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INDIANA UNIVERSITY ALUMNI ASSOCIATION

LAKE MONROE FAMILY CAMP

ENVIRONMENTAL ASSESSMENT

PREPARED BY:

ENVIRONMENTAL SCIENCE PROGRAM

SCHOOL of PUBLIC and ENVIRONMENTAL AFFAIRS

INDIANA UNIVERSITY

BLOOMINGTON, INDIANA

ENVIRONMENTAL ASSESSMENT of the INDIANA UNIVERSITY ALUMNI ASSOCIATION LAKE MONROE FAMILY CAMP

April 1977

SCHOOL of PUBLIC and
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Environmental Assessment Team

This environmental assessment was prepared by a team from the Environmental Science Program in the School of Public and Environmental Affairs, Indiana University, Bloomington. The members of the team and their areas of responsibility are listed below.

Craig Caupp:	Terrestrial ecology
Jim Chiesa:	Land use, water use, socioeconomics, site development alternatives, sewage treatment alternatives, unaffected environmental components, overall site suitability, editing
Dale Duffala:	Climate, air quality, geology, hydrology, erosion and runoff, water use, surveying, drafting
Linda Ellis:	Governmental roles in natural resource management
Michael Ewert:	Terrestrial ecology, site development alternatives, terrestrial activities of camp users, maintenance of camp grounds, unaffected environmental components
Philip Foster:	Aerial photography
Daniel Hudson:	Water quality, sewage treatment alternatives
Becky Miller:	Administrative assistant, report preparation
Glenn Montgomery:	Topography, soils, archeological and historical sites, site development alternatives, surveying, drafting
Scott Parrish:	Aquatic ecology, sewage treatment alternatives, erosion and runoff

J. C. Randolph, Project Director

Introduction

Description of the Proposed Project

The subject of this environmental assessment is the Indiana University Alumni Association Lake Monroe Family Camp. The camp is to be a recreational development with multiple land-use intensities and an expected clientele of families with small children. The following paragraphs describe the Alumni Family Camp in some detail.

The camp is to be located on the shore of Lake Monroe, a reservoir in Monroe County in southern Indiana, about nine miles southeast of Bloomington (Fig. 1). The site lies on Rush Ridge Road less than a mile east of State Route 446. A private north-south road passes through the center of the property. The property covers 124 acres, mostly in Sections 33 and 34 of Salt Creek Township, but with some acreage on a narrow peninsula in Section 3 of Polk Township. The peninsula separates the North Fork of the lake on its north side from the main body of the lake's upper basin on its south side. The eastern edge of the bulk of the property lies along the North Fork. A report on a survey of the property boundaries carried out by members of the environmental assessment team is attached as Appendix 1.

A site plan for the Alumni Family Camp has yet to be drafted. A final decision as to all the facilities the camp is to have has not been reached, either, but several sorts of structures and other land uses are certain to be included, and options as to the others can be delineated fairly clearly. (The following material is drawn from McFadzean, Everly and Assoc., 1976, and conversations with Alumni Association officials.)

Parts of the camp site will be rather intensively developed. These portions will support a program center, staff dormitories, a caretaker's house, a parking lot, a boat dock and shed, and active play areas. Some roadway will also have to be constructed in addition to that already present. Present plans call for the program center to include an assembly room large enough to accomodate 200 persons, to be used mainly for dining; offices and the camp manager's apartment; rooms for children's activities; a lounge and restrooms; an outdoor swimming pool on the order of 2600 square feet in size, along with associated showers; and probably laundry facilities and a kitchen with full food service. Catering has been considered as an alternative to on-site food preparation. The program center will be heated year round and fully air conditioned. The staff dormitories will be large enough to house between 25 and 50 people; the parking lot will have to accomodate at least 75 cars; about 15 slips are planned for the boat dock. A final decision on active play areas has yet to be reached, but they may include tennis courts and possibly also a softball field.

Guests will stay in very small cabins (196 square feet according to one suggestion) representing a less intensive mode of development than that for the structures mentioned above. Electricity and running water will be provided to the cabins, but no toilet or shower will be installed. It is not anticipated that the cabins will be air

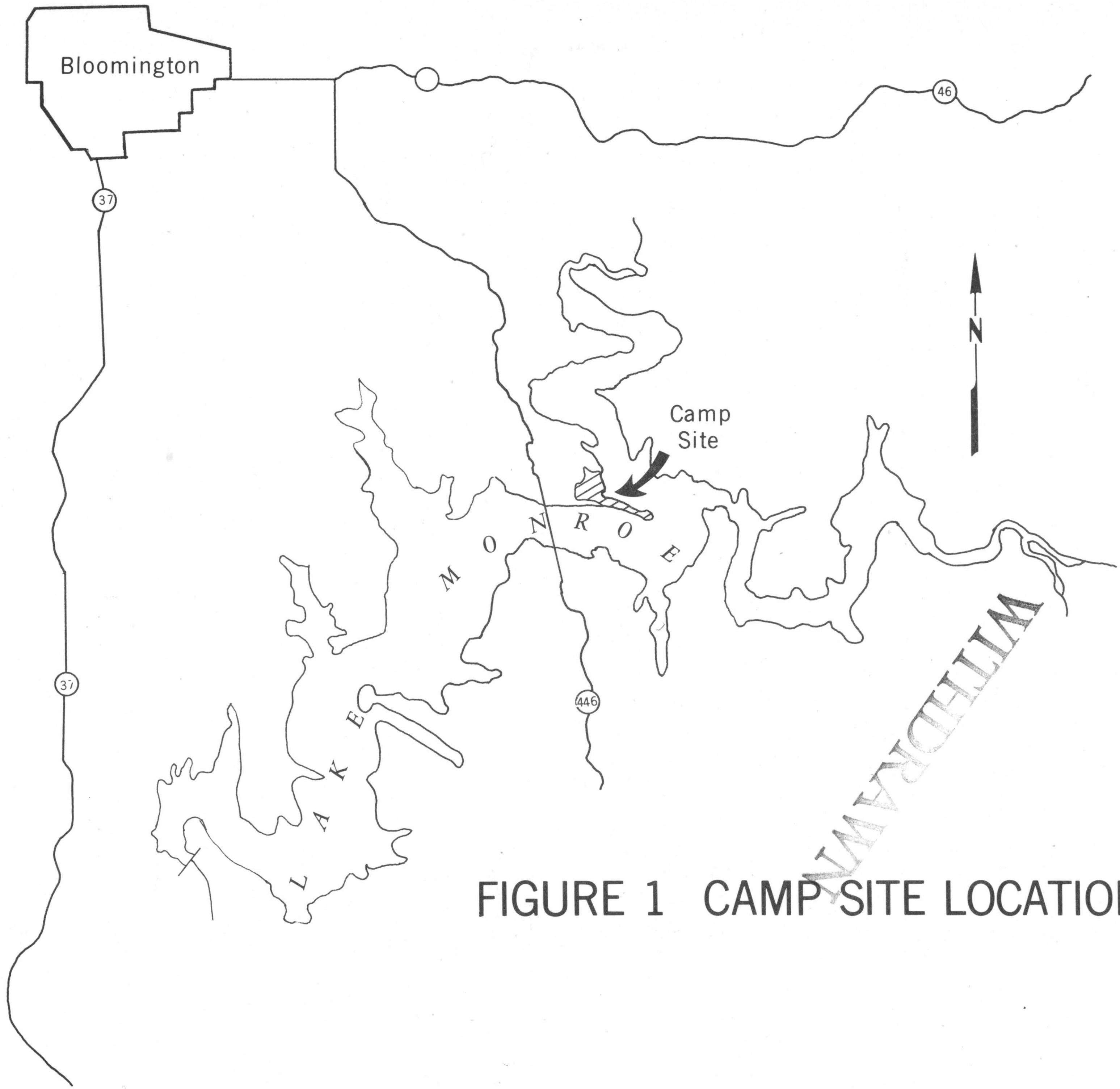


FIGURE 1 CAMP SITE LOCATION

conditioned. The cabins will be arranged in several clusters; there will be either one central facility with restrooms and showers or one such facility for each cluster. The total number of cabins is not likely to exceed 30.

Relatively undeveloped recreational uses planned for the camp include paths for walking and nature trails and possibly picnic areas. Much of the site is to be left as undeveloped wilderness.

While the program center will probably be capable of year-round operation, the main activity at the camp will take place during a 3½-month period in the summer. During this period, the camp is to offer a series of some 15 one-week sessions. Guests will arrive on a Sunday and leave the following Saturday. A structured program of recreational and educational events will be offered, in which guests may choose to participate or not to. The camp will provide child care services, so that parents who so desire may utilize the camp facilities on their own. Emphasis will be placed on using the cabins; recreational vehicles will not be encouraged. On the basis of experience with a similar camp in Wisconsin, the Alumni Association expects the Lake Monroe camp to be operating close to capacity all season long. It is possible that the camp may be used on weekends during the winter for special programs.

Purpose of This Assessment

The purpose of environmental impact assessment, in general, is to predict the effects of a proposed project on its environment, to suggest ways to mitigate those effects, and to evaluate those alternatives to the main proposal that might accomplish the same objectives in a manner that is environmentally more sound. This assessment follows common practice in that, in order to evaluate the impacts of a project on its environment, both the nature of the project and the nature of the existing environment (without the project) must be considered. The description of the current environment must be especially thorough due to its complexity and to the ease with which potential impacts can be missed if the assessment team is not aware of all potentially relevant aspects of environmental structure and function.

Beyond these descriptions, this assessment departs from traditional format. Because no site plan for the Alumni Family Camp has been prepared, and because some decisions with respect to the nature of the functions to be included within the camp have yet to be finalized, there is no specific, central proposal for which mitigating measures can be suggested and to which alternatives can be evaluated. In this assessment, then, a set of alternatives is generated for the two most environmentally significant aspects of camp development--location of camp components and sewage treatment; all alternatives within each set are then assessed simultaneously. Impacts of activities that do not depend on specific site and sewage treatment plans are then discussed separately. The major conclusions and recommendations of the assessment team are offered in a final section.

Finally, it should also be noted that this particular assessment is not required by law. The decision to have the environmental impacts of the Alumni Family Camp evaluated was a voluntary one taken by the Indiana University Alumni Association.

Current Environment of the Lake Monroe Alumni Family Camp Site

In order to assess the effects that the construction and operation of the Alumni Family Camp may have on its environment, a knowledge of the current status of that environment is necessary. The following sections describe the current natural environment of the Lake Monroe Alumni Family Camp site--the air, the land, and the water--both in themselves and as used by humans--along with aspects of the current social environment.

Air Resources

Where it is not noxious, there is a tendency to take the atmospheric portion of the environment for granted. However, the attractiveness of the land and water resources of the Lake Monroe area for recreational purposes is made possible by the climate of the region and enhanced by the quality of the air. These aspects of the atmospheric environment are described briefly in the following sections.

Climate

Indiana's climate is continental in nature, with hot summers and cold winters. Spring is usually the season of peak precipitation, with autumn generally the driest season. Severe weather occurrences include tornadoes and thunderstorms (Smith, 1976).

While climatic data are not available for the Alumni Family Camp site vicinity itself, such data are available for Bloomington and Monroe County in general. Conditions at the camp site are not likely to be significantly different.

Mean monthly precipitation and temperature data based on the normal period 1941-1970 for Bloomington are shown in Table 1. Average annual precipitation is 43.20 inches, including the aqueous fraction of about 14 inches of snow.

Table 1. Mean Monthly Precipitation and Temperature Data, Bloomington, Indiana, 1941-1970

Month	Mean Precipitation (inches)	Mean Temperature (°F)
January	3.30	31.2
February	2.74	34.2
March	3.88	42.7
April	4.01	55.5
May	4.59	64.5
June	4.72	73.0
July	4.14	76.2
August	3.38	74.7
September	3.30	68.2
October	2.41	58.0
November	3.52	44.2
December	3.21	33.6

Source: U.S. Department of Commerce (1973).

Mean annual temperature is 54.7°F, with temperatures ranging seasonally from a mean daily January minimum of 24°F to a mean daily July maximum of 89°F (U.S. Department of Commerce, 1973). Freeze data for Bloomington are given in Table 2. Generally, the frost-free period encompasses about half the year (Smith, 1976).

Other average climatic data for Bloomington include daily solar radiation of about 350 langleys, total annual sunshine of about 2700 hours, and a relative humidity of 72%. Mean annual pan evaporation for the Bloomington area is 44 inches, with a pan coefficient of 0.77. Mean annual lake evaporation, therefore, is 33.8 inches. Mean gross

Table 2. Freeze Data, Bloomington, Indiana, 1931-1960

Threshold Temperature (°F)	Mean Date of Last Spring Occurrence	Mean Date of First Fall Occurrence	Number of Days Between Two Occurrences
32	April 21	October 20	182
28	April 5	November 2	211
24	March 23	November 13	233
20	March 12	November 26	259
16	March 3	December 8	280

Note: The table provides the last spring occurrence and the first fall occurrence of temperatures at or below the given thresholds.

Source: U.S. Department of Commerce (1973).

evaporation between May 1 and October 31 is 79% of total gross evaporation (Schall, 1977).

Wind speed and direction vary locally within Monroe County, but prevailing winds are from the southwest. The tornado index for Monroe County is 0.45, indicating that the county has less than half of the Indiana state average of tornadoes per unit area to rural population (state average is set at one).

Air Quality

The camp site is located in an area of relatively good air quality, free of most direct inputs from pollutant-generating processes. Although site-specific data are unavailable, air quality monitoring has been conducted in downtown Bloomington by the Indiana Air Pollution Control Board and in Morgan-Monroe State Forest by the U.S. Environmental Protection Agency. Reliable data were gathered at both monitoring sites between 1969 and 1976 for total suspended particulate (TSP) concentrations, and between 1973 and 1976 for sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations. The Morgan-Monroe data were taken in a forested, rural area like that at the camp site and are more likely to resemble conditions at the site than the Bloomington data are; the latter are included as general background and for purposes of comparison.

Each state is required to meet primary and secondary federal air quality standards, which are shown in Table 3 for TSP, SO_2, and NO_2. The primary maximum concentrations for TSP and SO_2 and the secondary maximum concentration for TSP are 24-hour concentrations not to be exceeded more than once a year. The secondary maximum for SO_2 is the 3-hour concentration not to be exceeded more than once a year. When these maximums are exceeded, a violation is recorded (Code of Federal Regulations). Primary and secondary standards in general are those which must not be exceeded if damage to health and property, respectively, are to be avoided. The State of Indiana has also promulgated air quality standards; these are the same as the federal standards, except that Indiana has no secondary mean TSP standard.

Table 4 contains the mean concentration, highest observed concentration, second highest observed concentration, and the number of violations of air quality standards for each parameter at the Bloomington monitoring site. There was only one violation of primary TSP standards and only six violations of secondary TSP standards. Data from the monitoring of TSP, SO_2, and NO_2 in Morgan-Monroe State Forest in northern Monroe County are

Table 3. Federal Air Quality Standards

Pollutant	Primary Mean Concentration ($\mu g/m^3$)	Secondary Mean Concentration ($\mu g/m^3$)	Primary Maximum Concentration ($\mu g/m^3$)	Secondary Maximum Concentration ($\mu g/m^3$)
Total Suspended Particulate (TSP)	75[1]	60	260[2]	150[2]
Sulfur Dioxide (SO_2)	80	--	365[2]	1300[3]
Nitrogen Dioxide (NO_2)	100	100	--	--

[1]TSP mean is geometric
[2]maximum 24-hour concentration not to be exceeded more than once a year
[3]maximum 3-hour concentration not to be exceeded more than once a year

Source: Code of Federal Regulations.

Table 4. Air Quality Data, Bloomington

Pollutant	Year	Mean Concentration (μg/m³)	Highest Observed Concentration (μg/m³)	Second Highest Observed Concentration (μg/m³)	Number of Violations of Standards	
					Primary	Secondary
Total Suspended Particluate	1969	66	132	125	0	0
	1970	N/A	307	183	1	2
	1971	N/A	119	113	0	0
	1972	N/A	138	121	0	0
	1973	N/A	189	182	0	2
	1974	69	173	157	0	2
	1975	58.2	113	109	0	0
	1976	68	154	142	N/A	N/A
Sulfur Dioxide	1973	N/A	26	16	0	0
	1974	23	79	65	0	0
	1975	16.7	88	71	0	0
	1976	24	76	61	N/A	N/A
Nitrogen Dioxide	1973	N/A	43	38	0	0
	1974	34	62	58	0	0
	1975	43.3	170	76	0	0
	1976	38	76	74	N/A	N/A

N/A:Not available

Source: U.S. Environmental Protection Agency (1977).

given in Table 5. There were no violations of either primary or secondary standards.

Although no extended site-specific background noise level data are available, spot monitoring indicated levels of 30 to 45 dBA.

Table 5. Air Quality Data, Morgan-Monroe State Forest

Pollutant	Year	Mean Concentration ($\mu g/m^3$)	Highest Observed Concentration ($\mu g/m^3$)	Second Highest Observed Concentration ($\mu g/m^3$)	Number of Violations of Standards	
					Primary	Secondary
Total Suspended Particulate	1969	39	119	68	0	0
	1970	33	78	69	0	0
	1971	40	65	62	0	0
	1972	34	51	51	0	0
	1973	N/A	86	58	0	0
	1974	N/A	65	65	0	0
	1975	N/A	90	84	0	0
	1976	N/A	68	63	0	0
Sulfur Dioxide	1973	N/A	10	9	0	0
	1974	N/A	23	21	0	0
	1975	N/A	30	21	0	0
	1976	N/A	22	9	0	0
Nitrogen Dioxide	1973	N/A	20	13	0	0
	1974	N/A	85	78	0	0
	1975	N/A	30	20	0	0
	1976	N/A	38	11	0	0

N/A:Not available

Source: U.S. Environmental Protection Agency (1977).

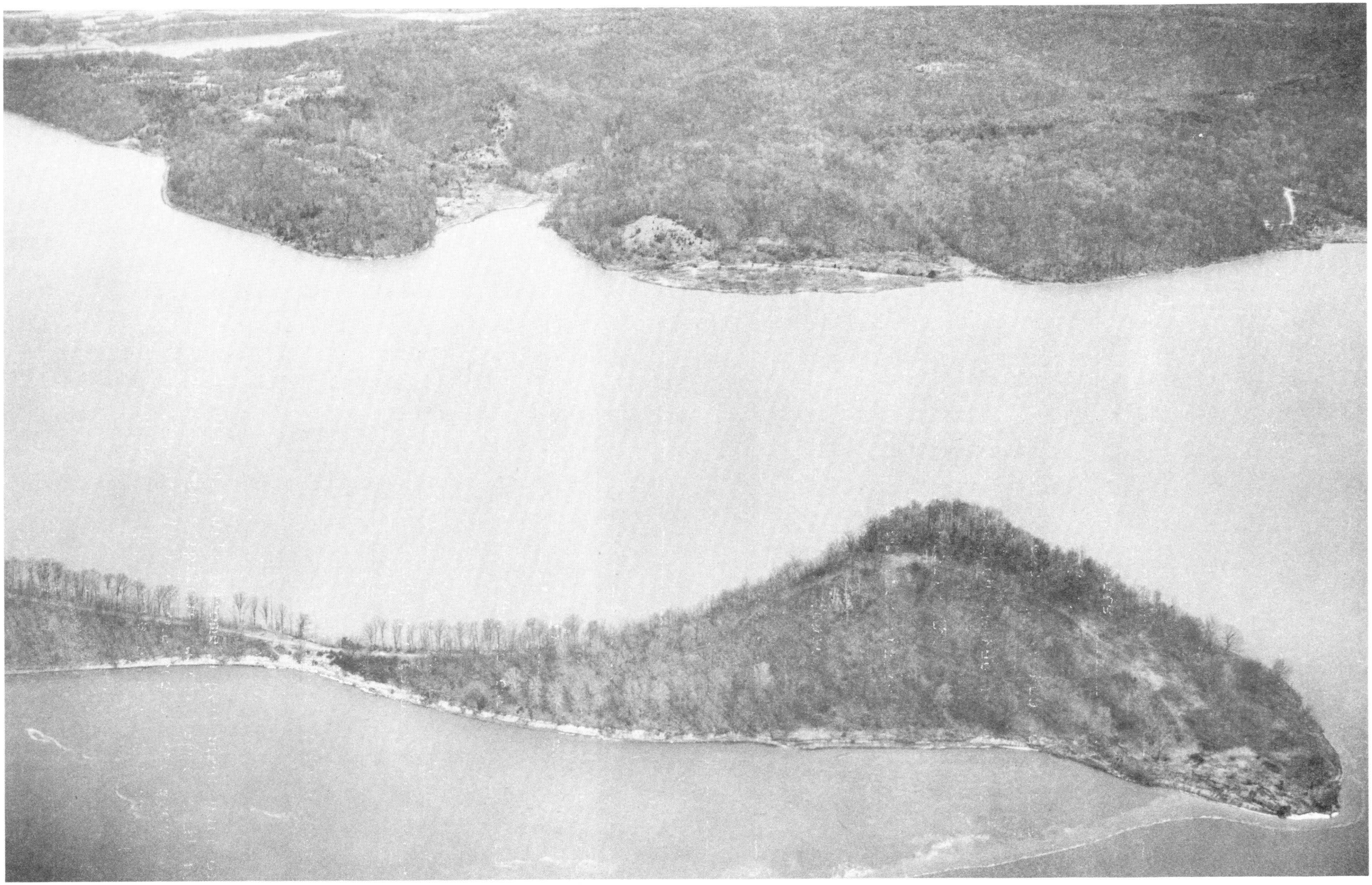


PLATE 1. CAMP SITE PENINSULA

Plate 1. Camp Site Peninsula

This oblique, north-looking view illustrates the substantial relief of the peninsula tip. A small abandoned quarry (left of the peninsula center) highlights the limestone that caps the peninsula. Siltstone forms the remaining sub-surface material surrounding this cap. Hagerstown silty clay loam soils overlay the limestone area while the Berks-Weikert soil complex is found elsewhere.

An artificial isthmus of hauled limestone and stabilizing pines is found in the narrowest portion of the peninsula. An archeological site, destroyed by Lake Monroe, lies just off the tip. The old channel of Salt Creek runs along the northern shore of the peninsula.

Old-field community A-4 and Brushland community B-6 are visible near the lower right corner. Brushland community B-5 is up the slope from the lower right corner. Pine plantation community F-2 lies on the lowest land point toward the right. (Refer to Figs. 8 and 9.)

While shelters may be placed on the summit, the remainder of the peninsula is unsuitable for development.

Land Resources

While Lake Monroe may be the most obvious natural resource in the camp site area, the land on which the camp is to be built is also an important environmental resource. Topography, geology, and soils can impose limitations on development; the results of ignoring these limitations can include unsound structures and water pollution. Ecological resources supported by the land, such as natural vegetation and wildlife, along with current human resources of the land, have implications with respect to the compatability of the current terrestrial environment with additional development. The current status of all of the above aspects of the land environment is discussed in the following sections.

Topography

The proposed camp site is situated within the physiographic unit known as the "Norman Upland" (Shaver, 1972), which lies in that portion of southern Indiana that was never glaciated, resulting in a topography that strongly reflects the influence of the local bedrock structure and lithology. The vicinity is rugged and characterized by steep, sloping land, dissected by a well established dendritic drainage system. The flat-topped narrow divides, steep slopes, and deep V-shaped valleys of the Lake Monroe region are typical of the Norman Upland.

On-site relief ranges from the normal lake pool level of 538 feet to just over 690 feet (Fig. 2). Gently sloping areas occupy the main ridgetop of the camp site. Land falling away to the north and west may be described as strongly sloping, averaging approximately 12%, while much steeper slopes are found on the south and east bordering Lake Monroe (see Fig. 3).

Sinkholes are common in the Lake Monroe region, but do not occur on the camp site or within a half-mile radius of it.

Geology

A geologic factor of importance to potential development is the proximity of any seismic features. While the Alumni Family Camp site is adjacent to the Mt. Carmel Fault, there is no evidence that any movement has taken place along the fault since late Paleozoic time (200 million years ago), nor does the fault appear to be related to the recently active fault zones of the lower Wabash, lower Ohio, and middle Mississippi valleys (Shaver, 1972). Although future movement of the fault is not to be entirely discounted, the presence of Lake Monroe reinforces the likelihood of continued stability. One topographic side effect of the location of the camp site on the downthrown side of the Mt. Carmel Fault is that, instead of participating in the 35-foot-per-mile regional dip of the Norman Upland to the west (Melhorn and Smith, 1959), the camp site lies in an area dipping to the east at a rate of 50 feet per mile.

The camp site is underlain by bedrock of two types--Borden Group siltstones and Harrodsburg limestone (shown in Fig. 4). The Borden

FIGURE 2 LOCAL RELIEF

Contour Interval in 10 Feet

0 ½
mile

Source: U.S. Geological Survey Allens Creek Topographic Sheet, 1966.

FIGURE 3 SLOPE DISTRIBUTION

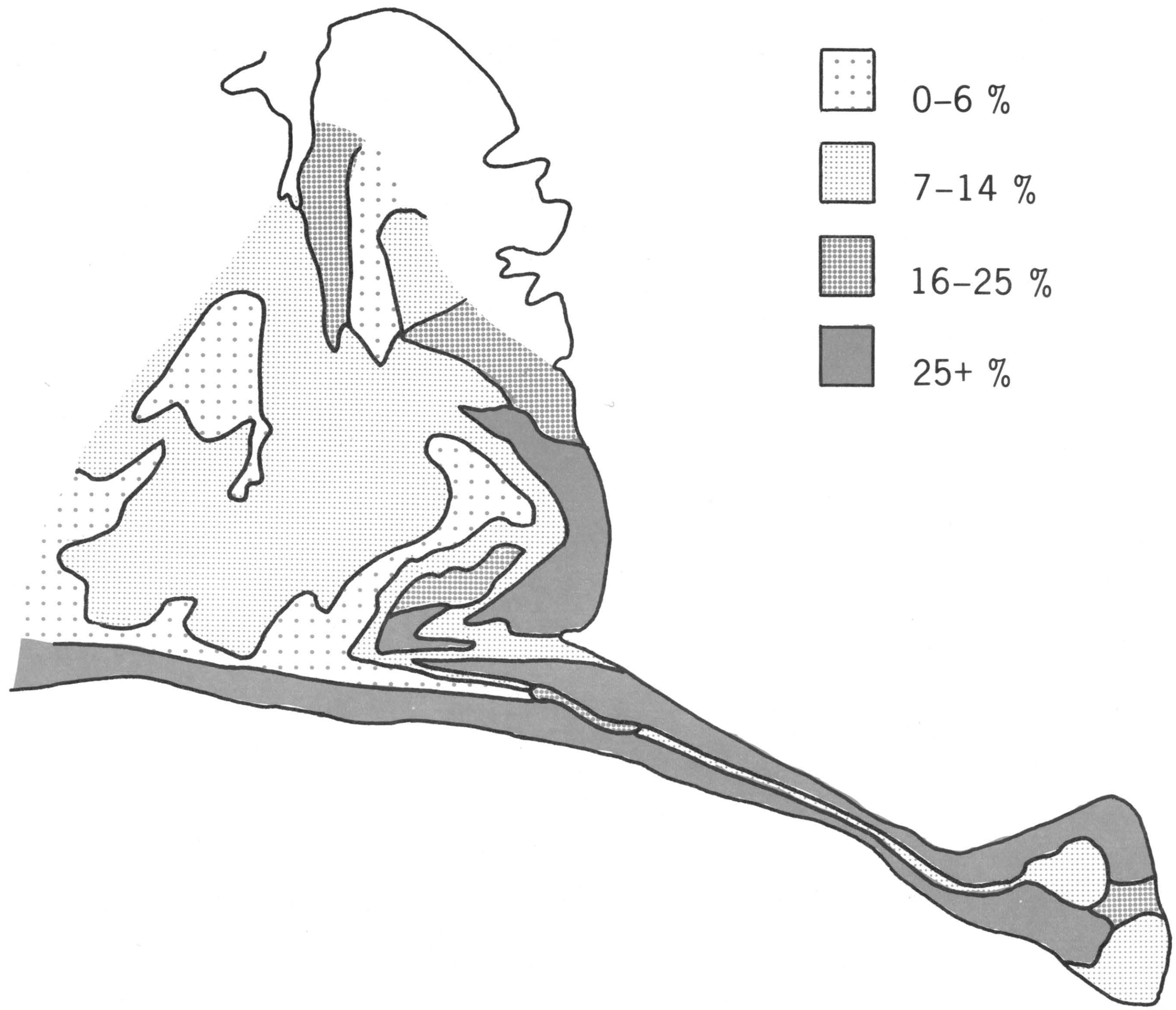
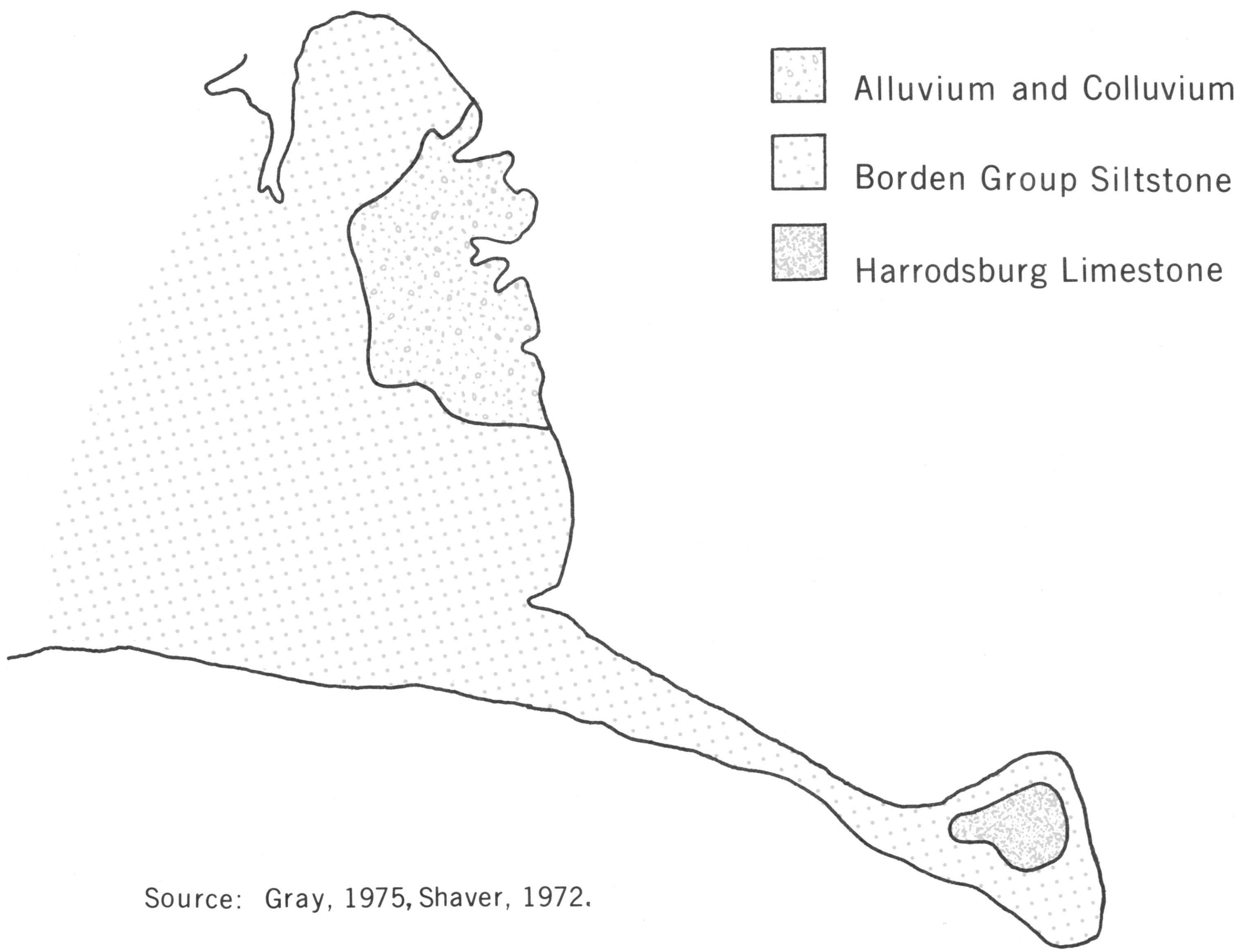


FIGURE 4 CAMP SITE GEOLOGY



Source: Gray, 1975, Shaver, 1972.

Group is of Mississippian age (250 million years) and predominantly consists of impermeable siltstones with some interbedded silty shales (Winslow, Gates, and Melhorn, 1960). The siltstones underlay most of the camp area, and soil depth to bedrock is rather shallow because the soils derived from siltstones tend to be thin and stony due to the slowness with which siltstone weathers. Figure 5 shows the depth of soil to bedrock in different parts of the camp area. The upper beds of the Borden Group exhibit a gradual transition to the Harrodsburg limestone above them and commonly contain many geodes and fossils (Melhorn and Smith, 1959).

The Harrodsburg limestone, also of Mississippian age, occupies a triangular area of about four acres on the eastern tip of the camp site peninsula (Fig. 4). This rather thin formation is well exposed in the abandoned quarry on the south side of the peninsula. The limestone is an impure, chrinoidal, and geode-bearing form that is of little commercial value. It is located in its normal depositional position immediately above the Borden Group (Shaver, 1972).

A rather large deposit of alluvium and colluvium is located in the northeastern area of the camp site adjacent to Lake Monroe. The alluvium consists mainly of silts and clays, with some sand and gravel mixed in (Shaver, 1972).

Soils

The general texture of soils on the Alumni Family Camp site is silt loam. These well drained soils are strongly acid and low in exchangeable bases. Permeability (the quality that enables soil to transmit water or air) is moderate throughout the property.

These soils fall out into types known as "series." The distribution of the various soil series over the camp site is mapped in Fig. 6, and the characteristics of the series are given in detailed fashion in Table 6. The information presented in the map and table is summarized in the following paragraphs.

Eroded Gilpin silt loam is found on 32 acres of the western slideslopes adjacent to the site's upland drainageways. This loamy soil is strongly sloping, moderately deep, and predominantly in forest. It is well drained and formed in strongly acid material weathered from siltstone.

Wellston silt loam occupies 30 acres of the most level areas and adjacent slideslopes on the property. This loamy soil is gently to moderately sloping, deep, and eroded. The soil is well drained and formed in 20 to 40 inches of loess over sandstone. Vegetation is evenly split between forest and open grassland.

The Berks-Weikert soils complex is entirely forested and occupies slightly more than 53 acres on the eastern slopes. These loamy soils are steep to very steep and shallow to moderately deep. About 55% of this complex is Berks and 20% Weikert. Berks is well drained, Weikert excessively drained; both are formed in material weathered from siltstone.

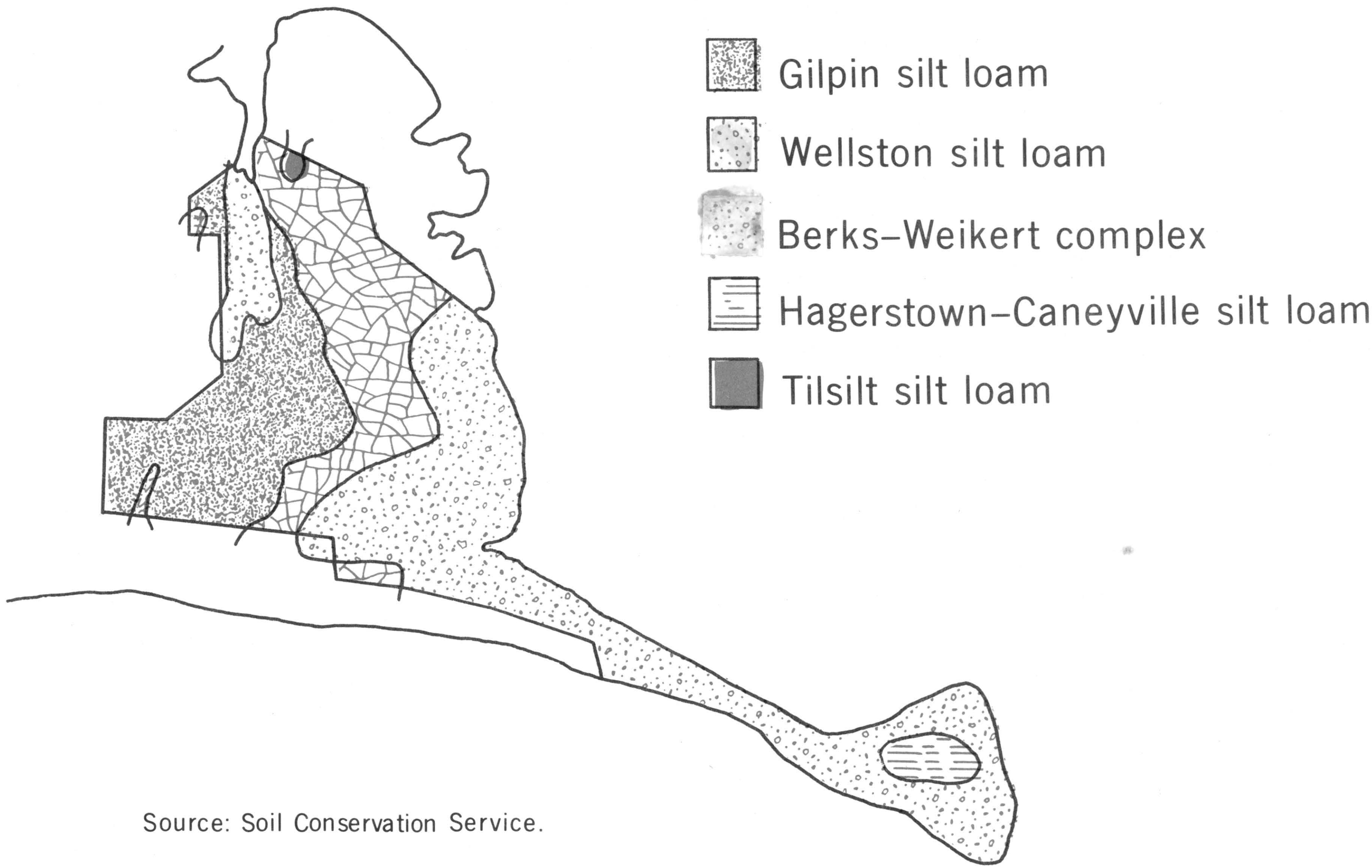
The end of the camp site peninsula is capped with 5.2 acres of moderately deep Hagerstown-Caneyville silt loam. These strongly sloping, loamy soils are well drained and were formed in 0 to 20 inches of loess over material weathered from limestone (as exemplified by the abandoned limestone quarry found within this area).

