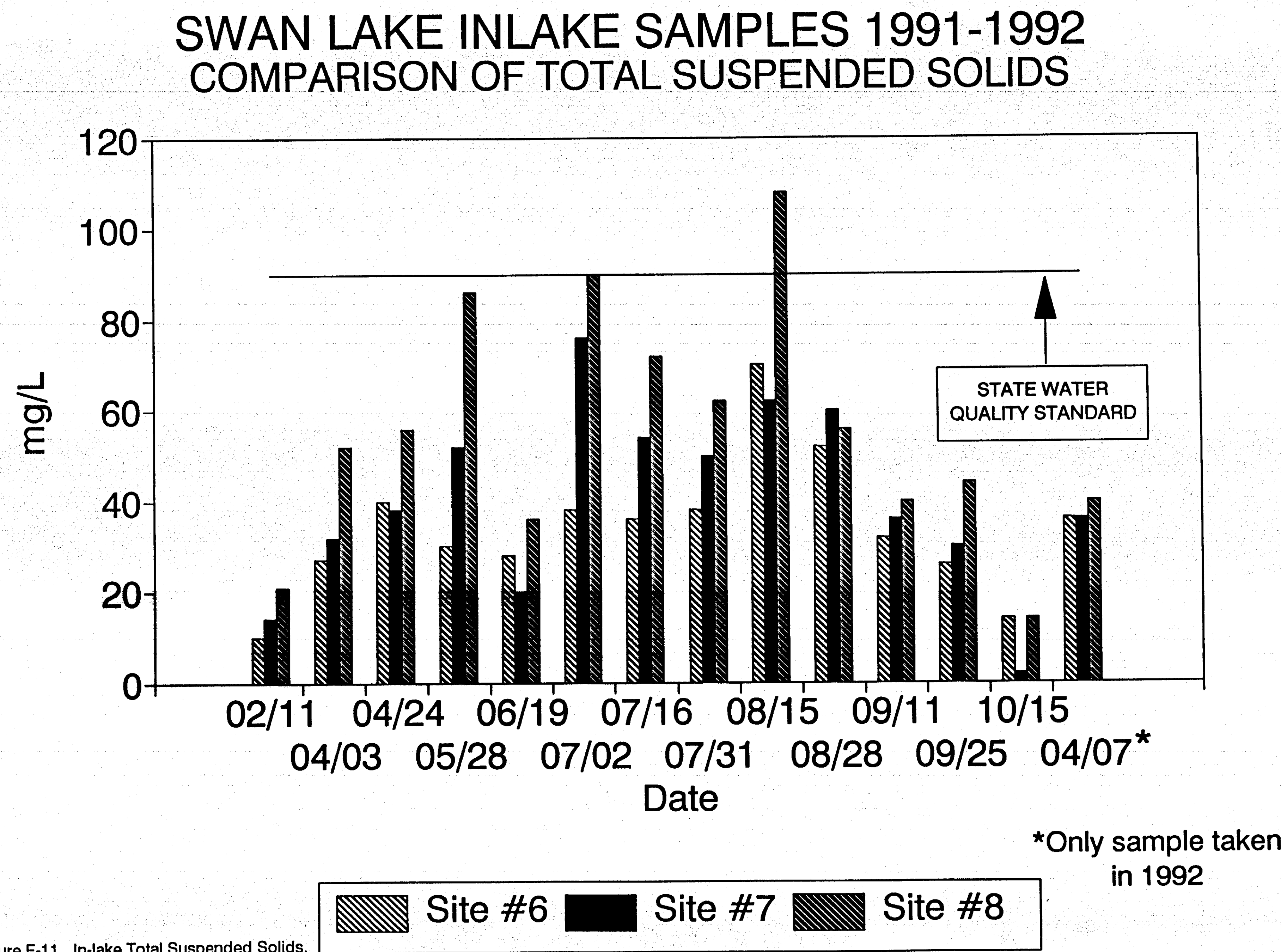


Figure F-11. In-lake Total Suspended Solids.

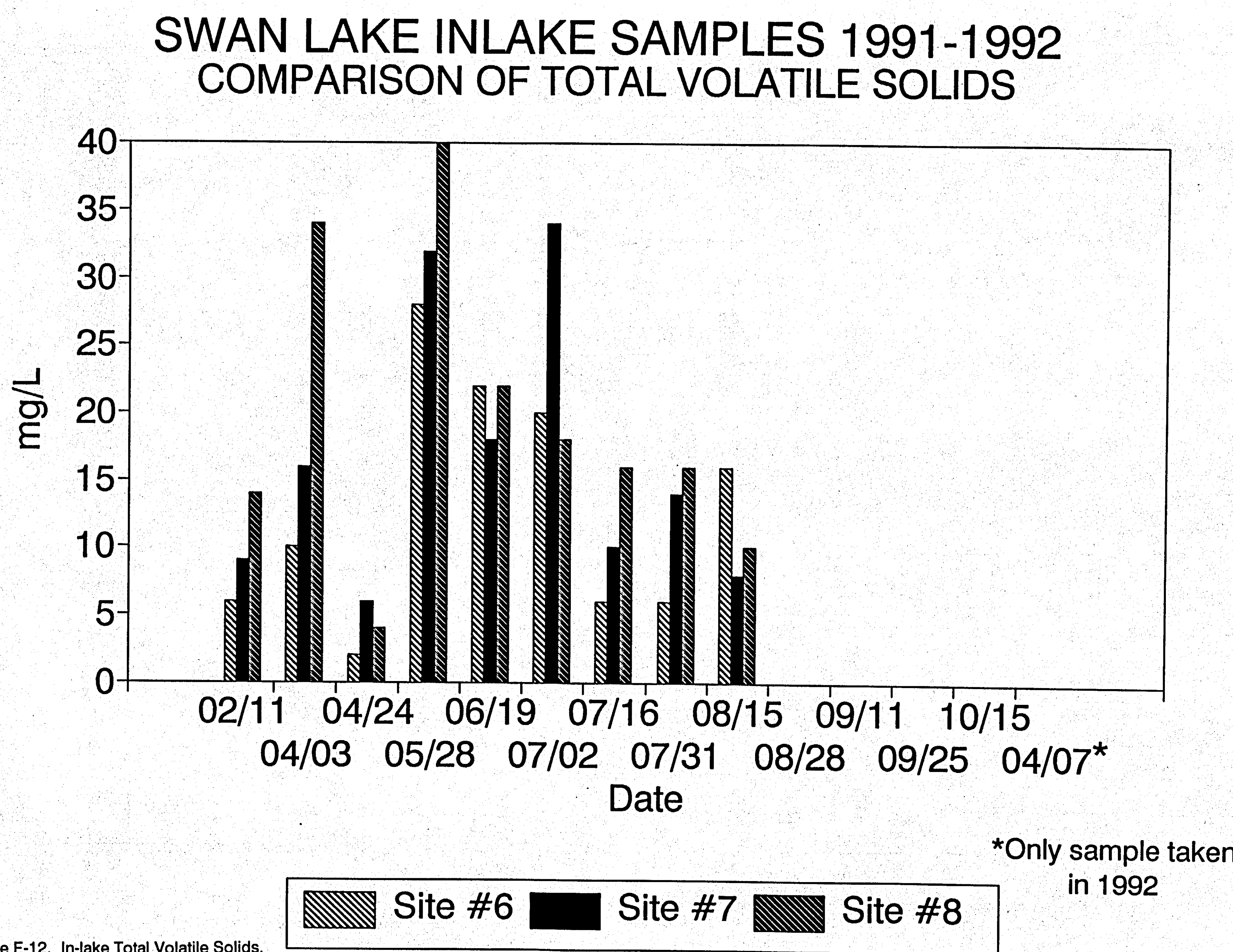


Figure F-12. In-lake Total Volatile Solids.

