UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-QUALITY RECONNAISSANCE OF LAKE TUSCALOOSA, ALABAMA
MARCH-JUNE 1975

Open-File Report 76-160

Prepared in cooperation with
Geological Survey of Alabama

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Factors for converting English units to International System (SI) units

The following factors may be used to convert the English units published herein to the International System of Units (SI). Subsequent reports will contain both the English and SI unit equivalents in the station manuscript descriptions until such time that all data will be published in SI units.

Multiply English units	By	To obtain SI units
	Length	
feet (ft)	0.3048	metres (m)
	Area	
acres	.004047	square kilometres (km^2)
square miles (mi^2)	2.590	square kilometres (km^2)
	Volume	
gallons (gal)	3.785	*litres (l)
cubic feet (ft^3)	.02832	cubic metres (m^3)
	Flow	
cubic feet per second (ft^3)	.02832	cubic metres per second (m^3/s)
	Mass	
ton (short)	.9072	tonne (t)
tons per square mile (T/mi^2)	.3503	tonnes per square kilometre (t/km^2)

* The unit litre is accepted for use with the Internation System (SI). See NBS Special Bulletin 330, p. 13, 1972 edition.

WATER-QUALITY RECONNAISSANCE OF LAKE TUSCALOOSA, ALABAMA

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By E. F. Hubbard

ABSTRACT

As part of a cooperative project to evaluate the impact of development on the Lake Tuscaloosa, Alabama, area, the U.S. Geological Survey made a water-quality investigation of the lake, lasting from March through June 1975. The purposes of this investigation were to assess the effects of existing development on lake water quality and to provide a documented set of baseline data against which future changes in water quality could be measured. The data obtained during the investigation were of four kinds--water-quality analyses, bed-material analyses, vertical profiles of selected water-quality parameters, and bacteriological determinations. These data indicate that the water quality of the lake is good; the indicators of severe pollution from development were not found in sufficient concentrations to cause immediate alarm.

INTRODUCTION

In late 1974 the Geological Survey of Alabama undertook an environmental research project with the city of Tuscaloosa and Tuscaloosa County to study the impact of housing development in the 15-minute Samantha quadrangle, which is a 249-square-mile (645-square kilometres) area north of Tuscaloosa and Northport in Tuscaloosa County. The principal geographic feature of this area and the focus for the investigation is Lake Tuscaloosa, a 5,875-acre (23.8 square kilometres) water-supply and recreation reservoir filled in 1969. [A table on page iv gives the factors that may be used to convert English units to International System (SI) units.]

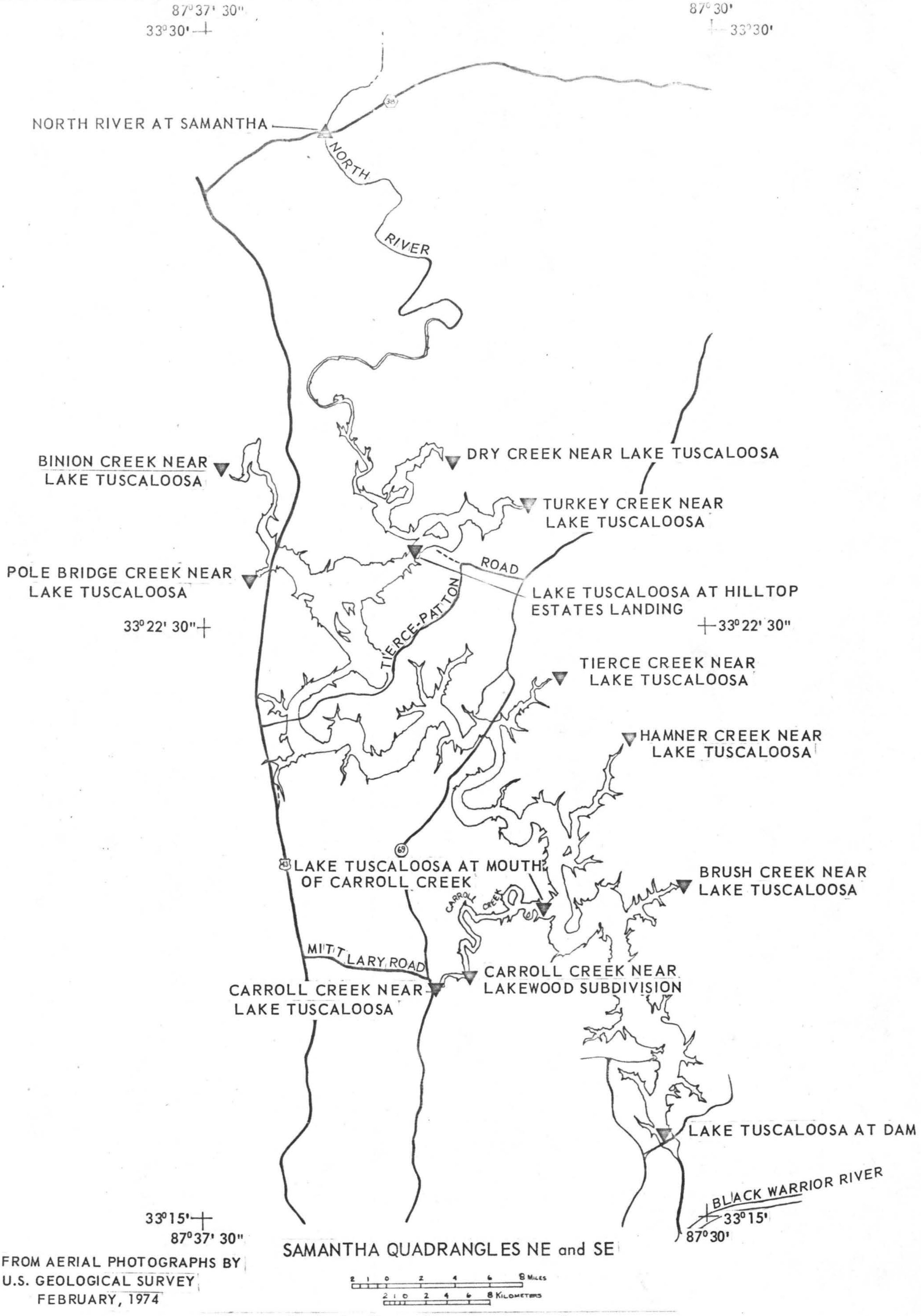
The city and county officials have expressed concern over the effects of development on the water quality of the lake. Of particular concern is the effect of seepage from septic tanks serving the many homes and cottages that are rapidly being built around the lake. The seepage of septic tank effluent is controlled by subsurface geologic and hydrologic conditions. The region is underlain by fractured, layered sandstone and shale covered by a thin layer of weathered material (clay and soil derived from the rock) or by thin deposits of sand and gravel. It seems possible, and even likely, that seepage from septic tanks in the thin soil layer could move to the rock surface and then flow laterally to the lake or, intercepting fractures in the rock, could find an avenue directly to the lake. Septic-tank effluent that does not have sufficient residence time in the soil zone would contain nutrients which would contribute to the eutrophication of the lake, or it could contain pathogenic organisms.

Another major concern was the effects of strip mining on sedimentation in the lake. T. W. Daniel, Jr., (written commun., 1975) estimates that more than 50 percent of the North River basin in the Samantha quadrangle is underlain by coal that could be recovered by surface mining. Elsewhere, strip mining, and other kinds of development that severely expose the soil, have greatly increased the sediment yield of stream basins.

Arteaga and Hubbard (1975) show a more than 60-fold increase in sediment yield of severely exposed basins over rural basins, using data from a study of streams in Maryland, the District of Columbia, Virginia, and North Carolina. Similarly, Collier and Musser (1964) estimated a sediment yield of 30,000 tons per square mile (10,500 tonnes per square kilometre) from strip-mined areas--as opposed to a yield of 27.9 tons per square mile (9.8 tonnes per square kilometre) from a nearby wooded area--during a study of the Beaver Creek basin, in 1959. Thus, extensive surface mining in the North River basin could greatly increase the sediment moving to Lake Tuscaloosa--increasing costs of treatment for water supply, diminishing the fishing, making the water more turbid, and reducing the storage capacity of the reservoir.

As a part of the environmental project, the U.S. Geological Survey conducted a sediment study and a general water-quality reconnaissance of the lake in cooperation with the Geological Survey of Alabama. The purposes of the U.S. Geological Survey investigations were to assess the effect of existing development on the water quality of the lake and to collect baseline information that subsequent investigators could use to determine the changes in water quality that may occur in the future. This paper reports the results of the water-quality reconnaissance. A separate report (Hubbard, 1976) gives the results of the sediment study.