FIGURE 5 DEPTH OF SOILS TO BEDROCK

Drill Hole	Feet
1	4.0
2	4.0
3	7.5
4	4.0
5	4.5
6	4.5
7	3.5
8	3.0
9	5.5
10	2.0
11	0.2
12	4.0

Source: McFadzean,et. al., 1976

FIGURE 6 SOIL SERIES



Source: Soil Conservation Service.

Table 6. Properties of Study Area Soils

Series Name and Texture	Acreage	Ground Cover		Depth (in.)			pH Surface Layer	Permeability (in./hr)	Plasticity Index (topsoil)	Potential Frost Action	Potential Corrosion in Subsoil	
		Type	Percent	Surface Layer	Subsoil	To Bedrock					Steel	Concrete
Gilpin silt loam	31.98	Forest Open grass	70 30	0-24	8-24	48	4.0-5.5	moderate 0.6-2.0	4-15	moderate	low	high
Berks-Weikert Complex	53.56	Forest	100	0-10	10-26	48	4.5-5.5	moderate 0.6-2.0	5-10	low	low	high
Wellston silt loam	29.64	Forest Open grass	50 50	0-7	7-25	50	5.1-6.5	moderate 0.6-2.0	4-10	moderate	moderate	high
Hagerstown-Caneyville silt loam	5.20	Forest Open grass	80 20	0-8	8-20	>40	5.1-7.3	moderate 0.6-2.0	5-25	moderate	moderate	low

Source: Soil Conservation Service and field observations.

In addition to the above soil series, two or three acres of Tilsit silt loam may occur on the extreme northern boundary of the camp site. The site contains no unusual or isolated soil types.

Terrestrial Ecology

Regional perspective. To better understand the relevance of the Alumni Family Camp site to the natural ecosystems of the Lake Monroe region, it is useful to review the ecological status of Monroe and Brown Counties. The greater area is relevant to the mobility of many wildlife species visiting the camp site and, to a lesser extent, to seed dispersal of plants.

Monroe and Brown Counties have 134,500 and 148,800 acres in woodlands, which constitute 51.2% and 71.8% of the total county land areas, respectively (Spencer, 1969). Due to the close proximity of Hoosier National Forest, Yellowwood State Forest, and Brown County State Park, as well as many privately owned wooded properties, the region surrounding the camp site is very extensively wooded (Map 3, inside back cover). As a matter of fact, without human intervention, the camp site and neighboring portions of Monroe and Brown Counties would be forested in all but a very few places. As it is, relatively undisturbed lands, primarily forest, old fields, and wetlands, extend from the camp site as far as 4.7 miles to the north, 11.9 miles to the east, 6.0 miles to the south, and 0.5 mile to the west (USDA, 1975). These contiguous natural areas in the vicinity of the camp cover about 200 square miles and may be expanded to 220 square miles with the addition of Yellowwood State Forest and adjacent properties north of State Route 46. Two areas have been officially recognized as having special wildlife management value. The Middle Fork Refuge is located only one mile east of the camp area and the North Fork Refuge lies 1.7 miles up the North Fork of Lake Monroe (Fig. 7). In addition, the proposed Indiana Wilderness (Nebo Ridge) occupies about 30,000 acres, beginning 0.6 mile east of the camp area (Schrodt et al., 1975).

In the Lake Monroe Land Suitability Study, Gray et al. (1975a) assessed the terrestrial ecology of the Lake Monroe region more thoroughly than can be accomplished here. Included in their document are species lists of the biota of the Lake Monroe area; these lists have been used extensively for ecological information of regional validity.

The regional forest currently includes 78 native and naturalized tree species, as listed in Gray et al. (1975a). Microhabitats and associated microclimates influence tree species composition of local areas. A study by Potzger (1939) in Salt Creek Township, of which the camp site is a part, and the generalized study by Gray et al. (1975a) indicate that topographic aspect is the most important factor determining tree species composition in local forests. North-facing slopes tend to have an abundance of American beeches and sugar and black maples, whereas south-facing slopes are dominated by oaks and hickories. Superimposed on this naturally occurring pattern are pine forests planted by man and "weed tree" forests from which there has been selective removal of certain species with subsequent replacement by less desirable species.

It is highly probable that as many as 25 species of amphibians, 25 species of reptiles, 85 species of common locally breeding birds, 79 species of common nonbreeding migrant and winter resident birds, and 40 species of mammals occur in the Lake Monroe region. Of greatest importance to this assessment, however, is the usage of the Lake Monroe region by large and widely ranging upland vertebrates, including ospreys, bald and golden eagles, turkey vultures, several species of hawks, large owls, wild turkeys, red and gray foxes, and white-tailed deer. For detailed natural histories of these animals and other basic information, the reader is referred to Bent (1963), Brown and Amadon (1968), Lack (1968), Martin et al. (1951), Minckler (1975), Reeves (1973), Sparks and Soper (1970), Trippensee (1948), and Welty (1975). All of these animals require large rural areas as habitat and decline in areas where the human population becomes dense.

Migratory wetland birds visit the portions of Lake Monroe adjacent to the camp site as autumn and spring migrants and occasionally as winter residents. During the late fall, winter, and spring of 1976-77, the most diverse group of birds was that of the diving ducks, including buffleheads, common goldeneyes, ring-necked ducks, scaups, and canvasbacks. About a hundred Canada geese and a single whistling swan were also present. Coots were ubiquitous, and herring and ring-billed gulls visited the area.

For many of these species the extensive wetland areas of Lake Monroe are more important than the camp site itself. The relevant wetland areas include the waterfowl refuges (Fig. 7) and extend upstream on the floodplains of the three forks of Salt Creek. Woody vegetation in these areas is dominated by willows, silver maples, and Eastern cottonwoods. Obligatory wetland animals observed on these

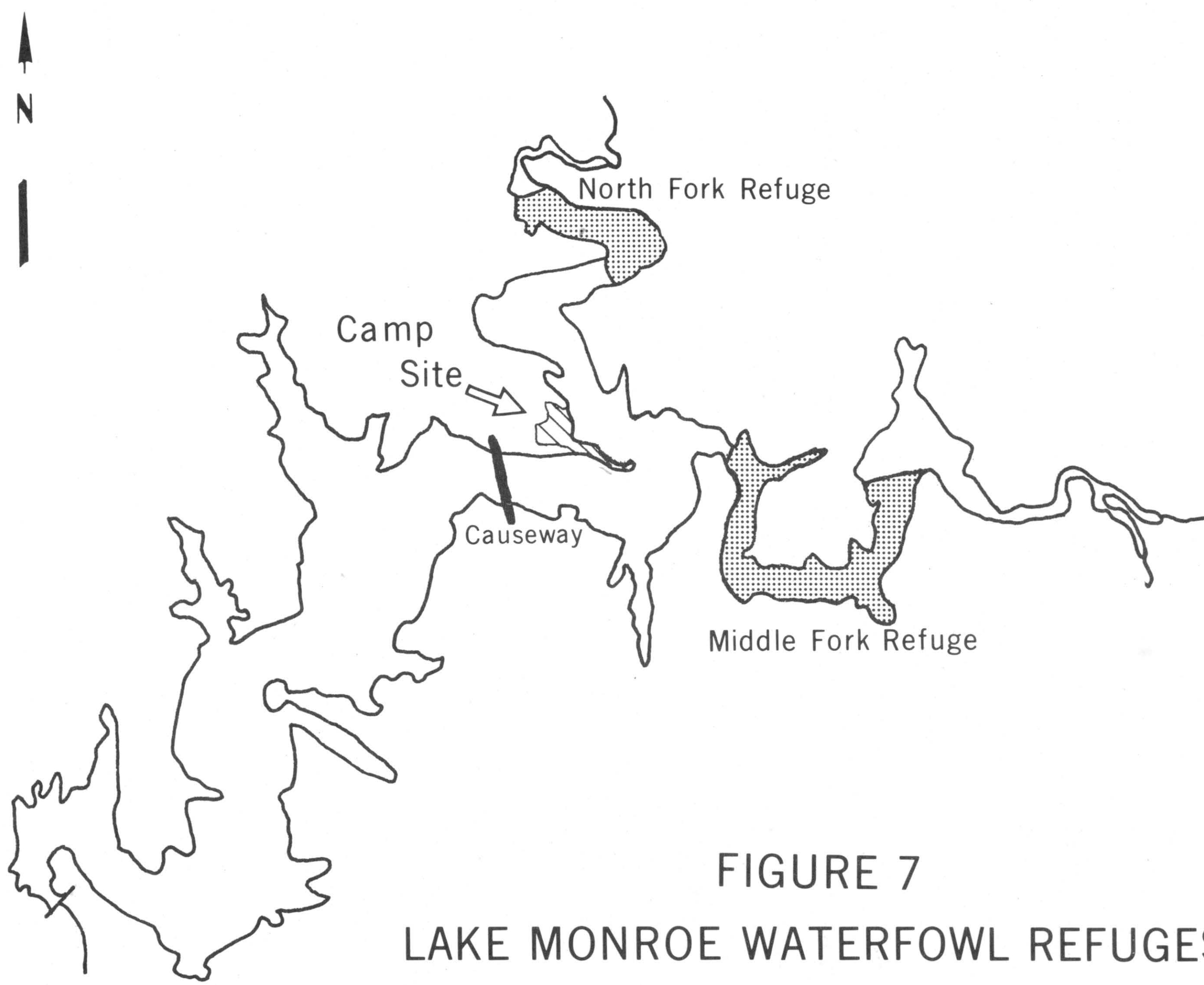


FIGURE 7
LAKE MONROE WATERFOWL REFUGES

floodplains within the last two years include 6 species of frogs and toads, 5 species of turtles, 4 species of herons, muskrats, and mink.

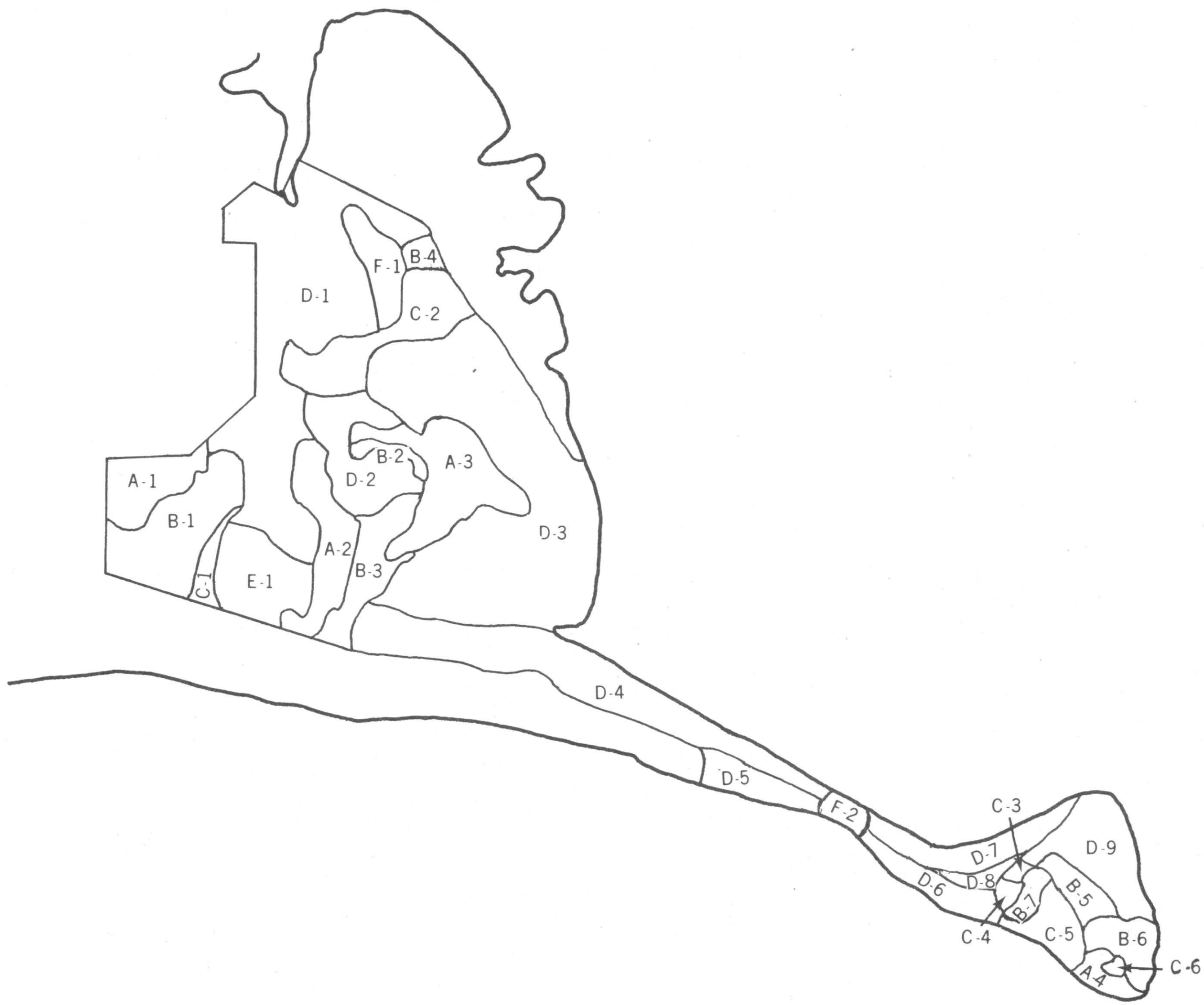
Biotic communities of the camp site: Introduction. The Alumni Family Camp site is a mosaic of grasslands, brush, and woodlands. This mosaic has resulted from an interaction between human activities (farming, lumbering, and grazing) and ecological succession. A cover map indicating dominant vegetation of the site is given in Fig. 8. There are six major vegetation types: (A) old fields, (B) brushlands, (C) brush forests, (D) forests, (E) old forests, and (F) pine plantations. Some of these areas are pictured in Plates 1-3. The grasslands have been perpetuated by continued human intervention. The brushland area represents a successional stage through which abandoned grassland is changing to forest, the terminal successional stage. For general information about regional vegetation and ecological succession, refer to Braun (1950), Daubenmire (1968), and Odum (1971).

The major community types were surveyed for this assessment and are described in the following pages, with each one broken down into the subcategories depicted in Fig. 8. In the vegetation survey, sampling techniques were varied to fit the irregular sizes and shapes of the biotic communities. Point-quarter transects, belt transects, and random sampling were used as appropriate. Only trees larger than 4.5 inches were measured except in the brush forest and pine plantation categories. All estimates of area were obtained using a compensating polar planimeter and aerial photographs.

Data on vegetation were collected between February 1 and April 9, 1977. The only tree species to leaf out during this period was the Ohio buckeye. Other species were identified by bark, branching, winter buds, and overall shape. Some species require observations of flowers and leaves for correct identification and remain only tentatively identified in this assessment. Correct identification of most herbaceous plants is even more dependent on the season. Only the earliest of the spring-blooming wild flowers are well documented in this assessment. During the period of field work, reptiles were not observed because they were still hibernating throughout Monroe County. Migratory summer resident song birds were still dispersed south of Indiana.

Old field communities (Series A, 16.6 acres). The many introduced grasses found in old fields on the site indicate that the former land use of these areas was pasture. These grasses include timothy, foxtail, meadow fescue, and red top. In some areas the native little bluestem and possibly other species of *Andropogon* are abundant because grazing has ceased. Goldenrod, Queen Anne's lace, thistle, ironweed, mullein, and common milkweed are other frequently encountered species. Animals observed as regular visitors to the old fields included flickers, robins, field sparrows, song sparrows, and dark-eyed juncos. During the late spring, black racer snakes and eastern box turtles probably enter these areas to sun and nest, respectively. Woodchucks may also feed in these areas, although none were observed. Voles may be expected where vegetation is matted.

FIGURE 8 VEGETATION DISTRIBUTION



Area A-1 (3.6 acres) is traversed by a woody hedgerow. The northern portion may have been the most recently plowed of all camp site property. The southern section is an advanced old field with <u>Andropogon</u> in abundance and invading woody plants including sassafras and small redcedars.

Area A-2 (4.4 acres) has the appearance of a pasture toward its southern end and contains a few apple trees and sumac. The northern portion has been invaded extensively by redcedar, raspberry bramble, and several species of deciduous tree saplings.

Area A-3 (7.6 acres) has been mowed recently. Along its border are several bittersweet vines climbing into adjacent woody brush. In the western portion of this area <u>Andropogon</u> is abundant.

Area A-4 (1 acre) borders on Lake Monroe and includes eroded and gullied areas. <u>Andropogon</u> is dispersed with isolated bush-sized individuals of wild cherry, hawthorn, prickly ash, white ash, tulip tree, redcedar, and raspberry bramble. This area is undoubtedly visited by the numerous cottontail rabbits living in the adjacent brushlands and brush forest.

<u>Brushland communities (Series B, 24.2 acres)</u>. These areas are characterized by a tangle of woody plants and occasional old-field grass remnants. Especially abundant plants include raspberry bramble, greenbrier, Japanese honeysuckle, smooth sumac, sassafras saplings, black walnut saplings, prickly ash, redcedar saplings, wild grape vines, trumpet vines, and rose bushes. A 1967 aerial photograph shows that many of the brushlands were pastures at that time.

Due to the tangle, movements of people and other large animals in such areas are often impeded, an impediment which smaller animals take advantage of. Both food (low leaves and abundant seeds and berries) and cover (the matted tangle) render these areas prime wildlife habitat for a large group of animals that are probably more abundant in Indiana today than they were in the past. Numerous mammal burrows in the brushland areas indicate the presence of medium-sized mammals. Cottontail rabbits were observed; opossums and woodchucks are probably present. Foxes were identified by their tracks, though no fox burrows were observed. Towhees, cardinals, dark-eyed juncos, and sparrows were the abundant songbirds in the brushlands. Several warblers may be expected as summer-breeding residents. One species of lizard, several harmless snakes, and the box turtle are summer residents in the brushlands.

Area B-1 (7.6 acres) is a rich brushland area. Plant species include Japanese honeysuckle, sassafras, raspberry bramble, hawthorns, sugar maple, ashes, and wild cherry. The Japanese honeysuckle covered an intensive patch, smothering out other species. The thick areas of honeysuckle and raspberry bramble of this area are especially suitable for cottontail rabbits and white-footed mice.

Area B-2 (0.7 acre) is the least dense of the brushland areas due to a xeric southern exposure. The broken woody canopy has allowed grasses and sedges to grow. Woody species noted were sumac, greenbrier, and small individuals of species such as oaks, bitternut hickory, and white ash. This brushland area has abrupt borders of field to the north and forest to the south such that birds in the interior of the forest are visible from the field.

Area B-3 (4.2 acres) is an unevenly dense area that is tangled in places and savanna-like in others. Vegetation includes sumacs, young black walnuts, raspberry brambles, grasses, and bitternut hickories. Area B-3 is utilized by wildlife moving from west of a road through the site to the small pond (Fig. 9) or the lake.

Area B-4 (1 acre) includes tulip tree saplings measuring 1.2 inches in mean dbh and 1-2 inches in median dbh, with the largest individual at 4.2 inches dbh. Species adding to the thick understory were Japanese honeysuckle, raspberry bramble, greenbrier, and little bluestem.

Area B-5 (1.4 acres) is a dense and almost pure stand of redbud that extends on both sides of a path out to the tip of the peninsula. The canopy is 8 to 10 feet high.

Area B-6 (2.3 acres) is an extension of Area B-5 where redbuds are fewer and patches of raspberry bramble are extensive. There is a dense stand of wild cherry and isolated hawthorns. Areas B-5, B-6, B-7, and C-5 join together to form rich small mammal habitat that is densest in the tangled vegetation at the margin of B-6 and C-5.

Area B-7 (1 acre) was the site of an old homestead. Redbud and similar woody shrubs are extremely dense. Raspberry brambles are present.

Brush forest communities (Series C, 12.2 acres). To the casual observer this community looks like forest. However, most trees are small, and brush forest is very dense and tangled. Many of the small trees are similarly aged and in intense competition with each other for space in what was once open brushland. As time passes some will die and spaces between remaining trees will become greater. Some brush species have persisted and have prevented the tree canopy from closing.

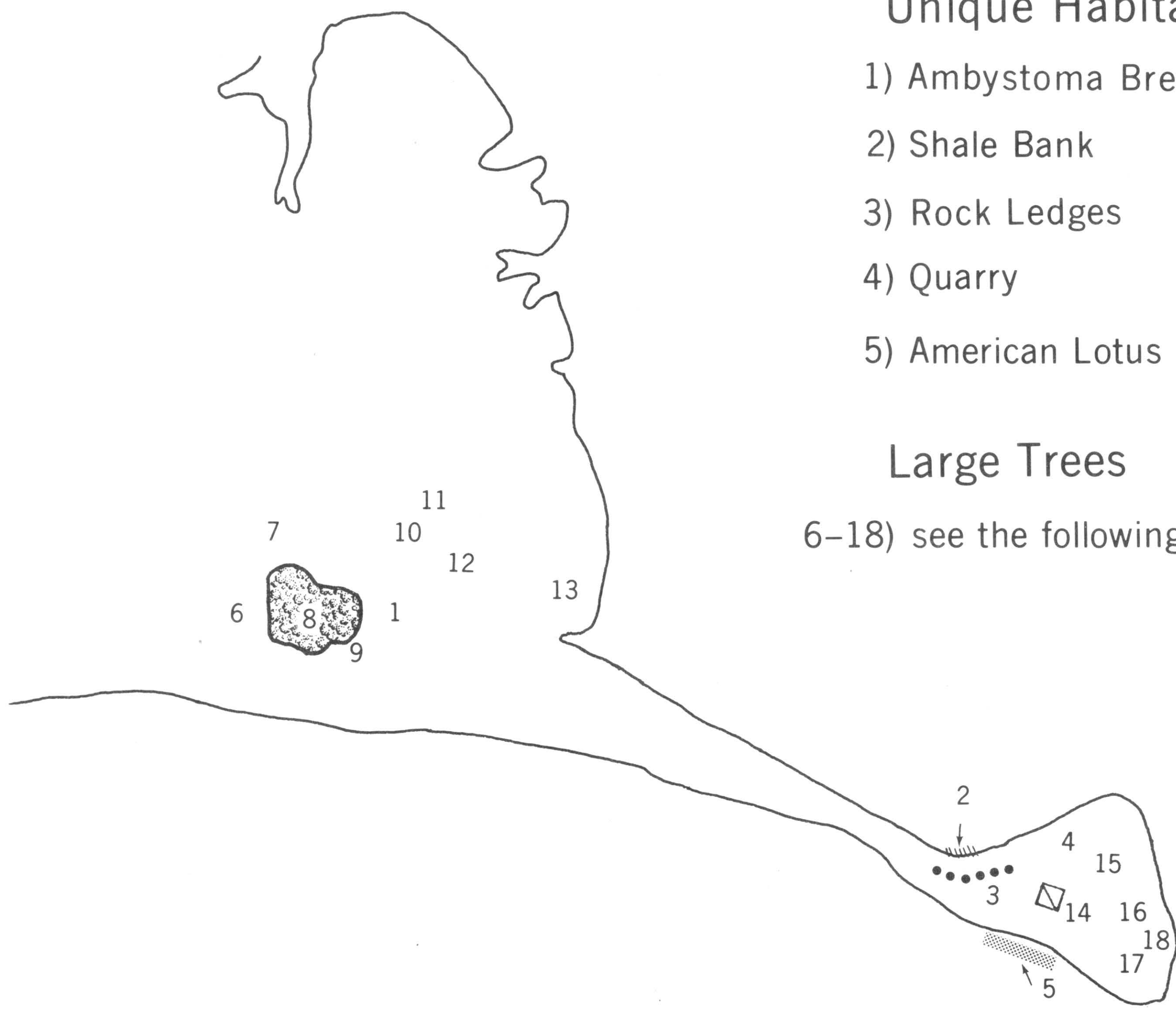
Brush forest is excellent habitat for white-tailed deer. Activities of ruffed grouse tend to center about brush forest with feeding forays into brushlands and along the edges of fields. Many birds nest in brush forest, especially birds of the thrasher and vireo groups, along with warblers, cuckoos, wrens, and, if near fields, mourning doves.

Area C-1 (1.1 acres) is distinguished by numerous redcedars having a mean dbh of 4.9 inches, a median dbh of 5 to 6 inches, and a maximum dbh of 7.3 inches. Associated trees in this area are small sugar maples and tulip trees, sassafras, white ash, and flowering dogwood. The area included a well-used deer trail extending into Area B-1 and evidence of deer beds.

Area C-2 (6.4 acres) includes tulip tree, sugar maple, and flowering dogwood as the most numerous tree species. Associated species are red oak, pin oak, red maple, American elm, hackberry, ironwood, musclewood, black cherry, sweet gum, sycamore, and sassafras. The mean dbh for the community is 7.7 inches, the median dbh 10 to 11 inches, and the maximum dbh 17 inches. Brush was very dense in the western portion of this area, but only moderately dense in the eastern portion.

Areas C-3 and C-4 (0.3 and 0.5 acres, respectively) are too small to warrant detailed analysis. Small chinkapin and red oaks and several hickory species are present in Area C-3. Area C-4 shows an unusual abundance of Ohio buckeye.

FIGURE 9 UNIQUE HABITATS AND UNUSUALLY LARGE TREES



Unique Habitats

1) Ambystoma Breeding Pond

2) Shale Bank

3) Rock Ledges

4) Quarry

5) American Lotus Mud Flat

Large Trees

6–18) see the following table

Table 7. Unusually Large Trees of the Alumni Family Camp Site. Refer to Fig. 9 for the locations of these trees.

Identifying Number on Fig. 9	Species	Diameter at Breast Height (inches)
6	Sugar maple	34
7	Black maple	30
8	American beech grove	23-40
9	Black walnut	22,23[1]
10	Red oak	60
11	Red oak	62
12	Black walnut	39
13	Red oak	40
14	Red oak	33
15	White oak	34
16	Pin oak	35
17	American elm	25
18	Sweet gum	29

[1]twin trunks

Area C-5 (3.4 acres) includes red oak, American beech, and white oak as the three most numerous tree species. Associated species are black oak, chinkapin oak, pin oak, pignut hickory, Ohio buckeye, sassafras, redbud, and redcedar. The mean dbh for trees is 18.5 inches, the median dbh 15 to 16 inches, and the maximum dbh 35.2 inches. The largest trees were very widely spaced in this forest, allowing dense development of shrubs and raspberry brambles.

Area C-6 (0.5 acre) is a pure stand of Ailanthus (tree of heaven) with a mean dbh of 4.3 inches, a median dbh of 4 to 5 inches, and a maximum dbh of 6.7 inches. Groundcover includes raspberry bramble, grass, and other old-field plants.

Forest communities (Series D, 87.6 acres). The areas included in this category are dominated by moderate- to large-sized hardwood trees. All of the forests were cut in the past, but occasional trees were left uncut and have reached very large size. Brush in the understory is sparse to moderately sparse. At ground level ferns and woodland wild flowers are common. An important feature of the overall forest community is the presence of windfalls, dead limbs, and trunks of trees lying on the ground.

The forest is a focal point in the life histories of some of the animals observed at the camp site or presumed to be living there. Several species of salamanders are fossorial in wooded areas (Williams, 1973) or hide beneath logs and other debris on the ground. Box turtles hibernate in woods at low elevations in ravines. Owls, squirrels, and raccoons use holes in trees for nesting or refuge, and woodpeckers use trees for feeding and nesting. Forests are important to a large group of songbirds, particularly titmice, fly catchers, creepers, nuthatches, and thrushes.

In Area D-1 (23.7 acres) American beech, red oak, and white oak are the most abundant tree species. Associated tree species are pignut, shagbark, and shellbark hickories; pin and black oaks; sugar and red maples; black walnut; black cherry; black gum; white ash; tulip tree; persimmon; slippery elm; American sycamore; flowering dogwood; ironwood; musclewood; and sassafras. The mean dbh of trees in Area D-1 is 11.8 inches, the median dbh is 10 to 11 inches, and the maximum dbh is 30 inches. Groundcover includes Christmas fern, adder's tongue lily, rue anemone, and wake-robin. The area includes an intermittant stream. Two-lined, slimy, and red-backed salamanders were found beneath logs near this stream. Common crows and turkey vultures were observed flying over this area. A barred owl was also seen flying into this area. Nuthatches, brown creepers, red-bellied and downey woodpeckers, and flickers were observed feeding, and the recent work of pileated woodpeckers was evident.

Area D-2 (6 acres) contains red oak, white oak, and shagbark and shellbark hickories as the most abundant tree species. Associated species are red maple, sugar maple, musclewood, ironwood, pin oak, tulip tree, persimmon, pignut hickory, and white ash. The trees of the community measure 15.9 inches in mean dbh and 15 to 16 inches in median dbh, with a maximum dbh of 61.6 inches. The area is an open, dry woods with sparse understory and clumps of grass growing at ground level. Fox squirrels were observed in this area as expected, because they they prefer dry forests with abundant nut trees.

Area D-3 (28.6 acres), red oak, white oak, and sugar maple are the three most numerous tree species. Associated tree species are black and chinkapin oaks; pignut, butternut, shagbark, and shellbark hickories; white ash; sugar maple; black cherry; sassafras; ironwood; musclewood; and slippery elm. The tree portion of the community was found to have a mean dbh of 11 inches, a median dbh of 11 to 12 inches, and a maximum dbh of 40 inches. This woodland borders on Lake Monroe and is one of the three areas where bald eagles were observed roosting next to the lake. Gray squirrels and a fox were observed in this woods during the late fall and early winter, and fox and deer tracks were numerous in the winter snow.

In Area D-4 (14.2 acres), American beech, sugar maple, and red oak are the most numerous tree species. Associated tree species are pignut hickory, black walnut, white oak, white ash, black cherry, black gum, bigtooth aspen, sassafras, and ironwood. Tree measurements for the community include a mean dbh of 11.9 inches, a median dbh of 9 to 10 inches, and a maximum dbh of 29 inches. The woody understory is very sparse and the herbaceous groundcover of woodland wild flowers is very dense in places. Especially numerous are squirrel corn and dutchman's breeches. Several cloves of may apples were present. This area includes another of the roosting areas for bald eagles. Eastern chipmunks and fox squirrels are numerous residents and visitors. Tufted titmice and Carolina chicadees frequent the area. During the winter there were numerous deer and fox tracks toward the west and along the road bordering the southern edge of this area.

In Area D-5 (2.9 acres), red oak, white oak, and white ash are the most numerous tree species. Associated species are hickories and bigtooth aspen. The mean dbh for trees in this community is 8 inches, the median dbh 8 to 9 inches, and the maximum dbh 15.5 inches. This area is located on a steep southern exposure creating dry conditions. The forest is open, with greenbrier, blue phlox, grasses, and pussy-toes as groundcover.

In Area D-6 (2.7 acres) red oak, American beech, and chinkapin oak are the most numerous species. Associated species are pignut, shagbark, and shellbark hickories; black maple; white ash; white oak; sassafras; and flowering dogwood. Tree measurements for the community include a mean dbh of 11.4 inches, a median dbh of 11 to 12 inches, and a maximum dbh of 26 inches. It is unusual for so many beech trees to be found on a south aspect as occurred in this stand. Groundcover is relatively xeric and includes woodland sedges, grasses, pussy-toes, and blue phlox. This area includes the third location where bald eagles were observed roosting. Eastern chipmunks are common in this area.

Area D-7 (3.4 acres) is a mixed mesophytic forest on a steep, north-facing slope. It is bordered along part of its southern edge by a system of rock ledges shown in Fig. 9. Because most of the area is not on the site and relatively inaccessible due to the steepness of the slopes, it was only casually inventoried. Trees observed from a distance included red and white oaks, pignut hickory, red and sugar maples, American beech, and white basswood. Groundcover included acute-leaved liverleaves, snow trillium, meadow rue, and wild ginger.

Area D-8 (0.8 acre) is a narrow, xeric ridge top. The most numerous tree species are chinkapin and red oaks and white basswood.

Associated tree species are Ohio buckeye, white ash, shagbark and shellbark hickories, black maple, and ironwood. Trees in the community measure 8.3 inches in mean dbh, 7 to 8 inches in median dbh, and 13.8 inches in maximum dbh.

Area D-9 (5.3 acres) is best described as a mixed mesophytic forest, but the diversity may be a result of the successional status of much of the area. Red and white oaks, pignut and bitternut hickories, black walnut, white ash, and sassafras are about equally represented. Additional tree species include chinkapin and pin oaks, American beech, sugar maple, American elm, hackberry, sweet gum, Kentucky coffee tree, flowering dogwood, ironwood, and redbud. Tree measurements for the community include a mean dbh of 10.7 inches, a median dbh of 9 to 10 inches, and a maximum dbh of 35 inches. In places, fragile ferns form a continuous groundcover. Woodland wild flowers are unusually diverse including squirrel corn, dutchman's breeches, downy yellow and other violets, mertensia, blood root, rue anemone, and yellow corydalis. On April 9, many songbirds including some warblers and blue-gray gnatcatchers were present, and fresh deer tracks were observed along the Lake Monroe shoreline of Areas D-9 and C-6.

Old forest communities (Series E, 5.2 acres). Area E-1 is the only area so designated. It may be viewed as an impoverished climax forest from which most large trees except American beech have been removed. The beeches have become giants and have been joined by smaller trees of several species to close the forest canopy. The forest contains 23 large beech trees measuring 32.6 inches in mean dbh, 32 to 33 inches in median dbh, and 40 inches in maximum dbh. There are numerous small beeches, indicating effective propagation for the species. Associated trees include red oak, red and sugar maples, black cherry, pignut hickory, and sassafras. The shrub layer is very sparse. Groundcover includes squawroot, beech drops, rue anemone, liverleaves, may apple, wake-robin, and adder's tongue lily. Several logs are present on the ground, providing habitat for plethodontid salamanders. Sereral tufted titmice were maintaining territories in the forest throughout the period of study. A red-tailed hawk was occasionally seen flying over Areas E-1, C-1, and B-1. Several of the large beech trees had cavities in their trunks and branches due to heart rot. These prime shelter areas for mammals were not observed in use.

Pine plantation communities (Series F, 2.6 acres). This community has been planted. It is now well represented in the Lake Monroe area, especially on ridge tops. The trees are usually placed in evenly spaced rows and may crowd each other as the stand ages. Most local animals lack special adaptations to pine forests. Ruffed grouse may enter pine plantations; barred owls are occasionally associated with them.

Area F-1 (3.2 acres) is a plantation of Scotch pine measuring 4.5 inches in mean dbh and 3 to 4 inches in median dbh, with a maximum dbh of 8 inches. The trees are crowding each other and some have died recently. Groundcover vegetation is absent. A gray squirrel was observed crossing the road that divides this area.

Area F-2 (0.4 acre) includes shortleaf pine and Virginia pine in an uneven planting. Eastern chipmunks are present in the vicinity.

Unique habitats. The portion of the Lake Monroe shoreline adjacent to the camp site is biologically impoverished. It is a largely barren area where land meets water abruptly. Both fluctuating waterline and steep slope probably contribute to this condition. Three species of wetland plants have become sparsely established. There is a mud flat of American lotus (Fig. 9). At the eastern end of this mud flat and at widely spaced points about the tip of the peninsula young black willow trees and begger-ticks are present. Muskrats have established refuge tunnels across the lotus mud flat and into the solid substrate of the more elevated shore. American coots were observed feeding very close to the shore at several points. It is probable that wading shore birds (Charadriidae and Scolopacidae), especially killdeers and sandpipers, are transitory visitors; none were observed. A second unique habitat is the small _Ambystoma_ breeding pond (Fig. 9). It is probably temporary (vernal) in most years. It contains a small stand of cattails and is used by Jefferson salamanders (genus _Ambystoma_), spring peepers, Blanchard's cricket frogs, and gray tree frogs for breeding. Other frogs and salamanders, which were not identified, probably also use the pond. It is the only pond in the immediate region of the camp site.

A very steep, eroding shale bank occurs on the camp site (Fig. 9). Trees have not been able to establish themselves on the bank. This natural feature of steep ravines often harbors dense populations of plethodontid salamanders; slimy, red-backed, and zig-zag salamanders would be expected locally.

Rock ledges are a portion of a limestone cap on the ridge top of the camp site peninsula (Fig. 9). Walking fern and sedum are plants restricted to the ledges. At the bases of the ledges snow trillium is present. Other localized types of plants might be found in this area if additional surveys were to be conducted.

The quarry is an artificial feature with vertical walls and a flat bottom that becomes very shallowly ponded for brief periods. Sycamore trees exceeding 20 years in age are growing out of the quarry. The quarry walls are south facing and xeric. None of the unique plants observed on the rock ledges were found here.

Large trees. Landscapes are often enhanced by preservation of unusually large trees. Some of the largest trees of the camp site were located and identified with this goal in mind. These trees are mapped in Fig. 9 and identified in Table 7.

Threatened and endangered species. Both the federal government and the State of Indiana have compiled lists of species having doubtful survival capabilities. The federal list applies to the United States as a whole (U.S. Public Law 93-205, 1974), and, for the most part, lists species threatened with extinction. The Indiana Department of Natural Resources has prepared a tentative list of species that are very rare and probably declining within the state. Many of these species have peripheral ranges and can find only marginal habitat in Indiana, although they have vigorous populations in other states.

Two species of plants listed by the federal government as threatened (U.S. House Document 94-51, 1974) have been reported from Monroe and Brown Counties. The first of these, the purple fringeless orchid (*Platanthera peramoena*) has been documented locally from Monroe, Brown, Greene, Lawrence, and Owen counties. This species prefers damp soil in low, flat woodlands, usually in association with American beech, sweet gum, and pin oak. It is often rather frequent where found. The other threatened plant, a bladderpod (Lesquerella globosa), has been reported from Monroe County, but a voucher specimen is lacking. The species prefers calcareous rocks and barrens.