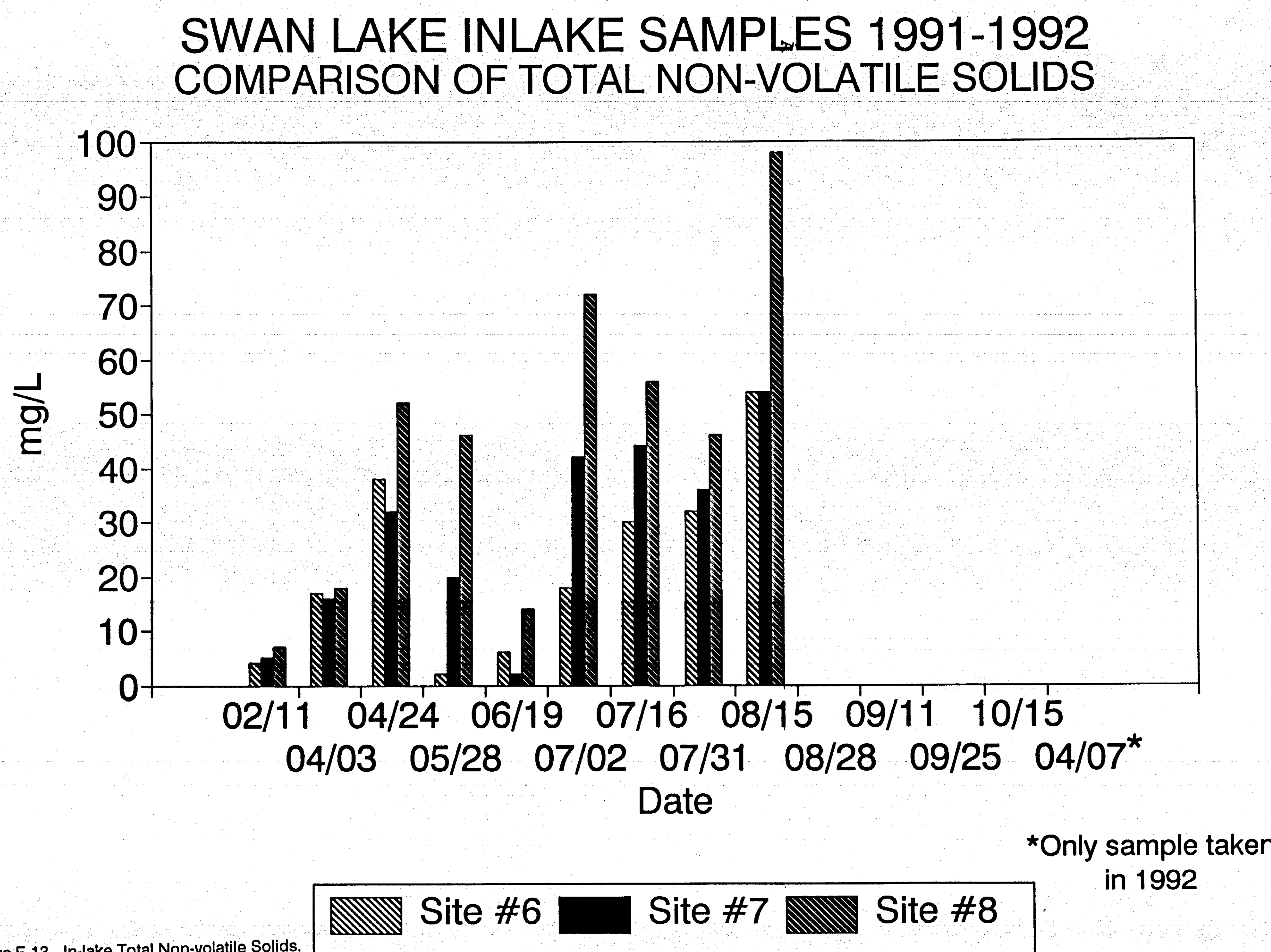


Figure F-13. In-lake Total Non-volatile Solids.

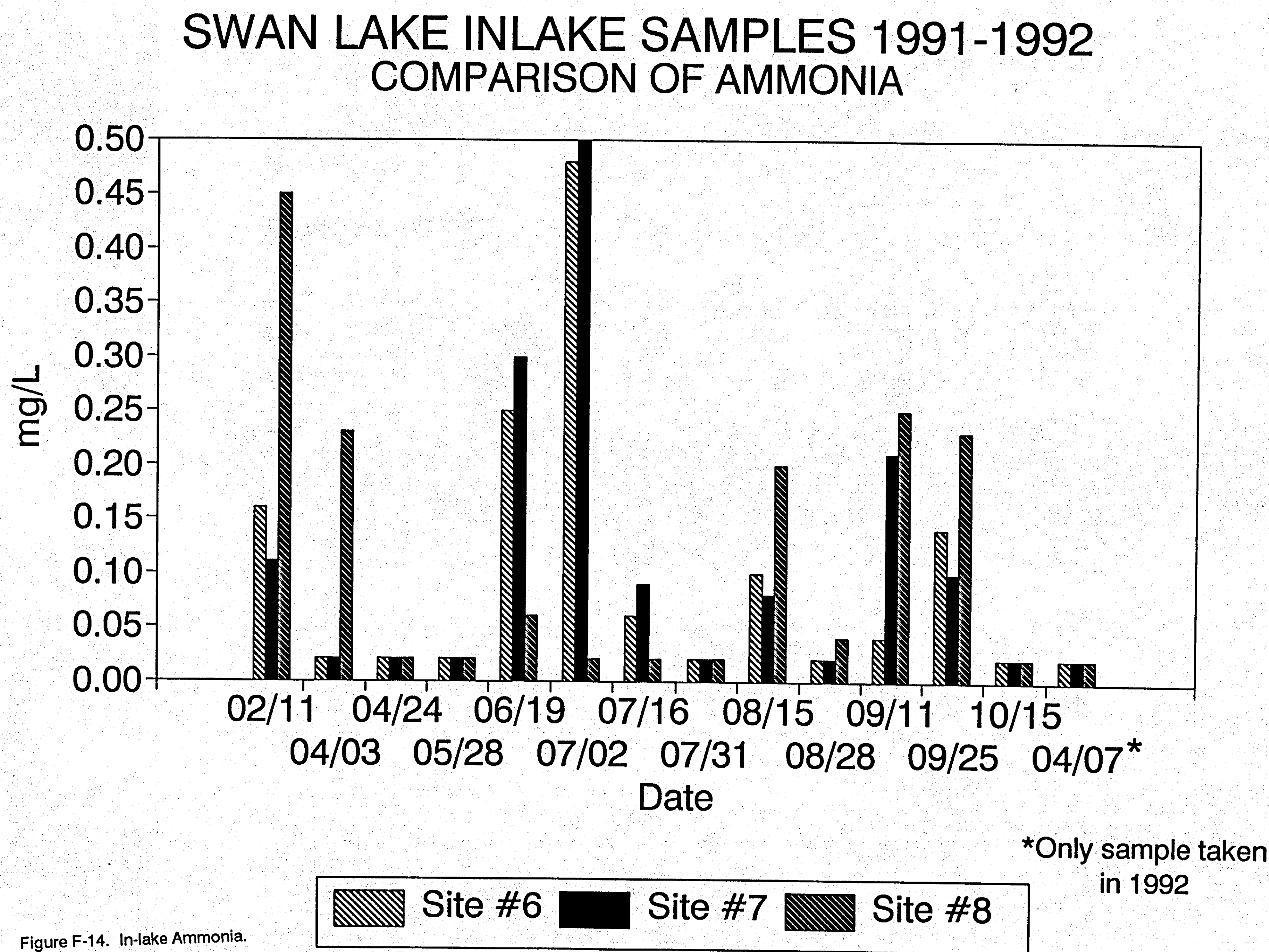


Figure F-14. In-lake Ammonia.