The reconnaissance principally involved four kinds of sampling--water samples for analyses of chemical quality, bed material samples for analyses of selected constituents, vertical profiles of selected key parameters of water quality, and water samples for bacteriological determinations. Most of the samples were collected at three locations--at the dam, at the mouth of Carroll Creek, and at Hilltop Estates landing--as shown on the map, figure 1. The strategy involved in the selection of the sampling sites was simple. The samples at the dam represent downstream conditions in the lake; at the mouth of Carroll Creek, the effects of the residential development; and at Hilltop Estates, upstream conditions in the lake. Bacteriological determinations were also made at other sites, mostly where small



BASE FROM AERIAL PHOTOGRAPHS BY
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FEBRUARY, 1974

Figure 1.–Lake Tuscaloosa and sampling sites.

streams entered the lake; and routine water-quality analyses of samples taken during this reconnaissance from North River at Samantha are included in this report.

Frequency of sampling was approximately once a month except for the bed-material samples, which were only collected once during the reconnaissance. The sampling trips were scheduled so the samples would represent a variety of hydrologic conditions on the lake. The samples of March 16 followed a significant flood event. Figure 2, a hydrograph of the average daily discharge of North River at Samantha, shows that the highest flood during the reconnaissance occurred on March 14. The peak discharge at Samantha was about equal to the mean annual flood. That is, for the period of record at this long-term gaging station, about half the annual peaks were lower than the flood of March 14 and about half were higher. Similarly, figure 3, a lake-level hydrograph, shows that the highest lake stage during the reconnaissance occurred on March 15. The lake was still relatively high on March 16 during the sampling. The water was muddy and contained large amounts of floating debris as is shown in figure 4.

In contrast, the sampling of April 29 followed a long decline in streamflow reflecting a period of dry weather. Lake level was as low as it had been since the start of the reconnaissance study.

The June 13 sampling trip was during a period of unsettled weather. Although inflows and lake levels were relatively low during this period, they exhibited quite a bit of variability. The lake contained a mixture of recently received runoff and water that had been in residence a considerable length of time. In contrast, the March 14 samples contained a high percentage of water that had recently entered the lake; 10 to 15

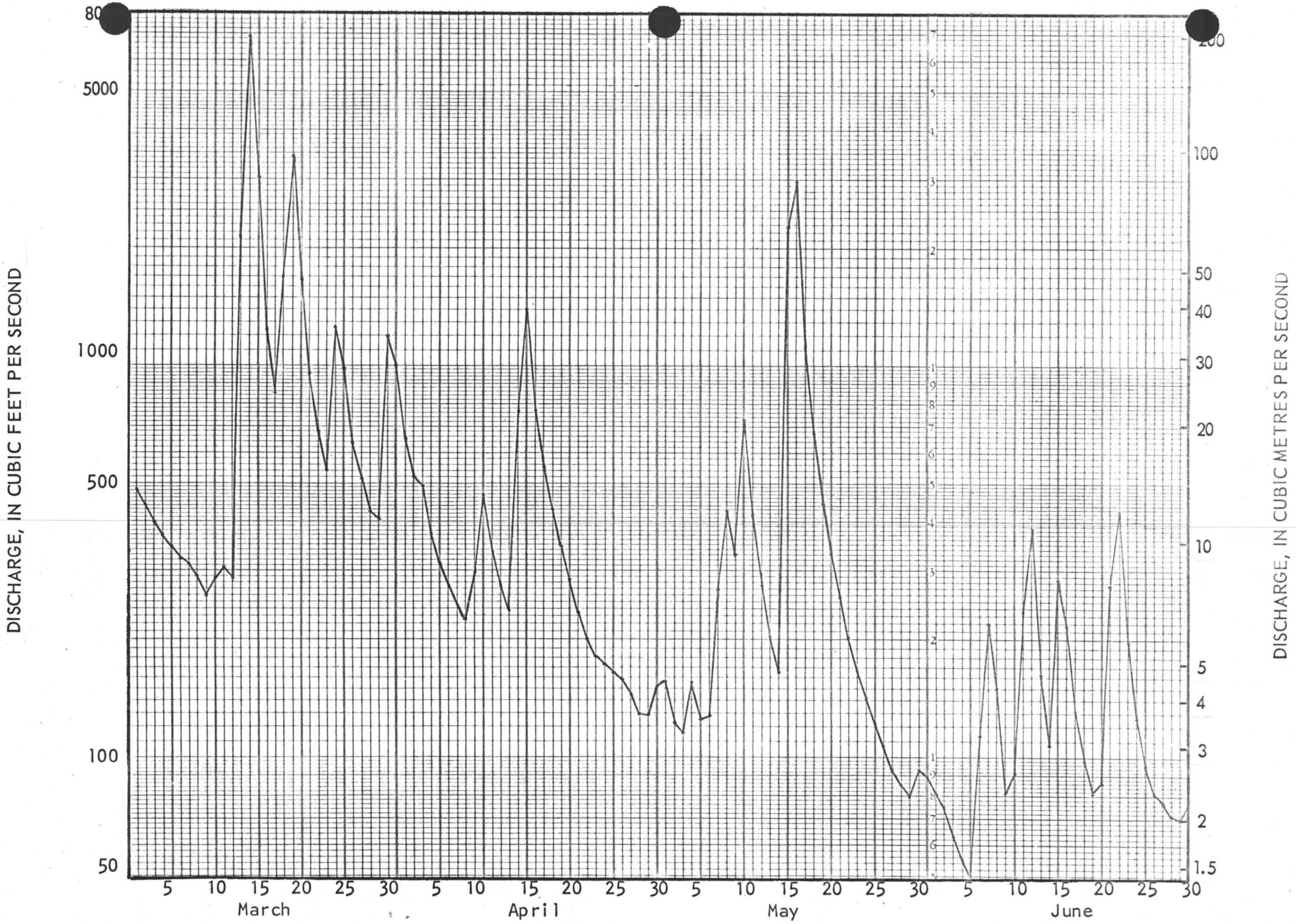

Figure 2.--Daily discharges of North River at Samantha, March through June 1975.

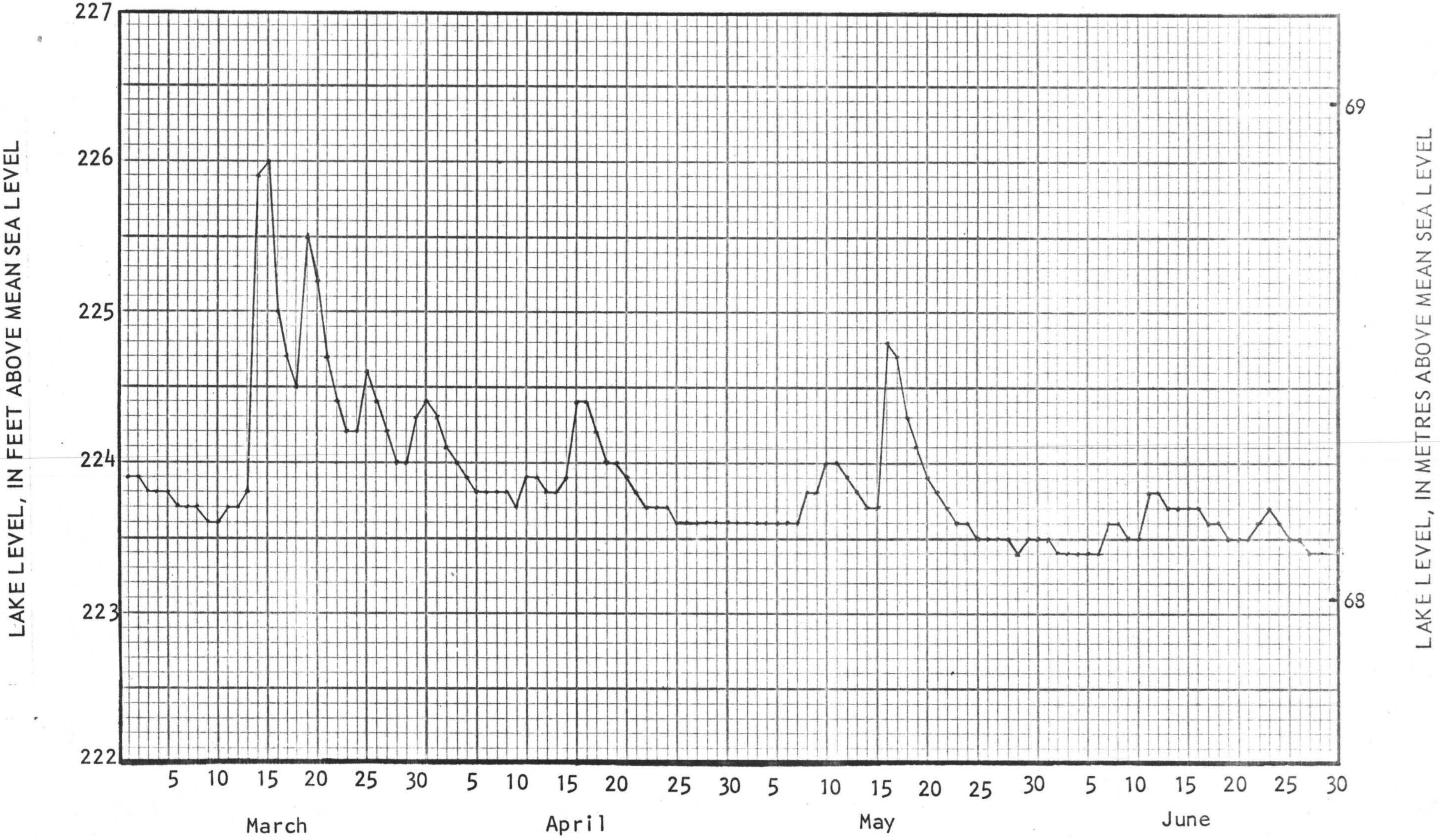

Figure 3.--Daily levels of Lake Tuscaloosa at dam, March through June 1975.