Table 8 lists endangered animals that are sufficiently local in recently documented occurrence to be relevant to the Alumni Family Camp project. Some confusion may exist concerning the status of bald eagles visiting the camp site. Migratory behavior patterns indicate that they are northern bald eagles because they visit the Lake Monroe area during the late autumn, winter, and early spring. These are not listed as threatened or endangered. Southern bald eagles wander north during July, August, and September (U.S. Bureau of Sport Fisheries and Wildlife, 1973), and documentation in the Lake Monroe area is uncertain. The species is listed in Table 8 to draw attention to the uncertainty and possible misunderstanding.

No threatened or endangered plants or animals have been observed on the camp site property.

Land Use

The manner in which land resources are used by man is an important facet of the Alumni Family Camp environment. In order to assess the compatibility of the proposed camp with the current land use environment of the site, that environment must be surveyed both on a regional scale and on the site and in its immediate vicinity.

Table 8. Endangered Vertebrate Species of the Lake Monroe Region

Species	Official Status	Distribution in Lake Monroe Region	Preferred Habitat	Significance for this Project
Southern Bald Eagle *Haliaeetus l. leucocephalus*	U.S. endangered		Near large rivers and lakes	This subspecies is not likely to be found on the site
Arctic Peregrine Falcon *Falco peregrinus tundrius*	U.S. endangered	Sighted over causeway	Variable, prefers nesting on cliffs	Negligible
Indiana Myotis (Bat) *Myotis sedalis*	U.S. endangered	Possible breeding population in the Lake Monroe region, particularly along the forks of Salt Creek	Roosts beneath loose bark of dead trees close to water on summer days	Negligible
Bobcat *Lynx rufus*	Indiana endangered	Reported on Nebo Ridge, 1970	Woodlands and brushy country in the Lake Monroe region; swamp forest in the South and rimrocks in the West	Negligible
Badger *Taxidea taxus*	Indiana endangered	Sighted in Owen and Morgan Counties	Old fields and prairies	Neglibible

Sources: Bent (1961), Mumford (1969), Schrodt *et al.* (1975), United States Public Law 93-205 (1974), Whitehead (April 5, 1977), Indiana Department of Natural Resources (no date).

The Lake Monroe region. The best recent source of land-use data for the Lake Monroe area is the Lake Monroe Land Suitability Study (summarized by Gray *et al.*, 1975b), which was carried out in 1974 by the School of Public and Environmental Affairs of Indiana University. Land use on a regional scale is not likely to have changed a great deal in the past three years.

The geographical distribution of land uses in the Lake Monroe area is depicted in units of ten acres in Map 4 (inside back cover). Gray *et al.* (1975b) have tabulated the proportions of the mapped area occupied by a number of uses.

Forests occupy 72% of the land in the Lake Monroe area, including almost all of the land east of State Route 446. Most of the forest on the south side of the lake is within the Hoosier National Forest on public land, while private forests predominate on the northern side of the lake.

Agricultural uses also occur within the region, occupying 16% of the land in the mapped area. About a third of the agricultural land, however, has actually been abandoned; most of that still being utilized is concentrated in the area west of Ramp Creek.

Minor portions of the land are comprised by parks and recreation areas and residential lands. Parks and recreation areas, which account for 7% of the land in the mapped area, occur in large parcels along the lake shore below the causeway. Land used for residential purposes (5%) is strung out along roads, mainly in the western half of the mapped area.

In general, then, the land surrounding Lake Monroe east of State Route 446 is mainly unused by humans, or at most used at a low level of intensity for activities such as hunting and hiking. Uses requiring modification of the original forestland, such as agriculture, recreation, and residential uses, comprise large portions of the watershed and its immediate environs west of State Route 446.

The site and its immediate vicinity. Information on land use on and around the site was obtained at low resolution from the Lake Monroe Land Suitability Study and at high resolution from field observations and aerial photographs.

The camp property itself is currently unused, except for occasional visits to the peninsula by campers. As detailed in the previous section, the center of the site is in abandoned cropland, as is the western edge of the property. The remainder of the site is forested.

The property is also immediately surrounded by forest, except for some more abandoned cropland to the west and the Seeber residence to the north. Some 130 acres of agricultural land exists within a mile of the site, including some on the eastern side of the North Fork, but virtually all of this has been abandoned.

Future land-use pattern. As any given development can induce changes in nearby land uses, deviations from the currently expected future pattern of land uses that are caused by the development are regarded as impacts of the proposed project. Thus, the expected pattern of future land uses should be a portion of the environmental baseline against which impacts are to be assessed.

From a regional perspective, projected population increases for parts of the townships surrounding the lower portion of the lake

(U.S. EPA, 1976) imply that a greater portion of the land in that area will be devoted to residential uses. Regional increases in population are likely to create a need for more recreational facilities. Both residential and recreational uses will probably expand at the expense of forested and agricultural, especially abandoned agricultural land. These changes are very difficult to quantify, as they depend on a complex of socioeconomic interactions that are unpredictable in detail.

As for the camp property itself, if the camp is not developed there, it is likely that some other project will be due to the high attractiveness of the property for a number of potential uses. Development of the site may induce development of some of the immediately surrounding land, such as the relatively flat abandoned cropland along the western boundary of the site.

WATER RESOURCES

The Lake Monroe area is of course chiefly known and valued for its water resources. The potential effects of any development such as the Alumni Family Camp upon these resources must thus be carefully assessed prior to construction. As a prerequisite to such an assessment, several aspects of the current aquatic environment of the camp site must be carefully surveyed. These include the flow characteristics of surface runoff from precipitation over the camp site and of water within the lake itself, the characteristics of any aquifers in the vicinity, the physical and chemical quality of the lake water, the ecological characteristics of the organisms living in the lake, and current use of the area's water resources by humans. Consideration is given to all these factors in the following sections.

Hydrology

Surface water. Surface water includes all water flowing over land, regardless of the size of the basin or channel. "Surface water" thus not only refers to the large quantities of water filling Lake Monroe, but also to the water running over the surface of the camp site during storms. This section deals with the physical characteristics of flowing water. Physical and chemical aspects of water quality are considered in the following section.

Rain water falling on the upland portions of the Alumni Family Camp site runs downhill over and through soils that are often waterlogged. For this reason, runoff flows in diffuse patterns over much of these portions of the site before gathering into rivulets and draining into Lake Monroe through one of the two larger ravines that have been classified as intermittent streams (U.S. Geological Survey, 1966). One of these two ravines flows in an easterly direction and empties into the small cove at the base of the camp site peninsula. The other runs northward on the west side of the camp site, draining into another cove north of the neighboring Seeber property. These drainage patterns are mapped in Fig. 10.

Generally, water flowing over land exerts an erosive force, leading to sedimentation of receiving streams and bodies of water. The degree of erosion can vary seasonally (Fig. 11).

Water draining from the Alumni Family Camp site is generally clear, despite the fact that runoff is rapid due to the high relief of the site and the shallowness of the soils over the impermeable siltstone bedrock. The clarity of the runoff is partly due to the dense forest canopy and the relatively thick layer of forest litter and leaves that covers the soil and absorbs the potentially erosive impact of precipitation. Erosion in the two intermittent streams is inhibited by their bedrock bottoms, and while flow through these streams and through the rivulets draining into them is indeed rapid, the diffuse upland flow is fairly slow and transports relatively little soil material. Consequently, erosion occurs at similar and very slow rates throughout the camp site area. A state of geologic equilibrium has been implied due to the lack of appreciable sedimentation (Shaver, 1972).

FIGURE 10 DRAINAGE PATTERNS

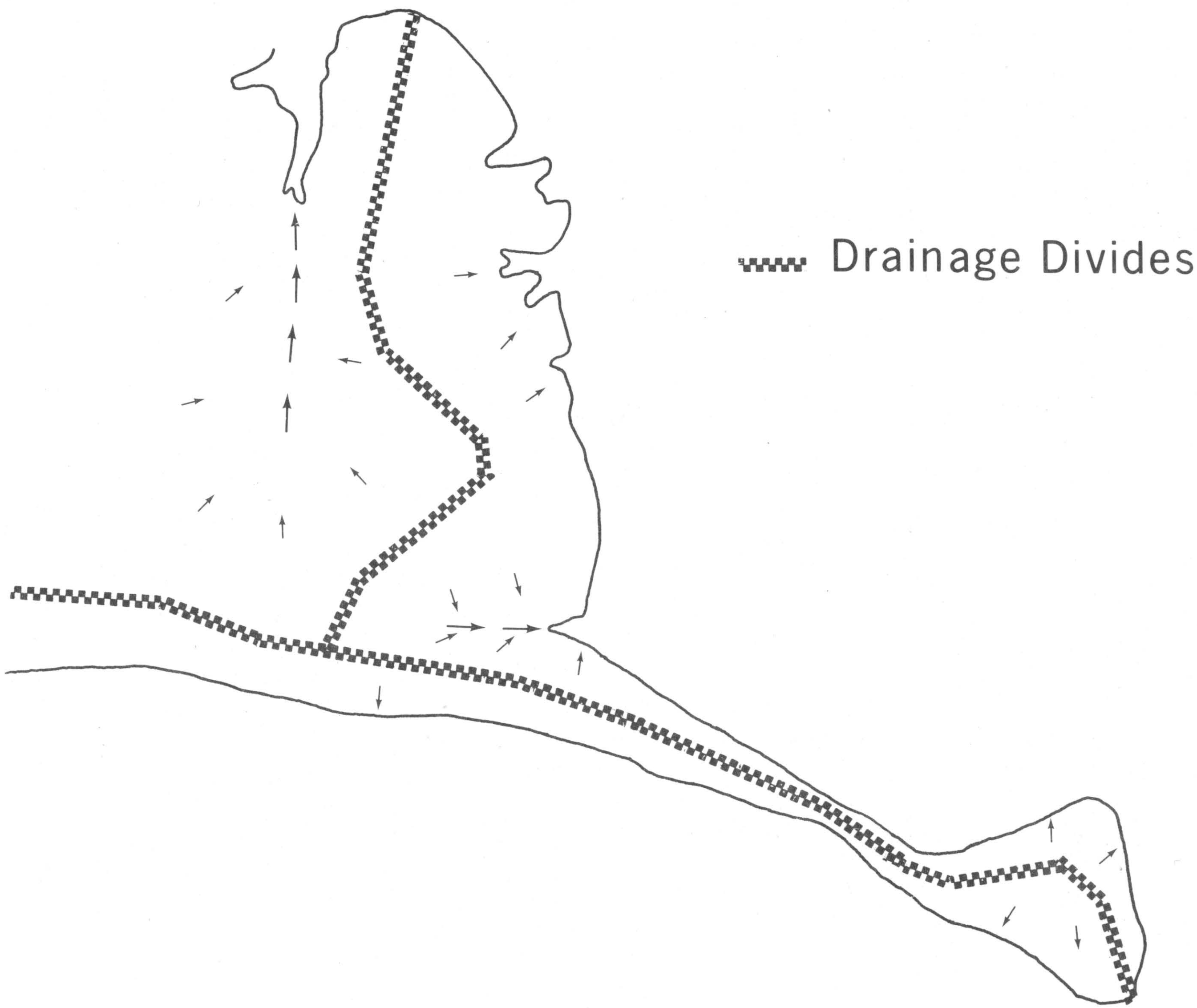
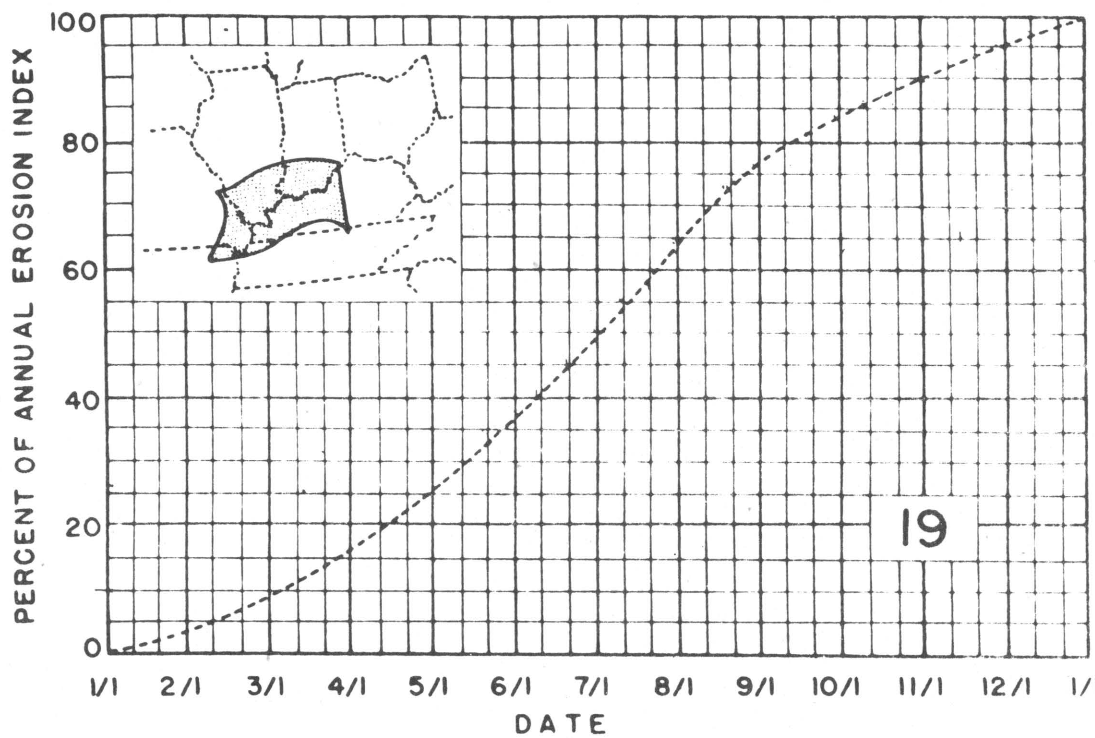


FIGURE 11 ANNUAL EROSION INDEX DISTRIBUTION



Source: Soil Conservation Service, 1971

Runoff from the camp site drains into the North Fork of Lake Monroe. This is the largest of the three forks of Salt Creek which merge to form the upper basin of the lake. The upper basin extends down to the causeway, and is shallow (about four meters deep) and pondlike in nature. The middle and lower basins cover the area between the causeway and the dam; together, they are roughly half again the size of the upper basin, at conservation pool level (see below) and average five or six meters in depth. The old Salt Creek channel meanders across the lake bottom as a trench seven to eleven meters deep. The North Fork channel runs close to the eastern shore of the camp site and adjacent to the northern shore of the camp site peninsula (see Fig.2).

Table 9 shows basic lake level data. The two primary control elevations are the 538-foot conservation pool stage and the 556-foot maximum flood control state (Frey, 1976). Seasonal fluctuations in lake level affect the total area of the lake, and during low stage periods (mainly in winter) land normally inundated is exposed. This exposed land is then subject to erosion during thawing periods. In the upper basin, lake level fluctuations can expose more land due to the relative shallowness of the water. A detailed study of Lake Monroe is forthcoming from the Water Resources Center of the Indiana University Geology Department and will contain valuable information about flow patterns, sedimentation, and nutrient cycling in the lake. This study should be checked when released for any further hydrologic implications of the Alumni Family Camp project.

Groundwater. The same geologic characteristics that made the construction of Lake Monroe possible result in small and unreliable

Table 9. Lake Monroe Stage Elevations

Elevation (ft above mean sea level)	Operating Level	Lake Surface Area (acres)
515	silt pool	3,280
515-538	low flow pool	10,750
538-556	flood control pool	18,450

Source: Frey (1976).

groundwater supplies at the camp site. The bedrock of the area has both low transmissability and permeability. This, coupled with the shallow soil layer and steep slopes, results in the rapid runoff of precipitation, and prevents the formation of a useful water table. Wells drilled into the Borden Group siltstone generally do not yield adequate qauntities of water for even domestic use. Wells drilled into the Harrodsburg limestone do in most places yield approximately two gallons per minute (Gates, 1962). While development of such a resource could supply a significant fraction of the camp's water needs, examination of the abandoned quarry on the camp site peninsula indicates that a significant water table is lacking at this point in the Harrodsburg Formation. Here, little seepage occurs, and accumulations of water on the quarry floor are mainly the result of precipitation and surface runoff. The lack of useful groundwater supplies has resulted in the installation of a six-inch water main to supply the needs of the area (McFadzean, Everly, and Associates, 1976).

Water Quality

As groundwater is an insignificant component of the aquatic environment of the camp site, and as the quality of runoff water is mainly important insofar as it affects the water quality of Lake Monroe, this section is restricted to a consideration of the water quality of the lake. Emphasis is placed on the upper basin, as that is the most relevant to the camp site, but because water quality in the upper basin affects water quality in the middle and lower basins and is affected by water quality in the watershed upstream, some consideration is also given to the lake as a whole and the North Fork watershed.

Water quality affects the overall quality of the lake as a natural resource not only directly but also through its influence on biological production (see the following section). Four main interdependent categories of physicochemical water quality factors control biological productivity in the upper basin. These are radiant energy input, nutrient input and loss, oxygen supply, and interactions of morphometry and motion (Mortimer, 1969). However, considering the shallowness of the basin, nutrient availability emerges as the most important of these factors (Gray *et al.*, 1975b), and is thus the one emphasized in this section.

The best recent water quality data for Lake Monroe are contained in a report written by D. G. Frey (1976). Frey's sampling network included stations in the upper basin south of the camp site peninsula and in the North Fork watershed. His data on each of the more important physicochemical aspects of water quality are discussed in sequence in the following subsections, along with background information on the significance of each of the factors.

Specific conductance. Specific conductance is a measure of the ability of a body of unit length and cross section to transmit electricity at a specified temperature. The ability to conduct electricity is conferred upon water by the presence of charged particles known as "ions." Thus, while conductance is not in itself a very interesting property from an ecological point of view, it can provide a measure of the ionic concentration, which has implications for nutrient dynamics and other aspects of lake function. It should be noted that, because the water in Lake Monroe is not a simple solution but contains a variety of ionic and undissociated species in changing proportions and amounts, conductance is not simply related to ionic concentration or to total dissolved solids. A general, qualitative relationship still holds true, though.

Frey reported conductance data from several stations on the North Fork of Salt Creek. He found that specific conductance declined with increasing discharge, and concluded that the low conductances found at high creek discharges were most likely to approximate conductances in upper Lake Monroe during the summer. These low conductances were under 100 micromhos, indicating relatively low ionic concentrations in the lake.

Alkalinity. Alkalinity is a measure of the ability of a solution to neutralize acids. Frey found the alkalinity of the North Fork of Salt Creek to be low, ranging from about 1.8 milliequivalents of bicarbonate and carbonate (titrated to pH 4.4) at low discharges to 0.3 milliequivalent of less at high discharges. Such "soft" water is characteristic of areas with siltstone bedrock.

pH. The pH is the negative logarithm of the concentration of hydrogen ions in water, and is thus inversely related to acidity. The pH of the North Fork of Salt Creek generally ranges from 7.0 to 7.4, with extremes at 6.4 and 7.7 (Frey, 1976). These data indicating slight alkalinity are consistent with the alkalinity data given above.

Frey suggested that in the shallower portions of Salt Creek and of the upper Lake Monroe basin, there could be biological controls on pH. If there were enough benthic algae present, the pH could increase significantly in the daytime due to photosynthetic removal of carbon dioxide (as carbonic acid) from the water, and decrease at night due to respiratory release of carbon dioxide. The pH might also be controlled chemically by some equilibrium system, usually involving alkaline earths.

Frey found pH to be negatively related to discharge. Neutral to slightly acidic conditions prevailed at high discharges.

It can be inferred from the alkalinity and pH data from the North Fork of Salt Creek that, at least at times of high creek discharge into the lake, the water near the Alumni Family Camp site is likely to be fairly neutral, neither significantly acidic nor significantly alkaline.

Nitrogen. Nitrogen occurs in varying chemical oxidation states in a number of different compounds in the water. Nitrogen is in its most chemically reduced form in ammonia, which is found in solution as ammounium ion (NH_4^+) or ammonium hydroxide (NH_4OH). The most oxidized forms of nitrogen are in nitrite (NO_2^-) and nitrate (NO_3^-). Nitrogen also occurs in aqueous situations in a number of intermediate oxidation states in compounds of lesser significance with respect to water quality, such as proteins and amino acids, urea, hydroxylamine, and dissolved nitrogen gas.

Interconversion of the various forms of nitrogen is to a great extent accomplished biologically. Both the biochemical pathways followed and the end products of the pathways depend on the biota present. Generally, phytoplankton can utilize both ammonia and nitrate as nitrogen sources (Hutchinson, 1967). Some, however, such as blue-green algae, can fix gaseous nitrogen into usable form, rendering the aquatic system less dependent on nitrogen inputs from upstream (Frey, 1976).

Nitrogen is generally considered to enter a lake mainly through inflowing water (Hutchinson, 1956), i.e., through the three forks of Salt Creek in the case of Lake Monroe. It has recently been found, however, that precipitation over the water can introduce considerable quantities of nitrogen (Likens and Bormann, 1974).

Ammonia contains nitrogen in its most reduced form. It thus occurs during periods of stratification at greater concentrations toward the bottom of the lake (Table 10), where heterotrophic bacteria are producing it in the process of decomposition of organic detritus and where there is insufficient oxygen to convert it into compounds with nitrogen in higher oxidation states.

According to Frey (1976), the chief point source of ammonia in the Lake Monroe watershed is the Nashville sewage treatment plant. Ammonia concentrations downstream from the plant can be exacerbated by low discharge and reduced oxygen levels, whereas the balance of nitrogen compounds can shift toward nitrate if sufficient flow and oxygen are present.

Table 10. Surface Concentrations (in μg N/l) of Ammonia and Nitrate Nitrogen in the Upper Basin of Lake Monroe on Selected Dates

Date	Ammonia Concentration (μg N/l)	Nitrate Concentration (μg N/l)
1974 September 16	4.4(14.0 at 7 m)[2]	4.1
October 12	26.3(28.2 at 4 m)[2]	2.1
1975 November 6[1]	26.4	18.3
December 3[1]	21.0	179
January 9[1]	16.3	345
February 20[1]		346
February 27[1]	13.3	241
March 13[1]	22.4	321
March 20[1]	27.8	373
March 30[1]	44.4	478
April 22[1]	4.5(13.9 at 6 m)[2]	248
May 6	4.2(46.5 at 10 m)[2]	104
June 25	11.8(41.3 at 5 m)[2]	39.7
July 14		7.6
July 28	25.1(>250 at 9 m)[2]	3.8
August 11	16.6(54.6 at 7 m)[2]	2.0
August 28	10.1(277 at 9 m)[2]	1.4

[1]These dates represent the period between the initiation of autumnal circulation and of summer stratification.

[2]Concentrations at the greatest depths (m) sampled are given in parentheses for dates during the stratification period in 1974 and 1975.

Source: Frey (1976).

A relatively minor portion of the watershed's nitrogen occurs as nitrite. At most of Frey's (1976) sampling stations, the nitrite concentration was a low 5 μg/l or less. Concentrations below the mixed zone of the lake were no greater than at the surface. Tributary streams generally had concentrations less than 2 μg/l.

Nitrate concentrations in Lake Monroe vary seasonally. This important nutrient accumulates as a result of tributary input through the fall and winter when there is little biological activity, eventually reaching levels of about 480 μg/l (Frey, 1976; see Table 10) during the initial peak tributary discharges of spring. But by April, the spring resurgence of biological activity in the form of increased macrophyte and planktonic production results in so much consumption of the nutrient that levels drop off to 1 to 4 μg/l in late summer and early fall.

<u>Phosphorus</u>. Phosphorus is present in a number of chemical forms in natural waters. It is most often measured in terms of an equivalent amount of orthophosphate (PO_4^{-3}) or total hydrolyzable phosphorus (TP). TP includes the phosphorus in polyphosphates, soluble organic compounds, particulate matter, and living organisms.

Frey found that, in the lake as a whole, phosphorus in both forms (soluble reactive phosphorus and TP) is present in concentrations of only a few micrograms per liter. During summer and autumn, the concentrations are often below the lower limit of detection.

Of the three lake basins, the upper is the direct recipient of the major share of the phosphorus input from tributaries, and thus has the highest phosphorus concentrations. During stratification, the greatest phosphate levels are found near the bottom of the deeper portions of the basin, but as mixing occurs, the concentration is distributed uniformly over the vertical water column. As fall progresses, TP increases, perhaps indicating an increased algal biomass (Frey, 1976; see Table 11).

Of the three forks of Salt Creek, the North Fork contributes the highest phosphorus concentrations to the lake. This is to be expected, as the North Fork is the most heavily subjected to human inputs, including sewage effluent, which always contains phosphorus. As the water from the creek moves down into the lake, phosphorus is removed from the water by the macrophytes, bacteria, and algae of the North Fork of the lake. The macrophyte beds of the upper basin thus serve as important regulators of phosphorus concentrations in the lower lake (Allanson et al., 1973).

Silicate. Silica is the most abundant acidic substance other than bicarbonate in lakes, and is required for diatom production. Silicon in natural water is mostly in the form of monomolecular silicic acid, H_2SiO_4 (aq.).

According to Frey (1976), the seasonal dynamics of silicate levels in Lake Monroe are much like those he found for nitrate (see Table 12). Again, concentrations build up in the winter, then begin decreasing in the spring due to biological utilization spurred by increases in the levels of light and temperature. This decrease is especially rapid in the upper basin, where biological activity is the most intense and where the shallowness results in less total silicate per unit surface area than anywhere else in the lake. Frey also found a vertical gradient in silicate concentration in the summer stratification period,

Table 11. Surface Concentrations (in μg P/l) of Soluble Reactive Phosphate and Total Hydrolyzable Phosphorus (TP) in the Upper Basin of Lake Monroe on Selected Dates

Date	Soluble Reactive Phosphate (μg P/l)	Total Phosphorus (μg P/l)
1974 September 16	2.4(3.7 at 7 m)[2]	17.8(22.7 at 7 m)[2]
October 12	0.7(0.6 at 4 m)[2]	20.3(25.9 at 4 m)[2]
1975 November 6[1]	1.7	17.2
December 3[1]	1.1	19.0
January 9[1]	2.7	19.4
January 30[1]	3.0	17.5
February 20[1]	2.3	
February 27[1]	13.1	89.2
March 13[1]	16.3	67.7
March 20[1]	11.7	66.2
March 30[1]		65.4
April 19[1]	4.9	21.2
May 5	1.4(2.2 at 10 m)[2]	16.0(15.8 at 16 m)[2]
June 25	(1.4 at 5 m)[2]	10.0(18.3 at 5 m)[2]
July 14	3.1(4.2 at 7 m)[2]	13.4(16.8 at 7 m)[2]
August 11	0.2(0.2 at 7 m)[2]	13.4(21.5 at 7 m)[2]
August 28	<0.1(0.6 at 9 m)[2]	13.9(18.6 at 9 m)[2]

[1]These dates represent the period between the initiation of autumnal circulation and of summer stratification. On any date in this period the concentration was uniform in the water column at the station.

[2]Concentrations at the greatest depths(m) sampled are given in parentheses for dates furing stratification periods in 1974 and 1975.

Source: Frey (1976).

Table 12. Reactive Silicate Concentrations in the Upper Basin of Lake Monroe (as mg Si/l)

Date		Silicate Concentration (mg Si/l)
1974	August 25	
	September 1	1.1
	September 7	0.78
	September 16	0.97
	October 24	0.98
1975	November 6[1]	0.62
	December 3[1]	2.52
	January 9[1]	4.34
	January 30[1]	3.97
	February 27[1]	2.26
	March 20[1]	3.15
	March 30[1]	2.90
	April 11[1]	3.18
	April 22[1]	3.50
	May 5	3.30
	May 29	2.57
	June 9	1.90
	June 25	1.87
	July 14	1.68
	July 28	0.68
	August 11	1.12
	August 28	0.85
	September 8	0.18

[1]These dates represent the period between the initiation of autumnal circulation and of summer stratification.

Source: Frey (1976).

due to biological utilization in the trophogenic (upper feeding) zone and increasing concentrations in the deep water.

Temperature. Frey (1976) reported that water temperature regimes in Lake Monroe vary from year to year with the weather. In general, though, the upper basin behaves almost like a separate lake with regard to temperature profiles during the summer. Stratification (a stable condition in which water nearer the surface is warmer than that nearer the bottom) occurs in the upper basin only during the first half of summer. In the rest of the summer, temperature does not vary with depth, except in the old Salt Creek channel, where the water is generally relatively cool. Some stratification may occur in late summer during periods of clear, calm weather, resulting in isolation of the bottom water and consequent oxygen deficiency there, although this depends on the oxygen demand generated in the water and organic sediments. Because of its larger surface area relative to volume, the upper basin warms more rapidly in the spring, cools more rapidly in autumn, and responds more strongly to summer variations in solar input than do the lower basins.

Light and turbidity. Light penetration is an important characteristic of water because it is related to clarity, and clear water is preferable for most human uses. Light penetration in Lake Monroe is limited primarily by turbidity arising from particulate matter suspended in the water and by the presence of algal cells and other biological material in the water. Frey (1976) has found that transparency as measured by Secchi disk readings is lower in the upper basin than in the portions of the lake below the causeway. There are several reasons for this. The upper basin receives particulate matter in storm discharges from the three forks of Salt Creek. This matter may stay in suspension for some time, as the shallowness of the basin facilitates stirring of the water by wind. If the amount of particulate input is relatively small, it may settle out entirely within the upper basin, thus preserving the higher transparencies in the water below the causeway. The upper basin is also the locus of the most intense biological activity within the lake, which also contributes to the lower levels of light penetration there.

Frey found that in autumn, before the major watershed flashes, transparencies were less in the North Fork than in that portion of the upper basin just above the causeway. He also found that late winter precipitation greatly reduced upper basin light penetration levels, but that recovery of transparency began in late April and lasted through June (Table 13).

Dissolved oxygen. The solubility of oxygen in natural waters is mainly a function of temperature, so that the concentration of oxygen in the lake as a whole and the distribution of the concentration through the vertical water column are both related to the temperature regime. This relationship is not a simple one, however, because the relatively simply physical process of diffusion across the air-water interface is not the only control over oxygen concentration in the lake. Biological activity can also add to or subtract from the oxygen dissolved in the water. Oxygen is evolved through photosynthesis, and is consumed in respiration, most pertinently in the respiration of organisms decomposing

Table 13. Secchi Disk Readings (in m) in the Upper Basin of Lake Monroe

Date	Secchi Disk Transparency (m)			
	Station c[1]	Station b[1]	Station a[1]	Station 4
1974 September 1	0.7	0.8	1.0	1.3
October 8	1.8	1.6		2.1
October 12				2.1
November 8				2.2
November 19	1.1	1.3	1.6	2.1
December 3				2.2
1975 January 9				1.6
January 30				0.6
February 20				0.9
February 23				0.1
March 30				0.4
April 11				0.5
April 22				1.2
May 6				1.7
June 25				3.0
July 28				2.8
August 11				2.2

[1]Stations a, b, and c are located at increasing distances up the North Fork from Station 4, which is in the main portion of the upper basin.

Source: Frey (1976).

organic matter (some organic matter may represent pollutants added by man). Oxygen concentration can, as a matter of fact, be used as an indicator of the status of a lake's biota. Thus, only waters with relatively high dissolved oxygen levels can support desirable sport fishes.

Frey (1976) reports that oxygen concentrations in Lake Monroe vary seasonally with both temperature and biological activity. In the winter, an ice cover blocking the air-water interface for a prolonged period of time can result in oxygen depletion. But the photosynthetic activity of the spring phytoplankton bloom can drive oxygen levels up to the saturation point. Then, during the summer stratification period, the deeper, noncirculating portion of the lake, especially the old Salt Creek channel (Frey, 1976; Allanson et al., 1973), is depleted of oxygen once more. In the upper basin, the midsummer breakup of stratification results in a redistribution of oxygen throughout the water column. Oxygen concentration in the entire lake increases as temperatures drop in the fall.

Summary. In summary, the water in Lake Monroe considered as a whole is of relatively high quality. The water is neither acid nor alkaline, dissolved oxygen concentrations are high enough to support a desirable fish community, and levels of critical nutrients are low enough to inhibit the production of nuisance algal blooms. The quality of water in the upper basin is not quite as high as that in the rest of the lake, but the upper basin helps keep the water quality in the other basins high by serving as a buffer against nutrient and particulate inputs from the watershed. In any event, the water in the upper basin can hardly be considered to be "polluted"; water in all parts of the lake is generally fit for a variety of uses, including recreation.

Aquatic Ecology

The aquatic biotic community can be divided into several components. The plankton is the assemblage of microscopic organisms floating in the water. This assemblage is divisible into phytoplankton, or photosynthetic algae ("net plankton" are those plankton species that can be caught in a very fine net; "nanoplankton" are those that cannot); bacterioplankton, which is the bacterial portion; and zooplankton, the animal portion that feeds upon the phytoplankton. Other components of the biotic community include the benthos, or organisms that dwell on the lake bottom; macrophytes, or rooted aquatic plants; and fishes. The following subsections discuss each of the above components--their population dynamics, their species compositions, and their interactions with the environment. As water quality is an integral part of that environment, this section should be considered in the context of the previous one.

Phytoplankton. A list of net phytoplankton species collected from the upper, middle, and lower basins at Lake Monroe during 1975 and 1976 is presented in Table 14 (Chang, 1976). Nannoplanktonic algae and protozoa identified in October 1974 from the upper basin of Lake Monroe are presented in Table 15 (Brakke, Chang, and Hartzell, 1975).

The existing phytoplankton data indicate large spatial and temporal variations in numbers and species compositions in the lake (Frey, 1976). On October 10, 1971, samples from the upper basin contained small

Table 14. Phytoplankton Species Identified from Lake Monroe during 1975 and 1976[1]

CHLOROPHYCEAE

Chlorococcales

Ankistrodesmus
Closteriopsis
Crucigenia
Lauterborniella
Oocystis
Pediastrum
Scenedesmus
Tetraedron

Tetrasporales

Cloecocystis

Volvocales

Chlamydomonas
Volvox

Zygnematales

Closterium
Cosmarium
Gonatozygon
Micrasterias
Spirogyra
Staurastrum

CHRYSOPHYCEAE

Dinobryon
Mallomonas
Ochromonas

CRYPTOPHYCEAE

Cryptophyles

Cryptomonas

CYANOPHYCEAE

Chroococcales

Chroococcus
Coelosphaerium
Dactylococcopsis
Gloeocapsa
Gomphosphaeria
Marssoniella
Merismopedia
Microcystis

Chamaesiphonales

Pleurocapsa

Oscillatoriales

Annabaena
Lyngbya
Oscillatoria

BACILLARIOPHYCEAE

Centrales

Cyclotella
Melosira
Stephanodiscus
Terpisnoe

Pennales

Amphiprora
Amphora
Asterionella
Cymbella
Fragilaria
Gyrosigma
Navicula
Neidium
Nitzschia
Surirella
Synedra
Tabellaris

Table 14. (continued)

XANTHOPHYCEAE	EUGLENOPHYCEAE
Asteroglocea	Euglenales
Ophiocytium	
	Euglena
	Trachelomonas
	Rhabdomonas

[1]Net samples were taken throughout the photogenic zone (0-6 meters) using a Kemmerer sample and counted on a Sedgwick-Rafter cell.

Source: Chang (1976).

Table 15. Nannoplanktonic Algae and Protozoa in the Upper Basin of Lake Monroe, October 19, 1974

Melosira italica
Melosira sp.
Dinobryon divergens
Dinobryon bavaricum
Stephanodiscus sp.
Merismopedia tenuissima
Merismopedia minor
Ankistrodesmus sp.
Cryptomonas sp.
Fragilaria crotonensis
Chroococcus limneticus
Chroococcus minor
Mallomonas akrokomas
Mallomonas sp.
Coelastrum sp.
Asterionella formosa
Anabaena lemmermanni
Coelosphaerium kutzingianum
Stombidium viride

Source: Brakke, Chang, and Hartzell, 1975.

quantities of net phytoplankton (121 cells/ml); even smaller quantities (22 cells/ml) were found in samples from the lower basin (Allanson, Zimmerman, and Smith, 1973). (This decrease in cell density down lake is a generally observed phenomenon (Frey, 1976).) The species compositions of the two samples are given in Table 16. In the upper basin, *Tribonema* and another green algal filament (unidentified) comprised 86% of the total, while the blue-greens (*Anabaena* and *Coelosphaerium*) accounted for only 8%.

In contrast, Docauer (1972) found large concentrations (up to 12,000 cells/ml) in the upper basin on September 22 and November 3 and 11, 1972. On these dates, the blue-greens (*Microcystis* and *Oscillatoria*) represented more than 90% of the total phytoplankton present.

The Allanson and Docauer samples were taken in separate years, but the phytoplankton community can also change dramatically within a given year, or even a given month. Three samples collected on June 15 and 28, 1974, and on July 5, 1974, from the upper basin demonstrate the rapidity with which phytoplankton assemblages within the lake can change (see Table 17).

On June 15 the forms present were dominated by the diatoms, which comprised over 75% of the total. *Dinobryon* and *Ceratium* represented 19% and 3.6%, respectively, and the blue-greens only 0.5%. In the sample taken on June 28, the diatom population was reduced significantly to only 12% of the total. The *Dinobryon* and *Ceratium* fractions rose to 56% and 11%, respectively, although their biomasses did not increase proportionately. However, the blue-greens, primarily *Anabaena*, did increase in biomass, representing almost 8% of the total. In the final

Table 16. Comparison of Integrated Cell Densities between the Upper and Lower Basins, October 10, 1971[1]

Taxa	Lower Basin cells/ml	Lower Basin percent of total	Upper Basin cells/ml	Upper Basin percent of total
Dinobryon colonies	4.070	18.1	4.070	3.4
Certium sp.	0.254	1.1	0.480	0.4
Unidentified flagellates	2.550	11.3	--	--
Anabaena filaments	1.800	8.0	4.750	3.9
Coelosphaerium colonies (?)	1.020	4.5	4.520	3.7
Tribonema filaments	3.300	14.7	55.000	45.5
Unidentified filamentous form	6.900	30.7	49.000	40.5
Staurastrum spp.	--	--	0.235	0.2
Fragilaria spp.	2.600	11.6	2.870	2.4
Totals	22.494	100.0	120.925	100.0

[1]Samples were collected from the upper 2 meters of the photogenic zone using a Lund tube sampler and counted on a Sedgwick-Rafter cell.