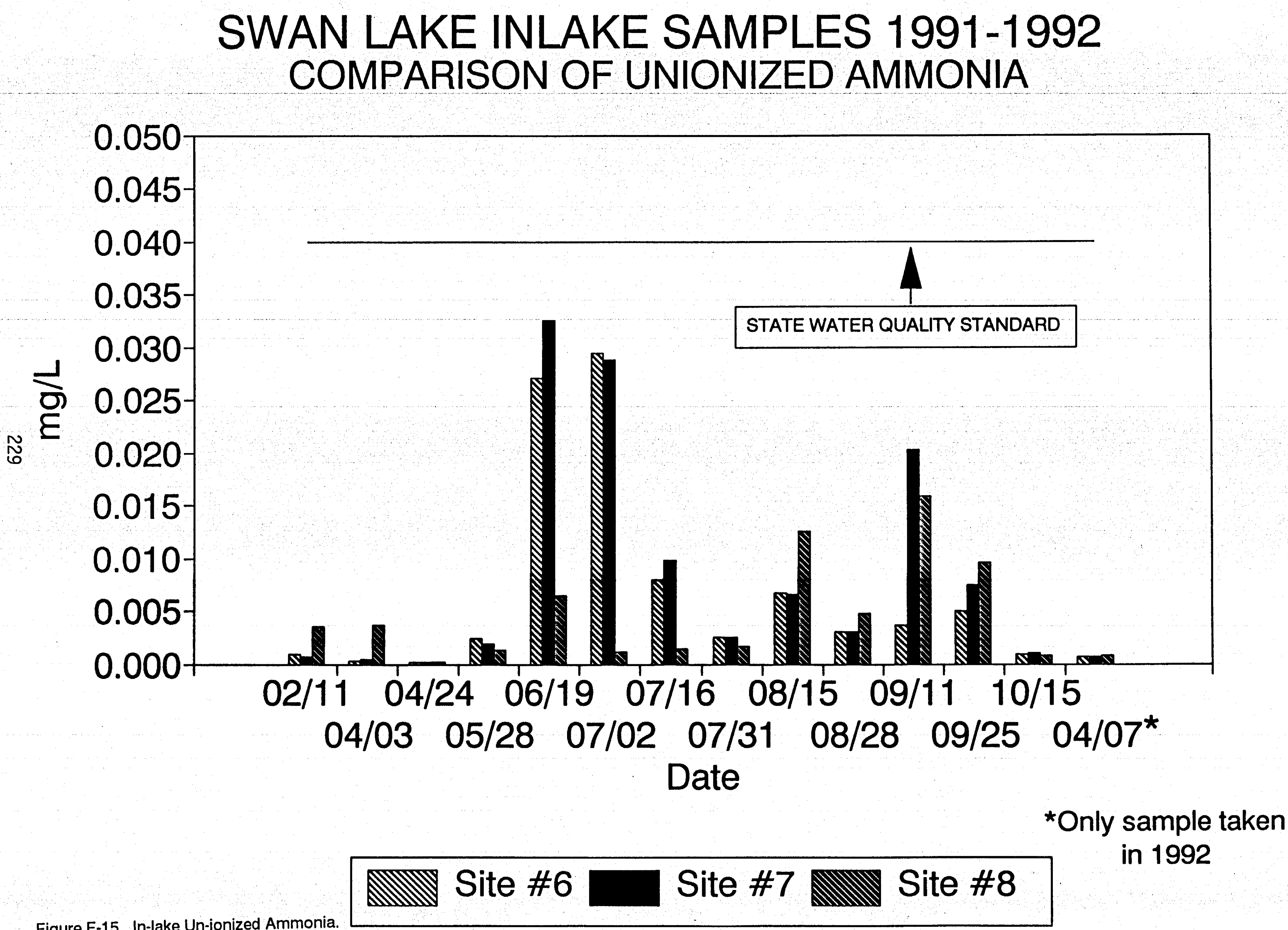


Figure F-15. In-lake Un-ionized Ammonia.

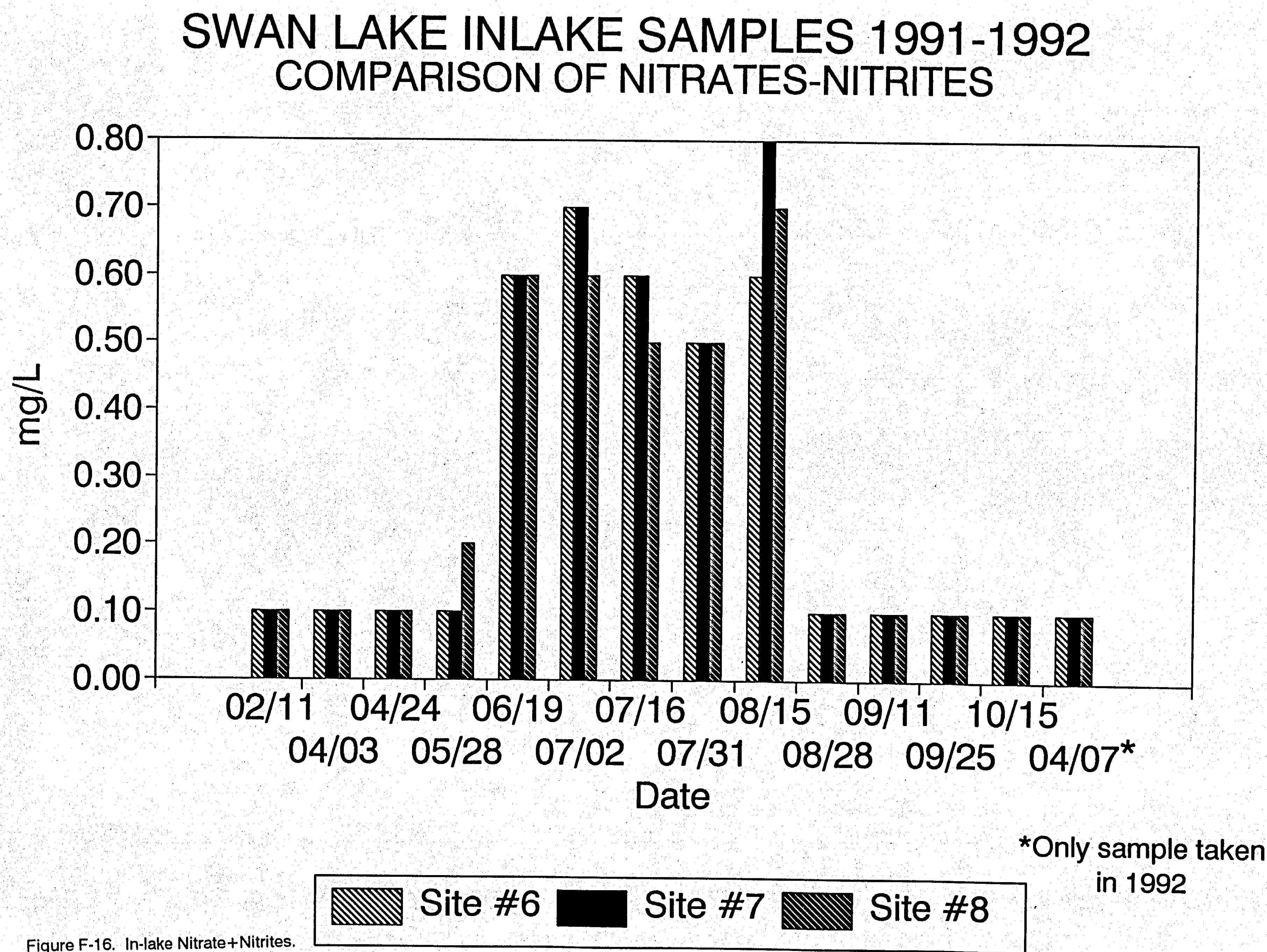


Figure F-16. In-lake Nitrate+Nitrites.

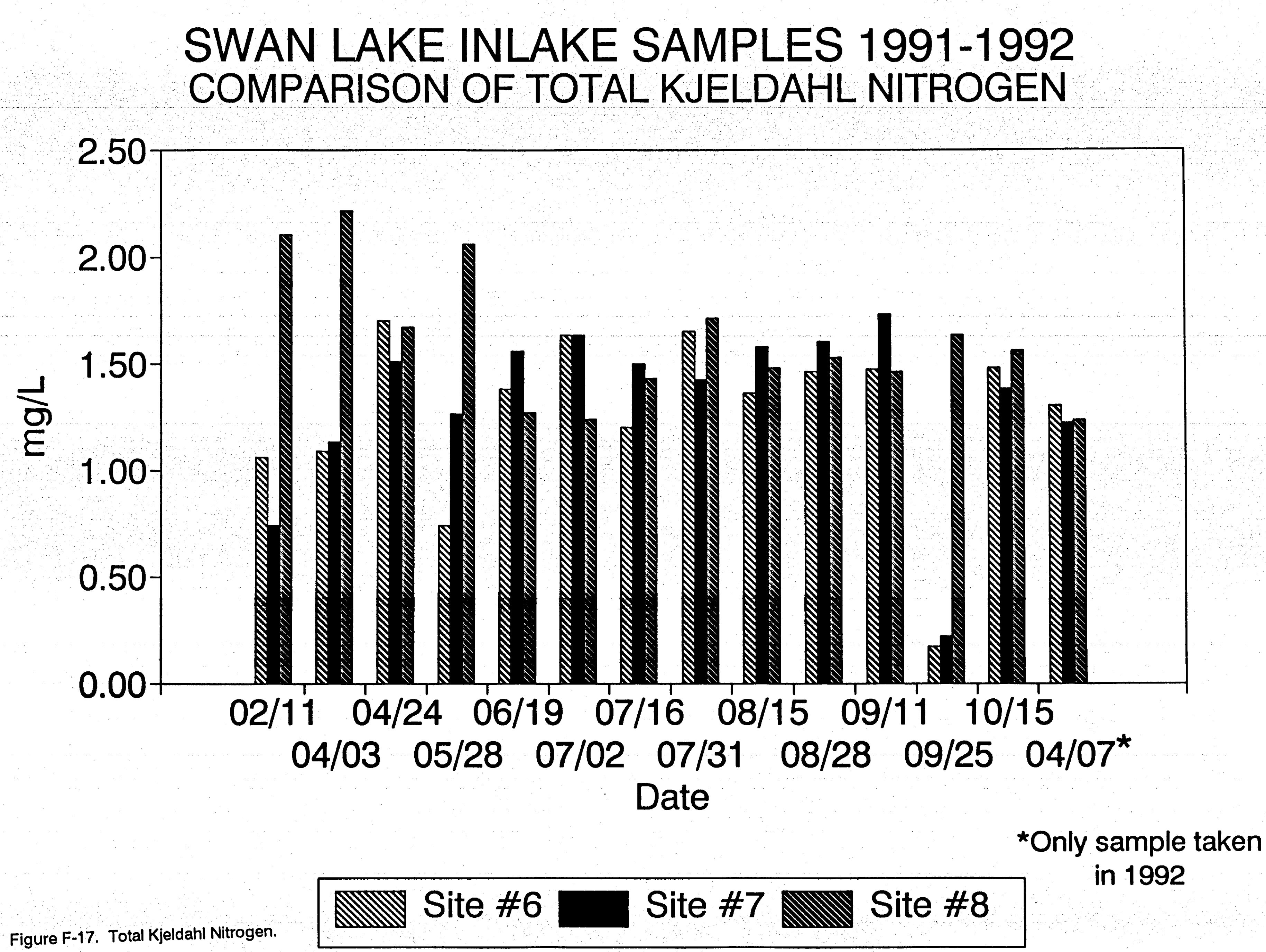


Figure F-17. Total Kjeldahl Nitrogen.