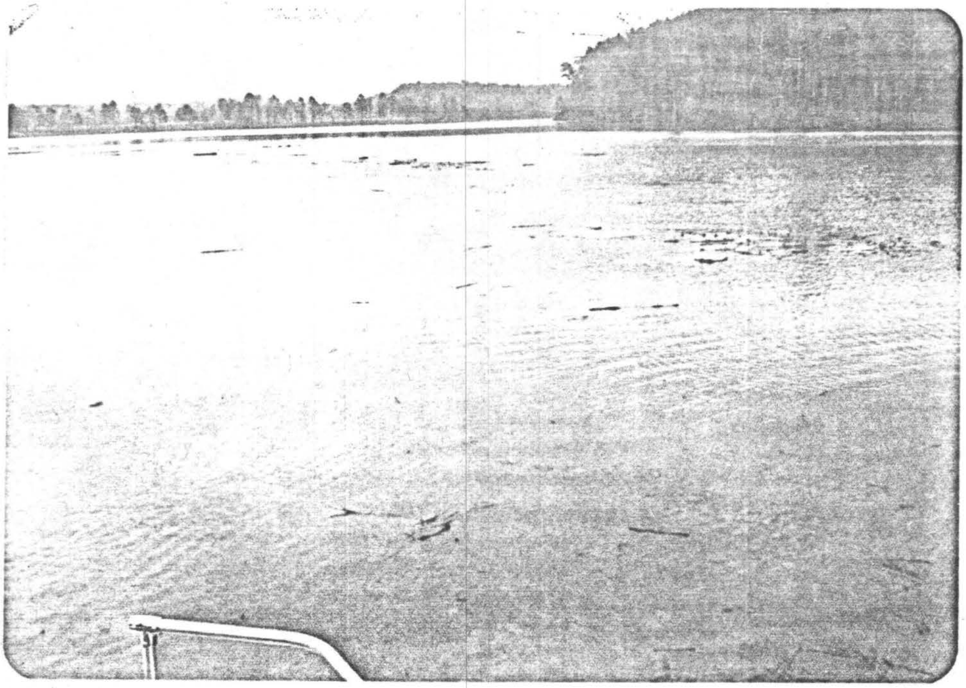

Figure 4.--Debris in Lake Tuscaloosa on March 16, 1975, following a flood.

percent was runoff from the storm of March 13 and 14; and on April 29 nearly 90 percent of the water in the lake had been in residence for longer than a month.

To further investigate the phenomena of stratification, additional samples were collected on July 14, after the nominal end of the reconnaissance. The results of the analyses of these samples also appear in this report.

Samples were also collected for miscellaneous purposes, including chemical-quality analyses for selected constituents and bacteriological determinations, at other locations and on other dates during the reconnaissance. The results of these samples also appear in this report.

The question of water quality of the lake is very complex. No single measurable parameter would be indicative of the water quality. Nor would any large group of parameters be completely definitive, if they were measured on only one occasion. A great many parameters determined over a realistically long time period is necessary to truly gain a picture of the health of a body of water. While this reconnaissance was as complete in coverage as was practical--in terms of number of parameters measured, number of points sampled, and distribution of samples in time--it only represents a period of 3 months. Thus, we cannot assume that the results obtained in late spring and early summer will be indicative of water quality throughout the year. Nor can we determine the trends in water-quality parameters that might be indicative of gradual pollution.

If the lake were grossly polluted, analysis of a few samples would tell the story. But, since the lake water is relatively pure, it is very difficult to interpret data collected during a few months and predict when and in what form significant pollution may occur.

BASIC DATA

Chemical analyses of water samples.--Water samples were analyzed for the dissolved mineral constituents commonly found in the highest concentrations in surface waters of Alabama, a procedure referred to as a "complete analysis" that also includes the measurement of certain physical parameters, including pH, temperature, and specific conductance. These data provide a general picture of the present chemical quality of the lake waters. Certain parameters are of special significance because an abnormally high value might indicate pollution from a suspected source. For example, high sulfate and low pH might suggest the presence of acid-mine drainage, or high nitrate and chloride could be associated with septic-tank seepage.

To further determine the water quality of the lake, the concentrations of nutrients and minor elements were also determined. Nutrients, which are principally the various forms of nitrogen and phosphorus, can be related to the rate of eutrophication of the lake--high nutrients, high rate of eutrophication. Nutrients, and particularly ammonia, may also be indicative of septic-tank pollution. A certain level of nutrients is beneficial to the plant and animal life in a lake, but too much can cause excessive algal growth, perhaps accompanied by depleted oxygen supply and fish kills.

The minor elements in the tables include toxic metals such as arsenic, cadmium, chromium, lead, and mercury. Often called "trace" elements, these substances are usually in water at concentrations several orders of magnitude below the more common dissolved constituents that are included in the standard analysis. Their toxicity makes these elements important in a reservoir intended for recreation and water supply.

Table 1 is a tabulation of the results of the chemical analyses. Most of the common constituents, including the nutrients, are in milligrams per litre (mg/l), which is approximately equivalent to parts per million by weight in these concentrations. Minor elements are in units of micrograms per litre (ug/l), which are about the same as parts per billion.

The quality of a body of water depends on a multitude of complexly interrelated factors that may vary drastically in both time and space. Some constituents, if they are present in excess or are deficient, can cause poor water quality. For example, an excess of arsenic in water might render it unfit for many uses. Other measurable constituents do not in themselves render the water unfit for use but are indicators, or evidence, that some less measurable pollutant is present. The concentrations of the harmless coliform bacteria in water, for example, were determined as evidence that pathogens might also be present.

Sometimes constituents must be present in water in certain combinations to cause problems. As a case in point, algal blooms only occur if all the essential nutrients are present in sufficient quantities to support the growth. One nutrient by itself, even if in concentrations sufficient to cause an algal bloom, might not cause the water to be unfit for use.

The intended use of water, of course, ultimately sets the water-quality criteria. An example of this concept is the ocean--a relatively unpolluted body of water in most areas, capable of propagating wildlife and providing recreation--but it is unsuited for public-water supply and for many industrial uses.

An approach to evaluating the water quality of Lake Tuscaloosa is to compare the physical parameters and chemical constituents that appear in table 1 with water-quality standards dictated by the primary uses of the lake--water supply and recreation. A report by the National Academy of Sciences, which the Environmental Protection Agency funded, "Water Quality Criteria, 1972," provides a comprehensive and up-to-date set of criteria that can be compared to the results of the chemical analyses of the Lake Tuscaloosa water.

With only isolated exceptions, the data in table 1 meet the criteria as specified for public-water supply in the National Academy of Sciences report. In most cases the concentrations that were determined for water samples collected from Lake Tuscaloosa were much lower than the recommended maximum, including all of the minor elements. Manganese, which can cause staining of laundry, is close to or exceeds the limit of 50 ug/1 in most of the samples. Periodic analyses of samples from North River at Samantha and other nearby streams indicate that these concentrations of manganese are fairly typical of surface waters in the area and probably result from natural causes. If it is a problem at all, manganese at these concentrations can be reduced to acceptable limits by water-treatment techniques.

Manganese does not generally occur in troublesome quantities in water where there is an abundance of dissolved oxygen. Iron, which stains laundry and porcelain fixtures at concentrations of more than 300 ug/1, also exhibits this property. Both these elements may exist in much greater concentrations during the summer and fall months in the zone of low dissolved oxygen that occurs in the deeper parts of the lake. This fact is substantiated by the occurrence of iron in a concentration of 1,600 ug/1 in the sample taken from a depth of 30 feet at Hilltop Estates landing. After the fall turnover, the anerobic conditions at depth would no longer occur, and the iron and manganese, when exposed to oxygen, would precipitate from the water leaving much lower concentrations--similar to most of those appearing in table 1. A more detailed discussion, documenting the occurrence and effects of the warm months stratification of the lake, appears in a subsequent part of this report.