Source: Allanson, Zimmerman, and Smith (1973).

Table 17. Species Composition of Phytoplankton, Upper Basin, Averaged from Integrated Vertical Samples

	June 15, 1974		June 28, 1974		July 5, 1974	
	cells/ml	percent of total	cells/ml	percent of total	cells/ml	percent of total
Diatoms						
Amphora	--	--	--	--	--	--
Asteriorella	3.506	64.0	0.086	2.9	0.205	1.7
Cymbella	--	--	--	--	--	--
Fragilaria	0.230	4.1	0.086	2.9	0.328	2.7
Melosira	0.374	6.7	0.115	4.0	0.862	7.1
Navicula	--	--	--	--	--	--
Neidium	--	--	--	--	--	--
Nitzschia	--	--	--	--	--	--
Pleurosigma	0.029	0.5	--	--	--	--
Stephanodiscus	--	--	--	--	--	--
Surirella	--	--	--	--	--	--
Synedra	--	--	0.086	2.9	0.082	0.7
Tabellaria	--	--	--	--	--	--
Subtotal	4.112	75.3	0.373	12.7	1.477	12.2
Blue-green algae						
Anabaena	--	--	0.230	7.9	1.663	13.6
Crucigenia	--	--	--	--	0.082	0.7
Gloeocapsa	--	--	--	--	0.020	0.2
Gomphosphaeria	0.029	0.5	--	--	--	--
Microcystis	--	--	--	--	0.020	0.2
Subtotal	0.029	0.5	0.230	7.9	1.79	14.7
Green algae						
Pediastrum	--	--	--	--	--	--
Staurastrum	--	--	--	--	0.028	--
Ankistrodesmus	--	--	--	--	--	--
Small Chlorococcales	0.058	1.1	--	--	0.020	0.2
Subtotal	0.058	1-1	--	--	0.048	0.4
Others						
Ceratium	0.201	3.6	0.316	10.9	0.123	1.0
Dinobryon	1.035	19.0	1.61	55.7	7.944	65.1
Other Chrysophyceae	0.029	0.5	0.028	0.9	--	--
Peritrichs	--	--	0.345	11.9	0.801	6.6
Subtotal	1.265	23.1	2.299	79.4	8.868	72.7
Total	5.491	100.0	2.902	100.0	12.178	100.0

Source: Brakke, Chang, and Hartzell (1975).

sample, taken on July 5, both Dinobryon and the blue-greens increased significantly in cell numbers and in relative composition. Dinobryon comprised approximately 65% and the blue-greens over 14% of the total population present.

The most recent data for the upper basin illustrate the changes in phytoplankton population and community composition that can occur over a period of several consecutive months. The data were taken from August 4 to November 24, 1975, recorded by Chang (1976) and summarized by Frey (1976).

In early August, the diatom Melosira dominated the phytoplankton population. The total cell density at this time was relatively low at 3.4 cells/ml. But by September 22, the numbers had increased significantly to a peak of 13.3 cells/ml. Melosira comprised 96% of the total population, with Fragilaria and Anabaena making up most of the remainder. A rapid decrease in Melosira in early October was partially offset by increases in Dinobryon and Anabaena. The total population density at this time was approximately 3 to 4 cells/ml. A combination of Melosira, Anabaena, Aphan, Zomenon, and Mallomonas produced a small peak in late October. However, by the second half of November all four species had declined significantly, resulting in a total population density of only 0.2 cell/ml.

Analysis of the phytoplankton data collected from 1971 to 1975 indicate the importance of controlling nutrient inputs to the Lake Monroe system (Frey, 1976). In two of the four years, small populations of diatoms and Dinobryon dominated the summer net phytoplankton. However, in 1972 a very large population of blue-green algae developed, which probably accounted for the largest oxygen deficit in deep water occurring in that year. The cause of the 1972 bloom is not clearly understood, although changes in the hydraulic input and attendant nutrient concentrations may have been important factors. The water quality of the entire lake may become endangered if disturbances within the watershed increase the nutrient loading rates to the point where blooms of blue-green algae develop every year, regardless of variations in the hydraulic patterns (Frey, 1976).

Bacterioplankton. Bacterial studies in Lake Monroe were conducted by Smith in 1971 (Allanson, Zimmerman, and Smith, 1973). Sampling sites in the lower basin at Fairfax peninsula were chosen to provide information on the effect of the Four Winds Marina and the swimming area to the north. Samples collected between July 1 and September 29, 1971, showed obligate aerobes such as *Pseudomonas*, *Achrobacter*, *Alcaligenes*, and *Flavobacterium* comprised more than 80% of all bacteria collected. *Corynebacterium*, *Micrococcus*, and *Staphylococcus* (gram-positive organisms) rarely exceeded 25% of the total for any given sample. The enteric pathogens, *Shigella* and *Salmonella*, showed maximums of 5.2% and 3.5%, respectively.

Zooplankton. A list of the zooplankton species identified from Lake Monroe between June and August, 1974, is presented in Table 18 (Brakke, Chang, and Hartzell, 1975).

Frey (1976) summarized the results of a series of samples obtained from the uppermost meter of the lake by Allanson, Zimmerman, and Smith (1973) at five different stations in October 1971. The samples

Table 18. Zooplankton in Lake Monroe, June to August 1974

Protozoa

- Codonella[1]
- Ceratium [1]
- Difflugia cristata[1]
- peritrich[1]

Rotifera

- Ascomorpha
- Asplanchna
- Branchionus
- Colurella
- Conochilus
- Filinia
- Gastropus
- Kellicottia[1]
- Kerratella cochlearis[1]
- Polyarthra euryptera
- Polyarthra vulgaris[1]
- Rotatoria
- Trichocerca

Cladocerna

- Alona sp.[2]
- Alonella sp.[2]
- Bosmina coregoni[1]
- Ceriodaphnia lacustris
- Chydorus sphaericus[2]
- Daphnia laevis[1]
- Daphnia retrocurva[1]
- Diaphanosoma leuchtenbirgeanum
- Holopedium gibberum[1]
- Leptodora kindtii
- Pleuroxus denticulatus[2]
- Pseudosida bidentata[1]
- Sida crystallina[2]

Copepoda

- Cyclops (2 sp.)[1]
- Limnocalanus
- Diaptomus[1]

Ostracoda

---

[1]Most commonly encountered organisms.

[2]Cladocera associated primarily with aquatic plants.

Source: Brakke, Chang, and Hartzell (1975).

contained approximately 13 cladocerans, 49 copepods, and 35 rotifers per liter. The cladocerans were comprised primarily by *Daphnia* and the rotifers by *Keratella*: most of the copepods were nauplii (larvae). Protozoans were dominated by the phytoflagellates *Dinobryon* and *Ceratium* (classified by some as phytoplankton), which together totaled 171 organisms per liter. Other protazoans collected included the thecate amoeboid genus *Arcella* and members of the Volvocales.

On October 21, 1971, Allanson, Zimmerman, and Smith collected samples from two stations in the upper and lower basins at depths of 0, 3, and 7 meters. Their data are summarized in Table 19. The copepods were the predominant forms present, accounting for more than half of the number of organisms collected in all six samples. Rotifers were the second most important group at the upper basin station. Comparison of the data obtained from the two stations indicates that zooplankton densities decrease down lake, paralleling a similar decrease in the phytoplankton (Frey, 1976).

Recent data collected between June 15 and July 5, 1974 by Frey (1976; Table 20) indicate that the zooplankton, like the phytoplankton, can change significantly in total population and species composition from time to time. The total mean zooplankton density in 1974 was considerably less than in 1971. Cladocerans replaced copepods as the dominant group of zooplankton. The copepod population was down to only 16% of the zooplankton population. Nauplii were again the most abundant copepod age class. Adults were dominated by the calanoid *Diaptomus* and by an unidentified cyclopoid; a second cyclopoid and the calanoid genus *Limnocalanus* were present in smaller numbers.

Table 19. Zooplankton Population Density by Major Groups at Depths of 0, 3, and 7 Meters on October 2, 1971

	Population Density (organisms/liter)					
	Lower Basin			Upper Basin		
Taxon	0 m	3 m	7 m	0 m	3 m	7 m
Daphnia	<1(<1)	51(33)	7(13)	<1(<1)	35(15)	20(18)
Copepods						
Calanoids	<1(<1)	24(16)	3(6)	3(3)	23(10)	12(11)
Cyclopoids	<1(<1)	5(3)	9(18)	6(5)	10(4)	9(7)
Nauplii	65(99)	46(30)	20(42)	91(79)	76(32)	64(56)
Rotifers	<1(<1)	28(18)	10(21)	15(13)	91(39)	9(8)
Total	66	154	49	116	235	114

Source: Frey (1976), as modified from Allanson, Zimmerman, and Smith (1973).

Table 20. Density of Zooplankton in Ten Series of Horizontal Clarke-Bumpus Tows in Lake Monroe between June 15 and July 5, 1974

Group	Taxon	Frequency (out of 10)	Organisms per Liter Mean	Organisms per Liter Range (excl. zero)
Rotifers	Keratella	10	6.25	1.3 - 11.3
	Polyarthra	10	5.39	1.4 - 13.6
	Conochilus	5	1.15	0.14 - 3.8
	Filinia	7	0.73	0.07 - 4.7
	Gastropus	3	0.36	+ - 2.8
	Kellicottia	7	0.27	0.05 - 1.3
	Trichocerca	8	0.20	0.05 - 0.92
	Testudinella	6	0.15	0.04 - 0.45
	Ascomorpha	1	0.09	0.91
	Rotaria	3	0.07	0.03 - 0.34
	Brachionus	1	0.01	0.09
	Colurella	1	+	+
	All rotifers		15.67	
Cladocera	Bosmina coregoni sens. lat.	10	25.18	0.47 - 99.5
	Daphnia retrocurva	10	3.93	0.80 - 16.9
	Holopedium gibberum	9	1.27	0.09 - 3.6
	Pseudosida bidentata	9	0.44	0.14 - 1.0
	Daphnia laevis	7	0.20	+ - 0.59
	Ceriodaphnia lacustris	6	0.09	0.05 - 0.38
	Leptodora kindti	4	0.02	0.04 - 0.07
	All cladocera		31.13	
Copepods	Nauplii	10	6.54	1.2 - 12.4
	Diaptomus	10	1.01	0.19 - 2.1
	Cyclopoid I	10	0.72	0.09 - 1.2
	Cyclopoid II	9	0.33	0.11 - 0.78
	Limnocalanus	4	0.28	+ - 2.4
	All copepods		8.88	
All zooplankton			55.68	

Source: Frey (1976).

Cladocera comprised 56% of the total zooplankton population. The presence of Bosmina in the coregoni complex, Holopedium gibberum, and Leptodora kindtii indicate a lake low in calcium and low in productivity (Frey, 1976). The annual variation in general levels of productivity and associated conditions in Lake Monroe were judged to be the primary causes of the changes observed in the zooplankton population from 1971 to 1974 (Frey, 1976).

Benthos. There have been no studies conducted on benthic animals in Lake Monroe. Frey (1976) hypothesized that these organisms consist primarily of midge larvae (Chironomidae), oligochaete worms, and variable numbers of Chaoborus, all of which are limited to areas subject to summer oxygen depletion.

Macrophytes. The macrophytes that have been identified in Lake Monroe are Myriophyllum, Sagittaria, Potamogeton, Ceratophyllum demersum, Najas flexilis, Najas guadalupensis, and Nelumbo lutea (Frey, 1976). The shallow upper basin of the lake contains extensive areas of macrophyte communities, especially in the North and Middle Forks of Salt Creek (Fig. 12). Frey (1976) has summarized the results of several authors with respect to the variability of macrophyte species composition from year to year. Allanson, Zimmerman, and Smith (1973) described two fairly distinct plant communities. A Potamogeton-Najas-Certophyllum-Myriophyllum community occurred in exposed areas of the open water, and a Najas-Potamogeton-Sagittaria community in sheltered locations. Single species stands of either Najas or Nelumbo comprised the majority of the offshore beds. In 1972, only Najas and Potomogeton were observed in the lake (Docauer, 1972). On September 3, 1975, Brandley (1976) estimated that Myriophyllum and Najas comprised about 97% of the total in the upper basin.

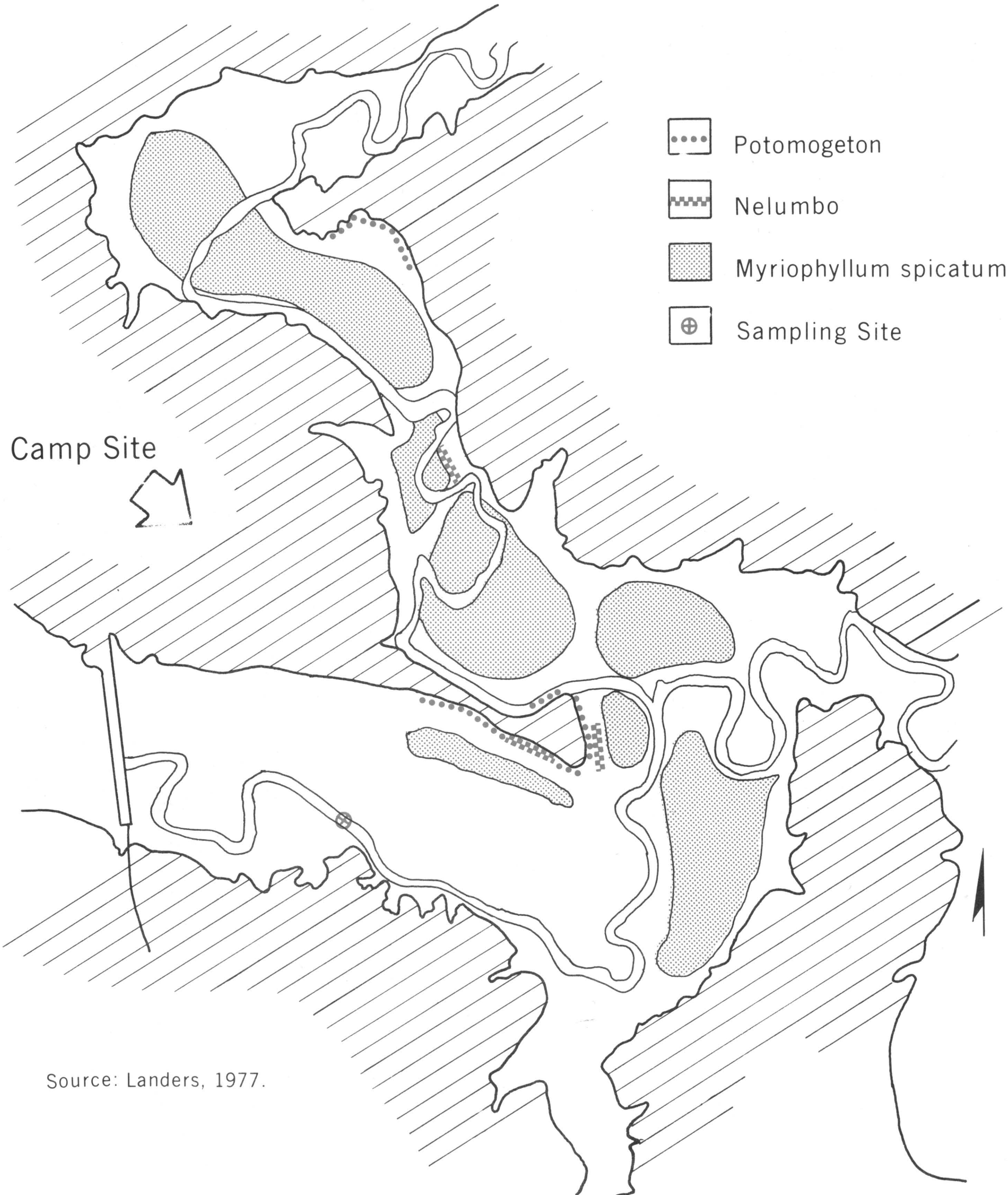
The areal extent and depth of the macrophyte beds in the upper basin can vary considerably from year to year. The beds covered about 75% of the North and Middle Forks of the Lake in 1971 (Docauer, 1972), 1974, and 1976 (Landers, 1977). But in 1972, the beds covered only 30% of the two forks. Also, the depth of the beds was only one meter in 1972, compared to two meters the year before (Docauer, 1972).

Several controlling mechanisms have been suggested to explain the annual variability of macrophyte development. Docauer (1972) believed the level of water input from March to May controlled macrophyte development by means of the degree of light attenuation due to increasing water depth and turbidity. Frey (1976) stressed the importance of nutrient concentrations after the spring watershed flush in determining the response of the lake. These concentrations are inversely related to discharge into the lake.

Macrophyte densities vary seasonally, developing a maximum biomass in late summer, and then dying back in autumn with a concomitant release of essential nutrients (Frey, 1976). The macrophytes in the upper basin of Lake Monroe covered approximately 1160 acres on September 3, 1975, but by November 25 they had been reduced to only 220 acres (Brandley, 1976).

Several investigators have emphasized the importance of the macrophytes of the upper basin in maintaining the water quality of the entire lake (Docauer, 1972; Allanson, Zimmerman, and Smith, 1973;

FIGURE 12 MAJOR MACROPHYTE BEDS, SUMMER 1976



Source: Landers, 1977.

Brakke, Chang, and Hartzel, 1975; Brandley, 1976; and Frey, 1976). The utilization of essential nutrients by the macrophytes and their associated epiphytes in the summer inhibits or curtails the development of nuisance phytoplankton blooms. The eventual release of nutrients from macrophyte decomposition occurs when other environmental conditions, such as temperature and solar radiation, are less favorable for phytoplankton development. Depending on the particular winter-spring hydraulic regime, a considerable amount of the nutrients released from the macrophytes can drain from the lake before stimulating excessive development of phytoplankton (Frey, 1976).

Fishes. A list of the species compositions and relative abundances of fish collected in Lake Monroe from 1968 to 1971 is presented in Table 21. These samples collected by Ridenour (1972) indicate that the predominant species were the bluegill and the largemouth bass. White crappies, yellow perch, and white suckers were also important, The data obtained between 1968 and 1971 suggest a declining percentage of largemouth bass and white suckers and relative increases in both bluegills and yellow perch.

More recent information has been compiled by Ridenour (1977) in a series of embayment samples taken from 1973 to 1975. A summary of the data collected is presented in Tables 22 and 23 (Ridenour, 1977). Generally, populations increased during this period but the average size of individuals fell off. The population density of largemouth bass increased 31% from 83 fish/acre in 1973 to 109 fish/acre in 1975; an increase of 6% in terms of pounds/acre was also recorded. It

Table 21. Species Compositions and Relative Abundances of Fishes Collected in Lake Monroe, 1968-1971

	Percent of Sample			
	1968	1969	1970	1971
Centrarchidae				
Largemouth bass	37.3	26.2	18.1	23.7
Smallmouth bass	--[1]	--[2]	--[1]	--[1]
Yellow bass	--[1]	--[1]	3.4	0.6
Warmouth	3.4	1.5	1.4	1.9
Bluegill	16.2	38.8	24.7	35.5
White crappie	0.9	8.9	23.5	4.6
Black crappie	0.4	--[1]	0.7	2.9
Pumpkinseed	--[1]	--[1]	0.4	--[1]
Longear sunfish	--[1]	1.4	1.0	3.3
Orange-spotted sunfish	0.1	--[2]	--[1]	0.1
Green sunfish	4.9	2.2	0.6	0.6
Redear sunfish	0.7	0.7	0.6	1.6
Ictaluridae				
Channel catfish	3.5	1.9	1.0	1.2
Flathead catfish	--[1]	--[2]	--[1]	--[1]
Black bullhead	0.3	2.0	1.5	--[1]
Yellow bullhead	9.0	0.4	1.5	0.1
Catostomidae				
Carp	0.3	1.7	2.4	1.5
White sucker	9.6	4.0	4.9	4.4
Spotted sucker	0.1	3.7	3.1	0.5
Percidae				
Yellow perch	6.4	3.7	11.0	16.9
Esocidae				
Northern pike	0.1	--[1]	--[1]	--[1]
Serranidae				
Rock bass	0.2	0.1	--[1]	--[1]
Total number of fish in sample	3,103	2.298	2,491	856

[1]None collected.

[2]Less than 0.1% of total

Source: Ridenour (1972), quoted in Brakke, Chang, and Hartzel (1975).

Table 22. Population Densities of Fishes in Samples Taken from Lake Monroe Embayments, 1973 and 1975

Species	1973 Population Density (per acre)	1973 Population Density (% of total)	1975 Population Density (per acre)	1975 Population Density (% of total)
Bluegill	1696	49	1422	58
Yellow bass	174	5	182	7
Crappie	120	3	107	4
Yellow perch	114	3	227	9
Largemouth bass	83	2	109	4
Carp	19	1	5	0.2
Total	3485		2453	

Source: Ridenour (1977).

Table 23. Standing Crops of Fishes in Samples Taken from Lake Monroe Embayments, 1973 and 1975

Species	1973 Standing Crop (lbs/acre)	1973 Standing Crop (% of total)	1975 Standing Crop (lbs/acre)	1975 Standing Crop (% of total)
Bluegill	93.8	29	45.9	24
Carp	62.6	19	44.4	23
Yellow perch	34.4	11	6.4	3
Largemouth bass	26.5	8	28.2	15
Crappie	29.1	9	11.8	6
Yellow bass	22.5	7	18.1	9.5
Total	324.4		190.4	

Source: Ridenour (1977).

appears that these increases occurred only in smaller bass, as the study showed a decreased abundance of larger bass over the same time period.

Bluegill populations decreased in number by 16% and in weight by 51%. These figures indicate that the decrease in standing crop was due to a large decrease in the larger, older bluegills.

The data show significant changes in other species as well. Yellow perch, yellow bass, and crappies all show increased abundance in population density, yet their standing crops by weight decreased. This represents an annual decrease in the size of individuals for all three species.

Ridenour (1977) also mentions the existence of a large forage base within the lake. In addition to the young of those fishes already mentioned, the forage base includes longear sunfish; warmouths; adult black and white crappies; brown, yellow, and black bullheads; log perch; spotted and white suckers; and several others.

Water Use

Lake Monroe was constructed for two primary purposes--flood control and low-flow augmentation of Salt Creek. The reservoir's secondary purposes, however, are more relevant to the Alumni Family Camp. These include provision of habitat for fish and wildlife, which is discussed in the sections on terrestrial and aquatic ecology, and provision of a municipal water supply and recreational opportunities, which are discussed in this section.

Lake Monroe serves as a drinking water source for Bloomington and Bedford. It is estimated that Bloomington will draw an average of 12 million gallons of water per day from the lake by 1980 and 21 million gallons per day by 1990. Daily maximums are expected to be about one-third higher. The pool can supply as much as 36 million gallons per day for this purpose. (Reservoir purposes and water supply data are as reported in Gray _et al._, 1975a.)

Data on the recreational use of Lake Monroe are given in Table 24. Information is given for both the lake as a whole and for the Cutright and Pine Grove boat ramps in the upper basin. These data are extrapolated from surveys taken at each of the recreational areas, in which respondents indicated the recreational activities they intended to engage in. The activities were not necessarily carried out at the site of the survey, but the data are likely to be generally indicative of the geographical distribution of recreational activities within the lake.

The major uses of the lake area as a whole are sightseeing, fishing, swimming, and picnicking. Swimming is less common in the upper basin as a whole and picnicking is less common around the North Fork. Boating was reported as an activity by a much lower fraction of people at the Pine Grove boat ramp than at Cutright or for the lake as a whole. While some Cutright visitors may have boated in the North Fork, that launch point is more probably used by boaters who want to get to the middle and lower basins or use the main body of the upper basin. For reasons of access, people who intend to boat in the North Fork are more likely to use the Pine Grove ramp. Therefore, the low Pine Grove boating figures probably reflect a relatively low incidence of boating in the North Fork.

Table 24. Distribution of Recreational Activities, Lake Monroe Recreation Areas, 1976

Activity	Number of People Engaging in Activity[1] All Areas	Cutright Boat Ramp	Pine Grove Boat Ramp
Camping	116,634	5,889	809
Picnicking	268,235	39,013	4,993
Boating	172,848	15,990	821
Fishing	289,383	54,432	14,887
Hunting	278	205	0
Sightseeing	268,391	2,383	0
Water skiing	41,759	5,478	193
Swimming	439,972	67,667	10,662
Other	2,641	1,375	432
Total[2]	1,301,336	156,393	27,724
Total (1975)	1,283,238		

[1]Number of people at the given site engaging in the given activity somewhere in the lake area.

[2]Totals do not equal sums of numbers listed above, as some people may engage in more than one use.

Source: U.S. Army Corps of Engineers (1977); data extrapolated from visitor surveys.

Cultural Resources

In environmental impact assessment, the objective is to evaluate the potential effects of a project on the total environment. While emphasis may properly be placed on the natural environment, the human cultural environment must also be assessed. In the preceding sections, various aspects of human activities relating to portions of the natural environment are discussed. The following sections describe aspects of the social environment not directly relating to any one sector of the natural environment. These include basic socioeconomic characteristics of the region; information on archeological and historical sites relevant to the camp property; and governmental roles in natural resource management in the Lake Monroe area.

Socioeconomics

In this section, basic data are provided on the numbers, education, employment status, and income of people living in the vicinity of the Alumni Family Camp site. The intent is merely to provide a general picture of the community within which the camp is being placed. All of the information given is drawn from the U.S. Bureau of the Census (1973, no date). Data are presented for the Monroe County community as a whole and for Monroe County Census Tract 15, which consists of the three townships bordering the lake--Clear Creek, Polk, and Salt

Creek. Data for the entire state are also given for purposes of comparison (Table 25). The information given is for 1970, the most recent year for which much of the data are available. While the absolute numbers given are likely to have changed significantly since then, most of the figures presented in Table 25 are percentages, and many of these may not have varied substantially in relation to each other.

General characteristics. The Alumni Family Camp site is located at the southern edge of Salt Creek Township in Monroe County. The township runs as far north as State Route 46, and includes no sizeable towns. There were 798 people in Salt Creek Township in 1970, down 4.7% from 1960.

The camp site peninsula extends over the township line into Polk Township to the south. West of Polk Township lies Clear Creek Township. These three townships together comprise Monroe County Census Tract 15, the smallest unit for which extensive socioeconomic data is readily available. The tract had a population of 3,566 in 1970.

Census Tract 15 comprises the southeast corner of Monroe County, a county of 84,849 people (1970), about half of whom live in one city--Bloomington. The most distinctive cultural feature of Monroe County is that it is the locus of the largest campus (32,000 students) of Indiana University. The effects of the university on the county population are reflected in the county's growth rate between 1960 and 1970. During this decade, when the campus was expanding its enrollment at a rapid rate, the county population was growing at a rate four times that of the state as a whole. The presence of the campus is also reflected in the relative youth of the county's population. Only 43%

Table 25. Selected Socioeconomic Variables, Indiana, Monroe County, and Census Tract 15 (Clear Creek, Polk, and Salt Creek Townships), 1970

Variable	Indiana	Monroe County	Census Tract 15
General			
Population	5,133,669	84,849	3,566
Increase since 1960 (%)	+11.4	+43.3	
Cumulative fertility rate women aged 34-44[1]	3,079	2,766	
Fraction of population at least 25 yrs old (%)	53.6	43.0	53.8
Education			
Median school years completed, persons aged 25 and over	12.1	12.6	10.4
Fraction of population with some college education, persons aged 25 and over (%)	16.8	38.5	12.1
Fraction of population currently enrolled in college (%)	3.3	26.8	1.4
Employment (persons aged 16 and over)			
Fraction of civilian labor force unemployed (%)	4.1	4.9	5.5
Nonworkers/workers[2]	1.43	1.34	
Fraction of those employed working outside county of residence (%)	16.9	6.7	
Fraction of workers employed in professional, technical, and kindred occupations (%)	12.3	25.6	8.0

Table 25. (continued)

Variable	Indiana	Monroe County	Census Tract 15
Employment (continued)			
Fraction of workers employed in clerical and kindred occupations (%)	16.2	18.0	11.4
Income			
Median family income ($/yr)	9,970	9,197	8,356
Fraction of families below poverty level (%)	7.4	7.5	6.8
Fraction of families earning at least $15,000/yr (%)	19.4	18.8	10.4

[1]Children ever born/100 women now 35-44 yrs old.

[2]In the total population.

Sources: U.S. Bureau of the Census (1973, no date).

of the residents of the county are at least 25 years old, whereas that age group makes up 54% of both the state as a whole and Census Tract 15.

One final curious statistic of a miscellaneous nature may be related to education and have implications for the county's future growth rate. In 1970, Monroe County had the third lowest cumulative fertility rate in the state (among women aged 35 to 44). It might be hypothesized that education (see below) may be inversely correlated with familism, although no support for this hypothesis is gained from an analysis of the two counties with lower fertility rates (Greene and Ohio); they are relatively poor, rural counties, and factors other than education are probably responsible.

Education. The significance of Indiana University with respect to the social characteristics of the county as a whole and its lack of significance with respect to the social characteristics of the Lake Monroe area are reflected in education data (Table 25). The median level of education in Monroe County is higher than that of any other county in the state, while the figure for Census Tract 15 is below the state average.

Disparities between the Lake Monroe area and the county as a whole are demonstrated even more strongly when college education in particular is considered. The fraction of people over 25 with some college education in Census Tract 15 is only a third of that in Monroe County, and the fraction of the population currently enrolled in college is only about a twentieth of that for the county as a whole.

Employment. The unemployment rate and the ratio of nonworkers to workers were not much different in Monroe County in 1970 from those in the state as a whole (Table 25). The unemployment rate in Census Tract 15, however, was fairly high.

Even larger disparities between Census Tract 15 and the county are evident in the distribution of workers among occupational types. Professional and technical occupations account for about a quarter of the jobs in Monroe County; this figure is about twice that for the state as a whole, and about three times that for Census Tract 15. Once again, these data may reflect the presence of the university. In addition, a significantly lower fraction of workers in the Lake Monroe area are employed in clerical professions than are so employed around the county and around the state.

Although the Indianapolis Standard Metropolitan Statistical Area ends at the Monroe County line, few people in the county commute elsewhere to work. In fact, proportion of Monroe County residents who commute to work is less than half the proportion for the state as a whole. This, together with the high commuter rates for the counties (Greene and Lawrence) bordering Monroe on the side opposite from Indianapolis suggest that Monroe County is not an exurb but an employment center in its own right.

Income. Family incomes in Census Tract 15 are both generally lower and less variant than those in the county and the state (Table 25). While the median annual family income in Monroe County was some $770 less than that in Indiana as a whole in 1970, the fractions of families below the poverty level and above $15,000 per year were similar to those of the state. The median family in Salt Creek Township earned about $840 less than its counterpart in the county, but the proportion of families below the poverty level was less than that in the county and in the state, and the fraction of families making at least $15,000 was substantially less.

Summary. In conclusion, then, Monroe County is something of a socioeconomic anomaly with respect to the rest of the counties in Indiana. Those social characteristics that might be expected to reflect the presence of a large university--age, education, professionalism of work force--vary widely from those of the state as a whole. Other characteristics, such as income, do not.

On the other hand, the more immediate environs of the Alumni Family Camp site represent, if anything, an even more faithful type of Midwestern cultural characteristics than the state as a whole does. In Census Tract 15, education, especially college education, does not appear to be valued very highly; unemployment is high, but not as much so as in urban areas; few people work in professional and other high-status jobs; and finally, people are less well off in terms of income than they are elsewhere, but not too many are actually poor.

Archeological and Historical Sites

Archeological and historical sites are an important part of our cultural heritage. Recognition of any historical and archeological resources in the area prior to construction is important so that any significant materials, artifacts, or information can be extracted from the site before it is disturbed. Areas on the site that may experience some form of alteration during construction were recently surveyed by Patrick J. Munson, Department of Anthropology, Indiana University. His subsequent letter to a member of the environmental assessment team is reproduced in its entirety on the following pages. The letter indicates the locations of possible archeological and historical sites on the camp property and the efforts required for exploration and, if necessary, full excavation of these sites. (The "Meeting Lodge-Parking Lot" location referred to in the letter is in the field in the center of the property. The "Shelter Houses" location is on the summit at the end of the camp site peninsula. These and other possible sites for the camp structures are fully discussed in the next major part of this assessment.)

Governmental Roles in Natural Resource Management

The Alumni Family Camp must be constructed and operated within the legal framework erected and administered by government. Thus, the roles and responsibilities of various governmental agencies with respect to the management of the natural resources of the Lake Monroe watershed are part of the cultural environment of the camp.

Currently, Lake Monroe serves five principle purposes. These are (1) flood control for the White River drainage system, (2) low flow augmentation in Salt Creek, (3) sediment storage, (4) public water supply, and (5) recreation. Due to the nature of policies affecting the lands around it, the lake has considerable value in providing fish and wildlife habitat as well. The maintenance of these functions is the responsibility of numerous federal, state, and local governmental agencies who share jurisdiction in determining the uses

INDIANA UNIVERSITY
Department of Anthropology
RAWLES HALL
BLOOMINGTON, INDIANA 47401

TEL. NO. 812—

January 20, 1977

Glenn Montgomery
SPEA
Poplars 433

Dear Glenn,

Re our conversation of last week and your recent note concerning the Lake Monroe project:

1) I have personally and recently examined the entirety of the shoreline within the project area (U.S. Army Corps of Engineers assessment of cultural resources, summer 1976) and as a consequence it can be stated with considerable confidence that only a single prehistoric site is located in the vicinity of the shoreline. This "site" exists today only as redeposited artifactual material which has washed up on the strandline ESE of the location marked "shelter houses" on your map. The site proper is beneath the lake, has probably already been highly disturbed or destroyed by wave action, and would not be effected in any way by the project.

2) Two other areas exist within the project area however which, based on my professional opinion and experience with archaeological materials in this general area, would seem to have a high probability of having prehistoric remains and which will be impacted by the proposed project; one is the "Shelter Houses" location and the other is the "Meeting Lodge-Parking Lot" location. I have already examined the surfaces of both locations and given the ground cover situation (heavy vegetation, absence of plowed surfaces) additional surface survey would produce little or no additional relevant information; both will require some form of subsurface testing to evaluate them further.

The Shelter House location is in my opinion very likely (I would say at least 50-50 chance) to have a few graves of Late Archaic (ca. 3000 - 500 B.C.), Late Woodland (ca. A.D. 400 - 900), and/or pioneer (ca. A.D. 1820 - 1850) peoples. It is additionally probable that there has been some slight or short-term occupation of this area by Archaic peoples (ca. 8000 - 500 B.C.) with resultant occupational features (pits, hearths, post holes, etc.). Given present ground cover the only way that such remains could be discovered is through test excavations.

I would recommend that approximately six 5 x 10' units be excavated in this area by a qualified archaeologist in order to evaluate the presence-absence and characteristics of prehistoric-early historic utilization of this location and to determine what steps, if any, would be necessary to preserve them or otherwise mitigate potential impact of construction activities. This should be done at least one month prior to start of construction (preferably much earlier than that). Estimated 50 - 100 man hours for testing, plus 0 - 300 additional hours for total mitigation (zero if nothing is found or if it can be mitigated during initial testing).

The Meeting Lodge-Parking Lot location has a high probability of having been used as an intermittent occupation area by Archaic peoples. The location has undoubtedly been plowed sometime in the past however, so that the upper six inches or so has already been disturbed. Recommend that some time well prior to start of construction (at least one month) a front-end loader (with operator) be utilized under the direction of a qualified archaeologist to remove the upper six inches of several strips (ca. 5 x 50') across the actual areas of the proposed meeting lodge, parking lot, and any roadways, and on the basis of this test it can be determined what steps, if any, would be necessary to preserve the sites or otherwise mitigate potential impact of any construction activities. Estimated 8 hours for machine and operator and 50 man hours for testing, plus 0 - 24 additional hours machine and operator and 0 - 300 man hours for total mitigation.

For the testing portion of this proposal we're talking about something like $500. Additional work, if it is necessary and as will be determined by the testing, could be considerably more (but also could be quite unnecessary).

It must be stressed that none of this work can be done until the ground is free of frost and "settled," which is unlikely to occur prior to mid-March.

Sincerely,

Pat

Patrick J. Munson
Associate Professor

to which public lands can be put. In addition, local governmental units are charged with insuring that private property uses, such as the Alumni Family Camp development, do not endanger or destroy opportunities for public utilization of natural resources of the watershed.

Under current environmental quality protection laws, responsibility is often fragmented among governmental units, and the citizen may find that the responsibilities of agencies are obscured by bureaucratic complexity. This section is designed as an aid to understanding the natural resource management goals and jurisdictions of various authorities. Because the regulatory requirements pertaining to any developmental action are dependent upon these individual agency roles, this understanding is a prerequisite for sound planning and efficient completion of the project as well. Relevant agencies are considered by level of government in the following subsections.

Federal regulatory agencies. The United States government owns the land under and around Lake Monroe, thus making it public land. The boundary line for public property is approximately 100 feet back from the shoreline at high water level, which is at 556 feet M.S.L. Exceptions are Allens Creek, Paynetown, and Fairfax State Recreation Areas and several state boating ramps, where larger land areas are included. Several federal agencies possess regulatory powers over this land. These include the Army Corps of Engineers, the Department of Agriculture, the Department of the Interior, and the Environmental Protection Agency.

Proposed and constructed by the U.S. Army Corps of Engineers, the reservoir is under the jurisdiction of the Recreation and Resource Management Branch of the Operations Division of the Middle Wabash Area of the Louisville District of the Corps. The resource manager of the Corps stationed at the reservoir controls the operation of the dam for flood prevention and low flow augmentation. In addition, he oversees the administration of public land-use regulations by the Indiana Department of Natural Resources (EQCC, 1975).