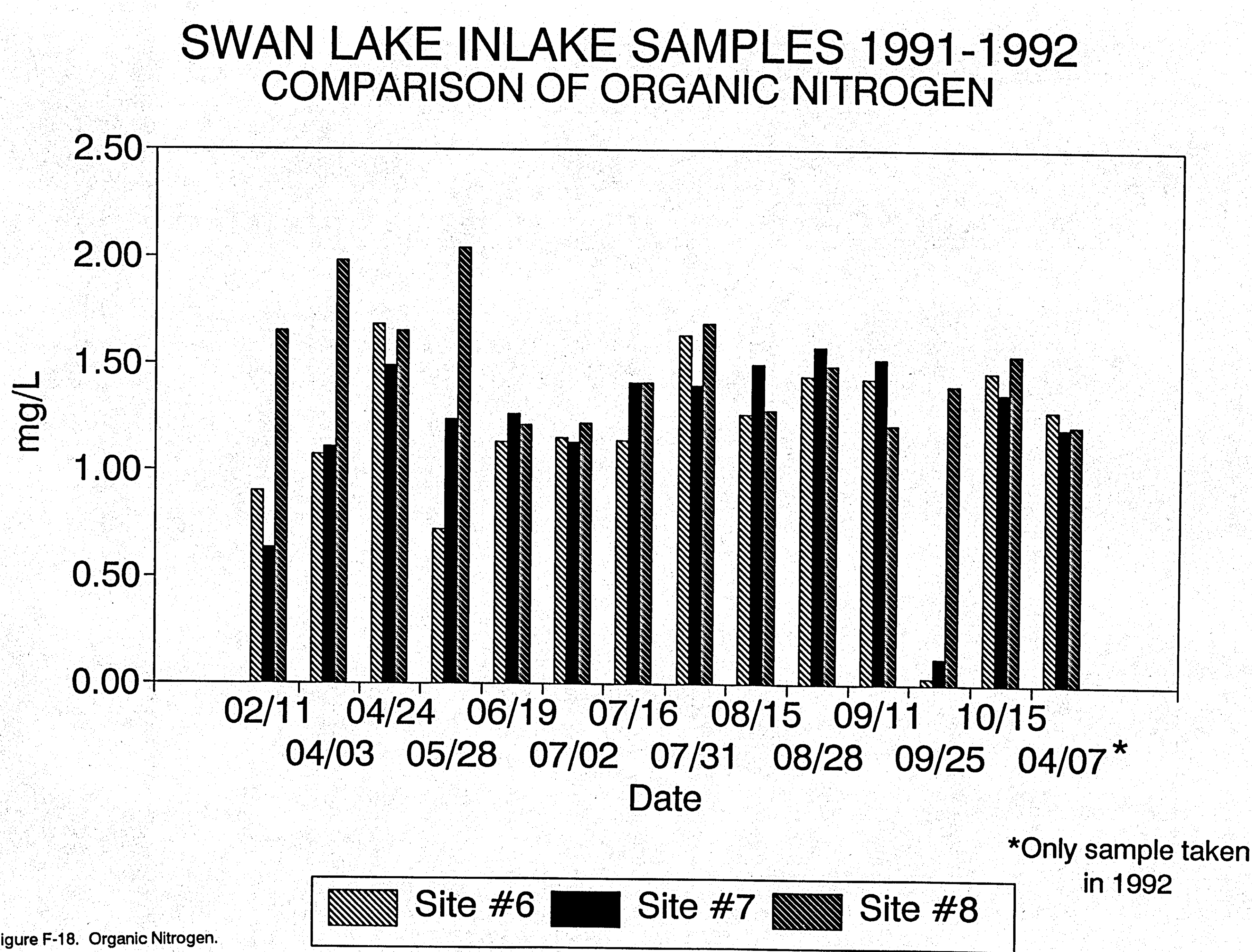


Figure F-18. Organic Nitrogen.

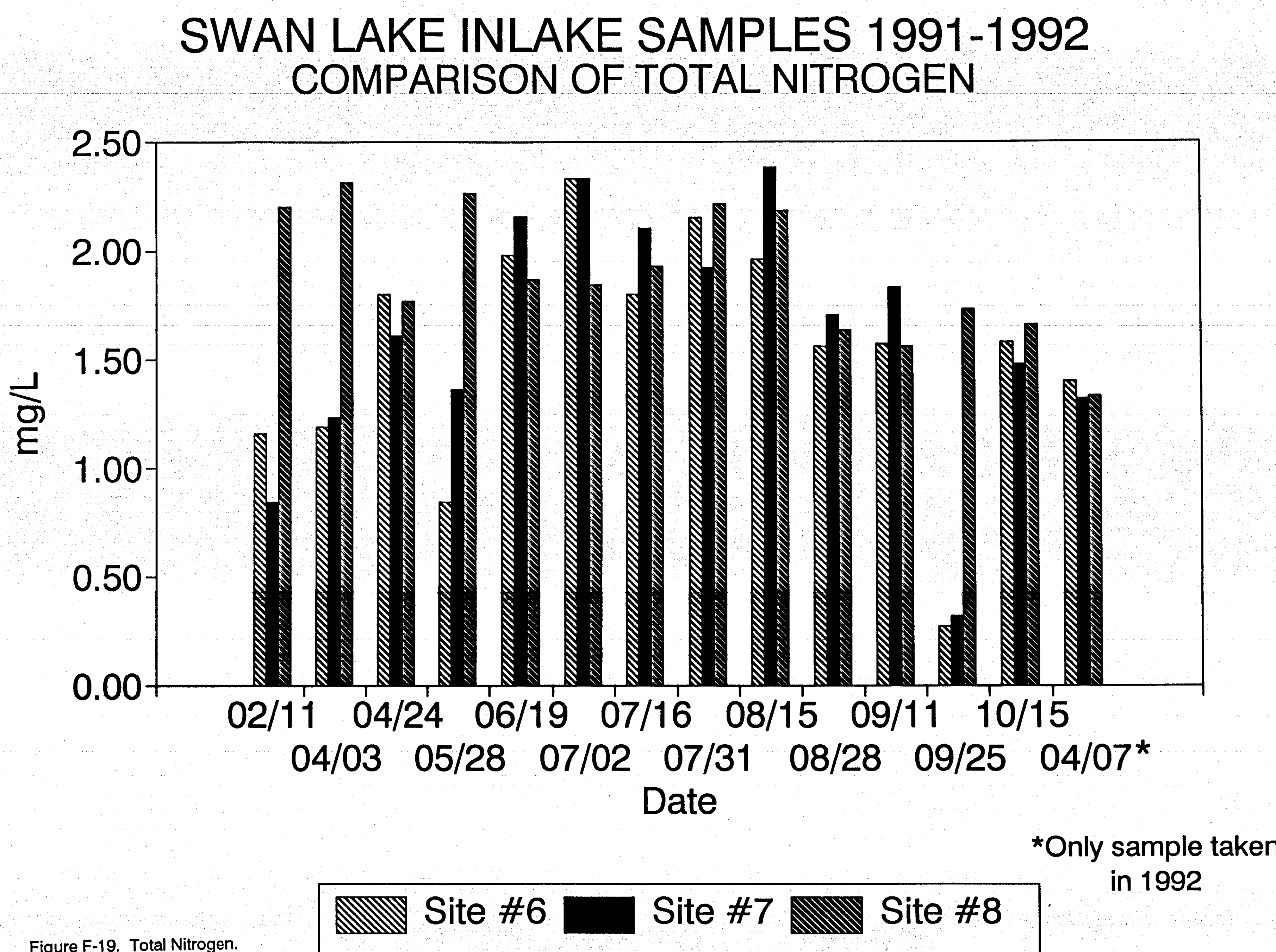


Figure F-19. Total Nitrogen.