While no chemical-quality parameter other than manganese and iron failed to meet the criteria, phosphorus and ammonia concentrations in a few samples did exceed those mentioned in the National Academy of Sciences report as being representative of natural, unpolluted water. Total phosphorus (phosphate expressed as phosphorus) ranges from 0.01 to 0.03 mg/l for relatively uncontaminated lake districts (National Academy of Sciences, 1972, p.81). All the water samples collected in March and April had concentrations that slightly exceeded these values. However, the report refers to some potable water supplies that have total phosphorus concentrations of more than 0.20 mg/l without experiencing aquatic-growth problems.

The report further states that levels of ammonia are normally 0.1 mg/l or less as nitrogen; higher concentrations are usually indicative of pollution. This concentration is equivalent to 0.13 mg/l of ammonia as is reported in table 1. The ammonia at the mouth of Carroll Creek in March was 0.30 mg/l, maybe as a result of the flooding of pastures upstream that occurred a few days before the sample was taken. In July an ammonia concentration of 0.47 mg/l was found in the deeper zone at Hilltop Estates, probably indicative of the effect of anerobic conditions on the nitrogen cycle. All other samples had ammonia concentrations at levels more typical of unpolluted waters.

In spite of these minor exceptions, the chemical quality of the water in Lake Tuscaloosa is very good. The sum of dissolved constituents generally ranged between 19 and 40 mg/l for the samples collected during the reconnaissance. The Public Health Service in 1962 established a limit of a 500 mg/l concentration of dissolved solids in drinking water. The lake water is far below this standard for total dissolved constituents, as it is for most individual constituents.

There is no conclusive evidence in the chemical-quality data that Lake Tuscaloosa is adversely affected by man's activities in the basin. Certainly there is no significant effect. These findings, however, should not encourage complacency; they are a strong argument to increase efforts to protect this unspoiled resource.

Chemical analyses of bottom deposits.--Chemical analyses of water samples represent conditions in the lake at the time they were collected; however, they do not indicate what has occurred in the past. Many water-quality problems are transitory in that some pollutants move through the system and are either assimilated or flushed out. The consequences of this pollution may be dire during its residence, but the pollutant itself might be undetectable a few hours, days, or weeks afterward.

To gain some insight into the occurrence of transitory pollution and to learn more about constituents that might occur in the lake water in almost undetectable concentrations, samples of the bottom deposits were collected at each of the three main sampling points on the lake. Clay particles, which compose much of the bottom deposits, have an electrical charge that attracts and holds other materials. Nutrients, minor elements, and pesticides all become concentrated in the bottom deposits as they adhere to the clay particles that enter the lake as fluvial sediment and then settle to the bottom.

The analyses of the bottom deposits appear in table 2. Bottom deposits were analyzed for nutrients, minor metals, and pesticides. Nutrients were sought because the entrapment of these materials in the bottom deposits can prevent the accelerated eutrophication of a body of water. If no fluvial sediment entered Lake Tuscaloosa, nutrient levels might be much higher. Minor elements and pesticides were included because of their typically low concentrations and transitory or seasonal occurrence in water. Their importance to this reconnaissance is the toxicity of many of these materials to man.

Nutrients are reported in milligrams per kilogram (mg/kg), which is parts per million by weight. Minor element concentrations in table 2 are also in parts per million, but to follow convention the units are micrograms per gram (ug/g). Table 2 gives pesticide concentrations in micrograms per kilogram (ug/kg), or parts per billion.

Nitrite or nitrate forms of nitrogen were not detected in the bottom material, probably owing to a reducing atmosphere in the deposits. Much nitrogen is present, however, in ammonia and in organic compounds. Phosphorus was also found in abundance. The concentrations of these materials are evidence that some significant amounts of nutrients are being trapped in the bottom deposits. There are examples in the literature where sediment inflow to a body of water that is enriched with nutrients has been reduced, resulting in an increase in algal production. This phenomenon would probably not occur in Lake Tuscaloosa because nutrient levels are relatively low, but it is an important point that sediment has beneficial effects as well as the more obvious detrimental effects.

The second part of table 2 lists the minor element concentrations occurring in the bottom deposits. Arsenic, lead, and zinc -- and copper and mercury to a lesser extent -- are concentrating in the bed material near the dam. An equivalent amount of these constituents in drinking water would be very high from a health standpoint. In comparison, James R. Avrett (written commun., 1975) reports that the maximum concentrations of these constituents determined from a series of two bottom-deposit samples collected at each of 13 sites in western Alabama from the Tombigbee River and its tributaries and from a tributary of the Tennessee River were:

arsenic	8,
copper (not determined),	
lead	72,
mercury	<0.1,
and zinc	54 mg/kg.

The reason for the much higher concentrations of mercury in Lake Tuscaloosa than in these streams is unknown.

Of the pesticides listed in table 2, only DDD, DDE, and DDT were detected. These materials were significantly higher at Hilltop Estates landing. In comparison, the maximum concentrations of DDE and DDT determined from bottom deposits at U.S. Geological Survey benchmark gaging stations in the United States during the water years, 1968 through 1970, were 29 and 43 ug/kg, respectively. Aerial crop-dusting operations have been observed on either side of the lake near Hilltop Estates on several occasions. These persistent pesticides could be residues accumulated from crop dusting in previous years.

Vertical profiles.--Part of the reconnaissance was to document the occurrence and effect of vertical stratification in the lake. During warm months a layer of heated water forms at the surface of the lake. Being lighter than the cooler water near the bottom, the heated water tends to resist mixing forces and remains on top. Little, or no, circulation may occur between the upper and lower layers of lake water. Thus, the lower layer may be cut off from contact with air, which could replenish the supply of dissolved oxygen as it is consumed by substances in the water. The lower layer becomes depleted in oxygen, allowing increases in the concentrations of dissolved substances like iron and manganese that would tend to precipitate in water containing dissolved oxygen. Water in the upper layer that contains more dissolved substances, being heavier, settles to the lower layer. The water in the lower layer is colder, has less dissolved oxygen, and is higher in dissolved constituents than is the upper layer.

When cold weather returns, the upper layer of water is cooled. Then, circulation resumes as the mixing effects of wind, water movement, and density currents overcome the stratification. This phenomenon is often referred to as the "fall turnover."

Vertical stratification was negligible when work was started on the reconnaissance in March. Figures 5, 6, and 7 depict the variation in water temperature and dissolved oxygen concentration with depth at the three principal sampling points. The curves depicting the temperature and dissolved oxygen concentrations for March are nearly vertical, indicating almost no variation with depth.

In April a slight break occurred in the vertical profiles; temperature and dissolved oxygen were definitely lower at depth than in the upper layer.

A well-defined vertical stratification had occurred by June and July. Temperatures decreased from 25 to 30° Celsius near the surface to 10 to 15° in the lower layer. Most of this decrease occurs in the zone between 5 and 20 feet (1½ and 6 metres) below the surface. Circulation across this zone would be very poor with little interchange of water between the upper and lower layers.

The dissolved-oxygen concentrations also decreased rapidly with depth. The stratification at Hilltop Estates landing is particularly well defined, with practically no dissolved oxygen present below a depth of about 20 feet (6 metres). The oxygen concentration also decreased rapidly with depth at the mouth of Carroll Creek and at the dam, following the pattern of the