Any construction, improvement, or excavation within the public land boundaries requires the permission of the Louisville District Engineer. This includes private developments such as the boat dock proposed at the family camp. The Corps has recently promulgated regulations establishing guidelines for the development of Lakeshore Management Plans. Such a plan is required for Lake Monroe and is administered by the State Department of Natural Resources. The purpose of the plan is to protect the natural shoreline, end the present lax approach to the administration of permits, and insure that private development does not encroach upon public land (EQCC, 1975).

The Chief Engineer of the Corps (through his subordinates) reviews and issues permits for the discharge of dredged or fill material into Lake Monroe at specific disposal sites. The Corps has no direct authority to regulate pollutant discharges from watercraft because this authority was transferred to the Secretary of the Department of Transportation by the Federal Water Pollution Control Act of 1972 (EQCC, 1975).

The Hoosier National Forest, managed by the Secretary of Agriculture through the Chief of the Forest Service and his subordinate, the Forest Supervisor in Bedford, Indiana, comprises much of the Lake Monroe watershed. Both branches of Salt Creek flow through large areas of the Hoosier National Forest and, for that reason, Forest Service policy may directly affect water quality and sedimentation rates in the reservoir.

The Secretary is responsible for protection of the National Forests (including wildlife) and can thus establish rules to prevent destruction by fire or depredation, and to regulate occupancy and use of the forest.

The Secretary may implement programs to reduce runoff and discharge and prevent soil erosion through the United States Soil Conservation Service. This agency serves primarily in giving local technical and engineering assistance through the Monroe County Soil and Water Conservation District.

Jurisdiction over public lands by the Department of the Interior includes the protection of timber owned by the United States from fire, disease, and insects (Gray et al., 1975b). The Bureau of Sport Fisheries and Wildlife, an Interior Department agency, exercises various powers in the Lake Monroe area, such as regulation of hunting seasons and methods of hunting and trapping. These regulations are enforced by the Indiana Department of Natural Resources.

The EPA is the general authority for controlling pollution of the nation's air and water. Under the Federal Water Pollution Control Act of 1972, enforcement of laws regulating the discharge of pollutants from a "point source" (such as a sewage effluent discharge point) has been delegated to individual states, with the EPA overseeing the establishment of water quality standards. (This is discussed further with respect to state regulatory agencies below.)

In general, federal agencies must maintain jurisdiction and effect policies concerning Lake Monroe and the surrounding lands because this property is owned by the federal government. However, except for the Forest Service, it is not usually necessary to deal directly with federal officials concerning matters of private development, although they should be notified of such actions. Most of the enforcement and management duties (such as permit issuance) have been delegated to agencies of the State of Indiana through agreement or property lease conditions.

State regulatory agencies. The state agencies receiving the bulk of the transfer of duties from the federal government have been the Department of Natural Resources and the Stream Pollution Control Board; the powers of the latter agency, together with those of a another state agency, the Environmental Management Board, are exercised through the State Board of Health. Other relevant state agencies include the Administrative Building Commission and the State Highway Commission. The roles of these agencies are discussed in the following paragraphs.

Enforcement of regulations promulgated by the Army Corps of Engineers concerning public use (recreation, fishing, boating, etc.) was transferred to the Department of Natural Resources (DNR) when Indiana leased water storage in the reservoir in 1967 (EQCC, 1975). The DNR was created by statute and consists of the Natural Resources Commission, a director, two deputy directors, and a staff. Its responsibilities focus on the regulation and management of the public use of state parks, forests, and navigable waters. The DNR has an enforcement division for both its own regulations and those of the Corps relating to the public use of Lake Monroe and construction in the surrounding area.

The Natural Resources Commission of Indiana is the agency that deals with the Corps in acquiring land and funds for reservoir projects. The Commission's focus of concern is flood control. Permits for obstruction of floodways and for construction, excavation, and deposition within floodways must be obtained from the Natural Resources Commission (EQCC, 1975).

Indiana Law requires a conservation permit from the DNR for changes in the shoreline of freshwater lakes. A permit is also needed for any building, boat dock, or structure on any land or water owned or leased by the DNR. (The 100-foot easement around the reservoir is leased to the DNR.) The Corps must concur in the issuance of this type of permit. The Division of Reservoir Management of the Bureau of Water and Mineral Resources of the DNR is the principle agency in activities concerning Lake Monroe (such as permit issuance).

The DNR also has the power to inspect watercraft and to insure the galley drains are inoperative before such watercraft are permitted to launch. Another regulation of lease compliance states that no refuse or waste of any kind may be thrown along the roads, picnic areas, campgrounds, or any other land around the reservoir. Exceptions include solid waste disposal sites and the use of spoil for fill, subject to regulation by or approval by the DNR (EQCC, 1975).

The DNR may also require written approval for the construction of ditches intersecting or passing near streams and lakes. Approval is required so that the alteration of drainage patterns in such a way as to accelerate erosion or reduce downstream water levels may be avoided.

The DNR Bureau of Land, Forest, and Wildlife Resources controls fish and wildlife through protection, propagation, and management (EQCC, 1975). Hunting and fishing licenses are issued by the DNR. The fact that wildlife is considered to be public property of the state means that some management practices, such as hunting regulations, can be extended to private property use when such an extension is in the public interest.

The Environmental Management Board (EMB), the State Board of Health, and the Stream Pollution Control Board (SPCB) determine policy and enforcement practices in all activities related to human sanitary systems and pollution of the state's waters. Their jurisdictions are not limited to these concerns, but these concerns are the focus of the following paragraphs because of their importance for the camp development.

The EMB is the newest of the boards in the area of water quality. Although it has a variety of environmental duties, the EMB primarily establishes policy and functions as a review board for the decisions of the other two agencies.

Powers of the State Board of Health include (1) the issuance and enforcement of orders that regulate the use of existing or proposed sanitary systems that do not meet prescribed health standards;

(2) prescription of treatment of sewage and industrial waste if such waste causes a health hazard; (3) approval, in conjunction with the SPCB, of proposed sewage disposal facilities; (4) control of pollution of water supply when jurisdiction is not possessed by the SPCB; and (5) enforcement of all laws and regulations concerning the character and location of plumbing, drainage, water supply, and sewage disposal for public buildings (Gray et al., 1975b).

The EMB is authorized to transfer its duties and powers to the SPCB and this has in fact been done in the area of water pollution control and wastewater treatment plant operation. The SPCB was created to control and prevent pollution of the state's waters by any substance deleterious to public health. Its powers include the rights to (1) order the construction of facilities to dispose of waste matter that is causing, contributing to, or about to cause or contribute to water pollution; (2) issue permits for construction, modification, or operation of any water pollution control facility; (3) administer the National Pollution Discharge Elimination System (NPDES) permit program for the discharge of pollutants into the subsurface or surface waters of the state; and (4) establish and enforce water quality standards for most waters of the state (including Lake Monroe) in accordance with the Federal Water Pollution Control Act of 1972.

It is through the NPDES permits that discharges are controlled and the water quality standards of the state are thus maintained. If the waste treatment system operated for the family camp requires a discharge, the Alumni Association must obtain an NPDES permit.

The Administrative Building Commission enforces provisions for construction, repair, and maintenance of all buildings (exceptions are 1-2 family residences and agricultural structures). These regulations should be consulted throughout project planning for approval of designs and specifications and to check whether any variances need be requested.

While the major powers of the State Highway Commission are concerned with coordinating and planning all accesses to state highways, they are also responsible for roads and parking areas on properties of the DNR. While specific plans are unknown at this time, if the camp includes roads or parking within 100 feet of the shoreline approval for such areas must be obtained from the State Highway Commission.

<u>Monroe County regulatory agencies</u>. The camp development is within the jurisdiction of a number of Monroe County agencies concerned with activities having environmental implications. These include the County Commissioners, the Monroe County Plan Commission, the County Highway Department, the Lake Monroe Regional Waste District, the County Board of Health, and the County Soil and Water Conservation District.

Facilities for the collection and disposal of refuse are under the control of the County Commissioners. Although the currently utilized Anderson Road landfill is owned by Indiana University, the Commissioners are authorized to establish rules for its operation. These regulations must satisfy the standards of the State Board of Health (EQCC, 1975). The County Commissioners also have among their powers and duties the jurisdiction to enact zoning ordinances. Zoning is, in fact, the primary means of governmental supervision over the uses of private land in the reservoir watershed, which includes the camp property. The Commissioners have created the Monroe County Plan Commission for the purpose of promoting orderly growth and rational use of the county's resources.

Upon creation, the Monroe County Plan Commission was required by state law to develop a comprehensive master plan that assesses and provides information on current environmental and developmental conditions in the county. Along with a zoning ordinance for regulating property uses, this plan is the major land-use and environmental control mechanism in operation at the local level.

The current zoning map places the camp site in a forest preserve zone. While development of recreational facilities is permitted, the complete zoning ordinance should be consulted early in the planning process to assure compliance with the developmental permit requirements of the Commission and to see if any variances are necessary. An important condition for the acquisition of a building permit from the Commission is approval of drainage plans. Analysis of these plans can be completed by the U.S. Soil Conservation Service.

The County Highway Department has the responsibility of constructing, maintaining, and altering county roads. Also, the County Highway Engineer must approve the entrances of access roads to county roads before construction permits are issued. Such approval will probably be required for the camp project, as it would appear to require access onto Rush Ridge Road.

Any changes in surface material, road grade, or road dimensions on Rush Ridge Road in connection with this project should be cleared with the Highway Engineer; plans for safe traffic movement and parking facilities should also be discussed with him. Because the County Highway Department does not have jurisdiction over State Highway 46, the State Highway Commission should be notified if any impacts on this right of way are anticipated.

The area immediately around Lake Monroe has been organized into a Regional Waste District as authorized by state statute and approved by the SPCB. The District is empowered to construct and finance sanitary systems including sewers and waste treatment facilities. It plays the major role in planning and coordinating activities to prevent the pollution of the reservoir.

The Monroe County Board of Health has basically the same powers as the State Board of Health regarding matters of public health. Jurisdiction to regulate sanitary waste systems has largely been assumed by the Lake Monroe Regional Waste District; requirements they impose must be consistent with those of the State Board of Health and its policy agency the SPCB.

The major concern of the Monroe County Soil and Water Conservation District is erosion. Because of the relation of siltation to water quality and loss of reservoir capacity, this agency should be consulted to provide engineering and technical assistance. The agency does extend such services to private property.

Environmental Impacts of the Alumni Family Camp Development

In this part of the assessment, the effects of the Alumni Family Camp development on the current environment of the camp property are discussed. Impacts are treated both explicitly in terms of direct effects of the camp on its environment and implicitly in terms of overall suitability of the site for development. Many of the environmental effects of the camp depend on which of several alternative methods of development is pursued. Implications of the terrestrial environment for alternative locations of camp structures and functions are discussed first. Then, various sewage treatment alternatives are described with respect to their effects on the aquatic environment. More impacts relating to the aquatic environment--those of erosion and runoff as exacerbated by the camp--are discussed next; these impacts are not alternative-dependent, but can be mitigated to some extent by careful planning and construction. A number of other environmental considerations requiring less space to describe are combined in a final section. These include those impacts of camp construction not relating to erosion, the effects of the recreational use of Lake Monroe's water resources, the impacts of the activities of camp patrons on the environment, and the overall suitability of the site for development.

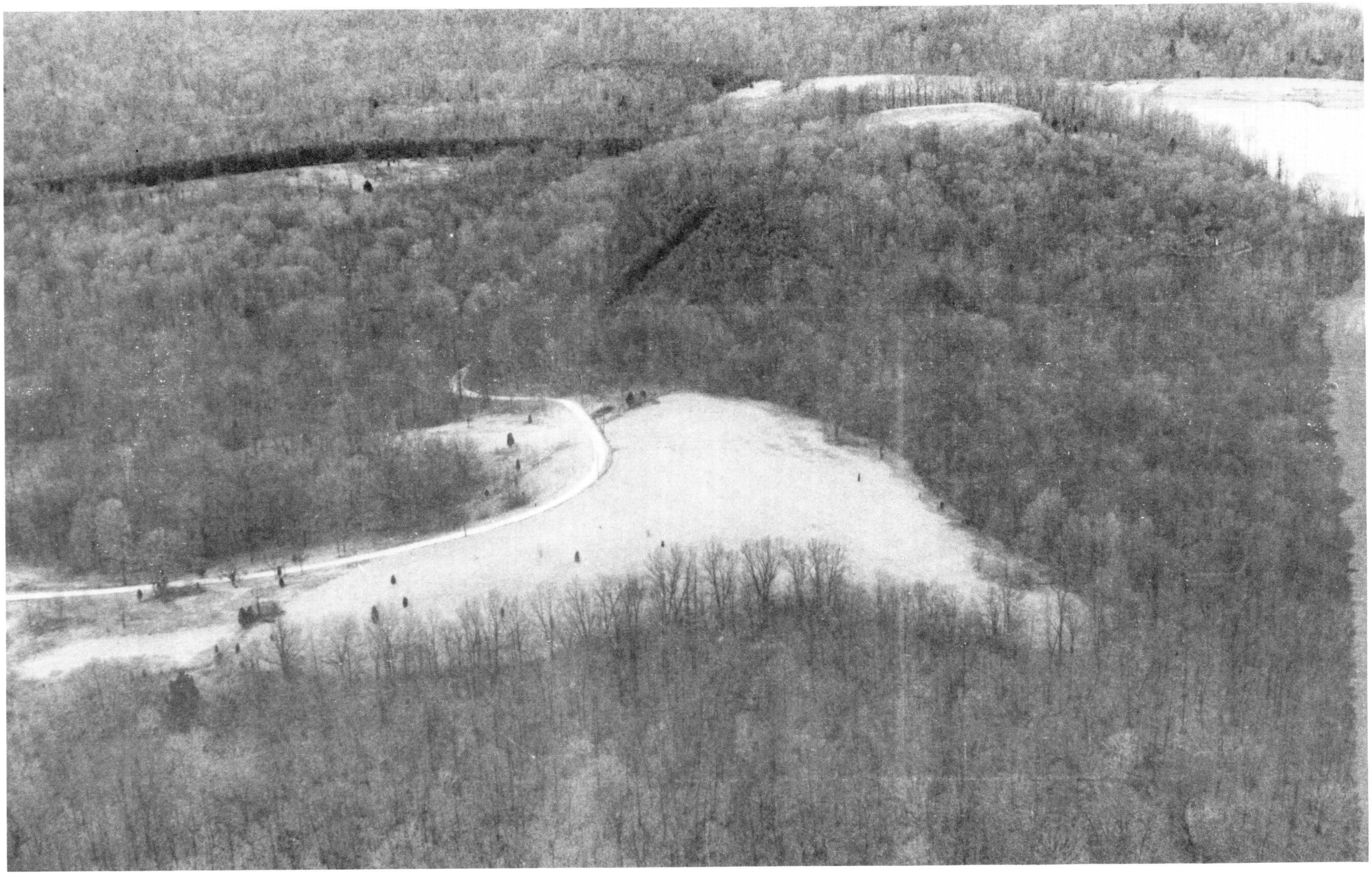


PLATE 2. CENTRAL DEVELOPMENT AREA

Plate 2. Central Development Area

The main flat-topped, narrow ridge with slopes to the east and west is shown in this north looking view. The Seeber easement road runs along the western edge of the field. Siltstone is the predominant sub-surface material. Wellston silt loam is found on the open, more level areas while the Berks-Weikert soils complex occupies sideslopes in the foreground. The open area may contain an archeological site.

Old-field community A-3 lies near the center of the photograph. Forest community Area D-2 is enclosed in the large curve of the road. Forest community Area D-1 occupies most of the area just above D-2. Pine plantation community F-1 is the dark, even-appearing forested area just above old field community A-3 and is divided diagonally by the road. The row of pines (dark trees) in the upper left portion of the photograph is not on the camp property. (Refer to Fig. 8.)

The old field is the most environmentally suitable area for intensive development. The most suitable location for cabins is just southwest of the pine plantation, although most of the other areas immediately adjacent to the field are also suitable.

Site Development Alternatives

Many of the impacts of the Alumni Family Camp development on land resources depend on where the various structures and functions of the camp are located. Potentially severe impacts on the natural environment can be alleviated to a great extent by judicious site planning. Conversely, the success of the camp as a recreational development can be significantly inhibited by soils and, to a lesser extent, by terrestrial biotic communities if the implications of these factors are ignored.

In the following sections, environmental considerations related to site development alternatives are discussed. Some initial generalizations with respect to the relative suitabilities of different areas of the camp site for various modes of recreational development are drawn from the results of the Lake Monroe Land Suitability Model. Then, the more specific surveys of camp site soils and of terrestrial ecology given in the preceding part of this assessment are each used to generate more specific siting suggestions. Finally, the two sets of suggestions based on soils and ecological information are synthesized to formulate more broadly based environmental siting guidelines; limitations on the validity of these guidelines are discussed.

Results of the Lake Monroe Land Suitability Model

In the initial stages of the site planning process, before any specific environmental site surveys are analyzed, it is useful to be able to make some generalizations as to potential environmental constraints on the location of project structures. These generalizations could hardly be expected to be the sole basis for formulation of a site plan, but they can be of assistance in indicating areas where research at a finer resolution is needed.

The Lake Monroe Land Suitability Model was developed to provide such generalizations for the land around Lake Monroe. On the basis of environmental criteria, the model provides quantitative ratings of parcels of land for suitability for a number of modes of development. The environmental criteria used are the presence of floodplains, slope (as a predictor of soil type), current land-use types, road distance to Bloomington, and distance to the nearest access road. Values for these variables are obtained from the data inventory assembled in 1974 for the Lake Monroe Land Suitability Study. The land parcels that can be evaluated by the model are the ten-acre cells depicted on Maps 3 and 4 (inside back cover). Modes of development relevant to this study include intensive and extensive recreation, paths and trails, and wilderness (lack of development). The model mechanism is further described, along with the means of access to the model, by Chiesa and Randolph (1976).

The model was run for the Alumni Family Camp site for each of the relevant modes of development. An analysis of the model results indicated that the critical factors for camp development were the slope-soil variable and the land-use variable (which indicates the presence of forests), as there are no floodplains on the site and the distance variables do not vary significantly from cell to cell.

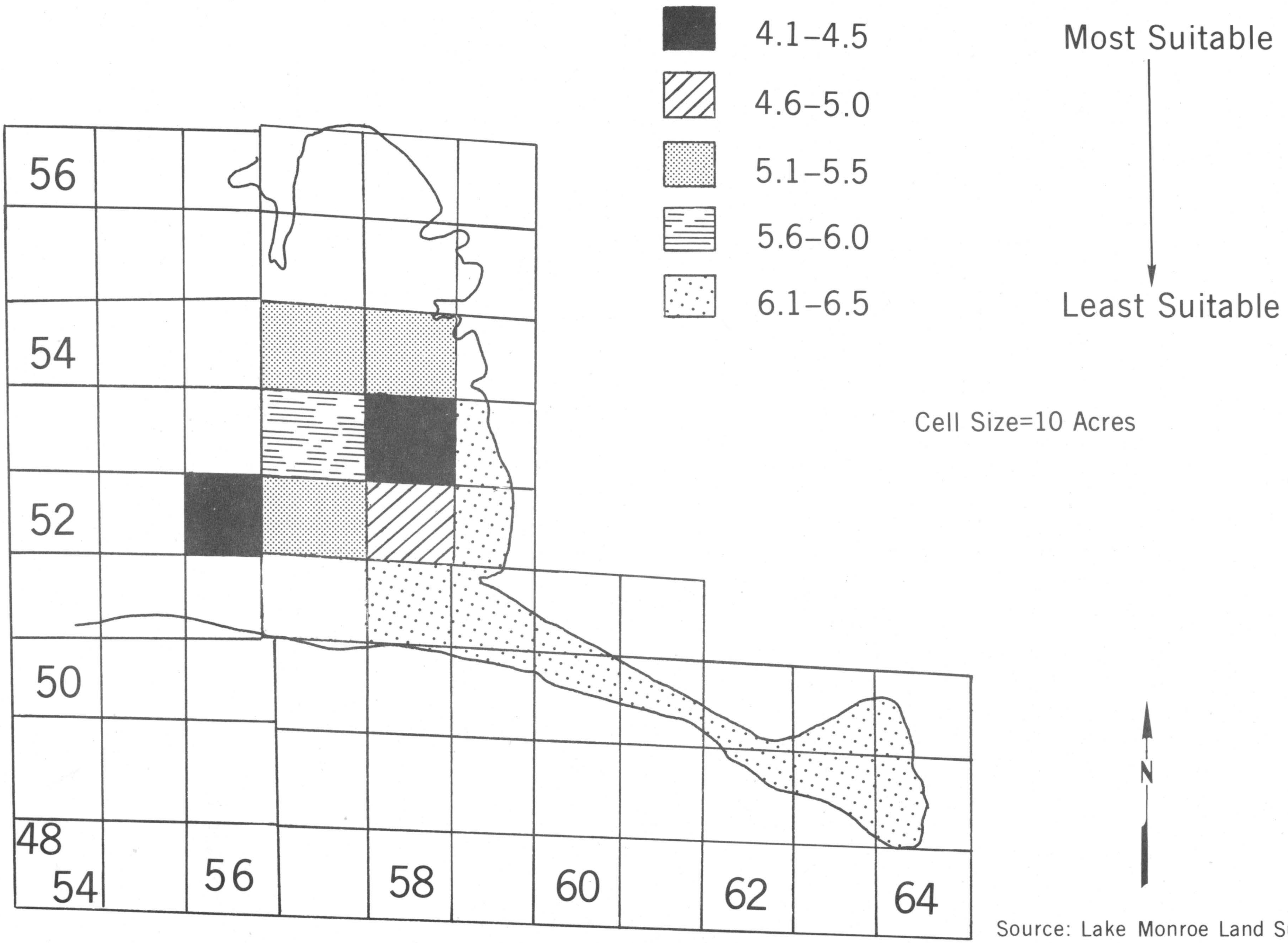
A suitability map for one of the developmental modes, intensive recreation (active play areas), is depicted in Fig. 13. Cells along the lake shore are rated unsuitable for intensive recreation due to both steep slopes and incompatibility of intensive recreation with the current land use (forest). The most suitable portions of the camp site are Cells (58,52) and (58,53), where slope is still somewhat limiting but where current land use (abandoned cropland) is environmentally compatible with intensive recreation, and Cell (56,52), where neither land use nor slope are limiting. When the results of the model for all relevant modes of development are considered, Cells (58,52) and (58,53) are found to be the most suitable for intensive recreation relative to other uses. Of the remainder of the site, Cells (56,52), (57,52), and (58,54) have the highest relative suitability ratings for uses requiring less intensive development. According to the model, the cells along the lake shore are generally unsuitable for any sort of development.

The low resolution of both the input to and the output from the model renders the results of the model unusable in the formulation of a final site plan. However, the model does provide some generalizations useful in the preparation of environmental guidelines within which the final site plan should be formulated. In this case, the model points out the importance of soils and slope and of forested areas as potential environmental limitations on development. The model also demonstrates that limitations from these two factors vary over the camp site interior, and suggests that a location with an optimal combination of both factors is likely to be the most suitable for the most intensively developed uses. Limitations imposed by the two critical factors of soils and terrestrial ecology are now explored more fully on the basis of information offered in the previous part of this assessment. These are then combined to synthesize environmental guidelines for planning of the camp site.

Implications of Soils for Site Development

Erosion and other negative impacts of the camp development on soils, as well as negative effects soils can have on the structural integrity of the camp, can be avoided or at least greatly reduced through careful location of camp structures and activities. In Table 26, limitations imposed by the various camp site soil series for several developmental activities are summarized. Limitations are identified qualitatively as either "slight," "moderate," or "severe" by the U.S. Soil Conservation Service. If soil limitations are "slight," the facility under consideration is easily erected, improved, or maintained, and there are few or no limitations affecting the intended use. "Moderate" soil limitations result from the effects of slope, soil texture, depth, wetness, stones, or plant growth deficiencies. These limiting factors can usually be mitigated through careful design and management. "Severe" soil limitations, caused by unfavorable soil texture, acidity, steep slopes, or large numbers of stones or rocks, render questionable the practicability of establishing the recreation facility under consideration on that soil series. Extreme

FIGURE 13 SUITABILITY FOR INTENSIVE RECREATION



Source: Lake Monroe Land Suitability Model

Table 26. Soil Limitations for Camp Development and Operation

Septic Tank Absorption Fields			Shallow Excavations			Cottages and Small Buildings			Tent and Camp Trailer Sites			Bridle Paths and Nature and Hiking Trails			Athletic Fields Intensive Play	
Slope	Limitation	Limiting Factor	Slope	Limitation	Limiting Factor	Slope	Limitation	Limiting Factor	Slope	Limitation	Limiting Factor	Slope	Limitation	Limiting Factor	Slope	Limitation
0-15%	Severe	depth to bedrock	0-15%	Severe	depth to bedrock	0-15%	Moderate	depth to bedrock	0-15%	Moderate	large stones	0-25%	Moderate	large stones	0- 6%	Severe
>15%	Severe	slope	>15%	Severe	slope	>15%	Severe	slope	>15%	Severe	slope	>25%	Severe	slope	> 6%	Severe
0-15%	Severe	depth to bedrock	0-15%	Severe	depth to bedrock	0- 8%	Moderate	large stones	0-15%	Moderate	large stones	0-25%	Moderate	large stones	0- 6%	Severe
>15%	Severe	depth to bedrock slope	>15%	Severe	depth to bedrock slope	8-15%	Moderate	large stones slope	>15%	Severe	slope	>25%	Severe	slope	> 6%	Severe
						>15%	Severe	slope								
0-15%	Moderate	depth to bedrock	0-15%	Moderate	depth to bedrock	0- 8%	Slight		0- 8%	Slight		0-15%	Slight		0- 2%	Slight
>15%	Severe	slope	>15%	Severe	slope	8-15%	Moderate	slope	8-15%	Moderate	slope	15-25%	Moderate	slope	2- 6%	Moderate
						>15%	Severe	slope	>15%	Severe	slope	>25%	Severe	slope	> 6%	Severe
0- 8%	Moderate	depth to bedrock	0- 8%	Moderate	depth to bedrock exces-sive clay	0- 8%	Moderate	low strength	0- 8%	Severe	erosion exces-sive clay	0-15%	Moderate Severe	exces-sive clay erosion	0- 2%	Slight
8-15%	Moderate	depth to bedrock slope	8-15%	Moderate	depth to bedrock slope exces-sive clay	8-15%	Moderate	slope low strength	8-15%	Moderate Severe	slope exces-sive clay erosion	15-25%	Moderate Severe	slope erosion exces-sive clay	2- 6%	Moderate Severe
>15%	Severe	slope	>15%	Severe	slope	>15%	Severe	slope	>15%	Severe	slope	>25%	Severe	slope	> 6%	Severe

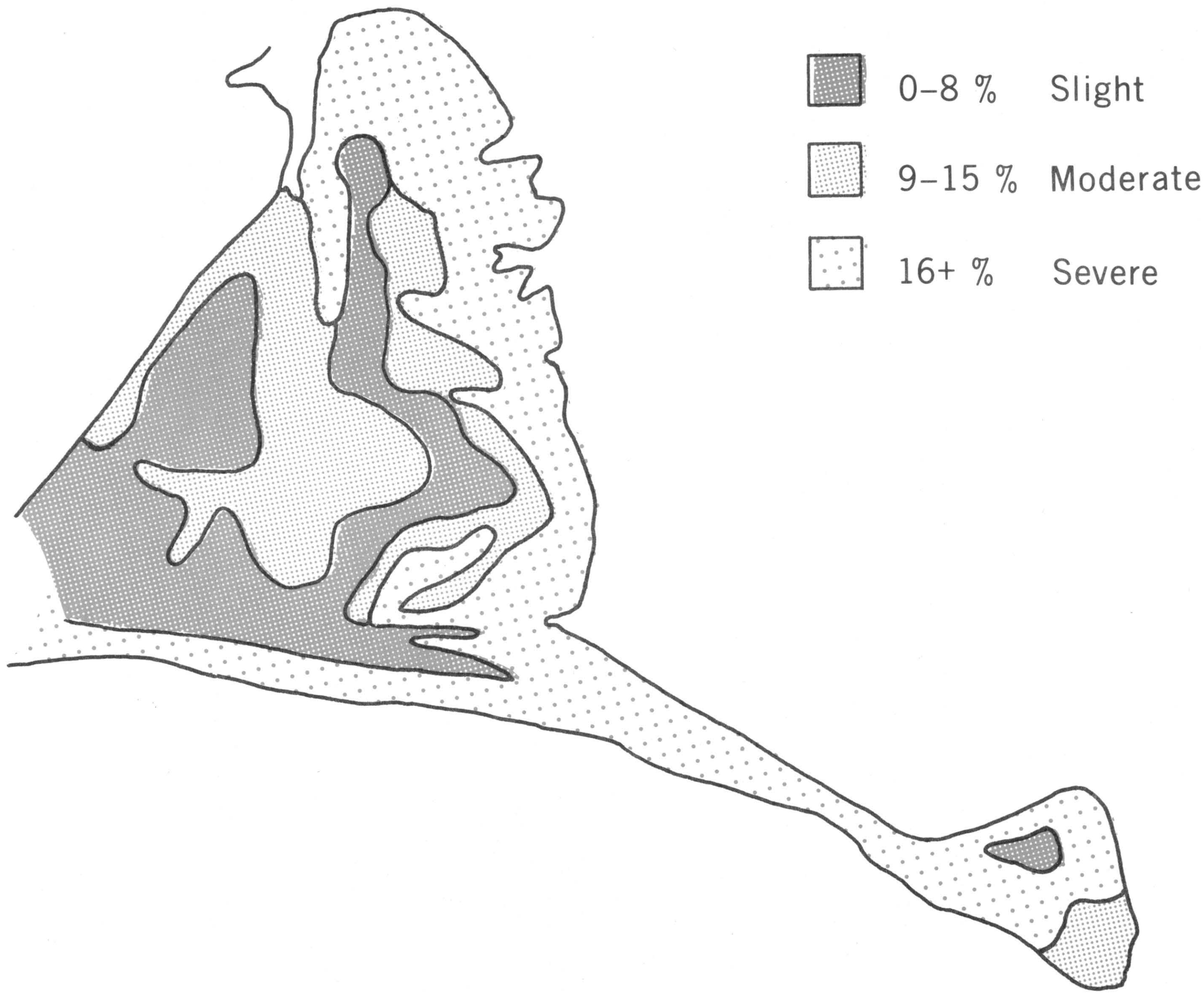
measures are frequently needed to overcome severe limitations, implying that usage is generally unsound or not practical. In the following pages, the geographical distribution of limitations imposed by soils on various types of recreational development on the camp site is discussed. Information is drawn from the Soil Conservation Service's current Monroe County soil survey.

Important soil features that should be considered with respect to seasonal or year-round cottages, washrooms, picnic shelters, and service buildings are slope, stoniness, depth to hard bedrock, shrink-swell potential, frost potential, hillside slippage, bearing capacity, and natural drainage. Suitability of soils for supporting vegetation and for underground utilities, if planned, should also be considered.

The Gilpin and Wellston soils on favorable slopes (<15%), are suitable areas for cabins or small buildings. Other locations on the site generally exhibit too great a slope, stoniness, or low strength conditions. Figure 14 is a suitability map for cottages and utility buildings drawn on the basis of soils.

Although the Alumni Association does not currently intend to provide tent and camp trailer sites, the suitability of such soils is evaluated here for possible future reference. Camping sites and the accompanying activities of outdoor living should be located on soils suitable for unsurfaced parking of camper trucks and trailers as well as heavy foot and vehicular traffic. Campsites that are suitable for either tents or trailers should be located on nearly level, relatively deep, well drained soils that are free of stones.

FIGURE 14 SOILS AND SLOPE LIMITATIONS FOR COTTAGES AND SMALL BUILDINGS



The soils should not be slippery when wet and their vegetative cover should be easy to maintain. Other factors considered should include hazards of wetness, permeability, micro-slopes, and surface soil texture.

Much of the site is characterized by slopes that would restrict campsites. Stoniness is prevalent and unfavorable in many places. The silty surface soils are occasionally slippery when wet. The nearly level Wellston soils afford the greatest potential for campsite development.

Playgrounds, athletic fields, and intensive play areas are subject to relatively heavy foot traffic. Such areas should be nearly level with no rocks, stones, or gravel on the soil surface and should be well drained, with a soil texture and consistency that provides a firm surface and a moderate or moderately high permeability. Soils should support the establishment and maintenance of good vegetative cover where needed.

There are relatively few satisfactory areas on the site that offer slight limitations for this use (Fig. 15). Small stones are present in many areas, soils have excessive clay, and steep slopes make siting playground areas difficult. Two locations on the major north-south ridge top with less than 2% slope on Wellston silt loam may offer suitable locations for intensive playground development. The moderate permeability in these areas is also favorable.

Criteria for determining limitations of soils for bridle paths and nature and hiking trails include soil texture, natural drainage, flood and erosion hazards, and the presence of stones. The most desirable soils for bridle paths and trails are well drained, have loamy texture, and are nearly level to sloping. They also have good stability, are not subject to erosion, and are free of coarse fragments, stones, or rock outcrops. Variability in slope gradient may serve to enhance interest, but over long distances steep gradients are usually not satisfactory for trails, as most users prefer slopes of less than 12%. Where slopes are steep, the paths can be placed on or near contour lines to prevent excessive erosion. A trail with excessive gradient could be the beginning of a gully if not properly maintained.

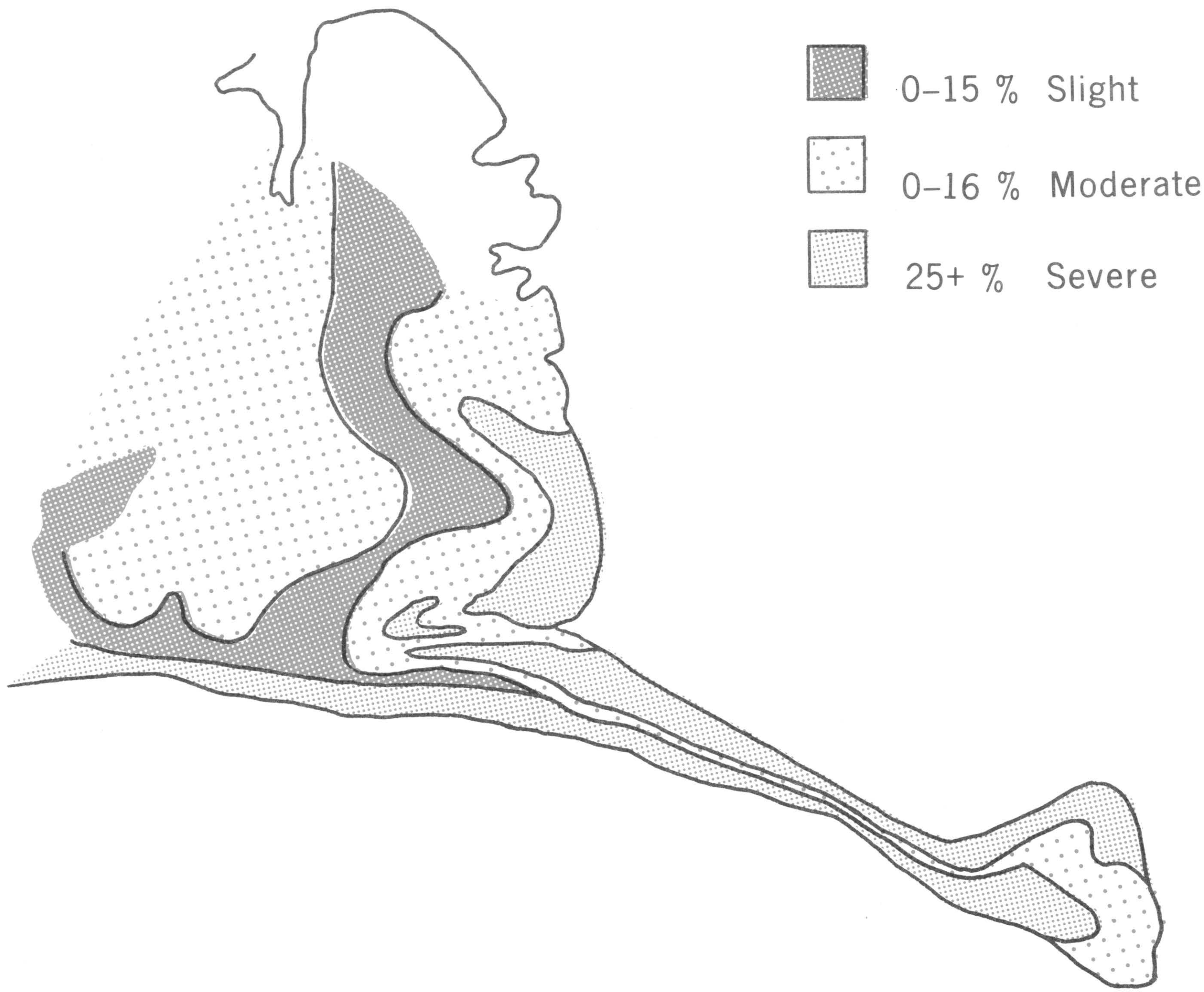
Hagerstown soils are rather clayey and thus become slippery and remain wet after rains. Gilpin and Berks-Weikert soils are stony and present hazards on steeply sloping soils used for foot trails. Wellston silt loam soils, found on the main ridge and sideslopes, would be the most favorable on which to develop and maintain trails. Slopes greater than 25% present severe limitations, regardless of soil type. Figure 16 designates areas where soils limit the development of paths and trails.

While not related to any of the particular types of recreational development mentioned above, there are a few additional groups of soil characteristics not discussed above that can impose limitations on construction work of a more general nature. While not explicitly analyzed in the geographical sense here, these characteristics do have implications for site planning that should be explored further before plans are finalized. These characteristics are summarized below.