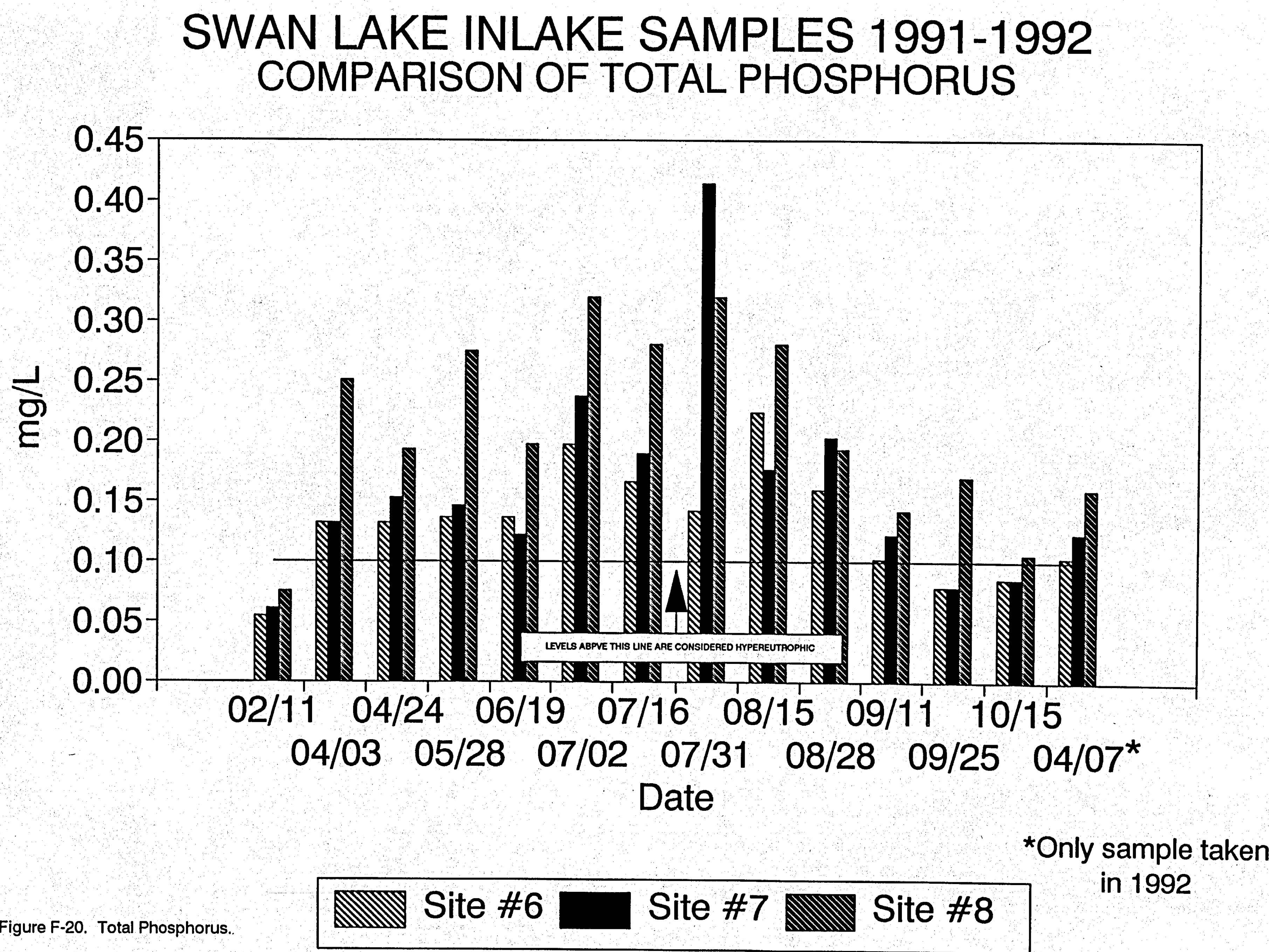


Figure F-20. Total Phosphorus.

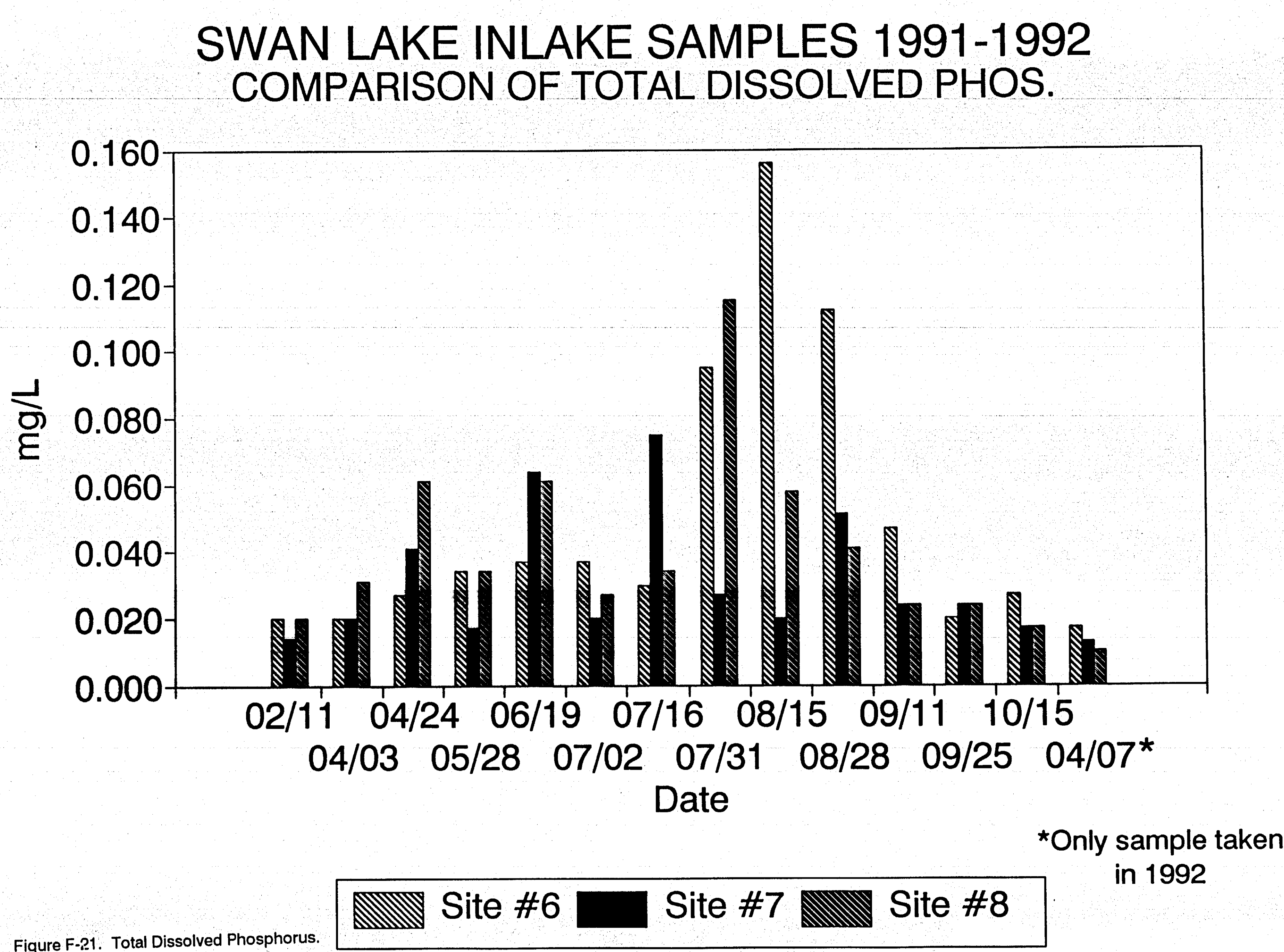


Figure F-21. Total Dissolved Phosphorus.