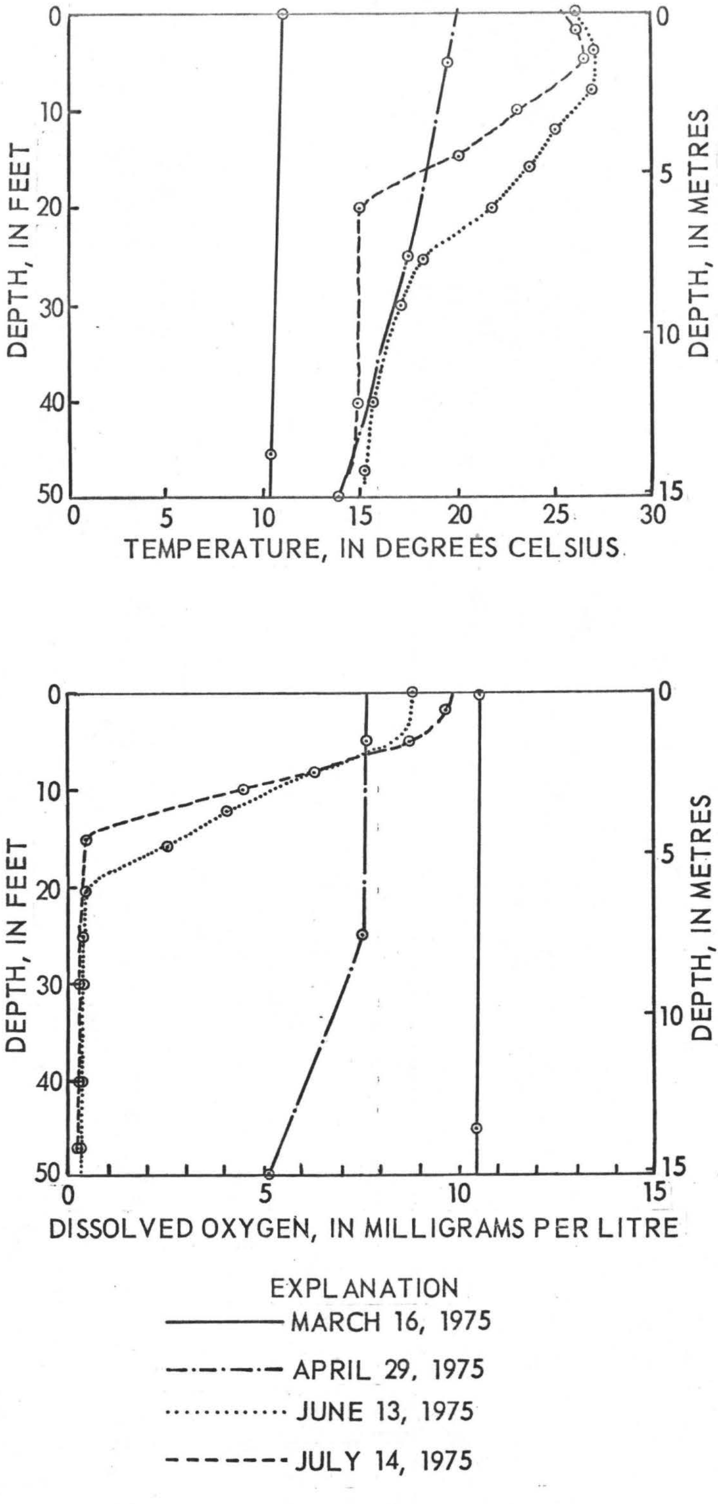

Figure 5.—Temperature and dissolved oxygen for Lake Tuscaloosa at Hilltop Estates landing.

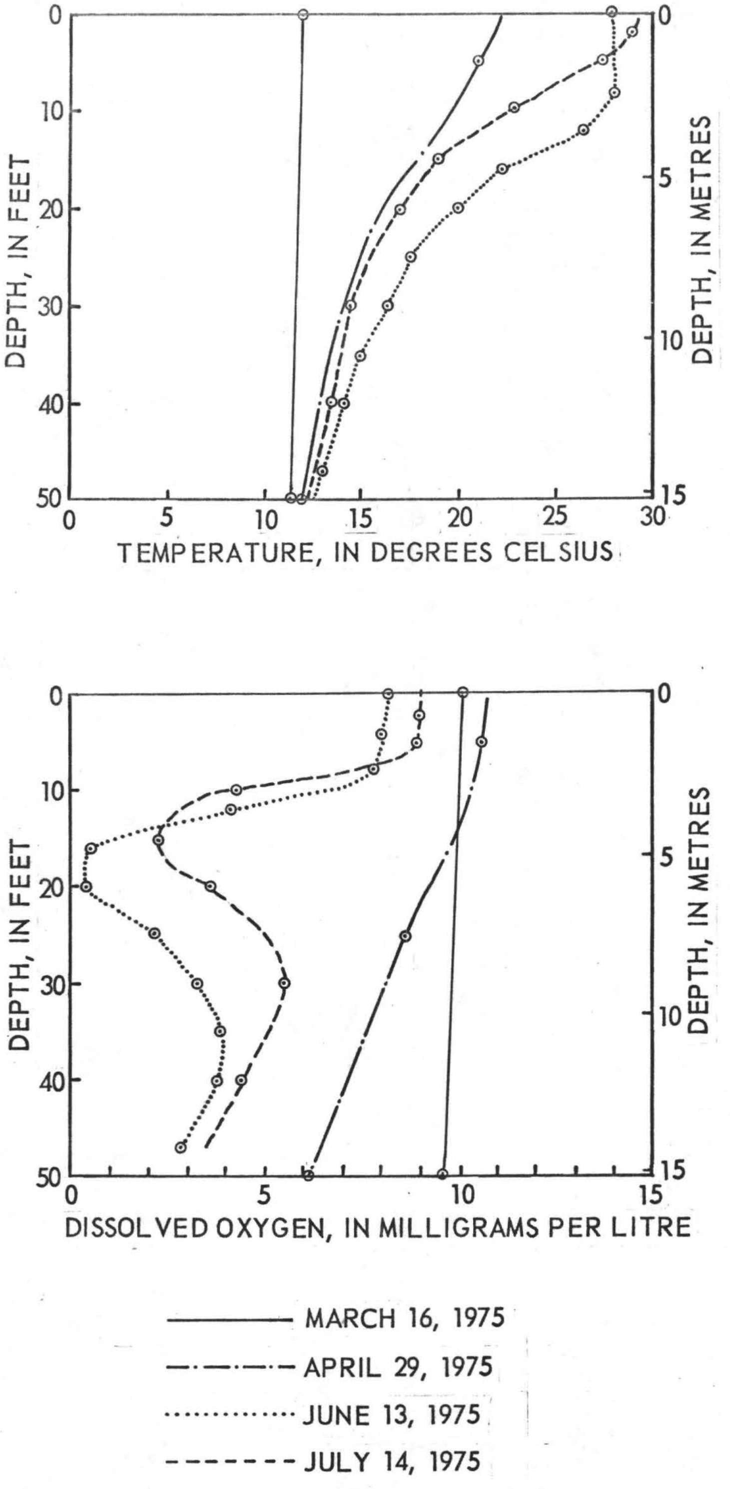

Figure 6.—Temperature and dissolved oxygen for Lake Tuscaloosa at Carroll Creek.

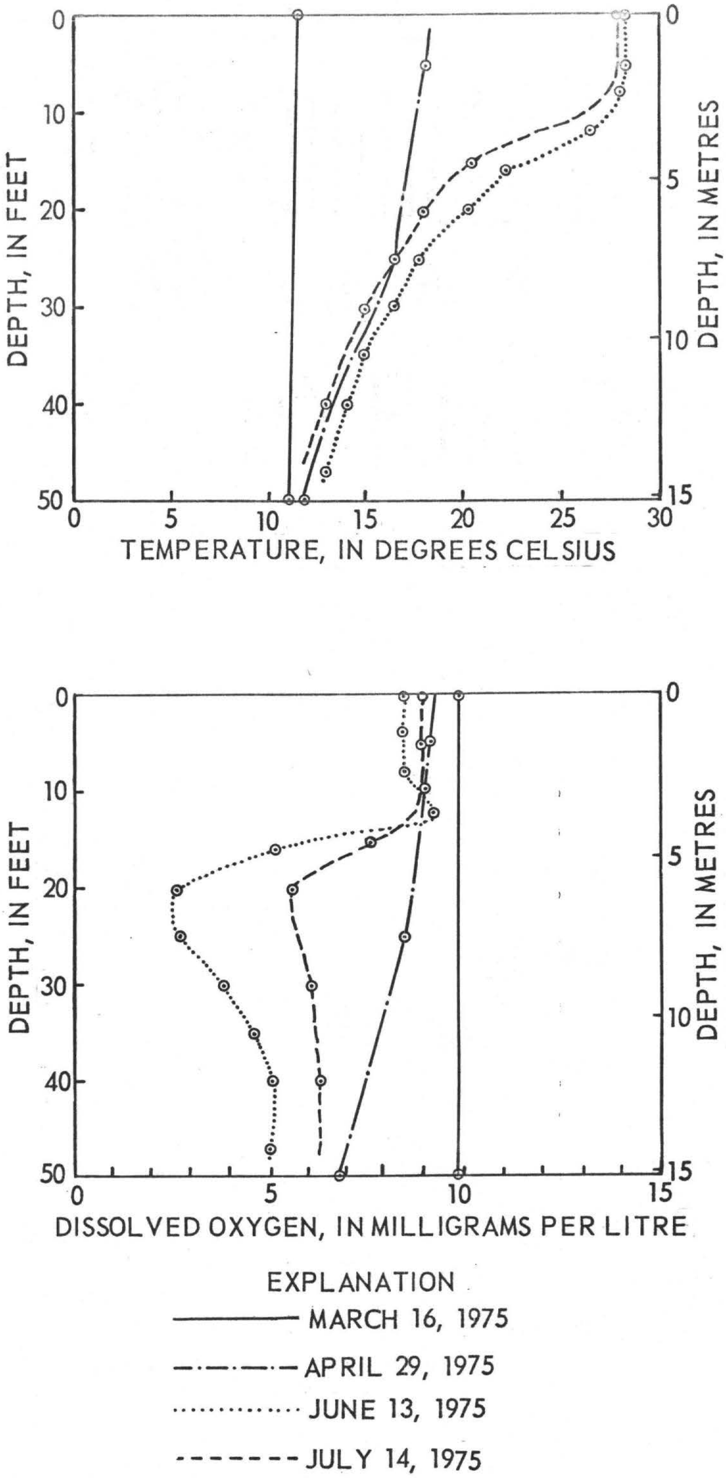

Figure 7.—Temperature and dissolved oxygen for Lake Tuscaloosa at dam.