Several soil properties may affect the cost of installation and length of service associated with buried pipes, metal conduits, and

FIGURE 15 SOILS AND SLOPE LIMITATIONS FOR INTENSIVE PLAY AREAS

FIGURE 16 SOILS AND SLOPE LIMITATIONS FOR BRIDLE PATHS AND NATURE AND HIKING TRAILS



concrete. Shallow soil depth to hard rock in some areas of the site will directly affect costs of excavating trenches. Hard rock fragments in the soil and backfill material could damage protective pipe coatings. Concrete or steel footings and pipes constructed within the area subsoils are subject to varying degrees of corrosion. Potential corrosivity ratings for steel, attributed to soil texture, carbonate, and moisture factors are generally low. The corrosion of concrete is mainly a chemical exchange between acid soil compounds and the alkaline compounds of which concrete is made. (The soils, of course, must be moist for corrosion to occur.) All soils in the interior of the camp have a high potential for corrosion of concrete placed in the subsoil. The probability of concrete corrosion will depend on the soil layer in which it is buried and on the type of concrete used.

The plasticity index is defined as the numerical difference between the relative moisture level at which a soil passes from a plastic content to a liquid state and the moisture content at which a soil changes from a semisolid to a plastic state. A low plasticity index, as low as 4 as in Gilpin soils, indicates that a small increase in moisture content will change the soil from a semisolid to a liquid condition. A high plasticity, as high as 25 in the Hagerstown-Caneyville series, means that considerable water can be added before the soil becomes liquid (see Table 6).

The potential frost action of a soil indicates its proclivity to raise its surface due to the accumulation of ice within the soil. All soils on the site exhibit a moderate potential for frost action except for the steeper Berks-Weikert soils, which have only a low potential.

Most soil materials on the site possess sufficient cohesiveness to stand during shallow excavation work. However, in one nearby area (two miles northeast of the study site in Section 23 of Salt Creek Township), landslides have been a problem along the east valley wall of the North Fork of Lake Monroe. Land slips in this area are numerous and have destroyed about 200 feet of a gravel roadway. The slides in this area occurred from slippage of the soil mass either at the bedrock surface or along a clay zone. Minor slippage could occur on the steep Berks-Weikert soils depending upon the nature of construction.

Implications of Terrestrial Ecology for Site Development

As in the case of soils, while it is inevitable that development will exert some adverse impacts on biotic communities, these can be minimized if environmental considerations are part of the site planning process. For example, to the extent that construction of such elements as parking lots, athletic fields, courts, and the swimming pool can be limited to the presently open grassy areas (especially Area A-3, Fig. 8), the ecological community dynamics of the area as a whole will be least disrupted, although grass and old-field flowering plants will be displaced.

If the family cabin units are not to be air conditioned, they will probably have to be placed in the shade of trees in order to be habitable. Both level and sloping forested land may thus be considered as locations for the cabins. Road cuts for construction equipment and for permanent service roads may require removal of several trees; roads into sloping areas will probably demand more space due to the cutting of contours. The cabins themselves should displace few trees, or the objective of having them in the shade will be defeated. One level area suitable for cabins is that consisting of the pine plantation (Area F-1) and the immediately surrounding areas (except for B-4 and the steep portion of D-1 to the northwest). However, the pines may not be tall enough to supply sufficient shade and the grove may be too dense to allow free motion of cooling evening breezes.

One forest not recommended for siting of cabins is the old beech grove (Area E-1) along the southern edge of the property. The trees have many dead and structurally unsound limbs that could fall on cabins. Identification and removal of such limbs would be a difficult task and would destroy wildlife habitat, which these dead or aging and often hollow structures provide. Another area that should not be used for cabins is the peninsula, where they may disturb the movement patterns of such sensitive animals as deer and foxes, even in the off-season.

A likely site for the caretaker's residence is at the southwestern corner of the property (Area B-1). There, some brushland habitat will be removed for the house site and more may be converted to a conventionally sized lawn. Overall community impacts will be minimized by building the caretaker's residence close to the main road into the camp property.

Synthesis of Environmental Implications

Ecological and soils information given in the previous two sections and in the preceding part of this assessment can now be used to synthesize some overall environmental constraints within which a final site plan should be devised.

As shown in Fig. 15, almost all of the camp is unsuitable for intensive recreation. The only area that exhibits only slight to moderate limitations due to slope and soils, is not within a forest, and is big enough for, say, a ball diamond, is the centrally located old field (Area A-3, Fig. 8; Plate 2). The same considerations make the field a suitable area for the program center and swimming pool, allowing all intensively developed uses to be centralized there. Tennis courts may either be combined with these facilities or extended into Area B-3, although care should be taken to avoid the *Ambystoma* breeding pond in planning such areas; the pond has value as a unique habitat (Fig. 9). Tennis courts could also be located immediately west of the pine plantation, but this would result in the destruction of forest and the preemption of the prime site for cabin placement.

While that portion of Area D-1 just southwest of Area F-1 (Fig. 8), i.e., the area between the pine plantation and the nearby ravine, may be an ideal location for the cabins, it is rather small. Much of the rest of the site interior is suitable for cabins, with some limitations imposed by slopes and soils (Fig. 14), including most of Area D-1, all of Area D-2, and the less steep (inner) parts of Area D-3. The latter area also has the advantage of being close to the lake. Though suitable on the basis of soils and slopes, Area E-1 should be avoided for reasons stated in the preceding section. Although blocks of cabins should be kept off the camp site peninsula, the summit of the peninsula would be a suitable location for a small shelter.

Nature and hiking trails are fairly compatible with wilderness. Only the steepest slopes along the lake shore are unsuitable for these (Fig. 16).

Of course, the site must be more carefully investigated before a final site plan is evolved. This is especially true with respect to soils considerations. While the vegetation maps (Figs. 8 and 9) presented within this assessment posssess as much detail as would ever be needed, the soils and slope maps must be redone at a higher level of resolution following detailed on-site topographic and soil surveys by qualified engineers. The U.S. Soil Conservation Service, on whose survey Figs. 14 to 16 are based, cautions against using its information as the sole source of data on soils when planning a site. Areas classified in this assessment as having "moderate" limitations probably include localities where limitations are actually slight or severe. Also, before final decisions are made with respect to the location of such major structures as the program center, a detailed map of depth to bedrock should be prepared. As shown in Fig. 5, this parameter varies widely over short distances. However, the lack of high-resolution data does not invalidate the environmental guidelines presented in this assessment. They may need to be refined somewhat with respect to the specific boundaries of the areas to which they apply, but within those refined areas, they should still be followed.

Sewage Treatment Alternatives

The Lake Monroe area is, of course, most noted for its water resources. Because of the importance of the lake as a recreational resource, as a drinking water supply, and as a habitat for aquatic life, potential impacts of the Alumni Family Camp development on the water quality of the lake must be evaluated carefully. Because the method of sewage treatment used by the camp can have important implications for water quality, and because no final decision has been reached as to which method to employ at the camp, an environmental evaluation of several sewage treatment alternatives is given in the following sections. While water quality is the most important factor to be considered in such an evaluation, sewage treatment can have other environmental impacts that vary with the alternative employed, and these are also taken into account in the evaluation below.

The environmental evaluation given in this assessment is not intended as a substitute for a detailed engineering analysis of sewage treatment alternatives. The objective here is to examine several fairly different approaches to sewage treatment from a strictly environmental point of view. The engineering feasibility of any specific option within these alternatives, the design specifications for such an option, and a detailed comparative analysis of the cost-effectiveness of the various alternatives are all beyond the scope of this assessment.

Alternatives

Four alternative methods of sewage treatment are considered. These are hauling of wastewater to a treatment plant in Bloomington, installation of a biological package treatment plant at the camp site, installation of a physical/chemical plant, and installation of a composting system for raw sewage and a filter treatment system for wash water.

Hauling merely involves the installation of a wastewater collection tank and the purchase of a tanker truck or contracting with the owner of such a truck so that the contents of the collection tank can be emptied into the truck and transported to one of Bloomington's municipal sewage treatment plants. Assuming an average daily wastewater flow of 15,000 gallons, three trips per day would be required by the largest trucks available to service the tank (data modified from McFadzean, Everly and Assoc., 1976).

A biological package plant is a small installation utilizing physical and biological methods to convert wastewater into an effluent of high enough quality to be discharged into natural waters. A typical plant would consist of a grinder, a bar screen, an aeration tank, a settling tank, and a chlorine contact tank or other method of disinfection. While biological treatment is able to reduce biological oxygen demand (BOD) and suspended solids to acceptable levels, it is not very helpful in reducing phosphorus concentrations. Because phosphorus is of critical concern in Lake Monroe, it would be necessary to supplement biological treatment with some chemical means of phosphorus removal.

A physical/chemical package plant is a small installation like the biological plant, but one that replaces the biological components of the treatment process (the aeration and settling tanks) with chemical means for the removal of BOD and suspended solids. In addition, phosphorus reductions of up to 98% can be achieved.

There are various composting systems available. The one discussed in this assessment is the Clivus Multrum (manufactured by Clivus Multrum USA, Inc.). The Clivus is a tank in which human wastes and organic kitchen garbage are decomposed aerobically to yield a compost that can either be used as such or hauled to a landfill. One Clivus tank is used for each toilet. The Clivus does not accept large volumes of liquid, so waterless toilets must be used, and water used in showers, in the swimming pool, in food preparation, and for laundry needs (collectively referred to as "gray water") must be treated separately. As BOD and suspended solids levels are much lower in gray water than in water heavily laden with organic wastes, a filtration system is sufficient to treat it. A peat bed filter is considered for illustrative purposes in this assessment. Available information indicates that abiotic filters, which are advantageous in other respects, are unable to remove soluble BOD. Evaporation ponds were also considered as a means of gray water treatment, but it was found that net evaporation rates were too low in the Lake Monroe area for ponds of practicable size to be effective.

Septic tank systems for sewage treatment, even for the caretaker's residence, are not considered as an alternative. Septic tank systems require at least four feet of soil beneath the septic field trenches to allow adequate soil filtration of the effluent. Due to the shallowness of the soils, it would be difficult to locate an area in the camp site where septic tank construction and use could occur. Slopes greater than 15% present additional problems to the use of septic tanks because the downslope flow of effluent would be hard to control (USDA, 1975b). This is especially critical because of the proximity of Lake Monroe and of major drainage channels flowing into the lake. These reasons, plus legal constraints on septic tank field size and location in the Lake Monroe watershed, preclude the use of septic tanks at the camp site.

Impacts on Water Quality

Importance of phosphorus. All of the treatment alternatives except hauling result in the discharge into Lake Monroe of an effluent with low levels of BOD, suspended solids, phosphorus, and other potential pollutants. Several recent studies indicate that it is phosphorus, however, which is of critical concern. Frey (1976) summarized the nutrient limitation experiments conducted by

Richard H. Hall of Procter and Gamble Co., Cincinnati, in September 1973. In all samples put through the Algal Assay Procedure (AAP) Bottle Test (Bartsh, 1971), single additions of either nitrogen, trace metals, or nitrilotriacetic acid resulted in no stimulation over the control. However, the addition of phosphate by itself increased the concentration of algae by about two orders of magnitude. Dr. Hall concluded that phosphorus was the limiting factor in his analysis.

The U.S. Environmental Protection Agency National Eutrophication Survey collected samples from the lake on May 10, 1973. The results of the Algal Assay Procedure Bottle Test indicated that phosphorus was the limiting nutrient at the time the assay samples were collected, and other data suggested phosphorus limitation at all sampling times.

The impact of increased nutrient loading rates into Lake Monroe would be minimized if biologically available phosphorus inputs can be controlled. Because the existing point source contributions constitute approximately 21% of the total phosphorus reaching the lake annually (U.S. EPA National Eutrophication Survey, 1976), it is extremely important for preserving the existing water quality that point source contributions of phosphorus be reduced as much as possible (Frey, 1976).

Potential effects of treated effluent on Lake Monroe. Water quality in the immediate vicinity of the effluent discharge point of the Alumni Family Camp sewage treatment system may be adversely affected through the local increment in suspended solids, BOD, phosphorus and other nutrients, and chlorine.

Suspended solids from the effluent will probably increase local turbidity, thus decreasing light penetration. In this event, the ability of submersed aquatic macrophytes and algae to photosynthesize would be decreased. During slow-flow conditions in the summer, the solid particles would settle out. These particles can clog the opercular cavities and gill filaments of fish dwelling near the lake bottom

(Consoer, Townsend & Associates and Morris, 1976). Settling of particles could also smother benthic insect larvae.

Any deficiency in oxygen due to increased BOD near the effluent outfall could increase the physiological stress on certain desirable fish species to the point where their tolerance limits to other physical environmental factors lessen. This may eliminate the area surrounding the outfall as a habitat for these species.

As phosphorus is the limiting factor on biological productivity in Lake Monroe, a bloom of surface algae may be expected to occur in the vicinity of the effluent discharge point. Light penetration in the area, already decreased due to higher levels of suspended solids, may be further reduced by the surface bloom, thus possibly causing partial diebacks of submersed algae and macrophytes. Decomposition of the latter and of the additional algae in the surface bloom once they die off could lead to anoxic conditions near the lake bottom having the effects on fish described above.

An increase of nutrients such as phosphorus and nitrogen could also cause compositional changes in the biota in the area surrounding the outfall. In phosphorus-limited systems such as Lake Monroe, sewage effluents that normally contain very high proportions of phosphorus can stimulate photosynthesis until nitrogen becomes the limiting factor. Then the relatively unobtrusive green algae and diatoms that are incapable of using atmospheric nitrogen directly are eliminated, and the noxious, nitrogen-fixing blue-green algae predominate (Wetzel, 1975). Such floral changes can result in faunal changes farther up the food web.

Chlorination of the effluent before discharge can be detrimental to aquatic life in the vicinity of the effluent outfall due to the production of toxic chlorinated organic compounds from the reaction of chlorine with the organics remaining in the treated effluent.

While the impacts noted above will probably occur regardless of where the effluent discharge point is located, certain site-specific effects can be expected in addition. From topographic considerations, there would appear to be two alternative outfall areas available. The first of these is the cove to the north of the site, and the second is the eastern shore of the site near the old Salt Creek channel.

An outfall line running northward from the site should extend into the main body of the cove, as the southern arm of the cove is dry except during spring and following storms. Even the main portion of the cove, however, is shallow and narrow and thus likely to be close to stagnant in the summer when flow of the open water in the North Fork is generally very slow. If no circulation were to occur at all between the cove and the remainder of the North Fork during the camp's operating period, the average phosphorus concentration in the cove would increase by 20 μg/l, far above the increment needed for tripling of carbon uptake by the algae in Frey's (1976) experiments. Of course, some mixing certainly occurs between the cove and North Fork waters, and it is scientifically unsound to apply Frey's results in a quantitative fashion to just any given situation in the lake. However, it is a safe conjecture that the cove is small and still enough that the effluent from the camp will probably increase the concentration of algae within the cove. Thus, by placing the effluent discharge point within such a small embayment, adverse biological effects may occur outside the immediate vicinity of the outfall itself.

In addition to the impacts exerted on truly aquatic species, if the discharge point is located in one of the marshy areas of the cove, the chlorine is likely to adversely effect such amphibious animals as bullfrogs, turtles, water snakes, herons, rails, and muskrats in the vicinity of the outfall. The amphibious biota of the entire cove may be affected by any modification of the food web caused by changes in algal species composition as a result of nutrient loading from the sewage treatment plant.

Special problems may also be encountered in locating the effluent discharge point near the old Salt Creek channel. This area east of the camp site does have the advantage of being a large, open water area with some circulation almost all the time. In the channel itself, however, dissolved oxygen concentrations can at times in summer and autumn be suboptimal, especially for fish. The effluent could only worsen this condition, especially at night when the induced higher concentrations of algae near the surface are respiring in the absence of photosynthesis.

Comparative evaluation of alternatives. The discharge from all three effluent-producing alternatives will have to meet state standards. These standards vary from case to case and will not be set for the Alumni Family Camp development until a specific sewage treatment plan is presented to the Indiana Stream Pollution Control Board. However, it is likely that the state will not allow BOD and suspended solids to be present in the effluent in concentrations greater than 12 ppm as a monthly average each (Skomp, 1977). While phosphorus limitations are not automatically placed on plants yielding less than 10 lbs/day, it is assumed that the state will impose such a standard in this case in recognition of the importance of phosphorus as a limiting nutrient in Lake Monroe. If a phosphorus limitation is imposed, it will apparently be at 1 ppm (ISPCB, 1977). (If the state does not set such a standard, the developers should meet the standard voluntarily in the interests of preserving the aquatic enivornment.)

Thus, state standards would require that the expected typical levels of 225 ppm of BOD and 11 ppm of phosphorus in the camp wastewater be reduced by 95% and 91%, respectively. Package plants can meet these specifications. The 88% removal rate that would be required of peat bed filters to reduce gray water phosphorus levels (typically 8 or 9 ppm) to the state standard is also within the capabilities of most peat beds. As even relatively inefficient peat beds can achieve 95% of BOD removal, the BOD concentration in the peat bed effluent should also be at least as low as the state standard (gray water data from Fogel and Lindstrom, 1976; peat bed data from Parrott and Boelter, 1977). Gray water discharge from the camp is expected to be about 12,000 gallons per day (modified from McFadzean, Everly and Assoc., 1976), or only about two-thirds the volume discharged when flush toilets are used. Thus, the Clivus/gray water system would result in substantially less total input of BOD and phosphorus to the lake.

While decreases in the quantity of effluent discharged are desirable, most of the local impacts on water quality described above are likely to occur even if the Clivus/peat filter system is used, though they may be mitigated to some degree. From the point of view of water quality, therefore, the most environmentally sound sewage treatment alternative is hauling, which results in no effluent to the lake at all. (Hauling does eventually result in an effluent, of course, but that is discharged into creeks where water quality is determined to a great extent by the effluent already being discharged into them.)

Nevertheless, the discharge into the lake of an effluent of the quality and volume yielded by the peat bed or even by the package plants should be regarded as an environmentally irresponsible option. In order to acquire a regional perspective, a comparison of various point sources of phosphorus input to the lake may be helpful.

The U.S. Environmental Protection Agency National Eutrophication Survey estimated the annual total phosphorus loading of the known domestic sewage treatment plants discharging into the Lake Monroe watershed in 1976 (Table 27).

Table 27. Phosphorus Discharges of Sewage Treatment Plants into the Lake Monroe Watershed, 1976

Source	Discharge (kg P/yr)
Nashville	1,810
Fairfax Recreation Area	265
Hardin Ridge Recreation Area	5
Ransburg Boy Scout Camp	10
Paynetown Recreation Area	265
Hardin Monroe Division	115

By comparison to the figures in Table 27, the Alumni Family Camp sewage treatment system is expected to yield 5.1 kg P/yr. This amount should not simply be dismissed as relatively trivial, as a comparison of the relative nutrient contribution of the camp requires knowledge of the location and duration of discharge of the other sources.

With the exception of Nashville, all of the existing sewage treatment plants discharge below the causeway. The condition of summer stratification in the middle and lower basins creates a large volume of water, approximately one-third the total conservation pool volume, which is excluded from normal circulation processes (Frey, 1976). Entrapment of discharged nutrients in the hypolimnion (below the mixing zone) would decrease their availability in the trophogenic zone of the lake. Because of th shallowness of the upper basin, thermal stratification occurs only during the first half of the summer. For the remainder of the summer, discharged nutrients would be distributed throughout the water column, thereby creating the possibility of more rapid phytoplankton response.

It is thus more proper to consider inputs to the upper basin separately. The only present point-source input to the upper basin is that from the Nashville sewage treatment plant. Unlike the other facilities, the Nashville sewage treatment plant operates year round. Therefore, only a portion of the seemingly large phosphorus discharge would be available during the productive season. In addition, dilution of Nashville's effluent in the North Fork of Salt Creek alleviates some of its impact on the local area where the creek joins the upper basin. For instance, between October 2, 1974, and April 29, 1974, the arithmetic mean of soluble reactive phosphorus decreased from 40.5 $\mu g/l$ a couple of kilometers below the Nashville plant to 6.1 $\mu g/l$ near Belmont.

Even if all the above caveats are taken into consideration--if all inputs below the causeway are subtracted out, if only the summer portion of the Nashville input is considered, and if that is decreased by as much as 50% to allow for assimilation with the North Fork of Salt Creek--the Alumni Family Camp package plant would be responsible for only a 2% increment in total point-source phosphorus loading into the upper basin of Lake Monroe. While the local impacts described above remain a point of concern, a 2% increase in input at the basin-wide level may be of little significance, especially when the assimilative capacities of the extensive macrophyte beds are taken into consideration.

Impacts on Land Use and Terrestrial Ecology

The major impact of the sewage treatment system on land use and terrestrial ecology is the occupation of land and consequent displacement of vegetation by the service road. Such a road would be required for all four alternatives. The hauling alternative would require the widest and most heavily trafficked road, and the peat filter the least, but these differences are probably not very significant. The hauling alternative may also require a garage, however, and that would occupy a significant quantity of land. As for the treatment system itself, a biological plant is likely to occupy more room than either a collection tank built for hauling purposes or a physical/chemical plant, but, again, this difference is not significant. The peat filter, on the other hand, will occupy substantially more land than either of the package plants. A bed 100 feet in diameter would be required to treat 12,000 gallons of gray water per day (data based on Parrott and Boelter, 1977). As it is questionable whether a parcel of land of that size and of suitable slope even exists on the site in a location sufficiently removed from the developed sections, the bed may have to be broken into several pieces, though they would have to lie reasonably close to each other for efficiency of service and wastewater distribution. The Clivus/peat system is thus the least desirable alternative in terms of impacts on land resources, and the package plants are the most desirable.

Other Environmental Impacts

The four sewage treatment alternatives differ from each other with respect to their impacts on several other aspects of the environment. Although these are generally minor in themselves, when taken together they play an important role in the alternative evaluation process.

Air pollution is a minor consideration, but hauling is obviously the least desirable from this point of view. The biological plant and the irrigation system for the peat filter are given to the production of aerosols; while the peat irrigation system is more likely to be responsible for the distribution of aerosols over a wide range, those of the biological plant will be more noxious. In any event, the impacts of such aerosols are unclear and not likely to be significant in this case.

From an aesthetic point of view, neither of the package plants should be unsightly if properly buffered, and the peat filter, despite its size, should be relatively unobtrusive in the context of the natural environment. Hauling, however, will result in significant aesthetic impacts. The relatively placid camp environment will be disturbed three times a day by the visits of a medium-sized truck. In addition, the process of emptying the collection tank into the truck may result in the emission of disagreeable odors.

One slight advantage accruing to the Clivus/peat system is that the Clivus Multrum produces an immediately useful end product. This compost can be used in gardening or, when seeded with grass, for erosion control on the site itself, or it can be sold. Utilization of wastes is an environmentally responsible activity and relates to the subsidiary educational functions of the camp.

Another relevant consideration is conservation of environmental resources, especially energy resources. Hauling would probably be the most energy-intensive alternative. The Clivus/peat system, on the other hand, only needs a minimal amount of energy to run its irrigation system. The package plants fall between the other two alternatives in energy use, with the physical/chemical requiring perhaps a little more than the biological. While the difference between the most and least energy-intensive uses is significant, the importance of energy conservation in an environmental assessment, which traditionally does not include costs already internalized, is diminished to the extent that energy savings are reflected in an analysis of cost effectiveness.

One additional disadvantage to hauling is the risk of an accident occurring, such as a spill at the loading point or a mishap on the road. While a major spill is unlikely, it could have severely detrimental local effects on land, water, and aesthetics. A truck breakdown, which is more likely, could have serious consequences for operation of the camp. Complex automatic systems such as the package plants are also subject to reliability problems of a minor order. Frequent monitoring and service can mitigate the probability of a system breakdown. The Clivus/peat system, with its heavy reliance on bioloigcal processes and few moving parts, may have the lowest risk of accident or malfunction of the four alternatives.

Overall Environmental Evaluation

Taking impacts on water and land and all other environmental considerations into account, the two most environmentally preferable sewage treatment alternatives are hauling wastewater to a plant in Bloomington for treatment and treating the wastewater on site with the Clivus Multrum/peat bed filter system. The major environmental advantage of hauling is that it does not result in discharge of effluent into Lake Monroe. Of all the environmental differences among sewage treatment alternatives, the quality and quantity of effluent produced is definitely the most important. In addition to producing an effluent, the Clivus/peat system also has the significant disadvantage of requiring a sizeable increment of land over that required by the other alternatives. However, the Clivus system has minor advantages with respect to aesthetics, energy use, end-product utility, and reliability. If a gray water treatment system could be found that was more economical of space and not disadvantageous otherwise, the Clivus system might be the most preferable alternative environmentally. With the Clivus and the peat bed taken together, though, hauling appears to be slightly preferable to the Clivus system.

The installation of a biological or physical/chemical package sewage treatment plant on the site is an environmentally less preferable option. The package plants would produce an effluent of considerably greater quantity than the Clivus/peat system, and have no significant advantages except that they occupy little space. Of the two plant types, the physical/chemical may be preferable on the basis of air quality, land use, and aesthetic considerations.

This should not be taken to mean that the package plants are environmentally unsound; it does mean that they are environmentally less desirable than hauling and the Clivus/peat system. Conceivably, other factors may persuade the developers to install a package plant at a significant, though not excessively large, expense to the environment. Other factors, however, are likely to reinforce environmental ones.

Hauling, for example, is significantly more flexible than on-site sewage treatment systems. The latter generally require some minimal level of input to function properly. If the camp is used only occasionally in the winter, this minimal level might not be maintained. Hauling, of course, can be done at any time of the year.

Perhaps the most important nonenvironmental factor is cost. This is likely to favor the Clivus/peat system heavily. The Clivus system has moderate installation costs and minimal operation and maintenance costs. The package plants require large installation costs and moderate operation and maintenance costs. Hauling involves a moderate initial capital investment, but large operation and maintenance costs, and is, in the long run, probably the most expensive of all. (Data from McFadzean, Everly and Assoc., 1976, and Clivus Multrum USA, Inc., no date.)

If a package plant is chosen as the means for sewage treatment at the camp, alternatives to chlorination as a disinfectant should be looked into. Ozonation, for example, is a more potent disinfectant than chlorine, and does not form halogenated organics as chlorination does (Winklehaus, 1977). In addition, ozonoation produces a beneficial by-produce--oxygen. However, ozonation is generally more costly than chlorination, and has no long-lived residual disinfectant effect. Other alternatives include gaseous chlorine dioxide and a dechlorination step.

While some nonenvironmental considerations are included above for general information, the above is not intended to be a general, exhaustive comparison of sewage treatment alternatives. The previous pages do constitute an environmental evaluation of selected approaches to sewage treatment that is an thorough as possible, given the current lack of any specific plans or designs for sewage treatment at the site.

Erosion and Runoff

In the following sections, impacts relating to erosion and runoff are discussed. The various types of erosion associated with rainfall and runoff are described as an introduction to a discussion of the effects the camp development is likely to have on rates of erosion. Effects of the camp on runoff and the effects of runoff on erosion are then described, followed by a section on the consequences of increased erosion and runoff for Lake Monroe. The final section offers suggestions as to measures the developers might take to mitigate the effects of the camp on erosion and runoff.

Erosion

While a number of natural forces can effect erosion, the only ones important in this context are those of water. Water detaches particles from the soil and transports the material through the effects of precipitation impact (rainsplash transport), unchanneled flow within the soil (sheet erosion), or by the formation of erosion channels (rill and gully erosion).

Rain falling directly on bare ground has a velocity of about 30 feet per second (Chow, 1964) and can move soil particles considerable distances by splashing and spattering, resulting in a net downslope transport of material in areas of high topographic relief. The amount of soil material transported can be controlled to a large extent by the presence of groundcover or dense forest canopy, which can intercept precipitation and decrease its velocity.

Sheet erosion is the uniform removal of soil over an entire soil surface. This type of erosion is not as apparent as rill and gully erosion, but is probably responsible for damaging a larger land surface (Chow, 1964). Sheet erosion probably occurs in the level upland areas of the camp site, but due to the dense vegetation cover, its effects are slight (Shaver, 1972).

Because of the high topographic relief, rill and gully erosion is the most significant erosional problem for the camp site. This type of erosion results from the formation of microchannels (rills) that merge to form larger gullies as water runs downslope. The ravines present throughout the camp site are examples of the effects of uncontrolled rill and gully erosion (Carson and Kirkby, 1972).

The construction of the Alumni Family Camp is likely to increase rates of erosion on the site. Rainsplash transport can be exacerbated by the removal of portions of the forest canopy or of leaf litter or other natural protection from the soil. Ground vegetation is especially important, because even small breaks in cover can assume great importance as points of accelerated erosion (Carson and Kirkby, 1972). Disturbance of the vegetative cover during construction can also accelerate rill and gully erosion on the steeper slopes of the area.

Even after construction, some aspects of camp utilization can still exacerbate erosion. For example, the disturbance of groundcover by the use of any foot or horse trails carelessly located on the shallow soils of slopes can result in severe erosion over the course of even one season. Foot paths created informally by camp users on soils unsuitable for such paths can also serve as points of accelerated erosion.

Erosion rates and the changes they undergo during construction can be estimated in a quantitative fashion. The rate of erosion depends on rainfall intensity, inherent erodibility of the soil type, length and degree of slope, type and density of the vegetation cover, and presence or absence of conservation practices. These factors are related by the Universal Soil Loss Equation,

$$A = R \cdot K \cdot LS \cdot C \cdot P,$$

where

- A is the estimated average annual soil loss in tons per year,
- R is the regional rainfall and erosivity index,
- K is the soil erodibility factor for each soil type,
- LS is a topographic factor combining the effects of slope length and steepness,
- C is a vegetation cover factor, and
- P is a conservation practice factor

(USDA, 1975a).

$\underline{R}$, $\underline{K}$, $\underline{C}$, and $\underline{P}$ values for the camp site soils are given in Table 28. $\underline{C}$ values can range from 0.001 for woodland and 0.01 for grassy meadows to 1.0 for barren ground (USDA, 1975a). The value of the $\underline{LS}$ factor can be derived from Table 29, given a measured slope length and steepness. Because precipitation is distributed throughout the year,

Table 28. Universal Soil Loss Equation Values, Alumni Family Camp Site

Soil Type	K Value	T Value
Hagerstown-Caneyville	0.37	4
Wellston	0.37	3
Berks-Weikert	0.32	3
Gilpin	0.28	4

For the Bloomington area:	R = 200
Before construction:	C = 1 P = 1
During construction:	C = 0.0035 P = 1

Source: Macnak (1977).

Table 29. Values of LS Factor for Specified Slope Length and Steepness

Percent Slope	Slope Length (feet) 25	50	75	100	150	200	300	400	500	600	800	1000
0.5	0.07	0.08	0.09	0.10	0.11	0.12	0.14	0.15	0.16	0.17	0.19	0.20
1	0.09	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.21	0.22	0.24	0.26
2	0.13	0.16	0.19	0.20	0.23	0.25	0.28	0.31	0.33	0.34	0.38	0.40
3	0.19	0.23	0.26	0.29	0.33	0.35	0.40	0.44	0.47	0.49	0.54	0.57
4	0.23	0.30	0.36	0.40	0.47	0.53	0.62	0.70	0.76	0.82	0.92	1.0
5	0.27	0.38	0.46	0.54	0.66	0.76	0.93	1.1	1.2	1.3	1.5	1.7
6	0.34	0.48	0.58	0.67	0.82	0.95	1.2	1.4	1.5	1.7	1.9	2.1
8	0.50	0.70	0.86	0.99	1.2	1.4	1.7	2.0	2.2	2.4	2.8	3.1
10	0.69	0.97	1.2	1.4	1.7	1.9	2.4	2.7	3.1	3.4	3.9	4.3
12	0.90	1.3	1.6	1.8	2.2	2.6	3.1	3.6	4.0	4.4	5.1	5.7
14	1.2	1.6	2.0	2.3	2.8	3.3	4.0	4.6	5.1	5.6	6.5	7.3
16	1.4	2.0	2.5	2.8	3.5	4.0	4.9	5.7	6.4	7.0	8.0	9.0
18	1.7	2.4	3.0	3.4	4.2	4.9	6.0	6.9	7.7	8.4	9.7	11.0
20	2.0	2.9	3.5	4.1	5.0	5.8	7.1	8.2	9.1	10.0	12.0	13.0
25	3.0	4.2	5.1	5.9	7.2	8.3	10.0	12.0	13.0	14.0	17.0	19.0
30	4.0	5.6	6.9	8.0	9.7	11.0	14.0	16.0	18.0	20.0	23.0	25.0
40	6.3	9.0	11.0	13.0	16.0	18.0	22.0	25.0	28.0	31.0	--	--
50	8.9	13.0	15.0	18.0	22.0	25.0	31.0	--	--	--	--	--
60	12.0	16.0	20.0	23.0	28.0	--	--	--	--	--	--	--

Source: USDA (1975a).

the preliminary A value calculated from the equation must be multiplied by the percentage of precipitation occurring during the time period under consideration. A cumulative frequency distribution of precipitation is shown in Fig. 11. Appendix 2 contains several examples of the calculations for various soil types of the camp site.

Using the Universal Soil Loss Equation rough estimates can be made of the amount of soil expected to be lost during the construction of the various camp facilities. The calculated amount A can be compared with an assigned T value for each soil type (see Table 28), where T represents the maximum loss of soil per acre per year before deterioration of the soil begins. For the Alumni Family Camp, the amounts of soil expected to be lost during construction exceed the maximum allowable losses (T) for all soil types, and while these estimated losses carry a sizeable potential margin of error, they are so much greater than the T values that it would appear to be highly advisable to institute erosion control practices to prevent excessive deterioration.

Runoff

Erosion can be increased by changes in runoff characteristics as well as by changes in groundcover. The presence of roofs and paved areas such as roads and parking lots can increase the volume and velocity of runoff and concentrate more of it into a shorter period after the start of a storm (USDA, 1975c). This occurs because the impermeability of paved areas and buildings will reduce the infiltration in the areas they occupy. Changes in vegetative cover brought about by construction may have similar effects. Even though the soils of the camp site are shallow, they have relatively high permeabilities (see Table 6), so that overland flow rarely occurs, although interflow between the surface and the bedrock is common. However, a local increase in the volume of runoff will rapidly exceed the soil's ability to absorb and transmit water, resulting in overland flow that can be severely damaging, especially in the case of steep slopes. For these reasons, methods to reduce or delay runoff are necessary and should be incorporated in the planning of camp facilities.

Larger runoff volumes from the site may also be sufficient to destroy the stability imparted by small "organic dams" in the intermittent streams draining the area. The accumulation of organic debris creates small pools in the streams that, at low to moderate flows, buffer the streambed against the errosive force of running water. At very high flows, the debris accumulations are dislodged and transported downstream along with increased amounts of sediment from the streambank (Fisher and Likens, 1973).

Effects of Increased Erosion and Runoff on Lake Monroe

Increased erosion and runoff resulting from the construction, presence, and operation of the Alumni Family Camp may not only adversely affect the land surface, but may also exert negative impacts on Lake Monroe through increased sediment, nutrient, and organic matter loading. The effects of increases in these three inputs are described in the following paragraphs. To the extent that careful planning and environmentally responsible construction practices are utilized, these impacts may be mitigated to some degree.

Increased sediment loading. Deforestation of an experimental watershed at Hubbard Brook in New England caused a 26% increase in runoff volumes and greatly increased erosion (Hobbie and Likens, 1973). The disturbance of the protective forest canopy on the camp site could significantly increase the turbidity of the water adjacent to the camp property. Light attenuation induced by increased turbidity and concomittant photoinhibition of the macrophytes in the water near the camp will probably decrease the concentration of dissolved oxygen through the loss of photosynthetically produced oxygen and through the increased oxygen demand of organisms decomposing the decaying plants. In that event, the existing summertime condition of severe oxygen depletion in the river channel (Frey, 1976) would be exacerbated thereby imposing a stress on fish populations. Prolonged anoxic conditions in the bottom sediments would limit the inhabitants of the benthic region to anaerobic forms.

Reduction of the macrophyte beds through increased turbidity could adversely affect the water quality in areas down lake from the camp. Frey (1976) emphasizes the importance of the macrophytes in facilitating sedimentation above the causeway by reducing the current velocity. Because much of the phosphorus is associated with silt-sized inorganic particles and detritus, the development of nuisance algae in the lower basin may increase if the sediment-filtering capacity of the macrophytes is reduced. Chapra and Tarapchak (1976) concluded that a lake's tolerance to phosphorus loading is in part a function of sedimentation processes occurring in the lake.

An additional role of the macrophytes and their attendant microfloral community is their ability to successfully compete for available nitrogen and phosphorus, thereby curtailing phytoplankton development (Frey, 1976; Hazler and Jones, 1949; Fitzgerald, 1969). The high concentrations of algae, primarily the blue-greens *Microcystis* and *Oscillatoria*, observed above the causeway in 1972 were related to the limited development of macrophytes in that year (Docauer, 1972). Brakke (1974) reported large blooms of the noxious blue-green algae *Anabaena* and *Microcystis* following macrophyte removal.

In addition to the above effects, high turbidity levels brought on by increased sedimentation could impair the feeding activities of filter-feeding organisms in the lake.

Increased nutrient loading. The disturbances to vegetative cover and the higher sedimentation rates that are likely to be brought about by construction and operation of the camp could also increase nutrient inputs to the lake.

Experiments in the Hubbard Brook watershed indicated that the system had limited capacity to retain nutrients when the vegetation was removed. The data showed substantial changes in the concentrations of nitrate, calcium, magnesium, sodium, and potassium ions. The loss of these nutrients was correlated with decreased nutrient uptake by plants; cessation of the evapotranspiration carried on by plants allowed larger quantities of water to move through the soil (Borman and Likens, 1969). Quantities of phosphorus in organic particles larger than one millimeter in diameter and in inorganic particles in the stream draining the manipulated watershed were 12 times higher than in a similar undistrubed watershed (Hobbie and Likens, 1973).

Tizler et al. (1976) showed that nutrient levels in Lake Tahoe were enhanced as sediments entered the lake, and that increased nutrient inputs alone led to higher primary productivity. Frey (1976) states that the high percentage of annual phosphorus input retained within Lake Monroe (more than 55%) is due to the fact that most phosphorus from nonpoint sources is particulate or associated with particles, which settle to the bottom. The productivity of the lake depends in part on the availability of this sedimentary phosphorus pool for biological recycling. The release of phosphorus to the overlying water is governed by such factors as pH; the presence of iron, aluminum, manganese, calcium, or organic particles; and the oxygen concentrations (Macpherson et al., 1958; Bortlson and Lee, 1974; Stumm and Morgan, 1970; Mortimer, 1941, 1942, 1971). Lee (1970) determined that the most important factor favoring the release of nutrients from the sediments is low oxygen concentration in the overlying water.