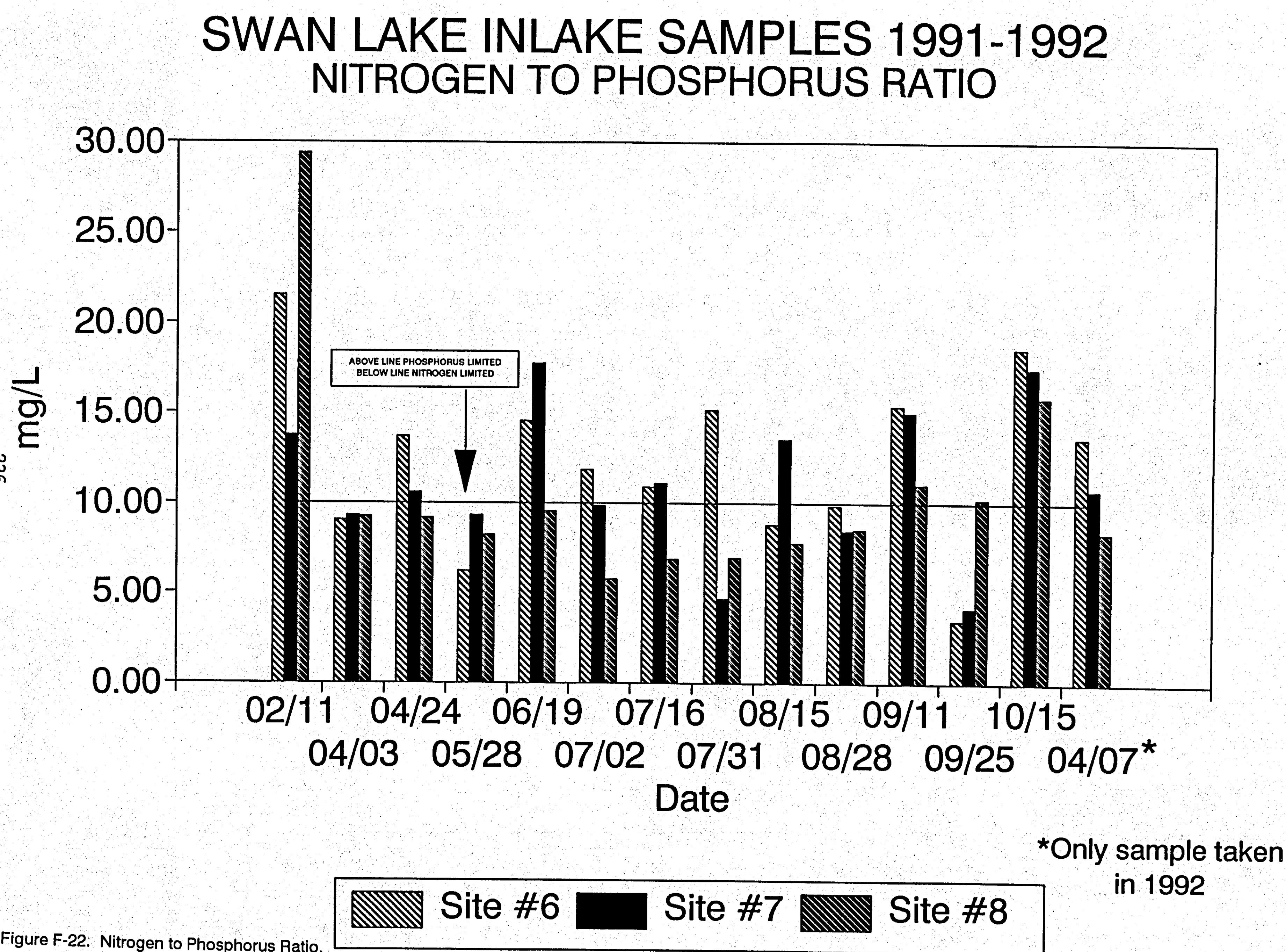


Figure F-22. Nitrogen to Phosphorus Ratio.

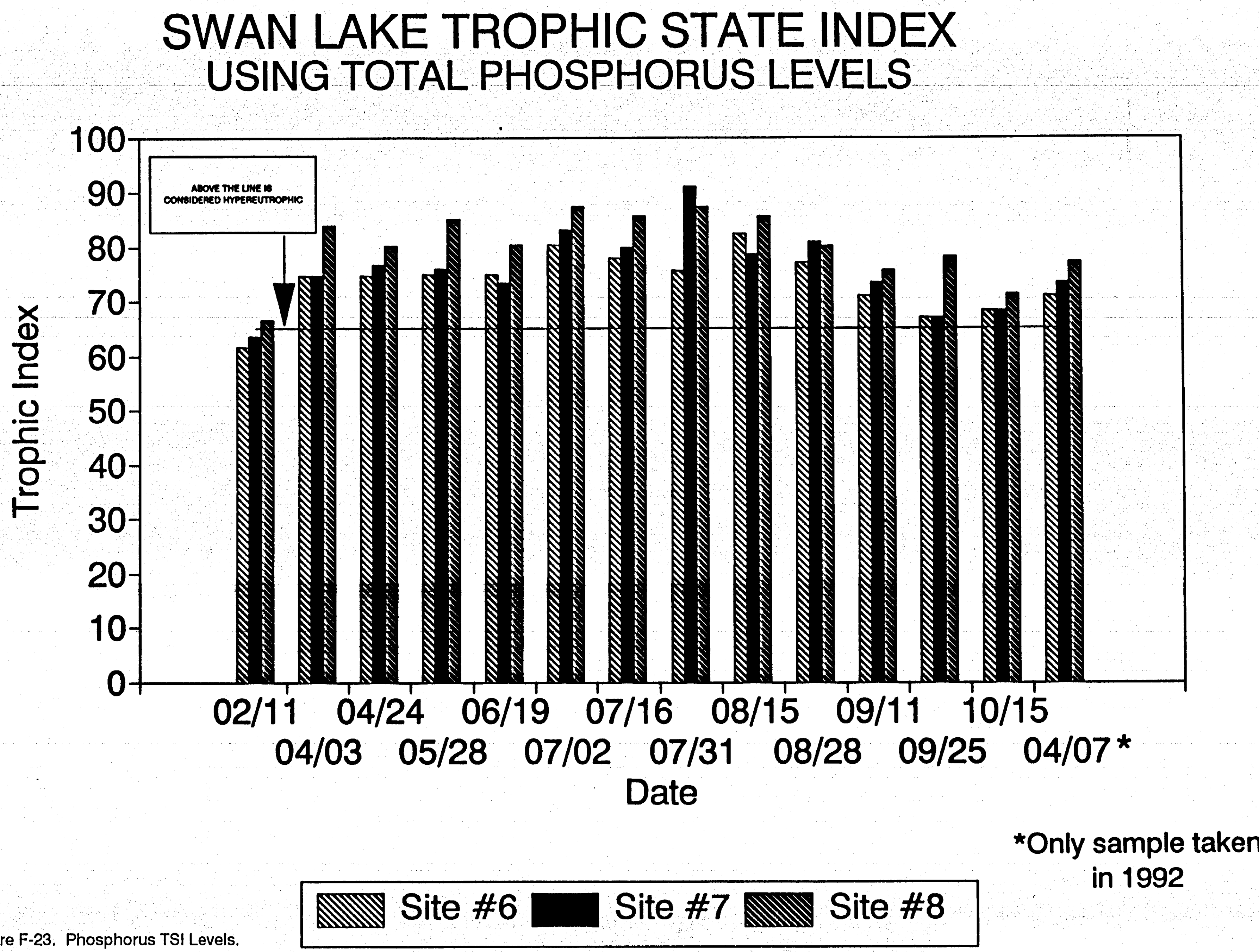


Figure F-23. Phosphorus TSI Levels.