change in temperature, initially. Between 25 and 40 feet (8 and 12 metres) however, the oxygen concentration increases over the minimum that occurs near 20 feet (6 metres). At 50 feet (15 metres), the total length of the probe, there was still a concentration of from 3 to 6 mg/l of dissolved oxygen at both sites on June 13 and July 14. These data suggest, in spite of the thermal stratification, that some vertical circulation was occurring at the dam and at Carroll Creek, perhaps caused by the inflow of cooler water from tributary streams.

To further document the occurrence of stratification, a point sample was collected from the upper and the lower layer in July rather than using the integration technique, which takes water equally from all depths in a vertical section. Chemical stratification was evident at Hilltop Estates, particularly of dissolved iron, which was 60 ug/l in the upper layer and 1,600 ug/l in the lower layer. At the other two sampling sites, however, there was little difference in the chemical analyses of water from the upper and lower layers.

The absence of stratification in the lake is preferable to having a lower layer of water depleted in oxygen and undesirably high in concentrations of some constituents. One can remember the furor that arose when it was publicized a few years ago that Lake Erie had a zone of zero dissolved oxygen. This occurrence was popularly blamed on manmade pollution, although subsequent studies have questioned this claim.

The data indicates that Lake Tuscaloosa has a zone of zero dissolved oxygen like Lake Erie, at least in the vicinity of Hilltop Estates landing. Whether this phenomenon is caused by manmade pollution and whether it is detrimental to the water-quality of the lake is beyond the scope of this reconnaissance. However, this occurrence should be studied to determine the size of the area of zero dissolved oxygen, an indicator of possible pollution of the lake.

Bacteriological determinations.--Rather than attempt to measure the multitude of microorganisms that are disease causing, it has become standard practice to measure coliform bacteria, which are normally present in large quantities in the intestinal tracts of man and other warm-blooded animals. Coliform bacteria, however, are widely distributed in the environment; in fact, some strains are associated with plants. A more specific indicator of pollution are fecal coliform, which are the species that thrive in the intestines of warm-blooded animals. Another useful group of indicator organisms are fecal streptococci, which are also specific indicators of pollution from warm-blooded animals.

One standardized method of counting these bacteria consists of filtering a known quantity of the water sample through a filter of selected size. The filter, which is impregnated with the proper nutrient, is incubated at the temperature most conducive to the growth of the bacteria sought. After incubation the numbers of bacterial colonies are counted and reported per 100 millilitres (ml) of sample water.

Table 3 lists the number of each of these three indicators found per 100 millilitres (ml) in water samples. These samples were collected at the three principal sampling points and at a number of other places that might help pinpoint sources of pollution, including inflowing streams.

National Academy of Sciences (1972) recommends that the geometric means of fecal coliform and total coliform densities in raw surface-water sources used for public supply not exceed 2,000/100 ml and 20,000/100 ml, respectively. The Alabama Water Improvement Commission (1975) in a draft entitled, "Water Use Classifications and Water Quality Criteria for the State of Alabama," also recommends that the geometric mean of fecal coliform densities not exceed 2,000/100 ml; however, for water intended for body-contact sports the Commission sets a more stringent standard of 200/100 ml.

Geldreich and Kenner (1969) show the relationship of various sources of bacterial pollution to the ratio of fecal coliform to fecal streptococci (FC/FS in table 3) as found in samples of the polluted water. They report a FC/FS ratio of 4.4 in human feces as opposed to FC/FS ratios that range from 0.02 to 0.6 in pets, rodents, livestock, and poultry. Thus, of the two indicators, fecal coliform predominates in bacterial pollution from human sources and fecal streptococci predominates in animal wastes. This generalization is complicated by the tendency of fecal coliform to die off more quickly than predominant strains of streptococci.

For example, if a body of water was polluted with wastes of human origin, the FC/FS ratio would probably be about 4, initially. After a period of time, the relative number of fecal coliform with respect to fecal streptococci would decrease because the fecal coliform die off more rapidly. Since fecal coliform is the numerator in the ratio, it would also decrease--maybe to 0.5. Thus, FC/FS ratios less than unity are not conclusive evidence that the pollution is from lower animals; such a ratio may only mean that the bacteria have been in residence for a substantial length of time.

For this reconnaissance, one might assume that FC/FS ratios exceeding unity would suggest pollution from human sources, perhaps septic-tank seepage, and that lower ratios would either be indicative of pollution from wild and domestic animals in the basin, runoff from pastures for example, or be indeterminate because of the long residence time of the bacteria in the water. Geldreich and Kenner in their 1969 paper warn against using the ratio method for samples from a point more than 24 hours travel time downstream from the source of pollution.

The FC/FS ratios for Lake Tuscaloosa were mixed. Following the March flood, the first samples had relatively high bacteria densities as compared with subsequent samples from the lake proper. The FC/FS ratios were about 0.4, which are probably related to the runoff from woods and farmland, including the flooding of pastures along tributaries to the lake. Figure 8 shows a flooded pasture where State Highway 43 crosses Carroll Creek.

Later, in April, the FC/FS ratios were much higher, ranging from 4.7 to 13.0; however, the densities of bacteria were so low that the ratios are probably meaningless.

A sample collected in May from North River at Samantha had an FC/FS ratio of 0.47, perhaps indicative of lower animal wastes; but, again, the densities are relatively low. A bacterial count this low is evidence that very little pollution of this kind from any source was present.

A few days later on May 28 and 29, 1975, Geological Survey of Alabama personnel collected a round of samples from flowing tributaries just upstream from the lake backwater. These samples, in general, had much higher bacteria densities than those collected from the sampling points on the lake. The FC/FS ratios were all less than unity, ranging from 0.74 to 0.01.

Followup sampling of some of the same sites on June 6 produced similar results over all, although there were some big changes in coliform densities at a couple of the sites. FC/FS ratios were all low again, which could mean that the bacteria were of lower animal origin, although low ratios are not conclusive evidence because of the more rapid die-off rate of fecal coliform, as discussed earlier.

The round of sampling from points in the lake on June 13 produced relatively low fecal coliform and streptococci counts--except for Carroll Creek near Lakewood Subdivision, which was a little higher than the others. Again the FC/FS ratios were not indicative of pollution of human origin.

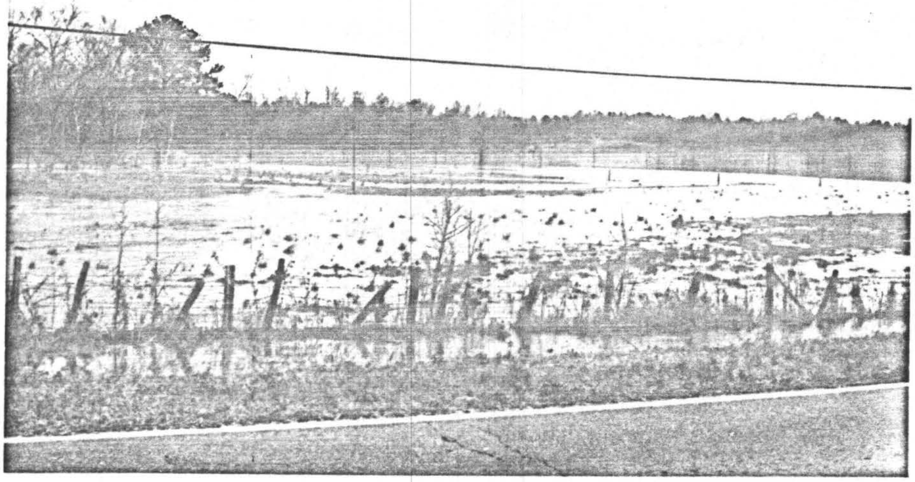

Figure 8.--Flooded pasture downstream from the crossing of Carroll Creek and U.S. Highway 43 on March 14, 1975.