Thus, the ability of the bottom sediments in Lake Monroe to retain essential nutrients such as phosphorus will depend to a certain degree on the factors controlling the oxygen demand of the sediments and of the overlying water.

Increased organic matter loading. The construction and operation of the camp will probably increase the amount of organic material entering Lake Monroe. The oxygen demand created by these materials could lower the dissolved oxygen concentration in the water and favor anaerobic conditions in the sediments. As mentioned above these conditions could become detrimental to fish populations and certain forms in the benthos. In addition, anoxic conditions in the sediments may favor the release of phosphorus and the production of objectionable gases such as methane and hydrogen sulfide.

Tree removal and the use of wood products in the construction of camp facilities will result in the scattering of tiny particles on the ground that could be easily transported to the lake via surface runoff. In addition, increased export rates of existing organic materials, such as limbs, twigs, and leaf litter, will occur during the operational phases of the camp as a result of increased surface runoff and disturbance of the stability of the drainage area.

Organic matter occurs in solution as well as in the particulate forms emphasized above. McDowell and Fisher (1976) state that when overland flow is significant and movement through terrestrial soils is bypassed, labile dissolved organic matter will assume significance in lotic food webs. Thus, loss of sufficient soil penetration and attendant surface runoff due to paved roads, parking lots, roofs, and vegetation removal may facilitate oxygen depletion through metabolic utilization by aquatic organisms.

Measures to Mitigate Impacts Relating to Erosion and Runoff

Some increase in rates of erosion and in volumes of runoff due to the Alumni Family Camp development is inevitable, so that some adverse environmental effects in this regard are unavoidable. Fortunately, however, careful planning and environmentally sound construction practices can mitigate some of the negative impacts mentioned above relating to erosion and runoff.

Less construction on steep slopes and immediate soil stabilization practices are necessary to diminish the amount of soil lost by erosion (Hittman Associates, 1973). All areas that will be left exposed for an appreciable length of time should be mulched. Sediments that are transported downstream anyway should be kept out of Lake Monroe by running the stream discharges through water diversions or filters. Technical information about processes to decrease erosion and sedimentation is available (Hittman Associates, 1972, 1973), and before construction begins, adequate site planning must be accomplished. The effects of slope and erosion at the camp site cannot be overemphasized; these factors are critical to the integrity of the environment and to the continued productive use of the area.

Given the existing natural drainage system of the camp site, managing the runoff from various facilities should not be difficult because the larger ravines have channels close to bedrock and erosion in them would not be severe. The presence of these ravines precludes the necessity of constructing new drainage systems, although the volume of flow must be controlled so that no bank erosion of the ravines occurs. Road construction should be kept to a minimum, utilizing existing roadbeds as much as possible. Due to the possible movement of gravel on the slopes and resultant erosion, roads should be paved and carefully drained. The parking lot, however, should be located in a level area and constructed of gravel. The gravel will allow for more infiltration of water than asphalt would, resulting in decreased runoff velocity and volume.

PLATE 3. PROPOSED BOAT DOCK LOCATION

Plate 3. Proposed Boat Dock Location

This west-looking view shows the cove at the base of the camp site peninsula. This cove receives one of the two intermittent streams draining the camp site. In this location the stream channel of the North Fork of Salt Creek follows the shore line closely. Siltstone is the characteristic sub-surface material with the Berks-Weikert soils complex occupying the steep slopes.

Old field community A-3 lies at the upper right. Forest community Area D-4 is on the left and D-3 is on the right. (Refer to Fig. 8.)

An old farm road is visible to the left of the inlet. The proximity of the central development area (upper right, see also Plate 2) to this potential site of water-based recreation facilities is illustrated.

Other Considerations

The following sections include discussions of potential environmental impacts of the Alumni Family Camp development that do not relate to any of the major categories discussed previously. These remaining impacts, which include many of importance, are those relating to construction activities (outside of impacts on erosion and runoff), water use, the land-based activities of camp guests, and the maintenance of the campgrounds. Aspects of the current environment that will not be affected by the camp are then mentioned, followed by a discussion of the site's overall suitability for the camp.

Construction Activities

Outside of the effects on erosion and runoff already discussed, construction activities can exert impacts on air quality, terrestrial ecology, socioeconomics, and archeological and historical sites.

Construction of camp facilities will result in the temporary dispersion of additional particulates into the air. Construction activities including excavation, cement and materials handling, road construction, paint spraying, and the burning of scrap materials can result in the dissemination through the air of dust, smoke, exhaust fumes from power equipment, and paint fumes. Although these impacts will be temporary, careful construction techniques can help minimize their effects.

Another major impact of construction will be the large temporary increase in noise levels at the camp site. Table 30 shows equipment noise ranges that could be expected to occur during construction

Table 30. Construction Equipment Noise Ranges

Equipment	Sound Level (dBA) at 50 feet
Compactors	71- 75
Front loaders	71- 85
Backhoes	71- 93
Tractors	76- 96
Graders	76- 94
Pavers	86- 88
Trucks	83- 94
Concrete mixers	75- 87
Pumps	68- 71
Generators	71- 82
Compressors	75- 86
Jack hammers and drills	81- 99
Pile drivers	95-107
Power saw	93-101[1]
Power mower	94-102[1]
Power wood planer	97-108[1]

[1]Sound level (dBA) at 3 feet.

Source: Leffel (1976).

Noise and other aspects of construction activity will affect wildlife on and near the site. The most important impact is likely to be the complete avoidance of the area by the shyest species, such as foxes and deer, while construction is going on. Movements of other shy species, which are probably adjusted to the presence of the neighboring Seeber family, would be readjusted as additional human presence is experienced. But ruffed grouse and other birds will be flushed out of local areas, and some animals with low mobility, such as snakes, box turtles, baby birds in ground-level nests, and mammals in shallow burrows, may be killed accidently by construction equipment.

Construction is likely to exert minimal socioeconomic impacts. A few employment opportunities may be generated locally, but the bulk of the construction force is likely to consist of workers already employed by the contractor. Any nearby cafeterias and restaurants on State Route 446 may experience a small increase in business. The only negative socioeconomic effect of any significance is likely to be an increase in traffic, but, while there may be a small increase in the early morning and late afternoon traffic on State Route 446, the largest proportional increase will occur on Rush Ridge Road, where it will probably bother no one.

Any archeological or historical sites present on the camp property may be severely disrupted or destroyed by construction activities if mitigative measures are not taken. Appropriate mitigative measures are described in the letter accompanying the section on archeological and historical sites in the preceding part of this assessment.

Water Use

Several comments of an environmental nature regarding the planning and construction of the proposed boat dock are assembled in this section, along with a brief discussion of impacts exerted on water use by the operation of the camp.

Boat dock. The most obvious location for a small boat dock is in the cove at the base of the camp site peninsula. An old farm road currently provides access to this cove. As there is little room for maneuvering at the cove level, this road should be left as is and restricted to service vehicle use. If the road is to be improved for general vehicle use, it should be given an impermeable surface such as asphalt or concrete. A gravel road would present traction problems and would result in considerable erosion into the cove. Steep sections of the road may need cross slope drains or other measures to slow the velocity of the runoff water.

A floating dock, attached with cables to the bedrock or to the shore, would exert less severe impacts than an anchored dock would. A floating dock would require no disturbance of the benthic zone, whereas an anchored dock would need posts or pilings driven into the bottom of the lake resulting in increased sedimentation and resuspension of sediments in the cove area. In addition, depth to bedrock is probably shallow in the cove, and this would result in increased construction expense. Waterproofing or treatment of any wood components could also affect aquatic life through the introduction of chemicals into the cove area. Such problems can be largely bypassed by constructing a floating dock.

The location of a launch ramp in the cove would have impacts related to limited space, construction (erosion and sedimentation), noise, and usage. Because water flow in the cove is low, the introduction of petroleum combustion byproducts from cars could present a serious hazard to aquatic ecosystem stability. The use of off-site ramps such as Paynetown, Cutright, or Pine Grove is strongly recommended. The advisability of motorboat use of the cove is also questionable, as it can lead to an increase in the hydrocarbon concentrations in the North Fork through engine exhaust and careless fueling procedures. Also, the operation of motorized craft in shallow areas could create enough turbulence to resuspend some of the bottom sediments. Zickler, Berger, and Hasler (1956) found that phosphorus release from the sediments approximately doubled if the sediments were agitated by turbulence. Propeller wash could also accelerate shoreline erosion. To reduce impacts in the cove area, motorboat access should be limited, if not prohibited. Sailboats, canoes, and rowboats would have fewer impacts on the lake.

As the dock is to have only about 15 slips, it will be small enough not to interfere with boat traffic above the old Salt Creek channel, which passes nearby. This channel is currently used by motorboats during low-water and macrophyte growth periods in the summer to eliminate mechanical problems with the motors.

Other aspects of water use. The primary uses of Lake Monroe--flood control and low-flow augmentation--are irrelevant to the Alumni Family Camp development, except insofar as they influence the position of the shoreline, and will not, in any case, be affected by the development. The lake's utility as a municipal water supply can be affected to the extent that the camp has adverse impacts on water quality, as discussed previously in this part of the assessment. But if proper mitigative measures are taken, the camp is not likely to have any adverse effect on the potability of the water in Lake Monroe, especially after treatment.

Of the various recreational uses of North Fork water by the camp, boating is likely to have the biggest impact on water use, because it takes place over an extensive area. If the Pine Grove user surveys accurately reflect the number of boaters on the North Fork, the presence of the camp may triple that number. In any case, boat use of the North Fork is likely to increase significantly, converting relatively solitudinous areas into more frequently visited (though hardly crowded) ones.

Terrestrial Activities of Camp Users

In addition to the impacts generated by recreational water use, the terrestrial activities of camp users will affect the environment. Impacts of Camp operation on terrestrial biotic communities will arise from the mere presence of large numbers of people in the camp area, as opposed to the relatively small numbers that set foot in the camp and adjacent property at the present time.

The most important characteristic of human occupation of the camp site is seasonality. If camp operation is restricted to a 3½-month heavy-use period during the late spring and summer and to weekend day visits during the autumn, winter, and early spring, many aspects of the ecological seasonal cycle will be minimally disturbed by the presence of people. Impacts that will be minimized by strict adherence to the seasonal pattern of use include disturbances to (1) the spring woodland wild flowers as might occur if large numbers of people are walking through the forest and stepping on the plants or picking them, (2) the migratory waterfowl--ducks, geese, and swans--that visit the neighboring waters of Lake Monroe, (3) the bald eagles that use the cove area and the peninsula as a day roost during the late autumn and winter, (4) the foxes and deer that currently wander out on the peninsula during the late fall, winter, and early spring, and (5) the ruffed grouse throughout the property during a period when most vegetation is leafless and minimally effective as a screen. To the grouse, the camp structures without the people actively moving about may be scarcely distinguishable from the currently undeveloped property. The deer and foxes, on the other hand, are disturbed by the lingering scent of people as well as their actual presence, so that the boat shed and any cabins sited on the camp site peninsula may obstruct fox and deer movement patterns. Occasionally, deer develop an abnormally high level of tolerance to the presence of people. Tolerance develops through repeated exposure to situations where people do not surprise or threaten them. The surprise element in the seasonal fluctuation in human occupation of the camp area and the continuance of deer hunting in the Lake Monroe area will probably prevent local deer from becoming tame.

Refrainment from intensive use of the camp during the late fall and winter is consistent with current use patterns of Lake Monroe. Very few people presently visit the lake and adjacent land areas during this period.

During the projected 3½-month period of intensive camp use, the Lake Monroe area as a whole is also subjected to intensive use. The bald eagles and most migratory waterfowl are not present and the foxes and deer may avoid certain areas that they use in the off-season. Breeding songbirds and small mammals including squirrels and rabbits will be present on the camp site; the showiest vegetation will be old-field flowers and a stand of American lotus adjacent to the south shore of the tip end of the peninsula (Fig. 9).

The kinds of disturbances to which most species of plants and wildlife will be subjected are relatively small, of the sort exemplified by children cutting down saplings and capturing the animals that can be easily caught and both children and adults picking flowers and flushing wildlife. In addition, increased vehicular traffic will probably increase the frequency of road mortality of certain animals. Box turtles and snakes are most susceptible to injury by the slow-moving traffic expected at the camp.

Impacts exerted by camp patrons moving about the lake region would be similar to those occurring on the camp site itself--minor disturbances to vegetation and spooking of wildlife. The magnitude of these impacts relative to those of the large numbers of people that presently use the Lake Monroe area would be quite small, except perhaps within a half-mile radius of the camp property.

In addition to affecting the vegetation and wildlife of the area, guests at the camp will also exert minor impacts on local air quality. The use of the camp facilities will result in the increased dispersion of particulates and exhaust fumes throughout the camp site area. Increased auto traffic for the transport of campers will result in higher concentrations of auto exhaust, which contains carbon monoxide, lead compounds, hydrocarbons, and nitrogen oxides. Use of campfires will also increase the particulate concentrations of the air. Background noise levels can be expected to rise due to food processing machinery, automobile use, and human voices.

Some impacts on water quality may also arise from use of terrestrial camp facilities. Undoubtedly, higher levels of various hydrocarbon products and heavy metals will be introduced to the lake. Drainage from the proposed parking lot may contain certain automobile byproducts such as oil, lead, and asbestos. In addition, the activities of campers in the streambeds draining the area could increase the destruction of small organic dams.

Maintenance of the Camp Grounds

It is of course advisable to keep the grounds of the Alumni Family Camp as free of artificial litter as possible. However, activities aimed at the "improvement" of the grounds in the undeveloped, natural portions of the camp, including efforts to clean up natural litter, clear out brush, and fill up ponds, could result in adverse impacts upon the value of the site as an ecological resource.

Leaf litter is an essential component of the forest nutrient cycle. When leaves fall from trees in autumn, they carry a considerable quantity of nutrients with them. When these leaves decompose, their nutrients can be reused by trees and wild flowers. If the leaves are removed after falling, the soil will probably become exhausted of nutrients and tree and wild flower growth will be inhibited.

Dead trees and their parts form valuable wildlife habitat. Various birds, especially woodpeckers, feed on insects that eat the wood and bark of standing dead trees. Many birds and mammals, including woodpeckers, owls, bats, squirrels, opossums, and raccoons, live in holes in dead trees. When the limbs and trunks of trees fall to the ground, they continue to form wildlife habitat. Salamanders, snakes, and woodland mice commonly hide under fallen logs, and an assortment of animals use large, hollow tree trunks for shelter.

Brushlands form valuable wildlife habitat in that they furnish food, retreats, and screens for shy species confronted with occasional human activity. The most valuable brushlands associated with the camp property occur in the southwestern corner, just east of the pine plantation, and over much of the tip end of the peninsula. Removal of these areas may eliminate ruffed grouse from the property and decrease songbird and rabbit populations. Loss of the screening function of many of the brushlands toward the western and northern ends of the site would probably discourage the deer and foxes that now use the property from coming even close.

The small pond situated near the junction of the peninsula road with the Seeber easement road is a unique breeding habitat for *Ambystoma* (salamanders) and frogs. Destruction of this pond to eradicate the few mosquitoes it can provide or for some alternative land use would result in the gradual elimination of the local salamander and frog populations. No other ponds occur locally, and, additionally, the salamanders have an innate tradition of migrating to the site of the present pond each year.

In contrast to the above maintenance measures, which would have adverse ecological effects, filling in the numerous old cisterns that presently occupy the property would not affect wildlife and would be advisable from the standpoint of safety.

Unaffected Environmental Components

The status of several aspects of the current environment as described in the preceding part of this assessment will suffer essentially no adverse effects from the Alumni Family Camp development.

The development is not large enough and does not exploit the atmospheric environment sufficiently to exert any impacts on climate, or even on local microclimates. The camp will also have no effect on what little groundwater underlies the site, assuming septic tank systems are not used.

As most of the camp employees will apparently be students from Bloomington, and as guests at the camp will come from outside the Lake Monroe area, effects on the socioeconomics of the area are likely to be negligible. Some local retailers may experience increased business on weekends. Guests may augment visitor levels slightly at public recreational areas around the lake.

The camp is not likely to have any impacts on threatened and endangered species, as none of these species are likely to occur on the site. Of the plants the purple fringeless orchid has only a remote chance of occurring in the lowest and flattest portions of Area D-1 (Fig. 8). It blooms during July and August and would probably be unrecognizable when not in bloom. The bladderpod has only an extremely remote chance of occurring in Areas D-7 and D-8 (Fig. 8), the only areas conforming in any manner to descriptions of its preferred habitat. None of the threatened or endangered animals are likely to reside on the site or even visit it on a regular basis.

Overall Site Suitability

In this section, the suitability of the proposed site for the Alumni Family Camp development is considered relative to the suitabilities of other sites. The overall environmental suitabilities of the proposed site and of the upper basin area in general for a recreational development of this type are also discussed.

In an attempt to determine the relative suitability of the site for the camp development, the Lake Monroe Land Suitability Model was employed to determine the suitabilities for intensive recreation of 50 lakeside cells in the general vicinity of the camp site. Only three cells were rated more suitable for intensive recreation than the portion of the site recommended for intensive development in this assessment (Plate 2). These were Cells (55,52), immediately west of the site; (53,59), about a mile northeast of the site; and (61,61), over a mile north-northeast of the site on the east side of the North Fork (see Map 3 or 4, inside back cover). Of course, land acquisition problems prevent the camp from being relocated. The important point here is that the present location is one of the most suitable ones in the general area for a recreational development of this type.

Aside from considerations as to relative suitabilities, the question still remains as to whether the site is a proper one in the absolute sense for the camp development, especially in the context of the upper basin environment. It is the conclusion of this assessment that, provided that judicious choices are made in the site planning process, and provided that reasonable measures are undertaken to mitigate the potential adverse effects of the camp on the environment, the Alumni

Family Camp is compatible with the current natural environment of the site and of the Lake Monroe region.

As mentioned in the preceding part of this assessment, if the camp is not built on the site, some other, perhaps more intensively developed, project probably will be. From this point of view, the camp may be seen as exerting an overall positive impact on the area, as the Alumni Association currently plans to leave much of the site's ecological features intact. Also, more intensive development of the site could induce additional development of the surrounding land. (For example, residential development could induce commercial development nearby.) On the other hand, it is in the interests of the owners of a wilderness-oriented recreational area to discourage additional development nearby. (In any event, the impacts of induced development are beyond the scope of this assessment; the conclusions of this assessment should be understood in this light, as they might not hold true if induced development were also considered.)

An alternative veiwpoint might be that the site should not be developed at all, but merely left as wilderness. The upper basin area is more forested and less developed than the land surrounding the lower basin, and the camp may be seen as setting an unfortunate developmental precedent. It could be argued that, while recreation is a proper use of the lake shore in the lower basin, the upper basin should be reserved for wilderness.

The environmental assessment team concurs with the objective of maintaining the wilderness value of the upper basin, but does not believe this objective should apply in full measure to the camp site.

The camp site is not especially suitable for wilderness, due to the presence of an access road and the proximity of State Route 446. The area is already disturbed by humans. This recently farmed, easily accessible tract of land is much more suitable for development than the relatively inaccessible lands east of the North Fork, much of which have remained in unspoiled wilderness for decades. The two areas are so different in character that development of one in an environmentally responsible manner should not imply that the other is suitable for development in any manner.

Conclusions and Recommendations

It is the major conclusion of this environmental assessment that the Indiana University Alumni Association Family Camp can be developed in an environmentally responsible manner. Attention to the following recommendations will assure compatibility with the natural environment of the site and of the Lake Monroe region.

Location of Recreational Facilities

- Recreational facilities should be located so as to preserve as much of the existing forest as possible, especially the largest trees, and to avoid areas with unsuitable slope and soil characteristics. Specifically,
    - The most intensive development should be confined to nonforested areas,
    - Cabins should be excluded from the camp site peninsula, and All development should be excluded from the old forest
    - (Area E-1, Fig. 8) on the south side of the property.
- To avoid as much pre-emption of brushland habitat as possible, the caretaker's house, if located in the southwest corner of the property, should be placed close to the access road.

Sewage Treatment

- Wastewater produced by the camp should be
  - Hauled to one of Bloomington's municipal sewage plants for treatment OR
  - Treated on-site by means of a combined composting and filtration system. An example of such an on-site system consists of Clivus to treat dry organic sewage and a peat bed filter to treat wash water.
- Should it be necessary to install physical/chemical or biological package sewage treatment plant,
  - Effluent should not be discharged into an intermittent stream or to the southern arm of the cove north of the site, and
  - Alternatives for disinfection other than chlorination should be investigated.
- If sewage is treated on-site, the phosphorus concentration of the effluent should not exceed 1 ppm (part per million).

Erosion and Runoff

- The forest canopy should be kept closed as much as possible and the natural groundcover left in place.
- Where soils must be exposed during construction activities, soil stabilization procedures should be initiated as soon as practicable.
- Roads should be
  - Kept to a minimum,
  - Drained carefully, and
  - Paved.
- Parking lots should be level and not be paved; gravel should be used.

- Water filters or bars or other diversion techniques should be placed at the mouths of drainage channels receiving large volumes of artificial runoff.
- Standard erosion control practices should be investigated and employed.

Other Considerations

- The natural character of the undeveloped portion of the grounds should be left intact as much as possible. Specifically,
  - Natural leaf and branch litter should be left in place in the forests,
  - As much brushland as possible should be left intact, especially toward the western and northern borders and the southwestern corner of the site and on the end of the camp site peninsula, should be left intact, and
  - The *Ambystoma* breeding pond should be left undisturbed.
- It is important that possible archeological and historical sites be fully investigated and, if necessary, excavated before construction activities begin.
- Impacts associated with use of the cove at the base of the camp site peninsula for boating purposes will be mitigated if
  - A floating boat dock is installed, rather than one fixed to the substrate,
  - No launch ramp is constructed, and
  - Use of the cove by motorboats is discouraged.

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Appendix 1

At the request of the Alumni Association, members of the assessment team surveyed the north and west boundary line of the camp property. This line was marked with blue flag stakes at 20-meter intervals. The survey was intended to serve locational and planning purposes, and while accurate, should not be construed as a legal survey. Field observations and measurements for soils, vegetation, and wildlife were made within these bounds (see Fig. 17).

The present camp (123 acres) is a combination of two smaller tracts. These tracts have been deeded and filed in the office of the Recorder of Monroe County, Indiana. A legal boundary description of the property follows.

Peninsula tract (34 acres). Part of the Southwest Quarter of Section 34, T-8-N, R-1-E, and part of the North Half of Section 3, T-7-N, R-1-E, all located in Monroe County, Indiana, more particularly described as follows:

Commencing at a point in the Southwest Quarter of Section 34, T-8-N, R-1-E, Monroe County, Indiana, where the centerline of Judah Road (the old county road) intersects the centerline of the road built by grantor Peninsula Development Corporation on the Eastern-most peninsula of land owned by grantor, thence South-Easterly along the centerline of the said peninsula road approximately 1420 feet until said centerline intersects the (East-West running) South boundary line of Section 34, thence Eastern along said South boundary line about 70 feet to Northwest corner of the east one-half of the Northeast Quarter of the Northwest Quarter of Section 3-71E, thence South along the West line of said half quarter 180 feet more or less until such line intersects government fee taking line on the South side of the peninsula, thence Easterly meandering along said fee taking line around tip of peninsula and thence Westerly along fee taking line as it proceeds up into the ravine (basin) located parallel to the Easternmost part of Judah Road, thence continuing on said fee taking line Easterly out of ravine (basin) to a point on Northern side of the ravine where fee taking line turns to North forming a corner. From this corner thence North along said fee taking line to a point approximately 850 feet North of the South line of the Southwest Quarter Section of Section 34, T-8-N, R-1-E (this point being on boundary line between grantor and Overlook Corporation) thence due West approximately 1180 feet, thence due South approximately 530 feet to a point intersecting the centerline of the said road built by grantor thence South-Easterly along said centerline to point of beginning. Together with easement and access rights on all access roads existing and those built later by Peninsula Development Corporation or its successors or assigns on all property owned by Peninsula Development Corporation.

Main tract (90 acres). Part of the West Half of Section 34, Township 8 North, Range 1 East, and part of the East Half of the East

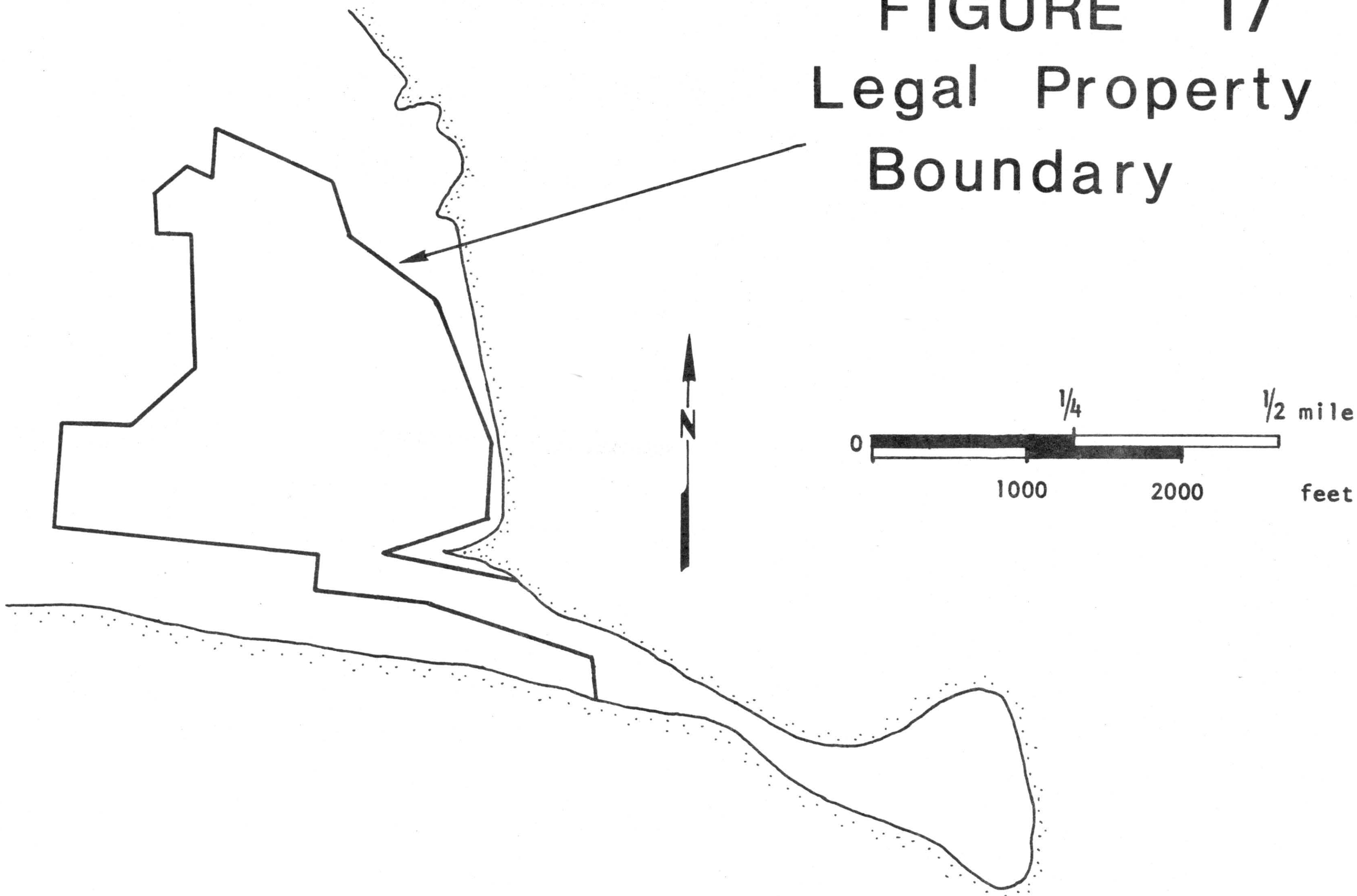

FIGURE 17
Legal Property
Boundary

Half of Section 33, Township 8 North, Range 1 East located in Monroe County, Indiana, more particularly described as follows, to-wit:

Beginning at a point 850 feet North of the South line of the West Half of Section 34 and on the Government Fee Taking Line for Monroe Reservoir, said point also going approximately 1750 feet East of the West line of said Half Section; thence in a Northwesterly direction meandering along said Fee Taking Line to a point where said line intersects the South line of the Seeber property; thence in a Northwesterly direction along said South line to where said line again intersects said Fee Taking Line; thence in a Southerly direction along said Fee Taking Line approximately 225.9 feet to a point; thence in a Northwesterly direction on said Fee Taking Line approximately 203 feet to a point; thence in a Southwesterly direction a distance 253.9 feet to a point 75 feet North and 250 feet West of the Northeast corner of the Southeast Quarter of Section 33, Township 8 North, Range 1 East; thence South parallel with the East line of the said Section a distance of 165 feet to a point; thence East parallel with the North line of said Southeast Quarter Section a distance of 200 feet to a point; thence South parallel with the East line of said Southeast Quarter Section a distance of 850 feet to a point; thence in a Southwesterly direction approximately 525 feet to a point on the North line of the Southeast Quarter of the Southeast Quarter of said Section 33, said point being 400 feet West of the East line of said Section; thence West on said North line of the Southeast Quarter of the said Southeast Quarter 450 feet to a point; thence South parallel with the East line of said Section approximately 675 feet to the South property line of the

Overlook Corporation; thence in a Southeasterly direction on said property line a distance of 1390 feet to a point; said point being approximately 430 feet North of the South line of Section 34; thence North approximately 370 feet to a point; thence East approximately 1180 feet to the Place of Beginning, containing 90 acres, more or less.

Appendix 2

The following examples are calculations of soil loss rates for each of the four soil types of the camp site. Two A values are calculated for each combination of slope length and steepness within each soil type. One is for an entire year, assuming existing groundcover, and the other is for a specified period of construction. Comparison of the A values with the assigned T values for each soil indicates the relative necessity for erosion control measures. (Values for R, K, C, and P are drawn from Table 28; values for LS are taken from Table 29. From Fig. 11, rainfall between June and August is 39% of that for the entire year, on the average.)

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

I. Gilpin R = 200 P = 1.0

K = 0.28 T = 4.0 tons/acre/year

For existing cover, C = 0.0035

During construction, C = 1.0

A. Slope length = 222.04 ft

Steepness = 18%

LS = 5.0

1. Expected yearly loss:

$A = (200)(0.28)(5)(1.0)(0.0035) = 0.98$ ton/acre/year.

2. Loss during construction between June 1 and August 31:

$A = (200)(0.28)(1.0)(5)(1.0)(0.39) = 109.2$ tons/acre/year.

B. Slope length = 345.3 ft

Steepness = 4%

LS = 0.66

1. Expected yearly loss:

$A = (200)(0.28)(0.66)(1.0)(0.0035) = 0.13$ ton/acre/year.

2. Loss during construction between June 1 and August 31:

$A = (200)(0.28)(0.66)(1.0)(1.0)(0.39) = 14.41$ tons/acre/year.

II. Hagerstown-Caneyville

R = 200 P = 1.0

K = 0.37 T = 4.0 tons/acre/year

For existing cover: C = 0.0035

During construction: C = 1.0

A. Slope length = 271.39 ft

Steepness = 7%

LS = 1.5

1. Expected yearly loss:

$A = (200)(0.37)(0.5)(1.0)(0.0035) = 0.39$ ton/acre/year.

2. Loss during construction between June 1 and August 31:

$A = (200)(0.37)(1.5)(1.0)(1.0)(0.39) = 43.29$ tons/acre/year.

III. Wellston

R = 200 P = 1.0

K = 0.37 T = 3 tons/acre/year

For existing cover C = 0.0035

During construction C = 1.0

A. Slope length = 690.81 ft

Steepness = 11%

LS = 4.2

1. Expected yearly loss:

$A = (200)(0.37)(4.2)(1.0)(0.0035) = 1.09$ tons/acre/year.

2. Loss during construction between June 1 and August 31:

$A = (200)(0.37)(4.2)(1.0)(1.0)(0.39) = 121.21$ tons/acre/year.

B. Slope length = 567.45 ft

Steepness = 9%

LS = 2.8

1. Expected yearly loss:

$A = (200)(0.37)(2.8)(1.0)(0.0035) = 0.73$ tons/acre/year.

2. Loss during construction between June 1 and August 31:

$A = (200)(0.37)(2.8)(1.0)(1.0)(0.39) = 80.81$ tons/acre/year.

IV. Berks-Weikart

R = 200 P = 1.0

K = 0.32 T = 3.0 tons/acre/year

For existing cover C = 0.0035

During construction C = 1.0

A. Slope length = 690.81 ft

Steepness = 16%

LS = 7.5

1. Expected yearly loss:

$A = (200)(0.32)(7.5)(1.0)(0.0035) = 1.68$ tons/acre/year.

2. Loss during construction between June 1 and August 31:

$A = (200)(0.32)(7.5)(1.0)(1.0)(0.39) = 187.20$ tons/acre/year.

B. Slope length = 148.03 ft

Steepness = 34%

LS = 12.2

1. Expected yearly loss:

$$A = (200)(0.32)(12.2)(1.0)(0.0035) = 2.73 \text{ tons/acre/year.}$$

2. Loss during construction between June 1 and August 31:

$$A = (200)(0.32)(12.2)(1.0)(1.0)(0.39) = 304.51 \text{ tons/acre/year.}$$

Similar calculations could be done for any time of the year using Fig. 11 to determine what percentage of total annual rainfall occurs in the specified time interval. The calculated $\underline{A}$ values are only estimates of how much soil could be lost given a specific set of conditions. It is obvious, however, that during construction of the Alumni Family Camp, severe erosion can occur and must be ameliorated.