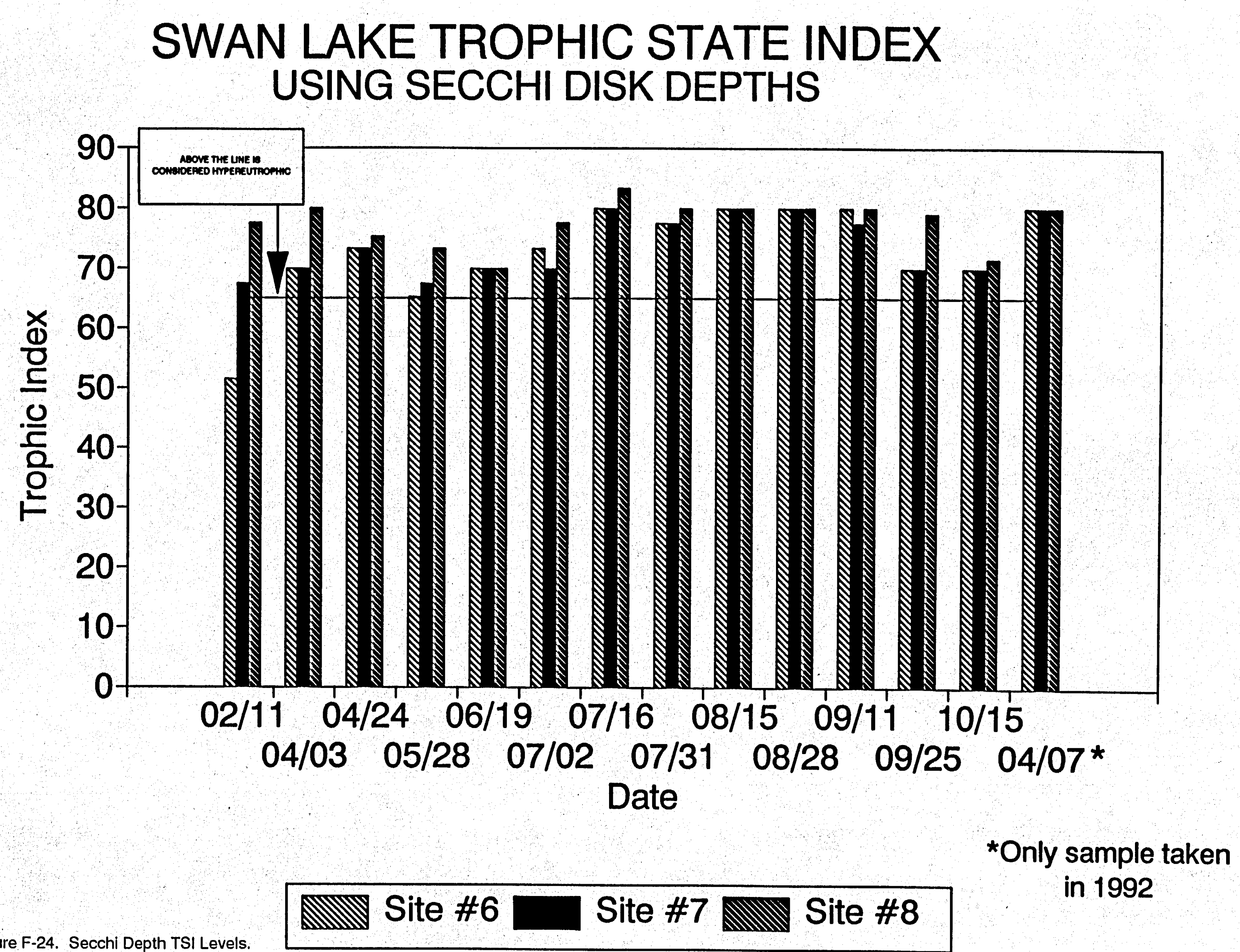


Figure F-24. Secchi Depth TSI Levels.

APPENDIX G - Elutriate Sample

Table G-1. Elutriate Sample.

MRD LAB No.90/270
sheet ~~1~~ 3 of 4

DEPARTMENT OF THE ARMY
Missouri River Division, Corps of Engineers
Division Laboratory
Omaha, Nebraska

Project: South Dakota Department of Water and Natural Resource
Date Sample Taken: 14 Mar 90
Date Sample Received: 17 Mar 90
Sample Description: Water and Sediment
Time Sample Taken: 3:00 PM
Comments: Swan Lake (Turner Co.) South Dakota

Customer Sample Id: **Swan Lake**
MRD Lab Sample No: M-1180
Sample Container: 3-1gal glass (water) and 1-1gal glass (sediment)

Analysis	Sediment Result	Units	Receiving Water Result	Units	Elutriate Water Result	Units
Ammonia Nitrogen			0.45	mg/L	5.3	mg/L
Chemical Oxygen Demand			39	mg/L	54	mg/L
Total Cyanide			<0.02	mg/L	<0.02	mg/L
Nitrate-Nitrite Nitrogen			0.19	mg/L	<0.01	mg/L
Total Phosphorus			0.09	mg/L	0.28	mg/L
Total Kjeldahl Nitrogen			2.0	mg/L	5.1	mg/L
Oil and Grease			<5	mg/L	<5	mg/L
Antimony	<10	mg/Kg	<1	ug/L	<1	ug/L
Arsenic	12	mg/Kg	2	ug/L	13	ug/L
Barium	310	mg/Kg	110	ug/L	260	ug/L
Beryllium	1.1	mg/Kg	<1	ug/L	<1	ug/L
Cadmium	<0.1	mg/Kg	<0.1	ug/L	<0.1	ug/L
Chromium	38	mg/Kg	<1	ug/L	<1	ug/L
Copper	23	mg/Kg	<10	ug/L	<10	ug/L
Iron	26000	mg/Kg	20	ug/L	80	ug/L
Lead	<5	mg/Kg	<1	ug/L	<1	ug/L
Magnesium	14000	mg/Kg	160	mg/L	170	mg/L
Manganese	1600	mg/Kg	<5	ug/L	1500	ug/L
Mercury	<0.1	mg/Kg	<0.2	ug/L	<0.2	ug/L
Selenium	0.50	mg/Kg	5.0	ug/L	1.0	ug/L
Zinc	98	mg/Kg	<10	ug/L	<10	ug/L
Nickel	36	mg/Kg	5	ug/L	3	ug/L
Aluminum	30000	mg/Kg	<50	ug/L	<50	ug/L
Calcium	93000	mg/Kg	220	mg/L	210	mg/L
Sodium	600	mg/Kg	94	mg/L	94	mg/L
Potassium	4900	mg/Kg	17	mg/L	23	mg/L
Silver	<1	mg/Kg	<10	ug/L	<10	ug/L
Simazine (Princep)	<100	ug/Kg	<0.1	ug/L	<0.1	ug/L
Metribuzin (Lexone)	<100	ug/Kg	<0.1	ug/L	<0.1	ug/L
Atrazine (Aatrex)	<100	ug/Kg	<0.1	ug/L	<0.1	ug/L
Aldrin	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
alpha-BHC	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
beta-BHC	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
gamma-BHC (Lindane)	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Mirex	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Chlordane	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
P'P"DDD	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
P'P"DDE	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
P'P"DDT	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Dieldrin	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Endosulfan I	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Propachlor (Ramrod)	<100	ug/Kg	<0.1	ug/L	<0.1	ug/L
Metolachlor (Dual)	<100	ug/Kg	<0.1	ug/L	<0.1	ug/L
Alachlor (Lasso)	<100	ug/Kg	<0.1	ug/L	<0.1	ug/L
Diazinon	<100	ug/Kg	<0.1	ug/L	<0.1	ug/L
Endrin	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Heptachlor	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Heptachlor epoxide	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Methoxychlor	<10	ug/Kg	<0.01	ug/L	<0.01	ug/L
Toxaphene	<500	ug/Kg	<0.50	ug/L	<0.50	ug/L
PCB-1016	<100	ug/Kg	<0.10	ug/L	<0.10	ug/L
PCB-1221	<100	ug/Kg	<0.10	ug/L	<0.10	ug/L
PCB-1232	<100	ug/Kg	<0.10	ug/L	<0.10	ug/L
PCB-1242	<100	ug/Kg	<0.10	ug/L	<0.10	ug/L
PCB-1248	<100	ug/Kg	<0.10	ug/L	<0.10	ug/L
PCB-1254	<100	ug/Kg	<0.10	ug/L	<0.10	ug/L
PCB-1260	<100	ug/Kg	<0.10	ug/L	<0.10	ug/L