A final sampling trip on July 14 produced different results. The FC/FS ratios for Pole Bridge, Tierce, and Brush Creeks were all indicative of human fecal wastes. Why this indication only appeared in one set of samples is beyond the scope of this study. Perhaps long residence time had caused the other samples to have low ratios, or the pollution from human sources is seasonal.

In summary, indicator bacteria levels are relatively low in samples taken from the lake. Samples from inflowing streams have higher bacterial levels, however. In at least one instance there was evidence that the bacteria in the streams were of human origin, which would suggest the presence of pathogenic organisms. A followup investigation or a monitoring program should be considered to determine the nature, source, and persistence of this apparent problem.

CONCLUSION

The results of this reconnaissance show that there was no gross pollution of Lake Tuscaloosa during March through June of 1975. There are, however, hints in the data that perhaps the lake is reaching the limit of its assimilative capacity in some areas. For example, nutrients a little higher than might be expected for unpolluted water were detected in some samples. Toxic materials, such as persistent pesticides and poisonous metals, have concentrated in the bottom deposits. A zone of zero dissolved oxygen exists during the warm months in the lower layer of water in some parts of the lake, and some inflowing streams have high levels of fecal bacteria, possibly of human origin.

It is important to emphasize that at no time was any constituent found in the water that significantly exceeded the standards for good water quality as established by the Environmental Protection Agency and the Alabama Water

Improvement Commission. Dissolved solids were very low, indicating that the general chemical quality of the water is good. Esthetically, the lake is beautiful: the water is unusually clear; there is a good fishery; and there are no undesirable odors or aquatic growths. There are no data that show that man-induced pollution has had a significant adverse affect on the quality of water in Lake Tuscaloosa.

A continuing surveillance of the lake to provide a guide in maintaining the water quality should be considered. A relatively inexpensive program of routine sampling could serve to monitor the areas in which there are signs of developing problems and could provide an early warning of the effects of undesirable or excessive development.

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Table 1.--Chemical analyses of water from selected sites.

NORTH RIVER NEAR SAMANTHA

			Milligrams per litre (except as noted)															
Depth of collection	Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe) (ug/l)	Manganese (Mn) (ug/l)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrogen, nitrite (N)	Nitrogen, nitrate (N)	Ammonia total (NH_4)	Nitrogen, organic (N)
Integrated	3-27-75	515	7.9	0	10	2.0	1.7	2.0	0.9	10	0	6.4	1.6	0.0	--	0.10	--	--
Integrated	4-21-75	64	9.0	120	--	1.2	1.5	2.0	.9	10	0	5.2	1.4	.0	--	.13	--	--
Integrated	5-23-75	169	8.2	220	--	2.1	1.7	2.4	1.0	10	0	6.4	1.8	.0	0.00	.16	0.12	0.07
Integrated	6-26-75	81	7.0	110	--	3.3	2.6	2.8	1.3	14	0	12.0	2.2	.0	--	.47	--	--

		Milligrams per litre (except as noted)										
							Hardness as $CaCO_3$					
Depth of collection	Date of collection	Phosphorus, total (P)	Phosphate, total (PO_4)	Phosphorus, dissolved ortho phosphate (P)	Dissolved ortho, phosphate (PO_4)	Dissolved solids (Sum of constituents)	Ca, Mg	Noncarbonate	Specific conductance (micromhos)	pH (units)	Water temperature (°C)	Total organic carbon
Integrated	3-27-75	--	--	--	--	28	12	4	36	6.7	13.5	--
Integrated	4-21-75	--	--	--	--	27	9	1	36	6.4	14.0	--
Integrated	5-23-75	0.02	0.06	0.01	0.02	29	12	4	40	6.8	21.0	--
Integrated	6- 5-75	--	--	--	--	--	--	--	--	--	--	6.3
Integrated	6-26-75	--	--	--	--	40	19	8	52	6.2	25.0	--

		Micrograms per litre (except as noted)												
Depth of collection	Date of collection	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Lithium (Li)	Mercury (Hg)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Zinc (Zn)	Sediment, suspended, concentration (mg/l)
Integrated	3-27-75	ND	<1	1	1	2	ND	1	<0.2	6	ND	70	4	--
Integrated	4-21-75	<1	<1	ND	2	1	1	1	<.2	1	ND	18	10	--
Integrated	5-23-75	<1	<1	ND	1	--	ND	--	<.2	--	--	64	9	--
Integrated	6-26-75	1	<1	ND	1	--	ND	--	<.2	--	--	28	8	--

Table 1.--Chemical analyses of water from selected sites--Continued

LAKE TUSCALOOSA AT HILLTOP ESTATES LANDING

		Milligrams per litre (except as noted)															
Depth of collection	Date of collection	Silica (SiO_2)	Iron (Fe) (ug/l)	Manganese (Mn) (ug/l)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrogen, nitrite (N)	Nitrogen, nitrate (N)	Ammonia total (NH_4)	Nitrogen, organic (N)
Integrated	3-16-75	6.2	0	36	1.2	1.3	1.6	1.0	5	0	5.2	1.8	0.0	0.00	0.10	0.11	0.30
Integrated	4-29-75	7.7	110	58	1.9	1.1	2.0	1.0	9	0	4.4	1.8	.0	.00	.02	.12	.18
Integrated	6-13-75	6.5	260	--	1.4	1.2	2.0	1.0	12	0	4.4	1.2	.0	.01	.05	.13	.13
8 ft	7-14-75	5.8	60	--	1.5	1.5	2.0	1.0	9	0	5.2	1.4	.0	.00	.05	.00	.20
30 ft	7-14-75	7.2	1,600	--	3.6	2.1	2.0	1.2	22	0	4.4	1.6	.0	.01	.09	.26	.20

		Milligrams per litre (except as noted)										
							Hardness as $CaCO_3$					
Depth of collection	Date of collection	Phosphorus, total (P)	Phosphate, total (PO_4)	Phosphorus, dissolved ortho phosphate (P)	Dissolved ortho, phosphate (PO_4)	Dissolved solids (Sum of constituents)	Ca, Mg	Noncarbonate	Specific conductance (micromhos)	pH (units)	Water temperature (°C)	Total organic carbon
Integrated	3-16-75	0.08	0.24	0.00	0.01	21	9	5	30	6.2	10.5	7.3
Integrated	4-29-75	.04	.12	.02	.06	24	9	2	31	6.3	19.5	--
Integrated	6-13-75	.03	.09	.00	.00	24	9	0	32	6.4	26.5	--
8 ft	7-14-75	.01	.03	.00	.00	23	10	3	37	5.9	27.0	--
30 ft	7-14-75	.02	.07	.00	.00	34	18	0	61	6.7	17.0	--

		Micrograms per litre (except as noted)												
Depth of collection	Date of collection	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Lithium (Li)	Mercury (Hg)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Zinc (Zn)	Sediment, suspended, concentration (mg/l)
Integrated	3-16-75	1	<1	ND	2	2	ND	1	ND	2	ND	46	5	59
Integrated	4-29-75	1	<1	ND	1	--	1	--	<0.2	--	--	62	10	8
Integrated	6-13-75	ND	<1	ND	1	--	ND	--	<.2	--	--	32	11	17

Table 1.--Chemical analyses of water from selected sites--Continued

LAKE TUSCALOOSA AT MOUTH OF CARROLL CREEK

		Milligrams per litre (except as noted)															
Depth of collection	Date of collection	Silica (SiO_2)	Iron (Fe) (ug/l)	Manganese (Mn) (ug/l)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrogen, nitrite (N)	Nitrogen, nitrate (N)	Ammonia total (NH_4)	Nitrogen, organic (N)
Integrated	3-16-75	6.6	30	68	1.5	1.3	1.6	1.0	6	0	4.6	1.6	0.0	0.00	0.20	0.30	0.30
Integrated	4-29-75	6.6	100	87	1.8	1.1	1.5	1.0	8	0	4.2	1.6	.0	.00	.05	.08	.16
Integrated	6-13-75	5.9	180	--	1.1	.9	1.7	.9	7	0	3.8	.8	.0	.00	.27	.09	.10
8 ft	7-14-75	5.6	60	--	1.2	1.1	1.7	.9	8	0	4.0	1.4	.0	.00	.05	.01	11
45 ft	7-14-75	6.3	90	--	1.5	1.1	1.6	.9	8	0	4.0	1.2	.0	.00	.09	.00	.60