R1W
R1E
10
12
14
16
18
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42
2
4
6
8
74
72
70
68
66
64
62
60
58
56
54
52
50
48
46
44
37
T8N
T7N
28
6
27
35
13
16

R1E
34
36
38
40
42
44
446
46
48
50
52
54
56
58
60
62
64
66
68
70
72
74
76
78
R1E
R2E
80
82
84
10
14
30
CO
CO
MONROE
BROWN
11
4
1
9
12

LEGEND

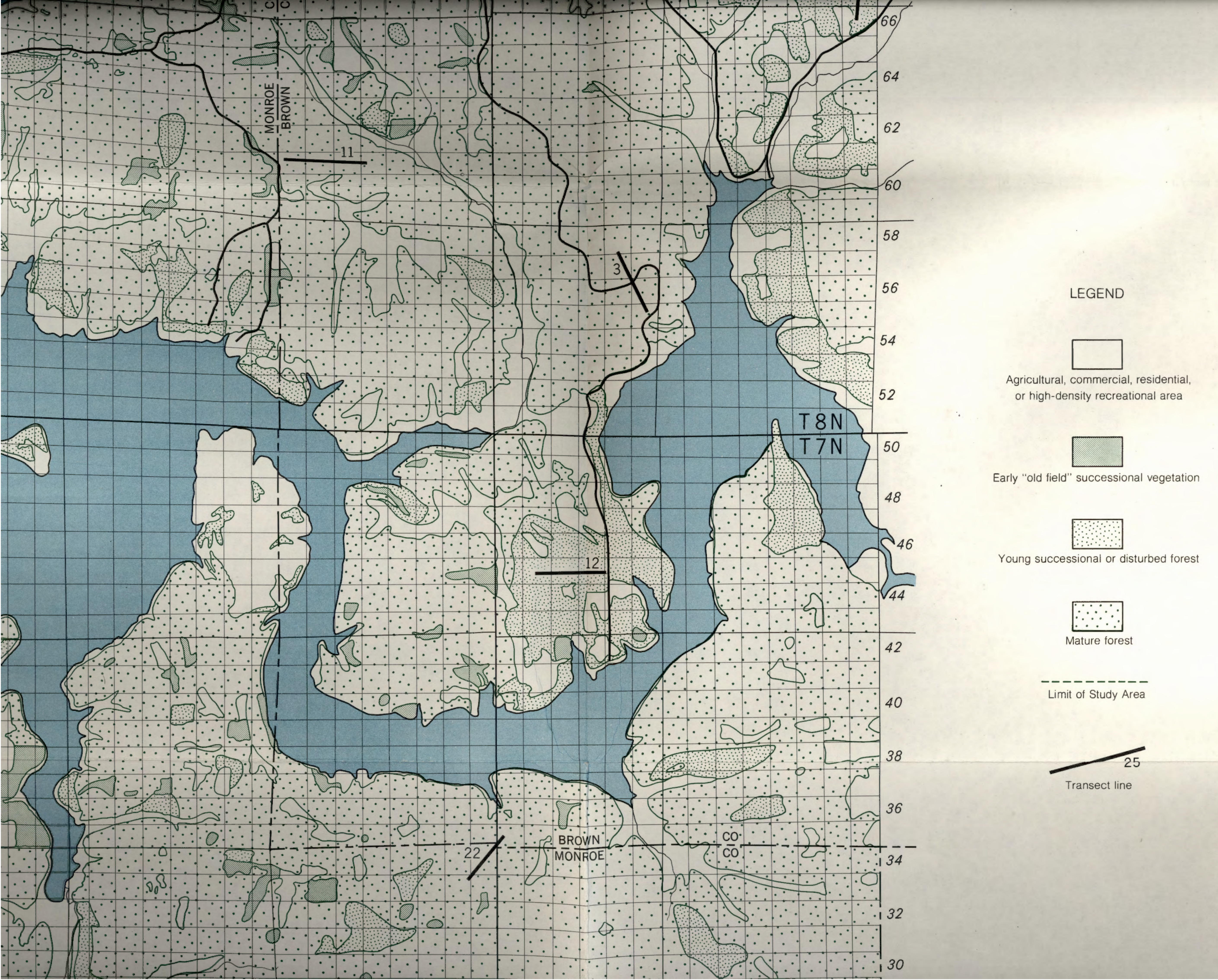
Agricultural, commercial, residential, or high-density recreational area

Early "old field" successional vegetation

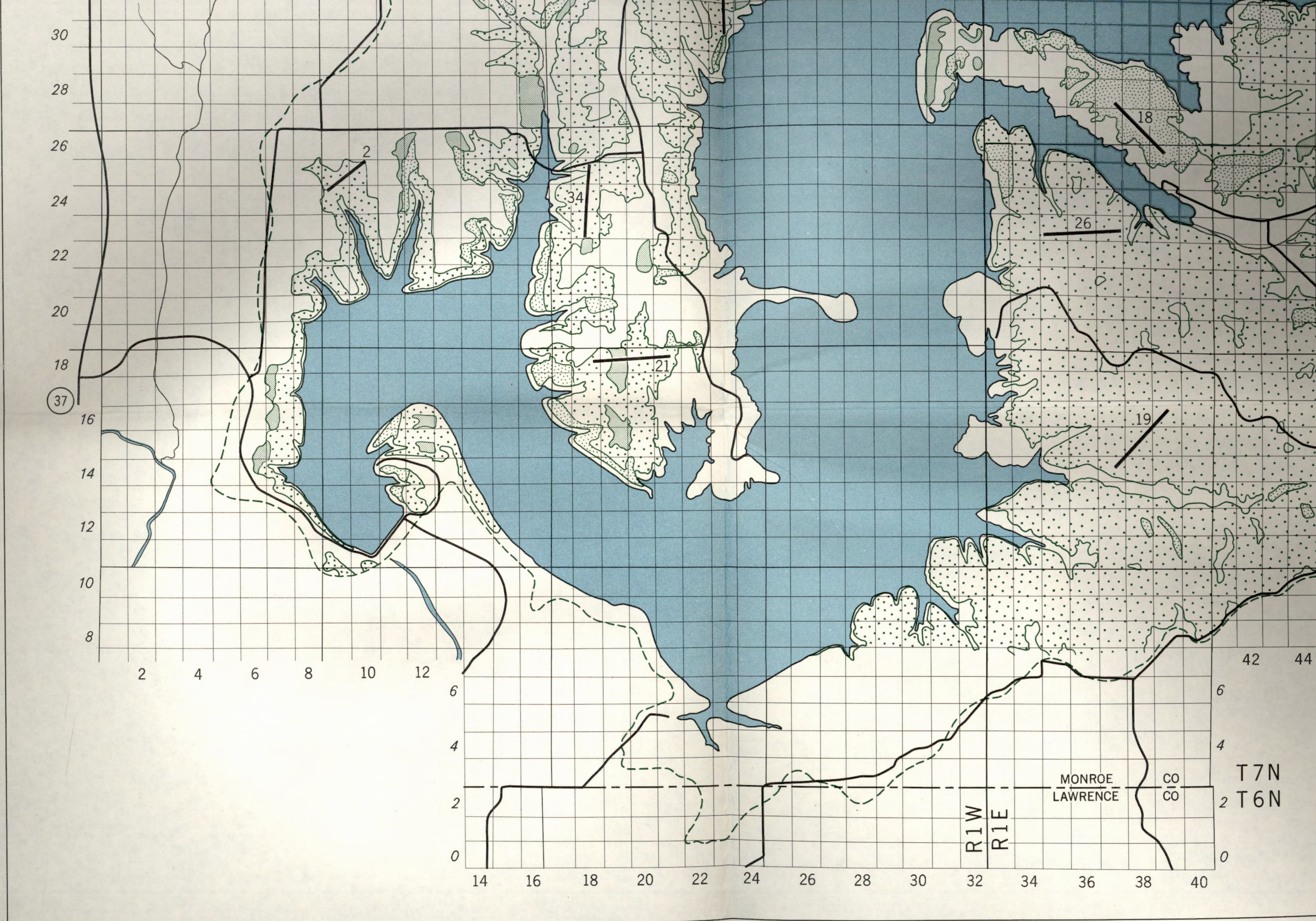
Young successional or disturbed forest

66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
37
T8N
T7N
27
35
13
16
29
32
33
31


MONROE
BROWN
4
1
9
11
15
7
23
22

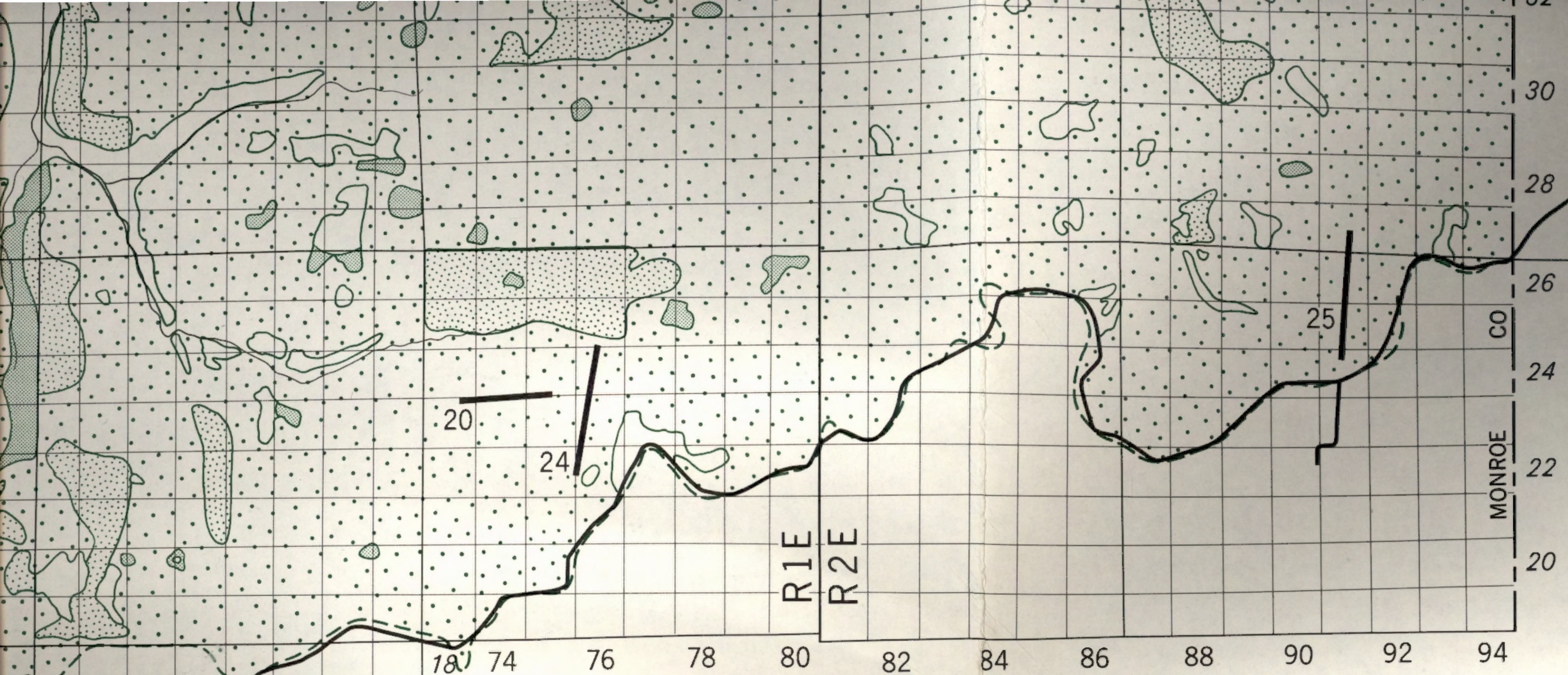


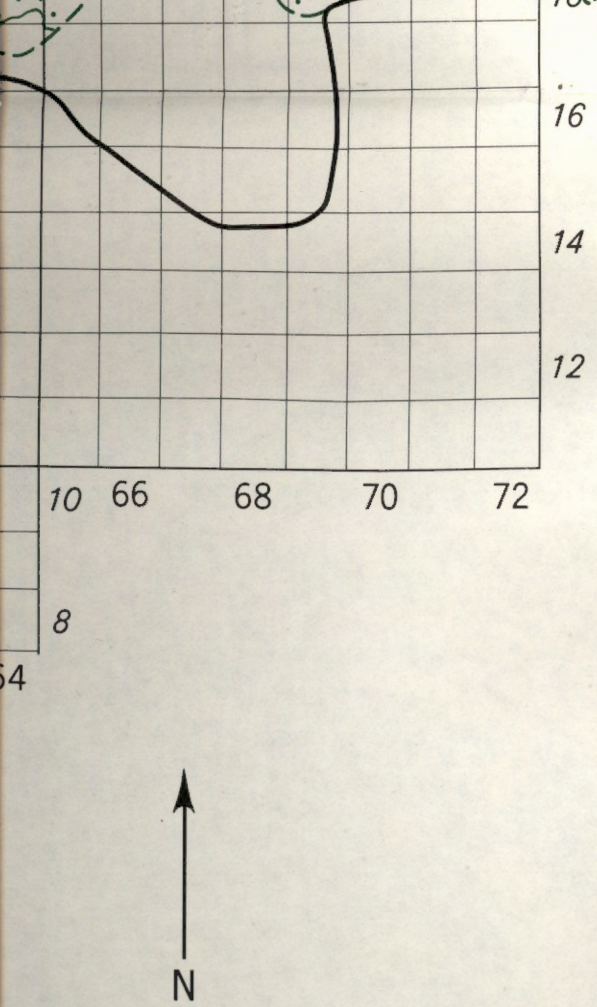
MONROE
BROWN
11
3
12
22
T8N
T7N
BROWN
MONROE
CO
CO
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
LEGEND
Agricultural, commercial, residential, or high-density recreational area
Early "old field" successional vegetation
Young successional or disturbed forest
Mature forest
Limit of Study Area
25
Transect line



37
R1W
R1E
MONROE CO
LAWRENCE CO
T7N
T6N
2
34
21
18
26
19

18
17
26
20
24
5
19
446
MONROE CO
LAWRENCE CO
T7N
T6N
R1W
R1E
1 ½ 0 1 Mile
1 .5 0 1 Km
N
28 30 32 34 36 38 40
42 44 46 48 50 52 54 56 58 60 62 64
10 66 68 70 72
18 74 76 78
0 2 4 6 8 10 12 14 16 18



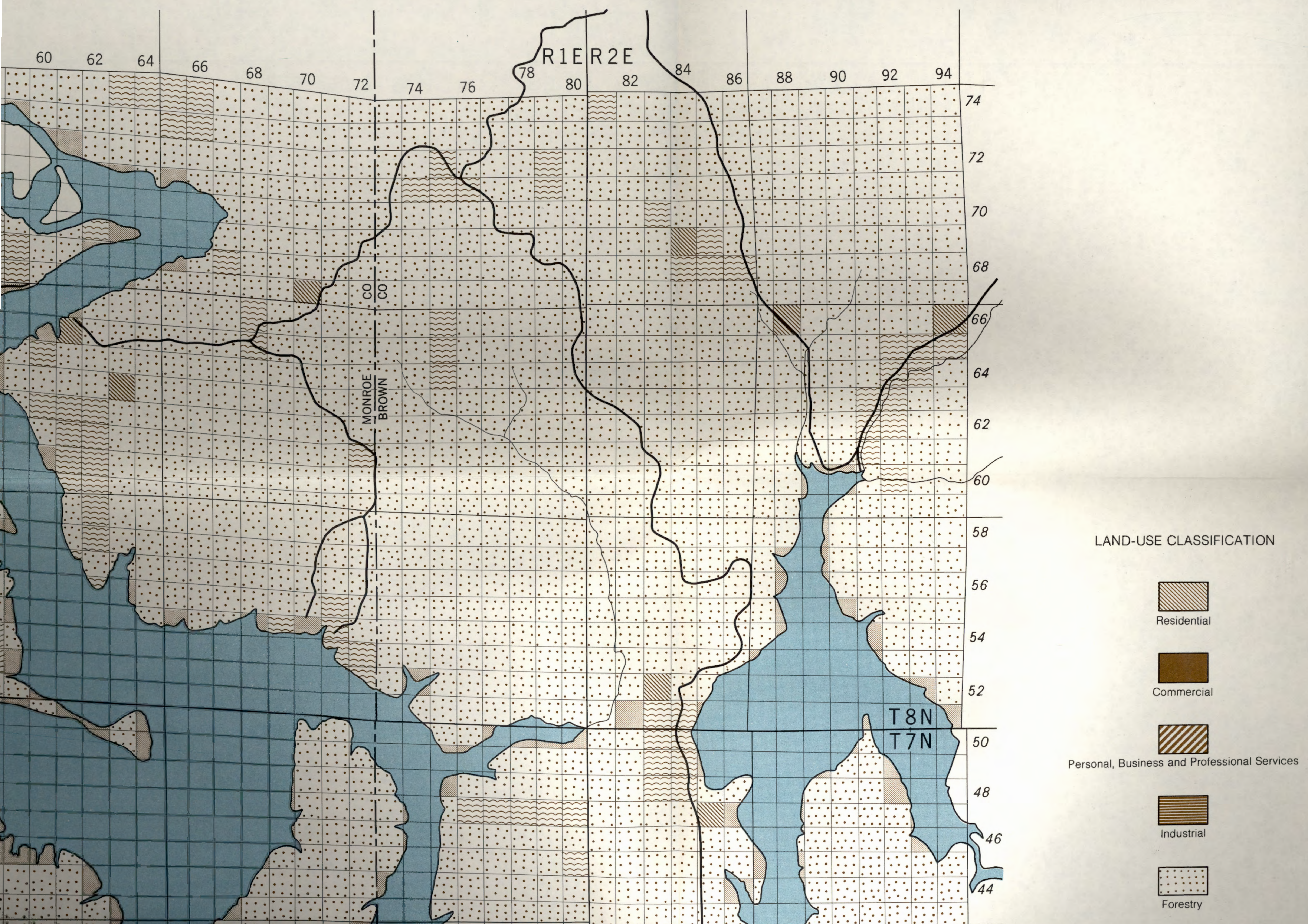


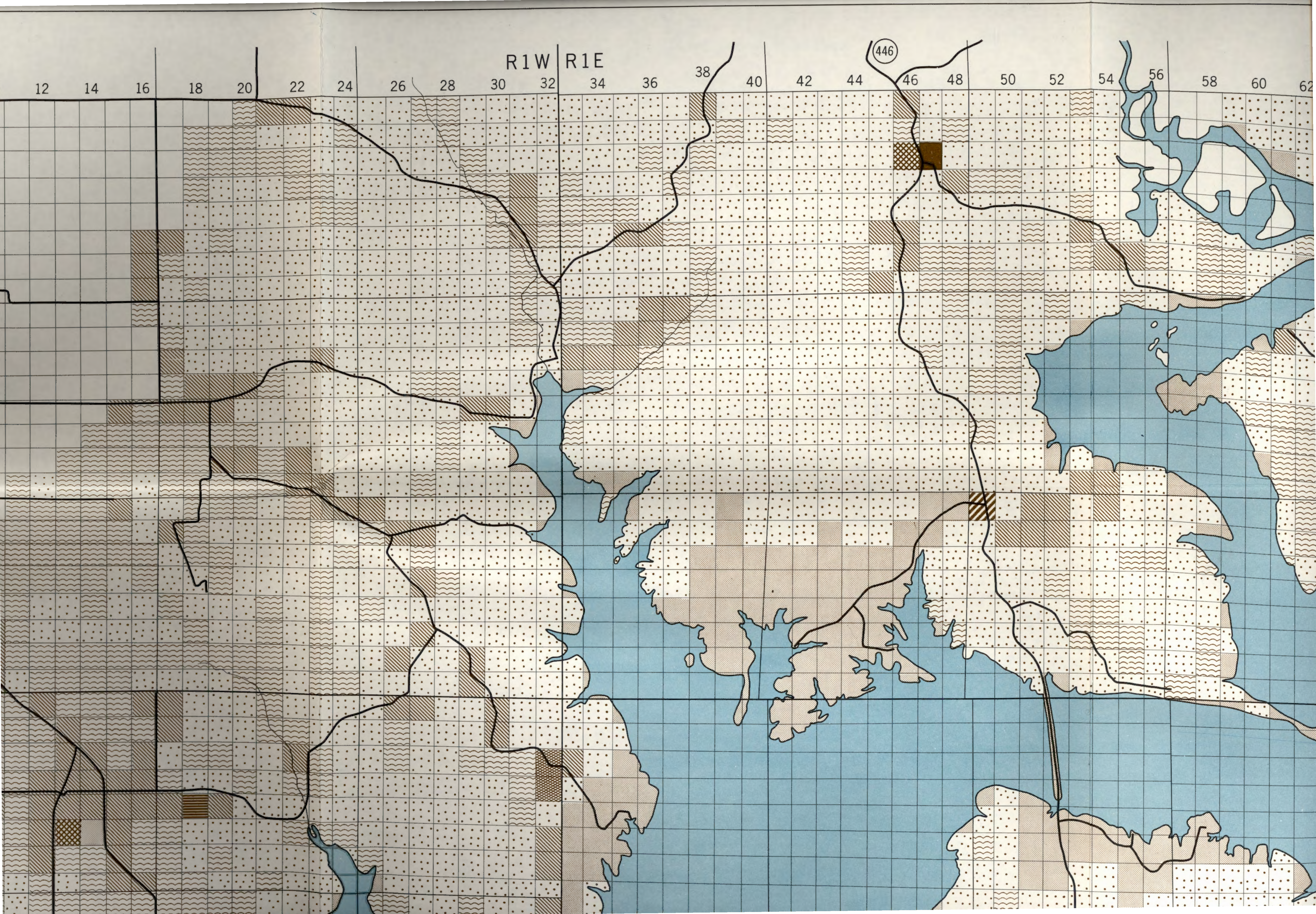
LAKE MONROE LAND SUITABILITY STUDY

VEGETATION MAP

MAP 3

Compiled in 1974 by J.C. Randolph and Edgar Lin: School of Public and Environmental Affairs, Indiana University. Cartography by Roger L. Purcell and James R. Tolen. Map Base: U.S. Geological Survey Topographic Maps, Scale 1:24,000


R1E R2E
60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94
74 72 70 68 66 64 62 60 58 56 54 52 50 48 46 44
MONROE CO
BROWN CO
T8N
T7N
LAND-USE CLASSIFICATION
Residential
Commercial
Personal, Business and Professional Services
Industrial
Forestry



R1W
R1E
446
12
14
16
18
20
22
24
26
28
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32
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36
38
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48
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56
58
60
62

R1W
R1E
10
12
14
16
18
20
22
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32
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36
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40
42
44
46
446
74
72
70
68
2
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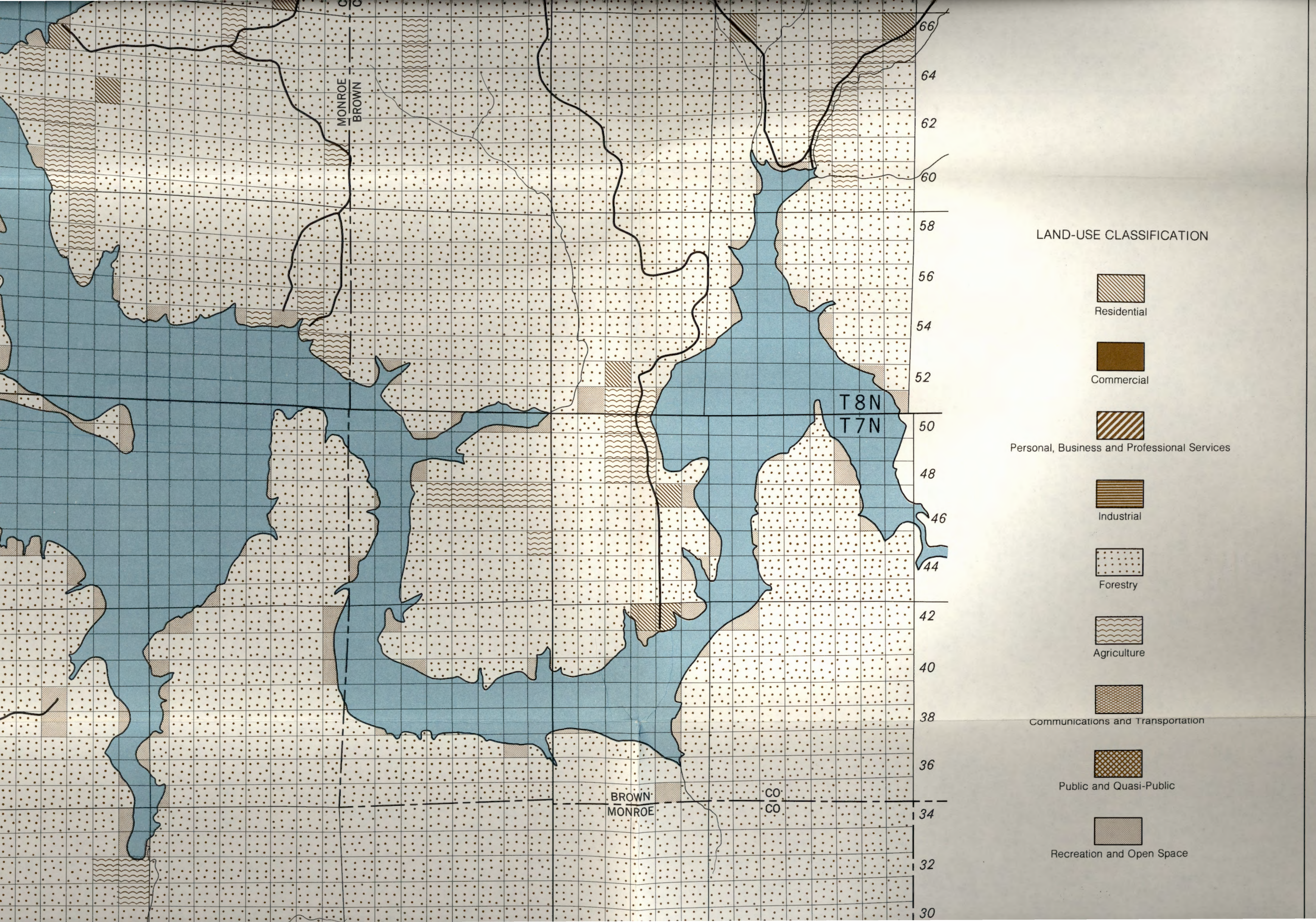
8
66
64
62
60
58
56
54
52
37
T8N
T7N
50
48
46
44


MONROE
BROWN
T8N
T7N
BROWN
MONROE
CO
CO
66
64
62
60
58
56
54
52
50
48
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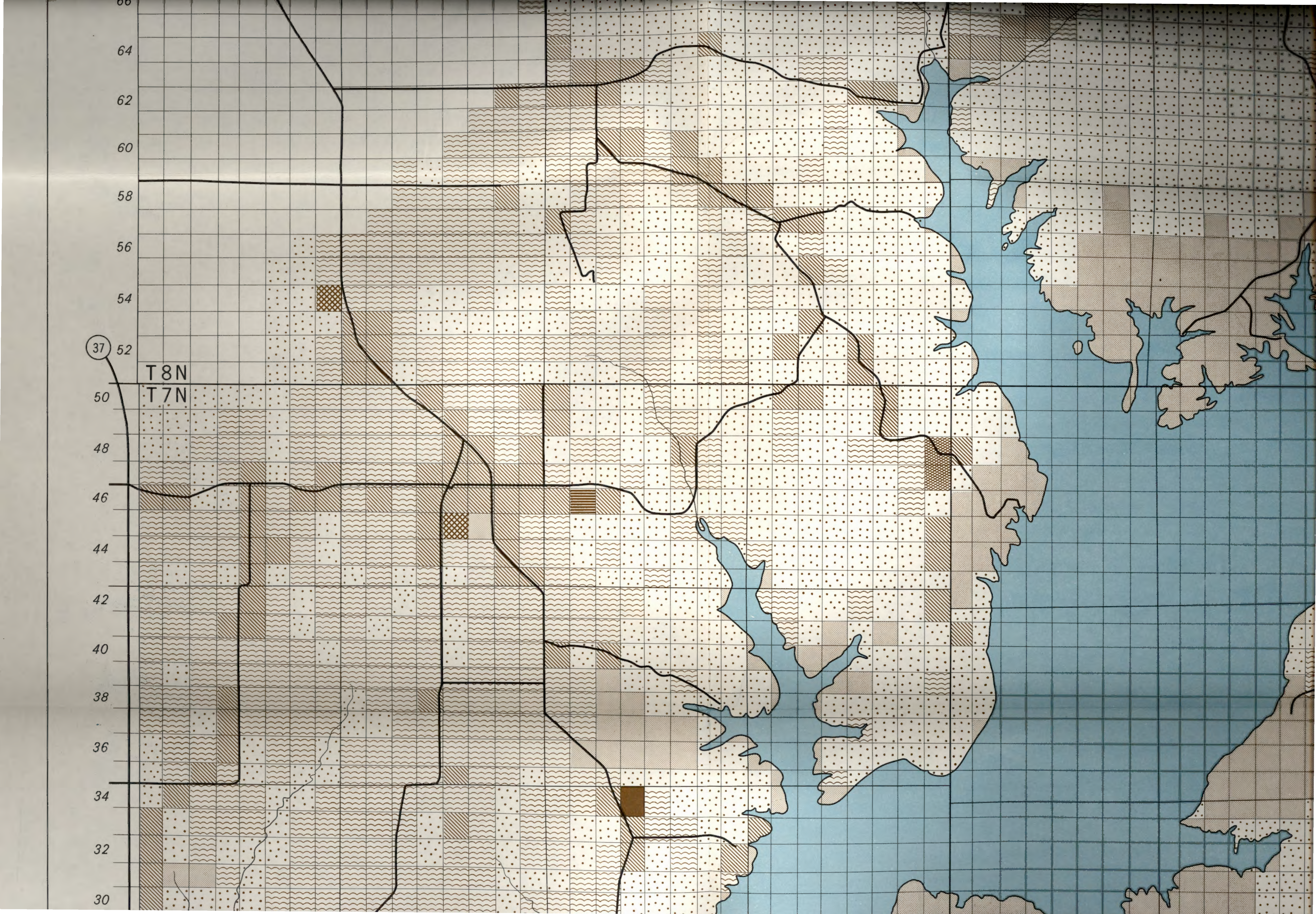
44
42
40
38
36
34
32
30
LAND-USE CLASSIFICATION
Residential
Commercial
Personal, Business and Professional Services
Industrial
Forestry
Agriculture
Communications and Transportation
Public and Quasi-Public
Recreation and Open Space


MONROE
BROWN



64
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T8N
T7N
50
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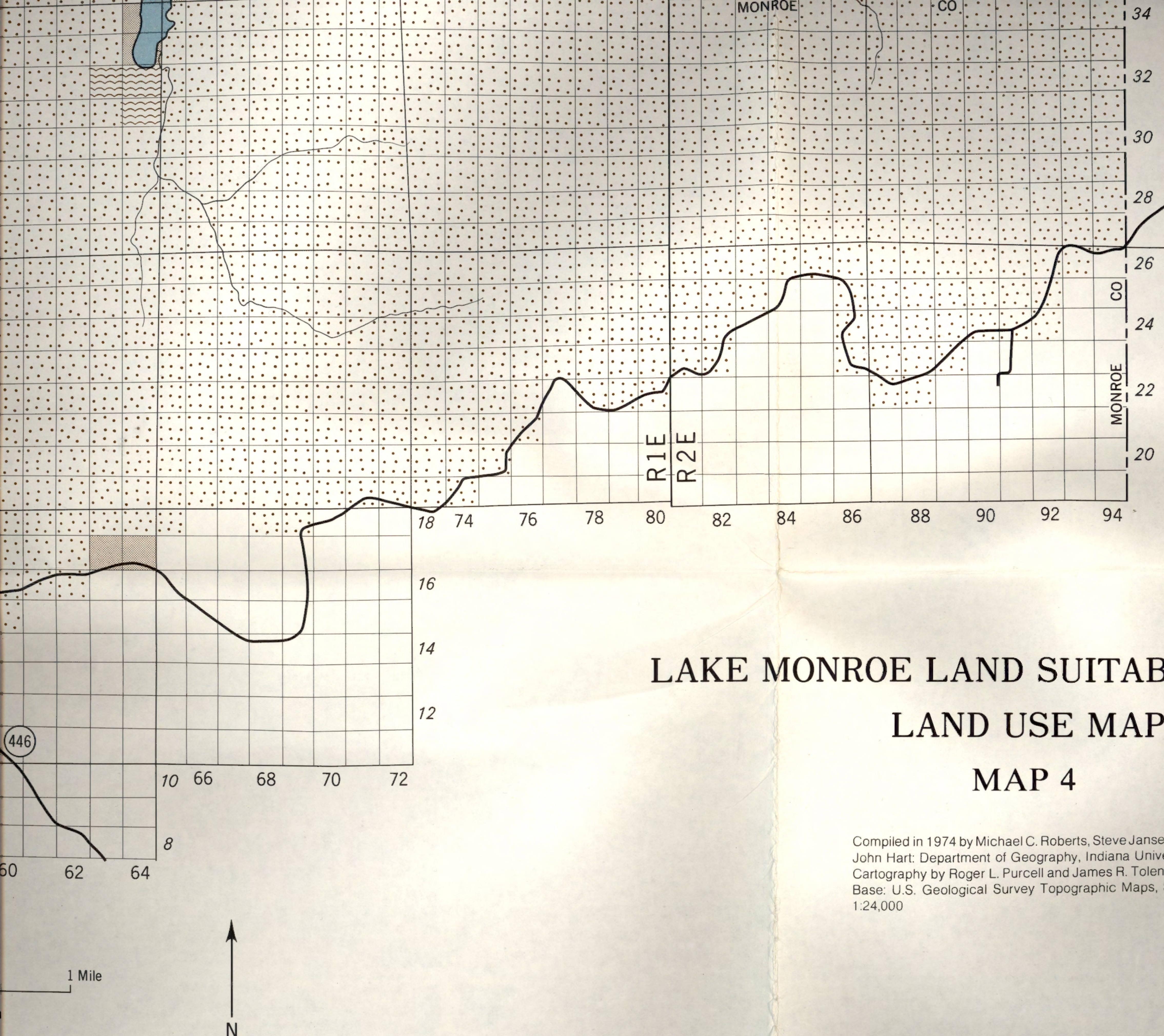
32
30



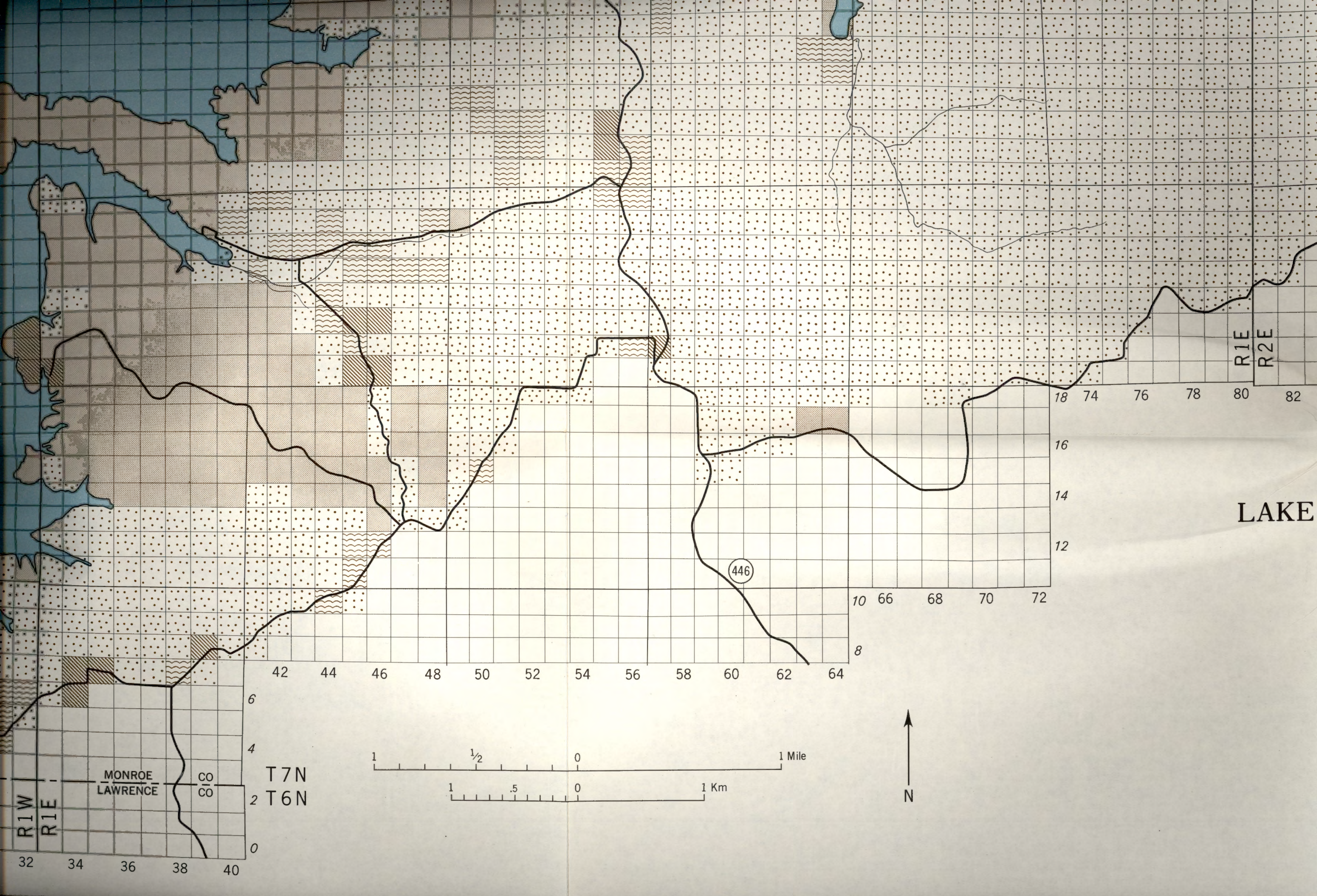
Recreation and Open Space

LAKE MONROE LAND SUITABILITY STUDY

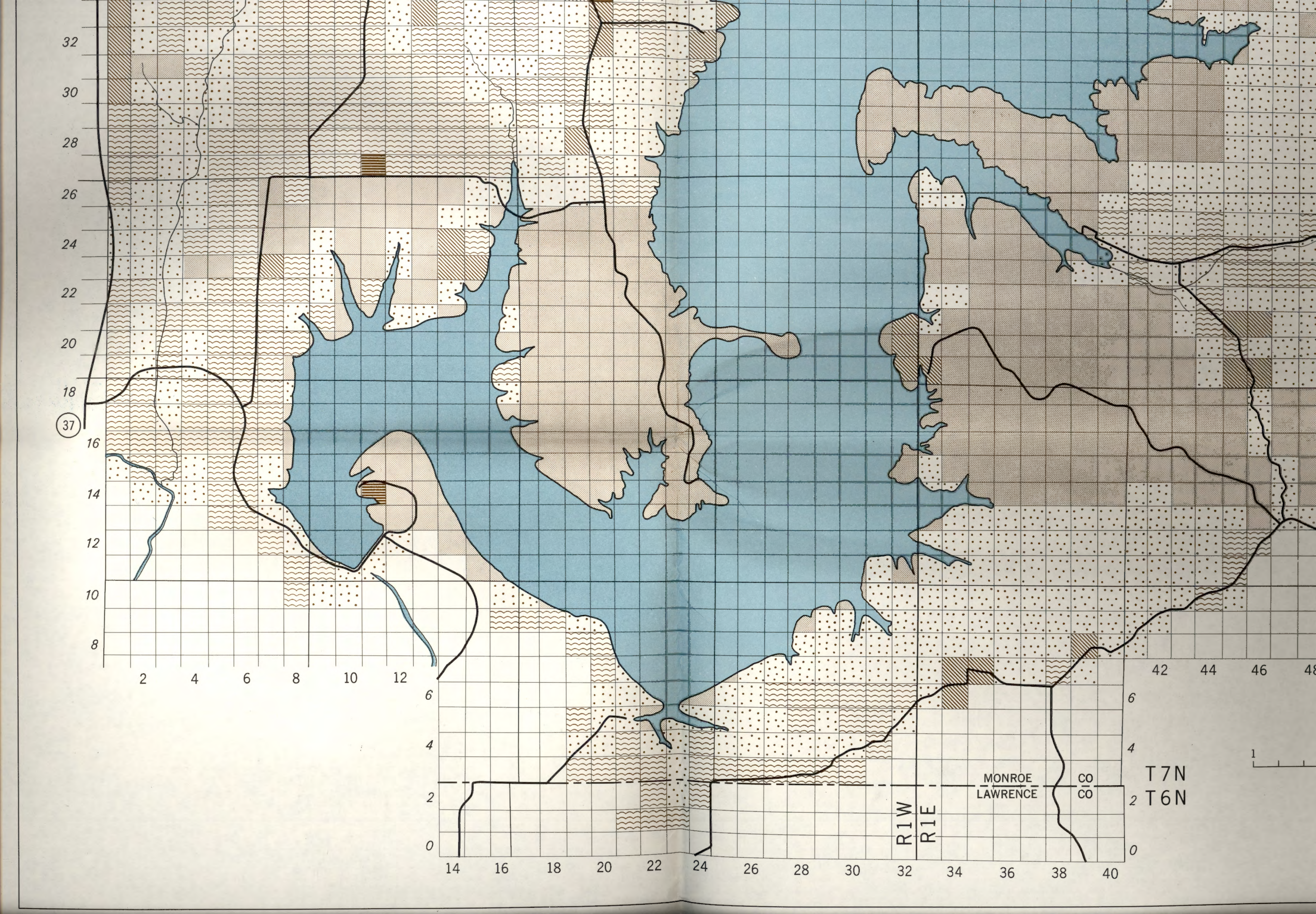
LAND USE MAP

MAP 4

Compiled in 1974 by Michael C. Roberts, Steve Jansen and John Hart: Department of Geography, Indiana University. Cartography by Roger L. Purcell and James R. Tolen. Map Base: U.S. Geological Survey Topographic Maps, Scale 1:24,000



LAKE
R1E
R2E
R1W
R1E
MONROE
LAWRENCE
CO
CO
T7N
T6N
446
1 Mile
1 Km
N



37
MONROE CO
LAWRENCE CO
T7N
T6N
R1W
R1E