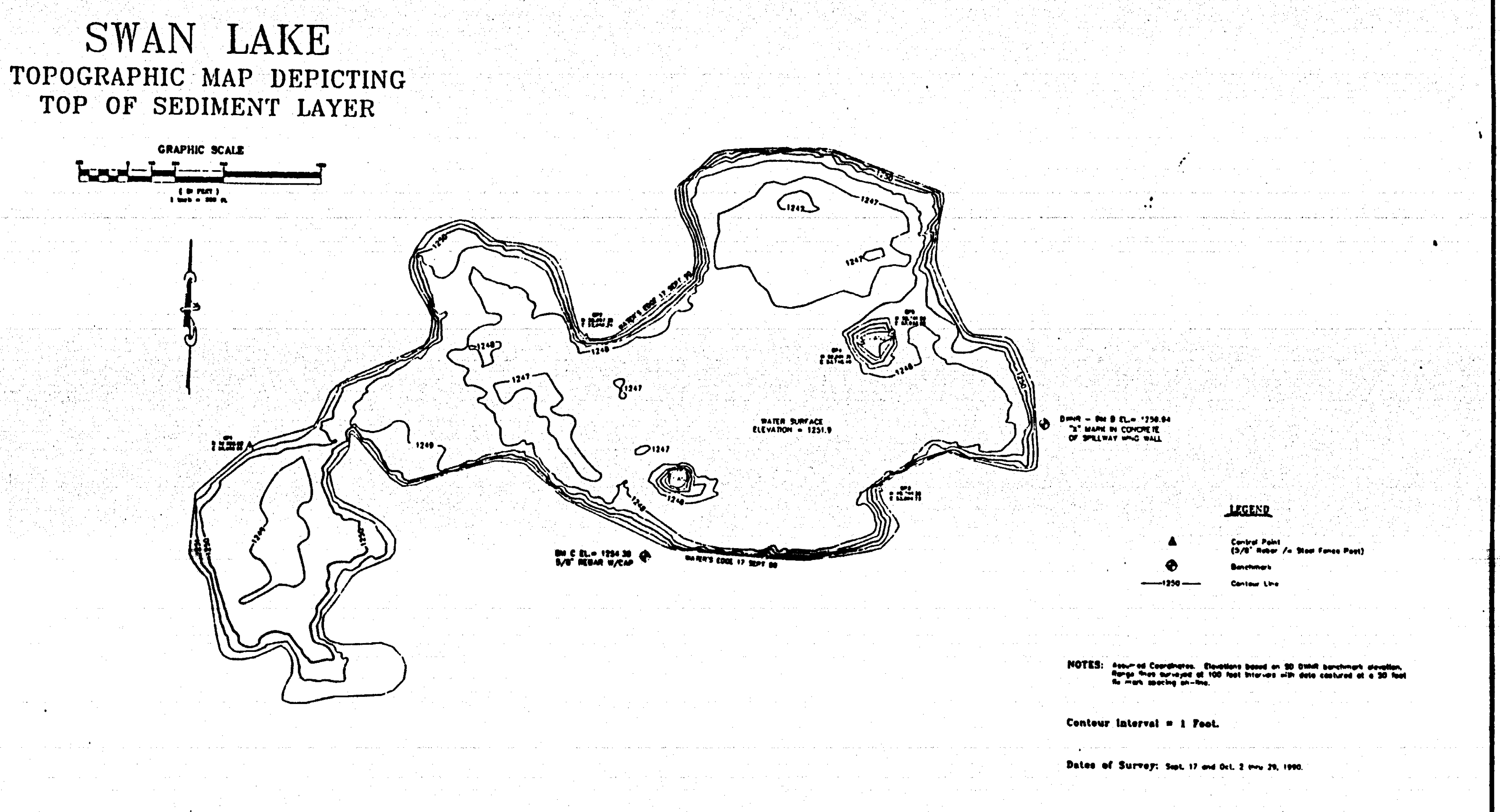
APPENDIX H - Maps of In-lake Sediment Survey

Table H-1. Sediment Volume Computations.

SWAN LAKE
SEDIMENT VOLUME COMPUTATIONS

STATION	AREAS in SQ FT		VOLUMES in CU. YDS.	
		SEDIMENT		SEDIMENT
0+00	0	0		
1+00	0	2406	0	4455
2+00	0	3775	0	11445
3+00	0	7614	0	21090
4+00	0	8997	0	30762
5+00	0	11326	0	37636
6+00	0	12100	0	43382
7+00	0	11884	0	44378
8+00	0	9877	0	40260
9+00	0	9556	0	35986
10+00	0	9972	0	36184
11+00	0	11334	0	39457
12+00	0	12589	0	44304
13+00	0	12978	0	47347
14+00	0	12094	0	46429
15+00	0	12068	0	44743
16+00	0	10664	0	42097
17+00	0	7762	0	34123
18+00	0	7587	0	28425
19+00	0	6985	0	26984
20+00	0	6969	0	25840
21+00	0	6616	0	25157
22+00	0	5603	0	22628
23+00	0	5738	0	21002
24+00	0	6182	0	22074
25+00	0	5700	0	22004
26+00	0	8194	0	25731
27+00	0	7701	0	29435
28+00	0	7074	0	27361
29+00	0	7310	0	26637
30+00	0	7430	0	27297
31+00	0	6187	0	25218
32+00	0	6310	0	23143
33+00	0	5412	0	21707
34+00	0	4205	0	17809
35+00	0	3931	0	15065
36+00	0	3648	0	14035
37+00	0	3969	0	14106
38+00	0	3770	0	14332
39+00	0	3133	0	12784
40+00	0	1542	0	8656
41+00	0	2271	0	7060
42+00	0	2991	0	9744
43+00	0	4981	0	14763
44+00	0	5603	0	19599
45+00	0	6572	0	22545
46+00	0	7932	0	26859
47+00	0	8114	0	29715
48+00	0	5950	0	26044
49+00	0	5042	0	20356
50+00	0	4840	0	18300
51+00	0	4099	0	16553
52+35	0	0	0	10247
			0	1323275

TOTAL ESTIMATED SEDIMENT VOLUME = 1,323,000 CU. YDS



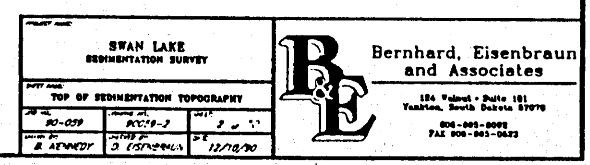


Figure H-1. Elevations of Top Sediment Layer.

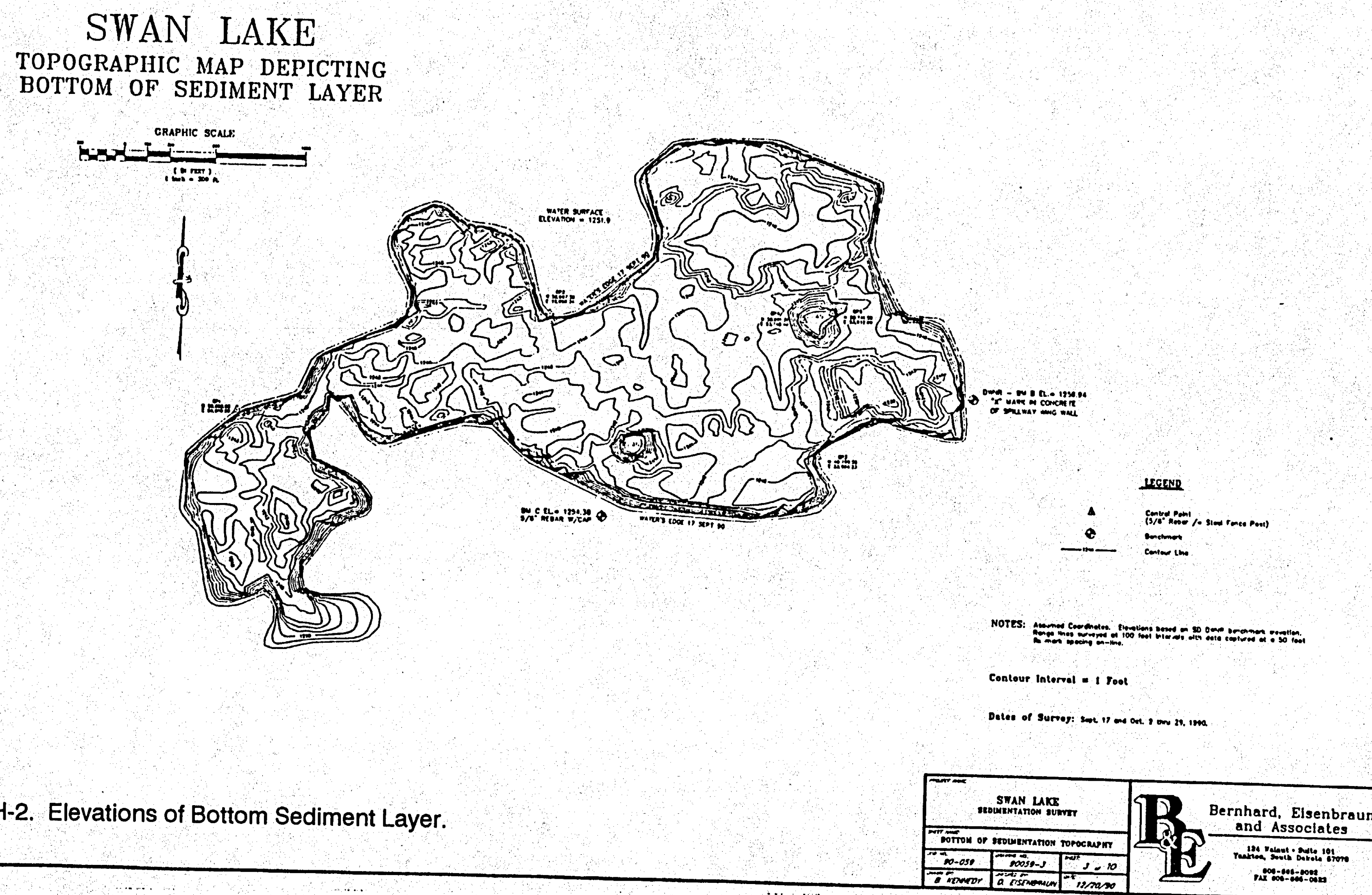


Figure H-2. Elevations of Bottom Sediment Layer.

This document was prepared [redacted] by the South Dakota Department of Environment and Natural Resources. Thirty-five documents were printed at a cost of $6.60 a copy.