		Milligrams per litre (except as noted)										
							Hardness as $CaCO_3$					
Depth collection	Date of collection	Phosphorus, total (P)	Phosphate, total (PO_4)	Phosphorus, dissolved ortho phosphate (P)	Dissolved ortho, phosphate (PO_4)	Dissolved solids (Sum of constituents)	Ca, Mg	Noncarbonate	Specific conductance (micromhos)	pH (units)	Water temperature (°C)	Total organic carbon
Integrated	3-16-75	0.05	0.15	0.00	0.00	22	9	4	27	6.2	11.5	8.9
Integrated	4-29-75	.06	.18	.04	.12	22	9	3	27	6.2	21.0	--
Integrated	6-13-75	.02	.05	.00	.01	19	6	1	26	6.1	27.5	--
8 ft	7-14-75	.00	.01	.00	.01	20	8	2	29	6.6	28.0	--
45 ft	7-14-75	.00	.00	.00	.00	21	8	2	29	6.5	13.0	--

		Micrograms per litre (except as noted)												
Depth of collection	Date of collection	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Lithium (Li)	Mercury (Hg)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Zinc (Zn)	Sediment, suspended, concentration (mg/l)
Integrated	3-16-75	1	<1	ND	2	1	1	1	ND	2	ND	37	4	14
Integrated	4-29-75	1	<1	ND	1	--	<1	--	<0.2	--	--	48	11	5
Integrated	6-13-75	1	<1	<1	1	--	ND	--	<0.2	--	--	32	13	3

Table 1.--Chemical analyses of water from selected sites--Continued

LAKE TUSCALOOSA AT DAM

Depth of collection	Date of collection	Milligrams per litre (except as noted) Silica (SiO_2)	Iron (Fe) (ug/l)	Manganese (Mn) (ug/l)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrogen, nitrite (N)	Nitrogen, nitrate (N)	Ammonia, total (NH_4)	Nitrogen, organic (N)
Integrated	3-16-75	6.8	50	65	1.5	1.3	1.4	1.0	6	0	5.2	1.6	0.0	0.00	0.20	0.13	0.32
Integrated	4-29-75	6.1	90	68	1.8	1.1	1.4	1.0	7	0	4.6	1.8	.0	.00	.08	.02	.12
Integrated	6-13-75	5.7	90	--	1.2	.9	1.7	1.0	7	0	4.6	1.4	.0	.00	.06	.09	.06
8 ft	7-14-75	5.8	70	--	1.4	1.1	1.6	1.0	10	0	4.2	1.2	.0	.00	.02	.00	14
45 ft	7-14-75	6.0	30	--	1.7	1.1	1.5	.8	7	0	5.0	1.4	.0	.00	.08	.00	8

Depth of collection	Date of collection	Milligrams per litre (except as noted) Phosphorus, total (P)	Phosphate, total (PO_4)	Phosphorus, dissolved ortho phosphate (P)	Dissolved ortho, phosphate (PO_4)	Dissolved solids (Sum of constituents)	Hardness as $CaCO_3$ Ca, Mg	Hardness as $CaCO_3$ Noncarbonate	Specific conductance (micromhos)	pH (units)	Water temperature (°C)	Total organic carbon
Integrated	3-16-75	0.03	0.09	0.00	0.00	22	9	4	29	6.3	11.5	12
Integrated	4-29-75	.06	.18	.05	.15	21	9	4	28	6.2	18.0	--
Integrated	6-13-75	.01	.04	.00	.00	20	7	2	27	6.1	28.0	--
8 ft	7-14-75	.00	.00	.00	.00	21	8	0	30	6.6	28.0	--
45 ft	7-14-75	.00	.00	.00	.00	21	9	4	30	6.1	13.0	--

Depth of collection	Date of collection	Micrograms per litre (except as noted) Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Lithium (Li)	Mercury (Hg)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Zinc (Zn)	Sediment, suspended, concentration (mg/l)
Integrated	3-16-75	1	<1	ND	1	1	ND	<1	ND	2	ND	32	4	15
Integrated	4-29-75	1	<1	ND	1	--	1	1	<0.2	--	--	59	11	3
Integrated	6-13-75	ND	<1	ND	1	--	ND	--	.3	--	--	38	13	2

ND - Specifically sought, not detected.

Table 2.--Chemical analyses of bottom deposits
(All results are total concentrations)

Nutrients

		Milligrams per kilogram					
Date	Sampling point	Nitrogen, nitrate (N)	Nitrogen, nitrite (N)	Nitrogen, nitrite plus nitrate (N)	Nitrogen, ammonia (N)	Nitrogen, kjeldahl (N)	Phosphorus (P)
4-29-75	Lake Tuscaloosa at Hilltop Estates landing	0.00	0.0	0.0	180	760	130
4-29-75	Lake Tuscaloosa at mouth of Carroll Creek	.00	.0	.0	130	440	120
4-29-75	Lake Tuscaloosa at dam	.00	.0	.0	210	1,600	160

Minor Elements

		Micrograms per gram										
Date	Sampling point	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Zinc (Zn)
4-29-75	Lake Tuscaloosa at Hilltop Estates landing	4	<10	<10	10	<10	10	1.3	<10	<10	10	10
4-29-75	Lake Tuscaloosa at mouth of Carroll Creek	2	<10	<10	<10	<10	10	1.3	<10	<10	<10	<10
4-29-75	Lake Tuscaloosa at dam	8	<10	<10	10	10	30	1.7	<10	<10	<10	40

Pesticides

		Micrograms per kilogram											
Date	Sampling point	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Ethyl parathion	Ethyl trithion	Ethion	Heptachlor epoxide
6-13-75	Lake Tuscaloosa at Hilltop Estates landing	0.0	0	89	69	120	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-13-75	Lake Tuscaloosa at mouth of Carroll Creek	.0	0	17	19	4.3	.0	.0	.0	.0	.0	.0	.0
6-13-75	Lake Tuscaloosa at dam	.0	0	36	20	19	.0	.0	.0	.0	.0	.0	.0

		Micrograms per kilogram											
Date	Sampling point	Heptachlor	Lindane	Malathion	Methyl parathion	Methyl trithion	PCB	PCN	Silvex	Toxaphene	2,4-D	2,4-DP	2,4,5-T
6-13-75	Lake Tuscaloosa at Hilltop Estates landing	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0
6-13-75	Lake Tuscaloosa at mouth of Carroll Creek	.0	.0	.0	.0	.0	0	0	0	0	0	0	0
6-13-75	Lake Tuscaloosa at dam	.0	.0	.0	.0	.0	0	0	0	0	0	0	0

Table 3.--Bacteriological determinations.

DATE	DATA	North R at Samantha	Dry C nr Lake Tuscaloosa	Turkey C nr Lake Tuscaloosa	Lake Tuscaloosa at Hilltop Estates Landing	Binion C nr Lake Tuscaloosa	Pole Bridge C nr Lake Tuscaloosa	Tierce C nr Lake Tuscaloosa	Hamner C nr Lake Tuscaloosa	Carroll C nr Lake Tuscaloosa	Carroll C nr Lakewood Subdivision	Lake Tuscaloosa at mouth of Carroll C	Brush C nr Lake Tuscaloosa	Lake Tuscaloosa at dam
3/16/75	Fecal coliform				570							320		64
	Streptococci				1,300							920		160
	Total coliform				1,700							490		220
	FC/FS				.44							.35		.40
5/13/75	Fecal coliform				52						28	23		31
	Streptococci				4						6	0		3
	Total coliform				--						--	--		--
	FC/FS				13.0						4.7	--		10.3
5/23/75	Fecal coliform	70												
	Streptococci	150												
	Total coliform	870												
	FC/FS	.47												
5/28/75 1/	Fecal coliform		26	490		160								
	Streptococci		69	1,600		470								
	Total coliform		1,600	8.000		630								
	FC/FS		.38	.31		.34								
5/29/75 1/	Fecal coliform						500	520	58	90			5,800	
	Streptococci						1,000	11,000	6,200	550			7,800	
	Total coliform						8,800	2/ TNTC	12,000	1,700			21,000	
	FC/FS						.50	.05	.01	.16			.74	
6/6/75 1/	Fecal coliform			300			1,900	90	40	12			280	
	Streptococci			3,700			3,700	1,000	870	14			2,110	
	Total coliform			7,500			18,000	2,300	1,800	1,400			3,300	
	FC/FS			.08			.51	.09	.05	.85			.13	
6/13/75	Fecal coliform			12	42						350	12		4
	Streptococci			35	87						530	14		2
	Total coliform			6,400	1,800						8,200	1,400		100
	FC/FS			.34	.48						.66	.86		2.0
7/14/75	Fecal coliform				14		1,900	2,500		4			1,200	
	Streptococci				4		370	530		0			380	
	Total coliform				--		--	--		--			--	
	FC/FS				3.5		5.1	4.7		--			3.2	

1/ Collected by Geological Survey of Alabama.

2/ Too numerous to count.